CHAPTER 7

HYDROLOGY
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CHAPTER 7

HYDROLOGY

7.10 Introduction

This chapter presents a description of the hydrologic considerations for permitting of the Crandall Canyon Mine operations. The information in this chapter was provided by the staff of GENWAL Resources, Inc. and by various consultant firms as noted under specific sections. Conclusions drawn herein are based upon detailed field reconnaissance and spring/seep surveys of the area, limited exploratory drilling and published hydrologic information on the area.

7.11 General Requirements

This chapter presents a description of:

- o existing hydrologic resources,
- o proposed operations and the potential impacts to the hydrologic resources,
- o methods of compliance with design criteria and performance standards, and
- o hydrologic reclamation plans for the Crandall Canyon Mine operations.

7.12 Certification

All maps, plans and cross-sections presented in this chapter which deal with the design of facilities or the determination of watershed characteristics have been certified by a professional engineer.

7.13 Inspection

Impoundments included in the runoff control plan will be inspected as described in Section 5.14 of this application.

7.20 Environmental Description

This section presents a description of the hydrologic resources within the Crandall Canyon Mine permit area and the South Crandall Lease area and the U-68082 lease mod area. Refer to Appendix 3-20, "Final Environmental Assessment, Modification of Federal Coal Lease UTU-68082, U.S. Forest Service" for additional information regarding hydrology in the lease mod area.

7.21 General Requirements

This section presents a description of the hydrologic resources within the Crandall Canyon Mine permit area and the South Crandall Lease area and the U-68082 lease mod area.

7.22 Cross Sections and Maps

Figures 7-1 through 7-12 and Plates 7-1 through 7-17 of this chapter depict existing surface and groundwater occurrences within and adjacent to the Crandall Canyon Mine permit area and the South Crandall Lease area and the U-68082 lease mod area. These figures also illustrate the topography, streams, springs, wells, water monitoring locations, and other hydrologic design information pertinent to the Crandall Canyon Mine and the South Crandall Lease area and the U-68082 lease mod area. Refer to 7-63 for a detailed map of the Little Bear Canyon watershed showing mining projection, geology and location of seeps below the Castle Gate sandstone where cover is less than 600' above the coal seams.

Plates 7-14 and 7-15 have been updated to show the groundwater and surface water rights within and adjacent to the South Crandall lease area and the U-68082 lease mod area. Plates 7-12 (seep and spring) and 7-16 (stream monitoring) have also been updated relative to the South Crandall lease area and the U-68082 lease mod area. Note that Plate 7-13 has been deleted from the MRP.

7.2 Sampling and Analysis

All water samples are collected and analyzed according to methods in either the "Standard Methods for the Examination of Water and Waste Water" or the 40 CFR parts 136 and 434.

7.24 Baseline Information

(It should be noted that the Dellenbach fee tract is included in the currently approved permit area. All current data for hydrologic, geologic, and climatologic information applies to the Dellenbach tract.) Baseline hydrologic information for the South Crandall Lease area is summarized in Appendix 7-58. Baseline hydrologic information for seeps, springs, and streams in the U-68082 lease mod area are summarized in Appendix 7-64.

In response to concerns for the possible effect of mining on certain seeps in the Little Bear drainage, GENWAL commits to preparing a map identifying and showing the general location of vegetation in the area that could potentially be affected by mining in Little Bear Canyon, and will also prepare a detailed map of the vegetation associated with the spring/seep sites (LBA7, LB7A, LB7B, LB7C, LB5A and LB12) in Little Bear Canyon. This mapping will be done in the 2005 field season. This information will then be added to the MRP as an appendix.

7.24.1 Groundwater Information

This section is a comprehensive view of the groundwater hydrology for the Crandall Canyon Mine permit and surrounding area and the the South Crandall Lease area and the U-68082 lease mod area.

Scope

This section presents discussions of groundwater conditions within and adjacent to the permit area, which consists of lease areas SL 062648 and U 054762, State leases ML21568 and ML21569, UTU-68082 and the South Crandall Lease area, UTU-78953 and the U-68082 lease mod area (Plate 7-12). Conclusions drawn herein are based upon detailed seep and spring surveys of the area, limited exploratory drilling, results of stream monitoring, and the results of groundwater investigations conducted by others in the region of the mine.

Methodology

Seep and spring surveys were conducted in 1985, 1987, and 1989 through 1993, within an area that extended approximately one mile north, west, and south of the boundaries of the permit area. Springs and seeps in the South Crandall Lease area were monitored again during 2003. Seeps, springs, and streams in the U-68082 lease mod area were monitored again during 2004. The study area for the survey was bounded by Huntington Creek on the east, the east-west ridge between the North Fork of Horse Canyon and the South Fork of Huntington Creek on the north, Bald Ridge and Bald Mountain in Scad Valley to the west, and Mill Fork on the south.

An aerial reconnaissance of the survey area was initially conducted to provide an indication of spring locations and site accessibility. The area was then traversed on foot to allow springs and seepage points to be precisely located, examined, and sampled. Geologic conditions at all seeps and springs were noted in the field, including lithologic and structural controls and the geologic formation from which the seepage issued. Signs of usage were also noted. The flow rate was visually estimated and (if sufficient water was present) a sample of the water was collected. The temperature of the water issuing from the spring was measured at the site. All samples were subsequently analyzed in the field for pH and specific conductance.

Hydrologic characteristics of the North Horn, Price River, Castlegate, Blackhawk Formation and Star Point Sandstone are reviewed in this section. Locations of seeps and springs monitored during 1985, 1987,1989 through 1993, and during 2003, and during 2004 are shown on Plate 7-12. The geologic occurrence and use of seeps and springs are found in Appendix 7-16. Flow rate and temperature measurements appear in Appendix 7-17. Specific conductivity and pH measurements are found in Appendices 7-18 and 7-19 respectively. Field water-quality measurements are summarized in Appendix 7-20. Laboratory analytical reports for groundwater collected from the eight quarterly sampled seep/spring locations are also contained in Appendix 7-20. Hydrologic baseline information from the South Crandall Lease area is summarized in Appendix 7-58. Hydrologic baseline from the U-68082 lease mod area is summarized in Appendix 7-64.

Seep and spring surveys were conducted in the area around the IBC (Federal Right-of Way UTU-77975)area during 1987, 1989 and 1990. No seeps or springs were identified in the IBC area. The area was resurveyed by Gary Gray and Erik Petersen in 1998.

Regional Groundwater Hydrology

Six formations outcrop in the Mine Permit Area (Plate 6-1). According to Doelling (1972), the Masuk Shale Member of the Mancos Shale (Km on Plate 6-1) is a light gray to blue-gray marine sandy shale in the mine vicinity. This unit is exposed at the mouth of Crandall Canyon and in adjacent areas along Huntington Creek. The Masuk Shale Member yields water locally to seeps and springs but does not serve as a regionally important aquifer (Danielson et al., 1981).

The Star Point Sandstone (Ksp) is predominantly a light-gray massive sandstone with minor interbedded layers of shale and siltstone near its base (Doelling, 1972). In the vicinity of the mine, the Star Point Sandstone is 350 to 450 feet thick. The Star Point Sandstone yields water to several minor and some major springs where fractured and jointed.

The Blackhawk Formation (Kb) is the principal coal-bearing unit in the region (Doelling, 1972). This formation consists of interbedded layers of sandstone, siltstone, shale, and coal, and reaches a thickness of about 1000 feet in the mine area. The principal coal seam (the Hiawatha seam) is present at the base of the formation. The formation yields water to springs and coal mines when fractured. At GENWAL the water has been encountered within the Starpoint Sandstone approximately 50-100 feet below the contact point with Hiawatha seam.

The Price River Formation overlies the Blackhawk Formation and consists of the tan to brown cliff-forming Castlegate Sandstone (Kc) and the slope forming Upper Price River Member (Kpr). Fluvial sandstones of the Castlegate are massive and medium- to coarse-grained. In the area of the mine, the Castlegate is approximately 200 feet thick. The Castlegate yields water locally to seeps and springs, but does not serve as an important regional aquifer because it is commonly drained within short distances from its recharge area due to deeply incised canyons (Danielson et al., 1981).

The Upper Price River Member (Kpr) consists predominantly of friable calcareous sandstones interbedded with pebbly conglomerates and shales. It forms steep receding slopes and reaches a maximum thickness of about 600 feet in the mine areas (Doelling, 1972). This formation yields water locally to seeps and springs (Danielson et al., 1981). However, like the Castlegate Sandstone, deeply incised canyons in the area prevent the Upper Price River Member from being an important regional aquifer.

The uppermost formation that outcrops within the permit area is the North Horn Formation (Tkn). This formation consists of interbedded limestones, sandstones, and shales (Doelling, 1972). Due to the presence of low-permeability strata in the formation, downward vertical migration of groundwater is limited. Consequently, springs in the North Horn Formation are formed where perched groundwater is forced to flow laterally in the subsurface until the formation intersects the land surface, forming a spring.

Investigations by Danielson et al. (1981) indicated that most, if not all, groundwater in the region is derived from snow melt. Recharge tends to be limited in areas underlain by the Price River Formation and older rocks (relative to recharge in areas underlain by younger rocks) due to slope steepness and relative imperviousness (both of which promote runoff rather than infiltration of snow melt).

Detailed potentiometric surface data are not available for the region surrounding the permit area. However, the deeply incised canyons interrupt the flow of groundwater in much of the area. Danielson et al. (1981) suggest that groundwater generally moves from high areas of recharge to low areas of drainage, principally along stream channels.

The predominant chemical constituents in most springs in the region are calcium and bicarbonate (Danielson et al., 1981). Dissolved solids concentrations generally range from about 50 to 750 milligrams per liter. Regionally, the concentrations of major dissolved constituents in water from individual geologic units is highly variable, due to the complex lithologic nature of the area (Danielson et al., 1981).

Mine Plan Area Aquifers

Results of the initial seep and spring inventories conducted in the study area were submitted previously to DOGM (EarthFax Engineering, 1985a, 1985b). All data associated with subsequent seep and spring inventories are located within this MRP. Locations of the seeps and springs discovered during the inventories are shown on Plate 7-12. Data collected during the inventories are included in Appendices 7-16 through 7-20. Data from the 2003 inventories in the South Crandall Lease area are presented in Appendix 7-58.

Approximately 60% of all the seeps and springs found during the early-season surveys had flows of one gallon per minute or less (Appendix 7-17). These flows typically decreased by the time of the late-season surveys, with most of the low-flow sources issuing only as seeps or being dry. The majority of seeps and springs issue from bedding planes separating porous sandstones or fractured zones from underlying low-permeability siltstone and shale beds.

The primary exception to the above generality is flow from seeps and springs along the western edge of UTU-68082 which discharge from the North Horn Formation, alluvium covering the North Horn Formation, or from Tufa deposits in Upper Joes Valley. Flow from most of these seeps and springs is attributed to discharge from the Joes Valley fault zone.

The occurrence of groundwater at Trail Mountain (Lines, 1985) is very similar to that at Crandall Canyon. The major water bearing unit at both mines is the Blackhawk-Star Point aquifer. The Trail Mountain Mine is overlain by perched aquifers in the Blackhawk, Castlegate, Price River, and North Horn Formations; these perched aquifers are separated by unsaturated zones (Lines, 1985). Seep and spring survey results at Crandall Canyon and at the South Crandall Lease area also reveal the presence of perched aquifers in the same formations. As at Trail Mountain, this perching occurs where more-permeable strata (aquifers) overlie less-permeable strata (aquitards and aquicludes) (Lines, 1985; Appendix 7-16).

The distribution of seeps and springs among the formations present at both the Trail Mountain (Lines, 1985) and Crandall Canyon (Appendix 7-16) mines is very similar. At both mine areas the largest percentage of seeps and springs are found in the North Horn and Price River Formations. Similarly, in both mine areas the smallest percentage of seeps and springs are found in the Castlegate Sandstone Formation and Blackhawk Formation. Some springs and seeps discharge from the Star Point Sandstone in the South Crandall Lease area. Little Bear Spring, which is a developed spring that provides municipal water to nearby towns, discharges from a fracture system in the Star Point Sandstone.

Because of its importance as a municipal water supply source and its proximity to proposed mining areas, Little Bear Spring has been extensively studied. Several hydrologic studies have been performed since 1977 to investigate the recharge source for Little Bear Spring. These studies have agreed that the spring flow is supported by a fault/fracture system. Since Little Bear Spring lies more than 300 feet below the level of the mineable coal seams and past mining encountered the fault/fracture system without significant inflow of water, there is general consensus among the Castle Valley Special Service District (CVSSD), mine operators, scientific community, and the regulatory agencies that adverse effect to the spring are unlikely. (Forest Service, BLM Joint Decision Notice/Finding of No Significant Impact, Coal Lease Application UTU-78953)

Several studies have been done that suggest a northerly component of flow feeding Little Bear Spring. These studies include:

(i) Vaughn Hansen Associated, *Water Quality and Hydrologic Study in Vicinity of Huntington Creek Mine No. 4 and Little Bear Spring*, Prepared for Swisher Coal Company, August1977.

(ii) Hydro-Sciences, Inc., *Ground Water Hydrology in the Vicinity of the Huntington No. 4 Mine,* Prepared for ARCO Coal Company, December 19, 1980.

(iii) Beaver Creek Coal Company, *Huntington Canyon No. 4 Mining and Reclamation Plan,* Prepared for UDOGM, 1983.

(iv) Utah Geological and Mineral Survey, *Effects of Coal Mining at Huntington Canyon No. 4 Mine on Little Bear Spring, Emery County,* Prepared for Castle Valley Special Services District, Job No. 84-005, January 21, 1984.

(v) Vaughn Hansen Associated, *Hydrologic Conditions in Huntington Canyon No. 4 Mine,* 1984.

These referenced studies are available for review at the Division's Public Information Center.

Other studies indicate that the Little Bear Spring may possibly be fed by fault/fracture system which intercepts surface water in Mill Fork Canyon southwest of the South Crandall Lease area. These scientific investigations include an investigation of the Little Bear Spring groundwater system and the groundwater systems encountered in the Crandall Canyon Mine (Appendix 7-52), a solute and isotopic investigation of groundwater from Little Bear Spring and the Star Point Sandstone and Blackhawk Formation groundwater systems the Crandall Canyon Mine (Appendix 7-53), an investigation of the hydraulic conductivity of the Star Point Sandstone in the vicinity of the Crandall Canyon Mine (Appendix 7-54), an investigation of the alluvial groundwater system in Mill Fork Canyon with implications for recharge to Little Bear Spring (Appendix 7-55), an investigation of the potential for Little Bear Spring recharge in Mill Fork Canyon (Appendix 7-56), and a fluorescent dye-tracing study that conclusively demonstrates the hydraulic connection between the stream/alluvial groundwater system in Mill Fork Canyon and Little Bear Spring (Appendix 7-57). Sunrise Engineering also performed a series of investigations using a proprietary geophysical technique that demonstrated a hydraulic connection between Little Bear Spring and the surface drainage in Mill Fork Canyon. These investigations are included as Appendix 7-59, Appendix 7-60, Appendix 7-61, and Appendix 7-62.

While the flow mechanisms conveying water to Little Bear Spring are not completely understood, additional hydrologic studies performed since the Mill Fork EA was written have indicated that adverse impacts to the spring are not expected due to the vertical separation between the coal seams and flow. (Forest Service, BLM Joint Decision Notice/Finding of No Significant Impact, Coal Lease Application UTU-78953)

The low flow rates from most of the seeps and springs emitting from the Blackhawk Formation (Appendices 7-16, ~~and~~ 7-17, and 7-58) result from the low hydraulic conductivity of the formation where it remains unfractured. Laboratory permeability data from a core sample taken in T17S-R6E-Sec27 at Trail Mountain indicate an average horizontal hydraulic conductivity of $1.3x10^{-2}$ feet per day, and an average vertical hydraulic conductivity of $3.8x10^{-3}$ feet per day for sandstone units of the Blackhawk Formation (Lines, 1985).

Shale and siltstone samples of the Blackhawk Formation have maximum horizontal and vertical hydraulic conductivities of only $1.0x10^{-7}$ and $1.2x10^{-6}$ feet per day, respectively (Lines, 1985). These low hydraulic conductivities of the shales and siltstones indicate that these finer-grained sediments within the Blackhawk serve as barriers to the downward migration of water. As a result, water recharge into the Blackhawk, either from adjacent formations, snow melt, or rainfall is allowed to percolate vertically through sandstone beds until a siltstone/shale bed is encountered at which time the water is forced to travel laterally along the bedding plane to the surface.

Similarly, the majority of the seeps and springs in the Castlegate, Star Point and North Horn Formations observed in the field surveys in Crandall Canyon also issue from bedding planes. Due to the presence of these vertical permeability barriers, the aquifers in the North Horn, Price, River, Castlegate, as well as in the upper portions of the Blackhawk Formations are perched, with no direct communication to the underlying regional Star Point aquifer. Consequently, any dewatering of the perched Star Point aquifer resulting from mining the Hiawatha Coal of the Blackhawk Formation has little potential of affecting seeps and springs in the area (Lines, 1985).

Most of the seeps and springs in and around the state lease areas, and the UTU-68082 leases principally drain perched aquifers in the North Horn and Price River Formations (Appendix 7-16). The North Horn and Price River Formation perched aquifers lie 470 to over 2410 feet above the top of the Hiawatha Coal Seam. These aquifers exist along bedding planes and are perched with no direct hydraulic connection to the existing or proposed mine workings in the Hiawatha coal bed.

As a result, mine dewatering is anticipated to have minimal, if any effects on these seeps and springs.

Lesser numbers of seeps and springs drain the perched aquifers in the Blackhawk Formation and lie approximately 420 or more feet above the potentiometric surface of the regional Star Point aquifer. With no direct communication to the underlying regional aquifer these water sources should not be affected by mine dewatering, if it occurs.

Elevations of perched aquifers overlying the Hiawatha Coal Seam are evidenced by the occurrence of seeps and springs (Plate 7-12). The locations of seeps and springs suggest that perched aquifers may be present in the following areas:

Approx. Elev.	**Location**	**Geologic Formation**
10,160 feet	Sec. 12,T16S,R6E, SE	North Horn
9,440 feet	Sec. 12,T16S,R6E, NE	Price River - base
8,720 feet	Sec. 1,T16S,R6E, NW	Blackhawk - top
9,920 feet	Sec. 2,T16S,R6E, SW, NW SW	North Horn
10,240 feet	Sec. 2,T16S,R6E, SW	North Horn
10,480 feet	Sec. 35T,15S,R6E, SE	North Horn
10,240 feet	Sec. 35T,15S,R6E, NW	North Horn - base
9,280 feet	Sec. 31T,15S,R7E, SW	Price River
9,680 feet	Sec. 25T,15S,R6E,S ½	Castlegate

Seeps and springs northwest of the permit area discharge from the North Horn Formation or alluvium covering the North Horn Formation in Upper Joe's Valley. In contrast to other seeps and springs in the study area, flows from many of these water sources increased substantially between the spring/early summer surveys and the fall surveys (Appendix 7-17). This anomalous water flow trend is attributed to three factors:

First is the groundwater recharge from the Joe's Valley Fault Zone. These water sources lie in two linear positions parallel to the fault zone. Those springs occurring in the valley bottom directly east or immediately contiguous to Indian Creek, and those springs on the west hillslope above Indian Creek which also follows the trace of the fault zone.
Secondly, recharge from water in the colluvium and alluvium on the west-facing slope of East Mountain flows downhill toward Upper Joe's Valley and discharges into the valley alluvium. The relatively late arrival (mid-summer) of this water is due to the lag time created as this snow melt-derived water travels through the soil to the valley floor.

Thirdly, the seeps and springs in Upper Joe's Valley lie in a different drainage basin than those in the rest of the study area, a drainage basin which has a contrasting flow pattern to that present in the Huntington Creek tributaries on the east-facing slopes of East Mountain.

According to the approved current mine plans for the UTU-68082 (LBA No. 9) area (which is bounded at the east margin of the LBA by the north and south trending Joes Valley Fault Zone) mining will not occur within approximately 1000 feet of the fault zone.

During the period of March and April 1987, a monitoring well (MW-1) was installed at the Crandall Canyon Mine in the location indicated in Plate 7-13. MW-1 provides less than 1 gpm of water and is used to supplement the water withdrawn from Crandall Creek for in-mine usage. MW-1 was drilled using air-rotary methods to a total depth of 375 feet, and encountered Star Point Sandstone through its entire depth (Figure 7-1).

The driller indicated that the formation was relatively homogenous except in the zone from 290 to 335 feet, where the sandstone became coarser. It is from this zone that the well is producing water, with water first being encountered at a depth of about 315 feet. The static water level, approximately one week after completion of the well, was at a depth of 186.1 feet below ground surface, indicating the presence of a significant upward pressure component (approximately 130 feet) within the saturated zone.

After completion of the well, a slug test was performed on the well to determine the approximate hydraulic characteristics of the Star Point Sandstone at the mine site. This test was performed by inserting approximately 10 feet of drill stem below the water surface and allowing the water level to stabilize over a period of 3.75 hours. Although water level recovery was measured during this period, the data are not adequate for slug-test analysis since the drill stem was present within the zone of influence of the injection test, thus displacing additional water during the recovery period.

Following stabilization of the water level, the drill stem was rapidly removed from below the water level and the resulting recovery to static conditions was measured for a period of more than 2 hours. Data collected from this test have been provided to the Division in a letter addressed to Mr. Dave Cline from Richard B. White of EarthFax Engineering, Inc. and dated April 30, 1987. Data collected for the first 700 seconds of the test are provided in Figure 7-2.

In-mine monitoring wells MW-4 and MW-5 were installed, completed, and developed in January, 1992. Monitoring well MW-3 is located in an area that was sealed in 1979 and is now inaccessible. Water-level data collected in January, 1992 from MW-2, MW-4, and MW-5 were used to produce the potentiometric surface map depicted on Plate 7-13. Slug tests were also performed on MW-4 and MW-5. (See Appendix 7-24).

The slug test data were analyzed using a method developed by Bouwer and Rice (1976). According to this method:

$$K = \frac{r_c^2 \ln(R_e/r_w)}{2L} \frac{1}{t} \ln \frac{Y_o}{y_t} \qquad (7\text{-}1a)$$

where K = hydraulic conductivity (feet per day)
r_c = radius of the casing (feet)
r_w = radius of the well
L = length of the screened section (feet)
t = time since test began (seconds)
y_o = maximum drawdown during test of drawdown immediately following slug injection or withdrawal (feet)
y_t = drawdown at time t (feet)

$$\ln(R_e/r_w) = \left[\frac{1.1}{\ln(H/r_w)} + \frac{C}{L/r_w}\right]^{-1}$$

where H = depth from static water level to the base of the producing zone
C = a dimensionless coefficient as a function of L/r_w obtained from Figure 3 of Bower and Rice (1976, p.426)

For the slug test conducted at MW-1,

r_c = r_w = 0.25 ft (hole radius of 3 inches)
L = 335-290 = 45 ft (length of the producing zone according to the driller's records)
H = 335-187 = 148 ft (distance between the static water level and the base of the producing zone
y_o = 2.50 ft (see Figure 7-2)
y_t = 2.10 ft at t = 400 s (see Figure 7-2)

$$\ln(R_o/r_w) = \left[\frac{1.1}{\ln(148/0.25)} + \frac{6.6}{45/0.25}\right]^{-1} = 4.8$$

By means of equation (7-1a) and these data, a hydraulic conductivity of 0.1 foot per day was calculated. Assuming that the 45-foot producing zone accounts for the entire thickness of the aquifer at the location of MW-1, this value converts to a transmissivity of 4.5 square feet per day.

Slug tests from MW-4 and MW-5 were analyzed using the same equation and the hydraulic conductivity for MW-4 was determined to be 0.6 foot per day (2.3 square feet per day) and 2.5 foot per day (13.0 square feet per day) for MW-5. The data sheets for MW-4 and MW-5 slug tests are included in Appendix 7-24. These determined transmissivities are similar to those measured by Lines (1985) from pumping tests performed in the Star Point Sandstone near Trail Mountain approximately 10 miles southwest of Crandall Canyon.

According to Danielson et al. (1981), the flow of groundwater in the region is generally from high-elevation recharge areas toward major canyons. In most locations, the piezometric surface in the Star Point Sandstone is below the mine floor. Minor inflow to the existing mine workings has been from the roof, even though the floor of the mine within the western third of the mine area is below the elevation of Crandall Creek. Most groundwater inflow into the mine occurs from sandstone paleochannels in the mine roof, especially where these sandstone rocks are fractured. In the westernmost portion of the Crandall Canyon Mine, the piezometric surface in the Star Point is at or slightly above the elevation of the mine floor. In these areas, minor amounts of groundwater weeps into the mine from fractured sandstone in the mine floor. In addition, as noted above, the depth to groundwater at the mouth of the mine (at MW-1) is approximately 186 feet below ground surface. Thus, it is reasonable to assume that groundwater within the Star Point Sandstone beneath the mine does not discharge into Crandall Creek.

Although the regional stratigraphic dip is to the west (see Chapter 6), the local strata generally dip to the southeast. As shown on Plate 7-13, the direction of groundwater flow in the Star Point Sandstone beneath the mine is generally eastward, from East Mountain to Huntington Canyon.

In the area of Trail Mountain (located approximately 10 miles southwest of Crandall Canyon) the hydraulic gradient of groundwater in the Star Point Sandstone varies from about 0.11 foot per foot in the recharge area near the ridge line to about 0.03 foot per foot in the discharge area in Straight Canyon (Lines, 1985). Due to the similarity of the geologic conditions in the two areas (Waddell et al., 1981), similar hydraulic gradients are expected in the East Mountain recharge area and Huntington Canyon discharge area, respectively.

Usage of most seeps and springs within the survey area is confined to deer, elk, and other wildlife and limited seasonal usage by livestock. Flowing surface water within each watershed does contribute to downstream water users such as industry, domestic water supplies, and recreation (i.e., cold water fisheries). As would be expected, wildlife usage of the springs is most abundant where flows are greatest and the sources are most accessible. Little Bear Spring has been developed for municipal use by adjacent municipalities.

Data indicate that the specific conductance of water issuing from springs in June generally increased with increasing stratigraphic depth. This is in agreement with the findings of Danielson et al, (1981). Springs issuing from the Price River Formation typically had a specific conductance, during the June survey, that varied from 150 to 450 umhos/cm at 25°C while those issuing from the Blackhawk Formation and Star Point Sandstone had a specific conductance varying from 500 to 1000 umhos/cm at 25°C.

The pH of water issuing from springs in the survey area showed no trends within or between formations. Values varied from 6.80 to 8.57, averaging 7.74. Hence, spring water in the study area is slightly alkaline.

In those springs with sufficient water to sample, pH generally increased slightly between June and October. Increases normally amounted to 0.1 to 0.5 pH unit. Specific conductance showed no consistent pattern between the June and October data, with approximately as many increases as decreases between June and October.

Water temperatures vary widely at the site. In general, water temperatures are lowest in springs issuing from fractures and highest in springs issuing from shallow colluvium over bedrock. Lower water temperatures generally occurred in the springs with relatively low specific conductances.

Appendix 7-42 contains water quality results for selected springs from 1988 through 1991. These water quality analyses generally have included pH, temperature, conductivity or TDS, total manganese (as Mn), and either total or dissolved iron (as Fe). Baseline discharge and water quality data from the South Crandall Lease area is included in Appendix 7-58. Baseline discharge and water quality data from the U-68082 lease mod area is included in Appendix 7-64.

Groundwater Development and Mine Dewatering

Water Supply

A few of the seeps or springs inventoried during the spring/seep surveys have been developed for beneficial use. No water wells used for consumption by humans or animals, other than MW-1, are known to exist within the study area of the spring inventory. However, groundwater which reaches the surface water within each watershed does contribute to downstream water users in Huntington Creek who have the water allocated for industry, domestic water supplies, agriculture, and recreation (i.e., cold water fisheries). Little Bear Spring has been developed as a municipal water source for adjacent municipalities.

Appendix 7-1 contains a listing of groundwater rights (and their associated seeps and springs) in and adjacent to the permit area (within a 1-mile perimeter boundary). This data was obtained from the files of the Utah Division of Water Rights. Locations of these water rights are denoted in Plate 7-14. Appendix 7-1 also shows what groundwater right corresponds to the seeps and springs observed in the field inventories.

Mine Dewatering

An underground water budget (amended August 23, 1994) appears in Appendix 7-21. Based on the water budget, current underground use of water for the mine equipment averages 14.3 gpm throughout the year. Infiltration along the mine floor and sumps totals 10 gpm and evaporation due to mine ventilation equals 50 to 60 gpm. Coal moisture content accounts for 68.5 gpm. The combined approximate total equals 150 gpm. The quantity of mine inflow that is lost to evaporation and infiltration are estimates based on experience at other mines, and the infrequent need to discharge into Crandall Creek. Additional water depletion analysis for Fish and Wildlife Service is provided in Chapter 3.

Although worst-case estimates of mine inflow are greater than the present inflow rate, the actual inflow rate to be encountered is unknown. In order to effectively treat mine inflow an additional sump and pump house will be built in the southeastern corner of Lease ML-21569 (Appendix 7-22). This new sump will be equipped with a Worthington pump capable of pumping 150 gpm at 400 psi. This proposed sump will serve as the primary treatment facility for mine inflow, as well as the active water supply for mining operations. The existing sump will be maintained as a secondary water treatment facility. If discharge is required, water to be discharged will be initially treated in the proposed sump in Lease ML-21569, then pumped to the secondary (presently existing) sump, prior to discharge into Crandall Creek.

In the event mine inflow rates exceed the capacity of these treatment facilities to treat the mine inflow to meet the discharge limit criteria outlined in the NPDES Permit (UPDES Permit No. UT0024368, authorizing two discharge points), GENWAL commits to modifying these treatment facilities and/or constructing additional facilities in order to ensure compliance with the UPDES Permit. Treatment facilities to be considered include enlargement and/or construction of additional underground sumps and/or surface settling ponds. If excessive water volumes are encountered the use of flocculants and gel-logs will be considered as stopgap measures until more permanent treatment facilities are in-place.

Make-up water for in-mine use is pumped from Crandall Creek into the main mine sump at no more than 75 gallons per minute (pump capacity). At its lowest recorded flow, at the lower flume, a minimum of 100 gallons per minute remains within Crandall Creek even when the mine is withdrawing water for in-mine use.

The majority of natural water inflow is occurring in the old mine workings (Leases U054762 and SL-062648). According to GENWAL personnel, natural mine inflow accounts for less than 400,000 gallons per year of the total water used in-mine. Only negligible mine inflow has been encountered in Lease UTU-68082 and State Lease ML-21569. Currently, water used in mining operations is being pumped to State Lease SL-21569 from the sump in the old mine workings. All inflow water is used in underground mining operations.

Effects of Mining Operation On Groundwater

Mine dewatering (resulting in removal of water from the aquifers) is the primary mechanism by which the groundwater system may be impacted. As previously stated, it is believed that the water emitting from seeps and springs in State Leases ML-21568 and ML-21569, as well as areas within and adjacent to UTU-68082 (LBA No.9) and groundwater supporting springs and seeps in the South Crandall Lease area (UTU-78953), originate from perched aquifers with no direct communication with the regional Star Point aquifer. Although groundwater discharging from Little Bear Spring travels through a fracture system in the Star Point Sandstone, it is believed that the fracture system is the conveyance system for the the groundwater. Groundwater migrating through the pore spaces in the Star Point Sandstone near the spring likely does not contribute any significant quantity of groundwater to the spring. This conclusion is based on the very low hydraulic coductivity of unfractured Star Point Sandstone described in a subsequent section (see also Appendix 7-54). Thus, dewatering resulting from mining the Hiawatha Coal of the Blackhawk Formation has little potential for impact on the regional aquifer or for a diminution of flow from Little Bear Spring. This observation is in agreement with conditions present at Trail Mountain as reported by Lines (1985).

Laboratory permeability data reported by Lines (1985) on cores collected from the Blackhawk Formation indicate that the hydraulic conductivity of shale and siltstone units of this formation is typically four to six orders of magnitude lower than the hydraulic conductivity of the sandstone units. The relatively higher hydraulic conductivity of the sandstones of the Blackhawk Formation compared with the siltstones and shales indicates that the finer-grained sediments of the formation serve as barriers to the downward movement of water. As water recharges the Blackhawk Formation (either through snow melt, rainfall, or subsurface seepage from an adjacent formation) it percolates downward within the sandstone beds. However, upon reaching a less-permeable siltstone or shale layer, the water is forced to flow laterally to the surface, issuing at the interface between two units of contracting hydraulic conductivity.

Notable exceptions to the above generality concerning the Blackhawk Formation are present at springs that issue from fractured sandstone within the formation. Examples of this phenomenon are present in springs SP-53 through SP-58 (Plate 7-12), where flow rates greater than 100 gallons per minute have been measured. Travertine deposits are common at these springs, which suggests that the recharge area for these springs is dominated by calcium carbonate. In areas, the upper portion of the Blackhawk Formation may serve more as a conveyance body rather than a significant source of water to these springs.

Results of slug tests on MW-1, MW-4 and MW-5 indicate that the Star Point Sandstone in the Crandall Canyon area has a hydraulic conductivity of 0.1 to 2.5 ft/day. Based on an average hydraulic conductivity of 1.0 ft/day, an average hydraulic gradient of 0.025 ft/ft (see Plate 1-8), an average Star Point porosity of 0.14 (Lines, 190\85) and the modified Darcy equation (Freeze and Cherry, 1979), the average linear velocity of groundwater flowing through the Star Point Sandstone beneath Lease #UTU-68082 and adjacent areas is approximately 0.2 ft/day.

Results of slug tests performed on the in-mine Star Point Sandstone wells MW-2, MW-6A, MW-7, and MW-6 by Mayo and Associates in 1997 (Appendix 7-54) indicated an average hydraulic conductivity of unfractured Star Point Sandstone of approximately 0.005 ft/day. Using information from these wells, the calculated average linear velocity of groundwater moving through the Star Point Sandstone is even less than 0.2 ft/day..

It is of note that laboratory permeability data provided by Lines (1985) from core samples collected approximately 10 miles south of Crandall Canyon indicate that the Star Point Sandstone has an average horizontal hydraulic conductivity of 2.3×10^{-2} ft/day and an average vertical hydraulic conductivity of 8.8×10^{-3} feet per day. With the range of slug test results at the mine and the lower values reported by Lines (1985), the velocity presented above is considered to be a maximum.

The potentiometric surface of the Star Point aquifer directly underlying the Hiawatha Seam (the coal bed mined at Crandall Canyon) is shown on Plate 7-13. The water table rises to the northwest under East Mountain at an average angle of 3 degrees, and lies from 50 to 115 feet below the Hiawatha coal seam. This regional water table is 150 feet below ground surface in the area of the mine portal, and up to 2220 feet below the surface under East Mountain in Sec. 2,T.16S.,R.6E.

Mitigation and Control Plan

Based on information presented in the preceding section, only minimal impacts on groundwater resources in the permit area may result. A probable hydrologic consequences determination that includes the South Crandall Lease area is included as a portion of this chapter and is located in Appendix 7-15. Installation of the main bypass culvert will not alter the Probable Hydrologic Consequences.

Mitigation for potential disruption to the Little Bear Spring will be accomplished though the construction of a water treatment plant which will provide replacement water for the spring. Construction of this water treatment plant will be done under the provisions of a water replacement agreement between GENWAL Resources, Inc. and the Castle Valley Special Service District who maintain culinary water rights to Little Bear springs. A copy of this water replacement agreement is included in Appendix 7-51. With construction of this water treatment plant an uninterrupted supply of culinary water will be assured irrespectively of whether mining can be conclusively shown to have affected Little Bear Spring. This is in compliance with special stipulation #17 of federal lease UTU-78953 (see Appendix 1-13).

Currently, treatment of mine water prior to discharge into Crandall Creek includes the use of two underground sumps. Discharge to Crandall Creek has occurred only 5 times prior to 1994 (UPDES Permit - Appendix 5-14).

7.24.2 Surface Water Information

Scope

This section presents discussion of surface water conditions within and adjacent to the permit area (lease areas SL062648 and U 054762, state leases ML21568 and ML21569, and UTU-68082) and in the South Crandall Lease area (UTU-78953) and the U-68082 lease mod area. Conclusions drawn herein are based upon a field reconnaissance of the area and a review of published hydrologic information.

Methodology

The U.S. Geological Survey established a gaging station at the mouth of Crandall Creek in 1978. The gaging station was maintained through water year 1984. Data collected from this station were obtained from the Water Resource Division of the USGS in Salt Lake City and used to determine seasonal variations in flows in areas adjacent to the mine plan area. Additional information is provided from Parshall flumes and instantaneous stream flow measurements by GENWAL in Blind Canyon, Horse Canyon, Indian Creek, Crandall Canyon, No Name Canyon, Little Bear Canyon, and several unnamed drainages in the South Crandall Lease area (Appendix 7-23, 7-58).

Regional Surface Water Hydrology

The region (including the existing permit area, the U-68082 lease mod area and the South Crandall Lease area) is drained by a combination of ephemeral, intermittent and perennial streams. Two watersheds within the permit area have both intermittent and perennial sections within the stream drainage: Crandall Canyon and Horse Canyon. Two additional perennial streams occur adjacent to the permit area: Indian Creek (which drains to Joe's Valley Reservoir) and Huntington Creek. There are no perennial drainages in the South Crandall Lease area, although the Forest Service considers the Little Bear drainage a "perennially functioning stream".

Crandall Creek is an east-flowing tributary of Huntington Creek, one of the major tributaries of the San Rafael River. Huntington Creek had annual flows near the city of Huntington ranging from 25,000 to 150,000 acre-feet during the period of October 1931 through September 1973, averaging 65,000 acre-feet per year (Waddell et al., 1981). Variations in the annual flow of Huntington Creek near Huntington are depicted on Figure 7-6. Approximately 50 to 70 percent of stream flow in the mountain streams of the region occurs during May through July (Waddell et al., 1981). Stream flow during this late spring/early summer period is the result of snow melt runoff.

Horse Canyon is also an east-flowing tributary of Huntington Creek. Instantaneous flow measurements collected during 1991 indicate that peak flow occurred during May and June with approximately 2500 gpm at station H-1 (see Plate 7-16). Minimal flow was observed during August, September, and October at approximately 15 gpm. No flow was observed at station HS-5 (located on the south fork of Horse Canyon near the fork) during September of 1992. Additionally, the main channel of Horse Canyon was observed to be dry approximately 340 feet above the fork. Stream flow and temperature measurements for Horse Canyon can be found in Appendix 7-23.

The quality of water in Huntington Creek and other similar streams in the area varies significantly with distance downstream. Waddell et al. (1981) found that concentrations of dissolved solids varied from 125 to 375 milligrams per liter in reaches of major streams above major diversions to 1600 to 4025 milligrams per liter in reaches below major irrigation diversions and population centers. The major ions at the upper sites were found to be calcium, magnesium, and bicarbonate, whereas sodium and sulfate became more dominant at the lower sites. They attributed these changes to (a) diversion of water containing low dissolved solids concentrations, (b) subsequent irrigation and return drainage from moderate to highly saline soils, (c) groundwater seepage, and (d) inflow of sewage and pollutants from population centers.

Average annual sediment yields within the Huntington Creek drainage basin range from approximately 0.1 acre-feet per square mile in the headwaters area to about 3.0 acre-feet per square mile near the confluence with the San Rafael River (Waddell et al., 1981). Increases in sediment yield with increasing distance downstream is generally the result of the water contacting increasing amounts of shale and sandstone in the downstream direction (Waddell et al., 1981).

Periodic instantaneous stream flow measurements for Indian Creek, collected by the U.S. Forest Service, are found in Appendix 7-44. These measurements were collected in Sec. 17,T.17S.,R.6E., during the period of July 1970 through April 1977. During seep and spring inventories conducted in the area by GENWAL in October and November of 1989, 1990, and 1991, the upper portion of Indian Creek was observed to be dry at elevations above 9120 feet in Sec. 34,T.15S.,R6.6E.

Observations of drainages located along the west facing slope of East Mountain in T15S R6E Section 35 W1/2 have been made during the seep and spring surveys from 1985 to 1990. The drainages have been found to be dry during all fall seep and spring surveys. Flow was observed during the fall 1991 survey; however, flow was not measured due to the existing field conditions (rain and melting snow) that would mask any natural perennial flow or lack of flow. Appendix 7-48 contains additional information concerning hydrologic conditions for the UTU-68082 (LBA No. 9) areas.

Mine Plan Area Surface Hydrology

The permit area (including the South Crandall Lease area and the U-68082 lease mod area) is drained by a combination of ephemeral, intermittent, and perennial streams. The watersheds are steep (with average slopes often exceeding 50 percent) and well vegetated (with percent covers also often exceeding 50 percent).

Within the South Crandall Lease area, no perennial streams have been identified. Based on the discharge data for these drainages (Appendix 7-58), the drainages in the South Crandall Lease would be considered ephemeral or intermittent. There are no perennial streams in the U-68082 lease mod area (see Appendix 7-64). The reaches of No Name Canyon creek would all be considered ephemeral or intermittent. The Forest Service considers parts of the Little Bear Canyon drainage as a "perennially functioning stream".

Flow measurements collected at the U.S. Geological Survey gaging station at the mouth of Crandall Creek can be found in Appendix 7-2. Flow measurements from a flume in Blind Creek, and estimated in Horse Creek are contained in Appendix 7-23. The Crandall Creek data are summarized in Figures 7-7 (monthly flow volumes) and 7-8 (monthly maximum and minimum flow rates) for the period of record (October 1978 - September 1984). Data collection from the Crandall Canyon gaging station was discontinued by the USGS in 1984.

As noted in Figures 7-7 and 7-8, the flow data for Crandall Creek are not complete for the winter months in most years, because of freezing conditions. Assuming an average flow of 30 acre-feet per month for the period of missing record, the average annual flow for the six-year period of data contained in Appendix 7-2 was 2740 acre-feet.

According to Figure 7-8, maximum flow rates in Crandall Creek normally occur in the months of May or June, while minimum recorded flows occurred during the months of September through November. During the period of record, the maximum recorded daily flow rate has been 88 cubic feet per second (on May 30, 1983). The minimum recorded daily flow rate was 0.28 cfs (on several days in September 1981). Lower minimum flows may have occurred during the winter months when data are lacking.

Plan and profile views of Crandall Creek adjacent to the surface facilities are shown on Plate 7-1. Selected cross sections are provided on Plate 7-2. As noted, Crandall Canyon is steep, with channel slopes normally exceeding 5 percent. The channel bottom is approximately 10 feet wide and side slopes are steep (generally greater than 100 percent).

Surface water-quality data collected from Crandall Creek by GENWAL are contained in Appendix 7-3 and summarized in Table 7-5A. These data, collected between June 1983 and November 1985, indicate that the dominant ions in Crandall Creek are calcium and bicarbonate. Total dissolved solids concentrations in the stream have varied from 180 to 286 milligrams per liter, with lower concentrations normally occurring during the high-flow season. Total suspended solids concentrations in Crandall Creek have varied during the period of record from <0.5 to 5.0 milligrams per liter (see Appendix 7-3). As expected, the highest suspended solids concentrations generally occur during periods of highest stream flow.

Parshall flumes were installed by GENWAL in Blind Canyon in July 1991 and in Crandall Canyon in May 1988. Locations of the lower and upper Crandall Canyon flumes (CF-1 and CF-1, respectively), and Blind Canyon flume (BF) are shown on Plate 7-16. Charts and tabulated flow data collected from the flumes are presented in Appendix 7-23.

Periodic instantaneous stream flow measurements collected in 1991 by GENWAL in Blind Canyon, Horse Canyon, and the north and south branches of Crandall Creek appear in Appendix 7-23. These measurements were collected from the locations shown on Plate 7-16. When the area was accessible, these measurements were collected monthly from January through June, bi-monthly from July through September, and monthly from October through December. During seep and spring surveys performed in the area by GENWAL in October 1989, the South Fork of Horse Canyon was observed to be dry above the forks (Plate 7-16). Blind Canyon was observed to be dry in October 1989 above the midpoint between stations B-2 and B-3 (Plate 7-16). See also Appendix 7-23 for additional evaluations on flow through September 1992.

Water quality data collected by the U.S. Forest Service from Indian Creek are summarized in Appendix 7-45.

Water quality and discharge data for streams in the South Crandall Lease area are presented in Appendix 7-58. Water quality and discharge data for seeps, springs, and streams in U-68082 lease mod area are presented in Appendix 7-64.

Table 7-5A
Concentrations of Selected Constituents in Crandall Creek

Constituent	Maximum	Date	Minimum	Date	Mean
	(mg/1)	(mg/1)	(mg/1)		
Upper Station[a] 60 Samples					
Total Diss. Solids	320	11/24/87	180	4/08/85	255
Total Susp. Solids	1472	5/16/84	0	7/17/86	59.3
pH[b]	8.28	10/29/86	6.75	1/14/84	7.78
Total Iron	0.34	6/28/83	<0.05	Several	0.06
Diss Iron	<0.05	Several	<0.05	Several	<0.05
Total Manganese	0.03	Several	<0.01	Several	0.01
Lower Station[a] 52 Samples					
Total Diss. Solids	323	1/29/86	165	11/07/84	259
Total Susp. Solids	1468	5/16/84	0	7/17/86	57.8
pH[b]	8.66	11/20/86	6.95	11/01/84	7.75
Total Iron	0.25	6/28/83	<0.05	Several	<0.05
Diss Iron	<0.05	Several	<0.05	Several	<0.05
Total Manganese	0.03	Several	<0.01	Several	0.01

(a) See Figure 7-8
(b) In standard pH units solids concentrations generally occur during period of highest flow.

Analytical results are for samples collected from 1971 through 1978. Samples were collected from Sec. 17,T.17S.,R6E.

Laboratory analytical results of water samples collected by GENWAL at the Crandall and Blind Canyon flume locations appear in Appendix 7-3. Crandall Canyon water quality data have been collected from July 1983 to 1991. Blind Canyon water quality data represent the period of November 1990 to 1991.

Surface water-quality data contained in Appendix 7-3 indicate that the dominate constituents in Crandall Creek are calcium and bicarbonate. Total dissolved solids concentrations in the stream have generally varied from 200 to 300 milligrams per liter, with lower concentrations in the streams have generally varied from 200 to 300 milligrams per liter, with lower concentrations normally occurring during the high-flow season. The highest suspended solids concentrations generally occur during periods of highest flow and are a result of overgrazing in the upper Crandall Canyon Watershed.

Blind Canyon Drainage Study

In consultation with the Division of Oil, Gas and Mining, Utah State Lands, the Manti-La Sal National Forest, the U.S. Forest Service Intermountain Research Station, and the U.S. Bureau of Land Management, GENWAL Resources Inc. committed to participating in a scientific study in which the pillars beneath the unnamed drainage in Blind Canyon in Utah State Lands (T15S-R6E-Sec 36) will be retreat-mined to determine effects of retreat-mining produced subsidence on watershed erosion and stream flow. This study would monitor the actual effects of mining as proposed in Section 36. The U.S.F.S. Intermountain Research Station's research proposal appears in Appendix 7-25. This research proposal has been developed during close communication between the Intermountain Research Station and GENWAL Resources Inc. (Appendix 7-25). GENWAL Resources Inc. has committed to help finance the U.S.F.S. Intermountain Research Station's study, and perform subsidence monitoring, collection of Blind Canyon water quality and discharge data, as well as provide additional field support.

The approximate number and locations of cross-sections to be measured by the Intermountain Research Station personnel, and the current profile of the Blind Canyon Drainage from the Western Section Line of T15S-R6E-S36 to Route 31 appear on Plate 7-17. The locations and number of cross-sections may be modified by the researchers as ground conditions dictate. A final drainage profile and actual cross-section locations will be provided to DOGM when they are known. In addition to the cross-sections depicted on Plate 7-17, approximately 25 cross-sections in Crandall Canyon will be measured to serve as a control.

A timetable of research and mining to be conducted is found in Appendix 7-26. This timetable was developed in consultation with the U.S.F.S. Intermountain Research Station's Principal Investigator, to ensure that baseline data will be collected prior to retreat mining subsidence within the study area. As part of an agreement between GENWAL Resources Inc. and the above-referenced parties, pre- and post-mining erosion calculations for the Blind Canyon drainage have been calculated to determine the maximum worst-case amount of increased erosion that could occur as a result of retreat mining. These calculations appear in Appendices 7-27 through 7-38. An overview of the erosion calculations is presented in Appendix 7-39. Final results of these calculations are presented in Appendix 7-38. Drawings applicable to the erosion calculations appear in Plates 7-8, 7-9, 7-10, 7-11, and 7-12.

Appendix 7-38 results indicate a worst-case erosion volume exiting State Lease ML-21569 (T15S-R6E-S36) that could potentially be transported onto Manti-La Sal National Forest land to be 0.145 ac-ft (one time event). Appendix 7-37 presents the pre-and post-SEDROUTE outputs. An increase of 0.006 ac-ft (annually) is calculated. This value is the sum of potential headcutting (Appendix 7-38) and SEDROUTE calculations (Appendix 7-37). In order to calculate a worst-case erosion value the following have been assumed:

1) all potentially erodible material is transported down the Blind Canyon drainage off of State Section 36 onto Manti-La Sal National Forest Service land,

2) headcutting erosion is calculated on rills (A, B, C, and D) (Plate 7-9), all ephemeral drainages,

3) headcutting is calculated for drainage "E" (Appendix 7-9), a drainage reach that also exhibits ephemeral flow, and

4) erosion is calculated at the eastern edge of Section 36 (stations 14.5 through 19) (Plate 7-9), over an area where a barrier pillar exists and erosion is extremely unlikely. Drainage erosion between stations 14.5 and 19 is extremely unlikely given the absence of a nick-point produced by retreat-mining (downward hydraulic jump), from which erosion can advance from in an upstream direction resulting in erosion. The more likely occurrence is for all but the smallest sizes of suspended sediment (colloidal) to be deposited upstream of station 14.5, and not reach Manti-La Sal Forest Service land further downstream.

The Manti-La Sal National Forest Service desires an equal or greater amount of sediment to be trapped elsewhere in the Manti-La Sal National Forest to offset potential increases of sedimentation on Forest Service land that could result from retreat-mining of State Section 36. As discussed with the U.S.F.S. Research Station personnel, and officials of the Manti-La Sal National Forest Service, erosion control measures cannot be implemented within the Blind Canyon drainage, on the State of Utah or Manti-La Sal National Forest Service lands, due to potential impacts on the U.S.F.S. Intermountain Research Station's study.

Consultations with Manti-La Sal National Forest Service personnel have resulted in identification of a site, Nuck Woodward Canyon where an erosion enhancement procedure can be conducted to reduce an equal or greater amount of sediment entering Huntington Creek. The enhancement procedure consists of graveling approximately 1/2 mile of the U.S.F.S road from the intersection of Route 31 to the trailhead area of the Nuck Woodward Canyon. An agreement whereby GENWAL donates $15,000 to the Manti-La Sal Forest to fund the Forest Service graveling of this road is provided in Appendix 7-49. This mutually agreed upon action by GENWAL Resources

Inc. and the Manti-La Sal National Forest, satisfies the U.S.F.S.'s "Net Beneficial Impact Policy." Additionally, GENWAL commits to remediating any adverse effects of retreat mining.

Thin-section microscopy and x-ray diffraction analyses of shales obtained from Crandall Canyon Mine overburden reveal the presence of a variety of bentonitic (swelling) clays. Moreover, carbonate cementation characteristics observed in thin-section and at outcrops, as well as groundwater analytical results, suggest pore-fluid chemistry conditions promote sealing of subsidence fractures (Appendix 7-41). This appendix also references a U.S. Forest Service study which indicates physical closure of subsidence fractures. The Crandall Canyon Mine overburden mineralogy, as well as physical closure of tension fractures, will aid in the protection of perched aquifers and surface waters.

SURFACE WATER DEVELOPMENT AND CONTROL

Water Supply

No extensive surface water development has occurred in the mine permit area or adjacent areas. GENWAL has historically pumped water from the stream near the sedimentation pond and from the sediment pond for use underground. GENWAL agrees to not pump from Crandall Creek at a rate that will cause the instream flow to decrease below 0.30 cfs. For the purpose to this determination, flow rates were measured using the flume at the "Lower Stream Station" indicated on Plate 7-7. No other points of development are known to exist on Crandall Creek or adjacent streams in the immediate vicinity of the mine plan area.

Appendix 7-1 presents a listing of surface water rights within the permitted and adjacent areas as obtained from the files of the Utah Division of Water Rights. Listing of these rights are noted on Plate 7-15 and summarized in Table 7-6.

Only one water-supply intake is known to exist on Crandall Creek. This intake is located immediately upstream from the sedimentation pond and is operated by GENWAL to obtain water for use at the mine. A search of records on file with the Utah Division of Water Rights and an examination of physical conditions along Crandall Creek and Huntington Creek indicate that no other water-supply intakes exist within one mile of the confluence of the two streams. It should be noted that an underground monitoring well (MW-1) drilled in 1987, currently serves as a water supply well for the mine. The use of this well supplements Crandall Creek for in-mine process water.

7.24.3 Geologic Information

Geologic information required for Sections 724.310 and 724.320 is provided in Chapter 6 and in this chapter under Sections 7.24.1 and 7.24.2.

7.24.4 Climatological Information

General

The Air Pollution Control Plan has been approved with conditions by the Department of Health letter of February 3, 1992. An amended Letter of Intent to Modify GENWAL's existing Air Pollution Control Plan was submitted to the Executive Secretary of the Division of Air Quality in September, 1995. Fugitive dust control measures to be used in connection with the GENWAL Mine facility are included within the remainder of this Section. The addition of the culvert expansion and a proposed increase in coal production has been included in the amended letter of intent.

The climatological information presented below is believed to be applicable to the South Crandall Lease area and the U-68082 lease mod area.

EXISTING ENVIRONMENT

Precipitation

Monthly Averages

Jan.	2.90"	Feb.	2.18"	Mar.	2.53"
Apr.	0.72"	May	1.67"	June	0.19"
July	0.96"	Aug.	2.29"	Sept.	0.32"
Oct.	0.40"	Nov.	2.66"	Dec.	3.18"

Yearly Average: 20.00"

Mean Monthly: 1.75"

TABLE 7-6

Surface Water Rights in the Crandall Canyon Mine Permit Area & Adjacent Areas

W.U. Claim No.	Owner	Claim Allotment	Use	Period of Use	Source
93-134	U.S. Forest Service	(d)	Stockwater	Jun 21 to Sept 30	Stream
93-175	U.S. Forest Service	(a)	Stockwater	July 6 to Sept 25	Stream
93-181	U.S. Forest Service	(b)	Stockwater	July 1 to Aug 30	Stream
93-182	U.S. Forest Service	(d)	Stockwater	May 21 to Aug 30	Stream
93-183	U.S. Forest Service	(a)	Stockwater	July 6 to Aug 25	Stream
93-184	UT State Lands&Forestry	(c)	Stockwater	Jan 1 to Dec 31	Stream
93-188	U.S. Forest Service	(d)	Stockwater	June 21 to Aug 30	Stream
93-190	U.S. Forest Service	(d)	Stockwater	June 21 to Sept 10	Stream
93-191	U.S. Forest Service	(a)	Stockwater	July 6 to Sept 25	Stream
93-192	U.S. Forest Service	(d)	Stockwater	June 21 to Sept 30	Stream
93-193	U.S. Forest Service	(E)	Stockwater	July 1 to Sept 30	
93-197	U.S. Forest Service	(d)	Stockwater	June 21 to Sept 30	Stream
93-198	U.S. Forest Service	(e)	Stockwater	July 1 to Sept 10	Stream
93-199	Pacificorp DBA UP&L	(j)	Stockwater	Jan 1 to Dec 31	Stream
93-201	U.S. Forest Service	(e)	Stockwater	July 1 to Sept 30	Stream
93-219	Huntington Clev. Irr. Co.	(i)	Varied*	Jan 1 to Dec 31	Stream
93-258	UT State Lands&Forestry	(c)	Stockwater	Jan 1 to Dec 31	Stream
93-336	U.S. Forest Service	(a)	Stockwater	July 6 to Sept 25	Stream
93-377	U.S. Forest Service	(f)	Stockwater	June 1 to Sept 30	Stream
93-383	UT State Lands&Forestry	(c)	Stockwater	Jan 1 to Dec 31	Stream
93-483	U.S. Forest Service	(a)	Stockwater	July 6 to Sept 25	Stream
93-606	U.S. Forest Service	(a)	Stockwater	June 6 to Sept 25	Stream
93-1180	U.S. Forest Service	(d)	Stockwater	June 21 to Sept 30	Stream
93-1590	U.S. Forest Service	(g)	Stockwater	June 21 to Sept 30	Stream
93-1673	U.S. Forest Service	(h)	Stockwater	June 6 to Sept 20	Stream

TABLE 7-6 (continued)

Surface Water Rights in the Crandall Canyon Mine Permit Area & Adjacent Areas

(a) Part of water right WUC 93-1403 on Crandall Canyon Allotment
(b) Part of water right WUC 93-507 on Horse Creek Allotment
(c) Part of water right WUC 93-500
(d) Part of water right WUC 93-116 on Gentry Mountain Allotment
(e) Part of water rights WUC 93-193, -198, -201, -1410, -1411, -1412, -1413, and -1414 on Crandall Canyon Allotment
(f) Part of water right WUC 93-377 on Little Joe's Valley Allotment
(g) Part of water right WUC 93-1588 on Trail Mountain Allotment
(h) Part of water rights WUC 93-985, -1632, and -1677 on Joe's Valley Allotment
(i) Part of water right WUC-93-219, a7941
(j) Claims 199, 1183

* Irrigation, stockwatering, domestic, power, industrial

Temperature

Summer Range: +32 to +90 Degrees Fahrenheit
Winter Range: -10 to +40 Degrees Fahrenheit

Evaporation

Potential evapotranspiration of 18 to 21 inches per year.

Wind

Average direction of prevailing winds from west and northwest. The average velocity of prevailing winds representative of the proposed mine plan area is 12 miles per hour as determined by the Utah State Climatological office.

EFFECTS OF MINING OPERATION ON AIR QUALITY

Estimate of Uncontrolled Emissions

The estimate of uncontrolled particulate emissions was determined by GENWAL and submitted to the State of Utah Department of Health for a coal production rate of 3,500,000 tons per year.

Description of Control Measures

Refer to Appendix 4-7 for measures that will be specifically committed to, for implementation. The air quality approval order authorizes the increase in coal production with the conditions noted therein.

A description of the controls and design features associated with the yard expansion can be found in Chapter 5 under section 5.26.

Climatological and Air Quality Monitoring

GENWAL does not require a continuous monitoring plan for the limited amount of dust, particuate emissions or diesel exhaust. (See State of Utah, Division of Health recommendations for monitoring letter included as Appendix 4-7).

7.24.5 Supplemental Information

Because GENWAL has an existing and approved permit it is not anticipated that any additional information will be required for the PHC.

7.24.6 Survey of Renewable Resource Lands

All renewable resource survey information is included in the Subsidence Control Plan in Section 5.25.

7.24.7 Alluvial Valley Floors

The permit area is located in a narrow V-shaped canyon with upland areas and steep hillslopes. The mine and permit area and the South Crandall Lease area and the U-68082 lease mod area are covered by a thin veneer of colluvial deposits and residual soils. The only alluvial materials are associated with the immediate stream channel which is less than 20 feet wide. These alluvial deposits are discontinuous as many portions of the stream are located directly on bedrock. As a result, the area is not underlain by an alluvial valley floor.

The area occupied by the surface facilities is a steep, narrow canyon hillslope and v-shaped narrow canyon bottom. No agricultural activities have been conducted in the area in the past nor will they be in the future due to the limited width of alluvium along the stream (less than 20 feet), to restrictive climatic conditions, and the limiting physical properties of the alluvial materials. Hence, the Crandall Creek area adjacent to the surface facilities is not an alluvial valley floor. This negative determination was also determined by the U.S. Soil Conservation Service (see Appendix 7-12).

7.25 Baseline Cumulative Impact Area Information

Sufficient information was provided by GENWAL during the initial permitting of the Crandall Canyon Mine for the Division to develop a Cumulative Hydrologic Impact Assessment (CHIA).

Geologic Information pertaining to Little Bear Spring

The Little Bear Spring is located close to the southern boundary of the South Crandall Lease area. This spring is an important source of culinary water for many residents of Emery County. In order to ensure that the spring would be protected from the effects of mining in the South Crandall lease area. the Forest Service and the BLM required a number of detailed hydrology studies to ascertain the source of the spring. Based on the result of these studies the federal government has concluded that the potential for mining this lease to alter the flow of Little Bear Spring is low and has issued a Finding of No Significant Impact (FONSI) regarding the proposal to conduct mining operations within the lease. The following studies were required by the Forest Service and BLM prior to leasing action and are included in this MRP as appendices in Chapter 7. Each report includes an extensive discussion of the geology of the South Crandall tract as relates to the occurrence of ground-water, aquifers, and recharge sources of the Little Bear Spring.

App 7-51 Little Bear Spring Water Replacement Agreement
App 7-52 Supplemental Hydrogeologic information for LBA 11
App 7-53 Summary of New Isotopic Information for LBA 11
App 7-54 Results of In-Mine Slug Tests
App 7-55 Investigation of Alluvial Ground Water System In Mill Fork Canyon

App 7-56 Investigation of Potential for Little Bear Spring Recharge
App 7-57 Determination of Recharge Location of Little Bear Spring (Dye Tracing)
App 7-58 Summary of Hydrologic Baseline Information, South Crandall Lease
App 7-59 Little Bear Spring Study (Initial study, 1998) AquaTrack
App 7-60 Little Bear Spring Study (Expanded Study, 1999) AquaTrack
App 7-61 Mill Fork Resistivity Study, 2001 AquaTrack
App 7-62 Little Bear Spring (2nd Expanded Study, 2001) AquaTrack

7.26 Modeling

No hydrologic model has been prepared or conducted at this site, nor is any planned.

7.27 Alternative Water Source Information

GENWAL recognizes the fact that the Division of Wildlife Resources, the U.S. Forest Service, the Division of Oil, Gas & Mining, and the State Engineer consider all seeps and springs to be important to wildlife and downstream users. If, during the monitoring of the springs, it is determined that over the course of time a spring has been dewatered, GENWAL will notify the Division of Wildlife Resources, the Division of Oil, Gas and Mining, the U.S. Forest Service, the State Engineer, and any affected downstream users. A determination as to the probable cause of diminished flow will be made and if mining activities are found to be the cause, work will begin on an acceptable mitigation plan involving the use of guzzlers or other replacement measures acceptable to GENWAL, DOGM, the U.S. Forest Service, the State Engineer, and affected downstream users. The Utah Division of State Lands and Forestry will also be conferred with in formulating any mitigation plans that will affect the lands in the State Leases.

These replacement measures will be designed in cooperation with the Division of Wildlife Resources, the Division of Oil, Gas and Mining and the U.S. Forest Service and placed in the area of the effected spring. No other sources of water, other than the springs located by the seep and spring survey, are known to exist in the mine plan area. GENWAL owns shares in the Huntington-Cleveland Irrigation Company that can be transferred if required, to meet the demands of an alternate water supply. A copy of the water share certificate which would be used as an alternative water source is included in Appendix 7-14.

Mitigation for potential disruption to the Little Bear Spring will be accomplished though the construction of a water treatment plant which will provide replacement water for the spring. Construction of this water treatment plant will be done under the provisions of a water replacement agreement between GENWAL Resources, Inc. and the Castle Valley Special Service District who maintain culinary water rights to Little Bear springs. A copy of this water replacement agreement is included in Appendix 7-51. With construction of this water treatment plant an uninterrupted supply of culinary water will be assured irrespectively of whether mining can be conclusively shown to have affected Little Bear Spring. This is in compliance with special stipulation #17 of federal lease UTU-78953 (see Appendix 1-13).

7.2 Probable Hydrologic Consequences Determination

The Probable Hydrologic Consequences (PHC) is included as a separate document in Appendix 7-15. Installation of the culvert expansion project does not change the conclusions presented in the current PHC.

7.29 Cumulative Hydrologic Impact Assessment

The Division has prepared a Cumulative Hydrologic Impact Assessment (CHIA) for this operation in the initial permit. A complete PHC is provided in Appendix 7-15 to aid in the determination as to whether a new CHIA is required for this renewal.

7.30 Operation Plan

7.31 General Requirements

This section describes the groundwater and surface water protection plan and water quality monitoring program implemented within the existing permit area and to be implemented for the refuse disposal site. The purpose of the groundwater and surface water protection plan is to minimize the potential for water pollution and changes in water quality and flow for surface and groundwater within and adjacent to disturbed areas. The purpose of the water quality monitoring program is to identify the potential impacts of coal mining operations on the hydrologic balance.

7.31.1 Hydrologic Balance Protection

Surface and Groundwater Protection Plan

GENWAL has included a plan to protect the surface and groundwater in the area of the mine facilities, topsoil storage site and refuse disposal site. The plan will ensure protection of the ground water and surface water resources of the sites by handling earth and refuse materials in a manner that prevents or controls, using the best technology currently available, the discharge of pollutants to the hydrologic system. Additionally, the GENWAL commits to handle acid- and toxic-forming materials, if encountered in the future, in a manner that will minimize acid- and toxic-forming discharge to surface or groundwater. The design details of the water protection plans are presented in Section 7.42 of this application.

In order to prevent material damage to the hydrologic balance and to protect the hydrologic systems possibly associated with the Joes Valley fault system, GENWAL plans to drill ahead before mining in the Incidental Boundary Change area adjacent to the Joes Valley fault in T. 16 S., R. 6 E. Sections 3 and 10.

When mining in the longwall gate entry nears the fault (between 200-300 feet away), an underground drill will be used to drill west toward the fault to determine its location. The drill will drill horizontally toward the fault up to 50 feet ahead of the entry face. If the fault is not encountered, the continuous miner will advance about 30-40 feet toward the fault, leaving at least 10 feet of coal between the entry and the end of the hole. The drill will again drill ahead. This sequence will continue until either water or fault gouge is encountered in the hole or the entry has been developed to its maximum extent (providing no fault was detected). If the fault is encountered prior to reaching the bleeder entries, then mining will stop and the bleeder entries will be relocated. At least 10 feet of solid coal will be left between the face of the entry and the fault.

Other indicators have been experienced during mining up next to Joe's Valley Fault. Any of these indicators being present will affect the above mining sequence. The indicators, which we have experienced are severe rib rashing in some cases; in others the ribs will stand up showing no rib rash. Severe water pressures have never been encountered. Large flows of water have occurred from cracks in the roof, but these flows have been associated with sand channels rather than the fault.

One horizontal hole will be drilled in the 10, 11 12 13 and 14th west panels. Should water be encountered by the drill hole, entry development would terminate at that point. Although large amounts of water and high pressure have not been previously encountered by mining near the fault, an emergency plan to handle water inundation from the fault has been developed. The plan consists of the following actions:

1. Pull equipment back from face
2. Erect two Kennedy stoppings at least 2 feet apart
3. Place appropriate sized de-water pipe w/valve at bottom of stoppings
4. Pump quick drying cement into the space between the stopping
5. After minimum drying time, close water valve

As a secondary measure of precaution, no longwall mining will take place in the 22 degree angle of draw projected from the Joes Valley fault. Therefore no subsidence from mining operations will intersect the fault or fault zone. Any hydrologic conditions specific to the Joes Valley Fault will not be impacted through mining or subsidence based on accessibility of the sites. Water monitoring reports will be submitted to the Division on a quarterly basis, and a summary report will be submitted yearly with the Annual Report for the mine.

All test and measurement instruments are operated, maintained and calibrated in accordance with the manufacturers instructions. The results of all field measurements are recorded and initialed by the sampler. When laboratory measurements are required, a specific set of sample bottles are pre-ordered from the laboratory. Bottles received from the laboratory are clean, pre-acidified and color-coded. Once the sample bottles are filled, they are individually labeled with water-proof, smudge-proof labels, placed in ice chests with ice packs and returned to the laboratory as soon as possible to insure proper holding times are met.

7.31.21 Groundwater Monitoring Plan

As noted in Section 7.24.1 only four springs were found during the June 1985 seep and spring survey within the area of potential subsidence with flow rates of one to two gallons per minute (SP-16, SP-17, SP-30, SP-36). By the time of the fall survey, all seeps and springs with the area of potential subsidence except SP-30 and SP-36 had dried up. Spring SP-30 was found to be dry during 1986 and in subsequent years to the present. The flow from SP-30 originally measured in 1985 is most likely attributable to higher than normal precipitation during 1983-1985. SP-30 occurs as diffuse seepage from the Blackhawk Formation above the mine portals and is collected in a diversion pipe to avoid problems at the portal face. Flow at SP-36 issues from a sandstone-shale contact within the Blackhawk Formation and showed evidence of use by elk and deer. All major springs (flows of at least five gallons per minute) found during the June 1985 survey were located outside of the area of potential subsidence at that time.

The Federal Lease #UTU-68082 and State Leases have since been added to the permit area, and the area of potential subsidence has therefore expanded. Additional spring and seep surveys were conducted in 1987, 1989, through 1993. The proposed groundwater monitoring program described below is based on the results of those surveys and is designed to evaluate impacts from the entire permit area, including the State Leases and Lease #UTU-68082 (LBA 9). A table clarifying the groundwater monitoring program is shown in Table 7-10 at the end of Chapter 7 text.

Previous to August 1994, groundwater monitoring for the Crandall Canyon Mine area included collection of water quality and quantity data from eleven springs as well as points of significant inflow to the underground workings. Based on the permit modification to include UTU-68082 (LBA #9), GENWAL conducts the monitoring of fourteen seeps and springs:

SP-30 and SP-36 are monitored to determine potential impacts in the immediate vicinity of the mine. SP-58 is monitored as an indicator of long-term changes in groundwater issuing from the Blackhawk Formation in a area that will not be affected by mining operations. The magnitude of these changes will be useful when interpreting changes at SP-30 and SP-36.

SP2-24, SP2-9, SP-47A, and SP1-3 are monitored since a water right has been filed on the springs by the U.S. Forest Service. Springs SP1-19 and SP1-22 are monitored as indicators of the water supply in the upper reaches of Blind Canyon and the North Fork of Crandall Canyon.

SP1-33, SP1-47, and SP2-1 are monitored as an indicator of changes in groundwater emanating near the western border of East Mountain, contiguous to Joe's Valley Fault.

SP1-9 (also SP1-19 mentioned above is located within this state lease) located in Lease ML-21569 and SP1-24 in lease ML-21568 are monitored to evaluate the effects of potential subsidence in the state leases. Plate 7-12 shows the location of each spring.

Samples were collected from each of the fourteen seeps/springs listed above, plus seeps SP2-14 and SP2-23, during the spring of 1994 and analyzed for both quantity and quality. Based on the information collected during 1994 and the past seep and spring surveys, springs SP-36, SP-58, SP2-9, SP2-24, SP1-33, and SP1-9 are monitored quarterly for quantity and quality. The remaining springs (SP-30, SP2-1, SP1-47, SP1-24, SP1-19, SP-47A, SP1-3, and SP1-22) are monitored for quantity and field chemical parameters only. Springs SP2-14 and SP2-23 have been removed from the list of springs to be monitored due to extremely low or no flow over the past few years and SP2-9, which is contiguous to these two springs, is a good indicator of the water quality and quantity for that area of the mine permit. Monitoring at the fourteen seeps/springs will continue on a quarterly basis.

Following reclamation the samples will be collected semiannually until the surety bond is released. At least one of these samples will be collected during the low-flow period (normally the fourth quarter). These samples are collected as close as possible to the point of issuance of the springs. Samples are analyzed according to the list of parameters in Table 7-4 which includes, flow, pH, conductivity or TDS, total iron, and total manganese as required by R645-301-724.1.

Samples collected during the low-flow period of the year (fourth quarter) will be analyzed according to the list of parameters contained in Table 7-5 (as requested in guidelines from DOGM) in the years 1990, 1995, 2000, and at 5-year intervals thereafter until the surety bond is released.

Even though SP-30 has been dry since the original measurement in 1985, monitoring at SP-30 will continue. By continuing to monitor SP-30, flow trends, as they relate to precipitation patterns, can be observed. Substitution of another spring in the vicinity was considered and dismissed due primarily to the long term monitoring correlation stated above and because there exists a lack of flowing springs in the vicinity of old mine workings. Additionally, when the physiographic location of the mine portal is compared with similar locations in adjacent canyons (ie; Blind Canyon, Horse Canyon, Little Bear, and Mill Fork) there are an apparent absence of springs on these mid to upper south facing hill slopes (Plate 7-12). The apparent absence of seeps and springs in these areas is primarily related to the geologic nature and limiting hydrologic characteristics of the Blackhawk Formation in its upper strata.

In conjunction with the South Crandall Lease (UTU-78953) and the SITLA/PacifiCorp sublease GENWAL will monitor four springs. The monitoring plan for the South Crandall Lease is described below. Monitoring site locations are shown on Plate 7-18. The monitoring protocols for each of the monitored springs are presented in Table 7-10.

The monitoring plan for springs includes springs in the Castlegate Sandstone, Blackhawk Formation, and Star Point Sandstone. As demonstrated in the PHC, it is believed that the potential for diminution of flow or degradation of the water quality of springs discharging from the Price River or North Horn Formations is remote.

Little Bear Spring will be regularly monitored to verify that impacts to not occur and to document the relationship between climatic variability and discharge from the spring. Quarterly water quality sampling at the spring will occur and the samples will be analyzed for the parameters listed in Table 7-4. Discharge from the spring is monitored by the Castle Valley Special Service District.

Springs LB-7, LB-7A, LB-7B, AND LB-7C discharge near the contact of the Blackhawk Formation and Castlegate Sandstone in Little Bear Canyon. Spring LB-12 discharges from the Blackhawk Formation near the bottom of Little Bear Canyon. These springs will be monitored quarterly for flow and field water-quality parameters. NOTE: multiple seam mining beyond spring site LB-7 in Little Bear Canyon is contingent upon a monitoring plan approved by the Division in concurrence with the Forest Service at least two years prior to mining in that area.

It should be noted that access to Little Bear Canyon can be hazardous. When ice or snow is present it can become unsafe to traverse the cliffs, and steep, rugged slopes in the canyon. It can also be dangerous to wade across Huntington Creek when stream flows are high. In consideration of these difficulties, a diligent attempt will be made each quarter to monitor the springs at times when conditions permit. However, there will likely be times when these springs are not accessible for monitoring.

Spring LB-5A discharges from a sandstone channel in the upper Blackhawk Formation overlying proposed mining areas. To monitor for potential impacts to groundwater systems in the Blackhawk Formation, LB-5A will be monitored quarterly for Table 7-4 parameters including flow and field water-quality parameters.

Spring SP-79 discharges from the Star Point Sandstone in the northeast portion of the proposed South Crandall Lease area. To monitor for potential impacts to Star Point Sandstone groundwater systems (stratigraphically below the mined coal seam) quarterly monitoring of this spring will occur. SP-79 will be monitored according to Table 7-4 parameters including flow and field water-quality parameters.

SP-18 and SP-22 are located in the Shingle Canyon (aka No Name Canyon) area in th northeast part of the permit area. SP-18 issues from the contract between the Blackhawk formation and the Star Point sandstone near the confluence of the drainage. SP-22 is located higher in right fork of Shingle Creek in the Blackhawk above the elevation of the coal seam to be mined. These springs will be monitored to verify that effects of mining in the U-68082 lease modification area. These springs will be monitored for flow and field parameters quarterly.

TABLE 7-4

Abbreviated Groundwater Analysis List

Field Measurements:

Water level or flow
pH
Specific conductance (umhos/cm)
Temperature (°C)

Laboratory Measurements:

Total dissolved solids
Total hardness (as $CaCO_3$)
Total Alkalinity
Bicarbonate (as HCO_3)
Carbonate (as CO_3)
Calcium (as Ca)
Chloride (as Cl)

Dissolved iron (as Fe)
Total Iron (as Fe)
Magnesium (as Mg)
Total Manganese (as Mn)
Potassium (as K)
Sodium (as Na)
Sulfate (as SO_4)

TABLE 7-5

Extended Groundwater Analysis List

Field Measurements:

Water level or flow
pH
Specific conductance (umhos/cm)
Temperature (°C)

Laboratory Measurements:

Total dissolved solids
Total hardness (as $CaCO_3$)
Total Alkalinity
Acidity
Aluminum (as Al)
Arsenic (as As)

Barium (as Ba)
Bicarbonate (as HCO_3)
Baron (as B)
Carbonate (as CO_3)
Cadmium (as Cd)(Dissolved)
Calcium (as Ca)(Dissolved)

Chloride (as Cl)
Copper (as (Cu)(Dissolved)
Dissolved Iron (as Fe)
Total Iron (as Fe)

Lead (as Pb)(Dissolved)
Magnesium (as Mg)(Dissolved)
Dissolved Manganese
Total Manganese (as Mn)
Molybdenum (as Mo)(Dissolved)

Nitrogen-Ammonia (as NH_3)
Nitrite (as NO_2)
Nitrate (as NO_3)
Potassium (as K)(Dissolved)
Phosphate (as PO_4)

Selenium (as Se)(Dissolved)
Sodium (as Na)(Dissolved)
Sulfate (as SO_4)
Zinc (as Zn)

All samples are preserved as soon as practicable after collection. Samples are collected and analyzed according to the methodology in the current edition of "Standard Methods for the Examination of Water and Wastewater" or the methodology in 40 CFR Parts 136 and 434.

On a quarterly basis an inventory will be conducted of the active portion of the mine to identify the location and geologic occurrence of mine inflows that exceed three gallons per minute. In consultation with DOGM, certain of these inflows (if they occur) will be selected for continued monitoring. Previously, only one such inflow existed, flowing from the roof of the mine from an exploratory hole (DH-1) that was vertically drilled from within the permit area at the location shown on Plate 3-2 (listed as "DRILL HOLE"). Flow from this hole was originally controlled with a valve. However, the overlying perched aquifer no longer produces a flow sufficient to monitor.

After selection of the inflow points to be monitored, data will be collected on a quarterly basis and analyzed according to Table 7-4. Samples collected during the low-flow period (normally the fourth quarter) will be analyzed according to Table 7-5 in the years 1990, 1995, 2000, and at 5-year intervals thereafter. Monitoring and sampling of the selected mine inflow points will continue, according to this schedule, in safely accessible portions of the mine.

Water rights apparently have been filed for two additional springs in the area surrounding the lease areas (93-1407 and 93-1408 on Plate 7-14). As noted in Section 7.24.1 the source at 93-1407 was not discovered until the fall of 1990. Until this time it was surmised to exist as only a seep (similar to 93-1408 (SP-47). Since its discovery GENWAL has committed to monitoring and sampling SP-1407 (SP-47a) in the groundwater monitoring plan submitted with the Right-of-Way application. Source 93-1408 existed as a seep in June but was dry in October, 1985. Hence, it was decided not to monitor 93-1408 on a long-term basis since it does not flow at a sufficient rate to permit sample collection. SP-47 was observed to be dry in October, 1989 and in June of 1990.

GENWAL installed monitoring wells near the mine portal (MW-1), and in the East Mains near their junction with the North Mains (MW-2) (Plate 7-13). Monitoring well MW-3 is located in an area sealed in 1979, and is now inaccessible. Monitoring wells MW-4 and MW-5 were installed in January 1992. These locations were chosen in areas where access will be maintained as long as possible.

Each underground monitoring well was drilled using air-rotary techniques (see Appendix 7-46 for completion diagrams). MW-1 was drilled to a total depth of 375 feet (Figure 7-1). As 6 5/8-inch diameter steel casing was cemented within a 10-inch diameter hole to a depth of 100 feet. A 6-inch diameter open hole completion exists from 100 to 375 feet. MW-2 was drilled to a total depth of 134 feet. Four-inch casing was set to 5 feet. A 3-inch open hole completion exists from 5 to 134 feet. Drilling of a larger diameter hole at greater depth was precluded by the inability of a larger drill rig to mobilize underground.

Monitoring well MW-4 was drilled to a depth of 111.5 feet. The hole has a 5" casing set to a depth of 4 feet, and a 1.5 inch PVC casing for the remainder, with a slot screen in the bottom 10 feet. MW-5 was drilled to a depth of 116.8 feet. It has a 5" casing to a depth of 4 feet, and a 2 inch PVC casing for the remainder, with a slot screen in the bottom 40 feet.

After drilling, each hole was surged with air to remove fines that had accumulated in the holes. Surging continued until the water discharging from the holes was visibly clear. A cap was placed over the surface casing to allow closure of each well when not in use.

Construction and initial sampling of the underground monitoring wells was completed in June, 1989 and June, 1992. Lithologic/completion logs of the wells have been submitted to DOGM along with the results of analyses of the first samples collected from the wells. An interpretation of the hydrogeology of the Star Point Sandstone beneath the mine appears in Section 7.24.1.

Water-level measurements and water-quality samples will be collected from the monitoring wells on a quarterly basis following completion during the first two years following completion of the in-mine wells and in the years 1990, 1995, 2000 and in 5-year intervals thereafter. During the operational period of the mine, water-quality samples collected from all wells will be analyzed according to the list provided in Table 7-4. Monitoring will continue according to this schedule in accessible wells until two years after the completion of surface reclamation activities.

Each monitoring well will be pumped prior to sampling to purge it of stagnant water standing in the hole. In the case of M-1, purging will be accomplished using a submersible pump. A bailer will be used for purging and sampling MW-2, MW-4 and MW-5. In each case, purging will continue until at least 3 times the volume of water standing in the well has been pumped. Samples will be collected directly from the discharge line of the pump. Samples will be preserved and stored in accordance with U.S. Environmental Protection Agency guidelines.

Groundwater monitoring data collected from the area will be submitted to DOGM on a quarterly basis. On an annual basis, a report will be submitted to DOGM summarizing all data collected during the year and containing an analysis of the mine water balance, accounting for mine inflows, outflows, consumptive uses, and sump storage (a copy of the annual report will also be given directly to the Price office of the U.S. Forest Service).

After the completion of mining activities and during the post-mining/reclamation period, water-level and quality samples will be collected annually from the designated springs and MW-1 until the termination of bonding. In-mine wells will be inaccessible following reclamation. Samples will be collected during the latter portion of the summer to represent low-flow conditions. Samples thus collected will be analyzed for the parameters listed in Table 7-4. A report will be submitted to DOGM on an annual basis summarizing the results and assessing mining impacts and system recovery since mining ceased.

7.31.22 Surface Water Monitoring Plan

Two 36-inch Parshall flumes were installed in July 1985 on Crandall Creek (one upstream from the surface facilities and one downstream (see Plate 7-16). A 12-inch Parshall flume has been installed in Blind Canyon to monitor possible effects of mining in State Lease ML-21569. These flumes are equipped with Stevens Type-F water-level recorders to allow the collection of continuous flow data. Charts will be changed and the flumes inspected on a monthly basis. Flume location and stream monitoring stations are shown on Plate 7-16.

Water quality samples will be collected from the flume locations quarterly, and analyzed according to the list contained in Table 7-8. In the years 1990, 1995, 2000 and every fifth year thereafter the samples collected during the low-flow period (normally fourth quarter) will be analyzed according to Table 7-9. All samples will be analyzed for total and dissolved constituents according to the indicated lists. Sampling and analysis will be conducted quarterly until the surface areas are reclaimed, at which time sampling will be conducted semiannually until the surety bond is released. For perennial streams, those samples will be collected during high-flow (normally second quarter) and low-flow (normally fourth quarter) periods. Discharges from the sedimentation pond will be analyzed in accordance with the NPDES permit for the facility.

Stream flow observations made during drilling operations as well as seep and spring surveys suggest that large portions of the south fork of Horse Creek, and both the north and south forks of Crandall Creek have only ephemeral and intermittent flows within State Leases ML-21568 and ML-21569 and portions of UTU-68082. Plate 7-16 shows the points of transition between perennial and intermittent flow for Horse Creek, Blind Creek, the north and south forks of Crandall Creek, and Indian Creek. Blind Creek has been determined to be intermittent.

Stream channel monitoring stations have been established along both the north and south forks of Crandall Creek, and the south branch of Horse Creek to determine what stream reaches exhibit perennial flow. Stream flow and water temperature were measured twice monthly from May through July, and monthly during the remainder of 1991 when the area was accessible. Stream monitoring results are found in Appendix 7-23. Stream monitoring was again done on September 28, 1992. These results are also contained in Appendix 7-23. Stream monitoring ceased at the end of 1992.

To provide for proper monitoring of Indian Creek (in Upper Joe's Valley) a 36-inch Parshall flume was installed. This flume is equipped with a Stevens Type-F water-level recorder to allow the collection of continuous flow data. Charts will be changed and the flumes inspected on a monthly basis. The location of this flume is depicted on Plate 7-16. Because of its higher elevation and limited access this flume is typically operational from June 1 through November 1 of any given year. If seasonal variations and access allow, this station will be operated for longer periods.

Water quality samples will be collected from the Indian Creek flume location quarterly (weather permitting), and analyzed according to the list contained in Table 7-8. In the years 1995, 2000 and every fifth year thereafter the samples collected during the low-flow period (normally fourth quarter) will be analyzed according to Table 7-9. All samples will be analyzed for total and dissolved constituents according to the indicated lists. When flumes or other monitoring devices are no longer required, they will be removed and the affected areas will be restored.

No retreat mining will be conducted within the designated stream channel buffer zones. Horse Canyon is located hydraulically upgradient and north of the UTU-68082 (LBA No. 9) north boundary line. Current mine plans show that because of limited coal height that neither development mining or retreat mining will occur beneath Horse Canyon and the stream channel buffer zones. Since mining has already occurred under Blind Canyon, Crandall Canyon, and beneath the upper reaches of the left fork (South Fork) tributary of Horse Canyon, any adverse effects to the respective streams should manifest as reduced stream flow and a continuous high volume inflow into the mine workings. If it is found that stream flows in Blind Canyon and Crandall Canyon have been impacted by mining, then a decision to monitor Horse Canyon on a continuous basis will be made.

In conjunction with the South Crandall Lease (UTU-78953) and the SITLA/PacifiCorp sublease GENWAL will monitor four creeks. The monitoring plan for the South Crandall Lease is described below. Monitoring site locations are shown on Plate 7-18. The monitoring protocols for each of the monitored creeks are presented in Table 7-10.

Little Bear Canyon Creek will be monitored quarterly for Table 7-8 parameters including flow and field water-quality parameters. The creek will be monitored approximately 100 feet above the confluence with Huntington Creek (Plate 7-18). Based on the range of discharge anticipated at the creek (see Appendix 7-58) discharge measurements at Little Bear Canyon Creek will likely be performed using a 90° v-notch weir or a portable 3-inch Parshall flume.

The ephemeral drainage in SW 1/4 of Section 4 T16S R7E will be monitored quarterly for Table 7-8 parameters including flow and field water-quality parameters. No discharge was observed in this drainage during drought conditions in 2003. If flow occurs in this drainage, the discharge will be measured using appropriate portable discharge measuring devices.

Monitoring station IBC-1 monitors the drainage located along the border of Sections 5 and 6, T16S, R7E. This drainage will be monitored quarterly for Table 7-8 parameters including flow and field water-quality parameters. Discharge in this drainage has been meager (Appendix 7-58) and discharge will likely be measured using a stopwatch and a calibrated bucket. The potential for impacts to this drainage are considered remote because only a small region in the extreme northwestern portion of the South Crandall Lease area is drained by this drainage. However, to verify that no impacts to this drainage occur, and to document the effects of climatic variability on stream discharge in the region, this creek will be monitored.

The creek in Section 5 T16S, R7E will be monitored quarterly for Table 7-8 parameters including flow and field water-quality measurements. This creek drains most of the northeastern portion of the South Crandall Lease area, where the initial mining in the lease area will occur. Additionally, the upper forks of this drainage will be monitored for flow and field water-quality measurements will be performed. Flow at each of the monitoring sites on this drainage has been meager. Thus, flow measurements will likely be performed using a stopwatch and a calibrated bucket.

In conjunction with mining in the U-68082 lease modification area GENWAL will monitor surface flow in Shingle Canyon (aka No Name Canyon), for flow and field parameters quarterly. This site is located immediately down stream from the confluence of the right and left forks of the canyon, and is shown on Plate 7-18.

TABLE 7-8

Abbreviated Surface Water Analysis List

Field Measurements:

Water level or flow
pH
Specific conductance (umhos/cm)
Temperature (°C)
Dissolved oxygen (ppm)

Laboratory Measurements:

Total dissolved solids
Total suspended solids
Total settleable solids
Total hardness (as $CaCO_3$)
Total Alkalinity
Bicarbonate (as HCO_3)

Carbonate (as CO_3)
Calcium (as Ca)
Chloride (as Cl)
Dissolved Iron (as Fe)
Total Iron as (Fe)
Magnesium (as Mg)

Dissolved Manganese
Total Manganese (as Mn)
Potassium (as K)
Sodium (as Na)
Sulfate (as SO_4)
Oil and Grease
Cation - Anion balance

TABLE 7-9

Extended Surface Water Analysis List
(Baseline Parameters)

Field Measurements:
Flow
pH
Specific conductance (umhos/cm)
Temperature (°C)
Dissolved oxygen (ppm)

Laboratory Measurements:

Total dissolved solids
Oil and Grease
Cation - Anion balance
Total suspended solids
Total settleable solids
Total hardness (as $CaCO_3$)
Total Alkalinity

Acidity as ($CaCO^3$)
Aluminum (as Al)
Arsenic (as As)
Bicarbonate (as HCO_3)
Boron (as B)
Carbonate (as CO_3)

Cadmium (as Cd)
Calcium (as Ca)
Chloride (as Cl)
Copper (as Cu)(Dissolved)
Dissolved iron (as F)
Total iron as (Fe)
Lead (as Pb)(Dissolved)
Magnesium (as Mg)(Dissolved)

Dissolved Manganese
Total Manganese (as Mn)
Molybdenum (as Mo)(Dissolved)
Nitrogen-Ammonia (as NH_3)
Nitrite (as NO_2)

Nitrate (as NO_3)
Potassium (as K)(Dissolved)
Phosphate (as PO_4)
Selenium (as Se)(Dissolved)
Sodium (as Na)(Dissolved)

Sulfate (as SO_4)
Zinc (as Zn)(Dissolved)

Table 7-10 Water Monitoring Program

Ground Water

Springs

1	SP-30	No Side Lower Crandall	Flow and field parameters quarterly
2	SP-36	No Side Lower Crandall	Flow, field parameters, and Table 7-4 parameters quarterly
3	SP-58	Forks of Crandall Crk.	Flow, field parameters, and Table 7-4 parameters quarterly
4	SP2-24	Top of East Mountain	Flow, field parameters, and Table 7-4 parameters quarterly
5	SP2-9	Top of East Mountain	Flow, field parameters, and Table 7-4 parameters quarterly
6	SP47A	Pt No of Crandall Mine	Flow and field parameters quarterly
7	SP1-3	Top of East Mountain	Flow and field parameters quarterly
8	SP1-19	Top of East Mountain	Flow and field parameters quarterly
9	SP1-22	Top of East Mountain	Flow and field parameters quarterly
10	SP1-33	Upper Joe's Valley	Flow, field parameters, and Table 7-4 parameters quarterly
11	SP1-47	Upper Joe's Valley	Flow and field parameters quarterly
12	SP2-1	Upper Joe's Valley	Flow and field parameters quarterly
13	SP1-9	Top of East Mountain	Flow, field parameters, and Table 7-4 parameters quarterly
14	SP1-24	Top of East Mountain	Flow and field parameters quarterly
15	LB-5A	Little Bear Canyon	Flow, field parameters, and Table 7-4 parameters quarterly
16	LB-7	Little Bear Canyon	Flow, field parameters quarterly
17	LB-7A	Little Bear Canyon	Flow, field parameters quarterly
18	LB-7B	Little Bear Canyon	Flow, field parameters quarterly
19	LB-7C	Little Bear Canyon	Flow, field parameters quarterly
20	LB-12	Little Bear Canyon	Flow, field parameters quarterly
21	SP-79	Huntington Canyon trib.	Flow, field parameters, and Table 7-4 parameters quarterly
22	Little Bear Spring		Flow, field parameters, and Table 7-4 parameters quarterly
23	SP-18	Shingle Canyon	Flow, field parameters quarterly.
24	SP-22	Shingle Canyon	Flow, filed parameters quarterly.

In-Mine Monitoring Wells

1	DH-1	Main North (Dry)	Flow, field parameters, and Table 7-4 parameters quarterly
2	DH-2	In Sealed Area	Flow, field parameters, and Table 7-4 parameters quarterly
3	MW-1	At Portals	Flow, field parameters, and Table 7-4 parameters quarterly
4	MW-2	At Mouth of Main East	Flow, field parameters, and Table 7-4 parameters quarterly
5	MW-3	In Sealed Area	Flow, field parameters, and Table 7-4 parameters quarterly
6	MW-4	In Sealed Area	Flow, field parameters, and Table 7-4 parameters quarterly
7	MW-5	Destroyed	Flow, field parameters, and Table 7-4 parameters quarterly
8	MW-6	Main South (DEEP)	Flow, field parameters, and Table 7-4 parameters quarterly
9	MW-6a	Main South (No of Dike)	Flow, field parameters, and Table 7-4 parameters quarterly
10	MW-7	Main West	Flow, field parameters, and Table 7-4 parameters quarterly
11	MW-8	Main South (So of Dike)	Flow, field parameters, and Table 7-4 parameters quarterly

Table 7-10 Water Monitoring Program (continued)

Surface Water

Streams

1 Upper Flume Crandall Creek	Flow, field parameters, and Table 7-8 parameters quarterly
2 Lower Flume Crandall Creek	Flow, field parameters, and Table 7-8 parameters quarterly
3 Horse Canyon Creek	Flow, field parameters, and Table 7-8 parameters quarterly
4 Blind Canyon Creek	Flow, field parameters, and Table 7-8 parameters quarterly
5 Indian Creek	Flow, field parameters, and Table 7-8 parameters quarterly
6 IBC-1	Flow, field parameters, and Table 7-8 parameters quarterly
7 Section 4 Creek	Flow, field parameters, and Table 7-8 parameters quarterly
8 Section 5 Creek (lower)	Flow, field parameters, and Table 7-8 parameters quarterly
9 Section 5 Creek (Upper Right Fork)	Flow and field parameters quarterly
10 Section 5 Creek (Upper Left Fork)	Flow and field parameters quarterly
11 Little Bear Creek	Flow, field parameters, and Table 7-8 parameters quarterly
12 Shingle Creek	Flow, Field parameters quarterly.

UPDES

1 001 – Sed Pond Discharge	Flow, field parameters, and UPDES parameters per occurrence
2 002 – Mine Water Discharge	Flow, field parameters, and UPDES parameters monthly

Note: See Plate 7-18 for Locations

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Baseline water quality samples will be collected quarterly from the stream monitoring station below the forks in Horse Canyon at location H-1 (Plate 7-16) and analyzed according to the list contained in Table 7-8. Instantaneous flow estimates will be made for stations H-1, HS-5, and HN-1 during the spring and summer water quality sampling event. This monitoring will continue for a period of three years at which time the need for continued monitoring of Horse canyon will be evaluated.

Surface-water monitoring data will be submitted to DOGM on a quarterly basis. At the end of each calendar year, an annual summary will be submitted. This annual summary will analyze and describe variations in flows and quality during the year and will include tables, graphs, hydrographs, etc. as appropriate.

If available data (testing within 24 hours of proposed discharge) indicate that the water in the pond meets the effluent limitations contained in R614-301-751 and any applicable UPDES permits, this water will be pumped directly to Crandall Creek. Any direct discharges will be monitored at the beginning and end of pumping from the pond. The pump inlet will be placed on a floating spring to avoid pulling excess sediment into the discharge table during pumping. Water will be pumped from below the water surface to avoid introduction of oil to the discharge water.

During the post-operational period, surface-water data will be collected from the upper and lower stations shown in Plate 7-7 and the inflow to the sedimentation pond as indicated on Plate 5-16. Flow data will be collected continuously from the flumes at the upper and lower Crandall Creek stations and twice annually (during the high- and low-flow seasons) from the sedimentation pond inflow during the post-mining period. In addition, water-quality samples will be collected from each station during the high- and low-flow seasons following mining. These samples will be analyzed for the parameters listed in Table 7-8. Data thus collected will be submitted to DOGM on a quarterly basis.

The post-mining reports will contain not only the laboratory and field data but also an assessment of current impacts from mining on surface-water systems and the amount of recovery of the system since mining. Surface-water monitoring following mining will continue until the termination of the bonding period.

7.31.3 Acid- and Toxic- Forming Materials

As discussed in Section 5.28.30, waste rock is not produced during mining operations. When incidental quantities of rock are encountered, the rock is left in the mine and will not be removed at any time in the future; thus, no negative effects are expected from the acid-forming potential of strata which overlie and underlie the Hiawatha seam. However, to further characterize the acid-forming potential of strata immediately above and below the Hiawatha seam, GENWAL collected additional roof- and floor-rock samples from three locations within the current mine workings (including the state lease and Lease #UTU-68082 areas). These new data also show the materials to be non-acid/non-toxic forming. Analytical results from these three sets of samples are contained in Appendix 6-2.

The presence of acid- or toxic-forming materials has been determined by laboratory testing (as defined in "Guidelines for Management of Topsoil and Overburden for Underground and Surface Coal Mining"). These data are contained in Appendix 6-2. If waste material is generated it will be tested for acid- or toxic-forming materials on a yearly basis or prior to disposal. If such material is identified, it will be stored in an enclosed area (i.e. dumpster) or within a containment (bermed) area until such time as it can be disposed of.

7.31.4 Transfer of Wells

Before final bond release, exploratory or monitoring wells will be sealed in a safe and environmentally sound manner in accordance with Sections 7.38 and 7.65.

7.31.5 Discharges

The Applicant will not discharge into the underground mine, unless specifically approved by the Division and/or meets the approval of MSHA. Discharges will be limited to the following:

1. Water
2. Coal processing waste
3. Fly ash from a coal-fired facility
4. Sludge from an acid-mine-drainage treatment facility
5. Flue-gas desulfurization sludge
6. Inert materials used for stabilizing underground mines
7. Underground development waste.

7.31.51 Gravity Discharges

The angle at which the coal bed is inclined from the horizontal (dip) prevents any gravity discharge of water from the surface entries.

7.31.6 Stream Buffer Zones

The disturbed area is drained by ephemeral "streams" which are tributaries to Crandall Creek. The undisturbed drainages will enter Crandall Canyon above and below the culvert. Stream buffer zones will be maintained above and below the culvert. Portions of the road lie within 100' of Crandall Creek. The sediment pond outslope is contiguous to Crandall Creek, a perennial stream at the mine facility area.

Crandall Creek water quality is protected from the impacts of the mine by the use of revegetation, silt fences and/or straw bales, and rip-rapped channels. In addition, buffer zone signs have been installed to indicate the area beyond which no disturbance shall take place. For additional information concerning stream buffer zone protection see pages 3-9 and 3-10 of this permit.

7.31.7 Cross Sections and Maps

Cross sections and maps, as required for R645-301-731.700, are presented within this application.

7.31.8 Water Rights and Replacement

In the event that the monitoring program identifies an impact to the water source in the permit and adjacent areas, the replacement of water rights will be addressed as described in Section 7.27 of this application.

7.3 Sediment Control Measures

The sediment control measures for the Crandall Canyon Mine operations are discussed in Section 7.42 of this application. This includes design, operation and maintenance of applicable siltation structures, sedimentation pond, diversions, and road drainage, as required.

7.33 Impoundments

There are no permanent impoundments associated with GENWAL's operations. Temporary impoundments of water collected for runoff control will occur in the sediment ponds and containment berms. The design of these structures is presented in Section 7.42 and 7.43 of this application.

7.34 Discharge Structures

Discharge from the sediment ponds will be conveyed by a 18-inch CMP culvert and an open channel acting as the principal and emergency spillways. The outlets of these spillways are protected by riprap. This design complies with R645-301-744.

7.35 Disposal of Excess Spoil

No significant excess spoil has been or will be developed by operating the underground mine. The only anticipated excess material will be from the sediment ponds. This limited volume of material will be removed from the ponds transported to an approved refuse disposal site, disposed of underground or sold with the coal.

7.36 Coal Mine Waste

Any refuse will be disposed of in accordance with the designs presented in Chapter 5 and Section 7.46 of this application.

7.37 Noncoal Mine Waste

Noncoal mine waste will be stored and final disposal of noncoal waste will comply with R645-301-747.

7.38 Temporary Casing and Sealing of Wells

Each well which has been identified in the approved permit application to be used to monitor ground water conditions will comply with R645-301-748 and be temporarily sealed before use. Drilling and Sealing of such wells will be done according to the procedure described in Chapter 6, Section 6.41.

7.40 Design Criteria and Plans

7.41 General Requirements

The runoff control plans for the Crandall Canyon Mine facilities includes the diversion of the undisturbed runoff from areas contributing to the facilities, the collection of all runoff from disturbed areas associated with the sites and the containment and treatment of this disturbed runoff through the use of sediment ponds, strawbales, silt fence, riprap, mulches and revegetation.

7.42 Sediment Control Measures

7.42.10 General Requirements

Appropriate sediment control measures will be designed, constructed and maintained using the best technology currently available to:

1. Prevent, to the extent possible, additional contributions of sediment to stream flow or to runoff outside the permit area.
2. Meet the effluent limitations under R645-301-751.
3. Minimize erosion to the extent possible.

Sediment control measures include practices carried out within and adjacent to the disturbed area. The sedimentation storage capacity of practices in and downstream from the disturbed areas will reflect the degree to which successful mining and reclamation techniques are applied to reduce erosion and control sediment. Sediment control measures consist of the utilization of proper mining and reclamation methods and sediment control practices, singly or in combination. Sediment control methods include, but are not limited to:

1. Retaining sediment within disturbed areas;
2. Diverting runoff away from disturbed areas;

3. Diverting runoff using protected channels or pipes through disturbed areas so as not to cause additional erosion;

4. Using straw dikes, riprap, check dams, mulches, vegetative sediment filters, dugout ponds and other measures that reduce overland flow velocities, reduce runoff volumes or trap sediment;

5. Treating with chemicals/paving;

6. For the purposes of UNDERGROUND COAL MINING AND RECLAMATION ACTIVITIES, treating mine drainage in underground sumps.

7.42.20 Siltation Structures

7.42.21 General Requirements

Additional contributions of suspended solids and sediment to stream flow or runoff outside the permit area will be prevented to the extent possible using the best technology currently available.

Alternate Sediment Control Areas and Small Area Exemptions

The Alternate Sediment Control Areas (ASCAs) at the Crandall Canyon Mine are shown on Plates 7-5 and Plate 2-3. Previously 8 areas existed as ASCA's or Small Area Exemptions (SAE's). However, under this proposed culvert expansion 3 of the eight areas will be eliminated from the MRP. They are SAE 1, SAE 3, and ASCA 4. ASCA's 2, 5, 6, 7, and 8 will remain. Three new ASCAs (ASCA 9, 10 and 11) will be added due to the culvert expansion project.

ASCA-2 (consisting of 0.34 acre) exists at the northwest corner of the site. This area was initially constructed as a substation pad and associated access road. Because the substation has not been installed and may not be installed in the future, SAE-2 was reclaimed. Of the total area, 0.15 acre received final reclamation treatment and 0.19 acre received interim reclamation treatment (see Chapter 5, Plate 7-16 and Plate 7-5C). An additional 0.90 acres of undisturbed area drains onto ASCA-2 from above.

ASCA-2 was reclaimed (interim and final) as outlined in Section 525.300. A 12-inch CMP culvert was installed to act as a discharge into UD-1. A silt fence and strawbale dike have been placed to trap the sediment and prevent erosion.

ASCA-5, ASCA-6, ASCA-7 and ASCA-11 consist of the topsoil stockpiles that are located on the north and south side of the access road east of the mine site in the areas indicated on Plate 2-3. Disturbed areas associated with the topsoil stockpiles are 0.20 acres, 0.22 acres, 0.62 acres and 0.65

acres for ASCA-5, ASCA-6, ASCA-7, and ASCA-11, respectively. All topsoil stockpiles have been protected from erosion by a combination of dikes, silt-fencing, berms, and a vegetative cover. ASCA-11 is the lower-north side topsoil stockpile area which will be used to store soil material from the culvert expansion project.

ASCA-8 consists of the Forest Service parking area west of the mine surface facilities (see Plate 7-16). This parking area was constructed by GENWAL for the Forest Service during the latest surface expansion. Although it is not part of the surface facilities, it is a disturbed area within the permit boundaries.
Sedimentation control will, therefore be provided. The disturbed area associated with ASCA-8 is 0.29 acre.

Sedimentation control for ASCA-8 will be provided by a silt fence installed in accordance with Figure 7-12 between the parking area and Crandall Creek. The silt fence will be periodically inspected and repaired as required to ensure that its integrity is maintained.

ASCA 9 & 10 are the pad slope areas at both ends of the culvert expansion project. The drainage from these areas can not be directed to the sediment pond and are too close to the creek to construct separate sediment ponds. Therefore GENWAL will use alternate sediment control methods such as silt fences, straw bale dikes and vegetative filters. Once vegetation has been successful and lasting GENWAL will submit evidence supporting a request for Small Area Exemption.

ASCA-11 is the new topsoil storage area located at the mouth of Crandall Canyon immediately across the road from the existing topsoil pile, ASCA-7. The topsoil storage area is bounded by the Crandall Canyon road on the southwest, the bluffs of Huntington Creek on the east and a sloping hillside onthe northwest. A silt fence will be constructed below the downstream toe of the stockpile to prevent sediment loss and treat runoff. The topsoil pile will cover an area of approximately 0.65 acres. The pile will be constructed using end-dump trucks and a front-end loader and will be blended into the existing hillside. The pile will be revegetated in accordance with the approved interim reclamation seed mix specified in Chapter 3 under 3.31 Disturbance and Interim Stablization.

7.42.22 Sedimentation Pond

Design

The sedimentation pond located in Crandall Canyon has been redesigned to control the additional storm runoff from the pad extension and from the designated undisturbed drainage areas above the pad extension associated with the proposed culvert expansion. The topography and watershed boundaries are shown on Plate 7-5 and 7-5C. Cross sections of the pond design are shown on Plate 7-3.

Stability Analyses

The stability of the embankment outslope for the revised sedimentation pond is presented in Appendix 7-6 Addendum. The existing sedimentation pond is being expanded to accommodate expansion of the surface facilities and the disturbed areas. The existing pond embankment stability analysis is presented in Appendix 7-6.

Runoff- and Sediment-Control Facilities

Results of analyses to determine the required size and hydraulics of the sedimentation pond are included in Appendix 7-4. Details of the sedimentation pond required for compliance with 30 CFR 77.216-1 and 30 CFR 77.216-2 are contained in Appendix 7-8. Permanent disposal of the sediment removed during cleanout will be in accordance with Section 535.

Prior to any discharges through the decant system on the sedimentation pond, a sample will be collected to determine total suspended solids, settleable solids, total dissolved solids, oil and grease, total iron, total manganese concentrations, and pH. The sample will be collected by opening the gate valve on the dewatering device, allowing water to flow from the pond through the primary spillway for a sufficient time to collect a sample of the water, and then immediately shutting the gate valve to prevent further dewatering. This sample will then be submitted to a laboratory for analyses of the indicated parameters.

After receipt of analytical results from the laboratory, if the pH and concentrations of total suspended solids, settleable solids, total dissolved solids, oil and grease, total iron, and total manganese are within the acceptable limits, water will be discharged from the pond through the dewatering device. If the parameters of concern are not within the acceptable limits, no water will be discharged through the device.

During discharge of water to Crandall Creek from the sedimentation pond, samples of the water will be collected at the discharge point at the beginning and end of the discharge time. These samples will be sent to a laboratory following the discharge period for analyses of total suspended solids, settleable solids, total dissolved solids, total iron, total manganese, oil and grease, and pH. Analytical results will be submitted to the Division with the subsequent quarterly report.

As noted on Plate 7-4, the emergency spillway discharges onto the boulder-covered slope adjacent to the sedimentation pond. Boulders that cover this slope were blasted from the cut above the pond during construction of the mine-access road. Due to the large size of the boulders, laboratory size-fraction analyses could not be conducted. However, the boulders are visually estimated to range in size up to at least 10 feet in diameter. It is further estimated that approximately 80 percent of the coarse rock on the slope is finer than 8 feet in diameter, 30 percent is finer than 5 feet in diameter, and 10 percent is finer than 3 feet in diameter.

The blasted rock has an approximate thickness of 15 to 20 feet at the top of the slope and 5 to 6 feet at the bottom of the slope. The soil that underlies the rock is a silty sand. Size-fraction analyses presented by Delta Geotechnical Consultants (1982) indicate that this soil is 70 percent sand and 30 percent silt and clay (the latter being minus 200 mesh).

The emergency spillway is lined with riprap and a filter blanket to reduce erosion potential. A concrete cutoff has also been installed immediately downstream of the inlet. The concrete cutoff ensures that the emergency spillway will not erode during a discharge event. Grading of the riprap, filter blanket, and embankment materials are shown in Figure 7-10. The spillway will discharge directly onto the boulder-covered slope. Due to the extreme thickness of the boulders and cobbles on the slope, additional erosion protection below the emergency-spillway outflow will not be required.

All new fill required to modify the embankment will be placed in 6-inch lifts. This new fill will be compacted in place by repeated passes of a front-end loader or equivalent prior to placing the next lift. Compaction will continue until the density of the material is at least 90 percent of Proctor density (as determined by sandcone density tests in the field).

As included in the original design, the interior of the pond will be lined with a 12-inch thick local, compacted clay to reduce seepage from the pond and, thereby, increase the stability of The embankment. The clay liner will be placed in 6-inch lifts and compacted during placement by at least four passes of a front end loader or equivalent. The initial layer will be disk-harrowed into the bottom of the pond prior to completion.

After pond cleanout, the thickness of the clay liner will be sampled by means of a bucket auger at 8 locations. Three holes will be placed along the ingress/egress route and five additional holes will be randomly selected from the remaining pond area. If any of the holes penetrate less than 10 inches of clay, additional clay will be compacted into the deficient areas of the pond.

All new construction on the revised sedimentation pond will be supervised by a Professional Engineer who is licensed in the State of Utah. An initial certification report will be prepared and certified by the supervisory PE for submission to DOGM following completion of construction activities. Plate 7-4a shows as-built drawings of the existing pond and riser detail. Plate 7-6a shows as-built cross sections through the existing pond. Appendix 7-10 contains as-built calculations for the existing sedimentation pond and the initial certification report. The initial certification report previously submitted to DOGM included:

- o Existing and required monitoring procedures and instrumentation,
- o The design depth and elevation of any impounded waters at the time of the report,
- o Existing storage capacity of the dam or embankment,
- o A discussion of any fires occurring in the construction material up to the date of certification, and
- o A discussion of any other aspects of the dam or embankment affecting stability.

Flow conditions in Crandall Creek adjacent to the sedimentation pond were examined to determine if flood flows may erode the downstream toe (see Appendix 7-5). As noted, the peak flow from the 100-year, 24-hour precipitation event will encroach 0.6 foot above the toe of the embankment. Thus, a riprap protective layer (with a median rock diameter of 12.5 inches) was placed along the lower 2.0 feet of the embankment as shown in Plate 7-4. Placement of this riprap will serve an incidental purpose of increasing the stability of the dam by placing additional weight on the downstream toe (Figure 7-10).

Following construction of the sedimentation pond as designed herein, all disturbed areas associated with pond construction (with the exception of the interior of the pond) will be revegetated with the temporary seed mixture. This mixture was developed in consultation with Lynn Kunzler of the Division and Walt Nowak of the U.S. Forest Service. This mixture provides rapid growth species, sod-forming species, and species that are compatible with other plants.

Seeding will be done in the late fall, just prior to the first heavy snowfall of the year (Plummer et al., 1968). Seeding will be accomplished by hydroseeder. Mulch will be placed after seeding. The mulch, which consists of two tons of straw or grass hay per acre of disturbed area, will be spread over the area to be planted by hydromulcher.

Following seeding, the revegetated outslopes of the pond will be inspected during normal pond inspections to determine the effectiveness of the seeding. Straw-bale dikes will be added as necessary to control excessive gullying on the dam face. These dikes will be installed as noted by Figure 7-11.

7.42.30 Diversions

Diversion UD-1 was placed along the western edge of the site at the location shown on Plate 7-5A to divert water from a 95-acre undisturbed watershed around the yard area. Analyses and design information associated with this and other diversions associated with the site are contained in Appendix 7-4.

Two additional diversions were designed to convey water from undisturbed areas away from the disturbed site. One (UD-2) was constructed in the northwest portion of the site along the proposed substation pad. The other was constructed in the northeastern portion of the site to convey water away from the portal area. Details of diversion design are presented in Appendix 7-4.

Existing and proposed culverts in the mine yard were examined to determine their adequacy with respect to passing the peak flow. Details of these designs are provided in Appendix 7-4.

Similarly, ditches within the disturbed area are designed to pass the peak flow from the 10-year, 6-hour storm. Typical cross sections and design calculations are contained in Appendix 7-4 for these ditches. Ditches have been evaluated for adequacy in passing the 10 year-24 hour storm and found to be of adequate size (see Appendix 7-4).

A berm was placed around the proposed power substation to prevent runoff water that accumulates thereon from flowing across the remainder of the site. A small channel on the substation pad collects water from the pad and adjacent undisturbed areas. A stilling basin was placed at the downstream end of this diversion to trap sediment prior to discharging into UD-1.

Proposed Expansion Area Surface Water Drainage and SedimentControl

Water on the extended mining pad associated with the proposed culvert expansion comes from two sources. The pad itself and two watershed areas located in undisturbed terrain to the south of the proposed pad. Runoff from the pad and watersheds will be collected and controlled by the use of drainage ditches and culverts. All runoff diverted through the drainage ditches and culverts will eventually go into a sediment pond. The watersheds are shown on Plate 7-5 and 7-5A. The location of drainage ditches and culverts can be also be found on plate 7-5.

All diversion ditches have been designed to have a triangular channel with a minimum depth of one foot and side slopes of 1H:1V. During the periods of peak flow at least 3" of the channel depth will be freeboard. The calculations associated with drainage ditch design can be found in Appendix 7-4.

7.42.40 Road Drainage

All of GENWAL's roads have been designed, located and constructed as required by the regulations R645-301-742.410 through R645-301-742-423.5.

7.43 Impoundment

There are no permanent impoundments associated with the GENWAL facilities. Temporary impoundments of water collected for runoff control will occur in the sediment pond. The physical design of the sediment pond are certified designs as required in R645-301-512 and are presented in Section 5.33 and Appendix 7-4 of this application. The sediment pond does not meet the criteria for MSHA regulations. The hydrologic design for the sediment pond is presented in Section 7.42.20 and Appendix 7-4. On cessation and reclamation of mining and disposal activities, the sediment pond will be removed.

7.44 Discharge Structures

The sediment pond is equipped with a decant, a riser pipe (cmp) principle overflow and a rip-rapped open-channel emergency spillway. Sediment pond details are covered under Section 7.42.20 and in Appendix 7-4.

7.45 Disposal of Excess Spoil

No significant excess spoil will be developed by the underground mine. In the event spoil is generated during the mining operations, this will be transported to an approved disposal site. The handling of these materials will comply with R645-301-745.

7.46 Coal Mine Waste

The disposal and placement of any refuse materials will be conducted in accordance with the plans presented in Chapter 5 of this application.

7.47 Disposal of Noncoal Mine Waste

Garbage

Solid waste generated from mining activities, such as garbage and paper products, is disposed of in large trash "dumpsters" located near the portal. A contract garbage hauling service, empties the contents of the dumpsters on a weekly basis and hauls the garbage to an approved dump or landfill.

Unusable Equipment

All salvageable mining equipment is sold to local scrap dealers: items such as broken bolts, worn out engine parts, and items which might be recycled. Any machinery or large parts are placed in a stockpile near the material storage area for periodic salvage by local scrap dealers. No mining equipment will be merely abandoned.

Petroleum Products

Oil and grease wastes are collected in tanks and returned to distributors for refining or used as heating fuel. In case of spills, a spill control plan has been developed and is located at the mine site.

7.48 Casing and Sealing of Wells

Following completion of reclamation, the monitoring wells for the mine site will be plugged and abandoned in accordance with R645-301-631 and R645-301-748. This will prevent the potential for disturbance to the hydrologic balance.

7.50 Performance Standards

All coal mining and reclamation operations will be conducted to minimize disturbance to the hydrologic balance within the permit and adjacent areas, to prevent material damage to the hydrologic balance outside the permit area and support approved postmining land uses in accordance with the terms and conditions of the approved permit and the performance standards of R645-301 and R645-302. For the purpose of SURFACE COAL MINING AND RECLAMATION ACTIVITIES, operations will be conducted to assure the protection or replacement of water rights in accordance with the terms and conditions of the approved permit and the performance standards of R645-301 and R645-302.

The following sections, 7.51 through 7.55 provide a commitment to meet the requirements of the applicable laws. Specific plans for accomplishing compliance are provided under the applicable, referenced sections of this Mining and Reclamation Plan.

7.51 Water Quality Standards and Effluent Limitations

Discharges of water from areas disturbed by coal mining and reclamation operations will be made in compliance with all Utah and federal water quality laws and regulations and with effluent limitations for coal mining promulgated by the U.S. Environmental Protection Agency set forth in 40 CFR Part 434.

7.52 Sediment Control Measures

Sediment control measures will be located, maintained, constructed and reclaimed according to plans and designs given under R645-301-732, R645-301-742 and R645-301-760. Refer to sections 7.32, 7.42 and 7.60 of this plan.

7.52.10 Siltation Structures

Siltation structures and diversions will be located, maintained, constructed and reclaimed according to plans and designs given under R645-301-732, R645-301-742 and R645-301-763. Refer to sections 7.32, 7.42 and 7.63 in this plan.

7.52.20 Road Drainage

Roads will be located, designed, constructed, reconstructed, used, maintained and reclaimed according to R645-301-732.400, R645-301-742-400, and R645-301-762. Refer to sections 7.32, 7.40 and 7.62 in this plan.

7.52.21 Erosion Control or Prevention

Control or prevent erosion, siltation and the air pollution attendant to erosion by vegetating or otherwise stabilizing all exposed surfaces in accordance with current, prudent engineering practices.

7.52.22 Suspended Solids

Control or prevent additional contributions of suspended solids to steam flow or runoff outside the permit area.

7.52.23 Effluent Standards

Neither cause nor contribute to, directly or indirectly, the violation of effluent standards given under R645-301-751. Refer to section 7.51 in this plan.

7.52.24 Surface and Groundwater Systems

Minimize the diminution to, or degradation of, the quality or quantity of surface and groundwater systems.

7.52.25 Normal Water Flow

Refrain from significantly altering the normal flow of water in streambeds or drainage channels.

7.53 Impoundments and Discharge Structures

Impoundments and discharge structures will be located, maintained, constructed and reclaimed to comply with R645-301-733, R645-301-734, R645-301-743 and R645-301-745 and R645-301-760. Refer to sections 7.33, 7.34, 7.43, 7.45 and 7.60 in this plan.

7.54 Disposal of Excess Spoil, Coal Mine Waste and Noncoal Mine Waste

Disposal areas for excess spoil, coal mine waste and noncoal mine waste will be located, maintained, constructed and reclaimed to comply with R645-301-735, R645-301-736, R645-301-745, R645-301-746, R645-301-747 and R645-301-760. Refer to sections 7.35, 7.36, 7.45, 7.46 7.47 and 7.60 in this plan.

7.55 Casing and Sealing of Wells

All wells will be managed to comply with R645-301-748 and R645-301-765. Water monitoring wells will be managed on a temporary basis according to R645-301-738. Refer to sections 7.38, 7.48, and 7.65 in this plan.

7.60 Reclamation

<u>Sealing of Mine Openings</u>

The Applicant has drilled from the Hiawatha seam upwards to the Blind Canyon seam as described in Chapter 6. The drilling occurred in areas that pillar extraction will occur and no provisions were made to seal the bore hole.

Temporary sealing of the portals, if needed, will be accomplished by the construction of protective barricades or other covering devices, fenced and posted with signs indicating the hazardous nature of the opening. Permanent closure plans will include sealing the portals as per the request of the U.S.G.S. (See Section 5.29).

Upon cessation of mining operations all drift openings to the surface from underground will be backfilled, regraded and reseed as per Section 5.40 of this plan. Prior to final sealing of any openings, the U.S.G.S. will require an on site inspection and a submission of formal sealing methods for approval. The formal sealing methods will be presented as a plan including cross sections demonstrating the measures taken to seal or manage mine openings will comply with R645-301-529.

Removal of Surface Structures

All waste material generated from the removal of the structures will be removed from the property and sold as scrap or disposed of in the appropriate approved state land fill. The only structures to remain after the mining operation will be the sedimentation system and all necessary diversions required to insure routing of disturbed area drainage to the pond and diversions to maintain the integrity of the pond until the requirements are met. The diversion ditch is shown on Plate 5-16.

Upon cessation of mining operations, the water supply well (MW-1) will be permanently abandoned in accordance with regulations promulgated by the Utah Division of Water Rights. This will include filling of the well with a neat cement grout in accordance with the regulations.

Disposition of Dams, Ponds and Diversions

Upon final cessation of mining the area will be reclaimed. Upon completion of the reclamation earthwork the sediment pond will be cleaned out and the material disposed of in the approved method. Once it is determined that the pond is no longer required for sediment control of the reclaimed area and Phase I reclamation has been deemed complete, the pond will be cleaned out again. The pond will only be reclaimed after vegetation has been established on the site and Phase I reclamation has been approved. The material in the pond should only be topsoil that has eroded from the reclaimed site, (care will be taken not to mix the pond liner with this topsoil). This topsoil will be stockpiled and allowed to dry at the edge of the pond. Once the topsoil has been dried, the sediment pond will be reclaimed and the topsoil spread on top of the pond area.

Recontouring

All areas affected by surface operations will be graded and restored to approximate original contour that is compatible with natural surroundings and postmining land use. For approximate contours prior to GENWAL's surface disturbance refer to the topography south of the road on Plate 5-20. The final regraded contours can be found on Plate 5-17.

Removal or Reduction of Cut Slopes & Highwalls

Backfilling and grading will proceed so as to eliminate the cutslopes and highwalls. This can be done by recontouring as per Section 5.40 of this Plan. The portals will be backfilled with soil and two rows of solid concrete blocks placed across each entry and then backfilled to the surface and recontoured as shown on Plate 5-17. The cut slope above the coal stockpile will be backfilled with material from the culvert expansion project.

Terracing and Erosion Control

No terracing will be done. All final grading, preparation of overburden before replacement of topsoil will be done along the contour to minimize erosion and instability unless this operation becomes hazardous to equipment operators in which case the grading, preparation and placement in a direction other than generally parallel to the contour will be used.

Final Reclamation

All areas affected by surface operations will be graded and restored to approximate original contour. All final grading will be done along the contour to minimize erosion and instability unless this operation becomes hazardous to the equipment operators. Backfilling and grading will proceed so as to eliminate the cut slopes and highwalls. Refer to Plates 5-16 and 5-17. Backfilling and grading will be done according to the reclamation timetable as originally submitted.

If possible, the topsoil will be redistributed in the late fall (late September or early October) just prior to the seeding to keep the seedbed free of weeds and annual grasses. Should weeds and annual grasses become established before seeding, they will be removed prior to seeding, refer to Chapters 2 and 3 for additional information.

Typical cross sections and topographic maps which adequately represent the existing land configuration of the area affected by surface operations are shown on Plates 3-7, 3-8 and 3-9 for existing ground as well as Plate 5-20 for premining topography and the geotextile-covered area. Postmining reclamation cross sections and surface topography will be as near to premining as is possible and practical, as noted on Plate 5-17.

A reclamation map showing post construction interim reclamation areas and final reclamation accompanies this document as Plates 7-16 and 5-17. Slope rounding on Plate 5-3 has been revised to meet the required slope of 1.5:1 at the specified reclaimed cross sections. Two distinct areas showing post construction interim reclamation and final reclamation can be found on Plates 7-5.

Reclamation hydrology is discussed in Appendix 7-4.

7.70 References

Anderson, A.G., A.S. Paintal, J.T. Davenport. 1970. Tentative Design Procedure for Riprap-Lined Channels. National Cooperative Highway Research Program Report No. 108. Highway Board, Nation Academy of Sciences. Washington, D.C.

Arabasz, W. J., R. B. Smith, and W. D. Richins (Ed.). 1979. Earthquake Studies in Utah 1850 to 1978. University of Utah Seismograph Stations, Department of Geology and Geophysics, University of Utah, Salt Lake City, Utah.

Barfield, B.J., R.C. Warner , and C.T. Haan, 1981. Applied Hydrology and Sedimentology for Disturbed Areas. Oklahoma Technical Press. Stillwater, Oklahoma.

Bouwer, H. and R.C. Rice. 1976. A Slug Test for Determining Hydraulic Conductivity of Unconfined Aquifers With Completely or Partially Penetrating Wells. Water Resources Research. 12(3):423-428.

Danielson T.W., M.D. ReMillard, and R.H. Fuller, 1981. Hydrology of the Coal-Resource Areas in the Upper Drainages of Huntington and Cottonwood Creeks, Central Utah. U.S.Geological Survey Water-Resources Investigations Open-File Report 81-539. Salt Lake City, Utah.

Doelling, H.H. 1972. Central Utah Coal Fields: Sevier-Sanpete, Wasatch Plateau, Book Cliffs, and Emery. Utah Geological and Mineral Survey Monograph Series No. 3. Salt Lake City, Utah.

Dunrud, C.R. 1976. Some Engineering Geologic Factors Controlling Coal Mines Subsidence in Utah and Colorado. U.S. Geological Survey Professional Paper 969. Washington, D.C.

EarthFax Engineering Report on Mine Plan Aquifers and Seep and Spring Surveys (1985a, 1985b)

EarthFax Engineering, Inc. 1990. Storage Pad Slope Stability Analysis at the Crandall Canyon Mine, Emery County, Utah. Project Report Prepared for GENWAL Resources Inc., Huntington, Utah.

Hawkins, R.H. and K.A. Marshall, 1979. Storm Hydrograph Program. Final Report to the Utah Division of Oil, Gas and Mining. Utah State University. Logan, Utah.

Lines, G.C. 1985. The Ground-Water System and Possible Effects of Underground Coal Mining in the Trail Mountain Area, Central Utah. U.S. Geological Survey Water-Supply Paper 2259.

Plummer, A.P., D.R. Christensen, and S.B. Monson. 1968. Restoring Big-Game Range in Utah. Utah Division of Wildlife Resources. Publication No. 68-3. Salt Lake City, Utah.

CHAPTER 7

FIGURES

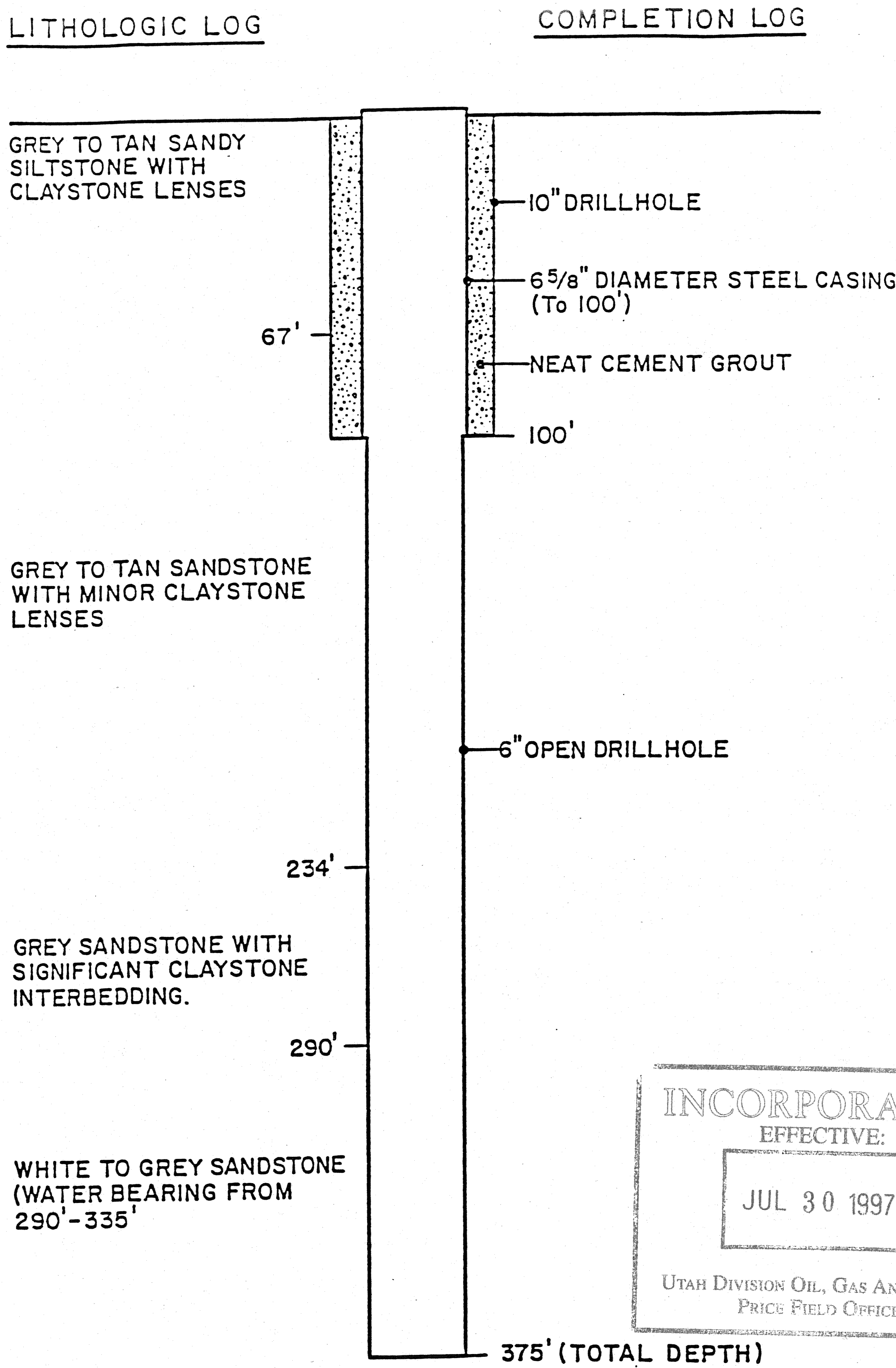


Figure 7-1. Well completion and lithologic log for MW-1.

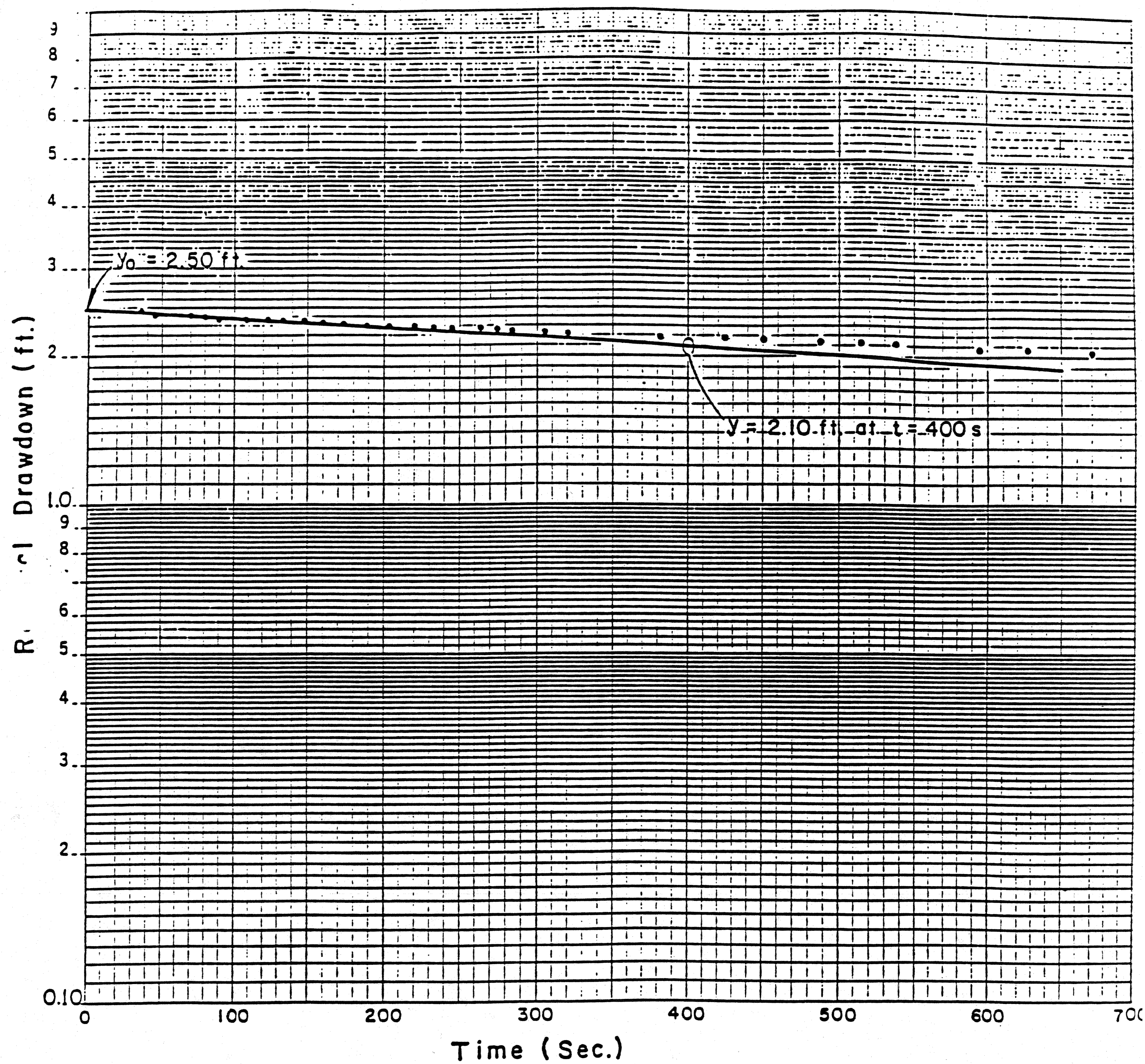


Figure 7-2. Results of slug withdrawal test in MW-1.

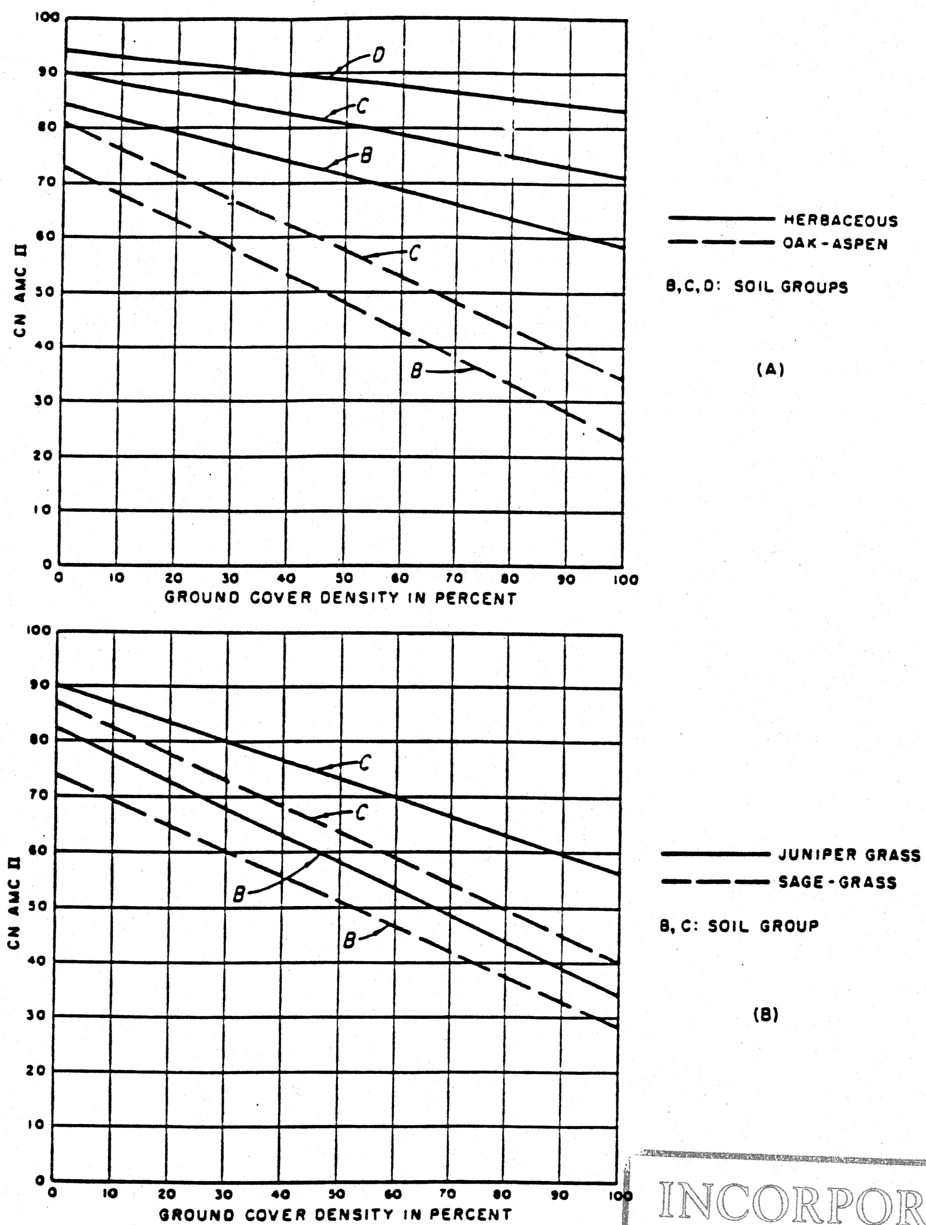


Figure 7-3. Runoff curve numbers for forest-range in the western U.S. (from U.S. Bureau of Reclamation, 1977).

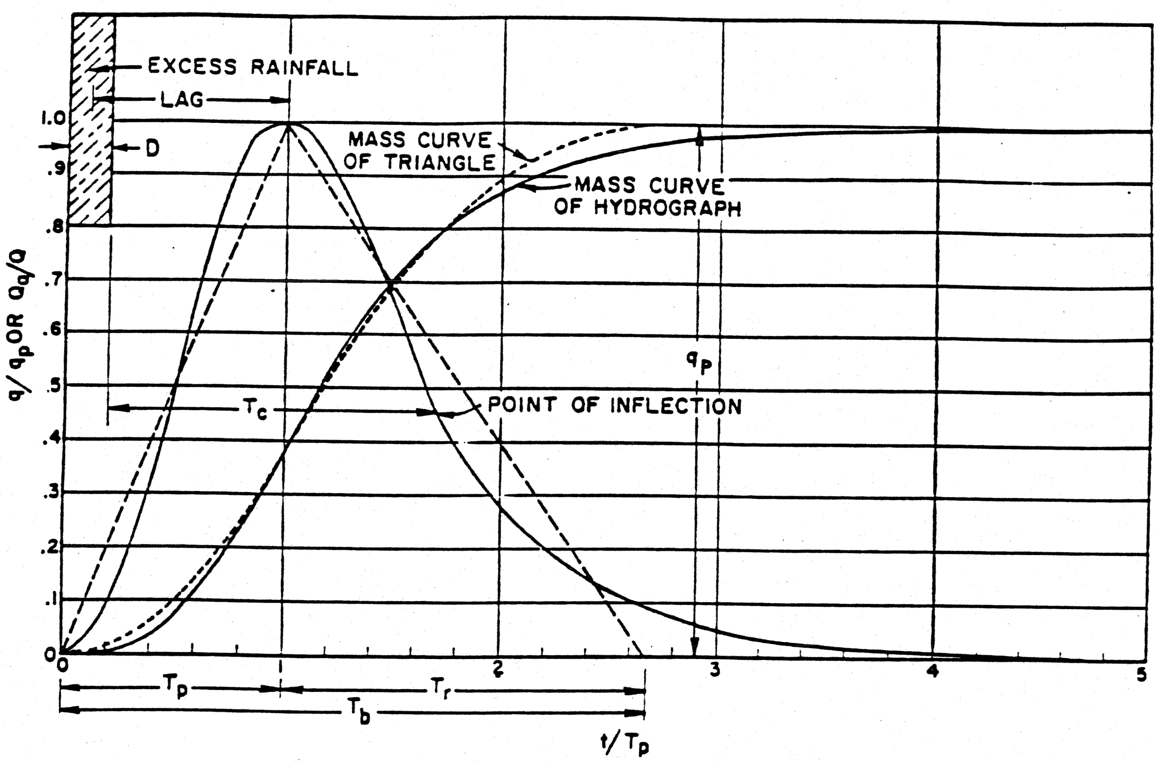


Figure 7-4. Curvilinear and triangular unit hydrographs (from U.S. Soil Conservation Service, 1972).

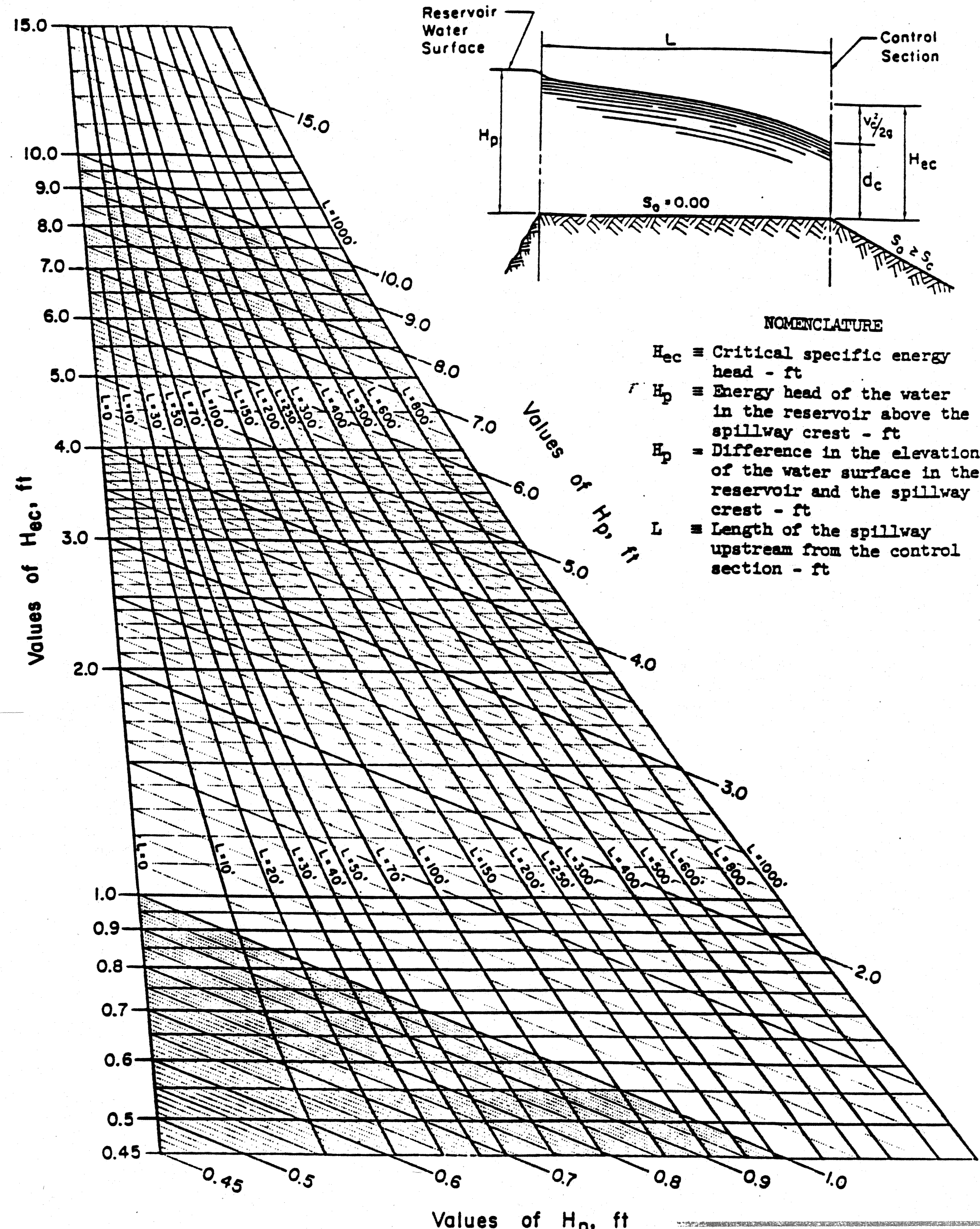


Figure 7-5. Head relationships for selected broad-crest weirs (from U.S. Soil Conservation Service, 1968)

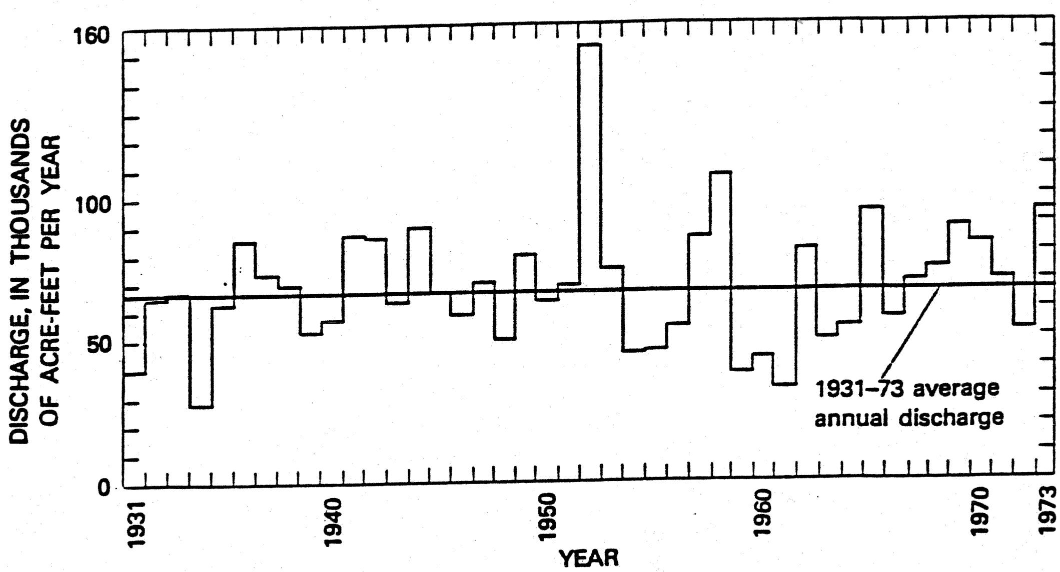


Figure 7-6. Annual discharge of Huntington Creek (from Waddell et al., 1981).

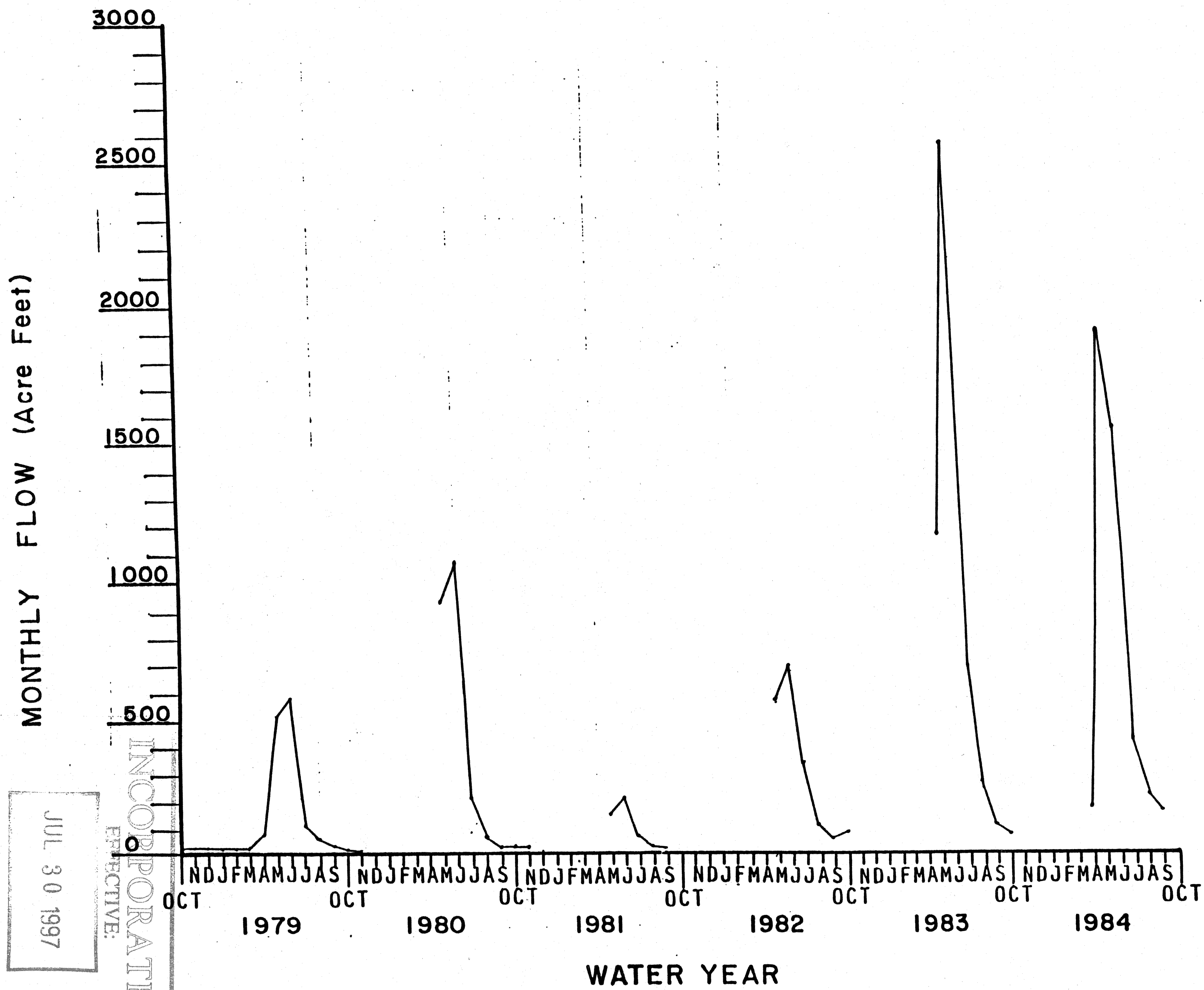


Figure 7-7. Monthly flow of Crandall Creek near Huntington.

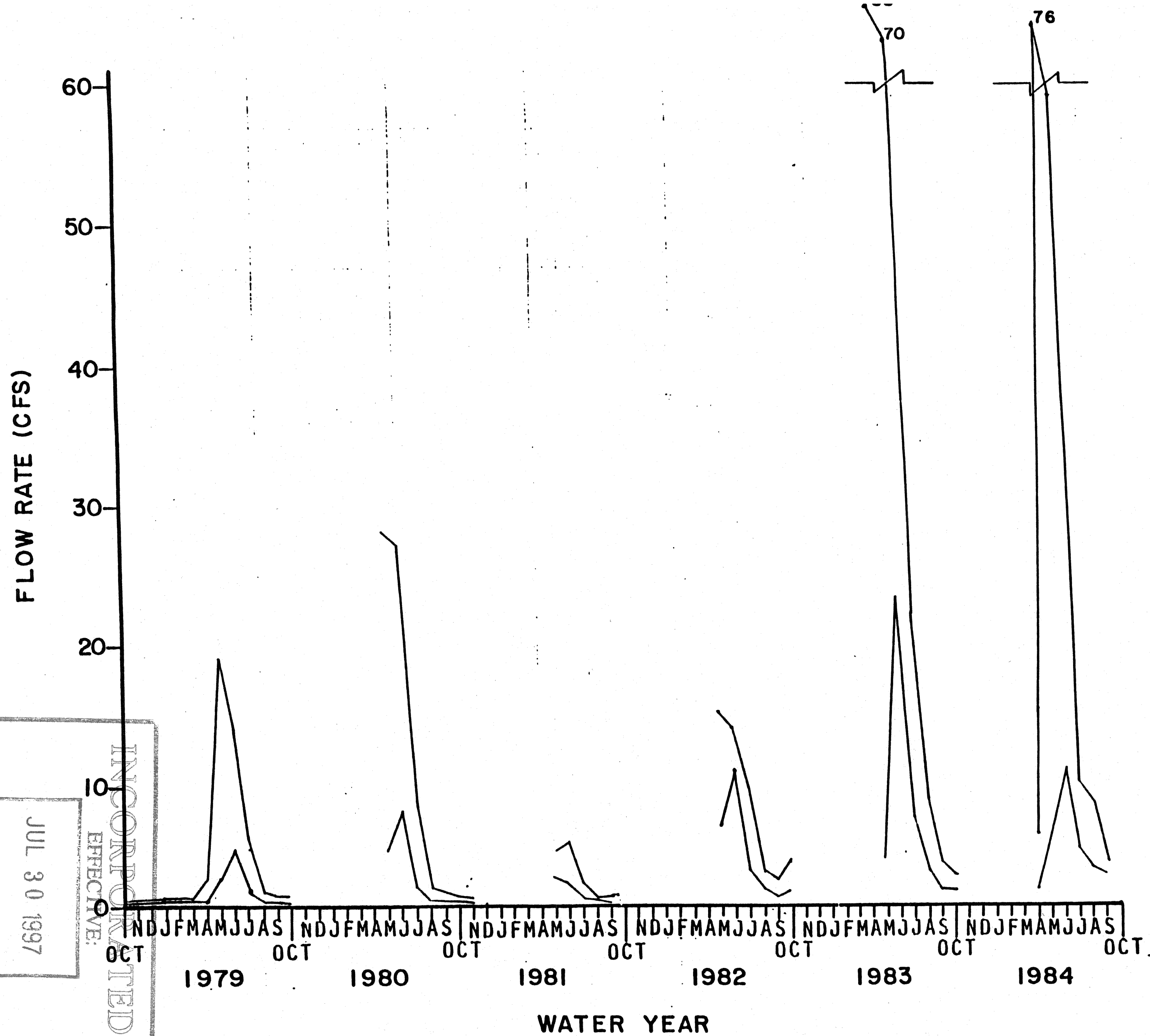


Figure 7-8. Maximum and minimum daily flows of Crandall Creek near Huntington.

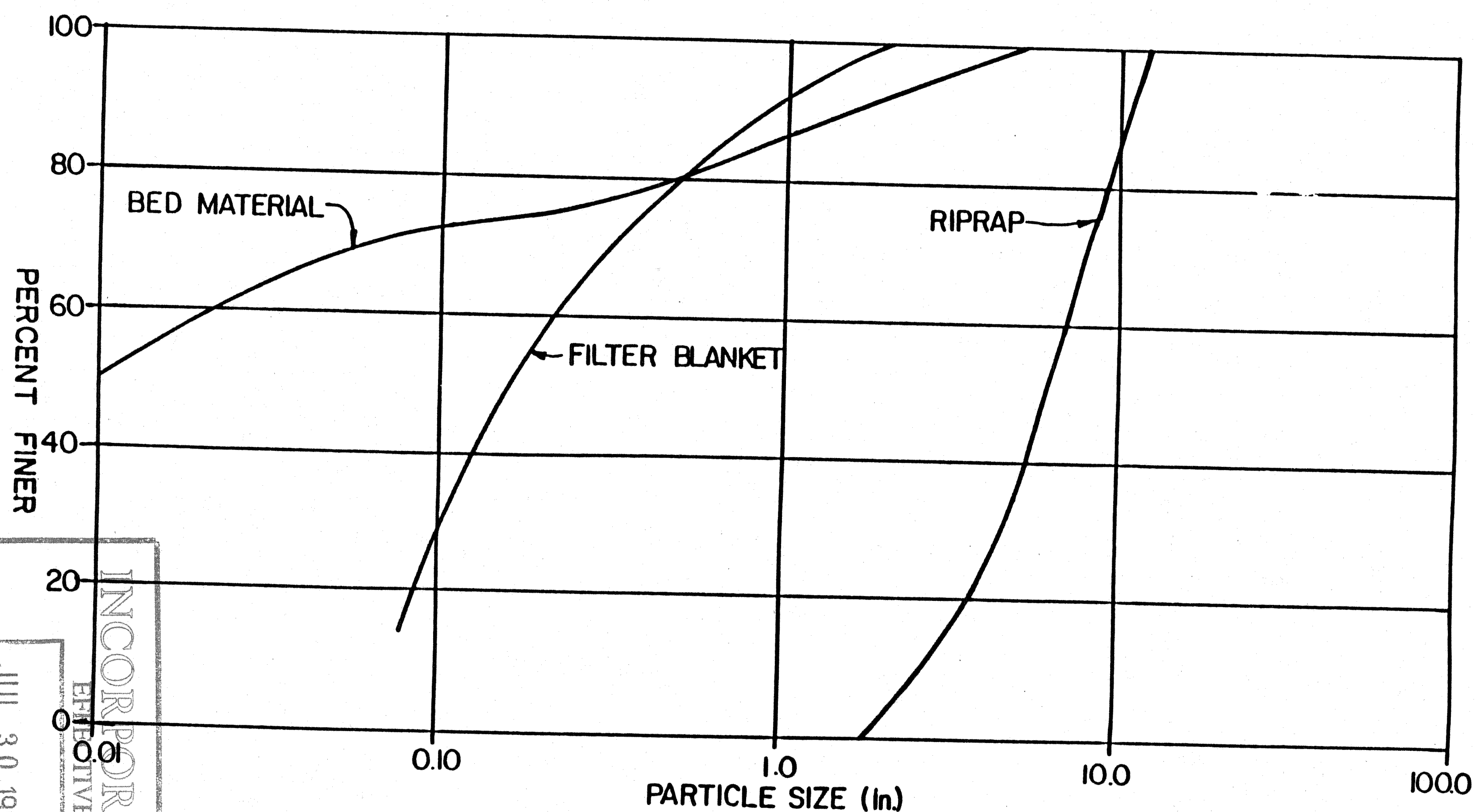
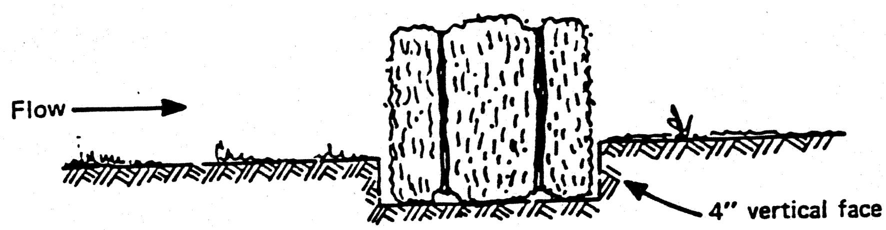
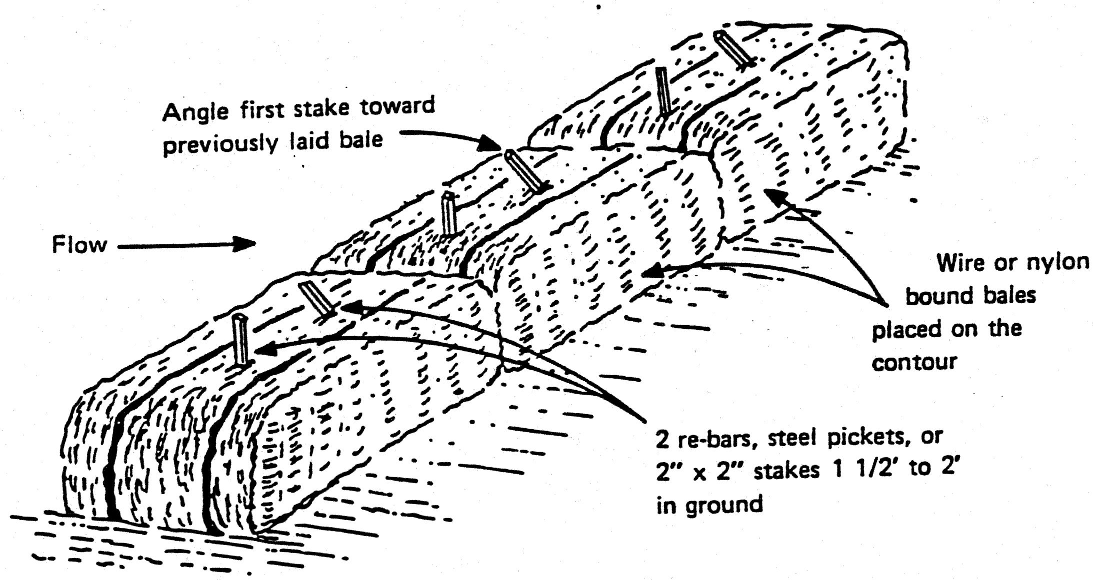


Figure 7-10. Gradation of embankment, filter, and riprap materials.



Embedding detail



Anchoring detail

Figure 7-11. Typical straw-bale dike.

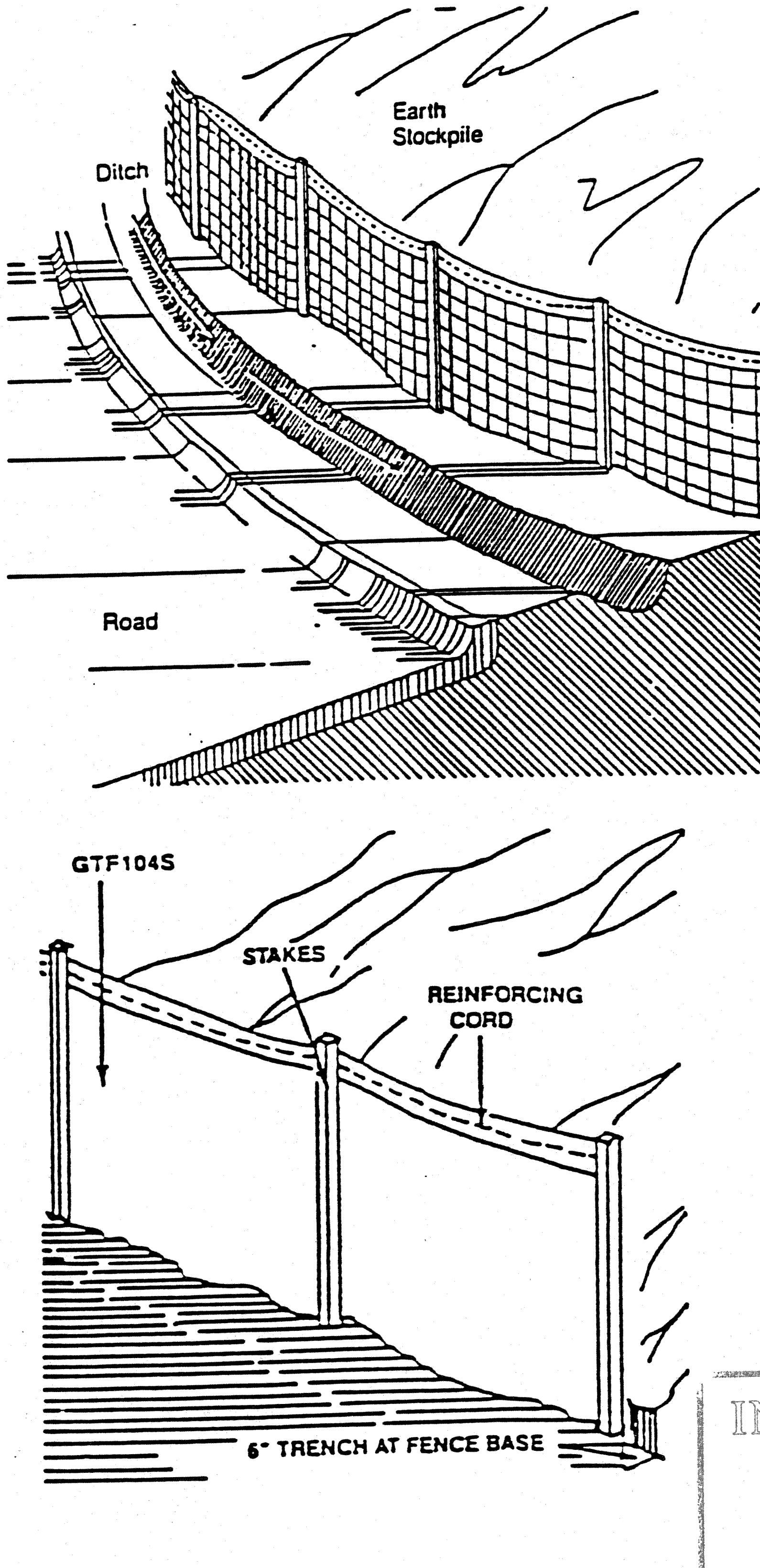


Figure 7-12.. Typical silt fence installation.

7.70 References

Anderson, A.G., A.S. Paintal, J.T. Davenport. 1970. Tentative Design Procedure for Riprap-Lined Channels. National Cooperative Highway Research Program Report No. 108. Highway Board, Nation Academy of Sciences. Washington, D.C.

Arabasz, W. J., R. B. Smith, and W. D. Richins (Ed.). 1979. Earthquake Studies in Utah 1850 to 1978. University of Utah Seismograph Stations, Department of Geology and Geophysics, University of Utah, Salt Lake City, Utah.

Barfield, B.J., R.C. Warner , and C.T. Haan, 1981. Applied Hydrology and Sedimentology for Disturbed Areas. Oklahoma Technical Press. Stillwater, Oklahoma.

Bouwer, H. and R.C. Rice. 1976. A Slug Test for Determining Hydraulic Conductivity of Unconfined Aquifers With Completely or Partially Penetrating Wells. Water Resources Research. 12(3):423-428.

Danielson T.W., M.D. ReMillard, and R.H. Fuller, 1981. Hydrology of the Coal-Resource Areas in the Upper Drainages ofHuntington and Cottonwood Creeks, Central Utah. U.S.Geological Survey Water-Resources Investigations Open-File Report 81-539. Salt Lake City, Utah.

Doelling, H.H. 1972. Central Utah Coal Fields: Sevier-Sanpete, Wasatch Plateau, Book Cliffs, and Emery. Utah Geological and Mineral Survey Monograph Series No. 3. Salt Lake City, Utah.

Dunrud, C.R. 1976. Some Engineering Geologic Factors Controlling Coal Mines Subsidence in Utah and Colorado. U.S. Geological Survey Professional Paper 969. Washington, D.C.

EarthFax Engineering Report on Mine Plan Aquifers and Seep and Spring Surveys (1985a, 1985b)

EarthFax Engineering, Inc. 1990. Storage Pad Slope Stability Analysis at the Crandall Canyon Mine, Emery County, Utah. Project Report Prepared for Genwal Coal Company, Huntington, Utah.

Hawkins, R.H. and K.A. Marshall, 1979. Storm Hydrograph Program. Final Report to the Utah Division of Oil, Gas and Mining. Utah State University. Logan, Utah.

Lines, G.C. 1985. The Ground-Water System and Possible Effects of Underground Coal Mining in the Trail Mountain Area, Central Utah. U.S. Geological Survey Water-Supply Paper 2259.

Plummer, A.P., D.R. Christensen, and S.B. Monson. 1968. Restoring Big-Game Range in Utah. Utah Division of Wildlife Resources. Publication No. 68-3. Salt Lake City, Utah.

Seed, H. B., and I. M. Idriss. 1982. Ground Motions and Soil Liquefaction during Earthquakes. Earthquake Engineering Research Institute, Berkeley, California.

U.S. Bureau Reclamation. 1977. Design of Small Dams. U.S. Government Printing Office. Washington, D.C.

U.S. Soil Conversation Service. 1956. National Engineering Handbook, Section 5: Hydraulics. U.S. Government Printing Office. Washington, D.C.

U.S. Soil Conservation Service. 1968. Hydraulics of Broad-Crested Spillways. Technical Release No. 39. U.S. Government Printing Office. Washington, D.C.

U.S. Soil Conservation Service. 1972. National Engineering Handbook, Section 4: Hydrology. U.S. Government Printing Office. Washington, D.C.

U.S. Soil Conservation Service. 1975. Reclamation of Utah's Surface Mined Lands. Salt Lake City, Utah.

Waddell, K.M., P.K. Contrato, C.T. Sumsison, and J.R. Butler. 1981. Hydrologic Reconnaissance of the Wasatch Plateau-Book Cliffs Coal-Fields Area, Utah. U.S. Geological Survey Water-Supply Paper 1068. Washington, D.C.

Warner, R.C., B.N. Wilson, B.J. Barfield, D.S. Logsdon, and P.J. Nebgen. 1980. A Hydrology and Sedimentology Watershed Model, Part II: Users' Manual. Department of Agricultural Engineering. University of Kentucky. Lexington, Kentucky.

Weider, M.F. K.G. Kirk, and L.E. Welborn. 1983. Simplified Analysis Routines for Surface and Groundwater Hydrology Applications in Surface Mining. Proceedings of the 1983 Symposium on Surface Mining Hydrology, Sedimentology, and Reclamation. University of Kentucky. Lexington, Kentucky.

Wilson, B.N., B.J. Barfield, and I.D. Moore. 1980. A Hydrology and Sedimentology Watershed Model, Part I: Modeling Techniques. Department of Agricultural Engineering. University of Kentucky. Lexington, Kentucky.

APPENDIX 7-1

SURFACE AND UNDERGROUND WATER RIGHTS

utah gov | State Online Services | Agency List | Business.utah.gov | Search Utah.gov GO

UTAH DIVISION OF WATER RIGHTS

Select Related Information

```
      (WARNING: Water Rights makes NO claims as to the accuracy of this data.) RUN DATE: 05/05/2004
WRNUM: 93-483       APPLICATION/CLAIM NO.:              CERT. NO.:
-----------------------------------------------------------------------------------------------
OWNERSHIP**************************************************************************************
-----------------------------------------------------------------------------------------------

NAME: USA Forest Service
ADDR: 324 25th Street
      Ogden UT 84401
LAND OWNED BY APPLICANT? Yes
-----------------------------------------------------------------------------------------------
DATES, ETC.************************************************************************************
-----------------------------------------------------------------------------------------------
FILED:                |PRIORITY:  00/00/1875|PUB BEGAN:          |PUB ENDED:          |NEWSPAPER:
ProtestEnd:           |PROTESTED: [No      ]|HEARNG HLD:         |SE ACTION: [       ]|ActionDate:         |PROOF DUE:
EXTENSION:            |ELEC/PROOF:[        ]|ELEC/PROOF:         |CERT/WUC:           |LAP, ETC:           |PROV LETTER:
RENOVATE:             |RECON REQ:           |TYPE: [            ]
PD Book No. 1     Map: 14
Type of Right: Diligence Claim            Source of Info: Proposed Determination        Status:
Related Distribution System:  Not part of any Distribution System
-----------------------------------------------------------------------------------------------
LOCATION OF WATER RIGHT************************************************************************
-----------------------------------------------------------------------------------------------
FLOW:                                               SOURCE: Shingle Canyon Creek
COUNTY: Emery         COMMON DESCRIPTION:

POINT OF DIVERSION -- POINT TO POINT:
( 1)Stockwatering directly on stream from a point in NW4SE4 Sec 31, T15S, R7E, SLBM,
                              to a point in NE4SE4 Sec 31, T15S, R7E, SLBM.
                         Source:
-----------------------------------------------------------------------------------------------
USES OF WATER RIGHT****************************************************************************
-----------------------------------------------------------------------------------------------
-----------------------------------------------------------------------------------------------
CLAIMS USED FOR PURPOSE DESCRIBED: See WUC 93-1403.
     Referenced To:  93-1403   Claims Groups:                    Type of Reference -- Claims: X  Purpose:    Remarks:
...............................................................................................
  ###STOCKWATERING: 153 Cattle or Equivalent                     Diversion Limit:                 PERIOD OF USE: 07/06 TO 09/25
Crandall Canyon Allotment
***********************************************************************************************
****************************************************E N D   O F   D A T A**********************
***********************************************************************************************
```

UTAH DIVISION OF WATER RIGHTS

Select Related Information

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      (WARNING: Water Rights makes NO claims as to the accuracy of this data.) RUN DATE: 05/05/2004
WRNUM: 93-1411      APPLICATION/CLAIM NO.:              CERT. NO.:
------------------------------------------------------------------------------------------------------
OWNERSHIP*********************************************************************************************
------------------------------------------------------------------------------------------------------

NAME: USA Forest Service
ADDR: 324 25th Street
      Ogden UT 84401
LAND OWNED BY APPLICANT? Yes
------------------------------------------------------------------------------------------------------
DATES, ETC.*******************************************************************************************
------------------------------------------------------------------------------------------------------
FILED:                   |PRIORITY:  00/00/1875|PUB BEGAN:          |PUB ENDED:           |NEWSPAPER:
ProtestEnd:              |PROTESTED: [No      ]|HEARNG HLD:         |SE ACTION: [        ]|ActionDate:          |PROOF DUE:
EXTENSION:               |ELEC/PROOF:[        ]|ELEC/PROOF:         |CERT/WUC:            |LAP, ETC:            |PROV LETTER:
RENOVATE:                |RECON REQ:           |TYPE: [             ]
PD Book No. 1     Map: 15
Type of Right: Diligence Claim            Source of Info: Proposed Determination        Status:
Related Distribution System:  Not part of any Distribution System
------------------------------------------------------------------------------------------------------
LOCATION OF WATER RIGHT*******************************************************************************
------------------------------------------------------------------------------------------------------
FLOW: 0.011 cfs                                 SOURCE: Little Bear Spring
COUNTY: Emery          COMMON DESCRIPTION:

POINT OF DIVERSION:
( 1)Stockwatering directly on spring located in NE4SW4 Sec 09, T16S, R7E, SLBM.
                          Source:
------------------------------------------------------------------------------------------------------
USES OF WATER RIGHT***********************************************************************************
------------------------------------------------------------------------------------------------------
------------------------------------------------------------------------------------------------------
CLAIMS USED FOR PURPOSE DESCRIBED: See WUC 93-198.
     Referenced To:  93-198    Claims Groups:                  Type of Reference -- Claims: X  Purpose:    Remarks:
......................................................................................................
  ###STOCKWATERING: 207 Cattle or Equivalent                   Diversion Limit:                 PERIOD OF USE: 07/01 TO 09/30
Crandall Ridge Allotment
******************************************************************************************************
*******************************************************E N D   O F   D A T A****************************
******************************************************************************************************
```

UTAH DIVISION OF WATER RIGHTS

Select Related Information

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      (WARNING: Water Rights makes NO claims as to the accuracy of this data.) RUN DATE: 05/05/2004
WRNUM: 93-116       APPLICATION/CLAIM NO.:              CERT. NO.:
----------------------------------------------------------------------------------------------------
OWNERSHIP*******************************************************************************************
----------------------------------------------------------------------------------------------------

NAME: USA Forest Service
ADDR: 324 25th Street
      Ogden UT 84401
LAND OWNED BY APPLICANT? Yes
----------------------------------------------------------------------------------------------------
DATES, ETC.*****************************************************************************************
----------------------------------------------------------------------------------------------------
FILED:                |PRIORITY:  00/00/1875|PUB BEGAN:           |PUB ENDED:           |NEWSPAPER:
ProtestEnd:           |PROTESTED: [No      ]|HEARNG HLD:          |SE ACTION: [        ]|ActionDate:          |PROOF DUE:
EXTENSION:            |ELEC/PROOF:[        ]|ELEC/PROOF:          |CERT/WUC:            |LAP, ETC:            |PROV LETTER:
RENOVATE:             |RECON REQ:           |TYPE: [             ]
PD Book No. 1     Map: 10
Type of Right: Diligence Claim             Source of Info: Proposed Determination        Status:
Related Distribution System:  Not part of any Distribution System
----------------------------------------------------------------------------------------------------
LOCATION OF WATER RIGHT*****************************************************************************
----------------------------------------------------------------------------------------------------
FLOW:                                                SOURCE: Huntington Creek
COUNTY: Emery        COMMON DESCRIPTION:

POINT OF DIVERSION -- POINT TO POINT:
( 1)Stockwatering directly on stream from a point in NE4SE4 Sec 08, T15S, R7E, SLBM,
                               to a point in SE4SE4 Sec 09, T16S, R7E, SLBM.
                          Source:
----------------------------------------------------------------------------------------------------
USES OF WATER RIGHT*********************************************************************************
----------------------------------------------------------------------------------------------------
----------------------------------------------------------------------------------------------------
CLAIMS USED FOR PURPOSE DESCRIBED: 88,99,116,118,120,130,132/137,139,142,144,151,166,180,182,188,190,192,195,197,200,259,261,403
                                   409,1180,1187,1307,1425/1479,1548,1549,91-972/982,1633
    Referenced To:            Claims Groups:    1              Type of Reference -- Claims:    Purpose:    Remarks:
....................................................................................................
  ###STOCKWATERING: 1440 Cattle or Equivalent                  Diversion Limit:             PERIOD OF USE: 06/21 TO 09/30
Gentry Mountain Allotment
****************************************************************************************************
*******************************************************E N D   O F   D A T A************************
****************************************************************************************************
```

UTAH DIVISION OF WATER RIGHTS

Select Related Information

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                         (WARNING: Water Rights makes NO claims as to the accuracy of this data.) RUN DATE: 05/05/20
CHANGE: a7941                        WATER RIGHT:93-219   CERT. NO.:           AMENDATORY? No
BASE WATER RIGHTS: 93-219
RIGHT EVIDENCED BY: A.H. Christensen Decree 1st class 93-219/222,224,
                    226,228,239,240,243,253,254,272,303,304,309,310,
CHANGES: Point of Diversion [X], Place of Use [X], Nature of Use [X], Reservoir Storage [ ].
*----------------------------------------------------------------------------------------------------------------*

NAME:  Huntington-Cleveland Irrigation Company
ADDR: P.O. Box 327
      Huntington UT 84528
INTEREST: 100%       REMARKS:
*----------------------------------------------------------------------------------------------------------------*
FILED:      12/16/1983|PRIORITY:   06/19/1974|ADV BEGAN:           |ADV ENDED:           |NEWSPAPER:
ProtestEnd:           |PROTESTED: [        ] |HEARNG HLD:          |SE ACTION: [        ]|ActionDate:06/15/1984|PROOF DUE:  01/31/1988
EXTENSION:            |ELEC/PROOF:[Election] |ELEC/PROOF:01/15/1988|CERT/WUC:            |LAP, ETC:            |PROV LETTER:
RENOVATE:             |RECON REQ:            |TYPE: [             ]
Status: WUC
Related Distribution System:  Not part of any Distribution System
*****************************************************************   *****************************************************************
**********************H E R E T O F O R E************************   ***********************H E R E A F T E R************************
*****************************************************************   *****************************************************************
```

HERETOFORE	HEREAFTER
FLOW: 392.25 cfs	FLOW: 392.25 cfs
SOURCE: Huntington Creek and Tributaries	SOURCE: Huntington Creek and Tributaries
COUNTY: Emery	COUNTY: Emery COM DESC:
Additional rights evidences by: 2nd class 93-220,2223,2226,2190,2229,2232,2235 2211,2214,2217,2199,2193,2238,2202, 2196,2205,2208;3rd Class 93-2221,2224,2227, 2191,2230,2233,2236,2212,2215,2218, 2200,2194,2239,2203,2197,2206,2209;4th class 93-2222,2225,2228,2192,2231,2234, 2237,2213,2216,2219,2201,2195,2240,2204 2198,2207,2210.	

(18) N 960 ft W 440 ft from E4 cor, Sec 15, T 17S, R 8E, SLBM Diverting Works: Source: North Ditch	(18) S 1320 ft W 300 ft from N4 cor, Sec 08, T 17S, R 8E, SLBM Diverting Works: Source: Seely & Collard Ditch (19) N 2290 ft W 65 ft from S4 cor, Sec 09, T 17S, R 8E, SLBM Diverting Works: Source: Cleveland Canal (20) N 2300 ft W 60 ft from S4 cor, Sec 09, T 17S, R 8E, SLBM Diverting Works: Source: Robins-Truman Ditch (21) S 850 ft W 530 ft from N4 cor, Sec 15, T 17S, R 8E, SLBM Diverting Works: Source: Huntington Canal (22) N 960 ft W 440 ft from E4 cor, Sec 15, T 17S, R 8E, SLBM Diverting Works: Source: North Ditch
Point Rediversion: (1) N 750 ft E 1950 ft from W4 cor, Sec 11, T 17S, R 10E, SLBM Diverting Works: Source: Cleveland Canal	Point Rediversion: (1) N 750 ft E 1950 ft from W4 cor, Sec 11, T 17S, R 10E, SLBM Diverting Works: Source: Cleveland Canal

NATURE OF USE ------>	**SAME AS HERETOFORE, AND IN ADDITION TO:**
SUPPLEMENTAL to Other Water Rights: No	SUPPLEMENTAL to Other Water Rights: No
IRR: 32673.2600 acs Sol/Sup: acs USED 03/02 - 11/14	IRR: 32673.2600 acs Sol/Sup: acs USED 03/02 - 11/14
STK: 6797 Cattle or Equivalent USED 01/01 - 12/31	STK: 6797 Cattle or Equivalent USED 01/01 - 12/31
DOM: 650 Families USED 01/01 - 12/31	DOM: 650 Families USED 01/01 - 12/31
	POW: Name: Huntington Plant USED 01/01 - 12/31 A Steam Generation Power Plant, Rated at
	OTH: OTHER: Various Municipal and USED 01/01 - 12/31 Industrial purposes.

E N D   O F   D A T A

```
POINT(S) OF DIVERSION ------>
---------------------------------------------------------------
Point Surface:
(1)  N 1750 ft W   95 ft from S4 cor, Sec 09, T 16S, R  7E, SLBM
            Diverting Works:
            Source:           Little Bear Canyon Spring
(2)  S  928 ft E  147 ft from N4 cor, Sec 23, T 16S, R  7E, SLBM
            Diverting Works:
            Source:           Ranger Station Spring
(3)  N 2045 ft E  185 ft from S4 cor, Sec 26, T 16S, R  7E, SLBM
            Diverting Works:
            Source:           Bear Canyon Spring
(4)  N 2026 ft W 2172 ft from S4 cor, Sec 26, T 16S, R  7E, SLBM
            Diverting Works:
            Source:           Birch Spring
(5)  N 2813 ft W 2716 ft from S4 cor, Sec 26, T 16S, R  7E, SLBM
            Diverting Works:
            Source:           Unnamed Spring
(6)  N  200 ft W 2700 ft from E4 cor, Sec 29, T 16S, R  7E, SLBM
            Diverting Works:
            Source:           Rilds Spring
(7)  S 1120 ft W 2020 ft from N4 cor, Sec 35, T 16S, R  7E, SLBM
            Diverting Works:
            Source:           Unnamed Spring
(8)  N  730 ft E 1110 ft from W4 cor, Sec 36, T 16S, R  7E, SLBM
            Diverting Works:
            Source:           Howard Ditch
(9)  N 1030 ft W  370 ft from SE cor, Sec 31, T 16S, R  8E, SLBM
            Diverting Works:
            Source:           Brinkerhoff Ditch
(10) N 2100 ft E 1800 ft from SW cor, Sec 05, T 17S, R  7E, SLBM
            Diverting Works:
            Source:           Elk Spring
(11) N  760 ft      0 ft from SW cor, Sec 05, T 17S, R  8E, SLBM
            Diverting Works:
            Source:           Harrison Ditch
(12) N  100 ft E 1270 ft from SW cor, Sec 05, T 17S, R  8E, SLBM
            Diverting Works:
            Source:           Rowley Ditch
(13) S  370 ft E  350 ft from NW cor, Sec 06, T 17S, R  8E, SLBM
            Diverting Works:
            Source:           Dell Lott Ditch
(14) S 1320 ft W  300 ft from N4 cor, Sec 08, T 17S, R  8E, SLBM
            Diverting Works:
            Source:           Seely & Collard Ditch
(15) N 2290 ft W   65 ft from S4 cor, Sec 09, T 17S, R  8E, SLBM
            Diverting Works:
            Source:           Cleveland Canal
(16) N 2300 ft W   60 ft from S4 cor, Sec 09, T 17S, R  8E, SLBM
            Diverting Works:
            Source:           Robins-Truman Ditch
(17) S  850 ft W  530 ft from N4 cor, Sec 15, T 17S, R  8E, SLBM
            Diverting Works:
            Source:           Huntington Canal
```

```
SAME AS HERETOFORE, AND IN ADDITION TO:
---------------------------------------------------------------
Point Surface:
(1)  N   40 ft W 1520 ft from SE cor, Sec 34, T 15S, R  7E, SLBM
            Diverting Works:
            Source:           Tie Fork Springs (#2)
(2)  N 1550 ft W   50 ft from SE cor, Sec 34, T 15S, R  7E, SLBM
            Diverting Works:
            Source:           Tie Fork Springs(#1)
(3)  S 1535 ft E  785 ft from NW cor, Sec 08, T 16S, R  7E, SLBM
            Diverting Works:
            Source:           UP&L Huntington Canyon Plant
(4)  N 1750 ft W   95 ft from S4 cor, Sec 09, T 16S, R  7E, SLBM
            Diverting Works:
            Source:           Little Bear Canyon Spring
(5)  N 2813 ft W 2716 ft from S4 cor, Sec 16, T 16S, R  7E, SLBM
            Diverting Works:
            Source:           Unnamed Spring
(6)  S  928 ft E  147 ft from N4 cor, Sec 23, T 16S, R  7E, SLBM
            Diverting Works:
            Source:           Ranger Station Spring
(7)  N 2026 ft W 2172 ft from S4 cor, Sec 26, T 16S, R  7E, SLBM
            Diverting Works:
            Source:           Birch Spring
(8)  N 1060 ft E  650 ft from W4 cor, Sec 26, T 16S, R  7E, SLBM
            Diverting Works:
            Source:           Gate Springs
(9)  N 2045 ft E  185 ft from S4 cor, Sec 26, T 16S, R  7E, SLBM
            Diverting Works:
            Source:           Bear Canyon Spring
(10) N  200 ft W 2700 ft from E4 cor, Sec 29, T 16S, R  7E, SLBM
            Diverting Works:
            Source:           Rilda Spring
(11) S 1120 ft W 2020 ft from N4 cor, Sec 35, T 16S, R  7E, SLBM
            Diverting Works:
            Source:           Unnamed Spring
(12) N 1030 ft W  370 ft from SE cor, Sec 36, T 16S, R  7E, SLBM
            Diverting Works:
            Source:           Brinkerhoff Ditch
(13) N 2100 ft E 1800 ft from SW cor, Sec 05, T 17S, R  7E, SLBM
            Diverting Works:
            Source:           Elk Spring
(14) N  760 ft      0 ft from SW cor, Sec 05, T 17S, R  8E, SLBM
            Diverting Works:
            Source:           Harrison Ditch
(15) N  100 ft E 1270 ft from SW cor, Sec 05, T 17S, R  8E, SLBM
            Diverting Works:
            Source:           Rowley Ditch
(16) S  370 ft E  350 ft from NW cor, Sec 06, T 17S, R  8E, SLBM
            Diverting Works:
            Source:           Dell Lott Ditch
(17) S  840 ft E 2480 ft from NW cor, Sec 08, T 17S, R  8E, SLBM
            Diverting Works:
            Source:           Huntington Treatment Plant
```

UTAH DIVISION OF WATER RIGHTS

Select Related Information

(WARNING: Water Rights makes NO claims as to the accuracy of this data.) RUN DATE: 05/05/2004

WRNUM: 93-2194 APPLICATION/CLAIM NO.: CERT. NO.:

OWNERSHIP

NAME: Huntington Cleveland Irrigation
ADDR: c/o J. Craig Smith & David B. Hartvigsen
215 S. State Street, Suite 650
Salt Lake City UT 84111

NAME: Huntington Cleveland Irrigation Company
ADDR: P.O. Box 327
Huntington UT 84528
LAND OWNED BY APPLICANT?

DATES, ETC.

FILED:	PRIORITY: 00/00/1884	PUB BEGAN:	PUB ENDED:	NEWSPAPER:	
ProtestEnd:	PROTESTED: [No]	HEARNG HLD:	SE ACTION: [ ]	ActionDate:	PROOF DUE:
EXTENSION:	ELEC/PROOF: [Election]	ELEC/PROOF: 01/15/1988	CERT/WUC: 07/02/1992	LAP, ETC:	PROV LETTER:
RENOVATE:	RECON REQ:	TYPE: [ ]			

PD Book No. 1 Map: 15
Type of Right: Decree Source of Info: BAD SOURCE OF DATA Status:
Related Distribution System: Not part of any Distribution System

LOCATION OF WATER RIGHT

FLOW: 77.25 cfs SOURCE: Little Bear Canyon Spring
COUNTY: Emery COMMON DESCRIPTION:

POINT OF DIVERSION -- SURFACE:
(1) N 1750 ft W 95 ft from S4 cor, Sec 09, T 16S, R 7E, SLBM
Diverting Works: Source:

USES OF WATER RIGHT

CLAIMS USED FOR PURPOSE DESCRIBED: 219/222,253,254,303,304,309,310,928,950,951,1136/1139,2190/2210,2220/2228,3195
Referenced To: Claims Groups: 1 Type of Reference -- Claims: Purpose: Remarks:

###DOMESTIC: 650 Family Diversion Limit: PERIOD OF USE: 01/01 TO 12/31
Within the service area of the North Emery Water User`s Association

```
------------------------------------------------------------------------------------------------
CLAIMS USED FOR PURPOSE DESCRIBED: 219/222,253,254,303,304,309,310,928,950,951,1136/1139,2190/2210,2220/2228,3195
     Referenced To:            Claims Groups:    2                     Type of Reference -- Claims:    Purpose:    Remarks:
................................................................................................
  ###MUNICIPAL: Huntington City                                                   PERIOD OF USE: 01/01 TO 12/31
------------------------------------------------------------------------------------------------
OTHER COMMENTS**********************************************************************************
------------------------------------------------------------------------------------------------
     This file referenced by: A.H. Christensen Decree 3rd Class.
     Domestic and municipal uses are recognized under this claim as long as there
     are shares of stock in the company owned by a municipality or a public water
     supplier.
     Uses allowed under this right include those recognized by the public water
     supplier.
     A total of 77.25 cfs can be diverted under any, each, or all of the following
     claims: 93-2191,2194,2197,2200,2203,2206,2209,2212,2215,2218,2221,2224,2227,
     2230,2233,2236,2239.
************************************************************************************************
*******************************************************E N D   O F   D A T A********************
************************************************************************************************
```

UTAH DIVISION OF WATER RIGHTS

Select Related Information

(WARNING: Water Rights makes NO claims as to the accuracy of this data.) RUN DATE: 05/05/2004

```
WRNUM: 93-2195      APPLICATION/CLAIM NO.:           CERT. NO.:
---------------------------------------------------------------------------------
OWNERSHIP************************************************************************
---------------------------------------------------------------------------------

NAME: Huntington Cleveland Irrigation Company
ADDR: P.O. Box 327
      Huntington UT 84528
LAND OWNED BY APPLICANT?
---------------------------------------------------------------------------------
DATES, ETC.**********************************************************************
---------------------------------------------------------------------------------
FILED:                 |PRIORITY:  00/00/1888|PUB BEGAN:           |PUB ENDED:           |NEWSPAPER:
ProtestEnd:            |PROTESTED: [No      ]|HEARNG HLD:          |SE ACTION: [        ]|ActionDate:          |PROOF DUE:
EXTENSION:             |ELEC/PROOF:[Election]|ELEC/PROOF:01/15/1988|CERT/WUC:  07/02/1992|LAP, ETC:            |PROV LETTER:
RENOVATE:              |RECON REQ:           |TYPE: [              ]
PD Book No. 1     Map: 15
Type of Right: Decree                  Source of Info: BAD SOURCE OF DATA          Status:
Related Distribution System:  Not part of any Distribution System
---------------------------------------------------------------------------------
LOCATION OF WATER RIGHT**********************************************************
---------------------------------------------------------------------------------
FLOW: 80.0 cfs                                 SOURCE: Little Bear Canyon Spring
COUNTY: Emery        COMMON DESCRIPTION:

POINT OF DIVERSION -- SURFACE:
(1) N 1750 ft W   95 ft from S4 cor, Sec 09, T 16S, R  7E, SLBM
      Diverting Works:                                                  Source:
---------------------------------------------------------------------------------
USES OF WATER RIGHT**************************************************************
---------------------------------------------------------------------------------
---------------------------------------------------------------------------------
CLAIMS USED FOR PURPOSE DESCRIBED: 219/222,253,254,303,304,309,310,928,950,951,1136/1139,2190/2210,2220/2228,3195
     Referenced To:            Claims Groups:    1              Type of Reference -- Claims:    Purpose:    Remarks:
.................................................................................
  ###DOMESTIC: 650 Family                                        Diversion Limit:              PERIOD OF USE: 01/01 TO 12/31
Within the service area of the North Emery Water User`s Association
---------------------------------------------------------------------------------
CLAIMS USED FOR PURPOSE DESCRIBED: 219/222,253,254,303,304,309,310,928,950,951,1136/1139,2190/2210,2220/2228,3195
     Referenced To:            Claims Groups:    2              Type of Reference -- Claims:    Purpose:    Remarks:
.................................................................................
  ###MUNICIPAL: Huntington City                                                                PERIOD OF USE: 01/01 TO 12/31
```

OTHER COMMENTS

This file referenced by: A.H. Christensen Decree 4th Class.
Domestic and municipal uses are recognized under this claim as long as there are shares of stock in the company owned by a municipality or a public water supplier.
Uses allowed under this right include those recognized by the public water supplier.
A total of 80.00 cfs can be diverted under any, each, or all of the following claims: 93-2192,2195,2198,2201,2204,2207,2210,2213,2216,2219,2222,2225,2228, 2231,2234,2237,2240.

E N D O F D A T A

UTAH DIVISION OF WATER RIGHTS

Select Related Information

(WARNING: Water Rights makes NO claims as to the accuracy of this data.) RUN DATE: 05/05/2004

```
WRNUM: 93-2193      APPLICATION/CLAIM NO.:          CERT. NO.:
----------------------------------------------------------------------------------------------
OWNERSHIP*************************************************************************************
----------------------------------------------------------------------------------------------

NAME: Huntington Cleveland Irrigation Company
ADDR: P.O. Box 327
      Huntington UT 84528
LAND OWNED BY APPLICANT?
----------------------------------------------------------------------------------------------
DATES, ETC.***********************************************************************************
----------------------------------------------------------------------------------------------
FILED:                |PRIORITY:  00/00/1879|PUB BEGAN:           |PUB ENDED:           |NEWSPAPER:
ProtestEnd:           |PROTESTED: [No      ]|HEARNG HLD:          |SE ACTION: [        ]|ActionDate:           |PROOF DUE:
EXTENSION:            |ELEC/PROOF:[Election]|ELEC/PROOF:01/15/1988|CERT/WUC:  07/02/1992|LAP, ETC:             |PROV LETTER:
RENOVATE:             |RECON REQ:           |TYPE: [             ]
PD Book No. 1     Map: 15
Type of Right: Decree                    Source of Info: BAD SOURCE OF DATA           Status:
Related Distribution System:  Not part of any Distribution System
----------------------------------------------------------------------------------------------
LOCATION OF WATER RIGHT***********************************************************************
----------------------------------------------------------------------------------------------
FLOW: 45.0 cfs                          SOURCE: Little Bear Canyon Spring
COUNTY: Emery        COMMON DESCRIPTION:

POINT OF DIVERSION -- SURFACE:
(1) N 1750 ft W   95 ft from S4 cor, Sec 09, T 16S, R  7E, SLBM
      Diverting Works:                                              Source:
----------------------------------------------------------------------------------------------
USES OF WATER RIGHT***************************************************************************
----------------------------------------------------------------------------------------------
----------------------------------------------------------------------------------------------
CLAIMS USED FOR PURPOSE DESCRIBED: 219/222,253,254,303,304,309,310,928,950,951,1136/1139,2190/2210,2220/2228,3195
     Referenced To:          Claims Groups:    1             Type of Reference -- Claims:    Purpose:    Remarks:
..............................................................................................
  ###DOMESTIC: 650 Family                                    Diversion Limit:              PERIOD OF USE: 01/01 TO 12/31
Within the service area of the North Emery Water User`s Association
----------------------------------------------------------------------------------------------
CLAIMS USED FOR PURPOSE DESCRIBED: 219/222,253,254,303,304,309,310,928,950,951,1136/1139,2190/2210,2220/2228,3195
     Referenced To:          Claims Groups:    2             Type of Reference -- Claims:    Purpose:    Remarks:
..............................................................................................
  ###MUNICIPAL: Huntington City                                                            PERIOD OF USE: 01/01 TO 12/31
```

```
----------------------------------------------------------------------------------------------------------------------------------
OTHER COMMENTS************************************************************************************************************
----------------------------------------------------------------------------------------------------------------------------------
     This file referenced by: A.H. Christensen Decree 2nd Class.
     Domestic and municipal uses are recognized under this claim as long as there
     are shares of stock in the company owned by a municipality or a public water
     supplier.
     Uses allowed under this right include those recognized by the public water
     supplier.
     A total of 45.00 cfs can be diverted under any, each, or all of the following
     claims: 93-2190,2193,2196,2199,2202,2205,2208,2211,2214,2217,2220,2223,2226,
     2229,2232,2235,2238.
**********************************************************************************************************************************
*******************************************************E N D   O F   D A T A*******************************************************
**********************************************************************************************************************************
```

UTAH DIVISION OF WATER RIGHTS

Select Related Information

```
      (WARNING: Water Rights makes NO claims as to the accuracy of this data.) RUN DATE: 05/05/2004
WRNUM: 93-254      APPLICATION/CLAIM NO.:          CERT. NO.:
--------------------------------------------------------------------------------------------------
OWNERSHIP*****************************************************************************************
--------------------------------------------------------------------------------------------------

NAME: Huntington Cleveland Irrigation
ADDR: c/o J. Craig Smith & David B. Hartvigsen
      215 S. State Street, Suite 650
      Salt Lake City UT 84111

NAME: Huntington Cleveland Irrigation Company
ADDR: P.O. Box 327
      Huntington UT 84528
LAND OWNED BY APPLICANT? Yes
--------------------------------------------------------------------------------------------------
DATES, ETC.***************************************************************************************
--------------------------------------------------------------------------------------------------
FILED:               |PRIORITY:  00/00/1875|PUB BEGAN:          |PUB ENDED:          |NEWSPAPER:
ProtestEnd:          |PROTESTED: [No      ]|HEARNG HLD:         |SE ACTION: [       ]|ActionDate:         |PROOF DUE:
EXTENSION:           |ELEC/PROOF:[Election]|ELEC/PROOF:01/15/1988|CERT/WUC:  07/02/1992|LAP, ETC:           |PROV LETTER:
RENOVATE:            |RECON REQ:           |TYPE: [              ]
PD Book No. 1     Map: 15
Type of Right: Diligence Claim            Source of Info: BAD SOURCE OF DATA          Status:
Related Distribution System:  Not part of any Distribution System
--------------------------------------------------------------------------------------------------
LOCATION OF WATER RIGHT***************************************************************************
--------------------------------------------------------------------------------------------------
FLOW: 150.0 cfs                            SOURCE: Little Bear Canyon Spring
COUNTY: Emery        COMMON DESCRIPTION:

POINT OF DIVERSION -- SURFACE:
(1) N 1750 ft W   95 ft from S4 cor, Sec 09, T 16S, R  7E, SLBM
      Diverting Works:                                              Source:
--------------------------------------------------------------------------------------------------
USES OF WATER RIGHT*******************************************************************************
--------------------------------------------------------------------------------------------------
--------------------------------------------------------------------------------------------------
CLAIMS USED FOR PURPOSE DESCRIBED: 219/222,253,254,303,304,309,310,928,950,951,1136/1139,2190/2210,2220/2228,3195
     Referenced To:          Claims Groups:    1               Type of Reference -- Claims:    Purpose:    Remarks:
..................................................................................................
  ###DOMESTIC: 650 Family                                Diversion Limit:               PERIOD OF USE: 01/01 TO 12/31
Within the service area of the North Emery Water User`s Association
```

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-----------------------------------------------------------------------------------------------------------------------
CLAIMS USED FOR PURPOSE DESCRIBED: 219/222,253,254,303,304,309,310,928,950,951,1136/1139,2190/2210,2220/2228,3195
     Referenced To:            Claims Groups:    2                  Type of Reference -- Claims:    Purpose:    Remarks:
.......................................................................................................................
  ###MUNICIPAL: Huntington City                                                             PERIOD OF USE: 01/01 TO 12/31
-----------------------------------------------------------------------------------------------------------------------
OTHER COMMENTS*********************************************************************************************************
-----------------------------------------------------------------------------------------------------------------------
     This file referenced by: A.H. Christensen Decree 1st Class.
     Domestic and municipal uses are recognized under this claim as long as there
     are shares of stock in the company owned by a municipality or a public water
     supplier.
     Uses allowed under this right include those recognized by the public water
     supplier.
     A total of 150.00 cfs can be diverted under any, each, or all of the following
     claims: 93-219/222,224,226,228,239,240,243,253,254,272,303,304,309,310.
***********************************************************************************************************************
*******************************************************E N D   O F   D A T A*******************************************
***********************************************************************************************************************
```

UTAH DIVISION OF WATER RIGHTS

Select Related Information

```
                    (WARNING: Water Rights makes NO claims as to the accuracy of this data.) RUN DATE: 05/05/20
EXCHANGE: E2504     (93-3703)      BASE WATER RIGHT:   -          STOCK/CONTRACT NUMBER:
RIGHT EVIDENCED BY: 2908 shares of stock in Huntington-Cleveland
                    Irrigation Company
-------------------------------------------------------------------------------------------------------------------------------
OWNERSHIP**********************************************************************************************************************
-------------------------------------------------------------------------------------------------------------------------------
*-----------------------------------------------------------------------------------------------------------------------------*

NAME:  Castle Valley Special Service District
ADDR: P. O. Box 877
      Castle Dale UT 84513
-------------------------------------------------------------------------------------------------------------------------------
DATES, ETC.********************************************************************************************************************
-------------------------------------------------------------------------------------------------------------------------------
FILED:     03/26/1987|PRIORITY:  03/26/1987|ADV BEGAN: 05/27/1987|ADV ENDED:              |NEWSPAPER:  Emery County Progress
ProtestEnd:07/10/1987|PROTESTED: [No      ]|HEARNG HLD:          |SE ACTION:  [Approved]|ActionDate:10/23/1987|PROOF DUE:
EXTENSION:           |ProofFiled:          |CertIssued:          |LAP, ETC:               |PROV LETTR:           |RENOVATE:
RECON REQ:           |TYPE: [              ]
Date Verified: 02/22/1994  Initials: MJK      Status: Approved
*******************************************************************************************************************************
**************************************************C U R R E N T   R I G H T*************************************************
*******************************************************************************************************************************
FLOW:   681.0 acre-feet
SOURCE: Huntington Creek
COUNTY: Emery
POINTS OF DIVERSION -- SURFACE:
(1) N 1030 ft W  370 ft from SE cor, Sec 36, T 16S, R  7E, SLBM
          Diverting Works:                                 Source:  Brinkerhoff Ditch
(2) N  760 ft      0 ft from SW cor, Sec 05, T 17S, R  8E, SLBM
          Diverting Works:                                 Source:  Harrison Ditch
(3) N  100 ft E 1270 ft from SW cor, Sec 05, T 17S, R  8E, SLBM
          Diverting Works:                                 Source:  Rowley Ditch
(4) S  370 ft E  350 ft from NW cor, Sec 06, T 17S, R  8E, SLBM
          Diverting Works:                                 Source:  Dell Lott Ditch
(5) S 1320 ft W  300 ft from N4 cor, Sec 08, T 17S, R  8E, SLBM
          Diverting Works:                                 Source:  Seely and Collard Ditch
(6) N 2300 ft W   60 ft from S4 cor, Sec 09, T 17S, R  8E, SLBM
          Diverting Works:                                 Source:  Robins-Truman Ditch
(7) N 2290 ft W   65 ft from S4 cor, Sec 09, T 17S, R  8E, SLBM
          Diverting Works:                                 Source:  Cleveland Canal
(8) N  960 ft W  440 ft from E4 cor, Sec 15, T 17S, R  8E, SLBM
```

Diverting Works: Source: North Ditch

NATURE OF USE:

###IRRIGATION: Total: 36673.26 acres Sole Supply: acres PERIOD OF USE: 03/02 TO 11/14

###STOCKWATERING: 6797 Cattle or Equivalent PERIOD OF USE: 01/01 TO 12/31

###DOMESTIC: 650 Families PERIOD OF USE: 01/01 TO 12/31

PLACE OF USE OF CURRENT RIGHT

	NORTH-WEST¼ NW NE SW SE	NORTH-EAST¼ NW NE SW SE	SOUTH-WEST¼ NW NE SW SE	SOUTH-EAST¼ NW NE SW SE
Sec 32 T 15S R 10E SLBM	* X: X: X: X*	* X: X: X: X*	* X: X: X: X*	* X: X: X: X*
Sec 33 T 15S R 10E SLBM	* X: X: X: X*	* X: X: X: X*	* X: X: X: X*	* X: X: X: X*
Sec 13 T 16S R 9E SLBM	* X: X: X: X*	* X: X: X: X*	* X: X: X: X*	* X: X: X: X*
Sec 24 T 16S R 9E SLBM	* X: X: X: X*	* X: X: X: X*	* X: X: X: X*	* X: X: X: X*
Sec 25 T 16S R 9E SLBM	* X: X: X: X*	* X: X: X: X*	* X: X: X: X*	* X: X: X: X*
Sec 36 T 16S R 9E SLBM	* X: X: X: X*	* X: X: X: X*	* X: X: X: X*	* X: X: X: X*
Sec 20 T 16S R 11E SLBM	* X: X: X: X*	* X: X: X: X*	* X: X: X: X*	* X: X: X: X*
Sec 21 T 16S R 11E SLBM	* X: X: X: X*	* X: X: X: X*	* X: X: X: X*	* X: X: X: X*
Sec 28 T 16S R 11E SLBM	* X: X: X: X*	* X: X: X: X*	* X: X: X: X*	* X: X: X: X*
Sec 29 T 16S R 11E SLBM	* X: X: X: X*	* X: X: X: X*	* X: X: X: X*	* X: X: X: X*
Sec 31 T 16S R 11E SLBM	* X: X: X: X*	* X: X: X: X*	* X: X: X: X*	* X: X: X: X*
Sec 32 T 16S R 11E SLBM	* X: X: X: X*	* X: X: X: X*	* X: X: X: X*	* X: X: X: X*
Sec 05 T 17S R 8E SLBM	* X: X: X: X*	* X: X: X: X*	* X: X: X: X*	* X: X: X: X*
Sec 08 T 17S R 8E SLBM	* X: X: X: X*	* X: X: X: X*	* X: X: X: X*	* X: X: X: X*
Sec 09 T 17S R 8E SLBM	* X: X: X: X*	* X: X: X: X*	* X: X: X: X*	* X: X: X: X*
Sec 10 T 17S R 8E SLBM	* X: X: X: X*	* X: X: X: X*	* X: X: X: X*	* X: X: X: X*
Sec 11 T 17S R 8E SLBM	* X: X: X: X*	* X: X: X: X*	* X: X: X: X*	* X: X: X: X*
Sec 12 T 17S R 8E SLBM	* X: X: X: X*	* X: X: X: X*	* X: X: X: X*	* X: X: X: X*
Sec 13 T 17S R 8E SLBM	* X: X: X: X*	* X: X: X: X*	* X: X: X: X*	* X: X: X: X*
Sec 14 T 17S R 8E SLBM	* X: X: X: X*	* X: X: X: X*	* X: X: X: X*	* X: X: X: X*
Sec 15 T 17S R 8E SLBM	* X: X: X: X*	* X: X: X: X*	* X: X: X: X*	* X: X: X: X*
Sec 23 T 17S R 8E SLBM	* X: X: X: X*	* X: X: X: X*	* X: X: X: X*	* X: X: X: X*
Sec 24 T 17S R 8E SLBM	* X: X: X: X*	* X: X: X: X*	* X: X: X: X*	* X: X: X: X*
Sec 25 T 17S R 8E SLBM	* X: X: X: X*	* X: X: X: X*	* X: X: X: X*	* X: X: X: X*
Sec 26 T 17S R 8E SLBM	* X: X: X: X*	* X: X: X: X*	* X: X: X: X*	* X: X: X: X*
Sec 35 T 17S R 8E SLBM	* X: X: X: X*	* X: X: X: X*	* X: X: X: X*	* X: X: X: X*
Sec 36 T 17S R 8E SLBM	* X: X: X: X*	* X: X: X: X*	* X: X: X: X*	* X: X: X: X*
Sec 01 T 17S R 9E SLBM	* X: X: X: X*	* X: X: X: X*	* X: X: X: X*	* X: X: X: X*
Sec 02 T 17S R 9E SLBM	* X: X: X: X*	* X: X: X: X*	* X: X: X: X*	* X: X: X: X*
Sec 03 T 17S R 9E SLBM	* X: X: X: X*	* X: X: X: X*	* X: X: X: X*	* X: X: X: X*
Sec 07 T 17S R 9E SLBM	* X: X: X: X*	* X: X: X: X*	* X: X: X: X*	* X: X: X: X*
Sec 08 T 17S R 9E SLBM	* X: X: X: X*	* X: X: X: X*	* X: X: X: X*	* X: X: X: X*
Sec 09 T 17S R 9E SLBM	* X: X: X: X*	* X: X: X: X*	* X: X: X: X*	* X: X: X: X*
Sec 10 T 17S R 9E SLBM	* X: X: X: X*	* X: X: X: X*	* X: X: X: X*	* X: X: X: X*
Sec 11 T 17S R 9E SLBM	* X: X: X: X*	* X: X: X: X*	* X: X: X: X*	* X: X: X: X*
Sec 12 T 17S R 9E SLBM	* X: X: X: X*	* X: X: X: X*	* X: X: X: X*	* X: X: X: X*
Sec 13 T 17S R 9E SLBM	* X: X: X: X*	* X: X: X: X*	* X: X: X: X*	* X: X: X: X*
Sec 14 T 17S R 9E SLBM	* X: X: X: X*	* X: X: X: X*	* X: X: X: X*	* X: X: X: X*
Sec 15 T 17S R 9E SLBM	* X: X: X: X*	* X: X: X: X*	* X: X: X: X*	* X: X: X: X*
Sec 16 T 17S R 9E SLBM	* X: X: X: X*	* X: X: X: X*	* X: X: X: X*	* X: X: X: X*
Sec 17 T 17S R 9E SLBM	* X: X: X: X*	* X: X: X: X*	* X: X: X: X*	* X: X: X: X*

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Sec 18 T 17S R  9E SLBM    * X: X: X: X*   * X: X: X: X*   * X: X: X: X*   * X: X: X: X*
Sec 19 T 17S R  9E SLBM    * X: X: X: X*   * X: X: X: X*   * X: X: X: X*   * X: X: X: X*
Sec 20 T 17S R  9E SLBM    * X: X: X: X*   * X: X: X: X*   * X: X: X: X*   * X: X: X: X*
Sec 22 T 17S R  9E SLBM    * X: X: X: X*   * X: X: X: X*   * X: X: X: X*   * X: X: X: X*
Sec 23 T 17S R  9E SLBM    * X: X: X: X*   * X: X: X: X*   * X: X: X: X*   * X: X: X: X*
Sec 24 T 17S R  9E SLBM    * X: X: X: X*   * X: X: X: X*   * X: X: X: X*   * X: X: X: X*
Sec 25 T 17S R  9E SLBM    * X: X: X: X*   * X: X: X: X*   * X: X: X: X*   * X: X: X: X*
Sec 27 T 17S R  9E SLBM    * X: X: X: X*   * X: X: X: X*   * X: X: X: X*   * X: X: X: X*
Sec 28 T 17S R  9E SLBM    * X: X: X: X*   * X: X: X: X*   * X: X: X: X*   * X: X: X: X*
Sec 29 T 17S R  9E SLBM    * X: X: X: X*   * X: X: X: X*   * X: X: X: X*   * X: X: X: X*
Sec 30 T 17S R  9E SLBM    * X: X: X: X*   * X: X: X: X*   * X: X: X: X*   * X: X: X: X*
Sec 31 T 17S R  9E SLBM    * X: X: X: X*   * X: X: X: X*   * X: X: X: X*   * X: X: X: X*
Sec 32 T 17S R  9E SLBM    * X: X: X: X*   * X: X: X: X*   * X: X: X: X*   * X: X: X: X*
Sec 33 T 17S R  9E SLBM    * X: X: X: X*   * X: X: X: X*   * X: X: X: X*   * X: X: X: X*
Sec 34 T 17S R  9E SLBM    * X: X: X: X*   * X: X: X: X*   * X: X: X: X*   * X: X: X: X*
Sec 01 T 17S R 10E SLBM    * X: X: X: X*   * X: X: X: X*   * X: X: X: X*   * X: X: X: X*
Sec 02 T 17S R 10E SLBM    * X: X: X: X*   * X: X: X: X*   * X: X: X: X*   * X: X: X: X*
Sec 03 T 17S R 10E SLBM    * X: X: X: X*   * X: X: X: X*   * X: X: X: X*   * X: X: X: X*
Sec 04 T 17S R 10E SLBM    * X: X: X: X*   * X: X: X: X*   * X: X: X: X*   * X: X: X: X*
Sec 05 T 17S R 10E SLBM    * X: X: X: X*   * X: X: X: X*   * X: X: X: X*   * X: X: X: X*
Sec 06 T 17S R 10E SLBM    * X: X: X: X*   * X: X: X: X*   * X: X: X: X*   * X: X: X: X*
Sec 07 T 17S R 10E SLBM    * X: X: X: X*   * X: X: X: X*   * X: X: X: X*   * X: X: X: X*
Sec 08 T 17S R 10E SLBM    * X: X: X: X*   * X: X: X: X*   * X: X: X: X*   * X: X: X: X*
Sec 09 T 17S R 10E SLBM    * X: X: X: X*   * X: X: X: X*   * X: X: X: X*   * X: X: X: X*
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Sec 11 T 17S R 10E SLBM    * X: X: X: X*   * X: X: X: X*   * X: X: X: X*   * X: X: X: X*
Sec 12 T 17S R 10E SLBM    * X: X: X: X*   * X: X: X: X*   * X: X: X: X*   * X: X: X: X*
Sec 15 T 17S R 10E SLBM    * X: X: X: X*   * X: X: X: X*   * X: X: X: X*   * X: X: X: X*
Sec 16 T 17S R 10E SLBM    * X: X: X: X*   * X: X: X: X*   * X: X: X: X*   * X: X: X: X*
Sec 17 T 17S R 10E SLBM    * X: X: X: X*   * X: X: X: X*   * X: X: X: X*   * X: X: X: X*
Sec 18 T 17S R 10E SLBM    * X: X: X: X*   * X: X: X: X*   * X: X: X: X*   * X: X: X: X*
Sec 19 T 17S R 10E SLBM    * X: X: X: X*   * X: X: X: X*   * X: X: X: X*   * X: X: X: X*
Sec 20 T 17S R 10E SLBM    * X: X: X: X*   * X: X: X: X*   * X: X: X: X*   * X: X: X: X*
Sec 21 T 17S R 10E SLBM    * X: X: X: X*   * X: X: X: X*   * X: X: X: X*   * X: X: X: X*
Sec 29 T 17S R 10E SLBM    * X: X: X: X*   * X: X: X: X*   * X: X: X: X*   * X: X: X: X*
Sec 05 T 17S R 11E SLBM    * X: X: X: X*   * X: X: X: X*   * X: X: X: X*   * X: X: X: X*
Sec 06 T 17S R 11E SLBM    * X: X: X: X*   * X: X: X: X*   * X: X: X: X*   * X: X: X: X*
Sec 07 T 17S R 11E SLBM    * X: X: X: X*   * X: X: X: X*   * X: X: X: X*   * X: X: X: X*
Sec 01 T 18S R  8E SLBM    * X: X: X: X*   * X: X: X: X*   * X: X: X: X*   * X: X: X: X*
Sec 02 T 18S R  8E SLBM    * X: X: X: X*   * X: X: X: X*   * X: X: X: X*   * X: X: X: X*
Sec 11 T 18S R  8E SLBM    * X: X: X: X*   * X: X: X: X*   * X: X: X: X*   * X: X: X: X*
Sec 12 T 18S R  8E SLBM    * X: X: X: X*   * X: X: X: X*   * X: X: X: X*   * X: X: X: X*
Sec 02 T 18S R  9E SLBM    * X: X: X: X*   * X: X: X: X*   * X: X: X: X*   * X: X: X: X*
Sec 03 T 18S R  9E SLBM    * X: X: X: X*   * X: X: X: X*   * X: X: X: X*   * X: X: X: X*
Sec 04 T 18S R  9E SLBM    * X: X: X: X*   * X: X: X: X*   * X: X: X: X*   * X: X: X: X*
Sec 05 T 18S R  9E SLBM    * X: X: X: X*   * X: X: X: X*   * X: X: X: X*   * X: X: X: X*
Sec 06 T 18S R  9E SLBM    * X: X: X: X*   * X: X: X: X*   * X: X: X: X*   * X: X: X: X*
Sec 07 T 18S R  9E SLBM    * X: X: X: X*   * X: X: X: X*   * X: X: X: X*   * X: X: X: X*
Sec 08 T 18S R  9E SLBM    * X: X: X: X*   * X: X: X: X*   * X: X: X: X*   * X: X: X: X*
Sec 09 T 18S R  9E SLBM    * X: X: X: X*   * X: X: X: X*   * X: X: X: X*   * X: X: X: X*
Sec 10 T 18S R  9E SLBM    * X: X: X: X*   * X: X: X: X*   * X: X: X: X*   * X: X: X: X*
Sec 11 T 18S R  9E SLBM    * X: X: X: X*   * X: X: X: X*   * X: X: X: X*   * X: X: X: X*
Sec 15 T 18S R  9E SLBM    * X: X: X: X*   * X: X: X: X*   * X: X: X: X*   * X: X: X: X*
Sec 16 T 18S R  9E SLBM    * X: X: X: X*   * X: X: X: X*   * X: X: X: X*   * X: X: X: X*
Sec 17 T 18S R  9E SLBM    * X: X: X: X*   * X: X: X: X*   * X: X: X: X*   * X: X: X: X*
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Sec 18 T 18S R  9E SLBM      * X: X: X: X*    * X: X: X: X*    * X: X: X: X*    * X: X: X: X*
Sec 20 T 18S R  9E SLBM      * X: X: X: X*    * X: X: X: X*    * X: X: X: X*    * X: X: X: X*
*****************************************************************************************************
*************************************P R O P O S E D   E X C H A N G E*******************************
*****************************************************************************************************
FLOW:   325.0 acre-feet                   PERIOD OF USE: 01/01 TO 12/31
SOURCE: See comments
     The proposed sources of supply are Huntingtion Creek, Big and Little Bear
     Springs, and 3 Tie Fork Springs.
COUNTY: Emery                             COMMON DESCRIPTION:
*---------------------------------------------------------------------------------------------------*
POINTS OF EXCHANGE -- SURFACE:
(1) N 1500 ft W   50 ft from SE cor, Sec 34, T 15S, R  7E, SLBM
          Diverting Works:                                Source:  Tie Fork Springs
(2) N 1490 ft E   30 ft from SW cor, Sec 35, T 15S, R  7E, SLBM
          Diverting Works:                                Source:  Tie Fork Springs
(3) N 1550 ft E  276 ft from SW cor, Sec 35, T 15S, R  7E, SLBM
          Diverting Works:                                Source:  Tie Fork Springs
(4) N 1750 ft W   95 ft from S4 cor, Sec 09, T 16S, R  7E, SLBM
          Diverting Works:                                Source:  Little Bear Spring
(5) S   90 ft W 1400 ft from E4 cor, Sec 26, T 16S, R  7E, SLBM
          Diverting Works:                                Source:  Big Bear Spring
(6) S  600 ft E 2480 ft from NW cor, Sec 08, T 17S, R  8E, SLBM
          Diverting Works:                                Source:  Huntingtion Creek (Treatment Plant)
*---------------------------------------------------------------------------------------------------*
POINT OF RELEASE:
FLOW:   681.0 acre-feet                   PERIOD OF USE: 01/01 TO 12/31
***Location of Release Point(s) is the SAME as Point(s) of Diversion in CURRENT RIGHT above.
*---------------------------------------------------------------------------------------------------*
NATURE OF USE:
.....................................................................................................
  ###MUNICIPAL: Huntingtion, Cleveland & Elmo, Cities of                     PERIOD OF USE: 01/01 TO 12/31
*---------------------------------------------------------------------------------------------------*
PLACE OF USE OF PROPOSED EXCHANGE*********************************************************************
*---------------------------------------------------------------------------------------------------*
                              NORTH-WEST¼      NORTH-EAST¼      SOUTH-WEST¼      SOUTH-EAST¼
                              NW NE SW SE      NW NE SW SE      NW NE SW SE      NW NE SW SE
Sec 32 T 16S R 10E SLBM      *  :  :  :  *    *  :  : X: X*    *  :  :  :  *    * X: X: X: X*
Sec 33 T 16S R 10E SLBM      *  :  : X: X*    *  :  :  :  *    * X: X: X: X*    *  :  :  :  *
Sec 24 T 17S R  8E SLBM      *  :  :  :  *    * X: X: X: X*    *  :  :  :  *    * X: X: X: X*
Sec 25 T 17S R  8E SLBM      *  :  :  :  *    * X: X:  :  *    *  :  :  :  *    *  :  :  :  *
Sec 13 T 17S R  9E SLBM      * X: X: X: X*    * X: X: X: X*    *  :  :  :  *    *  :  :  :  *
Sec 19 T 17S R  9E SLBM      * X: X: X: X*    *  :  :  :  *    * X: X: X: X*    *  :  :  :  *
Sec 30 T 17S R  9E SLBM      * X: X:  :  *    *  :  :  :  *    *  :  :  :  *    *  :  :  :  *
Sec 18 T 17S R 10E SLBM      * X: X: X: X*    * X: X: X: X*    *  :  :  :  *    *  :  :  :  *
*****************************************************************************************************
**********************************************E N D   O F   D A T A**********************************
*****************************************************************************************************
```

UTAH DIVISION OF WATER RIGHTS

Select Related Information

```
                    (WARNING: Water Rights makes NO claims as to the accuracy of this data.) RUN DATE: 05/05/20
CHANGE: a7941                 WATER RIGHT:93-219   CERT. NO.:              AMENDATORY? No
BASE WATER RIGHTS: 93-219
RIGHT EVIDENCED BY: A.H. Christensen Decree 1st class 93-219/222,224,
                   226,228,239,240,243,253,254,272,303,304,309,310,
CHANGES: Point of Diversion [X], Place of Use [X], Nature of Use [X], Reservoir Storage [ ].
*------------------------------------------------------------------------------------------------------*

NAME:  Huntington-Cleveland Irrigation Company
ADDR: P.O. Box 327
      Huntington UT 84528
INTEREST: 100%      REMARKS:
*------------------------------------------------------------------------------------------------------*
FILED:      12/16/1983|PRIORITY:  06/19/1974|ADV BEGAN:           |ADV ENDED:           |NEWSPAPER:
ProtestEnd:           |PROTESTED: [        ]|HEARNG HLD:          |SE ACTION: [        ]|ActionDate:06/15/1984|PROOF DUE:  01/31/1988
EXTENSION:            |ELEC/PROOF:[Election]|ELEC/PROOF:01/15/1988|CERT/WUC:            |LAP, ETC:            |PROV LETTER:
RENOVATE:             |RECON REQ:           |TYPE: [            ]
Status: WUC
Related Distribution System:  Not part of any Distribution System
*************************************************************   *************************************************************
*********************H E R E T O F O R E*********************   ***********************H E R E A F T E R*******************
*************************************************************   *************************************************************
```

HERETOFORE	HEREAFTER
FLOW: 392.25 cfs	FLOW: 392.25 cfs
SOURCE: Huntington Creek and Tributaries	SOURCE: Huntington Creek and Tributaries
COUNTY: Emery	COUNTY: Emery COM DESC:
Additional rights evidences by: 2nd class 93-220,2223,2226,2190,2229,2232,2235 2211,2214,2217,2199,2193,2238,2202, 2196,2205,2208;3rd Class 93-2221,2224,2227, 2191,2230,2233,2236,2212,2215,2218, 2200,2194,2239,2203,2197,2206,2209;4th class 93-2222,2225,2228,2192,2231,2234, 2237,2213,2216,2219,2201,2195,2240,2204 2198,2207,2210.	

POINT(S) OF DIVERSION ------>

Point Surface:
(1) N 1750 ft W 95 ft from S4 cor, Sec 09, T 16S, R 7E, SLBM
Diverting Works:
Source: Little Bear Canyon Spring
(2) S 928 ft E 147 ft from N4 cor, Sec 23, T 16S, R 7E, SLBM
Diverting Works:
Source: Ranger Station Spring
(3) N 2045 ft E 185 ft from S4 cor, Sec 26, T 16S, R 7E, SLBM
Diverting Works:
Source: Bear Canyon Spring
(4) N 2026 ft W 2172 ft from S4 cor, Sec 26, T 16S, R 7E, SLBM
Diverting Works:
Source: Birch Spring
(5) N 2813 ft W 2716 ft from S4 cor, Sec 26, T 16S, R 7E, SLBM
Diverting Works:
Source: Unnamed Spring
(6) N 200 ft W 2700 ft from E4 cor, Sec 29, T 16S, R 7E, SLBM
Diverting Works:
Source: Rilds Spring
(7) S 1120 ft W 2020 ft from N4 cor, Sec 35, T 16S, R 7E, SLBM
Diverting Works:
Source: Unnamed Spring
(8) N 730 ft E 1110 ft from W4 cor, Sec 36, T 16S, R 7E, SLBM
Diverting Works:
Source: Howard Ditch
(9) N 1030 ft W 370 ft from SE cor, Sec 31, T 16S, R 8E, SLBM
Diverting Works:
Source: Brinkerhoff Ditch
(10) N 2100 ft E 1800 ft from SW cor, Sec 05, T 17S, R 7E, SLBM
Diverting Works:
Source: Elk Spring
(11) N 760 ft 0 ft from SW cor, Sec 05, T 17S, R 8E, SLBM
Diverting Works:
Source: Harrison Ditch
(12) N 100 ft E 1270 ft from SW cor, Sec 05, T 17S, R 8E, SLBM
Diverting Works:
Source: Rowley Ditch
(13) S 370 ft E 350 ft from NW cor, Sec 06, T 17S, R 8E, SLBM
Diverting Works:
Source: Dell Lott Ditch
(14) S 1320 ft W 300 ft from N4 cor, Sec 08, T 17S, R 8E, SLBM
Diverting Works:
Source: Seely & Collard Ditch
(15) N 2290 ft W 65 ft from S4 cor, Sec 09, T 17S, R 8E, SLBM
Diverting Works:
Source: Cleveland Canal
(16) N 2300 ft W 60 ft from S4 cor, Sec 09, T 17S, R 8E, SLBM
Diverting Works:
Source: Robins-Truman Ditch
(17) S 850 ft W 530 ft from N4 cor, Sec 15, T 17S, R 8E, SLBM
Diverting Works:
Source: Huntington Canal

SAME AS HERETOFORE, AND IN ADDITION TO:

Point Surface:
(1) N 40 ft W 1520 ft from SE cor, Sec 34, T 15S, R 7E, SLBM
Diverting Works:
Source: Tie Fork Springs (#2)
(2) N 1550 ft W 50 ft from SE cor, Sec 34, T 15S, R 7E, SLBM
Diverting Works:
Source: Tie Fork Springs(#1)
(3) S 1535 ft E 785 ft from NW cor, Sec 08, T 16S, R 7E, SLBM
Diverting Works:
Source: UP&L Huntington Canyon Plant
(4) N 1750 ft W 95 ft from S4 cor, Sec 09, T 16S, R 7E, SLBM
Diverting Works:
Source: Little Bear Canyon Spring
(5) N 2813 ft W 2716 ft from S4 cor, Sec 16, T 16S, R 7E, SLBM
Diverting Works:
Source: Unnamed Spring
(6) S 928 ft E 147 ft from N4 cor, Sec 23, T 16S, R 7E, SLBM
Diverting Works:
Source: Ranger Station Spring
(7) N 2026 ft W 2172 ft from S4 cor, Sec 26, T 16S, R 7E, SLBM
Diverting Works:
Source: Birch Spring
(8) N 1060 ft E 650 ft from W4 cor, Sec 26, T 16S, R 7E, SLBM
Diverting Works:
Source: Gate Springs
(9) N 2045 ft E 185 ft from S4 cor, Sec 26, T 16S, R 7E, SLBM
Diverting Works:
Source: Bear Canyon Spring
(10) N 200 ft W 2700 ft from E4 cor, Sec 29, T 16S, R 7E, SLBM
Diverting Works:
Source: Rilda Spring
(11) S 1120 ft W 2020 ft from N4 cor, Sec 35, T 16S, R 7E, SLBM
Diverting Works:
Source: Unnamed Spring
(12) N 1030 ft W 370 ft from SE cor, Sec 36, T 16S, R 7E, SLBM
Diverting Works:
Source: Brinkerhoff Ditch
(13) N 2100 ft E 1800 ft from SW cor, Sec 05, T 17S, R 7E, SLBM
Diverting Works:
Source: Elk Spring
(14) N 760 ft 0 ft from SW cor, Sec 05, T 17S, R 8E, SLBM
Diverting Works:
Source: Harrison Ditch
(15) N 100 ft E 1270 ft from SW cor, Sec 05, T 17S, R 8E, SLBM
Diverting Works:
Source: Rowley Ditch
(16) S 370 ft E 350 ft from NW cor, Sec 06, T 17S, R 8E, SLBM
Diverting Works:
Source: Dell Lott Ditch
(17) S 840 ft E 2480 ft from NW cor, Sec 08, T 17S, R 8E, SLBM
Diverting Works:
Source: Huntington Treatment Plant

```
(18) N  960 ft W  440 ft from E4 cor, Sec 15, T 17S, R  8E, SLBM
          Diverting Works:
          Source:          North Ditch
-----------------------------------------------------------------
Point Rediversion:
(1)  N  750 ft E 1950 ft from W4 cor, Sec 11, T 17S, R 10E, SLBM
          Diverting Works:
          Source:          Cleveland Canal
-----------------------------------------------------------------

NATURE OF USE ------>
-----------------------------------------------------------------
SUPPLEMENTAL to Other Water Rights: No
-----------------------------------------------------------------
IRR:  32673.2600 acs Sol/Sup:           acs USED 03/02 - 11/14
.................................................................
STK: 6797 Cattle or Equivalent              USED 01/01 - 12/31
.................................................................
DOM: 650 Families                           USED 01/01 - 12/31
.................................................................
-----------------------------------------------------------------
```

```
(18) S 1320 ft W  300 ft from N4 cor, Sec 08, T 17S, R  8E, SLBM
          Diverting Works:
          Source:          Seely & Collard Ditch
(19) N 2290 ft W   65 ft from S4 cor, Sec 09, T 17S, R  8E, SLBM
          Diverting Works:
          Source:          Cleveland Canal
(20) N 2300 ft W   60 ft from S4 cor, Sec 09, T 17S, R  8E, SLBM
          Diverting Works:
          Source:          Robins-Truman Ditch
(21) S  850 ft W  530 ft from N4 cor, Sec 15, T 17S, R  8E, SLBM
          Diverting Works:
          Source:          Huntington Canal
(22) N  960 ft W  440 ft from E4 cor, Sec 15, T 17S, R  8E, SLBM
          Diverting Works:
          Source:          North Ditch
-----------------------------------------------------------------
Point Rediversion:
(1)  N  750 ft E 1950 ft from W4 cor, Sec 11, T 17S, R 10E, SLBM
          Diverting Works:
          Source:          Cleveland Canal
-----------------------------------------------------------------

SAME AS HERETOFORE, AND IN ADDITION TO:
-----------------------------------------------------------------
SUPPLEMENTAL to Other Water Rights: No
-----------------------------------------------------------------
IRR:  32673.2600 acs Sol/Sup:           acs USED 03/02 - 11/14
.................................................................
STK: 6797 Cattle or Equivalent              USED 01/01 - 12/31
.................................................................
DOM: 650 Families                           USED 01/01 - 12/31
.................................................................
POW: Name: Huntington Plant                 USED 01/01 - 12/31
     A Steam Generation Power Plant, Rated at
-----------------------------------------------------------------
.................................................................
OTH: OTHER:            Various Municipal and USED 01/01 - 12/31
     Industrial purposes.
-----------------------------------------------------------------
```

****
E N D   O F   D A T A
****

utah.gov State Online Services | Agency List | Business.utah.gov | Search Utah.gov GO

UTAH DIVISION OF WATER RIGHTS

Select Related Information

```
     (WARNING: Water Rights makes NO claims as to the accuracy of this data.) RUN DATE: 05/05/2004
WRNUM: 93-134      APPLICATION/CLAIM NO.:          CERT. NO.:
------------------------------------------------------------------------------------------------
OWNERSHIP***************************************************************************************
------------------------------------------------------------------------------------------------

NAME: USA Forest Service
ADDR: 324 25th Street
      Ogden UT 84401
LAND OWNED BY APPLICANT? Yes
------------------------------------------------------------------------------------------------
DATES, ETC.*************************************************************************************
------------------------------------------------------------------------------------------------
FILED:               |PRIORITY:  00/00/1875|PUB BEGAN:          |PUB ENDED:          |NEWSPAPER:
ProtestEnd:          |PROTESTED: [No      ]|HEARNG HLD:         |SE ACTION: [       ]|ActionDate:          |PROOF DUE:
EXTENSION:           |ELEC/PROOF:[        ]|ELEC/PROOF:         |CERT/WUC:           |LAP, ETC:            |PROV LETTER:
RENOVATE:            |RECON REQ:           |TYPE: [            ]
PD Book No. 1      Map: 15
Type of Right: Diligence Claim             Source of Info: Proposed Determination        Status:
Related Distribution System:  Not part of any Distribution System
------------------------------------------------------------------------------------------------
LOCATION OF WATER RIGHT*************************************************************************
------------------------------------------------------------------------------------------------
FLOW:                                            SOURCE: Tie Fork Canyon Creek
COUNTY: Emery        COMMON DESCRIPTION:

POINT OF DIVERSION -- POINT TO POINT:
( 1)Stockwatering directly on stream from a point in SE4SE4 Sec 34, T15S, R7E, SLBM,
                          to a point in SW4SE4 Sec 04, T16S, R7E, SLBM.
                    Source:
------------------------------------------------------------------------------------------------
USES OF WATER RIGHT*****************************************************************************
------------------------------------------------------------------------------------------------
------------------------------------------------------------------------------------------------
CLAIMS USED FOR PURPOSE DESCRIBED: See WUC 93-116.
     Referenced To:  93-116    Claims Groups:            Type of Reference -- Claims: X  Purpose:    Remarks:
................................................................................................
  ###STOCKWATERING: 1440 Cattle or Equivalent              Diversion Limit:           PERIOD OF USE: 06/21 TO 09/30
Gentry Mountain Allotment
************************************************************************************************
*******************************************************E N D   O F   D A T A********************
************************************************************************************************
```

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UTAH DIVISION OF WATER RIGHTS

Select Related Information

```
                         (WARNING: Water Rights makes NO claims as to the accuracy of this data.) RUN DATE: 05/05/20
CHANGE: a16000                     WATER RIGHT:93-3658  CERT. NO.:          AMENDATORY? No
BASE WATER RIGHTS: 93-3658
RIGHT EVIDENCED BY: A.H. Christensen Decree - Huntington Creek 93-219
                    Huntington-Cleveland Irr. Co. Stock A2468 & A2631
CHANGES: Point of Diversion [X], Place of Use [X], Nature of Use [X], Reservoir Storage [ ].
*-----------------------------------------------------------------------------------------------------------*

NAME:  Genwal Coal Company
ADDR: P.O. Box 1201
      Huntington UT 84528
INTEREST: 100%       REMARKS:
*-----------------------------------------------------------------------------------------------------------*
FILED:      02/04/1991|PRIORITY:  02/04/1991|ADV BEGAN: 02/20/1991|ADV ENDED:            |NEWSPAPER:  Emery County Progress
ProtestEnd:04/05/1991|PROTESTED: [No      ]|HEARNG HLD:           |SE ACTION: [Approved]|ActionDate:12/13/1991|PROOF DUE:  01/31/1995
EXTENSION:            |ELEC/PROOF:[Proof   ]|ELEC/PROOF:01/30/1995|CERT/WUC:             |LAP, ETC:             |PROV LETTER:
RENOVATE:             |RECON REQ:           |TYPE: [              ]
Status: Approved
Related Distribution System:  Not part of any Distribution System
*************************************************************   *************************************************************
**********************H E R E T O F O R E**********************   ***********************H E R E A F T E R***********************
*************************************************************   *************************************************************

|FLOW:   26.4 acre-feet                                        ||FLOW:   26.4 acre-feet                                         |
|------------------------------------------------------------- ||--------------------------------------------------------------|
|SOURCE: Huntington Creek & its Tributaries                    ||SOURCE: Well, Portal                                          |
|COUNTY: Emery                                                 ||COUNTY: Emery      COM DESC: 14 mi. NW Huntington              |

|POINT(S) OF DIVERSION ------>                                 ||CHANGED AS FOLLOWS:                                           |
|--------------------------------------------------------------||--------------------------------------------------------------|
|Point Surface:                                                ||                                                              |
|(1)  N 1550 ft W   50 ft from SE cor, Sec 34, T 15S, R  7E, SLBM||                                                            |
|           Diverting Works: Tie Fork Spring #1                 ||                                                              |
|           Source:                                             ||                                                              |
|(2)  N   40 ft W 1520 ft from SE cor, Sec 34, T 15S, R  7E, SLBM||                                                            |
|           Diverting Works: Tie Fork Spring #2                 ||                                                              |
|           Source:                                             ||                                                              |
|(3)  N 1750 ft W   95 ft from S4 cor, Sec 09, T 16S, R  7E, SLBM||                                                            |
|           Diverting Works: Little Bear Canyon Spring          ||                                                              |
|           Source:                                             ||                                                              |
|(4)  S  928 ft E  147 ft from N4 cor, Sec 23, T 16S, R  7E, SLBM||                                                            |
|           Diverting Works: Ranger Station Spring              ||                                                              |
```

```
              Source:
(5)  N 2045  ft E  185 ft from S4 cor, Sec 26, T 16S, R  7E, SLBM
             Diverting Works: Bear Canyon Spring
             Source:
(6)  N 2813  ft W 2716 ft from S4 cor, Sec 26, T 16S, R  7E, SLBM
             Diverting Works: Unnamed Spring
             Source:
(7)  N 2026  ft W 2172 ft from S4 cor, Sec 26, T 16S, R  7E, SLBM
             Diverting Works: Birch Spring
             Source:
(8)  N 1060  ft E  650 ft from W4 cor, Sec 26, T 16S, R  7E, SLBM
             Diverting Works: Gate Spring
             Source:
(9)  N  200  ft W 2700 ft from E4 cor, Sec 29, T 16S, R  7E, SLBM
             Diverting Works: Rilda Spring
             Source:
(10) S 1120  ft W 2020 ft from N4 cor, Sec 35, T 16S, R  7E, SLBM
             Diverting Works: Unnamed Spring
             Source:
(11) N 1030  ft W  370 ft from SE cor, Sec 36, T 16S, R  7E, SLBM
             Diverting Works: Brinkerhoff Ditch
             Source:
(12) S 1535  ft E  785 ft from NW cor, Sec 36, T 16S, R  7E, SLBM
             Diverting Works: UP&L Huntington Canyon Plant
             Source:
(13) N 2100  ft E 1800 ft from SW cor, Sec 05, T 17S, R  7E, SLBM
             Diverting Works: Elk Spring
             Source:
(14) N  760  ft      0 ft from SW cor, Sec 05, T 17S, R  8E, SLBM
             Diverting Works: Harrison Ditch
             Source:
(15) N  100  ft E 1270 ft from SW cor, Sec 05, T 17S, R  8E, SLBM
             Diverting Works: Rowley Ditch
             Source:
(16) S  370  ft E  350 ft from NW cor, Sec 06, T 17S, R  8E, SLBM
             Diverting Works: Dell Lott Ditch
             Source:
(17) S 1320  ft W  300 ft from N4 cor, Sec 08, T 17S, R  8E, SLBM
             Diverting Works: Seeley & Collard Ditch
             Source:
(18) S  840  ft E 2480 ft from NW cor, Sec 08, T 17S, R  8E, SLBM
             Diverting Works: Huntington Treatment Plant
             Source:
(19) N 2300  ft W   60 ft from S4 cor, Sec 09, T 17S, R  8E, SLBM
             Diverting Works: Robins-Truman Ditch
             Source:
(20) N 2290  ft W   65 ft from S4 cor, Sec 09, T 17S, R  8E, SLBM
             Diverting Works: Cleveland Canal
             Source:
(21) N  960  ft W  440 ft from E4 cor, Sec 15, T 17S, R  8E, SLBM
             Diverting Works: North Ditch
             Source:
(22) S  850  ft W  530 ft from N4 cor, Sec 15, T 17S, R  8E, SLBM
             Diverting Works: Huntington Canal
             Source:
```

```
Point Underground:                                   | UNDERGROUND: (If link present, additional well data available.)
                                                     | (1)  N  265 ft E 1115 ft from W4 cor, Sec 05, T 16S, R  7E, SLBM
                                                     |              Diameter:      ins.  Depth:       to       ft.
                                                     |      COMMENT:
                                                     | (2)  N  250 ft E 1100 ft from W4 cor, Sec 05, T 16S, R  7E, SLBM
                                                     |              Diameter:    9 ins.  Depth:   385 to       ft.
                                                     |      COMMENT:
Point Rediversion:
(1)  N  750 ft E 1950 ft from W4 cor, Sec 11, T 17S, R 10E, SLBM
         Diverting Works: Cleveland Canal
         Source:

PLACE OF USE ------>                                 | CHANGED as follows:
        --NW¼--  --NE¼--  --SW¼--  --SE¼--           |                              --NW¼--  --NE¼--  --SW¼--  --SE¼--
       |N N S S||N N S S||N N S S||N N S S|          |                             |N N S S||N N S S||N N S S||N N S S|
       |W E W E||W E W E||W E W E||W E W E|          |                             |W E W E||W E W E||W E W E||W E W E|
                                                     | Sec 31 T 15S R  7E SLBM      * : : : ** : : : ** : : : ** : : :X*
                                                     | Sec 32 T 15S R  7E SLBM      * : : : ** : : : ** : :X:X** : :X: *
                                                     | Sec 05 T 16S R  7E SLBM      *X:X:X: **X: : : ** : : : ** : : : *
                                                     | Sec 05 T 16S R  7E SLBM        *LOT  8
                                                     | Sec 06 T 16S R  7E SLBM      * : : : ** :X: :X** : : : ** : : : *

NATURE OF USE ------>                                | CHANGED as follows:
SUPPLEMENTAL to Other Water Rights: No               | SUPPLEMENTAL to Other Water Rights: No
IRR:  32673.2600 acs Sol/Sup:     acs USED 03/02 - 11/14 |
STK: 6797 Cattle or Equivalent        USED 01/01 - 12/31 |
DOM: 650 Families                     USED 01/01 - 12/31 |
                                                     | MIN: District:                      USED 01/01 - 12/31
                                                     |      Name:     Crandall Canyon
                                                     |      Ores:     Coal

*****************************************************************************************************
*******************************************************E N D   O F   D A T A*************************
*****************************************************************************************************
```

UTAH DIVISION OF WATER RIGHTS

Select Related Information

(WARNING: Water Rights makes NO claims as to the accuracy of this data.) RUN DATE: 05/05/2004

WRNUM: 93-3658 APPLICATION/CLAIM NO.: CERT. NO.:
CHANGES: a16000 Approved

OWNERSHIP

NAME: Huntington Cleveland Irrigation
ADDR: c/o J. Craig Smith & David B. Hartvigsen
215 S. State Street, Suite 650
Salt Lake City UT 84111

NAME: Huntington Cleveland Irrigation Company
ADDR: UT
LAND OWNED BY APPLICANT?

DATES, ETC.

```
FILED:          |PRIORITY:   00/00/1875|PUB BEGAN:      |PUB ENDED:          |NEWSPAPER:
ProtestEnd:     |PROTESTED:  [No      ]|HEARNG HLD:     |SE ACTION: [       ]|ActionDate:   |PROOF DUE:
EXTENSION:      |ELEC/PROOF:[         ]|ELEC/PROOF:     |CERT/WUC:           |LAP, ETC:     |PROV LETTER:
RENOVATE:       |RECON REQ:            |TYPE: [        ]
PD Book No.     Map:
Type of Right: Decree                  Source of Info: Ownership Segregation       Status:
Related Distribution System:  Not part of any Distribution System
```

LOCATION OF WATER RIGHT

FLOW: SOURCE: Tie Fork Springs
COUNTY: Emery COMMON DESCRIPTION:

POINTS OF DIVERSION -- SURFACE:
(1) N 1550 ft W 50 ft from SE cor, Sec 34, T 15S, R 7E, SLBM
Diverting Works: Source:
(2) N 40 ft W 1520 ft from SE cor, Sec 34, T 15S, R 7E, SLBM
Diverting Works: Source:

USES OF WATER RIGHT

CLAIMS USED FOR PURPOSE DESCRIBED: 3658
Referenced To: Claims Groups: 1 Type of Reference -- Claims: Purpose: Remarks:

SEGREGATION HISTORY

This Right was Segregated from 93-228, with Appl#: , Approval Date: / / under which Proof is to be submitted.
This Right as originally filed:

FLOW IN CFS	QUANTITY IN ACRE-FEET	WATER USES: IRRIGATED ACREAGE	WATER USES: STOCK (ELUs)	WATER USES: DOMESTIC (FAMILIES)

80 Shares - Cert. #2468 & #2631 - 0.33 AF/share - Chg. a-16000 - Genwal Coal

E N D O F D A T A

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UTAH DIVISION OF WATER RIGHTS

Select Related Information

```
      (WARNING: Water Rights makes NO claims as to the accuracy of this data.) RUN DATE: 05/05/2004
WRNUM: 93-1409      APPLICATION/CLAIM NO.:              CERT. NO.:
-----------------------------------------------------------------------------------------------
OWNERSHIP**************************************************************************************
-----------------------------------------------------------------------------------------------

NAME: USA Forest Service
ADDR: 324 25th Street
      Ogden UT 84401
LAND OWNED BY APPLICANT? Yes
-----------------------------------------------------------------------------------------------
DATES, ETC.************************************************************************************
-----------------------------------------------------------------------------------------------
FILED:                |PRIORITY:  00/00/1875|PUB BEGAN:         |PUB ENDED:           |NEWSPAPER:
ProtestEnd:           |PROTESTED: [No     ] |HEARNG HLD:        |SE ACTION: [        ]|ActionDate:          |PROOF DUE:
EXTENSION:            |ELEC/PROOF:[       ] |ELEC/PROOF:        |CERT/WUC:            |LAP, ETC:            |PROV LETTER:
RENOVATE:             |RECON REQ:           |TYPE: [           ]
PD Book No. 1     Map: 14
Type of Right: Diligence Claim            Source of Info: Proposed Determination        Status:
Related Distribution System:  Not part of any Distribution System
-----------------------------------------------------------------------------------------------
LOCATION OF WATER RIGHT************************************************************************
-----------------------------------------------------------------------------------------------
FLOW: 0.011 cfs                                SOURCE: Crandall Canyon Spring
COUNTY: Emery        COMMON DESCRIPTION:

POINT OF DIVERSION:
( 1)Stockwatering directly on spring located in SW4NW4 Sec 01, T16S, R6E, SLBM.
                          Source:
-----------------------------------------------------------------------------------------------
USES OF WATER RIGHT****************************************************************************
-----------------------------------------------------------------------------------------------
-----------------------------------------------------------------------------------------------
CLAIMS USED FOR PURPOSE DESCRIBED: See WUC 93-1403.
     Referenced To:  93-1403   Claims Groups:                   Type of Reference -- Claims: X  Purpose:    Remarks:
...............................................................................................
  ###STOCKWATERING: 153 Cattle or Equivalent                    Diversion Limit:               PERIOD OF USE: 07/06 TO 09/25
Crandall Canyon Allotment
***********************************************************************************************
*****************************************************E N D   O F   D A T A*********************
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```

UTAH DIVISION OF WATER RIGHTS

Select Related Information

(WARNING: Water Rights makes NO claims as to the accuracy of this data.) RUN DATE: 05/05/2004

WRNUM: 93-1408   APPLICATION/CLAIM NO.:   CERT. NO.:

OWNERSHIP

NAME: USA Forest Service
ADDR: 324 25th Street
Ogden UT 84401
LAND OWNED BY APPLICANT? Yes

DATES, ETC.

FILED:	PRIORITY: 00/00/1875	PUB BEGAN:	PUB ENDED:	NEWSPAPER:	
ProtestEnd:	PROTESTED: [No]	HEARNG HLD:	SE ACTION: [ ]	ActionDate:	PROOF DUE:
EXTENSION:	ELEC/PROOF: [ ]	ELEC/PROOF:	CERT/WUC:	LAP, ETC:	PROV LETTER:
RENOVATE:	RECON REQ:	TYPE: [ ]			

PD Book No. 1   Map: 14
Type of Right: Diligence Claim   Source of Info: Proposed Determination   Status:
Related Distribution System: Not part of any Distribution System

---

LOCATION OF WATER RIGHT

FLOW: 0.011 cfs   SOURCE: Humphrey Spring
COUNTY: Emery   COMMON DESCRIPTION:

POINT OF DIVERSION:
(1)Stockwatering directly on spring located in NW4NE4 Sec 06, T16S, R7E, SLBM.
Source:

USES OF WATER RIGHT

CLAIMS USED FOR PURPOSE DESCRIBED: See WUC 93-1403.
Referenced To: 93-1403   Claims Groups: Type of Reference -- Claims: X   Purpose: Remarks:

###STOCKWATERING: 153 Cattle or Equivalent   Diversion Limit: PERIOD OF USE: 07/06 TO 09/25
Crandall Canyon Allotment

END OF DATA

UTAH DIVISION OF WATER RIGHTS

Select Related Information

```
     (WARNING: Water Rights makes NO claims as to the accuracy of this data.) RUN DATE: 05/05/2004
WRNUM: 93-1407      APPLICATION/CLAIM NO.:            CERT. NO.:
----------------------------------------------------------------------------------------------------
OWNERSHIP*******************************************************************************************
----------------------------------------------------------------------------------------------------

NAME: USA Forest Service
ADDR: 324 25th Street
      Ogden UT 84401
LAND OWNED BY APPLICANT? Yes
----------------------------------------------------------------------------------------------------
DATES, ETC.*****************************************************************************************
----------------------------------------------------------------------------------------------------
FILED:                |PRIORITY:  00/00/1875|PUB BEGAN:         |PUB ENDED:          |NEWSPAPER:
ProtestEnd:           |PROTESTED: [No      ]|HEARNG HLD:        |SE ACTION: [       ]|ActionDate:         |PROOF DUE:
EXTENSION:            |ELEC/PROOF:[        ]|ELEC/PROOF:        |CERT/WUC:           |LAP, ETC:           |PROV LETTER:
RENOVATE:             |RECON REQ:           |TYPE: [            ]
PD Book No. 1     Map: 14
Type of Right: Diligence Claim              Source of Info: Proposed Determination       Status:
Related Distribution System:  Not part of any Distribution System
----------------------------------------------------------------------------------------------------
LOCATION OF WATER RIGHT*****************************************************************************
----------------------------------------------------------------------------------------------------
FLOW: 0.011 cfs                                   SOURCE: Crandall Ridge Spring
COUNTY: Emery        COMMON DESCRIPTION:

POINT OF DIVERSION:
( 1)Stockwatering directly on spring located in SW4SE4 Sec 31, T15S, R7E, SLBM.
                        Source:
----------------------------------------------------------------------------------------------------
USES OF WATER RIGHT*********************************************************************************
----------------------------------------------------------------------------------------------------
----------------------------------------------------------------------------------------------------
CLAIMS USED FOR PURPOSE DESCRIBED: See WUC 93-1403.
     Referenced To:  93-1403   Claims Groups:                Type of Reference -- Claims: X  Purpose:    Remarks:
....................................................................................................
  ###STOCKWATERING: 153 Cattle or Equivalent                 Diversion Limit:             PERIOD OF USE: 07/06 TO 09/25
Crandall Canyon Allotment
****************************************************************************************************
*******************************************************E N D   O F   D A T A************************
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UTAH DIVISION OF WATER RIGHTS

Select Related Information

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      (WARNING: Water Rights makes NO claims as to the accuracy of this data.) RUN DATE: 05/05/2004
WRNUM: 93-1404      APPLICATION/CLAIM NO.:            CERT. NO.:
------------------------------------------------------------------------------------------------------
OWNERSHIP*********************************************************************************************
------------------------------------------------------------------------------------------------------

NAME: USA Forest Service
ADDR: 324 25th Street
      Ogden UT 84401
LAND OWNED BY APPLICANT? Yes
------------------------------------------------------------------------------------------------------
DATES, ETC.*******************************************************************************************
------------------------------------------------------------------------------------------------------
FILED:                |PRIORITY:  00/00/1875|PUB BEGAN:         |PUB ENDED:          |NEWSPAPER:
ProtestEnd:           |PROTESTED: [No      ]|HEARNG HLD:        |SE ACTION: [       ]|ActionDate:          |PROOF DUE:
EXTENSION:            |ELEC/PROOF:[        ]|ELEC/PROOF:        |CERT/WUC:           |LAP, ETC:            |PROV LETTER:
RENOVATE:             |RECON REQ:           |TYPE: [            ]
PD Book No. 1     Map: 10
Type of Right: Diligence Claim          Source of Info: Proposed Determination       Status:
Related Distribution System:  Not part of any Distribution System
------------------------------------------------------------------------------------------------------
LOCATION OF WATER RIGHT*******************************************************************************
------------------------------------------------------------------------------------------------------
FLOW: 0.011 cfs                                     SOURCE: Georges Spring
COUNTY: Emery        COMMON DESCRIPTION:

POINT OF DIVERSION:
( 1)Stockwatering directly on spring located in SW4SW4 Sec 25, T15S, R6E, SLBM.
                          Source:
------------------------------------------------------------------------------------------------------
USES OF WATER RIGHT***********************************************************************************
------------------------------------------------------------------------------------------------------
------------------------------------------------------------------------------------------------------
CLAIMS USED FOR PURPOSE DESCRIBED: See WUC 93-1403.
     Referenced To:  93-1403   Claims Groups:                       Type of Reference -- Claims: X  Purpose:    Remarks:
......................................................................................................
  ###STOCKWATERING: 153 Cattle or Equivalent                        Diversion Limit:                 PERIOD OF USE: 07/06 TO 09/25
Crandall Canyon Allotment
******************************************************************************************************
*******************************************************E N D   O F   D A T A**************************
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UTAH DIVISION OF WATER RIGHTS

Select Related Information

```
      (WARNING: Water Rights makes NO claims as to the accuracy of this data.) RUN DATE: 05/05/2004
WRNUM: 93-1403      APPLICATION/CLAIM NO.:            CERT. NO.:
----------------------------------------------------------------------------------------------------------
OWNERSHIP*************************************************************************************************
----------------------------------------------------------------------------------------------------------

NAME: USA Forest Service
ADDR: 324 25th Street
      Ogden UT 84401
LAND OWNED BY APPLICANT? Yes
----------------------------------------------------------------------------------------------------------
DATES, ETC.***********************************************************************************************
----------------------------------------------------------------------------------------------------------
FILED:                 |PRIORITY:  00/00/1875|PUB BEGAN:             |PUB ENDED:            |NEWSPAPER:
ProtestEnd:            |PROTESTED: [No      ]|HEARNG HLD:            |SE ACTION: [         ]|ActionDate:            |PROOF DUE:
EXTENSION:             |ELEC/PROOF:[        ]|ELEC/PROOF:            |CERT/WUC:             |LAP, ETC:              |PROV LETTER:
RENOVATE:              |RECON REQ:           |TYPE: [             ]
PD Book No. 1     Map: 10
Type of Right: Diligence Claim              Source of Info: Proposed Determination        Status:
Related Distribution System:  Not part of any Distribution System
----------------------------------------------------------------------------------------------------------
LOCATION OF WATER RIGHT***********************************************************************************
----------------------------------------------------------------------------------------------------------
FLOW: 0.011 cfs                                      SOURCE: Chris Spring
COUNTY: Emery         COMMON DESCRIPTION:

POINT OF DIVERSION:
( 1)Stockwatering directly on spring located in NE4SW4 Sec 25, T15S, R6E, SLBM.
                          Source:
----------------------------------------------------------------------------------------------------------
USES OF WATER RIGHT***************************************************************************************
----------------------------------------------------------------------------------------------------------
----------------------------------------------------------------------------------------------------------
CLAIMS USED FOR PURPOSE DESCRIBED: 175,183,191,336,378,483,606,624,1176,1403,1404,1406,1407,1408,1409
     Referenced To:           Claims Groups:                       Type of Reference -- Claims:    Purpose:    Remarks:
..........................................................................................................
  ###STOCKWATERING: 153 Cattle or Equivalent                        Diversion Limit:               PERIOD OF USE: 07/06 TO 09/25
Crandall Canyon Allotment
**********************************************************************************************************
*******************************************************E N D   O F   D A T A******************************
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```
     (WARNING: Water Rights makes NO claims as to the accuracy of this data.) RUN DATE: 05/05/2004
WRNUM: 93-624       APPLICATION/CLAIM NO.:             CERT. NO.:
------------------------------------------------------------------------------------------------
OWNERSHIP***************************************************************************************
------------------------------------------------------------------------------------------------

NAME: USA Forest Service
ADDR: 324 25th Street
      Ogden UT 84401
LAND OWNED BY APPLICANT? Yes
------------------------------------------------------------------------------------------------
DATES, ETC.*************************************************************************************
------------------------------------------------------------------------------------------------
FILED:               |PRIORITY:  00/00/1875|PUB BEGAN:          |PUB ENDED:          |NEWSPAPER:
ProtestEnd:          |PROTESTED: [No      ]|HEARNG HLD:         |SE ACTION: [       ]|ActionDate:          |PROOF DUE:
EXTENSION:           |ELEC/PROOF:[        ]|ELEC/PROOF:         |CERT/WUC:           |LAP, ETC:            |PROV LETTER:
RENOVATE:            |RECON REQ:           |TYPE: [           ]
PD Book No. 1     Map: 10
Type of Right: Diligence Claim          Source of Info: Proposed Determination        Status:
Related Distribution System:  Not part of any Distribution System
------------------------------------------------------------------------------------------------
LOCATION OF WATER RIGHT*************************************************************************
------------------------------------------------------------------------------------------------
FLOW: 0.011 cfs                                   SOURCE: Spring
COUNTY: Emery        COMMON DESCRIPTION:

POINT OF DIVERSION:
( 1)Stockwatering directly on spring located in SW4NE4 Sec 26, T15S, R6E, SLBM.
                          Source:
------------------------------------------------------------------------------------------------
USES OF WATER RIGHT*****************************************************************************
------------------------------------------------------------------------------------------------
------------------------------------------------------------------------------------------------
CLAIMS USED FOR PURPOSE DESCRIBED: See WUC 93-1403.
     Referenced To:  93-1403   Claims Groups:                  Type of Reference -- Claims: X  Purpose:    Remarks:
................................................................................................
  ###STOCKWATERING: 153 Cattle or Equivalent                    Diversion Limit:              PERIOD OF USE: 07/06 TO 09/25
Crandall Canyon Allotment
************************************************************************************************
*******************************************************E N D   O F   D A T A********************
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```
     (WARNING: Water Rights makes NO claims as to the accuracy of this data.) RUN DATE: 05/05/2004
WRNUM: 93-1176      APPLICATION/CLAIM NO.:               CERT. NO.:
---------------------------------------------------------------------------------------------------
OWNERSHIP******************************************************************************************
---------------------------------------------------------------------------------------------------

NAME: USA Forest Service
ADDR: 324 25th Street
      Ogden UT 84401
LAND OWNED BY APPLICANT? Yes
---------------------------------------------------------------------------------------------------
DATES, ETC.****************************************************************************************
---------------------------------------------------------------------------------------------------
FILED:                 |PRIORITY:  00/00/1875|PUB BEGAN:           |PUB ENDED:          |NEWSPAPER:
ProtestEnd:            |PROTESTED: [No      ]|HEARNG HLD:          |SE ACTION: [       ]|ActionDate:          |PROOF DUE:
EXTENSION:             |ELEC/PROOF:[        ]|ELEC/PROOF:          |CERT/WUC:           |LAP, ETC:            |PROV LETTER:
RENOVATE:              |RECON REQ:           |TYPE: [              ]
PD Book No. 1     Map: 10
Type of Right: Diligence Claim            Source of Info: Proposed Determination        Status:
Related Distribution System:  Not part of any Distribution System
---------------------------------------------------------------------------------------------------
LOCATION OF WATER RIGHT****************************************************************************
---------------------------------------------------------------------------------------------------
FLOW: 0.015 cfs                                   SOURCE: Spring
COUNTY: Emery         COMMON DESCRIPTION:

POINT OF DIVERSION:
( 1)Stockwatering directly on spring located in NE4SW4 Sec 26, T15S, R6E, SLBM.
                         Source:
---------------------------------------------------------------------------------------------------
USES OF WATER RIGHT********************************************************************************
---------------------------------------------------------------------------------------------------
---------------------------------------------------------------------------------------------------
CLAIMS USED FOR PURPOSE DESCRIBED: See WUC 93-1403.
     Referenced To:  93-1403   Claims Groups:                    Type of Reference -- Claims: X  Purpose:    Remarks:
...................................................................................................
  ###STOCKWATERING: 153 Cattle or Equivalent                     Diversion Limit:              PERIOD OF USE: 07/06 TO 09/25
Crandall Canyon Allotment
***************************************************************************************************
******************************************************E N D   O F   D A T A************************
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UTAH DIVISION OF WATER RIGHTS

Select Related Information

```
     (WARNING: Water Rights makes NO claims as to the accuracy of this data.) RUN DATE: 05/05/2004
WRNUM: 93-1406      APPLICATION/CLAIM NO.:            CERT. NO.:
----------------------------------------------------------------------------------------------------
OWNERSHIP*******************************************************************************************
----------------------------------------------------------------------------------------------------

NAME: USA Forest Service
ADDR: 324 25th Street
      Ogden UT 84401
LAND OWNED BY APPLICANT? Yes
----------------------------------------------------------------------------------------------------
DATES, ETC.*****************************************************************************************
----------------------------------------------------------------------------------------------------
FILED:                |PRIORITY:  00/00/1875|PUB BEGAN:            |PUB ENDED:            |NEWSPAPER:
ProtestEnd:           |PROTESTED: [No      ]|HEARNG HLD:           |SE ACTION: [         ]|ActionDate:          |PROOF DUE:
EXTENSION:            |ELEC/PROOF:[        ]|ELEC/PROOF:           |CERT/WUC:             |LAP, ETC:            |PROV LETTER:
RENOVATE:             |RECON REQ:           |TYPE: [              ]
PD Book No. 1     Map: 14
Type of Right: Diligence Claim              Source of Info: Proposed Determination        Status:
Related Distribution System:  Not part of any Distribution System
----------------------------------------------------------------------------------------------------
LOCATION OF WATER RIGHT*****************************************************************************
----------------------------------------------------------------------------------------------------
FLOW: 0.011 cfs                                  SOURCE: Roys Spring
COUNTY: Emery        COMMON DESCRIPTION:

POINT OF DIVERSION:
( 1)Stockwatering directly on spring located in NE4SE4 Sec 35, T15S, R6E, SLBM.
                          Source:
----------------------------------------------------------------------------------------------------
USES OF WATER RIGHT*********************************************************************************
----------------------------------------------------------------------------------------------------
----------------------------------------------------------------------------------------------------
CLAIMS USED FOR PURPOSE DESCRIBED: See WUC 93-1403.
     Referenced To:  93-1403   Claims Groups:                 Type of Reference -- Claims: X  Purpose:    Remarks:
....................................................................................................
  ###STOCKWATERING: 153 Cattle or Equivalent                  Diversion Limit:               PERIOD OF USE: 07/06 TO 09/25
Crandall Canyon Allotment
****************************************************************************************************
*****************************************************E N D   O F   D A T A*************************
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UTAH DIVISION OF WATER RIGHTS

Select Related Information

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      (WARNING: Water Rights makes NO claims as to the accuracy of this data.) RUN DATE: 05/05/2004
WRNUM: 93-1410      APPLICATION/CLAIM NO.:            CERT. NO.:
------------------------------------------------------------------------------------------------
OWNERSHIP***************************************************************************************
------------------------------------------------------------------------------------------------

NAME: USA Forest Service
ADDR: 324 25th Street
      Ogden UT 84401
LAND OWNED BY APPLICANT? Yes
------------------------------------------------------------------------------------------------
DATES, ETC.*************************************************************************************
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FILED:                |PRIORITY:  00/00/1875|PUB BEGAN:          |PUB ENDED:          |NEWSPAPER:
ProtestEnd:           |PROTESTED: [No      ]|HEARNG HLD:         |SE ACTION: [       ]|ActionDate:          |PROOF DUE:
EXTENSION:            |ELEC/PROOF:[        ]|ELEC/PROOF:         |CERT/WUC:           |LAP, ETC:            |PROV LETTER:
RENOVATE:             |RECON REQ:           |TYPE: [              ]
PD Book No. 1     Map: 14c
Type of Right: Diligence Claim             Source of Info: Proposed Determination       Status:
Related Distribution System:  Not part of any Distribution System
------------------------------------------------------------------------------------------------
LOCATION OF WATER RIGHT*************************************************************************
------------------------------------------------------------------------------------------------
FLOW: 0.011 cfs                                 SOURCE: Edmond`s Willow Spring
COUNTY: Emery        COMMON DESCRIPTION:

POINT OF DIVERSION:
( 1)Stockwatering directly on spring located in NE4SW4 Sec 11, T16S, R6E, SLBM.
                          Source:
------------------------------------------------------------------------------------------------
USES OF WATER RIGHT*****************************************************************************
------------------------------------------------------------------------------------------------
------------------------------------------------------------------------------------------------
CLAIMS USED FOR PURPOSE DESCRIBED: See WUC 93-198.
     Referenced To:  93-198    Claims Groups:    1              Type of Reference -- Claims: X  Purpose:    Remarks:
................................................................................................
  ###STOCKWATERING: 207 Cattle or Equivalent                   Diversion Limit:              PERIOD OF USE: 07/01 TO 09/30
Crandall Ridge Allotment
************************************************************************************************
*******************************************************E N D   O F   D A T A********************
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UTAH DIVISION OF WATER RIGHTS

Select Related Information

(WARNING: Water Rights makes NO claims as to the accuracy of this data.) RUN DATE: 05/05/2004

WRNUM: 93-1588   APPLICATION/CLAIM NO.:   CERT. NO.:

OWNERSHIP

NAME: USA Forest Service
ADDR: 324 25th Street
      Ogden UT 84401
LAND OWNED BY APPLICANT?

DATES, ETC.

FILED:	PRIORITY: 00/00/1875	PUB BEGAN:	PUB ENDED:	NEWSPAPER:	
ProtestEnd:	PROTESTED: [No]	HEARNG HLD:	SE ACTION: [ ]	ActionDate:	PROOF DUE:
EXTENSION:	ELEC/PROOF: [ ]	ELEC/PROOF:	CERT/WUC:	LAP, ETC:	PROV LETTER:
RENOVATE:	RECON REQ:	TYPE: [ ]			

PD Book No. 3   Map: 14
Type of Right: Diligence Claim   Source of Info: Proposed Determination   Status:
Related Distribution System: Not part of any Distribution System

---

LOCATION OF WATER RIGHT

FLOW: 0.011 cfs   SOURCE: Spoon Creek Spring #6
COUNTY: BAD-COUNTY   COMMON DESCRIPTION:

POINT OF DIVERSION:
(1)Stockwatering directly on spring located in SW4SE4 Sec 34, T15S, R6E, SLBM.
Source:

USES OF WATER RIGHT

CLAIMS USED FOR PURPOSE DESCRIBED: 102,229,679,683,684,685,687,689,690/697,699,700,701,702,704,705,708,715,716,718,719,720,721
723/728,730,766,788,797,798,799,810,811,821,1254,1571/1597,1606,2115/2118,3374,3399,3400,3401
Referenced To: Claims Groups: 1   Type of Reference -- Claims: Purpose: Remarks:

###STOCKWATERING: 906 Cattle or Equivalent   Diversion Limit: PERIOD OF USE: 06/21 TO 09/20
Trail Mountain Allotment

END OF DATA

UTAH DIVISION OF WATER RIGHTS

Select Related Information

```
    (WARNING: Water Rights makes NO claims as to the accuracy of this data.) RUN DATE: 05/05/2004
WRNUM: 93-1589      APPLICATION/CLAIM NO.:                CERT. NO.:
-----------------------------------------------------------------------------------------------
OWNERSHIP**************************************************************************************
-----------------------------------------------------------------------------------------------

NAME: USA Forest Service
ADDR: 324 25th Street
      Ogden UT 84401
LAND OWNED BY APPLICANT?
-----------------------------------------------------------------------------------------------
DATES, ETC.************************************************************************************
-----------------------------------------------------------------------------------------------
FILED:                 |PRIORITY:  00/00/1875|PUB BEGAN:          |PUB ENDED:          |NEWSPAPER:
ProtestEnd:            |PROTESTED: [No      ]|HEARNG HLD:         |SE ACTION: [       ]|ActionDate:        |PROOF DUE:
EXTENSION:             |ELEC/PROOF:[        ]|ELEC/PROOF:         |CERT/WUC:           |LAP, ETC:          |PROV LETTER:
RENOVATE:              |RECON REQ:           |TYPE: [              ]
PD Book No. 3     Map: 14
Type of Right: Diligence Claim          Source of Info: Proposed Determination        Status:
Related Distribution System:  Not part of any Distribution System
-----------------------------------------------------------------------------------------------
LOCATION OF WATER RIGHT************************************************************************
-----------------------------------------------------------------------------------------------
FLOW: 0.011 cfs                               SOURCE: Spoon Creek Spring #7
COUNTY: BAD-COUNTY   COMMON DESCRIPTION:

POINT OF DIVERSION:
( 1)Stockwatering directly on spring located in NW4NE4 Sec 03, T16S, R6E, SLBM.
                          Source:
-----------------------------------------------------------------------------------------------
USES OF WATER RIGHT****************************************************************************
-----------------------------------------------------------------------------------------------
-----------------------------------------------------------------------------------------------
CLAIMS USED FOR PURPOSE DESCRIBED: See WUC 93-1588.
     Referenced To:  93-1588   Claims Groups:    1            Type of Reference -- Claims: X  Purpose:    Remarks:
...............................................................................................
  ###STOCKWATERING: 906 Cattle or Equivalent                  Diversion Limit:              PERIOD OF USE: 06/21 TO 09/20
Trail Mountain Allotment
***********************************************************************************************
***********************************************E N D   O F   D A T A***************************
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UTAH DIVISION OF WATER RIGHTS

Select Related Information

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      (WARNING: Water Rights makes NO claims as to the accuracy of this data.) RUN DATE: 05/05/2004
WRNUM: 93-1587      APPLICATION/CLAIM NO.:            CERT. NO.:
--------------------------------------------------------------------------------------------------
OWNERSHIP*****************************************************************************************
--------------------------------------------------------------------------------------------------

NAME: USA Forest Service
ADDR: 324 25th Street
      Ogden UT 84401
LAND OWNED BY APPLICANT?
--------------------------------------------------------------------------------------------------
DATES, ETC.***************************************************************************************
--------------------------------------------------------------------------------------------------
FILED:               |PRIORITY:  00/00/1875|PUB BEGAN:        |PUB ENDED:        |NEWSPAPER:
ProtestEnd:          |PROTESTED: [No      ]|HEARNG HLD:       |SE ACTION: [     ]|ActionDate:        |PROOF DUE:
EXTENSION:           |ELEC/PROOF:[        ]|ELEC/PROOF:       |CERT/WUC:         |LAP, ETC:          |PROV LETTER:
RENOVATE:            |RECON REQ:           |TYPE: [          ]
PD Book No. 3     Map: 14
Type of Right: Diligence Claim          Source of Info: Proposed Determination       Status:
Related Distribution System:  Not part of any Distribution System
--------------------------------------------------------------------------------------------------
LOCATION OF WATER RIGHT***************************************************************************
--------------------------------------------------------------------------------------------------
FLOW: 0.011 cfs                                   SOURCE: Spoon Creek Spring #8
COUNTY: BAD-COUNTY   COMMON DESCRIPTION:

POINT OF DIVERSION:
( 1)Stockwatering directly on spring located in NW4NE4 Sec 03, T16S, R6E, SLBM.
                          Source:
--------------------------------------------------------------------------------------------------
USES OF WATER RIGHT*******************************************************************************
--------------------------------------------------------------------------------------------------
--------------------------------------------------------------------------------------------------
CLAIMS USED FOR PURPOSE DESCRIBED: See WUC 93-1588.
     Referenced To:  93-1588   Claims Groups:    1            Type of Reference -- Claims: X  Purpose:    Remarks:
..................................................................................................
  ###STOCKWATERING: 906 Cattle or Equivalent                    Diversion Limit:             PERIOD OF USE: 06/21 TO 09/20
Trail Mountain Allotment
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*******************************************************E N D   O F   D A T A**********************
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UTAH DIVISION OF WATER RIGHTS

Select Related Information

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      (WARNING: Water Rights makes NO claims as to the accuracy of this data.) RUN DATE: 05/05/2004
WRNUM: 93-1586      APPLICATION/CLAIM NO.:              CERT. NO.:
----------------------------------------------------------------------------------------------------
OWNERSHIP*******************************************************************************************
----------------------------------------------------------------------------------------------------

NAME: USA Forest Service
ADDR: 324 25th Street
      Ogden UT 84401
LAND OWNED BY APPLICANT?
----------------------------------------------------------------------------------------------------
DATES, ETC.*****************************************************************************************
----------------------------------------------------------------------------------------------------
FILED:                |PRIORITY:  00/00/1875|PUB BEGAN:            |PUB ENDED:             |NEWSPAPER:
ProtestEnd:           |PROTESTED: [No      ]|HEARNG HLD:           |SE ACTION: [          ]|ActionDate:            |PROOF DUE:
EXTENSION:            |ELEC/PROOF:[        ]|ELEC/PROOF:           |CERT/WUC:              |LAP, ETC:              |PROV LETTER:
RENOVATE:             |RECON REQ:           |TYPE: [              ]
PD Book No. 3     Map: 14
Type of Right: Diligence Claim           Source of Info: Proposed Determination        Status:
Related Distribution System:  Not part of any Distribution System
----------------------------------------------------------------------------------------------------
LOCATION OF WATER RIGHT*****************************************************************************
----------------------------------------------------------------------------------------------------
FLOW: 0.011 cfs                                    SOURCE: Spoon Creek Spring #9
COUNTY: BAD-COUNTY   COMMON DESCRIPTION:

POINT OF DIVERSION:
( 1)Stockwatering directly on spring located in NW4NE4 Sec 03, T16S, R6E, SLBM.
                          Source:
----------------------------------------------------------------------------------------------------
USES OF WATER RIGHT*********************************************************************************
----------------------------------------------------------------------------------------------------
----------------------------------------------------------------------------------------------------
CLAIMS USED FOR PURPOSE DESCRIBED: See WUC 93-1588.
     Referenced To:  93-1588   Claims Groups:    1              Type of Reference -- Claims: X  Purpose:    Remarks:
....................................................................................................
  ###STOCKWATERING: 906 Cattle or Equivalent                 Diversion Limit:              PERIOD OF USE: 06/21 TO 09/20
Trail Mountain Allotment
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*******************************************************E N D   O F   D A T A************************
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     (WARNING: Water Rights makes NO claims as to the accuracy of this data.) RUN DATE: 05/05/2004
WRNUM: 93-1585     APPLICATION/CLAIM NO.:          CERT. NO.:
----------------------------------------------------------------------------------------------------
OWNERSHIP*******************************************************************************************
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NAME: USA Forest Service
ADDR: 324 25th Street
      Ogden UT 84401
LAND OWNED BY APPLICANT?
----------------------------------------------------------------------------------------------------
DATES, ETC.*****************************************************************************************
----------------------------------------------------------------------------------------------------
FILED:                |PRIORITY:  00/00/1875|PUB BEGAN:           |PUB ENDED:           |NEWSPAPER:
ProtestEnd:           |PROTESTED: [No      ]|HEARNG HLD:          |SE ACTION: [        ]|ActionDate:          |PROOF DUE:
EXTENSION:            |ELEC/PROOF:[        ]|ELEC/PROOF:          |CERT/WUC:            |LAP, ETC:            |PROV LETTER:
RENOVATE:             |RECON REQ:           |TYPE: [              ]
PD Book No. 3     Map: 14
Type of Right: Diligence Claim          Source of Info: Proposed Determination        Status:
Related Distribution System:  Not part of any Distribution System
----------------------------------------------------------------------------------------------------
LOCATION OF WATER RIGHT*****************************************************************************
----------------------------------------------------------------------------------------------------
FLOW: 0.011 cfs                                    SOURCE: Spoon Creek Spring #11
COUNTY: BAD-COUNTY    COMMON DESCRIPTION:

POINT OF DIVERSION:
( 1)Stockwatering directly on spring located in SW4NE4 Sec 03, T16S, R6E, SLBM.
                          Source:
----------------------------------------------------------------------------------------------------
USES OF WATER RIGHT*********************************************************************************
----------------------------------------------------------------------------------------------------
----------------------------------------------------------------------------------------------------
CLAIMS USED FOR PURPOSE DESCRIBED: See WUC 93-1588.
     Referenced To:  93-1588   Claims Groups:    1                Type of Reference -- Claims: X  Purpose:    Remarks:
....................................................................................................
  ###STOCKWATERING: 906 Cattle or Equivalent                       Diversion Limit:              PERIOD OF USE: 06/21 TO 09/20
Trail Mountain Allotment
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      (WARNING: Water Rights makes NO claims as to the accuracy of this data.) RUN DATE: 05/05/2004
WRNUM: 93-1584      APPLICATION/CLAIM NO.:              CERT. NO.:
------------------------------------------------------------------------------------------------
OWNERSHIP***************************************************************************************
------------------------------------------------------------------------------------------------

NAME: USA Forest Service
ADDR: 324 25th Street
      Ogden UT 84401
LAND OWNED BY APPLICANT?
------------------------------------------------------------------------------------------------
DATES, ETC.*************************************************************************************
------------------------------------------------------------------------------------------------
FILED:              |PRIORITY:  00/00/1875|PUB BEGAN:          |PUB ENDED:          |NEWSPAPER:
ProtestEnd:         |PROTESTED: [No      ]|HEARNG HLD:         |SE ACTION: [       ]|ActionDate:         |PROOF DUE:
EXTENSION:          |ELEC/PROOF:[        ]|ELEC/PROOF:         |CERT/WUC:           |LAP, ETC:           |PROV LETTER:
RENOVATE:           |RECON REQ:           |TYPE: [            ]
PD Book No. 3     Map: 14
Type of Right: Diligence Claim          Source of Info: Proposed Determination       Status:
Related Distribution System:  Not part of any Distribution System
------------------------------------------------------------------------------------------------
LOCATION OF WATER RIGHT*************************************************************************
------------------------------------------------------------------------------------------------
FLOW: 0.011 cfs                                   SOURCE: Spoon Creek Spring #12
COUNTY: BAD-COUNTY   COMMON DESCRIPTION:

POINT OF DIVERSION:
( 1)Stockwatering directly on spring located in SW4NE4 Sec 03, T16S, R6E, SLBM.
                          Source:
------------------------------------------------------------------------------------------------
USES OF WATER RIGHT*****************************************************************************
------------------------------------------------------------------------------------------------
------------------------------------------------------------------------------------------------
CLAIMS USED FOR PURPOSE DESCRIBED: See WUC 93-1588.
     Referenced To:  93-1588   Claims Groups:    1             Type of Reference -- Claims: X  Purpose:    Remarks:
................................................................................................
  ###STOCKWATERING: 906 Cattle or Equivalent                    Diversion Limit:              PERIOD OF USE: 06/21 TO 09/20
Trail Mountain Allotment
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     (WARNING: Water Rights makes NO claims as to the accuracy of this data.) RUN DATE: 05/05/2004
WRNUM: 93-1583     APPLICATION/CLAIM NO.:                CERT. NO.:
------------------------------------------------------------------------------------------------
OWNERSHIP***************************************************************************************
------------------------------------------------------------------------------------------------

NAME: USA Forest Service
ADDR: 324 25th Street
      Ogden UT 84401
LAND OWNED BY APPLICANT?
------------------------------------------------------------------------------------------------
DATES, ETC.*************************************************************************************
------------------------------------------------------------------------------------------------
FILED:                 |PRIORITY:  00/00/1875|PUB BEGAN:          |PUB ENDED:          |NEWSPAPER:
ProtestEnd:            |PROTESTED: [No      ]|HEARNG HLD:         |SE ACTION: [       ]|ActionDate:        |PROOF DUE:
EXTENSION:             |ELEC/PROOF:[        ]|ELEC/PROOF:         |CERT/WUC:           |LAP, ETC:          |PROV LETTER:
RENOVATE:              |RECON REQ:           |TYPE: [            ]
PD Book No. 3     Map: 14
Type of Right: Diligence Claim           Source of Info: Proposed Determination        Status:
Related Distribution System:  Not part of any Distribution System
------------------------------------------------------------------------------------------------
LOCATION OF WATER RIGHT*************************************************************************
------------------------------------------------------------------------------------------------
FLOW: 0.011 cfs                                SOURCE: Spoon Creek Spring #10
COUNTY: BAD-COUNTY    COMMON DESCRIPTION:

POINT OF DIVERSION:
( 1)Stockwatering directly on spring located in SE4NW4 Sec 03, T16S, R6E, SLBM.
                          Source:
------------------------------------------------------------------------------------------------
USES OF WATER RIGHT*****************************************************************************
------------------------------------------------------------------------------------------------
------------------------------------------------------------------------------------------------
CLAIMS USED FOR PURPOSE DESCRIBED: See WUC 93-1588.
     Referenced To:  93-1588   Claims Groups:    1            Type of Reference -- Claims: X  Purpose:    Remarks:
................................................................................................
  ###STOCKWATERING: 906 Cattle or Equivalent                   Diversion Limit:            PERIOD OF USE: 06/21 TO 09/20
Trail Mountain Allotment
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      (WARNING: Water Rights makes NO claims as to the accuracy of this data.) RUN DATE: 05/05/2004
WRNUM: 93-1582      APPLICATION/CLAIM NO.:              CERT. NO.:
------------------------------------------------------------------------------------------------------------
OWNERSHIP*******************************************************************************************************
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NAME: USA Forest Service
ADDR: 324 25th Street
      Ogden UT 84401
LAND OWNED BY APPLICANT?
------------------------------------------------------------------------------------------------------------
DATES, ETC.*****************************************************************************************************
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FILED:                |PRIORITY:  00/00/1875|PUB BEGAN:          |PUB ENDED:          |NEWSPAPER:
ProtestEnd:           |PROTESTED: [No      ]|HEARNG HLD:         |SE ACTION: [       ]|ActionDate:        |PROOF DUE:
EXTENSION:            |ELEC/PROOF:[        ]|ELEC/PROOF:         |CERT/WUC:           |LAP, ETC:          |PROV LETTER:
RENOVATE:             |RECON REQ:           |TYPE: [            ]
PD Book No. 3     Map: 14
Type of Right: Diligence Claim              Source of Info: Proposed Determination        Status:
Related Distribution System:  Not part of any Distribution System
------------------------------------------------------------------------------------------------------------
LOCATION OF WATER RIGHT*****************************************************************************************
------------------------------------------------------------------------------------------------------------
FLOW: 0.011 cfs                              SOURCE: Spoon Creek Spring #13
COUNTY: BAD-COUNTY    COMMON DESCRIPTION:

POINT OF DIVERSION:
( 1)Stockwatering directly on spring located in SW4NE4 Sec 03, T16S, R6E, SLBM.
                          Source:
------------------------------------------------------------------------------------------------------------
USES OF WATER RIGHT*********************************************************************************************
------------------------------------------------------------------------------------------------------------
------------------------------------------------------------------------------------------------------------
CLAIMS USED FOR PURPOSE DESCRIBED: See WUC 93-1588.
     Referenced To:  93-1588   Claims Groups:    1              Type of Reference -- Claims: X  Purpose:    Remarks:
............................................................................................................
  ###STOCKWATERING: 906 Cattle or Equivalent                     Diversion Limit:              PERIOD OF USE: 06/21 TO 09/20
Trail Mountain Allotment
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UTAH DIVISION OF WATER RIGHTS

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      (WARNING: Water Rights makes NO claims as to the accuracy of this data.) RUN DATE: 05/05/2004
WRNUM: 93-1581      APPLICATION/CLAIM NO.:             CERT. NO.:
--------------------------------------------------------------------------------------------------
OWNERSHIP*****************************************************************************************
--------------------------------------------------------------------------------------------------

NAME: USA Forest Service
ADDR: 324 25th Street
      Ogden UT 84401
LAND OWNED BY APPLICANT?
--------------------------------------------------------------------------------------------------
DATES, ETC.***************************************************************************************
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FILED:                |PRIORITY:  00/00/1875|PUB BEGAN:           |PUB ENDED:           |NEWSPAPER:
ProtestEnd:           |PROTESTED: [No      ]|HEARNG HLD:          |SE ACTION: [        ]|ActionDate:          |PROOF DUE:
EXTENSION:            |ELEC/PROOF:[        ]|ELEC/PROOF:          |CERT/WUC:            |LAP, ETC:            |PROV LETTER:
RENOVATE:             |RECON REQ:           |TYPE: [             ]
PD Book No. 3     Map: 14
Type of Right: Diligence Claim            Source of Info: Proposed Determination        Status:
Related Distribution System:  Not part of any Distribution System
--------------------------------------------------------------------------------------------------
LOCATION OF WATER RIGHT***************************************************************************
--------------------------------------------------------------------------------------------------
FLOW: 0.011 cfs                              SOURCE: Spoon Creek Spring #14
COUNTY: BAD-COUNTY   COMMON DESCRIPTION:

POINT OF DIVERSION:
( 1)Stockwatering directly on spring located in SW4NE4 Sec 03, T16S, R6E, SLBM.
                          Source:
--------------------------------------------------------------------------------------------------
USES OF WATER RIGHT*******************************************************************************
--------------------------------------------------------------------------------------------------
--------------------------------------------------------------------------------------------------
CLAIMS USED FOR PURPOSE DESCRIBED: See WUC 93-1588.
     Referenced To:  93-1588   Claims Groups:    1              Type of Reference -- Claims: X  Purpose:    Remarks:
..................................................................................................
  ###STOCKWATERING: 906 Cattle or Equivalent                    Diversion Limit:                PERIOD OF USE: 06/21 TO 09/20
Trail Mountain Allotment
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UTAH DIVISION OF WATER RIGHTS

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      (WARNING: Water Rights makes NO claims as to the accuracy of this data.) RUN DATE: 05/05/2004
WRNUM: 93-1580      APPLICATION/CLAIM NO.:              CERT. NO.:
-----------------------------------------------------------------------------------------------
OWNERSHIP**************************************************************************************
-----------------------------------------------------------------------------------------------

NAME: USA Forest Service
ADDR: 324 25th Street
      Ogden UT 84401
LAND OWNED BY APPLICANT?
-----------------------------------------------------------------------------------------------
DATES, ETC.************************************************************************************
-----------------------------------------------------------------------------------------------
FILED:               |PRIORITY:   00/00/1875|PUB BEGAN:         |PUB ENDED:         |NEWSPAPER:
ProtestEnd:          |PROTESTED: [No      ]|HEARNG HLD:         |SE ACTION: [      ]|ActionDate:        |PROOF DUE:
EXTENSION:           |ELEC/PROOF:[        ]|ELEC/PROOF:         |CERT/WUC:          |LAP, ETC:          |PROV LETTER:
RENOVATE:            |RECON REQ:           |TYPE: [          ]
PD Book No. 3    Map: 14
Type of Right: Diligence Claim          Source of Info: Proposed Determination       Status:
Related Distribution System:  Not part of any Distribution System
-----------------------------------------------------------------------------------------------
LOCATION OF WATER RIGHT************************************************************************
-----------------------------------------------------------------------------------------------
FLOW: 0.011 cfs                          SOURCE: Spoon Creek Spring #15
COUNTY: BAD-COUNTY   COMMON DESCRIPTION:

POINT OF DIVERSION:
( 1)Stockwatering directly on spring located in NW4SE4 Sec 03, T16S, R6E, SLBM.
                    Source:
-----------------------------------------------------------------------------------------------
USES OF WATER RIGHT****************************************************************************
-----------------------------------------------------------------------------------------------
-----------------------------------------------------------------------------------------------
CLAIMS USED FOR PURPOSE DESCRIBED: See WUC 93-1588.
     Referenced To:  93-1588   Claims Groups:    1         Type of Reference -- Claims: X  Purpose:    Remarks:
...............................................................................................
  ###STOCKWATERING: 906 Cattle or Equivalent               Diversion Limit:           PERIOD OF USE: 06/21 TO 09/20
Trail Mountain Allotment
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UTAH DIVISION OF WATER RIGHTS

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      (WARNING: Water Rights makes NO claims as to the accuracy of this data.) RUN DATE: 05/05/2004
WRNUM: 93-1579      APPLICATION/CLAIM NO.:              CERT. NO.:
------------------------------------------------------------------------------------------------
OWNERSHIP***************************************************************************************
------------------------------------------------------------------------------------------------

NAME: USA Forest Service
ADDR: 324 25th Street
      Ogden UT 84401
LAND OWNED BY APPLICANT?
------------------------------------------------------------------------------------------------
DATES, ETC.*************************************************************************************
------------------------------------------------------------------------------------------------
FILED:                |PRIORITY:  00/00/1875|PUB BEGAN:         |PUB ENDED:          |NEWSPAPER:
ProtestEnd:           |PROTESTED: [No      ]|HEARNG HLD:        |SE ACTION: [       ]|ActionDate:          |PROOF DUE:
EXTENSION:            |ELEC/PROOF:[        ]|ELEC/PROOF:        |CERT/WUC:           |LAP, ETC:            |PROV LETTER:
RENOVATE:             |RECON REQ:           |TYPE: [            ]
PD Book No. 3     Map: 14
Type of Right: Diligence Claim              Source of Info: Proposed Determination        Status:
Related Distribution System:  Not part of any Distribution System
------------------------------------------------------------------------------------------------
LOCATION OF WATER RIGHT*************************************************************************
------------------------------------------------------------------------------------------------
FLOW: 0.011 cfs                                  SOURCE: Spoon Creek Spring #16
COUNTY: BAD-COUNTY   COMMON DESCRIPTION:

POINT OF DIVERSION:
( 1)Stockwatering directly on spring located in NW4SE4 Sec 03, T16S, R6E, SLBM.
                          Source:
------------------------------------------------------------------------------------------------
USES OF WATER RIGHT*****************************************************************************
------------------------------------------------------------------------------------------------
------------------------------------------------------------------------------------------------
CLAIMS USED FOR PURPOSE DESCRIBED: See WUC 93-1588.
     Referenced To:  93-1588   Claims Groups:    1                 Type of Reference -- Claims: X  Purpose:    Remarks:
................................................................................................
  ###STOCKWATERING: 906 Cattle or Equivalent                        Diversion Limit:                 PERIOD OF USE: 06/21 TO 09/20
Trail Mountain Allotment
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*******************************************************E N D   O F   D A T A********************
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     (WARNING: Water Rights makes NO claims as to the accuracy of this data.) RUN DATE: 05/05/2004
WRNUM: 93-1578      APPLICATION/CLAIM NO.:              CERT. NO.:
-----------------------------------------------------------------------------------------------
OWNERSHIP**************************************************************************************
-----------------------------------------------------------------------------------------------

NAME: USA Forest Service
ADDR: 324 25th Street
      Ogden UT 84401
LAND OWNED BY APPLICANT?
-----------------------------------------------------------------------------------------------
DATES, ETC.************************************************************************************
-----------------------------------------------------------------------------------------------
FILED:               |PRIORITY:  00/00/1875|PUB BEGAN:          |PUB ENDED:          |NEWSPAPER:
ProtestEnd:          |PROTESTED: [No      ]|HEARNG HLD:         |SE ACTION: [       ]|ActionDate:         |PROOF DUE:
EXTENSION:           |ELEC/PROOF:[        ]|ELEC/PROOF:         |CERT/WUC:           |LAP, ETC:           |PROV LETTER:
RENOVATE:            |RECON REQ:           |TYPE: [             ]
PD Book No. 3     Map: 14
Type of Right: Diligence Claim           Source of Info: Proposed Determination        Status:
Related Distribution System:  Not part of any Distribution System
-----------------------------------------------------------------------------------------------
LOCATION OF WATER RIGHT************************************************************************
-----------------------------------------------------------------------------------------------
FLOW: 0.011 cfs                          SOURCE: Spoon Creek Spring #17
COUNTY: BAD-COUNTY   COMMON DESCRIPTION:

POINT OF DIVERSION:
( 1)Stockwatering directly on spring located in NW4SE4 Sec 03, T16S, R6E, SLBM.
                          Source:
-----------------------------------------------------------------------------------------------
USES OF WATER RIGHT****************************************************************************
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-----------------------------------------------------------------------------------------------
CLAIMS USED FOR PURPOSE DESCRIBED: See WUC 93-1588.
     Referenced To:  93-1588   Claims Groups:    1            Type of Reference -- Claims: X  Purpose:    Remarks:
...............................................................................................
  ###STOCKWATERING: 906 Cattle or Equivalent                   Diversion Limit:             PERIOD OF USE: 06/21 TO 09/20
Trail Mountain Allotment
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UTAH DIVISION OF WATER RIGHTS

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     (WARNING: Water Rights makes NO claims as to the accuracy of this data.) RUN DATE: 05/05/2004
WRNUM: 93-1577      APPLICATION/CLAIM NO.:            CERT. NO.:
------------------------------------------------------------------------------------------------------
OWNERSHIP*********************************************************************************************
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NAME: USA Forest Service
ADDR: 324 25th Street
      Ogden UT 84401
LAND OWNED BY APPLICANT?
------------------------------------------------------------------------------------------------------
DATES, ETC.*******************************************************************************************
------------------------------------------------------------------------------------------------------
FILED:                |PRIORITY:  00/00/1875|PUB BEGAN:           |PUB ENDED:           |NEWSPAPER:
ProtestEnd:           |PROTESTED: [No      ]|HEARNG HLD:          |SE ACTION: [        ]|ActionDate:          |PROOF DUE:
EXTENSION:            |ELEC/PROOF:[        ]|ELEC/PROOF:          |CERT/WUC:            |LAP, ETC:            |PROV LETTER:
RENOVATE:             |RECON REQ:           |TYPE: [            ]
PD Book No. 3      Map: 14
Type of Right: Diligence Claim           Source of Info: Proposed Determination        Status:
Related Distribution System:  Not part of any Distribution System
------------------------------------------------------------------------------------------------------
LOCATION OF WATER RIGHT*******************************************************************************
------------------------------------------------------------------------------------------------------
FLOW: 0.011 cfs                                   SOURCE: Spoon Creek Spring #18
COUNTY: BAD-COUNTY    COMMON DESCRIPTION:

POINT OF DIVERSION:
( 1)Stockwatering directly on spring located in SW4SE4 Sec 03, T16S, R6E, SLBM.
                          Source:
------------------------------------------------------------------------------------------------------
USES OF WATER RIGHT***********************************************************************************
------------------------------------------------------------------------------------------------------
------------------------------------------------------------------------------------------------------
CLAIMS USED FOR PURPOSE DESCRIBED: See WUC 93-1588.
     Referenced To:  93-1588   Claims Groups:    1              Type of Reference -- Claims: X  Purpose:    Remarks:
......................................................................................................
  ###STOCKWATERING: 906 Cattle or Equivalent                     Diversion Limit:               PERIOD OF USE: 06/21 TO 09/20
Trail Mountain Allotment
******************************************************************************************************
*******************************************************E N D   O F   D A T A**************************
******************************************************************************************************
```

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UTAH DIVISION OF WATER RIGHTS

Select Related Information

```
     (WARNING: Water Rights makes NO claims as to the accuracy of this data.) RUN DATE: 05/05/2004
WRNUM: 93-1576     APPLICATION/CLAIM NO.:               CERT. NO.:
CHANGES: a21560    Approved
---------------------------------------------------------------------------------------------
OWNERSHIP************************************************************************************
---------------------------------------------------------------------------------------------

NAME: USA Forest Service
ADDR: 324 25th Street
      Ogden UT 84401
LAND OWNED BY APPLICANT?
---------------------------------------------------------------------------------------------
DATES, ETC.**********************************************************************************
---------------------------------------------------------------------------------------------
FILED:               |PRIORITY:   00/00/1875|PUB BEGAN:         |PUB ENDED:         |NEWSPAPER:
ProtestEnd:          |PROTESTED: [No       ]|HEARNG HLD:        |SE ACTION: [      ]|ActionDate:        |PROOF DUE:
EXTENSION:           |ELEC/PROOF:[         ]|ELEC/PROOF:        |CERT/WUC:          |LAP, ETC:          |PROV LETTER:
RENOVATE:            |RECON REQ:            |TYPE: [          ]
PD Book No. 3    Map: 14
Type of Right: Diligence Claim           Source of Info: Proposed Determination       Status:
Related Distribution System:  Not part of any Distribution System
---------------------------------------------------------------------------------------------
LOCATION OF WATER RIGHT**********************************************************************
---------------------------------------------------------------------------------------------
FLOW: 0.011 cfs                               SOURCE: Spoon Creek Spring #19
COUNTY: BAD-COUNTY   COMMON DESCRIPTION:

POINT OF DIVERSION:
( 1)Stockwatering directly on spring located in NE4SW4 Sec 03, T16S, R6E, SLBM.
                          Source:
---------------------------------------------------------------------------------------------
USES OF WATER RIGHT**************************************************************************
---------------------------------------------------------------------------------------------
---------------------------------------------------------------------------------------------
CLAIMS USED FOR PURPOSE DESCRIBED: See WUC 93-1588.
     Referenced To:  93-1588   Claims Groups:    1          Type of Reference -- Claims: X  Purpose:    Remarks:
.............................................................................................
  ###STOCKWATERING: 906 Cattle or Equivalent                 Diversion Limit:            PERIOD OF USE: 06/21 TO 09/20
Trail Mountain Allotment
*********************************************************************************************
*****************************************************E N D   O F   D A T A*******************
*********************************************************************************************
```

UTAH DIVISION OF WATER RIGHTS

Select Related Information

```
      (WARNING: Water Rights makes NO claims as to the accuracy of this data.) RUN DATE: 05/05/2004
WRNUM: 93-1575      APPLICATION/CLAIM NO.:            CERT. NO.:
----------------------------------------------------------------------------------------------------
OWNERSHIP*******************************************************************************************
----------------------------------------------------------------------------------------------------

NAME: USA Forest Service
ADDR: 324 25th Street
      Ogden UT 84401
LAND OWNED BY APPLICANT?
----------------------------------------------------------------------------------------------------
DATES, ETC.*****************************************************************************************
----------------------------------------------------------------------------------------------------
FILED:                  |PRIORITY:  00/00/1875|PUB BEGAN:          |PUB ENDED:          |NEWSPAPER:
ProtestEnd:             |PROTESTED: [No      ]|HEARNG HLD:         |SE ACTION: [       ]|ActionDate:        |PROOF DUE:
EXTENSION:              |ELEC/PROOF:[        ]|ELEC/PROOF:         |CERT/WUC:           |LAP, ETC:          |PROV LETTER:
RENOVATE:               |RECON REQ:           |TYPE: [             ]
PD Book No. 3     Map: 14
Type of Right: Diligence Claim               Source of Info: Proposed Determination        Status:
Related Distribution System:  Not part of any Distribution System
----------------------------------------------------------------------------------------------------
LOCATION OF WATER RIGHT*****************************************************************************
----------------------------------------------------------------------------------------------------
FLOW: 0.011 cfs                                   SOURCE: Spoon Creek Spring #20
COUNTY: BAD-COUNTY    COMMON DESCRIPTION:

POINT OF DIVERSION:
( 1)Stockwatering directly on spring located in SW4SE4 Sec 03, T16S, R6E, SLBM.
                          Source:
----------------------------------------------------------------------------------------------------
USES OF WATER RIGHT*********************************************************************************
----------------------------------------------------------------------------------------------------
----------------------------------------------------------------------------------------------------
CLAIMS USED FOR PURPOSE DESCRIBED: See WUC 93-1588.
     Referenced To:  93-1588   Claims Groups:    1            Type of Reference -- Claims: X  Purpose:    Remarks:
....................................................................................................
  ###STOCKWATERING: 906 Cattle or Equivalent                  Diversion Limit:              PERIOD OF USE: 06/21 TO 09/20
Trail Mountain Allotment
****************************************************************************************************
*******************************************************E N D   O F   D A T A************************
****************************************************************************************************
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UTAH DIVISION OF WATER RIGHTS

Select Related Information

```
      (WARNING: Water Rights makes NO claims as to the accuracy of this data.) RUN DATE: 05/05/2004
WRNUM: 93-1574     APPLICATION/CLAIM NO.:            CERT. NO.:
------------------------------------------------------------------------------------------------
OWNERSHIP***************************************************************************************
------------------------------------------------------------------------------------------------

NAME: USA Forest Service
ADDR: 324 25th Street
      Ogden UT 84401
LAND OWNED BY APPLICANT?
------------------------------------------------------------------------------------------------
DATES, ETC.*************************************************************************************
------------------------------------------------------------------------------------------------
FILED:                |PRIORITY:  00/00/1875|PUB BEGAN:          |PUB ENDED:           |NEWSPAPER:
ProtestEnd:           |PROTESTED: [No      ]|HEARNG HLD:         |SE ACTION: [        ]|ActionDate:          |PROOF DUE:
EXTENSION:            |ELEC/PROOF:[        ]|ELEC/PROOF:         |CERT/WUC:            |LAP, ETC:            |PROV LETTER:
RENOVATE:             |RECON REQ:           |TYPE: [             ]
PD Book No. 3     Map: 14
Type of Right: Diligence Claim              Source of Info: Proposed Determination        Status:
Related Distribution System:  Not part of any Distribution System
------------------------------------------------------------------------------------------------
LOCATION OF WATER RIGHT*************************************************************************
------------------------------------------------------------------------------------------------
FLOW: 0.011 cfs                                   SOURCE: Spoon Creek Spring #21
COUNTY: BAD-COUNTY   COMMON DESCRIPTION:

POINT OF DIVERSION:
( 1)Stockwatering directly on spring located in SW4SE4 Sec 03, T16S, R6E, SLBM.
                          Source:
------------------------------------------------------------------------------------------------
USES OF WATER RIGHT*****************************************************************************
------------------------------------------------------------------------------------------------
------------------------------------------------------------------------------------------------
CLAIMS USED FOR PURPOSE DESCRIBED: See WUC 93-1588.
     Referenced To:  93-1588   Claims Groups:    1                Type of Reference -- Claims: X  Purpose:    Remarks:
................................................................................................
  ###STOCKWATERING: 906 Cattle or Equivalent                      Diversion Limit:                PERIOD OF USE: 06/21 TO 09/20
Trail Mountain Allotment
************************************************************************************************
*******************************************************E N D   O F   D A T A********************
************************************************************************************************
```

UTAH DIVISION OF WATER RIGHTS

Select Related Information

```
      (WARNING: Water Rights makes NO claims as to the accuracy of this data.) RUN DATE: 05/05/2004
WRNUM: 93-1573      APPLICATION/CLAIM NO.:              CERT. NO.:
----------------------------------------------------------------------------------------------------
OWNERSHIP*******************************************************************************************
----------------------------------------------------------------------------------------------------

NAME: USA Forest Service
ADDR: 324 25th Street
      Ogden UT 84401
LAND OWNED BY APPLICANT?
----------------------------------------------------------------------------------------------------
DATES, ETC.*****************************************************************************************
----------------------------------------------------------------------------------------------------
FILED:                    |PRIORITY:  00/00/1875|PUB BEGAN:            |PUB ENDED:            |NEWSPAPER:
ProtestEnd:               |PROTESTED: [No      ]|HEARNG HLD:           |SE ACTION: [         ]|ActionDate:           |PROOF DUE:
EXTENSION:                |ELEC/PROOF:[        ]|ELEC/PROOF:           |CERT/WUC:              |LAP, ETC:             |PROV LETTER:
RENOVATE:                 |RECON REQ:           |TYPE: [              ]
PD Book No. 3     Map: 14c
Type of Right: Diligence Claim             Source of Info: Proposed Determination        Status:
Related Distribution System:  Not part of any Distribution System
----------------------------------------------------------------------------------------------------
LOCATION OF WATER RIGHT*****************************************************************************
----------------------------------------------------------------------------------------------------
FLOW: 0.011 cfs                                    SOURCE: Spoon Creek Spring #22
COUNTY: BAD-COUNTY   COMMON DESCRIPTION:

POINT OF DIVERSION:
( 1)Stockwatering directly on spring located in NW4NE4 Sec 10, T16S, R6E, SLBM.
                          Source:
----------------------------------------------------------------------------------------------------
USES OF WATER RIGHT*********************************************************************************
----------------------------------------------------------------------------------------------------
----------------------------------------------------------------------------------------------------
CLAIMS USED FOR PURPOSE DESCRIBED: See WUC 93-1588.
     Referenced To:  93-1588   Claims Groups:    1              Type of Reference -- Claims: X  Purpose:    Remarks:
....................................................................................................
  ###STOCKWATERING: 906 Cattle or Equivalent                    Diversion Limit:                PERIOD OF USE: 06/21 TO 09/20
Trail Mountain Allotment
****************************************************************************************************
*******************************************************E N D   O F   D A T A************************
****************************************************************************************************
```

UTAH DIVISION OF WATER RIGHTS

(WARNING: Water Rights makes NO claims as to the accuracy of this data.) RUN DATE: 05/05/2004

WRNUM: 93-483 APPLICATION/CLAIM NO.: CERT. NO.:

OWNERSHIP

NAME: USA Forest Service
ADDR: 324 25th Street
Ogden UT 84401
LAND OWNED BY APPLICANT? Yes

DATES, ETC.

FILED:	PRIORITY: 00/00/1875	PUB BEGAN:	PUB ENDED:	NEWSPAPER:	
ProtestEnd:	PROTESTED: [No]	HEARNG HLD:	SE ACTION: [ ]	ActionDate:	PROOF DUE:
EXTENSION:	ELEC/PROOF: [ ]	ELEC/PROOF:	CERT/WUC:	LAP, ETC:	PROV LETTER:
RENOVATE:	RECON REQ:	TYPE: [ ]			

PD Book No. 1 Map: 14
Type of Right: Diligence Claim Source of Info: Proposed Determination Status:
Related Distribution System: Not part of any Distribution System

LOCATION OF WATER RIGHT

FLOW: SOURCE: Shingle Canyon Creek
COUNTY: Emery COMMON DESCRIPTION:

POINT OF DIVERSION -- POINT TO POINT:
(1)Stockwatering directly on stream from a point in NW4SE4 Sec 31, T15S, R7E, SLBM,
to a point in NE4SE4 Sec 31, T15S, R7E, SLBM.
Source:

USES OF WATER RIGHT

CLAIMS USED FOR PURPOSE DESCRIBED: See WUC 93-1403.
Referenced To: 93-1403 Claims Groups: Type of Reference -- Claims: X Purpose: Remarks:

###STOCKWATERING: 153 Cattle or Equivalent Diversion Limit: PERIOD OF USE: 07/06 TO 09/25
Crandall Canyon Allotment

E N D O F D A T A

UTAH DIVISION OF WATER RIGHTS

Select Related Information

```
      (WARNING: Water Rights makes NO claims as to the accuracy of this data.) RUN DATE: 05/05/2004
WRNUM: 93-1180     APPLICATION/CLAIM NO.:          CERT. NO.:
--------------------------------------------------------------------------------------------------------
OWNERSHIP***********************************************************************************************
--------------------------------------------------------------------------------------------------------

NAME: USA Forest Service
ADDR: 324 25th Street
      Ogden UT 84401
LAND OWNED BY APPLICANT? Yes
--------------------------------------------------------------------------------------------------------
DATES, ETC.*********************************************************************************************
--------------------------------------------------------------------------------------------------------
FILED:                |PRIORITY:  00/00/1875|PUB BEGAN:           |PUB ENDED:           |NEWSPAPER:
ProtestEnd:           |PROTESTED: [No      ]|HEARNG HLD:          |SE ACTION: [        ]|ActionDate:          |PROOF DUE:
EXTENSION:            |ELEC/PROOF:[        ]|ELEC/PROOF:          |CERT/WUC:            |LAP, ETC:            |PROV LETTER:
RENOVATE:             |RECON REQ:           |TYPE: [             ]
PD Book No. 1     Map: 14
Type of Right: Diligence Claim               Source of Info: Proposed Determination       Status:
Related Distribution System:  Not part of any Distribution System
--------------------------------------------------------------------------------------------------------
LOCATION OF WATER RIGHT*********************************************************************************
--------------------------------------------------------------------------------------------------------
FLOW:                                         SOURCE: Shingle Canyon Creek
COUNTY: Emery        COMMON DESCRIPTION:

POINT OF DIVERSION -- POINT TO POINT:
( 1)Stockwatering directly on stream from a point in NE4SE4 Sec 31, T15S, R7E, SLBM,
                          to a point in SW4NE4 Sec 32, T15S, R7E, SLBM.
                     Source:
--------------------------------------------------------------------------------------------------------
USES OF WATER RIGHT*************************************************************************************
--------------------------------------------------------------------------------------------------------
--------------------------------------------------------------------------------------------------------
CLAIMS USED FOR PURPOSE DESCRIBED: See WUC 93-116.
     Referenced To:  93-116    Claims Groups:                   Type of Reference -- Claims: X  Purpose:    Remarks:
........................................................................................................
  ###STOCKWATERING: 1440 Cattle or Equivalent                   Diversion Limit:                 PERIOD OF USE: 06/21 TO 09/30
Gentry Mountain Allotment
********************************************************************************************************
*******************************************************E N D   O F   D A T A****************************
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UTAH DIVISION OF WATER RIGHTS

Select Related Information

```
       (WARNING: Water Rights makes NO claims as to the accuracy of this data.) RUN DATE: 05/05/2004
WRNUM: 93-190      APPLICATION/CLAIM NO.:                CERT. NO.:
-----------------------------------------------------------------------------------------------------
OWNERSHIP********************************************************************************************
-----------------------------------------------------------------------------------------------------

NAME: USA Forest Service
ADDR: 324 25th Street
      Ogden UT 84401
LAND OWNED BY APPLICANT? Yes
-----------------------------------------------------------------------------------------------------
DATES, ETC.******************************************************************************************
-----------------------------------------------------------------------------------------------------
FILED:                |PRIORITY:   00/00/1875|PUB BEGAN:            |PUB ENDED:            |NEWSPAPER:
ProtestEnd:           |PROTESTED: [No      ]|HEARNG HLD:           |SE ACTION: [         ]|ActionDate:           |PROOF DUE:
EXTENSION:            |ELEC/PROOF:[        ]|ELEC/PROOF:           |CERT/WUC:             |LAP, ETC:             |PROV LETTER:
RENOVATE:             |RECON REQ:           |TYPE: [              ]
PD Book No. 1     Map: 14
Type of Right: Diligence Claim              Source of Info: Proposed Determination        Status:
Related Distribution System:  Not part of any Distribution System
-----------------------------------------------------------------------------------------------------
LOCATION OF WATER RIGHT******************************************************************************
-----------------------------------------------------------------------------------------------------
FLOW:                                              SOURCE: Crandall Canyon Creek
COUNTY: Emery        COMMON DESCRIPTION:

POINT OF DIVERSION -- POINT TO POINT:
( 1)Stockwatering directly on stream from a point at ,
                               to a point in NE4SE4 Sec 06, T16S, R7E, SLBM.
                          Source:
-----------------------------------------------------------------------------------------------------
USES OF WATER RIGHT**********************************************************************************
-----------------------------------------------------------------------------------------------------
-----------------------------------------------------------------------------------------------------
CLAIMS USED FOR PURPOSE DESCRIBED: See WUC 93-116.
     Referenced To:  93-116    Claims Groups:                        Type of Reference -- Claims: X  Purpose:    Remarks:
.....................................................................................................
  ###STOCKWATERING: 1440 Cattle or Equivalent                         Diversion Limit:                  PERIOD OF USE: 06/21 TO 09/30
Gentry Mountain Allotment
*****************************************************************************************************
*****************************************************E N D   O F   D A T A***************************
*****************************************************************************************************
```

UTAH DIVISION OF WATER RIGHTS

Select Related Information

```
      (WARNING: Water Rights makes NO claims as to the accuracy of this data.) RUN DATE: 05/05/2004
WRNUM: 93-191      APPLICATION/CLAIM NO.:          CERT. NO.:
-----------------------------------------------------------------------------------------------
OWNERSHIP**************************************************************************************
-----------------------------------------------------------------------------------------------

NAME: USA Forest Service
ADDR: 324 25th Street
      Ogden UT 84401
LAND OWNED BY APPLICANT? Yes
-----------------------------------------------------------------------------------------------
DATES, ETC.************************************************************************************
-----------------------------------------------------------------------------------------------
FILED:               |PRIORITY:  00/00/1875|PUB BEGAN:          |PUB ENDED:          |NEWSPAPER:
ProtestEnd:          |PROTESTED: [No      ]|HEARNG HLD:         |SE ACTION: [       ]|ActionDate:         |PROOF DUE:
EXTENSION:           |ELEC/PROOF:[        ]|ELEC/PROOF:         |CERT/WUC:           |LAP, ETC:           |PROV LETTER:
RENOVATE:            |RECON REQ:           |TYPE: [            ]
PD Book No. 1     Map: 14
Type of Right: Diligence Claim           Source of Info: Proposed Determination        Status:
Related Distribution System:  Not part of any Distribution System
-----------------------------------------------------------------------------------------------
LOCATION OF WATER RIGHT************************************************************************
-----------------------------------------------------------------------------------------------
FLOW:                                           SOURCE: Crandall Canyon Creek
COUNTY: Emery        COMMON DESCRIPTION:

POINT OF DIVERSION -- POINT TO POINT:
( 1)Stockwatering directly on stream from a point in SW4NW4 Sec 01, T16S, R6E, SLBM,
                           to a point in SE4NE4 Sec 01, T16S, R6E, SLBM.
                        Source:
-----------------------------------------------------------------------------------------------
USES OF WATER RIGHT****************************************************************************
-----------------------------------------------------------------------------------------------
-----------------------------------------------------------------------------------------------
CLAIMS USED FOR PURPOSE DESCRIBED: See WUC 93-1403.
     Referenced To:  93-1403   Claims Groups:                Type of Reference -- Claims: X  Purpose:    Remarks:
...............................................................................................
  ###STOCKWATERING: 153 Cattle or Equivalent                  Diversion Limit:            PERIOD OF USE: 07/06 TO 09/25
Crandall Canyon Allotment
***********************************************************************************************
******************************************************E N D   O F   D A T A********************
***********************************************************************************************
```

UTAH DIVISION OF WATER RIGHTS

Select Related Information

```
     (WARNING: Water Rights makes NO claims as to the accuracy of this data.) RUN DATE: 05/05/2004
WRNUM: 93-383      APPLICATION/CLAIM NO.:          CERT. NO.:
------------------------------------------------------------------------------------------------
OWNERSHIP***************************************************************************************
------------------------------------------------------------------------------------------------

NAME: Utah School and Institutional Trust Lands Admin.
ADDR: 675 East 500 South, 5th Floor
      Salt Lake City UT 84102
LAND OWNED BY APPLICANT? Yes
------------------------------------------------------------------------------------------------
DATES, ETC.*************************************************************************************
------------------------------------------------------------------------------------------------
FILED:              |PRIORITY:  00/00/1902|PUB BEGAN:          |PUB ENDED:          |NEWSPAPER:
ProtestEnd:         |PROTESTED: [No      ]|HEARNG HLD:         |SE ACTION: [       ]|ActionDate:         |PROOF DUE:
EXTENSION:          |ELEC/PROOF:[        ]|ELEC/PROOF:         |CERT/WUC:           |LAP, ETC:           |PROV LETTER:
RENOVATE:           |RECON REQ:           |TYPE: [            ]
PD Book No. 1     Map: 14
Type of Right: Diligence Claim          Source of Info: Proposed Determination        Status:
Related Distribution System:  Not part of any Distribution System
------------------------------------------------------------------------------------------------
LOCATION OF WATER RIGHT*************************************************************************
------------------------------------------------------------------------------------------------
FLOW:                                         SOURCE: Crandall Canyon Creek
COUNTY: Emery       COMMON DESCRIPTION:

POINT OF DIVERSION -- POINT TO POINT:
( 1)Stockwatering directly on stream from a point in SE4NW4 Sec 02, T16S, R6E, SLBM,
                              to a point in SE4NE4 Sec 02, T16S, R6E, SLBM.
                         Source:
------------------------------------------------------------------------------------------------
USES OF WATER RIGHT*****************************************************************************
------------------------------------------------------------------------------------------------
------------------------------------------------------------------------------------------------
CLAIMS USED FOR PURPOSE DESCRIBED: See WUC 93-500.
    Referenced To:  93-500    Claims Groups:    1             Type of Reference -- Claims: X  Purpose:    Remarks:
................................................................................................
  ###STOCKWATERING: 400 Cattle or Equivalent                   Diversion Limit:             PERIOD OF USE: 01/01 TO 12/31
************************************************************************************************
****************************************E N D   O F   D A T A***********************************
************************************************************************************************
```

APPENDIX 7-4

CRANDALL CANYON MINE
SEDIMENTATION AND DRAINAGE CONTROL PLAN

UTAH REGISTERED PROFESSIONAL ENGINEER
#154168
DAN W. GUY
4/4/03

PREPARED BY: *DAN W. GUY, P.E.*
BLACKHAWK ENGINEERING

COMPANY

214 EAST 1ST NORTH
PRICE, UTAH 84501

Revised: April 2003

CRANDALL CANYON MINE
SEDIMENTATION AND DRAINAGE CONTROL PLAN

TABLE OF CONTENTS

Tables:

Figures:

1. Introduction

The Sedimentation and Drainage Control Plan for the Crandall Canyon Mine has been designed according to the State of Utah R645- Coal Mining Rules, November 1, 1996. All design criteria and construction will be certified by a Utah Registered Professional Engineer.

This plan has been divided into the following three sections:

1) *Design of Drainage Control Structures for the Proposed Construction*
2) *Design of Sediment Control Structures*
3) *Design of Drainage Control Structures for Reclamation*

The general surface water control plan for this project will consist of the following:

(a) *The proposed pad expansion will necessitate modifications of a number of existing hydrologic structures on the site. In an effort to clarify the new plan, the entire sedimentation and drainage control plan has been re-evaluated for the site and presented in this Appendix.*

(b) *The general plan for the pad expansion is to divert undisturbed drainage from Crandall Canyon above the minesite through a 6' diameter CMP culvert beneath the expansion area and discharge below the disturbed area. As a result of the expansion, existing culverts C-2, C-8, C-10 and Ditch DD-9 will be removed. 2 new ditches (DD-12 & DD-13) and 3 new culverts (Main Canyon, C-11 and C-11A) will be added to provide for drainage control for the expanded facility. The existing sediment pond will also be expanded to contain additional runoff from the expansion area. All other existing drainage controls will remain unchanged. All minesite drainage controls are shown on Plate 7-5 "Drainage Map".*

(c) The main canyon culvert is sized to safely pass the runoff from a 100 year - 6 hour precipitation event. All other undisturbed diversions, disturbed ditches and culverts are sized to safely convey runoff from a 10 year - 24 hour precipitation event. The sediment pond is sized to contain runoff from a 10 year - 24 hour precipitation event, as required.

DESIGN OF DRAINAGE CONTROL STRUCTURES

Design Parameters:

2.1	***Precipitation***
2.2	***Flow***
2.3	***Velocity***
2.4	***Drainage Areas***
2.5	***Slopes, Lengths***
2.6	***Runoff***
2.7	***Runoff Curve Numbers***
2.8	***Culvert Sizing***
2.9	***Culverts***
2.10	***Ditches***

Tables:

Table 1	***Watershed Summary***
Table 2	***Watershed Parameters***
Table 3	***Runoff Summary - Undisturbed Diversions***
Table 4	***Runoff Summary - Drainage to Sediment Pond***
Table 5	***Runoff Control Structure Watershed Summary***
Table 6	***Runoff Control Structure Flow Summary***
Table 7	***Disturbed Ditch Design Summary***
Table 8	***Undisturbed Ditch Design Summary***
Table 9	***Disturbed Culvert Design Summary***
Table 10	***Undisturbed Culvert Design Summary***

Design Parameters:

2.1 Precipitation

The precipitation-frequency values for the area were taken from the existing plan which lists Miller, et.al. (1973) as the sources.

Frequency - Duration	***Precipitation***
10 year-6 hour	***1.55"***
10 year-24 hour	***2.50"***
25 year-6 hour	***1.90"***
100 year-6 hour	***2.40"***
100 year-24 hour	***3.70"***

2.2 Flow

Peak flows, flow depths, areas and velocities were calculated using the computer program "Office of Surface Mining Watershed Model", Storm Version 6.21 by Gary E. McIntosh. All flow is based on the SCS - TR55 Method for Type II storms.

Time of concentration of storm events was calculated for each drainage area using the following formula:

$$t_L = \frac{L^{0.8} (S+1)^{0.7}}{1900\, Y^{0.5}}$$

where:

t_C	=	***Time of Concentration (hrs.)***
t_L	=	***Lag Time (hrs.)*** $= 0.6\, t_C$
L	=	***Hydraulic Length of Watershed (ft.)***
Y	=	***Average Land Slope (%)***
S	=	$\frac{1000}{CN} - 10$

2.3 Velocity

Flow velocities for each ditch structure were calculated using the Storm computer program with Manning's Formula:

$$V = \frac{1.49}{n} R^{2/3} S^{1/3}$$

where:	V	=	*Velocity (fps)*
	R	=	*Hydraulic Radius (ft.)*
	S	=	*Slope (ft. per ft.)*
	n	=	*Manning's n; Table 3.1, p. 159,*

"Applied Hydrology and Sedimentology for Disturbed Areas", Barfield, Warner & Haan, 1983.

Note: The following Manning's n were used in the calculations:

Structure	Manning's n
Culverts (cmp)	0.020
Unlined Disturbed Area Ditches	0.035

2.4 Drainage Areas

All drainage areas were planimetered directly from Plate 7-5, Drainage Map, and Plate 7-5C, Watershed Boundaries.

2.5 Slopes, Lengths

All slopes and lengths were measured directly from the topography on Plate 7-

5, Drainage Map, and Plate 7-5C, Watershed Boundaries.

2.6 Runoff

Runoff was calculated using the SCS Formula for Type II Storms; using the Storm Version 6.21 computer program:

$$Q = \frac{(P - 0.2\,S)^2}{P + 0.8\,S}$$

where:

CN	=	Runoff Curve Number
Q	=	Runoff in inches
P	=	Precipitation in inches
S	=	$\frac{1000}{CN} - 10$

2.7 Runoff Curve Numbers

Two curve numbers were utilized for the undisturbed areas. Average curve numbers for the north facing and south facing slopes were determined from curves presented in Figure 7-3 (Chapter 7), using measured cover densities as reported in Chapter 3 and the northern half of lease area SL 062648, assuming a hydrologic soil group of C. Curve numbers of 60 and 69 were obtained for the north facing and south facing undisturbed areas, respectively, using Chart A for Oak-Aspen and ground cover densities of 45 and 26 for north facing and south facing areas, respectively. The above referenced Figure 7-3 (Chapter 7) is included in this Appendix as Figure 9.

Runoff curve numbers for reclaimed, disturbed and paved areas were selected based on comparison with Table 2.20 (p. 82, Barfield, et al, 1983) and

numbers previously approved in the M.R.P. A conservative number of 75 was used for reclaimed areas within the disturbed boundary. Curve numbers of 90 and 95

were used for all disturbed areas and paved areas, respectively. See Plates 7-5 and 7-5C for referenced areas.

The following is a summary of runoff curve numbers used in these calculations:

Watershed	*Runoff CN*
Undisturbed (North Facing):	*60*
Undisturbed (South Facing):	*69*
Reclaimed:	*75*
Disturbed:	*90*
Paved:	*95*

2.8 Culvert Sizing

Minimum culvert sizing is based on the following Manning's Equation; using the Haestad Methods, Flowmaster I, Version 3.42 computer program:

$$D = \left(\frac{2.16\ Q\ n}{\sqrt{S}}\right)^{0.35}$$

where: D	=	*Required Diameter (feet)*
Q	=	*QP = Peak Discharge (cfs)*
n	=	*Roughness Factor (0.020 for cmp)*
S	=	*Slope (ft. Per ft.)*

Using the above formula, minimum required culvert sizes were calculated for each applicable area. Culverts were then selected above the required minimum, and these sizes were checked for adequacy against the Culvert Nomograph included as Figure 1 of this report.

2.9 Culverts

As indicated in Section 1, the proposed pad expansion will necessitate modifications of a number of existing hydrologic structures on the site, including culverts. As a result of the expansion, existing culverts C-2, C-8 and C-10 will be removed. Two new culverts (Main Canyon, C-11) were added to provide drainage control for the expanded facility during phase I of the surface expansion. One more (C-11A) will be added during the phase II south portal construction. All other existing culverts on the site will remain unchanged.

Culverts have been sized according to the calculations previously described, and are summarized on the following tables. The culverts are shown on Plate 7-5, Drainage Map.

All undisturbed diversions are labeled with a UD number (i.e. UD-1). Two of these diversions are culverts (UD-1 and UD-3), and are clearly marked on Plate 7-5. Contributing watersheds for undisturbed diversions are labeled with a WSUD number, (i.e. WSUD-1) as shown on Plates 7-5 and 7-5C. All undisturbed diversion culverts will be fitted with trash racks to minimize plugging by rocks or other debris.

The proposed Main Canyon culvert is sized to carry runoff from a 100 year - 6 hour precipitation event for the Crandall Canyon area above the minesite. A 6' diameter C.M.P. culvert is proposed to carry the Crandall Canyon runoff beneath the expanded pad area and discharge below the minesite. Calculations in Table 10 show the proposed 6' diameter culvert to be more than adequate to carry the expected peak flow. The culvert will be equipped with an inlet headwall and trash rack and a properly sized outlet apron and energy dissipator for erosion protection. Runoff characteristics, flow and culvert design are presented in this Appendix.

The remaining undisturbed culverts on the site (UD-1 and UD-3) are existing. These culverts are adequate for a 10 year - 24 hour precipitation event, as shown on Table 10 of this Appendix.

Culverts carrying disturbed drainage are designed with a C number (i.e. C-1). Contributing watersheds for disturbed area culverts (and ditches) are designated with a WSDD number (i.e. WSDD-1) shown on Plate 7-5. All disturbed area drainage culverts have been designed to carry the runoff from a 10 year - 24 hour precipitation event. All calculations and design criteria are included in this Appendix.

Existing culverts C-2, C-8 and C-10 will be removed during the pad extension, and therefore are not included in this Appendix. These culverts are shown on Plate 7-5C, dated 03/21/91.

All culverts will be inspected regularly, and cleaned as necessary to provide for passage of design flows. Inlets and outlets shall also be maintained to prevent plugging, undue restriction of water flow and erosion. Culvert outlets will be rip-rapped where necessary to protect from erosion.

One culvert, UD-1, is considered a permanent diversion, and will remain in place after reclamation. This culvert is sized to carry runoff in-excess of a 100 year - 6 hour storm. Justification for leaving it in place is provided in the Reclamation Hydrology Section 4.1, of this Appendix.

All other culverts are considered temporary, and will be removed upon final reclamation, with the exception of the lower 300' of the Main Canyon Culvert. This portion of the culvert will be left in place until the sediment pond is removed during Phase II Reclamation. The remaining portion of the culvert will be removed at that time.

2.10 Ditches

The proposed pad expansion will necessitate modifications to hydrologic structures, including ditches. As a result of the expansion, existing ditch DD-9 will be eliminated. Two new ditches (DD-12 and DD-13) will be added to provide drainage control for the expanded facility. All other existing ditches on the site will remain unchanged.

Undisturbed diversions are designated with a UD number (i.e. UD-2). There is only one undisturbed diversion ditch - (UD-2). This ditch is existing. Contributing watersheds for the undisturbed diversion are labelled with a WSUD number (i.e. WSUD-2), and are shown on Plate 7-5C.

Disturbed diversions (ditches) are designated with a DD number (i.e. DD-1). Contributing watersheds for disturbed diversions are labelled with a WSDD number (i.e. WSDD-1) as shown on Plates 7-5 and 7-5C. All disturbed diversions carry runoff which ultimately goes to the sediment pond.

All ditches are designed to carry the expected runoff from respective watersheds from a 10 year - 6 hour precipitation event, with a minimum freeboard of 0.3'. Ditches were assumed to be unlined with a Manning's No. of 0.035. All ditches have been conservatively evaluated for size using the computer program "Office of Surface Mining Watershed Model," Storm, Version 6.21, by Gary E. McIntosh, to calculate peak flows, which were then routed into triangular shaped channels with 1:1 side slopes. This evaluation shows conditions which are not uncommon at minesites and which tend to maximize required flow depths. All ditches are designed with the steeper (1:1) side slopes to allow for maintenance by road grading or other equipment. Actual side slopes may vary in the field; however, as long as the ditch has the

required depth and cross-sectional area to carry the flow with required freeboard, the ditch is adequate.

Ditches with flow velocities of 5 fps or greater will be lined with properly sized rip-rap or other controls to protect from erosion.

All ditch slopes and lengths were taken from Plate 7-5, "Drainage Map".

A typical ditch section, as well as a summary of flow depths and sizes is provided in Figure 3 of this Appendix.

All ditches will be inspected regularly, constructed and maintained to the minimum dimensions to provide adequate capacity for the design flow. All ditches are temporary and will be removed during final reclamation.

Note: Ditches are adequate to carry runoff from the 10 year - 24 hour precipitation event.

2.11 Main Canyon Culvert

The proposed main canyon culvert will be placed to closely approximate the existing stream alignment. In an effort to protect the natural channel, the area will be covered with a filter fabric (geotextile material). An underdrain will then be installed on the fabric, consisting of an 18" perforated drain pipe surrounded by a bed of clean 2" drain drainrock. The underdrain will be covered by a second layer of fabric which in turn will be covered with a layer of marker material used to facilitate visibility during final reclamation. A layer of bedding material will then be placed over the marker material. The proposed 72" cmp culvert will then be installed on the bedding material and backfilled and compacted throughout the length of the mine site - approximately 1500'.

The culvert has been sized to safely carry the runoff from a 100 year - 6 hour precipitation event for all of Crandall Canyon above the minesite. The 100 year - 6 hour flow has been calculated at 222.79 cfs, as shown on Table 3. This flow can be carried by a 3.75' minimum diameter culvert, as calculated by the Manning's Equation and shown in Table 10; therefore, the proposed 6' diameter culvert is more than adequate.

There have been some questions raised as to previous main canyon flow calculations which showed the expected runoff from the 100 year - 6 hour storm to be as high as 431 cfs. It appears this number was generated by using a computer program called "Peak", using slightly different parameters than those used in this report.

The runoff numbers in this Appendix were calculated using the "Office of Surface Mining Watershed Model", Storm Version 6.21, by Gary E. McIntosh. All flows were based on the SCS-TR55 Method for Type II storms. This program has been supplied to the operators by the Division, and results have been consistently accepted by the agencies.

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In an effort to make the runoff values more conservative, yet realistic, for design purposes, some parameters, such as concentration time and SCS Upland Curve numbers were placed on the conservative side in the program. Based on these numbers, a very conservative flow of 222.79 cfs was obtained. It should be noted that this flow agrees closely with a previous calculation using the equation of Thomas and Lindskov (1983), which estimates the 100 year - 6 hour flow for the main canyon at 272 cfs.

Summary: It is obvious that the final number on the main channel flow is entirely dependent upon which computer program or method is used. Since the OSM Storm program has been used throughout calculations for this plan, and since it is a widely accepted method, the more conservative figure of 222.79 cfs has been used in design calculations for this plan.

2.12 Main Canyon Culvert Inlet Structure

The culvert inlet will be protected by an inlet section and trash rack, along with a rip-rapped headwall. An additional trash rack will be installed upstream of the inlet at a location convenient for maintenance and cleanout, as shown on Figure 10. Based on the Culvert Nomograph, Figure 1, the expected flow will enter the culvert at slightly over 1 diameter of head; therefore, additional headwall protection will be provided for a minimum of 5' above and around the inlet structure. Headwall protection will be of 18" D_{50} rip-rap, as shown on Figure 10.

A small side drainage enters Crandall Creek just west of the bypass culvert inlet. As the drainage calculations took into consideration the runoff from this side canyon, the bypass culvert and inlet riprap are adequately sized to handle drainage from this side canyon. The riprap has been extended up this drainage for a short distance (see Map 5-3) in order to protect the culvert inlet area.

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2.13 Main Canyon Culvert - Outlet Structure

The outlet of the 6' diameter main canyon culvert has been designed to flow into a rip-rap apron to protect against scouring and for energy dissipation. The rip-rap apron is designed to fit the natural channel configuration as closely as possible, and will allow runoff to re-enter the natural channel at a reduced velocity which is no greater than natural flow conditions. Runoff from the 100 year - 6 hour precipitation event in the canyon above the minesite has been calculated at 222.79 cfs.

The rip-rap apron design is based on Figure 7-26, Design of Outlet Protection - Maximum Tailwater Condition, "Applied Hydrology and Sedimentology for Disturbed Areas", Barfield, Warner and Haan, 1983. Based on the figure, the apron should be a minimum of 22' in length, widening from 6' to 15', with a 0% slope. The proposed length has been increased to 30', with an 18' width, to ensure adequate time for velocity reduction. The slope is kept at 0%. Rip-rap size is conservatively placed at 30" D_{50}. Rip-rap will be placed to a depth of 1.5 D_{50} and will be embedded in a 12" layer of 2" drain rock filter. Rip-rap will also be placed on 1:1 side slopes to the height of the culvert (6') at the culvert outlet tapering to 3' at the outlet of the apron. This rip rap apron has been sized and designed to adequately dissipate energy from flow velocities of a 100 year, 24 hour precipitation event and resist dislodgement. The drain rock filter bed will also serve to secure the rip rap boulders firmly in place, to add an additional element of stability, and prevent scouring underneath the boulder bed.

The natural channel below the proposed outlet has been measured from field surveys to have a bottom width of approximately 17' at the proposed apron outlet, with side slopes approximately 1:1. When the flow is routed from the culvert across the apron to the natural channel, the velocity is reduced from 21.70 fps at the culvert outlet to 10.83 fps at the outlet of the apron. Refer to 72" Culvert Outlet Rip-Rap Apron Flow Velocity Calculations in Section 4.6. Based on actual field measurements, the

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natural channel flow velocity would be approximately 11.02 fps at this location with the same flow of 222.79 cfs. Therefore, the velocity of the stream flow exiting the rip rap apron will be less than the velocity in the naturally existing stream bed, at that location, under similar conditions.

TABLE 1
WATERSHED SUMMARY

Watershed	Type	CN	Acres	Drains To		Final
Crandall	Undisturbed	69	3480.00	Main Culvert	-	Crandall Creek
WSUD-1	Undisturbed	69	84.88	Culvert UD-1	-	Crandall Creek
WSUD-2	Undisturbed	69	1.39	Ditch UD-2	-	Culvert UD-1
WSUD-3	Undisturbed	69	8.66	Culvert UD-3	-	Natural Drainage
WSDD-1	Undisturbed	69	0.14	Ditch DD-1	-	Sediment Pond
WSDD-1	Reclaimed	75	0.08	Ditch DD-1	-	Sediment Pond
WSDD-2	Reclaimed	75	0.15	Ditch DD-1	-	Sediment Pond
WSDD-3	Undisturbed	69	0.13	Ditch DD-3	-	Sediment Pond
WSDD-3	Reclaimed	75	0.15	Ditch DD-3	-	Sediment Pond
WSDD-3	Disturbed	90	0.26	Ditch DD-3	-	Sediment Pond
WSDD-3	Paved	95	0.33	Ditch DD-3	-	Sediment Pond
WSDD-4	Paved Road	95	0.11	Ditch DD-4	-	Sediment Pond
WSDD-4	Disturbed	90	0.08	Ditch DD-4	-	Sediment Pond
WSDD-5	Undisturbed	69	0.12	Ditch DD-5	-	Sediment Pond
WSDD-5	Reclaimed	75	0.33	Ditch DD-5	-	Sediment Pond
WSDD-5	Paved Road	95	0.33	Ditch DD-5	-	Sediment Pond
WSDD-7	Undisturbed	69	0.18	Ditch DD-7	-	Sediment Pond
WSDD-7	Disturbed	90	0.17	Ditch DD-7	-	Sediment Pond
WSDD-8	Undisturbed	69	3.59	Ditch DD-8	-	Sediment Pond
WSDD-8	Reclaimed	75	0.15	Ditch DD-8	-	Sediment Pond
WSDD-8	Disturbed	90	0.37	Ditch DD-8	-	Sediment Pond
WSDD-8	Paved Road	95	0.25	Ditch DD-8	-	Sediment Pond
WSDD-10	Undisturbed	69	0.07	Culvert C-4	-	Sediment Pond
WSDD-10	Reclaimed	75	0.12	Culvert C-4	-	Sediment Pond
WSDD-10	Disturbed	90	0.61	Culvert C-4	-	Sediment Pond
WSDD-10	Paved Road	95	0.27	Culvert C-4	-	Sediment Pond
WSDD-11	Undisturbed	69	2.09	Ditch DD-11	-	Sediment Pond
WSDD-11	Reclaimed	75	0.15	Ditch DD-11	-	Sediment Pond
WSDD-11	Disturbed	90	0.04	Ditch DD-11	-	Sediment Pond
WSDD-12	Undisturbed	60	8.82	Ditch DD-12	-	Sediment Pond
WSDD-12	Disturbed	90	2.29	Ditch DD-12	-	Sediment Pond
WSDD-13	Undisturbed	60	17.72	Ditch DD-13	-	Sediment Pond
WSDD-13	Disturbed	90	3.70	Culvert C-13	-	Sediment Pond
WSDD-13	Paved	95	0.27	Culvert C-13	-	Sediment Pond
WSDD-14	Disturbed	90	0.89	Sediment Pond	-	Sediment Pond
WSDD-14	Undisturbed	60	0.78	Sediment Pond	-	Sediment Pond
WSDD-14	Paved	95	0.02	Sediment Pond	-	Sediment Pond
WSDD-15	Paved Road	95	0.09	Ditch DD-7	-	Sediment Pond

TABLE 2
WATERSHED PARAMETERS

Watershed	Type	CN	Acres	Hyd. Length (ft.)	Land Slope (%)	Elev. Change(ft.)
Crandall	Und.	69	3480.00	16,500	17.58	2900
WSUD-1	Und.	69	84.88	3,100	53.55	1660
WSUD-2	Und.	69	1.39	320	78.13	250
WSUD-3	Und.	69	8.66	1300	70.77	920
WSDD-1	Und.	69	0.14	100	40.00	40
WSDD-1	Recl.	75	0.08	120	25.00	30
WSDD-2	Recl.	75	0.15	200	25.00	50
WSDD-3	Und.	69	0.13	80	50.00	40
WSDD-3	Recl.	75	0.15	100	48.00	48
WSDD-3	Dist.	90	0.26	125	56.00	70
WSDD-3	Paved	95	0.33	100	3.00	3
WSDD-4	Paved	95	0.11	250	8.33	20
WSDD-4	Dist.	90	0.08	100	10.00	10
WSDD-5	Und.	69	0.12	60	50.00	30
WSDD-5	Recl.	75	0.33	80	50.00	40
WSDD-5	Paved	95	0.33	300	8.33	25
WSDD-7	Und.	69	0.18	100	78.00	78
WSDD-7	Dist.	90	0.17	120	66.67	80
WSDD-8	Und.	69	3.59	700	65.71	460
WSDD-8	Recl.	75	0.15	80	62.50	50
WSDD-8	Dist.	90	0.37	60	65.71	39
WSDD-8	Paved	95	0.25	560	5.36	30
WSDD-10	Und.	69	0.07	45	62.22	28
WSDD-10	Recl.	75	0.12	50	72.00	36
WSDD-10	Dist.	90	0.61	120	62.50	75
WSDD-10	Paved	95	0.27	335	5.37	18
WSDD-11	Und.	69	2.09	570	64.91	370
WSDD-11	Recl.	75	0.15	30	66.67	20
WSDD-11	Dist.	90	0.04	35	66.67	23
WSDD-12	Und.	60	8.82	1600	42.50	680
WSDD-12	Dist.	90	2.29	80	72.73	58
WSDD-13	Und.	60	17.72	2100	53.81	1130
WSDD-13	Dist.	90	3.70	650	9.09	59
WSDD-13	Paved	95	0.27	40	4.00	2
WSDD-14	Dist.	90	0.89	140	16.11	23
WSDD-14	Und.	60	0.78	380	64.41	245
WSDD-14	Paved	95	0.02	30	3.00	1
WSDD-15	Paved	95	0.09	150	3.33	5

TABLE 3
RUNOFF SUMMARY
UNDISTURBED DIVERSIONS

Diversion	Main Culvert	UD-1	UD-2	UD-3
Watershed	Crandall Canyon	WSUD-1	WSUD-2	WSUD-3
Area (Acres)	3480.0	84.88	1.39	8.66
Runoff CN	69	69	69	69
10 year/6 hour Rainfall (in.)	1.55	1.55	1.55	1.55
Peak Flow 10/6 (cfs)	N/A	1.91	0.04	0.23
25 year/6 hour Rainfall (in.)	1.90	1.90	1.90	1.90
Peak Flow 25/6 (cfs)	N/A	3.68	0.08	0.43
100 year/6 hour Rainfall (in.)	2.40	2.40	2.40	2.40
Peak Flow 100/6 (cfs)	222.79	6.81	0.21	0.89
10 year/24 hour Rainfall (in.)	N/A	2.50	2.50	2.50
Runoff Volume 10/24 (ac.ft.)	N/A	2.98	0.05	0.30

TABLE 4
RUNOFF SUMMARY
DRAINAGE TO SEDIMENT POND

Watershed	Type	10 year/24 hour Volume-ac.ft.	10 year/24 hour Peak Flow-cfs	10 year/6 hour Peak Flow-cfs	25 year/6 hour Peak Flow-cfs
WSDD-1	Undisturbed	0.02	0.10	0.04	0.06
WSDD-1	Reclaimed	0.01	0.04	0.01	0.01
WSDD-2	Reclaimed	0.01	0.06	0.01	0.03
WSDD-3	Undisturbed	0.00	0.03	0.00	0.01
WSDD-3	Reclaimed	0.01	0.05	0.01	0.02
WSDD-3	Disturbed	0.03	0.18	0.08	0.12
WSDD-3	Paved	0.05	0.32	0.17	0.22
WSDD-4	Paved	0.02	0.12	0.07	0.09
WSDD-4	Disturbed	0.01	0.08	0.04	0.05
WSDD-5	Undisturbed	0.00	0.03	0.00	0.01
WSDD-5	Reclaimed	0.02	0.10	0.02	0.04
WSDD-5	Paved	0.05	0.39	0.21	0.27
WSDD-7	Undisturbed	0.01	0.05	0.00	0.01
WSDD-7	Disturbed	0.02	0.12	0.05	0.07
WSDD-7	Paved	0.02	0.11	0.06	0.08
WSDD-8	Undisturbed	0.13	0.75	0.10	0.20
WSDD-8	Reclaimed	0.01	0.05	0.01	0.02
WSDD-8	Disturbed	0.05	0.23	0.10	0.14
WSDD-8	Paved	0.04	0.37	0.20	0.26
WSDD-10	Undisturbed	0.00	0.03	0.00	0.01
WSDD-10	Reclaimed	0.01	0.03	0.01	0.01
WSDD-10	Disturbed	0.08	0.42	0.19	0.27
WSDD-10	Paved	0.04	0.35	0.19	0.24
WSDD-11	Undisturbed	0.07	0.47	0.06	0.12
WSDD-11	Reclaimed	0.01	0.04	0.01	0.02
WSDD-11	Disturbed	0.01	0.06	0.03	0.04
WSDD-12	Undisturbed	0.13	0.25	0.04	0.16
WSDD-12	Disturbed	0.29	3.33	1.51	2.10
WSDD-13	Undisturbed	0.26	0.49	0.07	0.30
WSDD-13	Disturbed	0.47	5.39	2.44	3.39
WSDD-13	Paved	0.04	0.20	0.11	0.14
WSDD-14	Disturbed	0.11	0.78	0.35	0.49
WSDD-14	Undisturbed	0.01	0.03	0.00	0.02
WSDD-14	Paved	0.02	0.07	0.04	0.05
Totals		2.06	15.13	6.23	9.07

TABLE 5
RUNOFF CONTROL STRUCTURE
WATERSHED SUMMARY

Structure	*Type*	*Contributing Watersheds*
Main Culvert	Culvert	Crandall Canyon Above Mine
UD-1	Culvert	WSUD-1
UD-2	Culvert	WSUD-2
UD-3	Culvert	WSUD-3
DD-1	Ditch	WSDD-1, WSDD-2
DD-3	Ditch	WSDD-1, WSDD-2, WSDD-3
DD-4	Ditch	WSDD-1, WSDD-2, WSDD-3, WSDD-4, WSDD-8, WSDD-12
DD-5	Ditch	WSDD-1, WSDD-2, WSDD-3, WSDD-4, WSDD-5, WSDD-8, WSDD-12
DD-7	Ditch	WSDD-7, WSDD-11
DD-8	Ditch	WSDD-8
DD-11	Ditch	WSDD-11
DD-12	Ditch	WSDD-12
DD-13	Ditch	WSDD-13
DD-14	Sheet Flow	WSDD-14
C-1	Culvert	WSDD-1, WSDD-2, WSDD-3, WSDD-8
C-3	Culvert	WSDD-7, WSDD-11, WSDD-15
C-4	Culvert	WSDD-10
C-5	Culvert	WSDD-11
C-6	Culvert	WSUD-2
C-7	Culvert	WSDD-1, WSDD-2, WSDD-3
C-9	Culvert	WSDD-4, WSDD-12
C-11	Culvert	WSDD-12
C-11A	Culvert	WSDD-12
C-12	Culvert	WSDD-1, 2, 3, 4, 5, 8, 12
C-13	Culvert	WSDD-13
C-14	Slot Culvert	WSDD-4
C-15	Slot Culvert	WSDD-15
C-16	Culvert	WSDD-13
C-17	Culvert	WSDD-13
Sediment Pond	Pond	WSDD-1, 2, 3, 4, 5, 7, 8, 10, 11, 12, 13, 14

TABLE 6
RUNOFF CONTROL STRUCTURE
FLOW SUMMARY

Structure	Type	10 year/6 hour Peak Flow-cfs	10 year/24 hour Peak Flow-cfs	25 year/6 hour Peak Flow-cfs	100 year/6 hour Peak Flow-cfs
Main Culvert	Culvert	-	-	-	222.79
UD-1	Culvert	1.91	-	3.68	6.81
UD-2	Ditch	0.04	-	0.08	0.21
UD-3	Culvert	0.23	-	0.43	0.89
DD-1	Ditch	0.06	0.20	0.10	-
DD-3	Ditch	0.32	0.78	0.47	-
DD-4	Ditch	2.39	5.96	3.49	-
DD-5	Ditch	2.62	6.48	3.81	-
DD-7	Ditch	0.21	0.85	0.34	-
DD-8	Ditch	0.41	1.40	0.62	-
DD-11	Ditch	0.10	0.57	0.18	-
DD-12	Ditch	1.55	3.58	2.26	-
DD-13	Ditch	2.62	6.08	3.83	-
DD-14	Sht Flw	0.39	0.88	0.56	-
C-1	Culvert	0.73	2.18	1.09	-
C-3	Culvert	0.21	0.85	0.34	-
C-4	Culvert	3.01	6.79	4.02	-
C-5	Culvert	0.10	0.57	0.18	-
C-6	Culvert	0.04	-	0.08	-
C-7	Culvert	0.32	0.78	0.47	
C-9	Culvert	0.11	0.20	0.14	-
C-11	Culvert	1.55	3.58	2.26	-
C-11A	Culvert	1.55	3.58	2.26	
C-12	Culvert	2.62	5.96	3.49	-
C-13	Culvert	2.62	6.08	3.83	-
C-14	Slot Cul.	0.11	0.20	0.14	-
C-15	Slot Cul.	0.06	0.11	0.08	-
C-16	Culvert	2.62	6.08	3.83	-
C-17	Culvert	2.62	6.08	3.83	-
Sediment Pond	Pond	6.23	15.13	9.07	-

TABLE 7
DISTURBED DITCH DESIGN SUMMARY

Ditch	***DD-1***	***DD-3***	***DD-4***	***DD-5***	***DD-7***	***DD-8***	***DD-11***
Slope (%)	30.77	3.00	11.91	4.50	3.33	3.59	3.00
Length (ft.)	130	75	168	628	142	557	173
Manning's No.	0.035	0.035	0.035	0.035	0.035	0.035	0.035
Side Slope (H:V)	1:1	1:1	1:1	1:1	1:1	1:1	1:1
****Bottom Width (ft.)***	0	0	0	0	0	0	0
Peak Flow 10/6 (cfs)	0.06	0.32	2.39	2.62	0.21	0.41	0.10
Peak Flow 10/24 (cfs)	0.20	0.78	5.96	6.48	0.85	1.40	0.57
Flow Depth (ft.) 10/6	0.14	0.40	0.66	0.75	0.33	0.47	0.26
Flow Depth (ft.) 10/24	0.22	0.56	0.92	1.06	0.57	0.67	0.50
Flow Area (ft^2)10/6	0.02	0.16	0.43	0.57	0.11	0.18	0.07
Flow Area (ft^2)10/24	0.05	0.31	0.85	1.12	0.32	0.45	0.25
Velocity (fps)10/6	3.15	2.00	5.55	4.61	1.87	2.28	1.50
Velocity (fps) 10/24	4.26	2.50	6.97	5.78	2.66	3.10	2.31
Rip-Rap Req'd (Y/N)	N	N	Y	N	N	N	N
Rip-Rap D_{50}	-	-	6"	-	-	-	-

***** All ditches are triangular.***
Note: Slope/Lengths from Plate 7-5.

TABLE 7
(Continued)
DISTURBED DITCH DESIGN SUMMARY

Ditch	*DD-12*	*DD-13 (MIN.)*	*DD-13 (MAX.)*
Slope (%)	*3.29*	*1.79*	*50.00*
Length (ft.)	*50*	*280*	*80*
Manning's No.	*0.035*	*0.035*	*0.035*
Side Slope (H:V)	*1:1*	*1:1*	*2:1*
Bottom Width (ft.)	*0*	*0*	*2*
Peak Flow 10/6 (cfs)	*1.55*	*2.62*	*2.62*
Peak Flow 10/24 (cfs)	*3.58*	*6.08*	*6.08*
Flow Depth (ft.) 10/6	*0.71*	*0.97*	*0.15*
Flow Depth (ft.) 10/24	*0.97*	*1.33*	*0.24*
Flow Area (ft^2) 10/6	*0.50*	*0.94*	*0.34*
Flow Area (ft^2) 10/24	*0.94*	*1.77*	*0.60*
Velocity (fps) 10/6	*3.07*	*2.79*	*7.66*
Velocity (fps) 10/24	*3.79*	*3.44*	*10.12*
Rip-Rap Req'd (Y/N)	*N*	*N*	*Y*
Rip-Rap D_{50}	*-*	*-*	*9"*

** All ditches are triangular.*
Note: Slope/Lengths from Plate 7-5.
Note: DD-12 is shortened due to construction of the south portal access ramp/fan pad.

TABLE 8
UNDISTURBED DITCH DESIGN SUMMARY

Ditch	***UD-2***
Slope (%)	***12.5***
Length (ft.)	***400***
Manning's No.	***0.035***
Side Slope (H:V)	***1:1***
Bottom Width (ft.)	***0***
Peak Flow-10/6 (cfs)	***0.04***
Flow Depth (ft.)	***0.14***
Flow Area (ft^2)	***0.02***
Velocity (fps)	***2.03***
Lined (Y/N)	***N***
Rip-Rap Req'd (Y/N)	***N***

Note: ***Slope/Lengths from Plate 7-5.***

TABLE 9
DISTURBED CULVERT DESIGN SUMMARY

Culvert	C-1	C-3	C-4	C-5	C-6	C-7	C-9	C-11	C-11A	C-12	C-13	C-14	C-15	C-16	C-17
Slope (%)	16.67	8.00	25.07	57.14	17.20	3.00	3.50	3.50	1.50	4.50	3.00	1.00	1.00	25.00	20.00
Length (ft.)	60	360	69	120	12	80	18	30	60	330	100	40	30	40	60
Manning's No.	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Peak Flow 10/6 (cfs)	0.73	0.21	3.01	0.10	0.04	0.32	0.11	1.55	1.55	2.62	2.62	0.11	0.06	2.62	2.62
Peak Flow 10/24 (cfs)	2.18	0.85	6.79	0.57	N/A	0.78	0.20	3.58	3.58	5.96	6.08	0.20	0.11	6.08	6.08
Min. Diam. Req'd (ft.) 10/6	0.41	0.28	0.60	0.14	0.13	0.39	0.25	0.68	0.80	0.79	0.85	0.32	0.25	0.57	0.60
Min. Diam. Req'd (ft.) 10/24	0.62	0.46	0.82	0.28	N/A	0.54	0.32	0.93	1.09	1.08	1.17	0.40	0.32	0.79	0.82
Diam. Installed (ft.)	1.50	2.00	2.00	1.00	1.00	1.00	1.00	1.50	1.50	2.00	2.00	1.00	1.00	1.67	1.50
Velocity (fps) 10/6	5.55	3.53	10.54	6.13	3.11	2.71	2.20	4.27	3.10	5.35	4.59	1.38	1.18	10.17	9.35
Velocity (fps) 10/24	7.30	5.01	12.91	9.47	N/A	3.39	2.56	5.26	3.83	6.56	5.67	1.60	1.38	12.55	11.54
Rip-Rap D_{50}	6"	-	12"	6"	-	-	-	-	-	6"	-	-	-	12"	12"

Note: Slope/Lengths from Plate 7-5.
Source: (Haestad Methods, Flowmaster I, Version 3.42)

TABLE 10
UNDISTURBED CULVERT DESIGN SUMMARY

Culvert	*Main Canyon	UD-1	UD-3
Slope (%)	8.00	23.33	11.96
Length (ft.)	1500	270	460
Manning's No.	0.02	0.02	0.02
Peak Flow 100/6 (cfs)	222.79	-	-
Peak Flow 10/6 (cfs)	-	1.91	0.23
Min. Diam. Req'd (ft.)	3.75	0.52	0.26
Diam. Installed (ft.)	6.00	3.50	2.00
Velocity (fps)	20.14	9.16	4.20

* Culvert to be installed under expansion plan.
All other undisturbed culverts are existing.

Note: Slope/Lengths from Plate 7-5.
Source: (Haestad Methods, Flowmaster I, Version 3.43)

Design Specifications:

Tables:

Figures:

3.1 ***Design Specification for Expanded Sediment Pond***

The sedimentation pond located in Crandall Canyon has been redesigned and reconstructed to control the additional storm runoff from the pad extension and from the undisturbed drainage areas above the pad extension. The "As-Constructed" topography and cross sections of the pond design are shown on Plate 7-3.

The pond has been sized to meet the requirements of R645-301-742.221.33 (DOGM), which stipulates that sedimentation ponds be capable of containing or treating the 10-year 24-hour precipitation event. According to Miller, et al (1973), the 10-year, 24-hour design storm for Crandall Canyon is 2.5 inches. The design storm calculations for the sedimentation pond are presented in Table 4 of this Appendix. These calculations include the proposed pad extension, the additional watersheds above the pad extension, the existing pad and reclaimed areas, and the undisturbed watersheds above the existing pad.

As required by R645-301-742.223, the 25 year-6 hour precipitation event was routed through the sedimentation pond to determine the adequacy of the spillway. Overflow from the pond is discharged to Crandall Creek. Total precipitation from the 25 year-6 hour storm is 1.9 inches (Miller, et al, 1973). The 25 year-6 hour flow is calculated at 9.07 cfs. Based on the calculations, the primary spillway is more than adequate to carry the expected runoff from a 25 year-6 hour event.

3.2 **Sediment Yield**

The Universal Soil Equation (USLE) was used to estimate sediment yield from all drainage areas contributing to the pond. All soil loss from this area was assumed to be delivered to, and deposited in the sedimentation pond.

Erosion rate (A) in tons-per-acre-per-year is determined using the USLE as follows:

$$A = (R)(K)(LS)(CP)$$

Where the variables R, K, LS, and CP are defined as follows:

Variable "R" is the rainfall factor which can be estimated from $R = 27P^{2.2}$; where P is the 2-year, 6-hour precipitation value. P for the Crandall Canyon area is estimated at 1.00" based on Figure 5.4, page 315, Barfield, et.al. 1983. Therefore, the estimated value of "R" for this area is 27.00.

Variable "K" is the soil erodibility factor. For disturbed areas, the "K" value is taken as 0.06 as determined from soils samples and shown on the soil erodibility chart, Figure 4. K is estimated to be 0.15 for undisturbed and reclaimed areas, based on soils data and the soil erodibility chart, Figure 5.

Variable "LS" is the length-slope factor. This figure was determined by calculating a weighted average slope length and percentage for the undisturbed, reclaimed and disturbed areas, respectively. The slope length and percentage were then substituted into the following equation to determine the LS Factor:

$$LS = \left(\frac{\pi}{72.6}\right)^{m}\left(\frac{430\,x^2 + 30\,x + 0.43}{6.613}\right)$$

where:

π = ***Field slope length in feet;***

m = ***0.5 if S is 5% or greater;***

x = ***sin θ;***

θ = ***Angle of slope in degrees.***

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Variable "CP" is the control practice factor, which can be divided into a cover and practice factor. Values were determined from Appendix 5A, Barfield, et.al., 1983.

Site	CP Factor
Disturbed Areas	1.20
Reclaimed Areas	0.100
Undisturbed Areas	0.003

The sediment volume is based on a density of 100 pounds per cubic foot of sediment.

SEDIMENT YIELD CALCULATIONS - USLE

Drainage	R	K	Acres	Slope Length Feet	%	LS	CP	A*	Yield**
Undisturbed	27.00	0.15	33.59	1700	53	79.60	0.003	00.967	0.015
Reclaimed	27.00	0.15	1.22	90	52	17.81	0.10	07.213	0.004
Disturbed	27.00	0.06	8.92	350	26	11.69	1.200	22.725	0.093

Total Sediment 1 year (ac.ft.)..0.112

Total Sediment 3 years (ac. ft.) 0.336

* A = tons/acre-year
** Yield = acre-ft/year

3.3 Sediment Pond Volume

The volumes shown in Table 11 are from the volumes calculated from the precipitation, runoff and sediment yield for a 10 year-24 hour precipitation event. The volumes were calculated based on the disturbed areas (and contributing undisturbed areas) runoff values, developed using the design parameters described in this section.

The sediment pond has been reconstructed, and the sediment pond volumes on Table 11, Table 12 and Figure 6 all represent the "As-Constructed" pond.

Expanded Area Pond Requirement
3 Year Sediment Storage

TABLE 11
SEDIMENT POND DESIGN

1.	*Use 2.50" for 10 year-24 hour event.*	
2.	*Runoff Volume (from Table 4, 10 yr/24 hr) =*	*2.060 ac. ft.*
3.	*Sediment Storage Volume*	
	USLE 0.112 ac.ft./yr. x 3 yrs. =	*0.336 ac. ft.*
4.	*Direct Precipitation into Pond*	
	0.441 acres x 2.50" / 12 in./ft. =	*0.092 ac. ft.*
5.	*Total Required Pond Volume*	
	2.060 + 0.336 + 0.092 =	*2.488 ac. ft.*
6.*	*Peak Flow (25 yr. - 6 hr. event) =*	*9.070 cfs*
7.	*Pond Actual Volume @ Principle Spillway = (See Table 12)*	*3.572 ac. ft.*

* *Peak Flow values from Table 4.*

TABLE 12
SEDIMENT POND
STAGE / VOLUME DATA

Elev.	Area	Volume	Acc. Volume (ac.ft.)	Remarks
7891	1981.95	.0000	.0000	Bottom of Pond
7892	4321.66	3151.81	0.0742	
7893	5600.21	4960.94	0.1862	
7894	6493.24	6046.71	0.3251	Sediment Cleanout level
7895.5	7302.36	6897.79	0.4834	Maximum Sediment Level
7896	8082.95	7692.66	0.6600	
7897	8894.51	8488.73	0.8579	
7898	9975.02	9434.77	1.0715	
7899	11055.91	10515.47	1.3129	
7900	12153.06	11604.49	1.5793	
7901	13120.22	12636.64	1.8694	
7902	14084.05	13602.14	2.1816	
7903	15043.33	14563.69	2.5160	
7904	.3284	15514.00	2.8721	
7905	.3544	16459.15	3.2500	
7905.81	.3816	14014.70	3.5717	Principal Spillway
7906	.4089	3373.83	3.6492	
7906.81	.4355	14694.57	3.9865	Emergency Spillway
7907	.4486	3516.78	4.0672	
7908	.4614	19033.61	4.5042	
7909	.4773	20271.80	4.9696	
7910	.4935	21611.97	5.4657	Top of Embankment

TABLE 13
SEDIMENT POND
STAGE / DISCHARGE DATA

Head (ft.)	*Q (cfs) Weir Controlled*	*Q (cfs) Orfice Controlled*	*Q (cfs) Pipe Flow Controlled*
0.0	-	-	-
0.2	*1.69*	*6.77*	*17.14*
0.4	*4.77*	*9.57*	*17.32*
0.6	*8.76*	*11.72*	*17.50*
0.8	*13.49*	*13.53*	*17.68*
1.0	*18.85*	*15.13*	*17.86*

Note: 1- *25 year-6 hour flow = 9.070 cfs.*
2- *Flow will be weir controlled at a head of 0.62' over riser inlet.*

Weir Controlled

$Q = CLH^{1.5}$; *where :* $C = 3.0$, L = *Circumference of Riser* = 6.2832'

Orifice Controlled

$Q = C'a\,(2gH)^{0.5}$; *where :* $C = 0.6$, a = *Area of Riser* = 3.1416 ft^2, $g = 32.2\ ft/sec^2$

Pipe Flow Controlled

$$Q = \frac{a\,(2gH')0.5}{(1+Ke+Kb+KcL)^{0.5}}$$; *where* a = *Area of Pipe* = 1.77 ft^2

H' = *Head* = $H + 9.1$ *(At outlet of Riser)*

$Ke = 1.0$

$Kb = 0.5$

$Kc = 0.043$

$L = 90'$

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3.4 Sediment Pond Summary

a) ***The sedimentation pond has been designed and constructed to contain the disturbed area (and contributing undisturbed area) runoff from a 10 year-24 hour precipitation event, along with 3 years of sediment storage capacity. Runoff to the pond will be directed by various ditches and culverts as described in the plan.***

b) ***The required volume for the sediment pond is calculated at 2.488 acre feet, including 3 years of sediment storage. The existing sediment pond size is 3.572 acre feet (at the principle spillway), which is more than adequate.***

c) ***The pond will meet a theoretical detention time of 24 hours. It is equipped with a culvert principle spillway and an open-channel emergency spillway. Any discharge from the pond will be in accordance with the approved UPDES Permit. The pond will be decanted as needed by a portable pump.***

d) ***The pond inlets will be protected from erosion, and the spillway will discharge into the main Crandall Canyon drainage.***

e) ***The pond is temporary, and will be removed upon final reclamation of the property.***

f) ***The pond expansion was constructed according to the regulations and under supervision of a Registered, Professional Engineer.***

g) ***The pond volume has been increased at the request of the Forest Service to provide a greater level of protection for the forest resources down stream from the mine site. The enlarged capacity (3.572 acre ft.) is over- designed to handle the following storm events :***

Storm Event	Pond Volume Required	Pond Capacity Provided
10 yr./ 24 hr.	2.06 acre ft.	173%
100 yr./ 6hr.	1.93 acre ft.	185%
50 yr./24 hr.	3.53 acre ft.	101%
100 yr./ 24 hr.	4.51 acre ft.	79%

DESIGN OF DRAINAGE CONTROL STRUCTURES FOR RECLAMATION

Reclamation Hydrology

4.1 General (Phase I)

During Phase I of reclamation, all disturbed area culverts and ditches will be removed except as shown on Plate 5-16. Undisturbed diversions UD-2 and UD-3 will also be removed, and the drainage from those areas will be directed to the sediment pond. Undisturbed diversion UD-1 will remain in place as a permanent structure for the following reasons:

(1) The diversion is necessary to continue to divert runoff from the reclaimed site, the U.S. Forest Service turnaround area and beneath the U.S. Forest Service Road;

(2) The 10 year-24 hour storm runoff from WSUD-1 is approximately 2.98 acre feet, which combined with runoff from the reclaimed site, exceeds the holding capacity of the sediment pond;

(3) The existing diversion is a 42" full-round C.M.P. pipe, which is well in excess of the size required to carry runoff from a 100 year-6 hour storm event for the area (See Table 10).

The main canyon 72" culvert will also be removed during Phase I reclamation, except for the lower approximately 300', which will be left in place to divert undisturbed and treated runoff beneath the sediment pond. Once the main canyon culvert is removed, Crandall Creek will be directed back to the original drainage channel through the area. Silt fences will be installed on both sides of the restored channel to treat runoff from the reclaimed pad areas, as shown on Plate 5-16.

The U.S. Forest Service Road will be left as a permanent feature. A berm and ditch (RD-1) will be established along the road. This ditch will direct all runoff from areas above the road to the sediment pond. The sediment pond will remain in place until Phase II of reclamation.

Watersheds are shown on Plates 7-5 and 7-5C. Reclamation drainage details are shown on Plates 5-16 and 5-17.

4.2 General (Phase II)

Once the criteria for Phase II Bond Release are met, the sediment pond will be removed and, the area recontoured and reseeded according to the plan. The remaining 300' of the main canyon 72" culvert will also be removed at this time. At the discretion of the U.S. Forest Service, the berm along the road can also be removed at this time, or left in place. If the berm if left in place, reclaimed ditch RD-1 will be extended through the reclaimed pond area to the main channel.

4.3 Reclamation - Disturbed Drainage Control

Drainage from all contributing watersheds above the U.S. Forest Service Road, except WSUD-1, will be collected in a reclamation ditch (RD-1) and diverted into the sediment pond during Phase I reclamation. Drainage from the reclaimed areas and contributing watersheds below the road, will be treated through silt fences along the restored natural main channel, during Phase I reclamation.

Approximately 300' of the main canyon culvert will remain in place beneath the sediment pond area during Phase I.

Upon Phase II reclamation, the sediment pond will be removed and the area restored. The remaining portion of the main canyon culvert will also be removed at this time. Silt fences along the previously reclaimed channel section may also be removed during Phase II; however, additional silt fences will be installed along the 300' section of culvert removal channel restoration.

Undisturbed diversion UD-1 will remain in place as a permanent diversion, as mentioned previously.

4.4 Restored Channels

Upon final reclamation, the main canyon drainage will be returned to the natural channel. During construction, this channel is to be covered by filter fabric and an underdrain system. The culvert will then be placed over the protected channel. Upon removal of the culvert, filter fabric will also be removed, exposing the natural channel. Construction in this manner will have a temporary effect on the riparian vegetation; however, this can readily be restored upon reclamation. Flow characteristics, bedding and other natural features of the natural channel will not be changed appreciably; therefore, no actual channel reconstruction or reclamation (beyond revegetation) is proposed.

No other channels are proposed to be restored within the reclaimed minesite.

4.5 Sediment Pond

The sediment pond will remain in place during Phase I reclamation. The pond will be removed during Phase II and all drainage will be returned to the Main Crandall Canyon channel at that time.

Calculations show the sediment pond to be adequately sized to contain the runoff from contributing watersheds from a 10 year-24 hour precipitation event, along with a minimum of 3 years of sediment storage. The principle and emergency spillways are each capable of passing the runoff from a 25 year-6 hour event, as required.

4.6 Calculations

For ease of calculation and to ensure a conservative runoff requirement for sediment pond adequacy, no curve numbers for contributing watersheds were changed for reclamation purposes. Contributing watershed characteristics and flows were taken from Tables 1 through 4 of this report. Watersheds and pre-reclamation drainage control are shown on Plates 7-5 and 7-5C. Phase I and Phase II drainage control are shown on Plates 5-16 and 5-17, respectively.

TABLE 14

RECLAMATION - PHASE I
RUNOFF SUMMARY
DRAINAGE TO SEDIMENT POND

Watershed	10 year/24 hour Volume-ac.ft.	10 year/ 6 hour Peak Flow-cfs	25 year/6 hour Peak Flow-cfs
WSUD-2	0.05	0.04	0.08
WSUD-3	0.30	0.23	0.43
WSDD-1	0.03	0.05	0.07
WSDD-2	0.01	0.01	0.03
WSDD-3	0.09	0.26	0.37
WSDD-4	0.03	0.11	0.14
WSDD-5	0.07	0.23	0.32
WSDD-7	0.05	0.11	0.16
WSDD-8	0.23	0.41	0.62
WSDD-10	0.13	0.39	0.53
WSDD-11	0.09	0.10	0.18
WSDD-14	0.13	0.39	0.56
Totals	1.21	2.33	3.49

Note: *Volumes and flows are totals from respective watersheds on Tables 3 and 4 of this report.*

TABLE 15

RECLAMATION - PHASE I RUNOFF CONTROL STRUCTURE WATERSHED SUMMARY

Structure	Type	Contributing Watersheds
Main Channel	Silt Fence	WSDD-12, WSDD-13
UD-1	Culvert	WSUD-1
RD-1	Ditch	WSUD-2, WSUD-3, WSDD-1 thru WSDD-11
Sediment Pond	Pond	WSUD-2, WSUD-3, WSDD-1 thru WSDD-11 and WSDD-14

TABLE 16

RECLAMATION - PHASE I RUNOFF CONTROL STRUCTURE FLOW SUMMARY

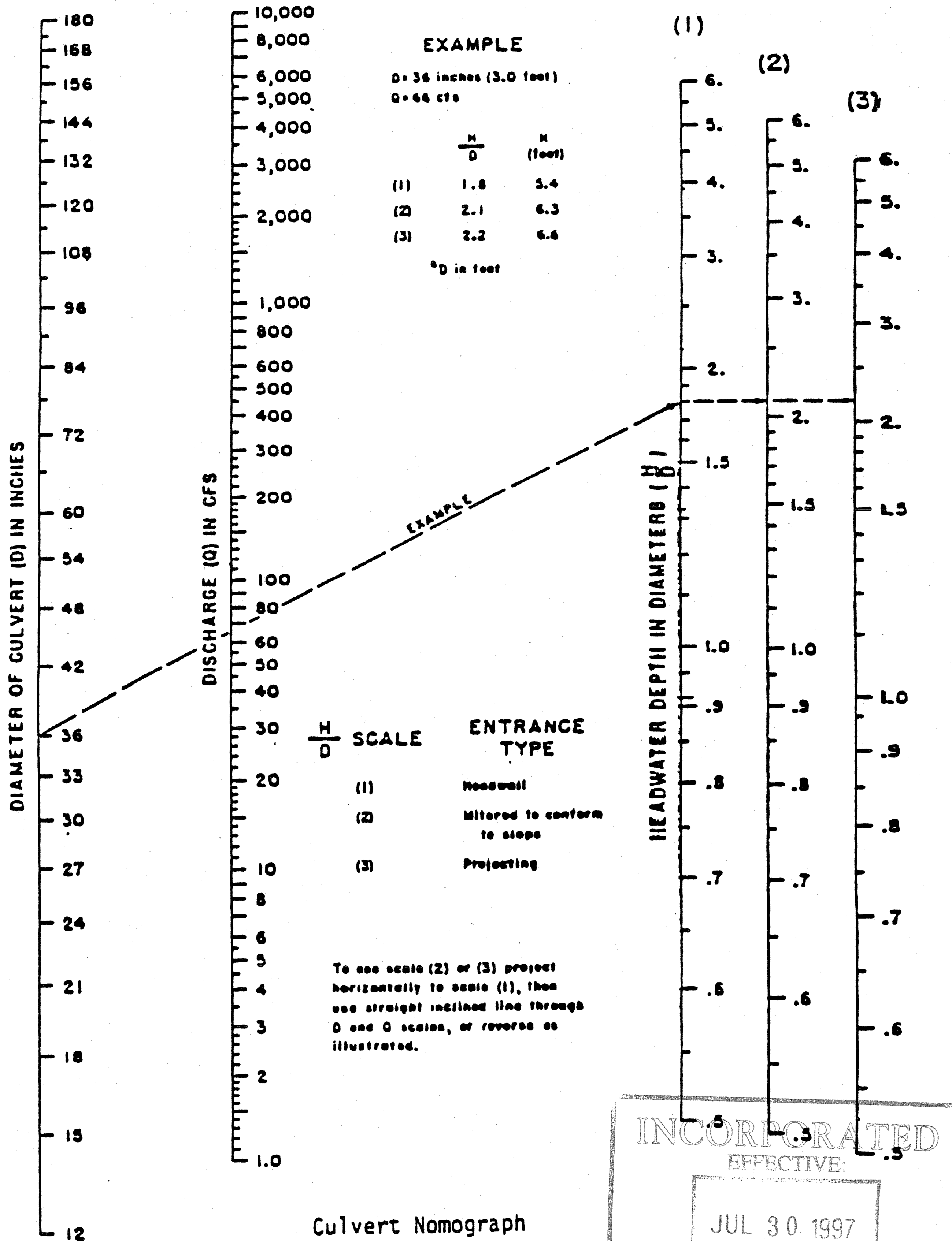
Structure	Type	10 year/6 hour Peak Flow (cfs)	25 year/6 hour Peak Flow (cfs)	100 year/6 hour Peak Flow (cfs)
Main Channel	Silt Fence	3.73	5.44	-
UD-1	Culvert	1.91	3.68	6.81
RD-1	Ditch	1.94	2.93	-
Sediment Pond	Pond	2.33	3.49	-

TABLE 17

RECLAMATION - PHASE 1
RECLAIMED DITCH DESIGN SUMMARY

Ditch	RD-1
Slope (%)	10.10
Length (ft.)	990
Manning's No.	0.035
Side Slope (H:V)	1.5:1
Bottom Width (ft.)	0
Peak Flow 10/6 (cfs)	1.94
Flow Depth (ft.)	0.52
Flow Area (ft^2)	0.40
Velocity (fps)	4.85
Lined (Y/N)	N
Rip Rap Req'd (Y/N)	N

Note: Slope / Length from Plate 5-16

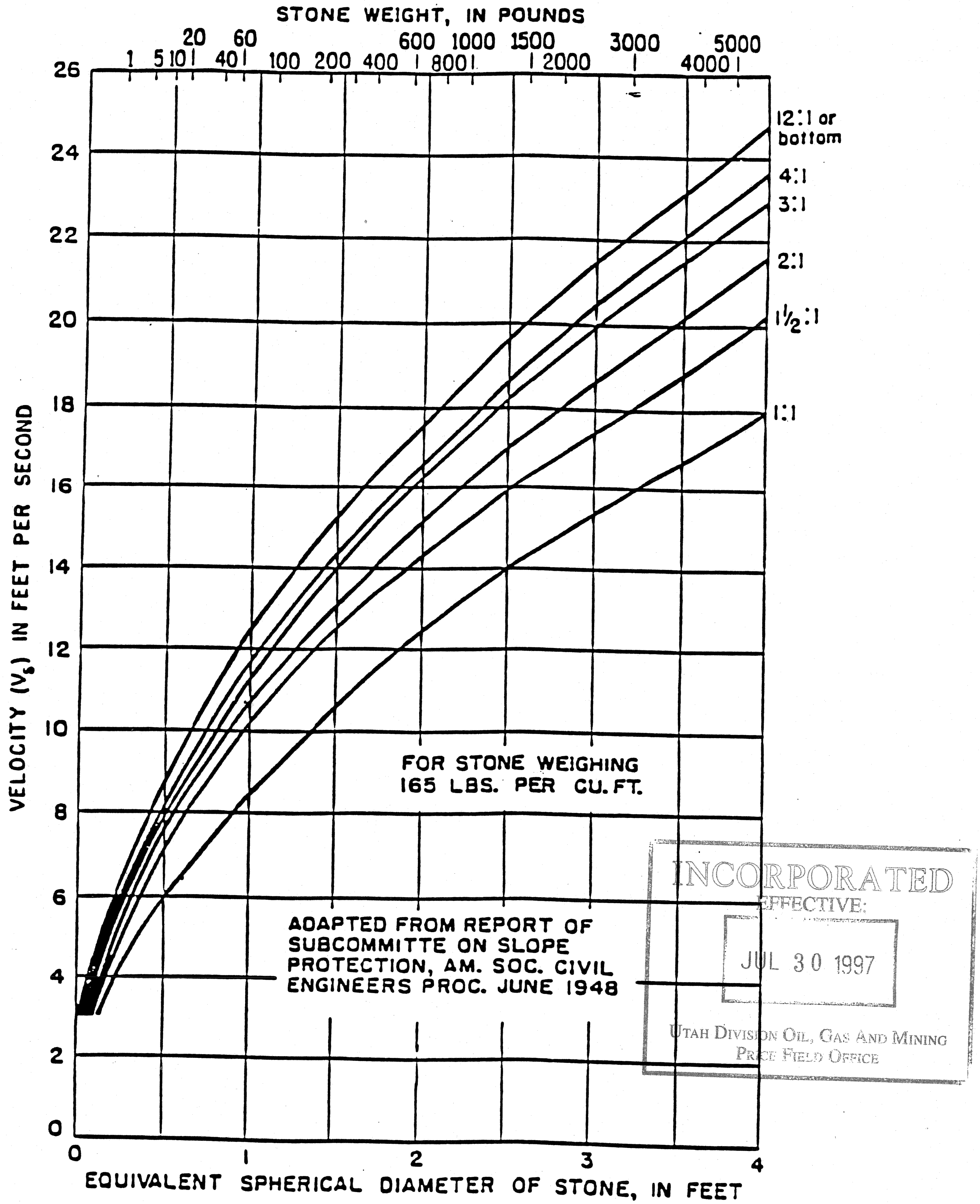


Culvert Nomograph

Headwater depth for corrugated-metal pipe culverts with entrance control. [U.S. Bureau of Public Roads.] 288-D-2909.

FIGURE 1

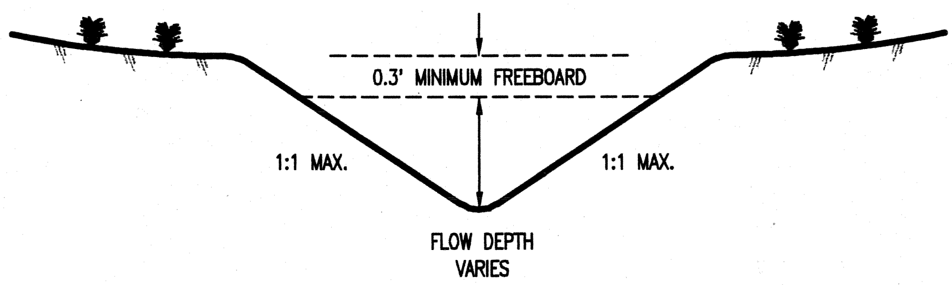
RIP-RAP CHART



SIZE OF STONE THAT WILL RESIST DISPLACEMENT FOR VARIOUS VELOCITIES AND SIDE SLOPES

FIGURE 2

UNDISTURBED AND DISTURBED DITCH TYPICAL SECTION



DITCH SIZING					
10 YEAR 6 HOUR STORM			* 10 YEAR 24 HOUR STORM		
DITCH	FLOW DEPTH	FLOW AREA	DITCH	FLOW DEPTH	FLOW AREA
UD-2	0.14	0.02	UD-2	–	–
DD-1	0.14	0.02	DD-1	0.22	0.05
DD-3	0.40	0.16	DD-3	0.56	0.31
DD-4	0.66	0.43	DD-4	0.92	0.85
DD-5	0.75	0.57	DD-5	1.06	1.12
DD-7	0.33	0.11	DD-7	0.57	0.32
DD-8	0.47	0.18	DD-8	0.67	0.45
DD-11	0.26	0.07	DD-11	0.50	0.25
DD-12	0.71	0.50	DD-12	0.97	0.94
DD-13	0.56	0.32	DD-13	0.77	0.59

NOTE:

DITCH CONFIGURATIONS MAY VARY IN FIELD; HOWEVER, MINIMUM FLOW DEPTHS AND AREAS WILL BE MAINTAINED.

* FOR REFERENCE ONLY.

FIGURE 3

FIGURE 4

SOIL ERODIBILITY CHART

(DISTURBED AREAS)

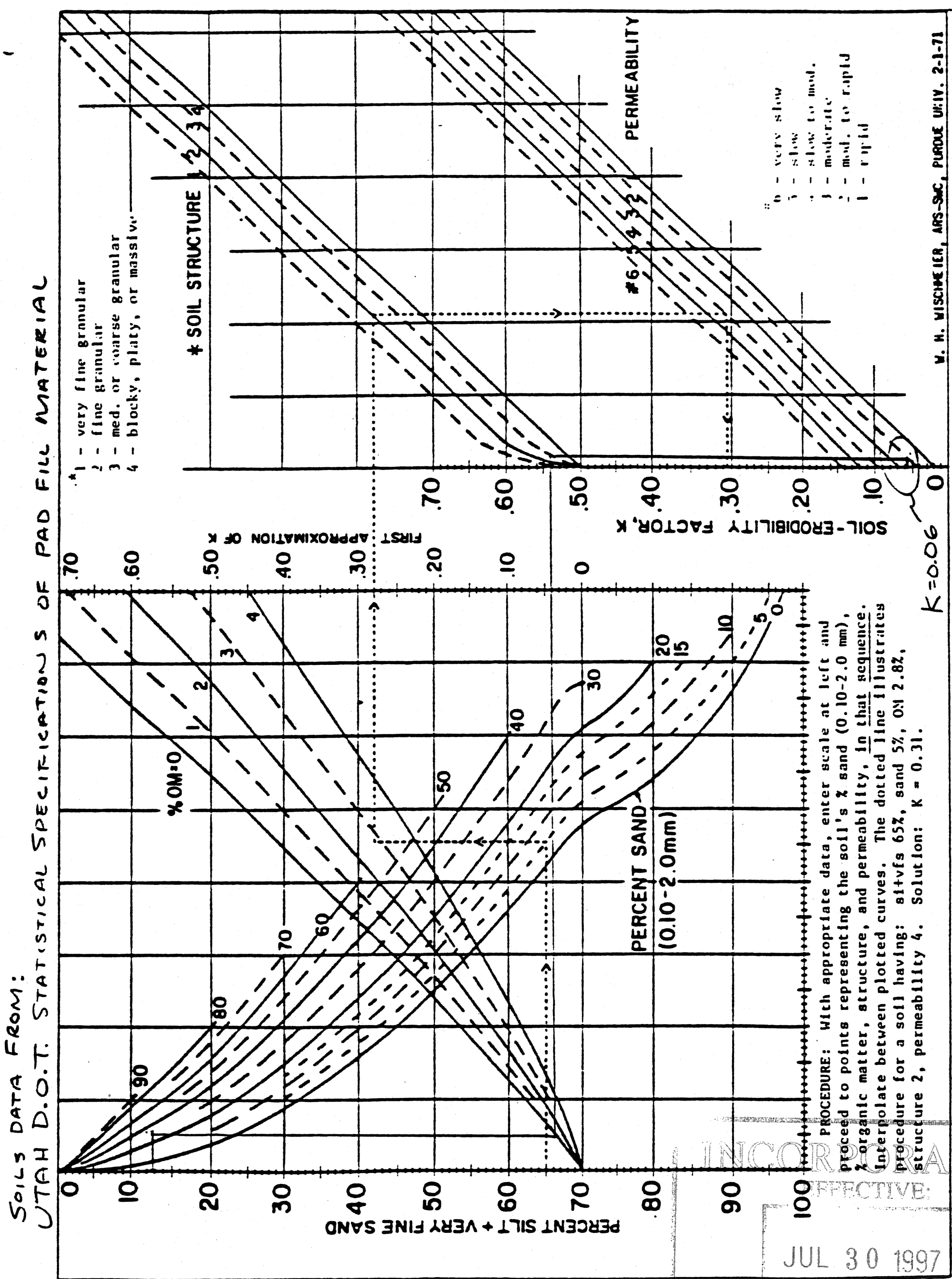
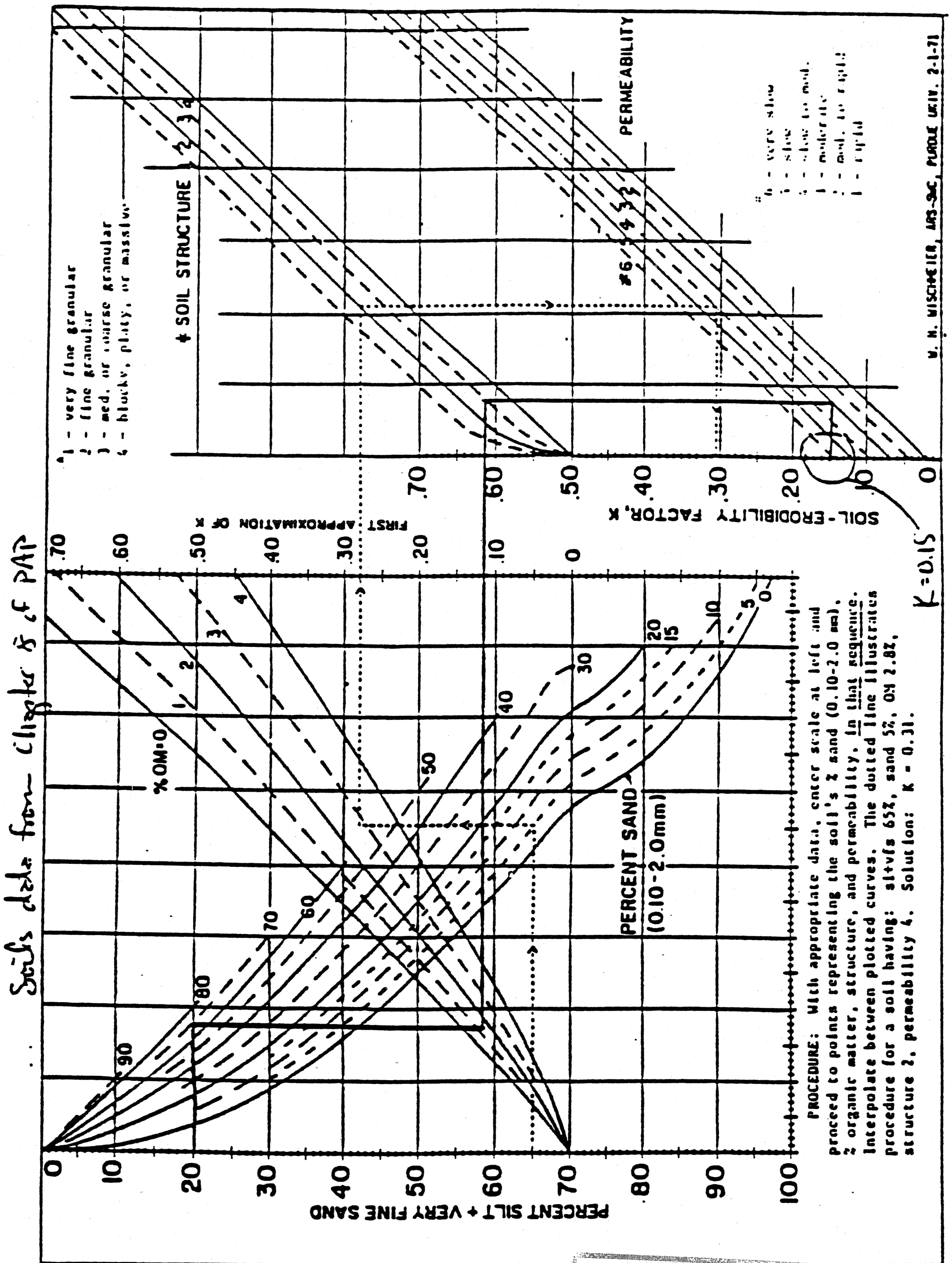


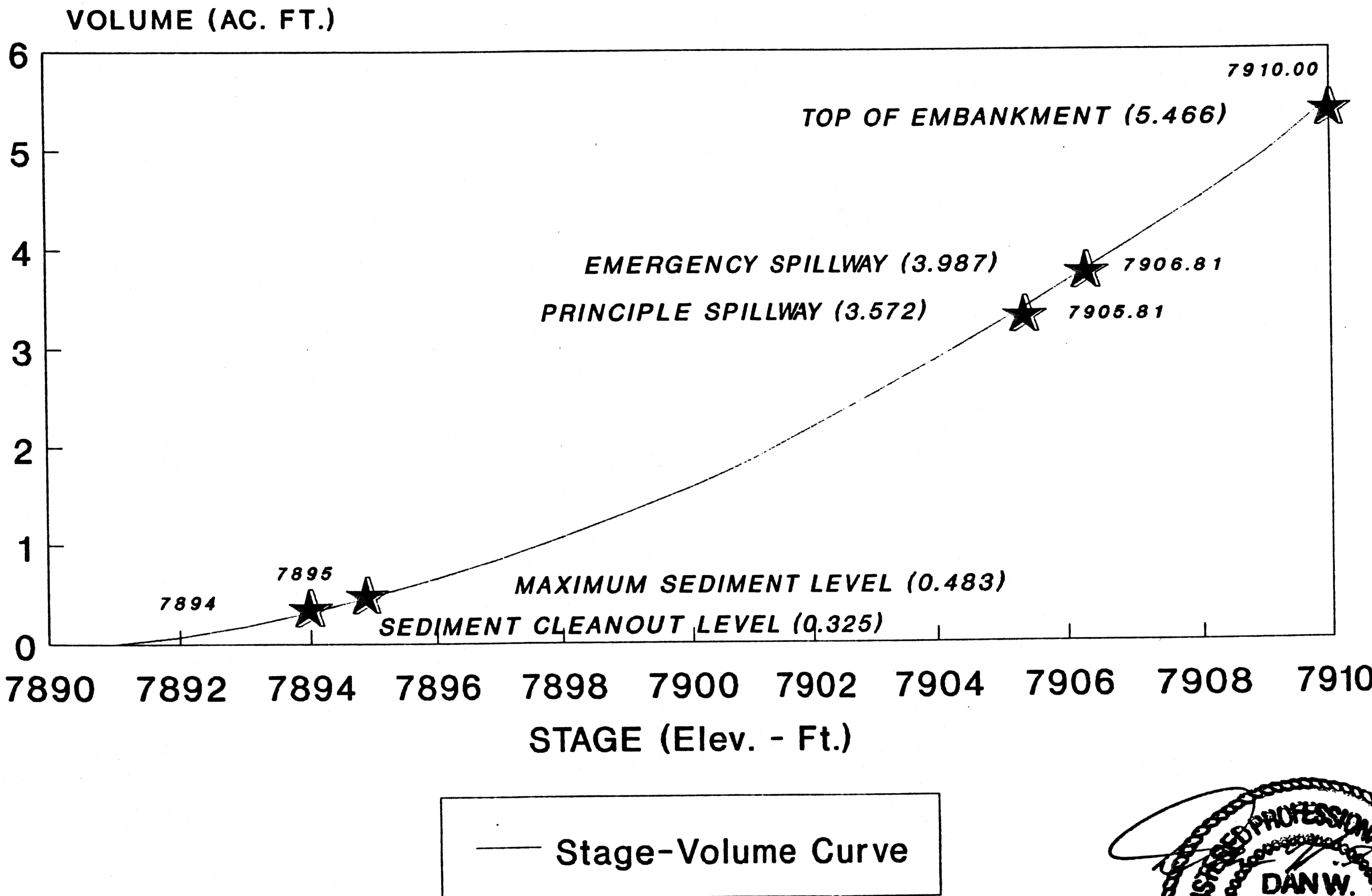
FIGURE 5

SOIL ERODIBILITY CHART (UNDISTURBED/RECLAIMED AREAS)



STAGE-VOLUME

GENWAL SEDIMENT POND (As-Constructed)



REGISTERED PROFESSIONAL ENGINEER
DAN W. GUY
No. 154168
11/21/97
STATE OF UTAH

FIGURE 6

SEDIMENT POND
STAGE–DISCHARGE CURVE

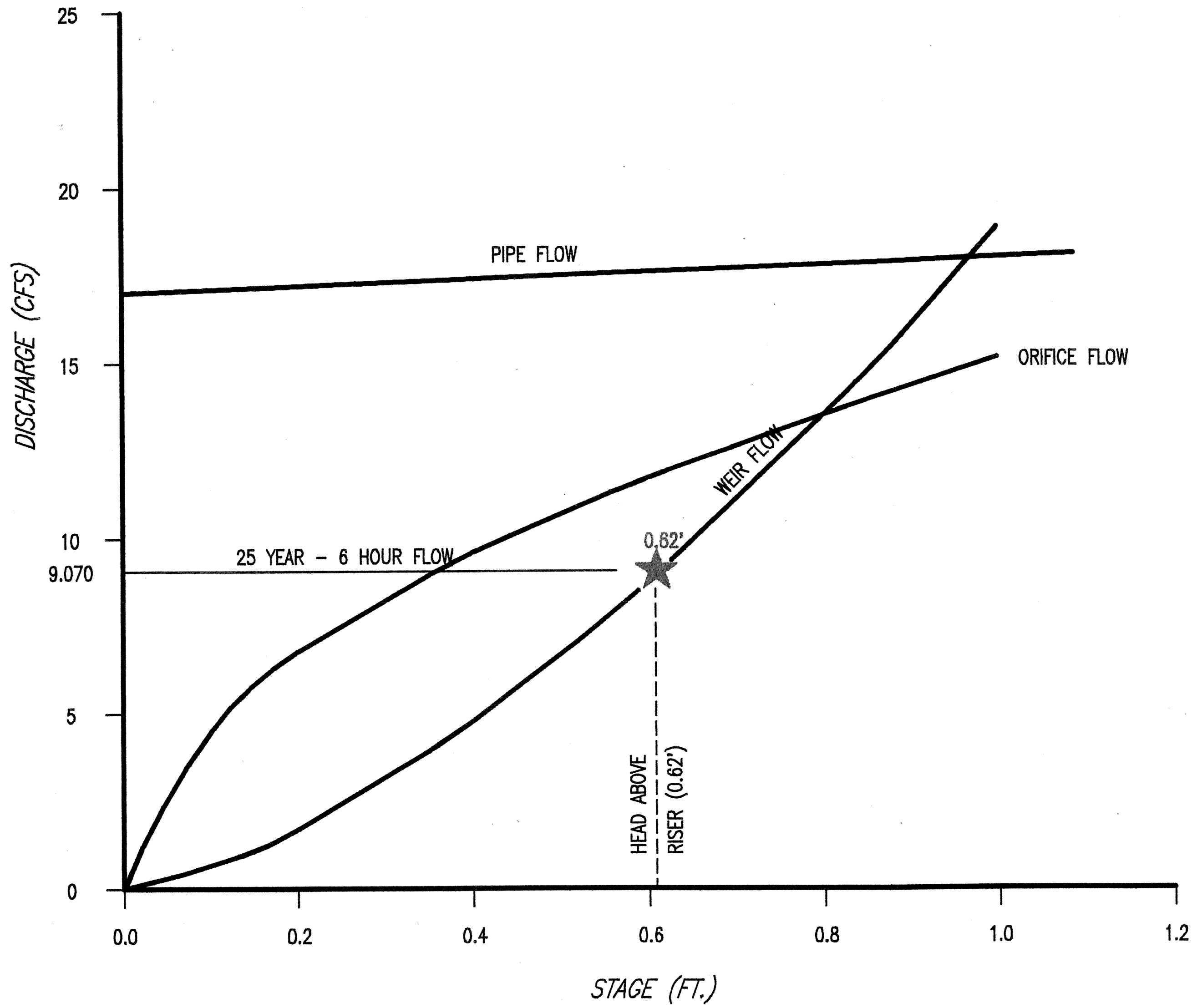
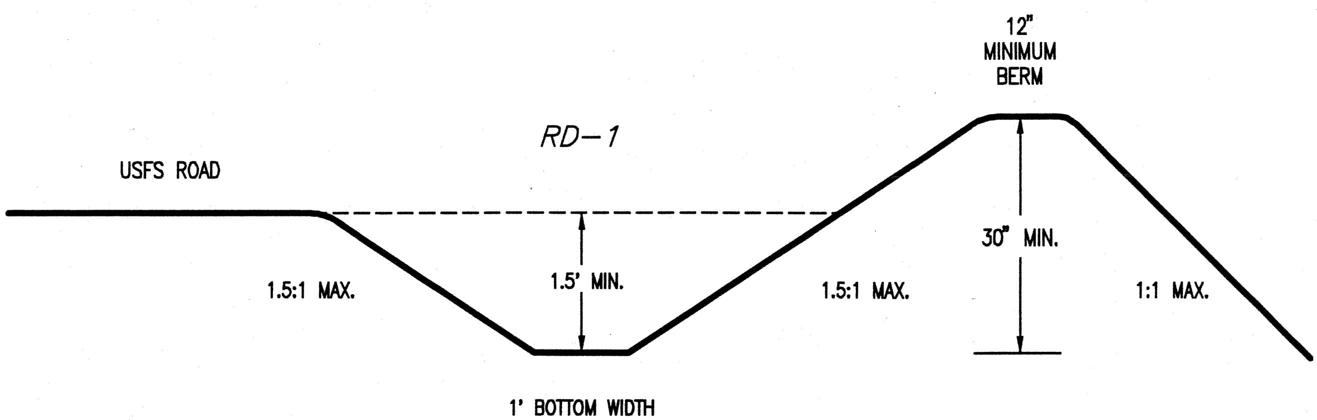


FIGURE 7

RECLAMATION DITCH RD-1
TYPICAL SECTION



DITCH SIZING		
DITCH	*FLOW DEPTH*	*FLOW AREA*
RD-1	*0.52*	*0.40*

NOTE:

DITCH CONFIGURATIONS MAY VARY IN FIELD; HOWEVER, MINIMUM FLOW DEPTHS AND AREAS WILL BE MAINTAINED.

FIGURE 8

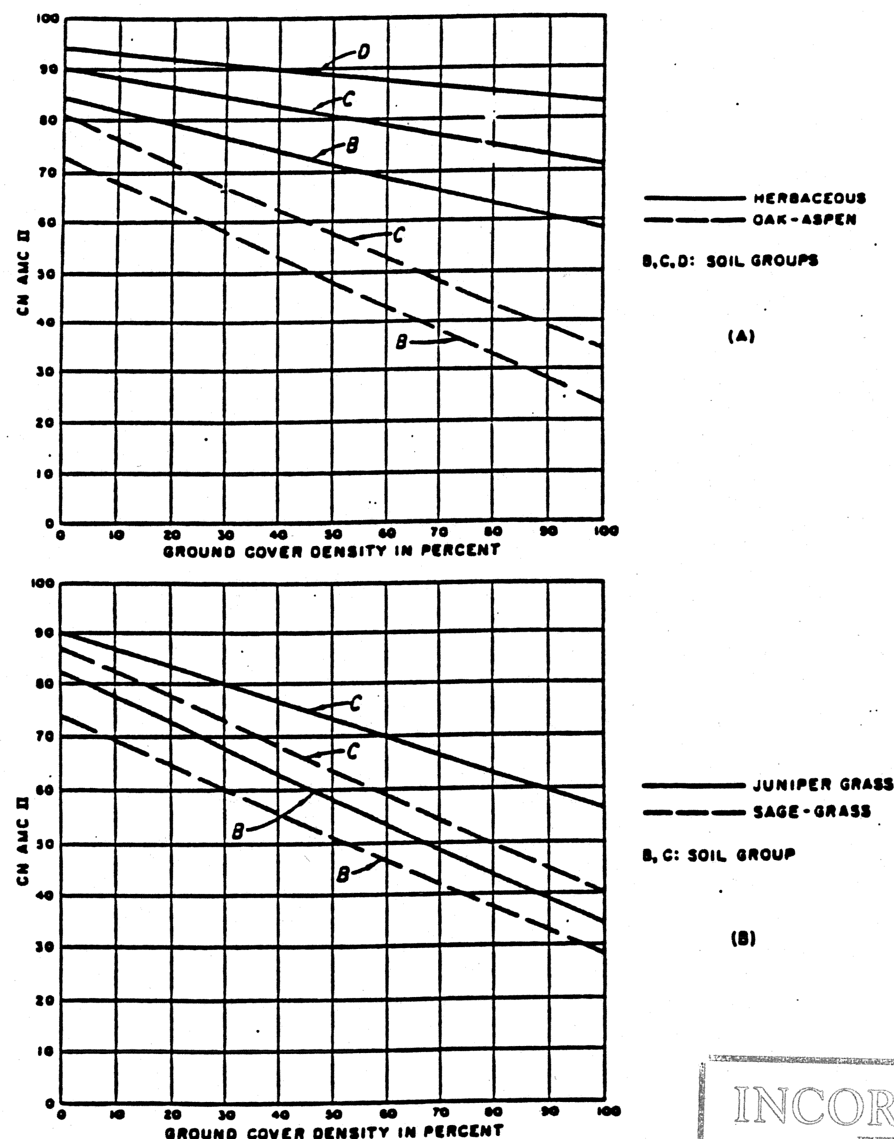
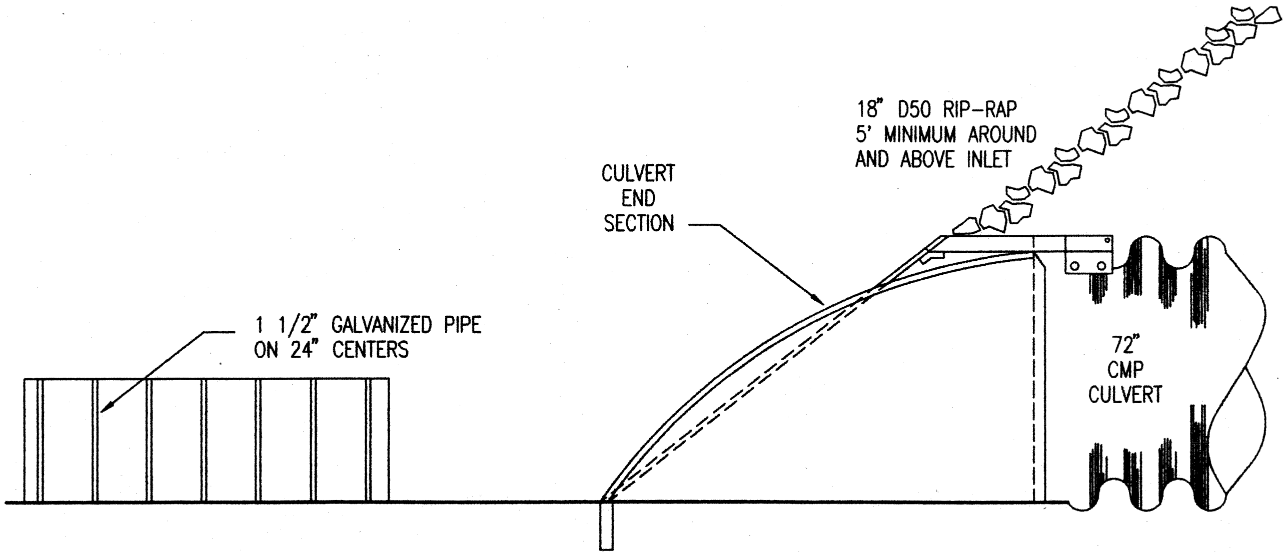


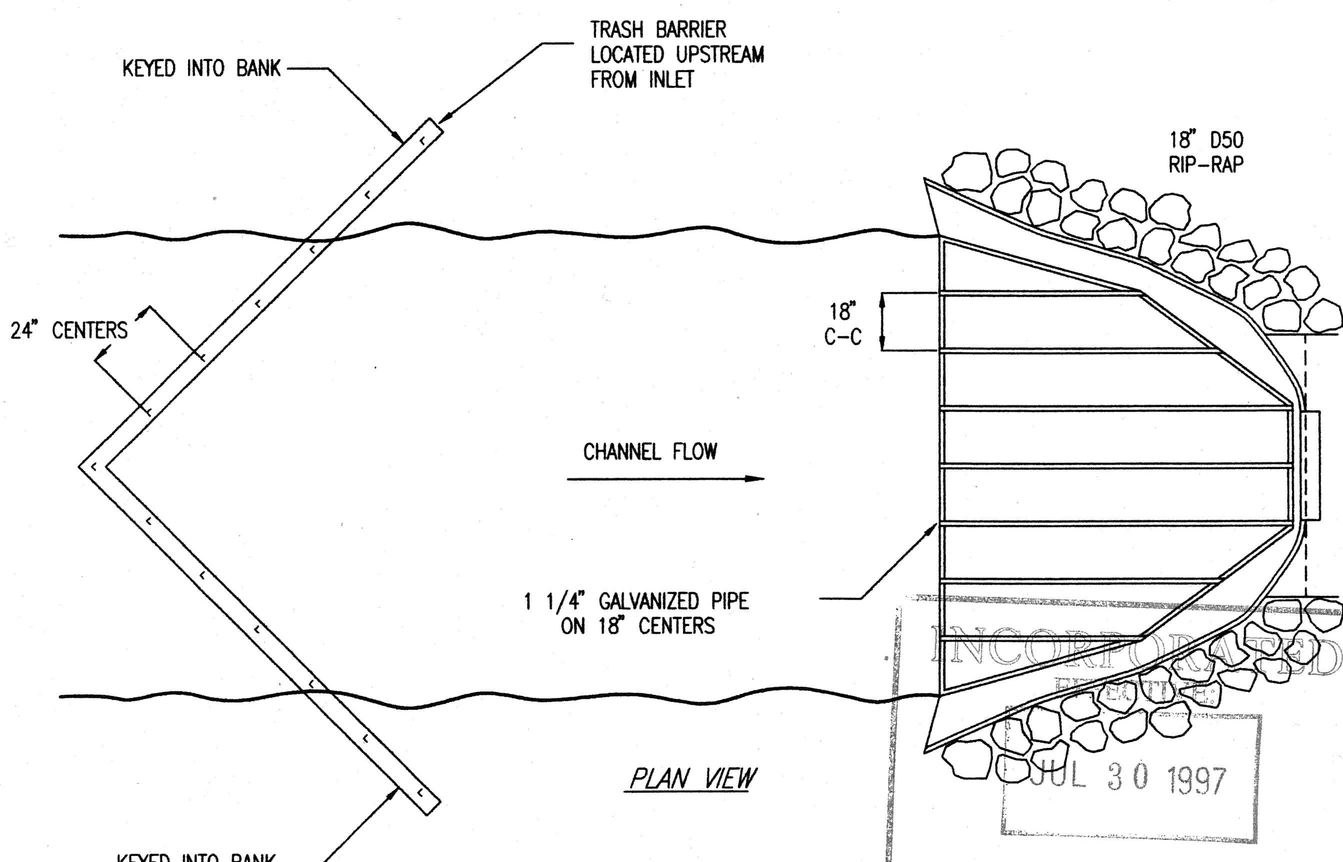
Figure 7-3. Runoff curve numbers for forest-range in the western U.S. (from U.S. Bureau of Reclamation, 1977).

FIGURE 9

MAIN CULVERT INLET AND TRASH BARRIERS



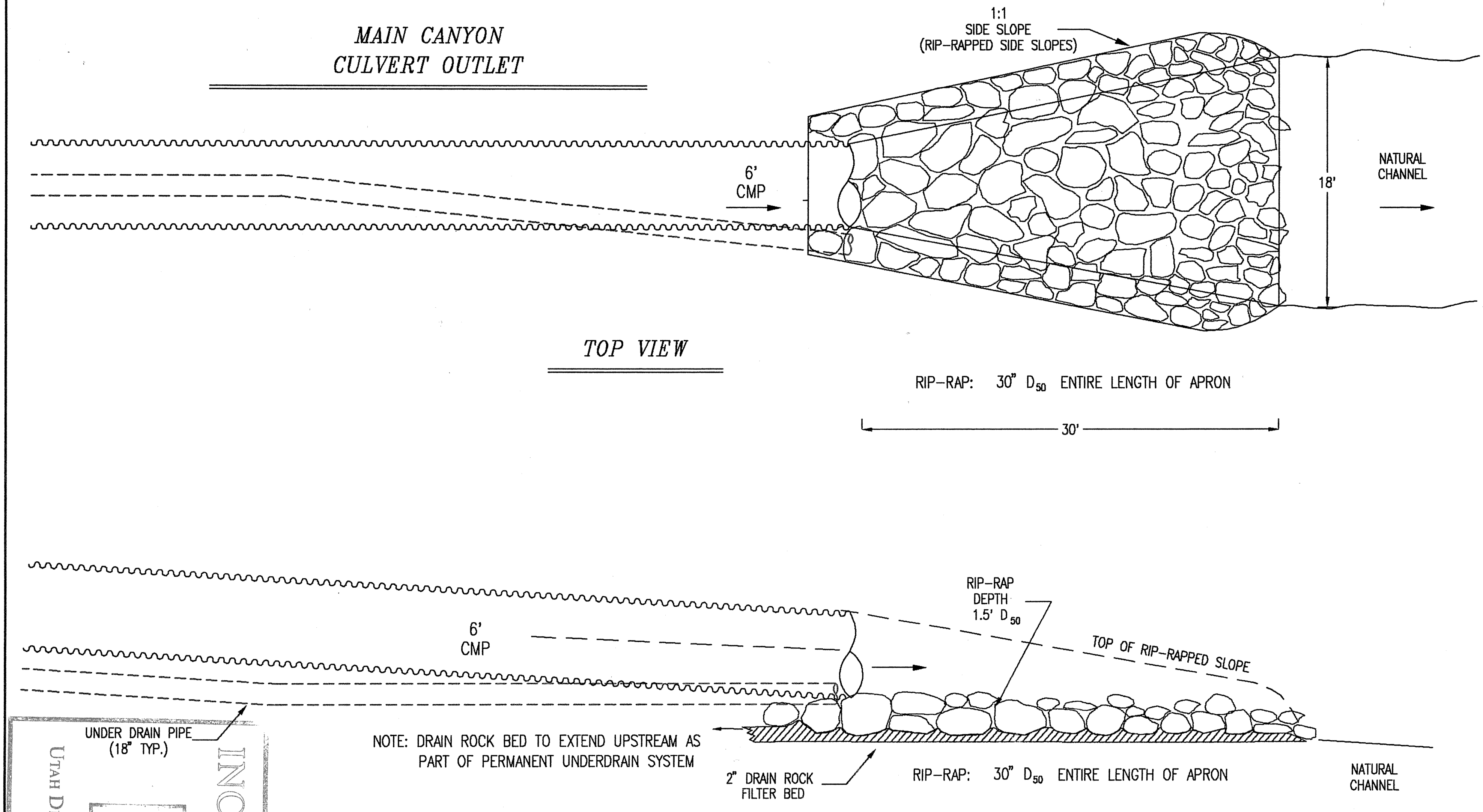
SIDE VIEW



PLAN VIEW

FIGURE 10

MAIN CANYON CULVERT OUTLET



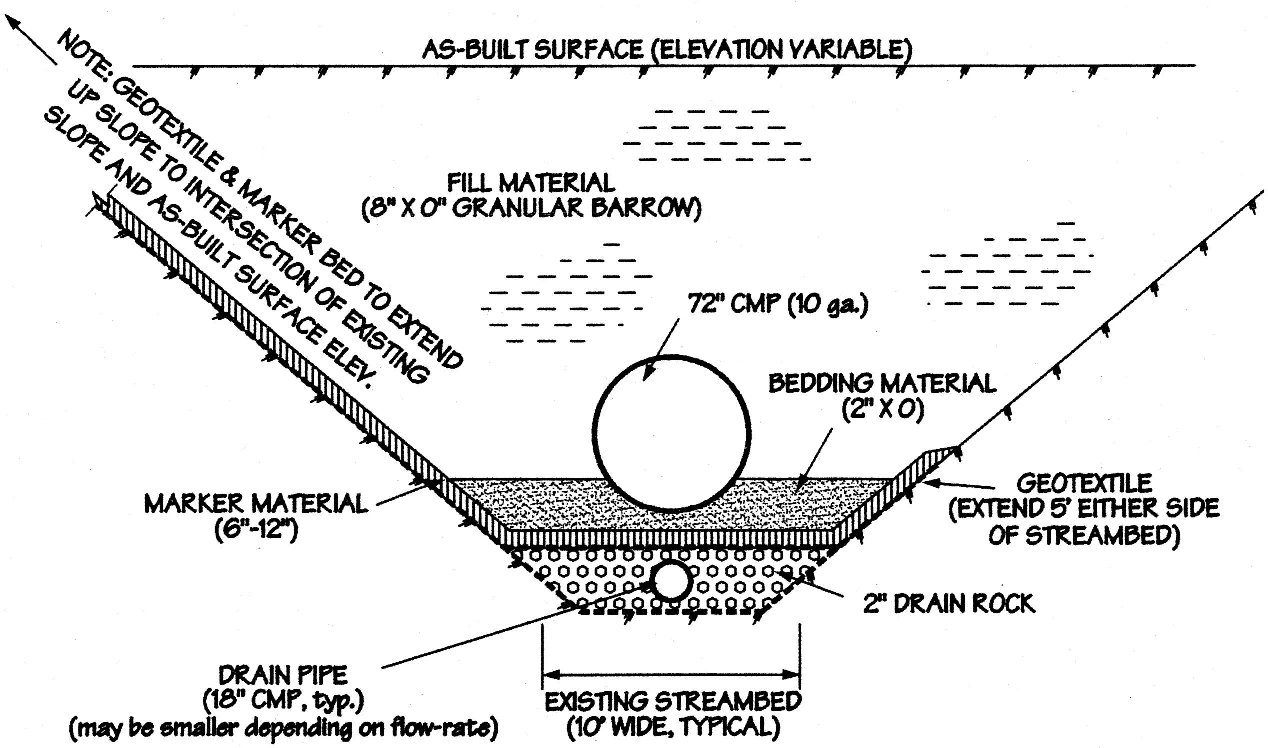
* DESIGN BASED ON FIGURE 7-26, DESIGN OF OUTLET PROTECTION – MAXIMUM TAILWATER CONDITION, "APPLIED HYDROLOGY AND SEDIMENTOLOGY FOR DISTURBED AREAS", BARFIELD, WARNER & HAAN, 1983.

SCALE: 1" = 10'

FIGURE 11

ACAD REF: FIGURE11A

TYPICAL UNDERDRAIN CONSTRUCTION



SCALE: 1" = 15'

Note: Culvert installation will generally follow the existing stream alignment, but may vary slightly to accommodate accepted engineering and installation standards.

FIGURE 12

DITCH FLOW CALCULATIONS

Title of run: DD-1 (10/6)

Solving for................= Depth Normal

Triangle

Flow depth (ft)...........= 0.14

First Side slope..........= 1.0

Second Side slope.........= 1.0

Slope of diversion........= 0.3077

Manning"s n...............= 0.035

CFS.......................= 0.06

Cross section area (sqft)..= 0.02

Hydrualic radius..........= 0.05

fps.......................= 3.15

Froude number.............= 2.52

T' le of run: DD-1 (10/24)

Solving for...............= Depth Normal

Triangle

Flow depth (ft)...........= 0.22

First Side slope..........= 1.0

Second Side slope.........= 1.0

Slope of diversion........= 0.3077

Manning"s n...............= 0.035

CFS.......................= 0.20

Cross section area (sqft)..= 0.05

Hydrualic radius..........= 0.08

fps.......................= 4.26

Froude number.............= 2.71

ˉ le of run: DD-3 (10/6)

Solving for................= Depth Normal

Triangle

Flow depth (ft)............= 0.40

First Side slope...........= 1.0

Second Side slope..........= 1.0

Slope of diversion.........= 0.0300

Manning"s n................= 0.035

CFS........................= 0.32

Cross section area (sqft)..= 0.16

Hydrualic radius...........= 0.14

fps........................= 2.00

Froude number..............= 0.94

' le of run: DD-3 (10/24)

Solving for.................= Depth Normal

Triangle

Flow depth (ft)............=	0.56
First Side slope...........=	1.0
Second Side slope..........=	1.0
Slope of diversion.........=	0.0300
Manning"s n................=	0.035
CFS........................=	0.78
Cross section area (sqft)..=	0.31
Hydrualic radius...........=	0.20
fps........................=	2.50
Froude number..............=	0.99

T-'-le of run: DD-4 (10/6)

Solving for...............= Depth Normal

Triangle

Flow depth (ft)...........=	0.66
First Side slope..........=	1.0
Second Side slope.........=	1.0
Slope of diversion........=	0.1191
Manning"s n...............=	0.035
CFS.......................=	2.39
Cross section area (sqft)..=	0.43
Hydrualic radius..........=	0.23
fps.......................=	5.55
Froude number.............=	2.03

T' le of run: DD-4 (10/24)

Solving for...............= Depth Normal

Triangle

Flow depth (ft)...........= 0.92

First Side slope..........= 1.0

Second Side slope.........= 1.0

Slope of diversion........= 0.1191

Manning"s n...............= 0.035

CFS.......................= 5.96

Cross section area (sqft)..= 0.85

Hydrualic radius..........= 0.33

fps.......................= 6.97

Froude number.............= 2.15

T· le of run: DD-5 (10/6)

Solving for................= Depth Normal

Triangle

Flow depth (ft)............= 0.75

First Side slope...........= 1.0

Second Side slope..........= 1.0

Slope of diversion.........= 0.0682

Manning"s n................= 0.035

CFS........................= 2.62

Cross section area (sqft)..= 0.57

Hydrualic radius...........= 0.27

fps........................= 4.61

Froude number..............= 1.57

" le of run: DD-5 (10/24)

Solving for...............= Depth Normal

Triangle

Flow depth (ft)...........=	1.06
First Side slope..........=	1.0
Second Side slope.........=	1.0
Slope of diversion........=	0.0682
Manning"s n...............=	0.035
CFS.......................=	6.48
Cross section area (sqft)..=	1.12
Hydrualic radius..........=	0.37
fps.......................=	5.78
Froude number.............=	1.66

' le of run: DD-7 (10/6)

Solving for................= Depth Normal

Triangle

Flow depth (ft)...........= 0.33

First Side slope..........= 1.0

Second Side slope.........= 1.0

Slope of diversion........= 0.0333

Manning"s n...............= 0.035

CFS.......................= 0.21

Cross section area (sqft)..= 0.11

Hydrualic radius..........= 0.12

fps.......................= 1.87

Froude number.............= 0.96

T··le of run: DD-7 (10/24)

Solving for................= Depth Normal

Triangle

Flow depth (ft)............=	0.57
First Side slope...........=	1.0
Second Side slope..........=	1.0
Slope of diversion.........=	0.0333
Manning"s n................=	0.035
CFS........................=	0.85
Cross section area (sqft)..=	0.32
Hydrualic radius...........=	0.20
fps........................=	2.66
Froude number..............=	1.05

Title of run: DD-8 (10/6)

Solving for................= Depth Normal

Triangle

Flow depth (ft)............=	0.42
First Side slope...........=	1.0
Second Side slope..........=	1.0
Slope of diversion.........=	0.0359
Manning"s n................=	0.035
CFS........................=	0.41
Cross section area (sqft)..=	0.18
Hydrualic radius...........=	0.15
fps........................=	2.28
Froude number..............=	1.04

le of run: DD-8 (10/24)

Solving for................= Depth Normal

Triangle

Flow depth (ft)...........=	0.67
First Side slope..........=	1.0
Second Side slope.........=	1.0
Slope of diversion........=	0.0359
Manning"s n...............=	0.035
CFS.......................=	1.40
Cross section area (sqft)..=	0.45
Hydrualic radius..........=	0.24
fps.......................=	3.10
Froude number.............=	1.12

le of run: DD-11 (10/6)

Solving for................= Depth Normal

Triangle

Flow depth (ft)............=	0.26
First Side slope...........=	1.0
Second Side slope..........=	1.0
Slope of diversion.........=	0.0300
Manning"s n................=	0.035
CFS........................=	0.10
Cross section area (sqft)..=	0.07
Hydrualic radius...........=	0.09
fps........................=	1.50
Froude number..............=	0.87

ʳ le of run: DD-11 (10/24)

Solving for................= Depth Normal

Triangle

Flow depth (ft)............=	0.50
First Side slope...........=	1.0
Second Side slope..........=	1.0
Slope of diversion.........=	0.0300
Manning"s n................=	0.035
CFS........................=	0.57
Cross section area (sqft)..=	0.25
Hydrualic radius...........=	0.18
fps........................=	2.31
Froude number..............=	0.97

T' le of run: DD-12 (10/6)

Solving for................= Depth Normal

Triangle

Flow depth (ft)............=	0.71
First Side slope...........=	1.0
Second Side slope..........=	1.0
Slope of diversion.........=	0.0329
Manning"s n................=	0.035
CFS........................=	1.55
Cross section area (sqft)..=	0.50
Hydrualic radius...........=	0.25
fps........................=	3.07
Froude number..............=	1.08

le of run: DD-12 (10/24)

Solving for................= Depth Normal

Triangle

Flow depth (ft)............=	0.97
First Side slope...........=	1.0
Second Side slope..........=	1.0
Slope of diversion.........=	0.0329
Manning"s n................=	0.035
CFS........................=	3.58
Cross section area (sqft)..=	0.94
Hydrualic radius...........=	0.34
fps........................=	3.79
Froude number..............=	1.14

T' le of run: DD-13 (10/6)

Solving for................= Depth Normal

Triangle

Flow depth (ft)............= 0.56

First Side slope...........= 1.0

Second Side slope..........= 1.0

Slope of diversion.........= 0.2250

Manning"s n................= 0.035

CFS........................= 2.18

Cross section area (sqft)..= 0.32

Hydrualic radius...........= 0.20

fps........................= 6.88

Froude number..............= 2.72

le of run: DD-13 (10/24)

Solving for................= Depth Normal

Triangle

Flow depth (ft)............= 0.77

First Side slope...........= 1.0

Second Side slope..........= 1.0

Slope of diversion.........= 0.2250

Manning"s n................= 0.035

CFS........................= 5.05

Cross section area (sqft)..= 0.59

Hydrualic radius...........= 0.27

fps........................= 8.49

Froude number..............= 2.87

le of run: UD-2 (10/6)

Solving for...............= Depth Normal

Triangle

Flow depth (ft)...........= 0.14

First Side slope..........= 1.0

Second Side slope.........= 1.0

Slope of diversion........= 0.1250

Manning"s n...............= 0.035

CFS.......................= 0.04

Cross section area (sqft)..= 0.02

Hydrualic radius..........= 0.05

fps.......................= 2.03

Froude number.............= 1.61

T'·le of run: UD-2 (100/6)

Solving for...............= Depth Normal

Triangle

Flow depth (ft)...........= 0.26

First Side slope..........= 1.0

Second Side slope.........= 1.0

Slope of diversion........= 0.1250

Manning"s n...............= 0.035

CFS.......................= 0.21

Cross section area (sqft)..= 0.07

Hydrualic radius..........= 0.09

fps.......................= 3.08

Froude number.............= 1.78

Title of run: DITCH RD-1

Solving for................= Depth Normal

'iiiangle

Flow depth (ft)............= 0.52

First Side slope...........= 1.5

Second Side slope..........= 1.5

Slope of diversion.........= 0.1010

Manning"s n................= 0.035

CFS........................= 1.94

Cross section area (sqft)..= 0.40

Hydrualic radius...........= 0.21

fps........................= 4.85

Froude number..............= 1.85

CULVERT FLOW CALCULATIONS

Circular Channel Analysis & Design
Solved with Manning's Equation

Open Channel - Uniform flow

Worksheet Name: GENWAL CULVERT

Comment: CRANDALL - MAIN CANYON (100/6)

Solve For Full Flow Diameter

Given Input Data:

Slope.............	0.0800 ft/ft
Manning's n.......	0.020
Discharge.........	222.79 cfs

Computed Results:

Full Flow Diameter.....	3.75 ft
Full Flow Depth........	3.75 ft
Velocity..........	20.14 fps
Flow Area.........	11.06 sf
Critical Depth....	3.70 ft
Critical Slope....	0.0728 ft/ft
Percent Full......	100.00 %
Full Capacity.....	222.79 cfs
QMAX @.94D........	239.66 cfs
Froude Number.....	FULL

Open Channel Flow Module, Version 3.43 (c) 1991
Haestad Methods, Inc. * 37 Brookside Rd * Waterbury, Ct

Circular Channel Analysis & Design
Solved with Manning's Equation

Open Channel - Uniform flow

Worksheet Name: GENWAL CULVERTS

Comment: CULVERT UD-1 (100/6)

Solve For Full Flow Diameter

Given Input Data:

Slope............	0.2333 ft/ft
Manning's n.......	0.020
Discharge.........	6.81 cfs

Computed Results:

Full Flow Diameter.....	0.83 ft
Full Flow Depth........	0.83 ft
Velocity..........	12.58 fps
Flow Area.........	0.54 sf
Critical Depth....	0.83 ft
Critical Slope....	0.2206 ft/ft
Percent Full......	100.00 %
Full Capacity.....	6.81 cfs
QMAX @.94D........	7.33 cfs
Froude Number.....	FULL

Circular Channel Analysis & Design
Solved with Manning's Equation

Open Channel - Uniform flow

Worksheet Name: GENWAL CULVERT

Comment: CULVERT UD-1

Solve For Full Flow Diameter

Given Input Data:

Slope.............	0.2333 ft/ft
Manning's n.......	0.020
Discharge.........	1.91 cfs

Computed Results:

Full Flow Diameter.....	0.52 ft
Full Flow Depth........	0.52 ft
Velocity..........	9.16 fps
Flow Area.........	0.21 sf
Critical Depth....	0.51 ft
Critical Slope....	0.2186 ft/ft
Percent Full......	100.00 %
Full Capacity.....	1.91 cfs
QMAX @.94D........	2.05 cfs
Froude Number.....	FULL

Circular Channel Analysis & Design
Solved with Manning's Equation

Open Channel - Uniform flow

Worksheet Name: GENWAL CULVERT

Comment: CULVERT UD-3

Solve For Full Flow Diameter

Given Input Data:

Slope.............	0.1196 ft/ft
Manning's n.......	0.020
Discharge.........	0.23 cfs

Computed Results:

Full Flow Diameter.....	0.26 ft
Full Flow Depth........	0.26 ft
Velocity..........	4.20 fps
Flow Area.........	0.05 sf
Critical Depth....	0.25 ft
Critical Slope....	0.1047 ft/ft
Percent Full......	100.00 %
Full Capacity.....	0.23 cfs
QMAX @.94D........	0.25 cfs
Froude Number.....	FULL

Circular Channel Analysis & Design
Solved with Manning's Equation

Open Channel - Uniform flow

Worksheet Name: GENWAL CULVERT

Comment: CULVERT C-1 (10/6)

Solve For Full Flow Diameter

Given Input Data:

Slope............	0.1167 ft/ft
Manning's n.......	0.020
Discharge.........	0.73 cfs

Computed Results:

Full Flow Diameter.....	0.41 ft
Full Flow Depth........	0.41 ft
Velocity..........	5.55 fps
Flow Area.........	0.13 sf
Critical Depth....	0.40 ft
Critical Slope....	0.1031 ft/ft
Percent Full......	100.00 %
Full Capacity.....	0.73 cfs
QMAX @.94D........	0.79 cfs
Froude Number.....	FULL

Circular Channel Analysis & Design
Solved with Manning's Equation

Open Channel - Uniform flow

Worksheet Name: GENWAL CULVERT

Comment: CULVERT C-1 (10/24)

Solve For Full Flow Diameter

Given Input Data:

Slope.............	0.1167 ft/ft
Manning's n.......	0.020
Discharge.........	2.18 cfs

Computed Results:

Full Flow Diameter.....	0.62 ft
Full Flow Depth........	0.62 ft
Velocity..........	7.30 fps
Flow Area.........	0.30 sf
Critical Depth....	0.60 ft
Critical Slope....	0.1043 ft/ft
Percent Full......	100.00 %
Full Capacity.....	2.18 cfs
QMAX @.94D........	2.35 cfs
Froude Number.....	FULL

Circular Channel Analysis & Design
Solved with Manning's Equation

Open Channel - Uniform flow

Worksheet Name: GENWAL CULVERT

Comment: CULVERT C-3 (10/6)

Solve For Full Flow Diameter

Given Input Data:

Slope.............	0.0800 ft/ft
Manning's n.......	0.020
Discharge.........	0.21 cfs

Computed Results:

Full Flow Diameter.....	0.28 ft
Full Flow Depth........	0.28 ft
Velocity..........	3.53 fps
Flow Area.........	0.06 sf
Critical Depth....	0.26 ft
Critical Slope....	0.0692 ft/ft
Percent Full......	100.00 %
Full Capacity.....	0.21 cfs
QMAX @.94D........	0.23 cfs
Froude Number.....	FULL

Circular Channel Analysis & Design
Solved with Manning's Equation

Open Channel - Uniform flow

Worksheet Name: GENWAL CULVERT

Comment: CULVERT C-3 (10/24)

Solve For Full Flow Diameter

Given Input Data:

Slope.............	0.0800 ft/ft
Manning's n.......	0.020
Discharge.........	0.85 cfs

Computed Results:

Full Flow Diameter.....	0.46 ft
Full Flow Depth........	0.46 ft
Velocity..........	5.01 fps
Flow Area.........	0.17 sf
Critical Depth....	0.44 ft
Critical Slope....	0.0693 ft/ft
Percent Full......	100.00 %
Full Capacity.....	0.85 cfs
QMAX @.94D........	0.91 cfs
Froude Number.....	FULL

Circular Channel Analysis & Design
Solved with Manning's Equation

Open Channel - Uniform flow

Worksheet Name: GENWAL CULVERT

Comment: CULVERT C-4 (10/6)

Solve For Full Flow Diameter

Given Input Data:

Slope.............	0.2507 ft/ft
Manning's n.......	0.020
Discharge.........	3.01 cfs

Computed Results:

Full Flow Diameter.....	0.60 ft
Full Flow Depth........	0.60 ft
Velocity..........	10.54 fps
Flow Area.........	0.29 sf
Critical Depth....	0.60 ft
Critical Slope....	0.2366 ft/ft
Percent Full......	100.00 %
Full Capacity.....	3.01 cfs
QMAX @.94D........	3.24 cfs
Froude Number.....	FULL

Circular Channel Analysis & Design
Solved with Manning's Equation

Open Channel - Uniform flow

Worksheet Name: GENWAL CULVERT

Comment: CULVERT C-4 (10/24)

Solve For Full Flow Diameter

Given Input Data:

Slope..............	0.2507 ft/ft
Manning's n........	0.020
Discharge..........	6.79 cfs

Computed Results:

Full Flow Diameter.....	0.82 ft
Full Flow Depth........	0.82 ft
Velocity..........	12.91 fps
Flow Area.........	0.53 sf
Critical Depth....	0.82 ft
Critical Slope....	0.2379 ft/ft
Percent Full......	100.00 %
Full Capacity.....	6.79 cfs
QMAX @.94D........	7.30 cfs
Froude Number.....	FULL

Circular Channel Analysis & Design
Solved with Manning's Equation

Open Channel - Uniform flow

Worksheet Name: GENWAL CULVERT

Comment: CULVERT C-5 (10/6)

Solve For Full Flow Diameter

Given Input Data:

Slope.............	0.5714 ft/ft
Manning's n.......	0.020
Discharge.........	0.10 cfs

Computed Results:

Full Flow Diameter.....	0.14 ft
Full Flow Depth........	0.14 ft
Velocity..........	6.13 fps
Flow Area.........	0.02 sf
Critical Depth....	0.14 ft
Critical Slope....	0.5483 ft/ft
Percent Full......	100.00 %
Full Capacity.....	0.10 cfs
QMAX @.94D........	0.11 cfs
Froude Number.....	FULL

Circular Channel Analysis & Design
Solved with Manning's Equation

Open Channel - Uniform flow

Worksheet Name: GENWAL CULVERT

Comment: CULVERT C-5 (10/24)

Solve For Full Flow Diameter

Given Input Data:

Slope............	0.5714 ft/ft
Manning's n.......	0.020
Discharge.........	0.57 cfs

Computed Results:

Full Flow Diameter.....	0.28 ft
Full Flow Depth........	0.28 ft
Velocity..........	9.47 fps
Flow Area.........	0.06 sf
Critical Depth....	0.28 ft
Critical Slope....	0.5527 ft/ft
Percent Full......	100.00 %
Full Capacity.....	0.57 cfs
QMAX @.94D........	0.61 cfs
Froude Number.....	FULL

Circular Channel Analysis & Design
Solved with Manning's Equation

Open Channel - Uniform flow

Worksheet Name: GENWAL CULVERT

Comment: CULVERT C-6 (10/6)

Solve For Full Flow Diameter

Given Input Data:

Slope.............	0.1720 ft/ft
Manning's n........	0.020
Discharge.........	0.04 cfs

Computed Results:

Full Flow Diameter.....	0.13 ft
Full Flow Depth........	0.13 ft
Velocity..........	3.11 fps
Flow Area.........	0.01 sf
Critical Depth....	0.12 ft
Critical Slope....	0.1520 ft/ft
Percent Full......	100.00 %
Full Capacity.....	0.04 cfs
QMAX @.94D........	0.04 cfs
Froude Number.....	FULL

Circular Channel Analysis & Design
Solved with Manning's Equation

Open Channel - Uniform flow

Worksheet Name: GENWAL CULVERT

Comment: CULVERT C-7 (10/6)

Solve For Full Flow Diameter

Given Input Data:

Slope............	0.0300 ft/ft
Manning's n.......	0.020
Discharge.........	0.32 cfs

Computed Results:

Full Flow Diameter.....	0.39 ft
Full Flow Depth........	0.39 ft
Velocity..........	2.71 fps
Flow Area.........	0.12 sf
Critical Depth....	0.31 ft
Critical Slope....	0.0321 ft/ft
Percent Full......	100.00 %
Full Capacity.....	0.32 cfs
QMAX @.94D........	0.34 cfs
Froude Number.....	FULL

Circular Channel Analysis & Design
Solved with Manning's Equation

Open Channel - Uniform flow

Worksheet Name: GENWAL CULVERT

Comment: CULVERT C-7 (10/24)

Solve For Full Flow Diameter

Given Input Data:

Slope.............	0.0300 ft/ft
Manning's n.......	0.020
Discharge.........	0.78 cfs

Computed Results:

Full Flow Diameter.....	0.54 ft
Full Flow Depth........	0.54 ft
Velocity..........	3.39 fps
Flow Area.........	0.23 sf
Critical Depth....	0.44 ft
Critical Slope....	0.0305 ft/ft
Percent Full......	100.00 %
Full Capacity.....	0.78 cfs
QMAX @.94D........	0.84 cfs
Froude Number.....	FULL

Circular Channel Analysis & Design
Solved with Manning's Equation

Open Channel - Uniform flow

Worksheet Name: GENWAL CULVERT

Comment: CULVERT C-9 (10/6)

Solve For Full Flow Diameter

Given Input Data:

Slope............	0.0350 ft/ft
Manning's n.......	0.020
Discharge.........	0.11 cfs

Computed Results:

Full Flow Diameter.....	0.25 ft
Full Flow Depth........	0.25 ft
Velocity..........	2.20 fps
Flow Area.........	0.05 sf
Critical Depth....	0.20 ft
Critical Slope....	0.0372 ft/ft
Percent Full......	100.00 %
Full Capacity.....	0.11 cfs
QMAX @.94D........	0.12 cfs
Froude Number.....	FULL

Circular Channel Analysis & Design
Solved with Manning's Equation

Open Channel - Uniform flow

Worksheet Name: GENWAL CULVERT

Comment: CULVERT C-9 (10/24)

Solve For Full Flow Diameter

Given Input Data:

Slope.............	0.0350 ft/ft
Manning's n.......	0.020
Discharge.........	0.20 cfs

Computed Results:

Full Flow Diameter.....	0.32 ft
Full Flow Depth........	0.32 ft
Velocity..........	2.56 fps
Flow Area.........	0.08 sf
Critical Depth....	0.25 ft
Critical Slope....	0.0360 ft/ft
Percent Full......	100.00 %
Full Capacity.....	0.20 cfs
QMAX @.94D........	0.22 cfs
Froude Number.....	FULL

Circular Channel Analysis & Design
Solved with Manning's Equation

Open Channel - Uniform flow

Worksheet Name: GENWAL CULVERT

Comment: CULVERT C-11 (10/6)

Solve For Full Flow Diameter

Given Input Data:

Slope............	0.0350 ft/ft
Manning's n.......	0.020
Discharge.........	1.55 cfs

Computed Results:

Full Flow Diameter.....	0.68 ft
Full Flow Depth........	0.68 ft
Velocity..........	4.27 fps
Flow Area.........	0.36 sf
Critical Depth....	0.58 ft
Critical Slope....	0.0328 ft/ft
Percent Full......	100.00 %
Full Capacity.....	1.55 cfs
QMAX @.94D........	1.67 cfs
Froude Number.....	FULL

Circular Channel Analysis & Design
Solved with Manning's Equation

Open Channel - Uniform flow

Worksheet Name: GENWAL CULVERT

Comment: CULVERT C-11 (10/24)

Solve For Full Flow Diameter

Given Input Data:

Slope.............	0.0350 ft/ft
Manning's n.......	0.020
Discharge.........	3.58 cfs

Computed Results:

Full Flow Diameter.....	0.93 ft
Full Flow Depth........	0.93 ft
Velocity..........	5.26 fps
Flow Area.........	0.68 sf
Critical Depth....	0.81 ft
Critical Slope....	0.0319 ft/ft
Percent Full......	100.00 %
Full Capacity.....	3.58 cfs
QMAX @.94D........	3.85 cfs
Froude Number.....	FULL

CULVERT FLOW CALCULATIONS

(Revised October 1998)

FOR CULVERTS: C-4, C-9, C-12, C-13, C-14, C-15, C-16, C-17

Circular Channel Analysis & Design
Solved with Manning's Equation

Open Channel - Uniform flow

Worksheet Name: GENWAL CULVERTS

Comment: CULVERT C-4 (10/6)

Solve For Full Flow Diameter

Given Input Data:

Slope.............	0.2507 ft/ft
Manning's n.......	0.020
Discharge.........	0.39 cfs

Computed Results:

Full Flow Diameter.....	0.28 ft
Full Flow Depth........	0.28 ft
Velocity..........	6.32 fps
Flow Area.........	0.06 sf
Critical Depth....	0.28 ft
Critical Slope....	0.2329 ft/ft
Percent Full......	100.00 %
Full Capacity.....	0.39 cfs
QMAX @.94D........	0.42 cfs
Froude Number.....	FULL

Circular Channel Analysis & Design
Solved with Manning's Equation

Open Channel - Uniform flow

Worksheet Name: GENWAL CULVERTS

Comment: CULVERT C-4 (10/24)

Solve For Full Flow Diameter

Given Input Data:

Slope.............	0.2507 ft/ft
Manning's n........	0.020
Discharge..........	0.83 cfs

Computed Results:

Full Flow Diameter.....	0.37 ft
Full Flow Depth........	0.37 ft
Velocity..........	7.64 fps
Flow Area.........	0.11 sf
Critical Depth....	0.37 ft
Critical Slope....	0.2344 ft/ft
Percent Full......	100.00 %
Full Capacity.....	0.83 cfs
QMAX @.94D........	0.89 cfs
Froude Number.....	FULL

Circular Channel Analysis & Design
Solved with Manning's Equation

Open Channel - Uniform flow

Worksheet Name: GENWAL CULVERTS

Comment: CULVERT C-9 (10/6)

Solve For Full Flow Diameter

Given Input Data:

Slope.............	0.0350 ft/ft
Manning's n.......	0.020
Discharge.........	1.66 cfs

Computed Results:

Full Flow Diameter.....	0.70 ft
Full Flow Depth........	0.70 ft
Velocity..........	4.34 fps
Flow Area.........	0.38 sf
Critical Depth....	0.60 ft
Critical Slope....	0.0327 ft/ft
Percent Full......	100.00 %
Full Capacity.....	1.66 cfs
QMAX @.94D........	1.79 cfs
Froude Number.....	FULL

Circular Channel Analysis & Design
Solved with Manning's Equation

Open Channel - Uniform flow

Worksheet Name: GENWAL CULVERTS

Comment: CULVERT C-9 (10/24)

Solve For Full Flow Diameter

Given Input Data:

Slope.............	0.0350 ft/ft
Manning's n........	0.020
Discharge.........	3.78 cfs

Computed Results:

Full Flow Diameter.....	0.95 ft
Full Flow Depth........	0.95 ft
Velocity..........	5.33 fps
Flow Area.........	0.71 sf
Critical Depth....	0.83 ft
Critical Slope....	0.0318 ft/ft
Percent Full......	100.00 %
Full Capacity.....	3.78 cfs
QMAX @.94D........	4.07 cfs
Froude Number.....	FULL

Circular Channel Analysis & Design
Solved with Manning's Equation

Open Channel - Uniform flow

Worksheet Name: GENWAL CULVERTS

Comment: CULVERT C-12 (10/6)

Solve For Full Flow Diameter

Given Input Data:

Slope.............	0.0450 ft/ft
Manning's n........	0.020
Discharge..........	2.62 cfs

Computed Results:

Full Flow Diameter.....	0.79 ft
Full Flow Depth........	0.79 ft
Velocity..........	5.35 fps
Flow Area.........	0.49 sf
Critical Depth....	0.71 ft
Critical Slope....	0.0396 ft/ft
Percent Full......	100.00 %
Full Capacity.....	2.62 cfs
QMAX @.94D........	2.82 cfs
Froude Number.....	FULL

Circular Channel Analysis & Design
Solved with Manning's Equation

Open Channel - Uniform flow

Worksheet Name: GENWAL CULVERTS

Comment: CULVERT C-12 (10/24)

Solve For Full Flow Diameter

Given Input Data:

Slope.............	0.0450 ft/ft
Manning's n........	0.020
Discharge.........	5.96 cfs

Computed Results:

Full Flow Diameter.....	1.08 ft
Full Flow Depth........	1.08 ft
Velocity..........	6.56 fps
Flow Area.........	0.91 sf
Critical Depth....	0.98 ft
Critical Slope....	0.0392 ft/ft
Percent Full......	100.00 %
Full Capacity.....	5.96 cfs
QMAX @.94D........	6.41 cfs
Froude Number.....	FULL

Circular Channel Analysis & Design
Solved with Manning's Equation

Open Channel - Uniform flow

Worksheet Name: GENWAL CULVERTS

Comment: CULVERT C-13 (10/6)

Solve For Full Flow Diameter

Given Input Data:

Slope.............	0.0300 ft/ft
Manning's n.......	0.020
Discharge.........	2.62 cfs

Computed Results:

Full Flow Diameter.....	0.85 ft
Full Flow Depth........	0.85 ft
Velocity..........	4.59 fps
Flow Area.........	0.57 sf
Critical Depth....	0.72 ft
Critical Slope....	0.0288 ft/ft
Percent Full......	100.00 %
Full Capacity.....	2.62 cfs
QMAX @.94D........	2.82 cfs
Froude Number.....	FULL

Circular Channel Analysis & Design
Solved with Manning's Equation

Open Channel - Uniform flow

Worksheet Name: GENWAL CULVERTS

Comment: CULVERT C-13 (10/24)

Solve For Full Flow Diameter

Given Input Data:

Slope.............	0.0300 ft/ft
Manning's n.......	0.020
Discharge.........	6.08 cfs

Computed Results:

Full Flow Diameter.....	1.17 ft
Full Flow Depth........	1.17 ft
Velocity..........	5.67 fps
Flow Area.........	1.07 sf
Critical Depth....	1.00 ft
Critical Slope....	0.0279 ft/ft
Percent Full......	100.00 %
Full Capacity.....	6.08 cfs
QMAX @.94D........	6.54 cfs
Froude Number.....	FULL

Circular Channel Analysis & Design
Solved with Manning's Equation

Open Channel - Uniform flow

Worksheet Name: GENWAL CULVERTS

Comment: CULVERT C-14 (10/6)

Solve For Full Flow Diameter

Given Input Data:

Slope............	0.0100 ft/ft
Manning's n.......	0.020
Discharge.........	0.11 cfs

Computed Results:

Full Flow Diameter.....	0.32 ft
Full Flow Depth........	0.32 ft
Velocity..........	1.38 fps
Flow Area.........	0.08 sf
Critical Depth....	0.19 ft
Critical Slope....	0.0233 ft/ft
Percent Full......	100.00 %
Full Capacity.....	0.11 cfs
QMAX @.94D........	0.12 cfs
Froude Number.....	FULL

Circular Channel Analysis & Design
Solved with Manning's Equation

Open Channel - Uniform flow

Worksheet Name: GENWAL CULVERTS

Comment: CULVERT C-14 (10/24)

Solve For Full Flow Diameter

Given Input Data:

Slope.............	0.0100 ft/ft
Manning's n.......	0.020
Discharge.........	0.20 cfs

Computed Results:

Full Flow Diameter.....	0.40 ft
Full Flow Depth........	0.40 ft
Velocity..........	1.60 fps
Flow Area.........	0.13 sf
Critical Depth....	0.24 ft
Critical Slope....	0.0220 ft/ft
Percent Full......	100.00 %
Full Capacity.....	0.20 cfs
QMAX @.94D........	0.22 cfs
Froude Number.....	FULL

Circular Channel Analysis & Design
Solved with Manning's Equation

Open Channel - Uniform flow

Worksheet Name: GENWAL CULVERTS

Comment: CULVERT C-15 (10/6)

Solve For Full Flow Diameter

Given Input Data:

Slope.............	0.0100 ft/ft
Manning's n.......	0.020
Discharge.........	0.06 cfs

Computed Results:

Full Flow Diameter.....	0.25 ft
Full Flow Depth........	0.25 ft
Velocity..........	1.18 fps
Flow Area.........	0.05 sf
Critical Depth....	0.15 ft
Critical Slope....	0.0248 ft/ft
Percent Full......	100.00 %
Full Capacity.....	0.06 cfs
QMAX @.94D........	0.06 cfs
Froude Number.....	FULL

Circular Channel Analysis & Design
Solved with Manning's Equation

Open Channel - Uniform flow

Worksheet Name: GENWAL CULVERTS

Comment: CULVERT C-15 (10/24)

Solve For Full Flow Diameter

Given Input Data:

Slope............	0.0100 ft/ft
Manning's n.......	0.020
Discharge.........	0.11 cfs

Computed Results:

Full Flow Diameter.....	0.32 ft
Full Flow Depth........	0.32 ft
Velocity..........	1.38 fps
Flow Area.........	0.08 sf
Critical Depth....	0.19 ft
Critical Slope....	0.0233 ft/ft
Percent Full......	100.00 %
Full Capacity.....	0.11 cfs
QMAX @.94D........	0.12 cfs
Froude Number.....	FULL

Circular Channel Analysis & Design
Solved with Manning's Equation

Open Channel - Uniform flow

Worksheet Name: GENWAL CULVERTS

Comment: CULVERT C-16 (10/6)

Solve For Full Flow Diameter

Given Input Data:

Slope.............	0.2500 ft/ft
Manning's n.......	0.020
Discharge.........	2.62 cfs

Computed Results:

Full Flow Diameter.....	0.57 ft
Full Flow Depth........	0.57 ft
Velocity..........	10.17 fps
Flow Area.........	0.26 sf
Critical Depth....	0.57 ft
Critical Slope....	0.2357 ft/ft
Percent Full......	100.00 %
Full Capacity.....	2.62 cfs
QMAX @.94D........	2.82 cfs
Froude Number.....	FULL

Circular Channel Analysis & Design
Solved with Manning's Equation

Open Channel - Uniform flow

Worksheet Name: GENWAL CULVERTS

Comment: CULVERT C-16 (10/24)

Solve For Full Flow Diameter

Given Input Data:

Slope.............	0.2500 ft/ft
Manning's n.......	0.020
Discharge.........	6.08 cfs

Computed Results:

Full Flow Diameter.....	0.79 ft
Full Flow Depth........	0.79 ft
Velocity..........	12.55 fps
Flow Area.........	0.48 sf
Critical Depth....	0.78 ft
Critical Slope....	0.2370 ft/ft
Percent Full......	100.00 %
Full Capacity.....	6.08 cfs
QMAX @.94D........	6.54 cfs
Froude Number.....	FULL

Circular Channel Analysis & Design
Solved with Manning's Equation

Open Channel - Uniform flow

Worksheet Name: GENWAL CULVERTS

Comment: CULVERT C-17 (10/6)

Solve For Full Flow Diameter

Given Input Data:

Slope............	0.2000 ft/ft
Manning's n.......	0.020
Discharge.........	2.62 cfs

Computed Results:

Full Flow Diameter.....	0.60 ft
Full Flow Depth........	0.60 ft
Velocity..........	9.35 fps
Flow Area.........	0.28 sf
Critical Depth....	0.59 ft
Critical Slope....	0.1861 ft/ft
Percent Full......	100.00 %
Full Capacity.....	2.62 cfs
QMAX @.94D........	2.82 cfs
Froude Number.....	FULL

Circular Channel Analysis & Design
Solved with Manning's Equation

Open Channel - Uniform flow

Worksheet Name: GENWAL CULVERTS

Comment: CULVERT C-17 (10/24)

Solve For Full Flow Diameter

Given Input Data:

Slope.............	0.2000 ft/ft
Manning's n.......	0.020
Discharge.........	6.08 cfs

Computed Results:

Full Flow Diameter.....	0.82 ft
Full Flow Depth........	0.82 ft
Velocity..........	11.54 fps
Flow Area.........	0.53 sf
Critical Depth....	0.81 ft
Critical Slope....	0.1874 ft/ft
Percent Full......	100.00 %
Full Capacity.....	6.08 cfs
QMAX @.94D........	6.54 cfs
Froude Number.....	FULL

WATERSHED RUNOFF CALCULATIONS

```
Project Title          = CRANDALL - MAIN - UNDISTURBED (100/6)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:         Null


-- Watershed data for watershed # 1
    Curve number               =    69.0
    Area                       =  3480.0 acres
    Hydraulic length           = 16500.00 Feet
    Elevation change           =  2900.0 feet.
    Concentration time         =    1.09 hours
    Concentration time type = SCS Upland Curves
    Unit hydrograph type       = Forested

-- Total Area              =  3480.0 acres

-- Storm data
    Total precipitation    =      2.4 inches
    Storm type             = SCS 6 hour design storm
    Peak Discharge         =  222.79 cfs
    Discharge volume       =  109.07 acre ft
```

```
Project Title          = WSUD-1 (UNDISTURBED 10/6)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:          Null


-- Watershed data for watershed # 1
    Curve number                =    69.0
    Area                        =    84.9 acres
    Hydraulic length            = 3100.00 Feet
    Elevation change            =  1660.0 feet.
    Concentration time          =    0.47 hours
    Concentration time type = SCS Upland Curves
    Unit hydrograph type        = Forested

-- Total Area             =    84.9 acres

-- Storm data
    Total precipitation  =     1.5 inches
    Storm type           = SCS 6 hour design storm
    Peak Discharge       =    1.91 cfs
    Discharge volume     =    0.58 acre ft
```

```
Project Title          = WSUD-1 (UNDISTURBED 25/6)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:          Null


-- Watershed data for watershed # 1
    Curve number               =    69.0
    Area                       =    84.9 acres
    Hydraulic length           = 3100.00 Feet
    Elevation change           =  1660.0 feet.
    Concentration time         =    0.47 hours
    Concentration time type    = SCS Upland Curves
    Unit hydrograph type       = Forested

-- Total Area              =    84.9 acres

-- Storm data
    Total precipitation     =     1.9 inches
    Storm type              = SCS 6 hour design storm
    Peak Discharge          =    3.68 cfs
    Discharge volume        =    1.29 acre ft
```

```
Project Title          = WSUD-1 (UNDISTURBED 100/6)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:          Null



-- Watershed data for watershed # 1
    Curve number               =    69.0
    Area                       =    84.9 acres
    Hydraulic length           = 3100.00 Feet
    Elevation change           =  1660.0 feet.
    Concentration time         =    0.47 hours
    Concentration time type    = SCS Upland Curves
    Unit hydrograph type       = Forested

-- Total Area            =    84.9 acres

-- Storm data
    Total precipitation    =     2.4 inches
    Storm type             = SCS 6 hour design storm
    Peak Discharge         =    6.81 cfs
    Discharge volume       =    2.66 acre ft
```

```
Project Title           = WSUD-1 (UNDISTURBED 10/24)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:          Null


-- Watershed data for watershed # 1
    Curve number                =    69.0
    Area                        =    84.9 acres
    Hydraulic length            = 3100.00 Feet
    Elevation change            =  1660.0 feet.
    Concentration time          =    0.47 hours
    Concentration time type     = SCS Upland Curves
    Unit hydrograph type        = Forested

-- Total Area               =    84.9 acres

-- Storm data
    Total precipitation      =     2.5 inches
    Storm type               = SCS Type 2 storm, 24 hour storm
    Peak Discharge           =    8.04 cfs
    Discharge volume         =    2.98 acre ft
```

```
Project Title          = WSUD-2 (UNDISTURBED 10/6)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:          Null


-- Watershed data for watershed # 1
    Curve number                =    69.0
    Area                        =     1.4 acres
    Hydraulic length            =  320.00 Feet
    Elevation change            =   250.0 feet.
    Concentration time          =    0.04 hours
    Concentration time type = SCS Upland Curves
    Unit hydrograph type        = Forested

-- Total Area              =      1.4 acres

-- Storm data
    Total precipitation   =     1.5 inches
    Storm type            = SCS 6 hour design storm
    Peak Discharge        =    0.04 cfs
    Discharge volume      =    0.01 acre ft
```

```
Project Title            = WSUD-2 (UNDISTURBED 25/6)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:           Null


-- Watershed data for watershed # 1
    Curve number                =    69.0
    Area                        =     1.4 acres
    Hydraulic length            =  320.00 Feet
    Elevation change            =   250.0 feet.
    Concentration time          =    0.04 hours
    Concentration time type = SCS Upland Curves
    Unit hydrograph type        = Forested

-- Total Area                =     1.4 acres

-- Storm data
    Total precipitation  =      1.9 inches
    Storm type           = SCS 6 hour design storm
    Peak Discharge       =    0.08 cfs
    Discharge volume     =    0.02 acre ft
```

```
Project Title          = WSUD-2 (UNDISTURBED 100/6)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:          Null


-- Watershed data for watershed # 1
    Curve number                =    69.0
    Area                        =     1.4 acres
    Hydraulic length            =  320.00 Feet
    Elevation change            =   250.0 feet.
    Concentration time          =    0.04 hours
    Concentration time type = SCS Upland Curves
    Unit hydrograph type        = Forested

-- Total Area               =     1.4 acres

-- Storm data
    Total precipitation  =     2.4 inches
    Storm type           = SCS 6 hour design storm
    Peak Discharge       =    0.21 cfs
    Discharge volume     =    0.04 acre ft
```

```
Project Title            = WSUD-2 (UNDISTURBED 10/24)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:           Null


-- Watershed data for watershed # 1
    Curve number                =    69.0
    Area                        =     1.4 acres
    Hydraulic length            =  320.00 Feet
    Elevation change            =   250.0 feet.
    Concentration time          =    0.04 hours
    Concentration time type = SCS Upland Curves
    Unit hydrograph type        = Forested

-- Total Area               =      1.4 acres

-- Storm data
    Total precipitation   =      2.5 inches
    Storm type            = SCS Type 2 storm, 24 hour storm
    Peak Discharge        =     0.34 cfs
    Discharge volume      =     0.05 acre ft
```

```
Project Title           = WSUD-3 (UNDISTURBED 10/6)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:          Null


-- Watershed data for watershed # 1
    Curve number                 =    69.0
    Area                         =     8.7 acres
    Hydraulic length             = 1300.00 Feet
    Elevation change             =   920.0 feet.
    Concentration time           =    0.17 hours
    Concentration time type      = SCS Upland Curves
    Unit hydrograph type         = Forested

-- Total Area              =      8.7 acres

-- Storm data
    Total precipitation  =     1.5 inches
    Storm type           = SCS 6 hour design storm
    Peak Discharge       =    0.23 cfs
    Discharge volume     =    0.06 acre ft
```

```
Project Title            = WSUD-3 (UNDISTURBED 25/6)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:          Null


-- Watershed data for watershed # 1
    Curve number                =    69.0
    Area                        =     8.7 acres
    Hydraulic length            = 1300.00 Feet
    Elevation change            =   920.0 feet.
    Concentration time          =    0.17 hours
    Concentration time type     = SCS Upland Curves
    Unit hydrograph type        = Forested

-- Total Area             =      8.7 acres

-- Storm data
    Total precipitation  =      1.9 inches
    Storm type           = SCS 6 hour design storm
    Peak Discharge       =     0.43 cfs
    Discharge volume     =     0.13 acre ft
```

```
Project Title          = WSUD-3 (UNDISTURBED 100/6)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:          Null


-- Watershed data for watershed # 1
    Curve number                =    69.0
    Area                        =     8.7 acres
    Hydraulic length            = 1300.00 Feet
    Elevation change            =   920.0 feet.
    Concentration time          =    0.17 hours
    Concentration time type     = SCS Upland Curves
    Unit hydrograph type        = Forested

-- Total Area               =     8.7 acres

-- Storm data
    Total precipitation     =     2.4 inches
    Storm type              = SCS 6 hour design storm
    Peak Discharge          =    0.89 cfs
    Discharge volume        =    0.27 acre ft
```

```
Project Title          = WSUD-3 (UNDISTURBED 10/24)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:          Null



-- Watershed data for watershed # 1
    Curve number                =    69.0
    Area                        =     8.7 acres
    Hydraulic length            = 1300.00 Feet
    Elevation change            =   920.0 feet.
    Concentration time          =    0.17 hours
    Concentration time type     = SCS Upland Curves
    Unit hydrograph type        = Forested

-- Total Area               =      8.7 acres

-- Storm data
    Total precipitation      =      2.5 inches
    Storm type               = SCS Type 2 storm, 24 hour storm
    Peak Discharge           =     1.38 cfs
    Discharge volume         =     0.30 acre ft
```

```
Project Title            = WSDD-1 (DISTURBED - 10/6)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:          Null


-- Watershed data for watershed # 1
    Curve number                 =    90.0
    Area                         =     0.1 acres
    Hydraulic length             =  100.00 Feet
    Elevation change             =    40.0 feet.
    Concentration time           =    0.00 hours
    Concentration time type = SCS Upland Curves
    Unit hydrograph type         = Disturbed

-- Total Area              =      0.1 acres

-- Storm data
    Total precipitation    =      1.5 inches
    Storm type             = SCS 6 hour design storm
    Peak Discharge         =    0.04 cfs
    Discharge volume       =    0.01 acre ft
```

```
Project Title          = WSDD-1 (DISTURBED - 25/6)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:          Null


-- Watershed data for watershed # 1
    Curve number                =    90.0
    Area                        =     0.1 acres
    Hydraulic length            =  100.00 Feet
    Elevation change            =    40.0 feet.
    Concentration time          =    0.00 hours
    Concentration time type     = SCS Upland Curves
    Unit hydrograph type        = Disturbed

-- Total Area               =     0.1 acres

-- Storm data
    Total precipitation      =     1.9 inches
    Storm type               = SCS 6 hour design storm
    Peak Discharge           =    0.06 cfs
    Discharge volume         =    0.01 acre ft
```

```
Project Title           = WSDD-1 (DISTURBED - 10/24)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:          Null


-- Watershed data for watershed # 1
    Curve number              =    90.0
    Area                      =     0.1 acres
    Hydraulic length          =  100.00 Feet
    Elevation change          =    40.0 feet.
    Concentration time        =    0.00 hours
    Concentration time type   = SCS Upland Curves
    Unit hydrograph type      = Disturbed

-- Total Area             =     0.1 acres

-- Storm data
    Total precipitation    =     2.5 inches
    Storm type             = SCS Type 2 storm, 24 hour storm
    Peak Discharge         =    0.10 cfs
    Discharge volume       =    0.02 acre ft
```

```
Project Title          = WSDD-1 (RECLAIMED - 10/6)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:          Null


-- Watershed data for watershed # 1
    Curve number                =    75.0
    Area                        =     0.1 acres
    Hydraulic length            =  120.00 Feet
    Elevation change            =    30.0 feet.
    Concentration time          =    0.01 hours
    Concentration time type = SCS Upland Curves
    Unit hydrograph type        = Disturbed

-- Total Area               =     0.1 acres

-- Storm data
    Total precipitation      =     1.5 inches
    Storm type               = SCS 6 hour design storm
    Peak Discharge           =    0.01 cfs
    Discharge volume         =    0.00 acre ft
```

```
Project Title          = WSDD-1 (RECLAIMED - 25/6)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:          Null


-- Watershed data for watershed # 1
    Curve number                =    75.0
    Area                        =     0.1 acres
    Hydraulic length            =  120.00 Feet
    Elevation change            =    30.0 feet.
    Concentration time          =    0.01 hours
    Concentration time type     = SCS Upland Curves
    Unit hydrograph type        = Disturbed

-- Total Area                =     0.1 acres

-- Storm data
    Total precipitation      =      1.9 inches
    Storm type               = SCS 6 hour design storm
    Peak Discharge           =     0.01 cfs
    Discharge volume         =     0.00 acre ft
```

```
Project Title          = WSDD-1 (RECLAIMED - 10/24)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:          Null


-- Watershed data for watershed # 1
    Curve number               =    75.0
    Area                       =     0.1 acres
    Hydraulic length           =  120.00 Feet
    Elevation change           =    30.0 feet.
    Concentration time         =    0.01 hours
    Concentration time type = SCS Upland Curves
    Unit hydrograph type       = Disturbed

-- Total Area              =      0.1 acres

-- Storm data
    Total precipitation  =      2.5 inches
    Storm type           = SCS Type 2 storm, 24 hour storm
    Peak Discharge       =    0.04 cfs
    Discharge volume     =    0.01 acre ft
```

```
Project Title          = WSDD-2 (RECLAIMED - 10/6)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:          Null


-- Watershed data for watershed # 1
    Curve number                =    75.0
    Area                        =     0.2 acres
    Hydraulic length            =  200.00 Feet
    Elevation change            =    50.0 feet.
    Concentration time          =    0.01 hours
    Concentration time type = SCS Upland Curves
    Unit hydrograph type        = Disturbed

-- Total Area             =      0.2 acres

-- Storm data
    Total precipitation  =     1.5 inches
    Storm type           = SCS 6 hour design storm
    Peak Discharge       =    0.01 cfs
    Discharge volume     =    0.00 acre ft
```

```
Project Title          = WSDD-2 (RECLAIMED - 25/6)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:         Null


-- Watershed data for watershed # 1
    Curve number                =    75.0
    Area                        =     0.2 acres
    Hydraulic length            =  200.00 Feet
    Elevation change            =    50.0 feet.
    Concentration time          =    0.01 hours
    Concentration time type = SCS Upland Curves
    Unit hydrograph type        = Disturbed

-- Total Area             =      0.2 acres

-- Storm data
    Total precipitation  =      1.9 inches
    Storm type           = SCS 6 hour design storm
    Peak Discharge       =     0.03 cfs
    Discharge volume     =     0.00 acre ft
```

```
Project Title          = WSDD-2 (RECLAIMED - 10/24)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:         Null


-- Watershed data for watershed # 1
    Curve number                =    75.0
    Area                        =     0.2 acres
    Hydraulic length            =  200.00 Feet
    Elevation change            =    50.0 feet.
    Concentration time          =    0.01 hours
    Concentration time type = SCS Upland Curves
    Unit hydrograph type    = Disturbed

-- Total Area             =     0.2 acres

-- Storm data
    Total precipitation   =     2.5 inches
    Storm type            = SCS Type 2 storm, 24 hour storm
    Peak Discharge        =    0.06 cfs
    Discharge volume      =    0.01 acre ft
```

```
Project Title          = WSUD-3 (UNDISTURBED - 10/6)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:          Null


-- Watershed data for watershed # 1
    Curve number                =    69.0
    Area                        =     8.8 acres
    Hydraulic length            = 1300.00 Feet
    Elevation change            =   920.0 feet.
    Concentration time          =    0.17 hours
    Concentration time type = SCS Upland Curves
    Unit hydrograph type        = Forested

-- Total Area               =     8.8 acres

-- Storm data
    Total precipitation    =     1.5 inches
    Storm type             = SCS 6 hour design storm
    Peak Discharge         =    0.23 cfs
    Discharge volume       =    0.06 acre ft
```

```
Project Title          = WSUD-3 (UNDISTURBED - 25/6)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:          Null


-- Watershed data for watershed # 1
    Curve number               =    69.0
    Area                       =     8.8 acres
    Hydraulic length           = 1300.00 Feet
    Elevation change           =   920.0 feet.
    Concentration time         =    0.17 hours
    Concentration time type    = SCS Upland Curves
    Unit hydrograph type       = Forested

-- Total Area               =     8.8 acres

-- Storm data
    Total precipitation   =     1.9 inches
    Storm type            = SCS 6 hour design storm
    Peak Discharge        =    0.43 cfs
    Discharge volume      =    0.13 acre ft
```

```
Project Title            = WSUD-3 (UNDISTURBED - 100/6)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:          Null


-- Watershed data for watershed # 1
    Curve number                 =    69.0
    Area                         =     8.8 acres
    Hydraulic length             = 1300.00 Feet
    Elevation change             =   920.0 feet.
    Concentration time           =    0.17 hours
    Concentration time type      = SCS Upland Curves
    Unit hydrograph type         = Forested

-- Total Area                =     8.8 acres

-- Storm data
    Total precipitation      =     2.4 inches
    Storm type               = SCS 6 hour design storm
    Peak Discharge           =    0.90 cfs
    Discharge volume         =    0.27 acre ft
```

```
Project Title          = WSUD-3 (UNDISTURBED - 10/24)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:          Null


-- Watershed data for watershed # 1
    Curve number                =    69.0
    Area                        =     8.8 acres
    Hydraulic length            = 1300.00 Feet
    Elevation change            =   920.0 feet.
    Concentration time          =    0.17 hours
    Concentration time type     = SCS Upland Curves
    Unit hydrograph type        = Forested

-- Total Area               =     8.8 acres

-- Storm data
    Total precipitation    =     2.5 inches
    Storm type             = SCS Type 2 storm, 24 hour storm
    Peak Discharge         =    1.40 cfs
    Discharge volume       =    0.31 acre ft
```

```
Project Title          = WSDD-3 (UNDISTURBED - 10/6)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:          Null


-- Watershed data for watershed # 1
    Curve number                =    69.0
    Area                        =     0.1 acres
    Hydraulic length            =   80.00 Feet
    Elevation change            =    40.0 feet.
    Concentration time          =    0.01 hours
    Concentration time type = SCS Upland Curves
    Unit hydrograph type        = Forested

-- Total Area              =     0.1 acres

-- Storm data
    Total precipitation    =     1.5 inches
    Storm type             = SCS 6 hour design storm
    Peak Discharge         =    0.00 cfs
    Discharge volume       =    0.00 acre ft
```

```
Project Title          = WSDD-3 (UNDISTURBED - 25/6)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:          Null


-- Watershed data for watershed # 1
    Curve number                =    69.0
    Area                        =     0.1 acres
    Hydraulic length            =   80.00 Feet
    Elevation change            =    40.0 feet.
    Concentration time          =    0.01 hours
    Concentration time type = SCS Upland Curves
    Unit hydrograph type     = Forested

-- Total Area              =      0.1 acres

-- Storm data
    Total precipitation   =      1.9 inches
    Storm type            = SCS 6 hour design storm
    Peak Discharge        =    0.01 cfs
    Discharge volume      =    0.00 acre ft
```

```
Project Title          = WSDD-3 (UNDISTURBED - 10/24)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:          Null


-- Watershed data for watershed # 1
    Curve number                =    69.0
    Area                        =     0.1 acres
    Hydraulic length            =   80.00 Feet
    Elevation change            =    40.0 feet.
    Concentration time          =    0.01 hours
    Concentration time type = SCS Upland Curves
    Unit hydrograph type        = Forested

-- Total Area               =      0.1 acres

-- Storm data
    Total precipitation     =      2.5 inches
    Storm type              = SCS Type 2 storm, 24 hour storm
    Peak Discharge          =     0.03 cfs
    Discharge volume        =     0.00 acre ft
```

```
Project Title          = WSDD-3 (RECLAIMED - 10/6)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:          Null


-- Watershed data for watershed # 1
    Curve number               =    75.0
    Area                       =     0.2 acres
    Hydraulic length           =  100.00 Feet
    Elevation change           =    48.0 feet.
    Concentration time         =    0.00 hours
    Concentration time type = SCS Upland Curves
    Unit hydrograph type     = Disturbed

-- Total Area              =     0.2 acres

-- Storm data
    Total precipitation   =     1.5 inches
    Storm type            = SCS 6 hour design storm
    Peak Discharge        =    0.01 cfs
    Discharge volume      =    0.00 acre ft
```

```
Project Title          = WSDD-3 (RECLAIMED - 25/6)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:          Null



-- Watershed data for watershed # 1
    Curve number               =    75.0
    Area                       =     0.2 acres
    Hydraulic length           =  100.00 Feet
    Elevation change           =    48.0 feet.
    Concentration time         =    0.00 hours
    Concentration time type = SCS Upland Curves
    Unit hydrograph type       = Disturbed

-- Total Area              =      0.2 acres

-- Storm data
    Total precipitation    =     1.9 inches
    Storm type             = SCS 6 hour design storm
    Peak Discharge         =    0.02 cfs
    Discharge volume       =    0.00 acre ft
```

```
Project Title          = WSDD-3 (RECLAIMED - 10/24)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:         Null


-- Watershed data for watershed # 1
    Curve number                =    75.0
    Area                        =     0.2 acres
    Hydraulic length            =  100.00 Feet
    Elevation change            =    48.0 feet.
    Concentration time          =    0.00 hours
    Concentration time type = SCS Upland Curves
    Unit hydrograph type        = Disturbed

-- Total Area               =       0.2 acres

-- Storm data
    Total precipitation     =     2.5 inches
    Storm type              = SCS Type 2 storm, 24 hour storm
    Peak Discharge          =    0.05 cfs
    Discharge volume        =    0.01 acre ft
```

```
Project Title            = WSDD-3 (DISTURBED 10/6)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:          Null


-- Watershed data for watershed # 1
    Curve number                =    90.0
    Area                        =     0.3 acres
    Hydraulic length            =  125.00 Feet
    Elevation change            =    70.0 feet.
    Concentration time          =    0.00 hours
    Concentration time type = SCS Upland Curves
    Unit hydrograph type        = Disturbed

-- Total Area               =      0.3 acres

-- Storm data
    Total precipitation     =      1.5 inches
    Storm type              = SCS 6 hour design storm
    Peak Discharge          =    0.08 cfs
    Discharge volume        =    0.02 acre ft
```

```
Project Title          = WSDD-3 (DISTURBED 25/6)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:          Null


-- Watershed data for watershed # 1
    Curve number                =    90.0
    Area                        =     0.3 acres
    Hydraulic length            =  125.00 Feet
    Elevation change            =    70.0 feet.
    Concentration time          =    0.00 hours
    Concentration time type = SCS Upland Curves
    Unit hydrograph type        = Disturbed

-- Total Area              =      0.3 acres

-- Storm data
    Total precipitation     =      1.9 inches
    Storm type              = SCS 6 hour design storm
    Peak Discharge          =     0.12 cfs
    Discharge volume        =     0.02 acre ft
```

```
Project Title          = WSDD-3 (DISTURBED 10/24)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:          Null


-- Watershed data for watershed # 1
    Curve number                =    90.0
    Area                        =     0.3 acres
    Hydraulic length            =  125.00 Feet
    Elevation change            =    70.0 feet.
    Concentration time          =    0.00 hours
    Concentration time type = SCS Upland Curves
    Unit hydrograph type        = Disturbed

-- Total Area                =       0.3 acres

-- Storm data
    Total precipitation  =       2.5 inches
    Storm type           = SCS Type 2 storm, 24 hour storm
    Peak Discharge       =    0.18 cfs
    Discharge volume     =    0.03 acre ft
```

```
Project Title          = WSDD-3 (PAVED 10/6)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:          Null


-- Watershed data for watershed # 1
    Curve number                =    95.0
    Area                        =     0.3 acres
    Hydraulic length            =  100.00 Feet
    Elevation change            =     3.0 feet.
    Concentration time          =    0.01 hours
    Concentration time type = SCS Upland Curves
    Unit hydrograph type        = Disturbed

-- Total Area              =      0.3 acres

-- Storm data
    Total precipitation    =      1.5 inches
    Storm type             = SCS 6 hour design storm
    Peak Discharge         =    0.17 cfs
    Discharge volume       =    0.03 acre ft
```

```
Project Title            = WSDD-3 (PAVED 25/6)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:         Null


-- Watershed data for watershed # 1
    Curve number                =    95.0
    Area                        =     0.3 acres
    Hydraulic length            =  100.00 Feet
    Elevation change            =     3.0 feet.
    Concentration time          =    0.01 hours
    Concentration time type = SCS Upland Curves
    Unit hydrograph type        = Disturbed

-- Total Area               =      0.3 acres

-- Storm data
    Total precipitation  =      1.9 inches
    Storm type           = SCS 6 hour design storm
    Peak Discharge       =    0.22 cfs
    Discharge volume     =    0.04 acre ft
```

```
Project Title          = WSDD-3 (PAVED 10/24)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:          Null


-- Watershed data for watershed # 1
    Curve number                =     95.0
    Area                        =      0.3 acres
    Hydraulic length            =   100.00 Feet
    Elevation change            =      3.0 feet.
    Concentration time          =     0.01 hours
    Concentration time type     = SCS Upland Curves
    Unit hydrograph type        = Disturbed

-- Total Area               =      0.3 acres

-- Storm data
    Total precipitation     =      2.5 inches
    Storm type              = SCS Type 2 storm, 24 hour storm
    Peak Discharge          =     0.32 cfs
    Discharge volume        =     0.05 acre ft
```

```
Project Title          = WSDD-4 (PAVED 10/6)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:         Null


-- Watershed data for watershed # 1
    Curve number                =    95.0
    Area                        =     0.1 acres
    Hydraulic length            =  250.00 Feet
    Elevation change            =    20.0 feet.
    Concentration time          =    0.01 hours
    Concentration time type = SCS Upland Curves
    Unit hydrograph type        = Disturbed

-- Total Area              =     0.1 acres

-- Storm data
    Total precipitation    =     1.5 inches
    Storm type             = SCS 6 hour design storm
    Peak Discharge         =    0.07 cfs
    Discharge volume       =    0.01 acre ft
```

```
Project Title            = WSDD-4 (PAVED 25/6)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:          Null


-- Watershed data for watershed # 1
    Curve number                =    95.0
    Area                        =     0.1 acres
    Hydraulic length            =  250.00 Feet
    Elevation change            =    20.0 feet.
    Concentration time          =    0.01 hours
    Concentration time type = SCS Upland Curves
    Unit hydrograph type        = Disturbed

-- Total Area               =     0.1 acres

-- Storm data
    Total precipitation    =      1.9 inches
    Storm type             = SCS 6 hour design storm
    Peak Discharge         =    0.09 cfs
    Discharge volume       =    0.01 acre ft
```

```
Project Title             = WSDD-4 (PAVED 10/24)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:          Null


-- Watershed data for watershed # 1
    Curve number              =    95.0
    Area                      =     0.1 acres
    Hydraulic length          =  250.00 Feet
    Elevation change          =    20.0 feet.
    Concentration time        =    0.01 hours
    Concentration time type = SCS Upland Curves
    Unit hydrograph type      = Disturbed

-- Total Area             =     0.1 acres

-- Storm data
    Total precipitation  =     2.5 inches
    Storm type           = SCS Type 2 storm, 24 hour storm
    Peak Discharge       =    0.12 cfs
    Discharge volume     =    0.02 acre ft
```

```
Project Title              = WSDD-4 (DISTURBED 10/6)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:          Null


-- Watershed data for watershed # 1
    Curve number                =    90.0
    Area                        =     0.1 acres
    Hydraulic length            =  100.00 Feet
    Elevation change            =    10.0 feet.
    Concentration time          =    0.01 hours
    Concentration time type = SCS Upland Curves
    Unit hydrograph type        = Disturbed

-- Total Area               =     0.1 acres

-- Storm data
    Total precipitation  =     1.5 inches
    Storm type           = SCS 6 hour design storm
    Peak Discharge       =    0.04 cfs
    Discharge volume     =    0.01 acre ft
```

```
Project Title           = WSDD-4 (DISTURBED 25/6)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:         Null


-- Watershed data for watershed # 1
    Curve number                =    90.0
    Area                        =     0.1 acres
    Hydraulic length            =  100.00 Feet
    Elevation change            =    10.0 feet.
    Concentration time          =    0.01 hours
    Concentration time type = SCS Upland Curves
    Unit hydrograph type    = Disturbed

-- Total Area               =     0.1 acres

-- Storm data
    Total precipitation  =     1.9 inches
    Storm type           = SCS 6 hour design storm
    Peak Discharge       =    0.05 cfs
    Discharge volume     =    0.01 acre ft
```

```
Project Title          = WSDD-4 (DISTURBED 10/24)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:          Null


-- Watershed data for watershed # 1
    Curve number                 =    90.0
    Area                         =     0.1 acres
    Hydraulic length             =  100.00 Feet
    Elevation change             =    10.0 feet.
    Concentration time           =    0.01 hours
    Concentration time type = SCS Upland Curves
    Unit hydrograph type         = Disturbed

-- Total Area              =      0.1 acres

-- Storm data
    Total precipitation  =      2.5 inches
    Storm type           = SCS Type 2 storm, 24 hour storm
    Peak Discharge       =    0.08 cfs
    Discharge volume     =    0.01 acre ft
```

```
Project Title          = WSDD-5 (UNDISTURBED - 10/6)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:          Null


-- Watershed data for watershed # 1
    Curve number                =    69.0
    Area                        =     0.1 acres
    Hydraulic length            =   60.00 Feet
    Elevation change            =    30.0 feet.
    Concentration time          =    0.01 hours
    Concentration time type = SCS Upland Curves
    Unit hydrograph type        = Forested

-- Total Area              =      0.1 acres

-- Storm data
    Total precipitation    =      1.5 inches
    Storm type             = SCS 6 hour design storm
    Peak Discharge         =    0.00 cfs
    Discharge volume       =    0.00 acre ft
```

Project Title = WSDD-5 (UNDISTURBED - 25/6)

WATERSHED HYDROGRAPH

Inflow into structure # 1

Structure type: Null

-- Watershed data for watershed # 1

Curve number	=	69.0
Area	=	0.1 acres
Hydraulic length	=	60.00 Feet
Elevation change	=	30.0 feet.
Concentration time	=	0.01 hours
Concentration time type	=	SCS Upland Curves
Unit hydrograph type	=	Forested

-- Total Area = 0.1 acres

-- Storm data

Total precipitation	=	1.9 inches
Storm type	=	SCS 6 hour design storm
Peak Discharge	=	0.01 cfs
Discharge volume	=	0.00 acre ft

```
Project Title          = WSDD-5 (UNDISTURBED - 10/24)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:           Null


-- Watershed data for watershed # 1
    Curve number                =    69.0
    Area                        =     0.1 acres
    Hydraulic length            =   60.00 Feet
    Elevation change            =    30.0 feet.
    Concentration time          =    0.01 hours
    Concentration time type = SCS Upland Curves
    Unit hydrograph type        = Forested

-- Total Area               =      0.1 acres

-- Storm data
    Total precipitation  =      2.5 inches
    Storm type           = SCS Type 2 storm, 24 hour storm
    Peak Discharge       =     0.03 cfs
    Discharge volume     =     0.00 acre ft
```

```
Project Title          = WSDD-5 (RECLAIMED - 10/6)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:          Null



-- Watershed data for watershed # 1
    Curve number                =    75.0
    Area                        =     0.3 acres
    Hydraulic length            =   80.00 Feet
    Elevation change            =    40.0 feet.
    Concentration time          =    0.00 hours
    Concentration time type = SCS Upland Curves
    Unit hydrograph type        = Disturbed

-- Total Area               =     0.3 acres

-- Storm data
    Total precipitation  =     1.5 inches
    Storm type           = SCS 6 hour design storm
    Peak Discharge       =    0.02 cfs
    Discharge volume     =    0.01 acre ft
```

```
Project Title          = WSDD-5 (RECLAIMED - 25/6)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:          Null


-- Watershed data for watershed # 1
    Curve number                =    75.0
    Area                        =     0.3 acres
    Hydraulic length            =   80.00 Feet
    Elevation change            =    40.0 feet.
    Concentration time          =    0.00 hours
    Concentration time type = SCS Upland Curves
    Unit hydrograph type        = Disturbed

-- Total Area              =     0.3 acres

-- Storm data
    Total precipitation    =      1.9 inches
    Storm type             = SCS 6 hour design storm
    Peak Discharge         =    0.04 cfs
    Discharge volume       =    0.01 acre ft
```

```
Project Title            = WSDD-5 (RECLAIMED - 10/24)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:          Null


-- Watershed data for watershed # 1
    Curve number                =    75.0
    Area                        =     0.3 acres
    Hydraulic length            =   80.00 Feet
    Elevation change            =    40.0 feet.
    Concentration time          =    0.00 hours
    Concentration time type = SCS Upland Curves
    Unit hydrograph type        = Disturbed

-- Total Area                =      0.3 acres

-- Storm data
    Total precipitation   =      2.5 inches
    Storm type            = SCS Type 2 storm, 24 hour storm
    Peak Discharge        =     0.10 cfs
    Discharge volume      =     0.02 acre ft
```

Project Title = WSDD-5 (PAVED - 10/6)

WATERSHED HYDROGRAPH

Inflow into structure # 1

Structure type: Null

-- Watershed data for watershed # 1

Curve number	= 95.0
Area	= 0.3 acres
Hydraulic length	= 300.00 Feet
Elevation change	= 25.0 feet.
Concentration time	= 0.01 hours
Concentration time type	= SCS Upland Curves
Unit hydrograph type	= Disturbed

-- Total Area = 0.3 acres

-- Storm data

Total precipitation	= 1.5 inches
Storm type	= SCS 6 hour design storm
Peak Discharge	= 0.21 cfs
Discharge volume	= 0.03 acre ft

```
Project Title           = WSDD-5 (PAVED - 25/6)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:          Null


-- Watershed data for watershed # 1
    Curve number                =    95.0
    Area                        =     0.3 acres
    Hydraulic length            =  300.00 Feet
    Elevation change            =    25.0 feet.
    Concentration time          =    0.01 hours
    Concentration time type = SCS Upland Curves
    Unit hydrograph type        = Disturbed

-- Total Area                =     0.3 acres

-- Storm data
    Total precipitation     =     1.9 inches
    Storm type              = SCS 6 hour design storm
    Peak Discharge          =    0.27 cfs
    Discharge volume        =    0.04 acre ft
```

Project Title = WSDD-5 (PAVED - 10/24)

WATERSHED HYDROGRAPH

Inflow into structure # 1

Structure type: Null

-- Watershed data for watershed # 1

Curve number	=	95.0
Area	=	0.3 acres
Hydraulic length	=	300.00 Feet
Elevation change	=	25.0 feet.
Concentration time	=	0.01 hours
Concentration time type	=	SCS Upland Curves
Unit hydrograph type	=	Disturbed

-- Total Area = 0.3 acres

-- Storm data

Total precipitation	=	2.5 inches
Storm type	=	SCS Type 2 storm, 24 hour storm
Peak Discharge	=	0.39 cfs
Discharge volume	=	0.05 acre ft

```
Project Title           = WSDD-7 (UNDISTURBED 10/6)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:          Null


-- Watershed data for watershed # 1
    Curve number              =    69.0
    Area                      =     0.2 acres
    Hydraulic length          =  100.00 Feet
    Elevation change          =    78.0 feet.
    Concentration time        =    0.01 hours
    Concentration time type = SCS Upland Curves
    Unit hydrograph type      = Forested

-- Total Area             =      0.2 acres

-- Storm data
    Total precipitation   =      1.5 inches
    Storm type            = SCS 6 hour design storm
    Peak Discharge        =    0.00 cfs
    Discharge volume      =    0.00 acre ft
```

```
Project Title          = WSDD-7 (UNDISTURBED 25/6)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:          Null



-- Watershed data for watershed # 1
    Curve number                =    69.0
    Area                        =     0.2 acres
    Hydraulic length            =  100.00 Feet
    Elevation change            =    78.0 feet.
    Concentration time          =    0.01 hours
    Concentration time type = SCS Upland Curves
    Unit hydrograph type        = Forested

-- Total Area               =      0.2 acres

-- Storm data
    Total precipitation     =      1.9 inches
    Storm type              = SCS 6 hour design storm
    Peak Discharge          =    0.01 cfs
    Discharge volume        =    0.00 acre ft
```

```
Project Title           = WSDD-7 (UNDISTURBED 10/24)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:          Null


-- Watershed data for watershed # 1
    Curve number                 =    69.0
    Area                         =     0.2 acres
    Hydraulic length             =  100.00 Feet
    Elevation change             =    78.0 feet.
    Concentration time           =    0.01 hours
    Concentration time type = SCS Upland Curves
    Unit hydrograph type         = Forested

-- Total Area               =      0.2 acres

-- Storm data
    Total precipitation      =     2.5 inches
    Storm type               = SCS Type 2 storm, 24 hour storm
    Peak Discharge           =    0.05 cfs
    Discharge volume         =    0.01 acre ft
```

```
Project Title              = WSDD-7 (DISTURBED 10/6)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:            Null


-- Watershed data for watershed # 1
    Curve number                  =     90.0
    Area                          =      0.2 acres
    Hydraulic length              =   120.00 Feet
    Elevation change              =     80.0 feet.
    Concentration time            =     0.00 hours
    Concentration time type = SCS Upland Curves
    Unit hydrograph type          = Disturbed

-- Total Area              =      0.2 acres

-- Storm data
    Total precipitation   =      1.5 inches
    Storm type            = SCS 6 hour design storm
    Peak Discharge        =     0.05 cfs
    Discharge volume      =     0.01 acre ft
```

```
Project Title          = WSDD-7 (DISTURBED 25/6)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:          Null


-- Watershed data for watershed # 1
    Curve number                =    90.0
    Area                        =     0.2 acres
    Hydraulic length            =  120.00 Feet
    Elevation change            =    80.0 feet.
    Concentration time          =    0.00 hours
    Concentration time type = SCS Upland Curves
    Unit hydrograph type        = Disturbed

-- Total Area               =     0.2 acres

-- Storm data
    Total precipitation  =      1.9 inches
    Storm type           = SCS 6 hour design storm
    Peak Discharge       =    0.07 cfs
    Discharge volume     =    0.01 acre ft
```

```
Project Title           = WSDD-7 (DISTURBED 10/24)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:          Null



-- Watershed data for watershed # 1
    Curve number                =    90.0
    Area                        =     0.2 acres
    Hydraulic length            =  120.00 Feet
    Elevation change            =    80.0 feet.
    Concentration time          =    0.00 hours
    Concentration time type = SCS Upland Curves
    Unit hydrograph type        = Disturbed

-- Total Area              =     0.2 acres

-- Storm data
    Total precipitation  =     2.5 inches
    Storm type           = SCS Type 2 storm, 24 hour storm
    Peak Discharge       =    0.12 cfs
    Discharge volume     =    0.02 acre ft
```

```
Project Title            = WSDD-7 (PAVED 10/6)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:          Null


-- Watershed data for watershed # 1
    Curve number                =    95.0
    Area                        =     0.1 acres
    Hydraulic length            =  150.00 Feet
    Elevation change            =     5.0 feet.
    Concentration time          =    0.01 hours
    Concentration time type = SCS Upland Curves
    Unit hydrograph type    = Disturbed

-- Total Area               =     0.1 acres

-- Storm data
    Total precipitation  =     1.5 inches
    Storm type           = SCS 6 hour design storm
    Peak Discharge       =    0.06 cfs
    Discharge volume     =    0.01 acre ft
```

```
Project Title          = WSDD-7 (PAVED 25/6)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:          Null


-- Watershed data for watershed # 1
    Curve number                =    95.0
    Area                        =     0.1 acres
    Hydraulic length            =  150.00 Feet
    Elevation change            =     5.0 feet.
    Concentration time          =    0.01 hours
    Concentration time type = SCS Upland Curves
    Unit hydrograph type        = Disturbed

-- Total Area              =     0.1 acres

-- Storm data
    Total precipitation  =     1.9 inches
    Storm type           = SCS 6 hour design storm
    Peak Discharge       =    0.08 cfs
    Discharge volume     =    0.01 acre ft
```

```
Project Title              = WSDD-7 (PAVED 10/24)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:            Null


-- Watershed data for watershed # 1
    Curve number                =    95.0
    Area                        =     0.1 acres
    Hydraulic length            =  150.00 Feet
    Elevation change            =     5.0 feet.
    Concentration time          =    0.01 hours
    Concentration time type = SCS Upland Curves
    Unit hydrograph type        = Disturbed

-- Total Area              =      0.1 acres

-- Storm data
    Total precipitation  =      2.5 inches
    Storm type           = SCS Type 2 storm, 24 hour storm
    Peak Discharge       =     0.11 cfs
    Discharge volume     =     0.02 acre ft
```

```
Project Title          = WSDD-8 (UNDISTURBED 10/6)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:          Null


-- Watershed data for watershed # 1
    Curve number               =    69.0
    Area                       =     3.6 acres
    Hydraulic length           =  700.00 Feet
    Elevation change           =   460.0 feet.
    Concentration time         =    0.09 hours
    Concentration time type = SCS Upland Curves
    Unit hydrograph type       = Forested

-- Total Area              =     3.6 acres

-- Storm data
    Total precipitation  =      1.5 inches
    Storm type           = SCS 6 hour design storm
    Peak Discharge       =    0.10 cfs
    Discharge volume     =    0.02 acre ft
```

```
Project Title          = WSDD-8 (UNDISTURBED 25/6)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:          Null


-- Watershed data for watershed # 1
    Curve number                =    69.0
    Area                        =     3.6 acres
    Hydraulic length            =  700.00 Feet
    Elevation change            =   460.0 feet.
    Concentration time          =    0.09 hours
    Concentration time type     = SCS Upland Curves
    Unit hydrograph type        = Forested

-- Total Area               =     3.6 acres

-- Storm data
    Total precipitation   =     1.9 inches
    Storm type            = SCS 6 hour design storm
    Peak Discharge        =    0.20 cfs
    Discharge volume      =    0.05 acre ft
```

```
Project Title              = WSDD-8 (UNDISTURBED 10/24)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:           Null


-- Watershed data for watershed # 1
    Curve number                  =    69.0
    Area                          =     3.6 acres
    Hydraulic length              =  700.00 Feet
    Elevation change              =   460.0 feet.
    Concentration time            =    0.09 hours
    Concentration time type = SCS Upland Curves
    Unit hydrograph type          = Forested

-- Total Area              =     3.6 acres

-- Storm data
    Total precipitation  =      2.5 inches
    Storm type           = SCS Type 2 storm, 24 hour storm
    Peak Discharge       =    0.75 cfs
    Discharge volume     =    0.13 acre ft
```

```
Project Title              = WSDD-8 (RECLAIMED 10/6)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:          Null


-- Watershed data for watershed # 1
    Curve number                =    75.0
    Area                        =     0.2 acres
    Hydraulic length            =   80.00 Feet
    Elevation change            =    50.0 feet.
    Concentration time          =    0.00 hours
    Concentration time type = SCS Upland Curves
    Unit hydrograph type        = Disturbed

-- Total Area               =       0.2 acres

-- Storm data
    Total precipitation  =      1.5 inches
    Storm type           = SCS 6 hour design storm
    Peak Discharge       =     0.01 cfs
    Discharge volume     =     0.00 acre ft
```

```
Project Title          = WSDD-8 (RECLAIMED 25/6)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:          Null


-- Watershed data for watershed # 1
    Curve number                =    75.0
    Area                        =     0.2 acres
    Hydraulic length            =   80.00 Feet
    Elevation change            =    50.0 feet.
    Concentration time          =    0.00 hours
    Concentration time type = SCS Upland Curves
    Unit hydrograph type        = Disturbed

-- Total Area               =      0.2 acres

-- Storm data
    Total precipitation   =      1.9 inches
    Storm type            = SCS 6 hour design storm
    Peak Discharge        =    0.02 cfs
    Discharge volume      =    0.00 acre ft
```

```
Project Title           = WSDD-8 (RECLAIMED 10/24)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:          Null


-- Watershed data for watershed # 1
    Curve number                =    75.0
    Area                        =     0.2 acres
    Hydraulic length            =   80.00 Feet
    Elevation change            =    50.0 feet.
    Concentration time          =    0.00 hours
    Concentration time type = SCS Upland Curves
    Unit hydrograph type        = Disturbed

-- Total Area               =     0.2 acres

-- Storm data
    Total precipitation     =     2.5 inches
    Storm type              = SCS Type 2 storm, 24 hour storm
    Peak Discharge          =    0.05 cfs
    Discharge volume        =    0.01 acre ft
```

Project Title = WSDD-8 (DISTURBED 10/6)

WATERSHED HYDROGRAPH

Inflow into structure # 1

Structure type: Null

-- Watershed data for watershed # 1

Curve number	=	90.0
Area	=	0.4 acres
Hydraulic length	=	60.00 Feet
Elevation change	=	39.0 feet.
Concentration time	=	0.00 hours
Concentration time type	=	SCS Upland Curves
Unit hydrograph type	=	Disturbed

-- Total Area = 0.4 acres

-- Storm data

Total precipitation	=	1.5 inches
Storm type	=	SCS 6 hour design storm
Peak Discharge	=	0.10 cfs
Discharge volume	=	0.02 acre ft

```
Project Title              = WSDD-8 (DISTURBED 25/6)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:           Null


-- Watershed data for watershed # 1
    Curve number                 =    90.0
    Area                         =     0.4 acres
    Hydraulic length             =   60.00 Feet
    Elevation change             =    39.0 feet.
    Concentration time           =    0.00 hours
    Concentration time type = SCS Upland Curves
    Unit hydrograph type     = Disturbed

-- Total Area              =      0.4 acres

-- Storm data
    Total precipitation   =     1.9 inches
    Storm type            = SCS 6 hour design storm
    Peak Discharge        =    0.14 cfs
    Discharge volume      =    0.03 acre ft
```

```
Project Title          = WSDD-8 (DISTURBED 10/24)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:         Null


-- Watershed data for watershed # 1
    Curve number                =    90.0
    Area                        =     0.4 acres
    Hydraulic length            =   60.00 Feet
    Elevation change            =    39.0 feet.
    Concentration time          =    0.00 hours
    Concentration time type = SCS Upland Curves
    Unit hydrograph type        = Disturbed

-- Total Area               =      0.4 acres

-- Storm data
    Total precipitation     =      2.5 inches
    Storm type              = SCS Type 2 storm, 24 hour storm
    Peak Discharge          =     0.23 cfs
    Discharge volume        =     0.05 acre ft
```

```
Project Title            = WSDD-8 (PAVED 10/6)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:          Null


-- Watershed data for watershed # 1
    Curve number                =    95.0
    Area                        =     0.3 acres
    Hydraulic length            =  560.00 Feet
    Elevation change            =    30.0 feet.
    Concentration time          =    0.03 hours
    Concentration time type = SCS Upland Curves
    Unit hydrograph type        = Disturbed

-- Total Area               =     0.3 acres

-- Storm data
    Total precipitation   =     1.5 inches
    Storm type            = SCS 6 hour design storm
    Peak Discharge        =    0.20 cfs
    Discharge volume      =    0.02 acre ft
```

```
Project Title              = WSDD-8 (PAVED 25/6)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:          Null


-- Watershed data for watershed # 1
    Curve number                =    95.0
    Area                        =     0.3 acres
    Hydraulic length            =  560.00 Feet
    Elevation change            =    30.0 feet.
    Concentration time          =    0.03 hours
    Concentration time type = SCS Upland Curves
    Unit hydrograph type        = Disturbed

-- Total Area               =     0.3 acres

-- Storm data
    Total precipitation     =     1.9 inches
    Storm type              = SCS 6 hour design storm
    Peak Discharge          =    0.26 cfs
    Discharge volume        =    0.03 acre ft
```

```
Project Title          = WSDD-8 (PAVED 10/24)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:          Null


-- Watershed data for watershed # 1
    Curve number                =    95.0
    Area                        =     0.3 acres
    Hydraulic length            =  560.00 Feet
    Elevation change            =    30.0 feet.
    Concentration time          =    0.03 hours
    Concentration time type = SCS Upland Curves
    Unit hydrograph type        = Disturbed

-- Total Area               =     0.3 acres

-- Storm data
    Total precipitation     =     2.5 inches
    Storm type              = SCS Type 2 storm, 24 hour storm
    Peak Discharge          =    0.37 cfs
    Discharge volume        =    0.04 acre ft
```

```
Project Title            = WSDD-10 (UNDISTURBED - 10/6)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:            Null


-- Watershed data for watershed # 1
    Curve number                =    69.0
    Area                        =     0.1 acres
    Hydraulic length            =   45.00 Feet
    Elevation change            =    28.0 feet.
    Concentration time          =    0.01 hours
    Concentration time type     = SCS Upland Curves
    Unit hydrograph type        = Forested

-- Total Area               =     0.1 acres

-- Storm data
    Total precipitation      =     1.5 inches
    Storm type               = SCS 6 hour design storm
    Peak Discharge           =    0.00 cfs
    Discharge volume         =    0.00 acre ft
```

```
Project Title            = WSDD-10 (UNDISTURBED - 25/6)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:          Null


-- Watershed data for watershed # 1
    Curve number                =    69.0
    Area                        =     0.1 acres
    Hydraulic length            =   45.00 Feet
    Elevation change            =    28.0 feet.
    Concentration time          =    0.01 hours
    Concentration time type = SCS Upland Curves
    Unit hydrograph type        = Forested

-- Total Area             =     0.1 acres

-- Storm data
    Total precipitation     =     1.9 inches
    Storm type              = SCS 6 hour design storm
    Peak Discharge          =    0.01 cfs
    Discharge volume        =    0.00 acre ft
```

```
Project Title            = WSDD-10 (UNDISTURBED - 10/24)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:         Null


-- Watershed data for watershed # 1
    Curve number               =    69.0
    Area                       =     0.1 acres
    Hydraulic length           =   45.00 Feet
    Elevation change           =    28.0 feet.
    Concentration time         =    0.01 hours
    Concentration time type = SCS Upland Curves
    Unit hydrograph type       = Forested

-- Total Area              =      0.1 acres

-- Storm data
    Total precipitation  =     2.5 inches
    Storm type           = SCS Type 2 storm, 24 hour storm
    Peak Discharge       =    0.03 cfs
    Discharge volume     =    0.00 acre ft
```

```
Project Title           = WSDD-10 (RECLAIMED - 10/6)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:          Null


-- Watershed data for watershed # 1
    Curve number                =    75.0
    Area                        =     0.1 acres
    Hydraulic length            =   50.00 Feet
    Elevation change            =    36.0 feet.
    Concentration time          =    0.00 hours
    Concentration time type = SCS Upland Curves
    Unit hydrograph type    = Disturbed

-- Total Area               =      0.1 acres

-- Storm data
    Total precipitation  =      1.5 inches
    Storm type           = SCS 6 hour design storm
    Peak Discharge       =    0.01 cfs
    Discharge volume     =    0.00 acre ft
```

```
Project Title          = WSDD-10 (RECLAIMED - 25/6)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:          Null


-- Watershed data for watershed # 1
    Curve number                 =    75.0
    Area                         =     0.1 acres
    Hydraulic length             =   50.00 Feet
    Elevation change             =    36.0 feet.
    Concentration time           =    0.00 hours
    Concentration time type = SCS Upland Curves
    Unit hydrograph type         = Disturbed

-- Total Area               =      0.1 acres

-- Storm data
    Total precipitation    =      1.9 inches
    Storm type             = SCS 6 hour design storm
    Peak Discharge         =    0.01 cfs
    Discharge volume       =    0.00 acre ft
```

```
Project Title          = WSDD-10 (RECLAIMED - 10/24)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:          Null


-- Watershed data for watershed # 1
    Curve number                =    75.0
    Area                        =     0.1 acres
    Hydraulic length            =   50.00 Feet
    Elevation change            =    36.0 feet.
    Concentration time          =    0.00 hours
    Concentration time type = SCS Upland Curves
    Unit hydrograph type        = Disturbed

-- Total Area              =      0.1 acres

-- Storm data
    Total precipitation     =      2.5 inches
    Storm type              = SCS Type 2 storm, 24 hour storm
    Peak Discharge          =    0.03 cfs
    Discharge volume        =    0.01 acre ft
```

```
Project Title              = WSDD-10 (DISTURBED 10/6)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:           Null


-- Watershed data for watershed # 1
    Curve number                 =    90.0
    Area                         =     0.6 acres
    Hydraulic length             =  120.00 Feet
    Elevation change             =    75.0 feet.
    Concentration time           =    0.00 hours
    Concentration time type = SCS Upland Curves
    Unit hydrograph type     = Disturbed

-- Total Area            =      0.6 acres

-- Storm data
    Total precipitation  =      1.5 inches
    Storm type              = SCS 6 hour design storm
    Peak Discharge          =    0.19 cfs
    Discharge volume        =    0.04 acre ft
```

Project Title = WSDD-10 (DISTURBED 25/6)

WATERSHED HYDROGRAPH

Inflow into structure # 1

Structure type: Null

-- Watershed data for watershed # 1

Curve number	=	90.0
Area	=	0.6 acres
Hydraulic length	=	120.00 Feet
Elevation change	=	75.0 feet.
Concentration time	=	0.00 hours
Concentration time type	=	SCS Upland Curves
Unit hydrograph type	=	Disturbed

-- Total Area = 0.6 acres

-- Storm data

Total precipitation	=	1.9 inches
Storm type	=	SCS 6 hour design storm
Peak Discharge	=	0.27 cfs
Discharge volume	=	0.05 acre ft

```
Project Title           = WSDD-10 (DISTURBED 10/24)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:          Null


-- Watershed data for watershed # 1
    Curve number                =     90.0
    Area                        =      0.6 acres
    Hydraulic length            =   120.00 Feet
    Elevation change            =     75.0 feet.
    Concentration time          =     0.00 hours
    Concentration time type     = SCS Upland Curves
    Unit hydrograph type        = Disturbed

-- Total Area               =      0.6 acres

-- Storm data
    Total precipitation    =      2.5 inches
    Storm type             = SCS Type 2 storm, 24 hour storm
    Peak Discharge         =     0.42 cfs
    Discharge volume       =     0.08 acre ft
```

```
Project Title              = WSDD-10 (PAVED 10/6)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:          Null


-- Watershed data for watershed # 1
    Curve number                =    95.0
    Area                        =     0.3 acres
    Hydraulic length            =  335.00 Feet
    Elevation change            =    18.0 feet.
    Concentration time          =    0.02 hours
    Concentration time type = SCS Upland Curves
    Unit hydrograph type        = Disturbed

-- Total Area               =      0.3 acres

-- Storm data
    Total precipitation    =      1.5 inches
    Storm type             = SCS 6 hour design storm
    Peak Discharge         =    0.19 cfs
    Discharge volume       =    0.02 acre ft
```

```
Project Title            = WSDD-10 (PAVED 25/6)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:          Null


-- Watershed data for watershed # 1
    Curve number                =    95.0
    Area                        =     0.3 acres
    Hydraulic length            =  335.00 Feet
    Elevation change            =    18.0 feet.
    Concentration time          =    0.02 hours
    Concentration time type = SCS Upland Curves
    Unit hydrograph type        = Disturbed

-- Total Area               =      0.3 acres

-- Storm data
    Total precipitation  =     1.9 inches
    Storm type           = SCS 6 hour design storm
    Peak Discharge       =    0.24 cfs
    Discharge volume     =    0.03 acre ft
```

```
Project Title           = WSDD-10 (PAVED 10/24)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:          Null


-- Watershed data for watershed # 1
    Curve number              =    95.0
    Area                      =     0.3 acres
    Hydraulic length          =  335.00 Feet
    Elevation change          =    18.0 feet.
    Concentration time        =    0.02 hours
    Concentration time type = SCS Upland Curves
    Unit hydrograph type      = Disturbed

-- Total Area              =     0.3 acres

-- Storm data
    Total precipitation    =     2.5 inches
    Storm type             = SCS Type 2 storm, 24 hour storm
    Peak Discharge         =    0.35 cfs
    Discharge volume       =    0.04 acre ft
```

```
Project Title             = WSDD-11 (UNDISTURBED 10/6)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:          Null


-- Watershed data for watershed # 1
    Curve number                =    69.0
    Area                        =     2.1 acres
    Hydraulic length            =  570.00 Feet
    Elevation change            =   370.0 feet.
    Concentration time          =    0.08 hours
    Concentration time type = SCS Upland Curves
    Unit hydrograph type        = Forested

-- Total Area               =      2.1 acres

-- Storm data
    Total precipitation  =      1.5 inches
    Storm type           = SCS 6 hour design storm
    Peak Discharge       =    0.06 cfs
    Discharge volume     =    0.01 acre ft
```

```
Project Title          = WSDD-11 (UNDISTURBED 25/6)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:          Null


-- Watershed data for watershed # 1
    Curve number                =    69.0
    Area                        =     2.1 acres
    Hydraulic length            =  570.00 Feet
    Elevation change            =   370.0 feet.
    Concentration time          =    0.08 hours
    Concentration time type = SCS Upland Curves
    Unit hydrograph type        = Forested

-- Total Area              =      2.1 acres

-- Storm data
    Total precipitation    =      1.9 inches
    Storm type             = SCS 6 hour design storm
    Peak Discharge         =    0.12 cfs
    Discharge volume       =    0.03 acre ft
```

```
Project Title          = WSDD-11 (UNDISTURBED 10/24)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:          Null



-- Watershed data for watershed # 1
    Curve number                =    69.0
    Area                        =     2.1 acres
    Hydraulic length            =  570.00 Feet
    Elevation change            =   370.0 feet.
    Concentration time          =    0.08 hours
    Concentration time type = SCS Upland Curves
    Unit hydrograph type        = Forested

-- Total Area               =      2.1 acres

-- Storm data
    Total precipitation     =      2.5 inches
    Storm type              = SCS Type 2 storm, 24 hour storm
    Peak Discharge          =    0.47 cfs
    Discharge volume        =    0.07 acre ft
```

```
Project Title          = WSDD-11 (RECLAIMED 10/6)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:          Null


-- Watershed data for watershed # 1
    Curve number               =    75.0
    Area                       =     0.2 acres
    Hydraulic length           =   30.00 Feet
    Elevation change           =    20.0 feet.
    Concentration time         =    0.00 hours
    Concentration time type = SCS Upland Curves
    Unit hydrograph type       = Disturbed

-- Total Area              =      0.2 acres

-- Storm data
    Total precipitation    =      1.5 inches
    Storm type             = SCS 6 hour design storm
    Peak Discharge         =    0.01 cfs
    Discharge volume       =    0.00 acre ft
```

```
Project Title          = WSDD-11 (RECLAIMED 25/6)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:           Null


-- Watershed data for watershed # 1
    Curve number                =    75.0
    Area                        =     0.2 acres
    Hydraulic length            =   30.00 Feet
    Elevation change            =    20.0 feet.
    Concentration time          =    0.00 hours
    Concentration time type = SCS Upland Curves
    Unit hydrograph type        = Disturbed

-- Total Area              =      0.2 acres

-- Storm data
    Total precipitation     =      1.9 inches
    Storm type              = SCS 6 hour design storm
    Peak Discharge          =     0.02 cfs
    Discharge volume        =     0.00 acre ft
```

```
Project Title              = WSDD-11 (RECLAIMED 10/24)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:          Null


-- Watershed data for watershed # 1
    Curve number                 =    75.0
    Area                         =     0.2 acres
    Hydraulic length             =   30.00 Feet
    Elevation change             =    20.0 feet.
    Concentration time           =    0.00 hours
    Concentration time type = SCS Upland Curves
    Unit hydrograph type         = Disturbed

-- Total Area             =      0.2 acres

-- Storm data
    Total precipitation    =      2.5 inches
    Storm type             = SCS Type 2 storm, 24 hour storm
    Peak Discharge         =    0.04 cfs
    Discharge volume       =    0.01 acre ft
```

```
Project Title           = WSDD-11 (DISTURBED 10/6)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:          Null


-- Watershed data for watershed # 1
    Curve number                =    90.0
    Area                        =     0.1 acres
    Hydraulic length            =   35.00 Feet
    Elevation change            =    23.0 feet.
    Concentration time          =    0.00 hours
    Concentration time type = SCS Upland Curves
    Unit hydrograph type     = Disturbed

-- Total Area              =     0.1 acres

-- Storm data
    Total precipitation   =     1.5 inches
    Storm type            = SCS 6 hour design storm
    Peak Discharge        =    0.03 cfs
    Discharge volume      =    0.01 acre ft
```

```
Project Title              = WSDD-11 (DISTURBED 25/6)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:          Null


-- Watershed data for watershed # 1
    Curve number                =    90.0
    Area                        =     0.1 acres
    Hydraulic length            =   35.00 Feet
    Elevation change            =    23.0 feet.
    Concentration time          =    0.00 hours
    Concentration time type = SCS Upland Curves
    Unit hydrograph type        = Disturbed

-- Total Area               =      0.1 acres

-- Storm data
    Total precipitation    =      1.9 inches
    Storm type             = SCS 6 hour design storm
    Peak Discharge         =    0.04 cfs
    Discharge volume       =    0.01 acre ft
```

```
Project Title          = WSDD-11 (DISTURBED 10/24)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:          Null


-- Watershed data for watershed # 1
    Curve number                =    90.0
    Area                        =     0.1 acres
    Hydraulic length            =   35.00 Feet
    Elevation change            =    23.0 feet.
    Concentration time          =    0.00 hours
    Concentration time type = SCS Upland Curves
    Unit hydrograph type    = Disturbed

-- Total Area             =      0.1 acres

-- Storm data
    Total precipitation  =      2.5 inches
    Storm type           = SCS Type 2 storm, 24 hour storm
    Peak Discharge       =    0.06 cfs
    Discharge volume     =    0.01 acre ft
```

```
Project Title          = WSDD-12 (UNDISTURBED 10/6)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:          Null


-- Watershed data for watershed # 1
    Curve number              =    60.0
    Area                      =     8.8 acres
    Hydraulic length          = 1600.00 Feet
    Elevation change          =   680.0 feet.
    Concentration time        =    0.27 hours
    Concentration time type   = SCS Upland Curves
    Unit hydrograph type      = Forested

-- Total Area              =      8.8 acres

-- Storm data
    Total precipitation    =      1.5 inches
    Storm type             = SCS 6 hour design storm
    Peak Discharge         =    0.04 cfs
    Discharge volume       =    0.01 acre ft
```

```
Project Title          = WSDD-12 (UNDISTURBED 25/6)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:          Null


-- Watershed data for watershed # 1
    Curve number               =    60.0
    Area                       =     8.8 acres
    Hydraulic length           = 1600.00 Feet
    Elevation change           =   680.0 feet.
    Concentration time         =    0.27 hours
    Concentration time type    = SCS Upland Curves
    Unit hydrograph type       = Forested

-- Total Area              =     8.8 acres

-- Storm data
    Total precipitation     =     1.9 inches
    Storm type              = SCS 6 hour design storm
    Peak Discharge          =    0.16 cfs
    Discharge volume        =    0.03 acre ft
```

```
Project Title           = WSDD-12 (UNDISTURBED 10/24)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:         Null


-- Watershed data for watershed # 1
    Curve number               =    60.0
    Area                       =     8.8 acres
    Hydraulic length           = 1600.00 Feet
    Elevation change           =   680.0 feet.
    Concentration time         =    0.27 hours
    Concentration time type    = SCS Upland Curves
    Unit hydrograph type       = Forested

-- Total Area               =     8.8 acres

-- Storm data
    Total precipitation     =     2.5 inches
    Storm type              = SCS Type 2 storm, 24 hour storm
    Peak Discharge          =    0.25 cfs
    Discharge volume        =    0.13 acre ft
```

```
Project Title           = WSDD-12 (DISTURBED 10/6)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:          Null


-- Watershed data for watershed # 1
    Curve number                =    90.0
    Area                        =     2.3 acres
    Hydraulic length            =  450.00 Feet
    Elevation change            =    20.0 feet.
    Concentration time          =    0.06 hours
    Concentration time type = SCS Upland Curves
    Unit hydrograph type        = Disturbed

-- Total Area               =      2.3 acres

-- Storm data
    Total precipitation     =      1.5 inches
    Storm type              = SCS 6 hour design storm
    Peak Discharge          =    1.51 cfs
    Discharge volume        =    0.14 acre ft
```

```
Project Title            = WSDD-12 (DISTURBED 25/6)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:          Null


-- Watershed data for watershed # 1
    Curve number                =    90.0
    Area                        =     2.3 acres
    Hydraulic length            =  450.00 Feet
    Elevation change            =    20.0 feet.
    Concentration time          =    0.06 hours
    Concentration time type = SCS Upland Curves
    Unit hydrograph type        = Disturbed

-- Total Area               =       2.3 acres

-- Storm data
    Total precipitation    =      1.9 inches
    Storm type             = SCS 6 hour design storm
    Peak Discharge         =     2.10 cfs
    Discharge volume       =     0.19 acre ft
```

```
Project Title          = WSDD-12 (DISTURBED 10/24)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:         Null



-- Watershed data for watershed # 1
    Curve number              =    90.0
    Area                      =     2.3 acres
    Hydraulic length          =  450.00 Feet
    Elevation change          =    20.0 feet.
    Concentration time        =    0.06 hours
    Concentration time type = SCS Upland Curves
    Unit hydrograph type      = Disturbed

-- Total Area             =     2.3 acres

-- Storm data
    Total precipitation  =     2.5 inches
    Storm type           = SCS Type 2 storm, 24 hour storm
    Peak Discharge       =    3.33 cfs
    Discharge volume     =    0.29 acre ft
```

```
Project Title          = WSDD-13 (UNDISTURBED - 10/6)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:          Null


-- Watershed data for watershed # 1
    Curve number                =    60.0
    Area                        =    17.7 acres
    Hydraulic length            = 2100.00 Feet
    Elevation change            =  1130.0 feet.
    Concentration time          =    0.31 hours
    Concentration time type     = SCS Upland Curves
    Unit hydrograph type        = Forested

-- Total Area               =    17.7 acres

-- Storm data
    Total precipitation   =     1.5 inches
    Storm type            = SCS 6 hour design storm
    Peak Discharge        =    0.07 cfs
    Discharge volume      =    0.01 acre ft
```

```
Project Title          = WSDD-13 (UNDISTURBED - 25/6)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:          Null


-- Watershed data for watershed # 1
    Curve number                =    60.0
    Area                        =    17.7 acres
    Hydraulic length            = 2100.00 Feet
    Elevation change            =  1130.0 feet.
    Concentration time          =    0.31 hours
    Concentration time type     = SCS Upland Curves
    Unit hydrograph type        = Forested

-- Total Area               =    17.7 acres

-- Storm data
    Total precipitation     =     1.9 inches
    Storm type              = SCS 6 hour design storm
    Peak Discharge          =    0.30 cfs
    Discharge volume        =    0.07 acre ft
```

```
Project Title          = WSDD-13 (UNDISTURBED - 10/24)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:          Null


-- Watershed data for watershed # 1
    Curve number                =     60.0
    Area                        =     17.7 acres
    Hydraulic length            = 2100.00 Feet
    Elevation change            =   1130.0 feet.
    Concentration time          =     0.31 hours
    Concentration time type     = SCS Upland Curves
    Unit hydrograph type        = Forested

-- Total Area               =     17.7 acres

-- Storm data
    Total precipitation     =      2.5 inches
    Storm type              = SCS Type 2 storm, 24 hour storm
    Peak Discharge          =     0.49 cfs
    Discharge volume        =     0.26 acre ft
```

```
Project Title           = WSDD-13 (DISTURBED - 10/6)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:         Null


-- Watershed data for watershed # 1
    Curve number                =    90.0
    Area                        =     3.7 acres
    Hydraulic length            =  650.00 Feet
    Elevation change            =    59.0 feet.
    Concentration time          =    0.06 hours
    Concentration time type = SCS Upland Curves
    Unit hydrograph type    = Disturbed

-- Total Area              =     3.7 acres

-- Storm data
    Total precipitation   =     1.5 inches
    Storm type            = SCS 6 hour design storm
    Peak Discharge        =    2.44 cfs
    Discharge volume      =    0.22 acre ft
```

```
Project Title          = WSDD-13 (DISTURBED - 25/6)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:          Null


-- Watershed data for watershed # 1
    Curve number                =    90.0
    Area                        =     3.7 acres
    Hydraulic length            =  650.00 Feet
    Elevation change            =    59.0 feet.
    Concentration time          =    0.06 hours
    Concentration time type = SCS Upland Curves
    Unit hydrograph type        = Disturbed

-- Total Area               =     3.7 acres

-- Storm data
    Total precipitation    =     1.9 inches
    Storm type             = SCS 6 hour design storm
    Peak Discharge         =    3.39 cfs
    Discharge volume       =    0.31 acre ft
```

```
Project Title          = WSDD-13 (DISTURBED - 10/24)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:         Null


-- Watershed data for watershed # 1
    Curve number                =    90.0
    Area                        =     3.7 acres
    Hydraulic length            =  650.00 Feet
    Elevation change            =    59.0 feet.
    Concentration time          =    0.06 hours
    Concentration time type     = SCS Upland Curves
    Unit hydrograph type        = Disturbed

-- Total Area               =     3.7 acres

-- Storm data
    Total precipitation    =      2.5 inches
    Storm type             = SCS Type 2 storm, 24 hour storm
    Peak Discharge         =    5.39 cfs
    Discharge volume       =    0.47 acre ft
```

```
Project Title          = WSDD-13 (PAVED - 10/6)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:          Null


-- Watershed data for watershed # 1
    Curve number                =    95.0
    Area                        =     0.3 acres
    Hydraulic length            =   40.00 Feet
    Elevation change            =     2.0 feet.
    Concentration time          =    0.00 hours
    Concentration time type = SCS Upland Curves
    Unit hydrograph type        = Disturbed

-- Total Area               =     0.3 acres

-- Storm data
    Total precipitation    =      1.5 inches
    Storm type             = SCS 6 hour design storm
    Peak Discharge         =    0.11 cfs
    Discharge volume       =    0.02 acre ft
```

```
Project Title          = WSDD-13 (PAVED - 25/6)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:         Null


-- Watershed data for watershed # 1
    Curve number                =    95.0
    Area                        =     0.3 acres
    Hydraulic length            =   40.00 Feet
    Elevation change            =     2.0 feet.
    Concentration time          =    0.00 hours
    Concentration time type = SCS Upland Curves
    Unit hydrograph type    = Disturbed

-- Total Area           =      0.3 acres

-- Storm data
    Total precipitation  =     1.9 inches
    Storm type           = SCS 6 hour design storm
    Peak Discharge       =    0.14 cfs
    Discharge volume     =    0.03 acre ft
```

```
Project Title           = WSDD-13 (PAVED - 10/24)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:         Null


-- Watershed data for watershed # 1
    Curve number              =    95.0
    Area                      =     0.3 acres
    Hydraulic length          =   40.00 Feet
    Elevation change          =     2.0 feet.
    Concentration time        =    0.00 hours
    Concentration time type   = SCS Upland Curves
    Unit hydrograph type      = Disturbed

-- Total Area             =     0.3 acres

-- Storm data
    Total precipitation    =     2.5 inches
    Storm type             = SCS Type 2 storm, 24 hour storm
    Peak Discharge         =    0.20 cfs
    Discharge volume       =    0.04 acre ft
```

```
Project Title          = WSDD-14 (DISTURBED 10/6)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:         Null



-- Watershed data for watershed # 1
    Curve number                =    90.0
    Area                        =     0.9 acres
    Hydraulic length            =  140.00 Feet
    Elevation change            =    23.0 feet.
    Concentration time          =    0.01 hours
    Concentration time type = SCS Upland Curves
    Unit hydrograph type        = Disturbed

-- Total Area               =     0.9 acres

-- Storm data
    Total precipitation  =     1.5 inches
    Storm type           = SCS 6 hour design storm
    Peak Discharge       =    0.35 cfs
    Discharge volume     =    0.05 acre ft
```

Project Title = WSDD-14 (DISTURBED 25/6)
WATERSHED HYDROGRAPH
Inflow into structure # 1
Structure type: Null

-- Watershed data for watershed # 1

Curve number	=	90.0
Area	=	0.9 acres
Hydraulic length	=	140.00 Feet
Elevation change	=	23.0 feet.
Concentration time	=	0.01 hours
Concentration time type	=	SCS Upland Curves
Unit hydrograph type	=	Disturbed

-- Total Area = 0.9 acres

-- Storm data

Total precipitation	=	1.9 inches
Storm type	=	SCS 6 hour design storm
Peak Discharge	=	0.49 cfs
Discharge volume	=	0.07 acre ft

```
Project Title           = WSDD-14 (DISTURBED 10/24)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:         Null


-- Watershed data for watershed # 1
    Curve number               =    90.0
    Area                       =     0.9 acres
    Hydraulic length           =  140.00 Feet
    Elevation change           =    23.0 feet.
    Concentration time         =    0.01 hours
    Concentration time type = SCS Upland Curves
    Unit hydrograph type    = Disturbed

-- Total Area              =     0.9 acres

-- Storm data
    Total precipitation  =     2.5 inches
    Storm type           = SCS Type 2 storm, 24 hour storm
    Peak Discharge       =    0.78 cfs
    Discharge volume     =    0.11 acre ft
```

```
Project Title          = WSDD-14 (UNDISTURBED 10/6)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:          Null


-- Watershed data for watershed # 1
    Curve number                =    60.0
    Area                        =     0.8 acres
    Hydraulic length            =  380.00 Feet
    Elevation change            =   245.0 feet.
    Concentration time          =    0.05 hours
    Concentration time type = SCS Upland Curves
    Unit hydrograph type        = Forested

-- Total Area                =     0.8 acres

-- Storm data
    Total precipitation      =     1.5 inches
    Storm type               = SCS 6 hour design storm
    Peak Discharge           =    0.00 cfs
    Discharge volume         =    0.00 acre ft
```

```
Project Title           = WSDD-14 (UNDISTURBED 25/6)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:          Null


-- Watershed data for watershed # 1
    Curve number                =    60.0
    Area                        =     0.8 acres
    Hydraulic length            =  380.00 Feet
    Elevation change            =   245.0 feet.
    Concentration time          =    0.05 hours
    Concentration time type = SCS Upland Curves
    Unit hydrograph type        = Forested

-- Total Area               =      0.8 acres

-- Storm data
    Total precipitation  =      1.9 inches
    Storm type           = SCS 6 hour design storm
    Peak Discharge       =    0.02 cfs
    Discharge volume     =    0.00 acre ft
```

```
Project Title          = WSDD-14 (UNDISTURBED 10/24)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:          Null


-- Watershed data for watershed # 1
    Curve number                =    60.0
    Area                        =     0.8 acres
    Hydraulic length            =  380.00 Feet
    Elevation change            =   245.0 feet.
    Concentration time          =    0.05 hours
    Concentration time type = SCS Upland Curves
    Unit hydrograph type    = Forested

-- Total Area               =     0.8 acres

-- Storm data
    Total precipitation   =     2.5 inches
    Storm type            = SCS Type 2 storm, 24 hour storm
    Peak Discharge        =    0.03 cfs
    Discharge volume      =    0.01 acre ft
```

```
Project Title            = WSDD-14 (PAVED - 10/6)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:          Null



-- Watershed data for watershed # 1
    Curve number                 =    95.0
    Area                         =     0.1 acres
    Hydraulic length             =   30.00 Feet
    Elevation change             =     1.0 feet.
    Concentration time           =    0.00 hours
    Concentration time type = SCS Upland Curves
    Unit hydrograph type    = Disturbed

-- Total Area            =      0.1 acres

-- Storm data
    Total precipitation  =      1.5 inches
    Storm type           = SCS 6 hour design storm
    Peak Discharge       =     0.04 cfs
    Discharge volume     =     0.01 acre ft
```

```
Project Title          = WSDD-14 (PAVED - 25/6)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:         Null



-- Watershed data for watershed # 1
    Curve number               =    95.0
    Area                       =     0.1 acres
    Hydraulic length           =   30.00 Feet
    Elevation change           =     1.0 feet.
    Concentration time         =    0.00 hours
    Concentration time type = SCS Upland Curves
    Unit hydrograph type       = Disturbed

-- Total Area             =     0.1 acres

-- Storm data
    Total precipitation  =     1.9 inches
    Storm type           = SCS 6 hour design storm
    Peak Discharge       =    0.05 cfs
    Discharge volume     =    0.01 acre ft
```

```
Project Title           = WSDD-14 (PAVED - 10/24)
WATERSHED HYDROGRAPH
     Inflow into structure #  1
     Structure type:         Null



-- Watershed data for watershed # 1
    Curve number               =    95.0
    Area                       =     0.1 acres
    Hydraulic length           =   30.00 Feet
    Elevation change           =     1.0 feet.
    Concentration time         =    0.00 hours
    Concentration time type = SCS Upland Curves
    Unit hydrograph type    = Disturbed

-- Total Area              =     0.1 acres

-- Storm data
    Total precipitation   =     2.5 inches
    Storm type            = SCS Type 2 storm, 24 hour storm
    Peak Discharge        =    0.07 cfs
    Discharge volume      =    0.02 acre ft
```

DITCH FLOW CALCULATIONS

```
Title of run: DD-13 (MIN. 10/6)
   Solving for...............= Depth Normal
Triangle
   Flow depth (ft)...........=     0.97
   First Side slope..........=      1.0
   Second Side slope.........=      1.0
   Slope of diversion........=   0.0179
   Manning"s n...............=    0.035
   CFS.......................=     2.62
   Cross section area (sqft)..=    0.94
   Hydrualic radius..........=     0.34
   fps.......................=     2.79
   Froude number.............=     0.84
```

```
Title of run: DD-13 (MIN. 10/24)
   Solving for...............= Depth Normal
  iangle
   Flow depth (ft)...........=    1.33
   First Side slope..........=     1.0
   Second Side slope.........=     1.0
   Slope of diversion........=  0.0179
   Manning"s n...............=   0.035
   CFS.......................=    6.08
   Cross section area (sqft)..=   1.77
   Hydrualic radius..........=    0.47
   fps.......................=    3.44
   Froude number.............=    0.89
```

```
Title of run: DD-13 (MAX. 10/6)
   Solving for...............= Depth Normal
  apedeziod
   Flow depth (ft)...........=    0.15
   First Side slope..........=     2.0
   Second Side slope.........=     2.0
   Bottom width (ft).........=    2.00
   Slope of diversion........=  0.5000
   Manning"s n...............=   0.035
   CFS.......................=    2.62
   Cross section area (sqft)..=    0.34
   Hydrualic radius..........=    0.13
   fps.......................=    7.66
   Froude number.............=    3.77
```

```
Title of run: DD-13 (MAX. 10/24)
   Solving for................= Depth Normal
  apedeziod
   Flow depth (ft)............=    0.24
   First Side slope...........=     2.0
   Second Side slope..........=     2.0
   Bottom width (ft)..........=    2.00
   Slope of diversion.........=  0.5000
   Manning"s n................=   0.035
   CFS........................=    6.08
   Cross section area (sqft)..=    0.60
   Hydrualic radius...........=    0.19
   fps........................=   10.12
   Froude number..............=    4.04
```

72" CULVERT OUTLET
RIP-RAP APRON
FLOW VELOCITY CALCULATIONS

Title of run: BEGIN APRON **(ZONE A)**

Solving for................= Depth Normal

Trapedeziod

Flow depth (ft)............	=	2.03
First Side slope...........	=	1.0
Second Side slope..........	=	1.0
Bottom width (ft)..........	=	6.00
Slope of diversion.........	=	0.0667
Manning"s n................	=	0.035
CFS........................	=	222.79
Cross section area (sqft)..	=	16.29
Hydrualic radius...........	=	1.39
fps........................	=	13.68
Froude number..............	=	2.05

Title of run: MIDDLE APRON (15') **(ZONE B)**

Solving for..............= Depth Normal

Trapedeziod

Flow depth (ft)...........=	1.37
First Side slope..........=	1.0
Second Side slope.........=	1.0
Bottom width (ft).........=	12.00
Slope of diversion........=	0.0667
Manning"s n...............=	0.035
CFS.......................=	222.79
Cross section area (sqft)..=	18.38
Hydrualic radius..........=	1.16
fps.......................=	12.12
Froude number.............=	1.99

```
Title of run: END APRON (30')  (ZONE C)
   Solving for...............= Depth Normal
Trapedeziod
   Flow depth (ft)...........=    1.08
   First Side slope..........=     1.0
   Second Side slope.........=     1.0
   Bottom width (ft).........=   18.00
   Slope of diversion........=  0.0667
   Manning"s n...............=   0.035
   CFS.......................=  222.79
   Cross section area (sqft)..=  20.57
   Hydrualic radius..........=    0.98
   fps.......................=   10.83
   Froude number.............=    1.93
```

Title of run: NATURAL CHANNEL

```
   Solving for...............= Depth Normal
Trapedeziod
   Flow depth (ft)...........=    1.12
   First Side slope..........=     1.0
   Second Side slope.........=     1.0
   Bottom width (ft).........=   17.00
   Slope of diversion........=  0.0667
   Manning"s n...............=   0.035
   CFS.......................=  222.79
   Cross section area (sqft)..=  20.22
   Hydrualic radius..........=    1.00
   fps.......................=   11.02
   Froude number.............=    1.94
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APPENDIX 7-15

PROBABLE HYDROLOGIC

CONSEQUENCES DETERMINATION

1/23/95 revised 9/03

R645-301-728 Probable Hydrologic Consequences Determination

This document has been prepared in accordance with requirements of the State of Utah R645 Coal Mining Rules. The format follows the regulations R645-301-718.100 through R645-301-728.400. This Probable Hydrologic Consequences evaluation of the coal mining and reclamation operations has been prepared by GENWAL Resources, Inc. to provide a description of the potential impacts of the mining operation on the hydrologic systems and the means to prevent or mitigate those identified impacts.

R645-301-728.100 Determination

This determination section presents a brief summary of the surface water, groundwater, and geologic resource descriptions of the permit area and the South Crandall Lease area and the U-68082 lease mod area and a description of the possible impacts of the coal mine on the hydrologic resources.

The geologic and hydrologic data and their associated appendices are contained in Chapter 6 and Chapter 7, respectively. The potential sources of contamination to the hydrologic resources in the area of the mine were identified through site visits, knowledge of the working operations of the mine and discussions with GENWAL Resources personnel. These potential contamination sources and impacts include:

Water Quantity
- Interception of groundwater and surface water
- Water consumption within the mine
- Seepage from mine sumps
- Pumping from Crandall Creek

Water Quality
- Additional sediment contribution
- Fugitive dust
- Oil and grease
- Mine water discharge
- Acid-toxic materials
- Flooding or Streamflow Alteration

Each of these potential sources of contamination or impact and their associated mitigating measures or circumstances are discussed in the following sections.

Water Quantity Impacts

Possible impacts to the surface and groundwater systems from the mining operation could affect the quantity of water in the mine area. Interception, consumption, and seepage of surface or groundwater are possible mechanisms which could affect the water systems.

Interception.

A limited potential exists for interception of groundwater or surface water due to subsidence which may affect the perched aquifers (springs and seeps), and stream flows in Crandall Canyon, Blind Canyon, Horse Creek, the upper headwaters of the Indian Creek drainage (Upper Joes Valley), and the streams and springs of the South Crandall Lease area and the U-68082 lease mod area. The potential for hydrologic impacts may result from creating subsurface interconnections from the more permeable zones in the strata as a result of mine subsidence. This can be expressed by the potential interrelated occurrences of intercepted groundwater flow in the overlying perched aquifers, the interruption or lessening of flow to springs, or the interception of surface water flow from ephemeral streams.

Groundwater Interception.

Typically, groundwater interception and translocation of that water is the primary mechanism by which the groundwater system may be impacted. As indicated in Section 7.24.1 of this permit, the regional groundwater system, located in the Blackhawk-Starpoint aquifer at the Crandall Canyon Mine, is below the Hiawatha Coal.

Monitoring of in-mine and surface wells indicate that the potentiometric surface of the regional Blackhawk-Star Point aquifer in the mine area lies approximately 50 to 60 feet below the top of the Star Point Sandstone over most of the mine. In the westernmost portion of the mine, near the Joes Valley Fault system, the potentiometric surface of the Star Point Sandstone is at or slightly above the elevation of the floor of the mine. In these areas, minor amounts of groundwater weep from the floor of the mine. In the remainder of the mining areas, because mining is being conducted in the Hiawatha seam of the Blackhawk Formation, which overlies the Starpoint Sandstone, dewatering of the Blackhawk-Starpoint aquifer by the Crandall Canyon Mine is not possible.

Historically, the springs within the permit area which are monitored on a quarterly basis, in the perched aquifer of the Blackhawk Formation above the mine, have not been affected by operating the Crandall Canyon Mine. Because of the tightness of the joints and the presence of aquicludes, significant mine in-flows from the overlying strata have not occurred and nor are they anticipated.

A reconnaissance of field information and data available from the old Huntington #4 permit indicates that Little Bear Spring located in T16S-R7E-Sec9 (see Plates 7-12, 7-13, and 7-14) emanates from the Panther (lowest member) of the Star Point Formation. Previous drilling within the mine area has shown that the three members of the Starpoint Sandstone are vertically isolated from one another. The Spring Canyon member is located within the upper 100 feet of the Starpoint Sandstone. This member has been found to contain water in some areas of the mine. The Storrs member was isolated from the Spring Canyon member by interbedded shale and siltstone. It did not appear to contain any appreciable water. The Panther member was found to be about 36 feet thick at a depth of 315 to 351 feet. Flow from this bed varied from about 2.1-7.0 gallons per minute. Although Little Bear spring emanate out of the Panther member, age dating showed the water to be of recent age (<50 years old). Age dating of water from the Starpoint Sandstone shows it to be of an age greater than 10,000 years old. It appears that Little Bear Spring emanates from a fault zone which may be serving as a conduit for diversion of recent water intercepted in some of the larger drainages in the area. It is doubtful that mining activities would have any affect on flow from Little Bear Spring due to the large age difference between the water encountered underground and the water flowing out of Little Bear Spring.

Meetings with the Castle Valley Special Service District officials and their representatives, as well as the other water user districts of the area, was held on 10 June 1993. The concern of the Castle Valley Special Service District regarding diminution and mitigation of the Little Bear Spring flow that could result from future mining were discussed. Given the elevations of the Starpoint potentiometric surface, in relation to that of the Hiawatha Coal Seam, it was shown that the present and future mine workings would not interfere with the Starpoint aquifer.

Little Bear Spring is a developed spring that provides municipal water to nearby municipalities. It emanates from a fracture system in the Panther Member of the Star Point Sandstone that trends in an approximate northeast-southwest direction.

Because of its importance as a municipal water supply source and its proximity to proposed mining areas, Little Bear Spring has been extensively studied. Several hydrologic studies have been performed since 1977 to investigate the recharge source for Little Bear Spring (Forest Service Project File). These studies have agreed that the spring flow is supported by a fault/fracture system. Since Little Bear Spring lies more than 300 feet below the level of the mineable coal seams and past mining encountered the fault/fracture system without significant inflow of water, there is general consensus among the Castle Valley Special Service District (CVSSD), mine operators, scientific community, and the regulatory agencies that adverse effect to the spring are unlikely.

Several studies have been done that suggest a northerly component of flow feeding Little Bear Spring. These studies include:

- Vaughn Hansen Associated, *Water Quality and Hydrologic Study in Vicinity of Huntington Creek Mine No. 4 and Little Bear Spring*, Prepared for Swisher Coal Company, August1977.
- Hydro-Sciences, Inc., *Ground Water Hydrology in the Vicinity of the Huntington No. 4 Mine,* Prepared for ARCO Coal Company, December 19, 1980.
- Beaver Creek Coal Company, *Huntington Canyon No. 4 Mining and Reclamation Plan,* Prepared for UDOGM, 1983.

- Utah Geological and Mineral Survey, *Effects of Coal Mining at Huntington Canyon No. 4 Mine on Little Bear Spring, Emery County,* Prepared for Castle Valley Special Services District, Job No. 84-005, January 21, 1984.
- Vaughn Hansen Associated, *Hydrologic Conditions in Huntington Canyon No. 4 Mine,* 1984.

These referenced studies are available for review at the Division's Public Information Center.

Other studies indicate that the Little Bear Spring may possibly be fed by fault/fracture system which intercepts surface water in Mill Fork Canyon southwest of the South Crandall Lease area. These scientific investigations include an investigation of the Little Bear Spring groundwater system and the groundwater systems encountered in the Crandall Canyon Mine (Appendix 7-52), a solute and isotopic investigation of groundwater from Little Bear Spring and the Star Point Sandstone and Blackhawk Formation groundwater systems the Crandall Canyon Mine (Appendix 7-53), an investigation of the hydraulic conductivity of the Star Point Sandstone in the vicinity of the Crandall Canyon Mine (Appendix 7-54), an investigation of the alluvial groundwater system in Mill Fork Canyon with implications for recharge to Little Bear Spring (Appendix 7-55), an investigation of the potential for Little Bear Spring recharge in Mill Fork Canyon (Appendix 7-56), and a fluorescent dye-tracing study that conclusively demonstrates the hydraulic connection between the stream/alluvial groundwater system in Mill Fork Canyon and Little Bear Spring (Appendix 7-57). Sunrise Engineering also performed a series of investigations using a proprietary geophysical technique that demonstrated a hydraulic connection between Little Bear Spring and the surface drainage in Mill Fork Canyon. These investigations are included as Appendix 7-59, Appendix 7-60, Appendix 7-61, and Appendix 7-62.

These studies, taken as a whole, have indicated that Little Bear Spring is possibly recharged through surface water and alluvial groundwater losses in Mill Fork Canyon, located well beyond the boundary of the South Crandall Lease area, approximately 1.5 miles southwest of the spring. The basis for this assumption is discussed briefly below. The reader is referred to the above mentioned appendices for a more rigorous discussion of the recharge of Little Bear Spring.

The assumption that Little Bear Spring may possibly be recharged from surface-water and alluvial groundwater losses in Mill Fork Canyon is based on several findings. These include:

1) the finding that, from a water budged standpoint, there is sufficient water available in Mill Fork Canyon to account for the recharge to Little Bear Spring and any surface water drainage that leaves the Mill Fork drainage and flows into Huntington Creek,

2) the finding that there is a chemical and isotopic match (or a plausible chemical evolutionary pathway) between surface waters and alluvial groundwaters in Mill Fork Canyon and groundwater at Little Bear Spring, and

3) the finding that there is a demonstrated hydraulic connection between Mill Fork Canyon and Little Bear Spring and the hydraulic gradient and flow volume through the connection is sufficient to provide Mill Fork water to the spring.

These findings are discussed below.

An investigation was performed in 2001 to determine the quantity of water available in Mill Fork Canyon to recharge Little Bear Spring (Appendix 7-56). It is the finding of this investigation that there is an excess of approximately 300 gpm in the Mill Fork drainage that is available for recharge to the spring. Indeed, it is difficult to explain the loss of approximately 300 gpm from the drainage basin without taking the recharge to Little Bear Spring into account. This finding is based on a comparative analysis of baseflow in the Crandall Creek drainage, which is very similar in geology, topography, aspect, and elevation to the Mill Fork Creek drainage. The baseflow in Crandall Canyon Creek during most years is approximately 300 gpm greater than that in Mill Fork.

Another investigation examined the capacity of the alluvial groundwater system in Mill Fork Canyon to transmit sufficient groundwater to sustain the baseflow of Little Bear Creek during periods when there is not surface flow in the Mill Fork drainage (Appendix 7-55). This investigation was based on a quantitative determination of the flow of groundwater migrating through the alluvial groundwater system above the spring recharge location compared to that flowing through the alluvial deposits below the spring recharge location in Mill Fork Canyon. It is the conclusion of this investigation that there is appreciably more groundwater flowing through the alluvial deposits above the spring recharge location as compared to that flowing in the alluvial deposits below the spring recharge location (approximately 300 gpm more).

Investigations regarding the solute and isotopic compositions of groundwater at Little Bear Spring and other shallow groundwater systems in the vicinity have been performed. These investigations have also examined the solute and isotopic compositions of Star Point Sandstone groundwater systems encountered in the Crandall Canyon Mine. These studies are included as Appendix 7-52 and Appendix 7-53. It is the findings of these investigations that groundwater discharging from Little Bear Spring is modern in origin (>50 years old), while groundwater from deep Star Point Sandstone groundwater systems in the Crandall Canyon Mine have a mean groundwater age of many thousands of years. Shallow Groundwater systems (that provide baseflow to upper Mill Fork Creek) are modern in origin. The solute composition of groundwater in Little Bear Spring and that of surface water and shallow alluvial groundwater in Mill Fork Canyon are similar.

The fact that the discharge in Little Bear Spring shows rapid seasonal variations in discharge rate suggests that the recharge is related to a shallow recharge source that is closely tied to seasonal recharge. The ancient groundwater systems encountered in the Star Point Sandstone in area coal mines do not exhibit seasonal variability.

Finally, in order to explore the assumption that Little Bear Spring may possibly be recharged from Mill Fork Canyon, a fluorescent dye tracing study was performed in 2001 (Appendix 7-57).

In this investigation, fluorescent dye was placed in the upper Mill Fork drainage immediately above the spring recharge location. A positive dye recovery occurred at Little Bear Spring within 40 days of the dye placement. Thus, a hydraulic connection between the alluvial system in upper Mill Fork Canyon was positively confirmed.

The elevation of the spring recharge location in upper Mill Fork Canyon is approximately 7710 to 7790 feet, while the elevation of Little Bear Spring is approximately 7475 feet. Thus, there is a substantial hydraulic gradient between the possible Mill Fork recharge location and Little Bear Spring. It is important to note that the possible recharge location for Little Bear Spring in Mill Fork Canyon is outside the boundaries of the South Crandall Lease area. Likewise, the groundwater flowpath connecting Mill Fork Canyon and Little Bear Spring is outside of the area of potential coal mining by GENWAL Resources.

While the flow mechanisms conveying water to Little Bear Spring are not completely understood, additional hydrologic studies performed since the Mill Fork EA was written have indicated that adverse impacts to the spring are not expected due to the vertical separation between the coal seams and flow. (Forest Service, BLM Joint Decision Notice/Finding of No Significant Impact, Coal Lease Application UTU-78953)

In conclusion, because mining occurs above the Panther Member of the Star Point Formation, the source of water of the Little Bear Spring; because the mine is relatively dry; and because age dating has shown that the water sampled underground from the Starpoint Sandstone and from Little Bear Springs are not the same age (: there is little, if any chance, that current or proposed future mine workings of the Crandall Canyon Mine could affect the Little Bear Spring. Operation of the mine should not adversely impact the Star Point aquifer or Little Bear Spring.

Mitigation for potential disruption to the Little Bear Spring will be accomplished though the construction of a water treatment plant which will provide replacement water for the spring. Construction of this water treatment plant will be done under the provisions of a water replacement agreement between GENWAL Resources, Inc. and the Castle Valley Special Service District who maintain culinary water rights to Little Bear springs. A copy of this water replacement agreement is included in Appendix 7-51. With construction of this water treatment plant an uninterrupted supply of culinary water will be assured irrespectively of whether mining can be conclusively shown to have affected Little Bear Spring. This is in compliance with special stipulation #17 of federal lease UTU-78953 (see Appendix 1-13).

<u>Spring and Seep Interception</u>.

There is a potential for impact to overlying seeps and springs through interception of the perched aquifers as a result of subsidence. Seeps and springs throughout the mine area and the South Crandall Lease area and the U-68082 lease mod area have been identified through intensive field and aerial surveys. These survey results are presented in Chapter 7, Section 7.24.1, associated appendices, and are shown on Plate 7-12. Water rights have also been researched and are provided in Chapter 7, Table 7-6.

Genwal is currently monitoring the water flow rates and quality of representative springs and seeps as indicated in section 7.31 within and adjacent to the current mine permit area (including LBA No. 9 and the South Crandall Lease area). The springs which are monitored cover both the proposed aerial extent of the mine and also are located within each of the major lithologic units from the Blackhawk (above the regional aquifer) to the North Horn Formation (which caps the highest portions of the top of East Mountain).

As stated in Section 7.24.1, the water emitting from seeps and springs which overlie the coal seam originates from perched aquifers. These perched aquifers appear to have no direct communication with the Star Point Sandstone, or with the mine. Isotopic sampling has shown the chemistry of these springs to be substantially different than water from underground sources or the Starpoint Sandstone. These springs do not appear to have any vertical communication with the Blackhawk or Star Point Sandstone formations even when subsidence has occurred. This is due to the extensive interbedded shale in the intervening strata. Also, during the drilling conducted for the LBA No. 9 only one hole, DH-7, intercepted any groundwater. These data indicate that a significant zone of non-saturated, low-permeability strata (aquitard or aquiclude) are present between the Star Point Sandstone and the overlying perched aquifers .

Natural groundwater inflow to the Crandall Canyon Mine is limited. Inflows tend to be of short and limited duration. Most of the natural inflows are from mined-out areas of the longwall. Less frequently, natural inflows occur from bolt holes in the roof and from very limited sections at the face. Genwal has an operational monitoring plan which includes monitoring surface flows from Crandall, Blind Canyon and Indian Creeks using flumes and continuous recorders. In addition, Genwal has committed to monitor Horse Canyon at station H-1 on a quarterly basis. Genwal is currently monitoring 14 springs on a quarterly basis across their potential area of influence (see Chapter 7 for additional details).

Due to the dryness of the mine, water from Crandall Creek had been pumped into the mine to provide dust control water and water for the mining equipment. A water supply well provides shower water for the bathhouse. Based on the 1992 mine water records, approximately 6.9 million gallons of water were used in the mining operation. Of this volume, it is estimated that approximately 6.2 millon gallons of water were pumped into the mine from either the water supply well MW-1 or from Crandall Creek. These volumes, indicate that the water collected from natural inflow underground was approximately 700,000 gallons, which is about 10 percent of the 1992 water usage. This amounts to a 1.3 gpm inflow rate. Much of the natural inflow water is used in the mining operation. Discharge from the mine had occurred only 3 times prior to 1990.

In the event that a subsidence fracture did reach the surface or intercept one of the overlying perched aquifers, it is likely that the affect would be temporary in nature. As indicated in Appendix 7-41, the clays within the Blackhawk Formation have a tendency to swell when exposed to water. Therefore, if the fracturing from subsidence did intersect a saturated, perched aquifer and conveyed water, the clays within the formation would swell and seal the fracture. This self-healing condition has been identified within the headwaters of the Huntington Creek drainage (DeGraff, 1978) and at other mines in the area.

An alternative water source plan has been developed in the event any water rights or springs/seeps impacted in a long-term manner by the mining operation or reclamation activities. This plan is detailed in Chapter 7, Section 7.27.

Surface Water Interception.

The possible surface water interception impacts may affect stream flows in Crandall Canyon, Blind Canyon, Horse Creek, the headwaters of Indian Creek, and drainages in the South Crandall Lease area and in the U-68082 lease mod area. These impacts would likely be the result of subsidence fractures intersecting the ground surface. If these fractures occur within or across a surface drainage channel, then a potential is created for the surface flow within the drainage to be temporarily intercepted. For the drainages within and adjacent to the Crandall Canyon Mine, all sections of the streams that are perennial will be protected from subsidence by limiting retreat mining activities within the area of the stream buffer zones as discussed in Section 5.25 of this permit.

The potential for significant water loss for these drainages is minimal. This conclusion is based on the existing hydrologic and geologic information presented in Section 7.24 and Appendices 7-2 and 7-23 and past mining experience within the Huntington Creek drainage. In addition, the streams in the majority of the surface area which overlies the current or proposed mine workings are ephemeral. However, due to the concerns raised by the U.S. Forest Service, regarding their uncertainty in supporting this conclusion, Genwal Resources Inc. has initiated extensive studies of within Blind and portion of Crandall Canyon to determine if mining through these drainages have an adverse affect on the surface or groundwater resources within the drainage. Until the results of these studies are determined, Genwal will continue to protect the those portions of the streams that have been proven to be perennial.

It is important to note that the geologic units located in the formations stratigraphically above the Blackhawk Formation and the Hiawatha coal seam at the Crandall Canyon mine are hydrologically isolated from the contiguous area. East Mountain is bounded on the north by the South (Left) Fork of Huntington Creek; on the west by Upper Joes Valley; on the south by Cottonwood Canyon; and on the east by Huntington Canyon. Data show that the regional aquifer is located below the Hiawatha Coal. Field data indicate that Blind Canyon is ephemeral and that Horse Canyon is perennial only in that area where it intersects or is below the regional aquifer. Based on the baseline data (Appendix 7-58), it is apparent that all of the surface-water drainages in the South Crandall Lease area are likely ephemeral or intermittent in nature. The drainages in the U-68082 lease mod area are all ephemeral or intermittent.

The perennial portion of Crandall Canyon extends above the regional aquifer. This occurs because the perched Price River and North Horn Formation cover a broader area of this watershed and because Crandall Canyon has a larger drainage area (and thus, more potential for recharge and increased runoff) than the other two canyons.

Consumption.

The consumption of water by the mining operation is a combination of moisture added to the mined coal through the mining process and that which is extracted with the coal as well as evaporation due to ventilation of the mine workings. It is estimated that mining extraction and the mining process utilize approximately 200 gpm during the two 8-hour mining shifts per day. The volume of water extracted by ventilation is estimated to be approximately 50 gpm.

Seepage from Mine Sumps.

Underground sumps are utilized to store water pumped underground or collected from groundwater inflows until the water is used as mine process water. During the period that water is stored in these sumps it is probable for some seepage to occur to the underlying formation (Spring Canyon member). For the Crandall Canyon Mine, the potential volume of such seepage is expected to be quite low because of the presence of a fine grained mudstone strata underlying the Hiawatha seam within the Blackhawk Formation. This layer limits the downward movement of seepage to a very slow rate.

Pumping from Crandall Creek.

Due to the past need for supplemental water underground, there is also potential for decreased surface flows in Crandall Canyon due to pumping from Crandall Creek. Surface water availability could only be impacted by excessive pumping of water from Crandall Creek for the operation. This is not expected to occur since Genwal has committed to not pump from Crandall Creek at a rate that will dewater the stream (Chapter 7, Section 7.24.2). (Genwal will have determined the baseline water flow which needs to remain within Crandall Creek to sustain the existing flora and fauna by August 31, 1995).

Water Quality Impacts.

The quality of the surface and groundwater in the mine area may potentially be affected by increased sediment loading, dust from the operations, mine water discharges, hydrocarbons used in the mining operations, and seepage losses from within the mine. The following sections discuss these potential impacts and mitigating measures.

With the installation of the main diversion culvert during the expansion of the mine yard facility area it is possible that additional sedimentation could occur. Genwal will install a pair of silt fences downstream in Crandall Canyon to collect any suspended material that may occur as a result of the installation of the 18" drain pipe bedded in drain rock or the 72" culvert. The silt fences will be checked periodically and cleaned out as needed to maintain maximum efficiency.

Once the culvert is in place and operable, the creek will be diverted through the culvert thus bypassing the disturbed area and minimizing the potential for runoff from the disturbed area accidentally flowing directly into the creek. The sediment pond may experience an increase in sediment loading during the construction process and until the construction has been completed. This would be a short term effect. The sediment pond will also be enlarged during the construction process to accomodate the increase in disturbed area. The net result will be that the pond will be better suited to handle runoff from the disturbed area once it has been reconstructed and enlarged. Drainage from the Forest Service parking area will now report directly to the sediment pond. All drainage from the disturbed area will report directly to the sediment pond and the potential for drainage to bypass the sediment pond and flow into the creek untreated will be virtually eliminated.

Flow in Crandall Creek will be temporarily (during the remainder of the life of the mine) diverted through the 72" culvert. However, when reclamation occurs, the channel will be replaced exactly in the same location as it existed prior to the culvert placement. Genwal will lay a geotextile over the existing channel to preserve the channel morphology prior to installation of the drain rock and 18" drain pipe. The drain rock and drain pipe will serve to allow any drainage from the channel bed or adjacent seepage from colluvial materials to flow downstream. Then, the 72" diversion pipe will be placed over this drain. The drain will preserve the integrity of the fill, thus minimizing the potential for problems from settling of the 72" pipe and ensuring the successful operation of the bypass culvert.

Increased Sediment Loading.

As discussed in Section 7.24.2, the permit area is drained by ephemeral, intermittent, and perennial watersheds. These watersheds are steep (with average slopes 50 percent) and well vegetated (with vegetative cover also often exceeding 50 percent). The primary potential for impact to surface water is in the form of increased sedimentation from the operations.

Sediment yield will naturally increase (on a temporary basis during construction and revegetation) from areas disturbed for the operation. A runoff control plan, required by the Division of Oil, Gas, and Mining, provides for the containment or treatment of all runoff and sediment produced from the disturbed areas. Based on this plan, described in Chapter 7, Section 7.42.22, the majority of the disturbed area runoff is directed to the sediment pond. The designed sediment storage for the pond is 1.02 acre feet, including 0.084 acre feet from disturbed areas and 0.018 acre feet from undisturbed and reclaimed areas, over a 10 year period. Storm runoff was determined to be 1.98 acre feet. The pond is designed with a total storage volume of 3.27 acre feet, which allows for complete containment of sediment.

There are 7 small areas (ASCA 2, 5, 6, 7, 8, 9, & 10) which do not drain to the sediment pond, as shown on Plate 7-5, and described in Chapter 7, Section 7.42.21. Sediment yield from these areas is minimized through the use of sediment traps, straw bale dikes, silt fences, and vegetation as described in Section 7.42.21. Sediment yield from the facility and the disturbed areas is minimized through the installation and maintenance of the above described controls.

A secondary potential source may exist due to subsidence creating surface irregularities which would be more susceptible to erosion. Calculations presented in Appendices 7-27 to 7-40 indicate a very small potential for increased sedimentation reaching a perennial stream. A study has been conducted by Genwal and the U.S. Forest Service in Blind Canyon to measure the amount of subsidence, erosion, and the associated sediment yield which may be produced as a result of current mining operations. (Refer to Appendices 7-38 and 7-39).

Fugitive dust.

The potential impacts of fugitive dust from the Crandall Canyon Mine includes reduced air quality in the facilities area and a small decrease in the surface water quality of Crandall Creek. The air quality degradation result from particulate emissions from the paved road and pad, reclamation activities, and from coal loading operations. The water quality degradation and sediment loading increase would result from the settlement of dust within the waters of Crandall Creek. Placement of the stream within the culvert under the expanded mine yard will serve to minimize the possiblity of coal dust settling in Crandall Creek.

These impacts are mitigated by sweeping the paved access roads and portions of the pad, water sprays in the coal handling process, and contemporaneous reclamation. These actions minimize the dust production from the facilities area.

Oil and grease.

The use of oil, grease, and flammable hydrocarbon-based products in the mine facilities area creates the possibility of contamination within and adjacent to the facilities area. Contamination could result from spillage of these products during maintenance of the mine equipment, accidental spillage during filling of fuel tanks, or leakage from equipment during operations. Such contamination could impact the soils, groundwater, and possibly surface waters downstream of the facility.

The impacts from spillage during maintenance activities and during filling of tanks will be mitigated by the implementation of the SPCC plan. Additionally, the runoff from all areas of the site where equipment will be operating is drained to the sedimentation pond. The pond is equipped with an oil and grease skimmer to prevent the release of hydrocarbons.

Mine water discharge.

A potential impact to water quality would be from mine water discharges. Currently there is no discharge from the Crandall Canyon Mine. However, when the underground sumps are full and mining consumption is minimal, such as during a longwall move or vacation, discharges may occur. Prior to 1990, there were only three discharges from the mine and these discharges were of a limited nature in both duration and quantity. The mine has an UPDES discharge permit. The quality of the discharge water is good, and meets the requirements of the discharge permit.

Acid-toxic materials.

As discussed in Section 5.28.30, waste rock is not normally produced during mining operations. When incidental quantities of rock are encountered, the rock is left in the mine and will not be removed in the future; thus, the strata which overlie and underlie the Hiawatha seam are not expected to cause any negative effects or create acid-forming potential. Additionally, the mine is currently considered to be a "dry-mine" and the minimal volume of water that is encountered underground does not exhibit any acid or toxic characteristics. All waters encountered have had a slightly alkaline chemistry. Laboratory data have shown that no materials are present within the coal, underburden, overburden, etc. which are of an acid or toxic nature.

Further, handling plans have been implemented for earth, refuse, and acid-toxic forming materials (if encountered), which, if needed, will prevent or control discharge of pollutants to the hydrologic system (Section 7.31.3). This will be accomplished using the best technology currently available.

However, to further characterize the acid-forming potential of strata immediately above and below the Hiawatha seam, the applicant has collected roof-, floor-rock, and coal samples from locations within the current mine workings. Analytical results from these sets of samples, Appendix 6-2, indicate that acid and toxic forming materials are not present within the overburden or underburden.

Flooding or Streamflow Alteration.

The potential for flooding is minimized by the design and installation of adequately sized diversions, sediment pond and velocity control structures as described in Chapter 7, Section 7.40. All diversions are sized for a 25 year - 24 hour storm event. Ditches, culverts and sediment pond are designed for a 10 year - 24 hour storm event. Ditches, culverts and sediment pond are designed for a 10 year - 24 hour storm event.

Crandall Creek will be culverted for a distance of about 1,100 feet through the expanded mine yard area. While a minimal short term impact will occur as the culvert is being installed, the long term affect will be to reduce the potential for sediment to flow from the disturbed area into the creek. It will also reduce the potential for flow within Crandall Creek to impinge upon the sediment pond embankment due to their close proximity. The slopes of the sediment pond will be 2:1 on the outslope. The toe of the sediment pond has been fortified with an additional 2 feet of 12.5 inch D-50 rip-rap for protection and stabilization. The culvert outlet downstream from the pond will minimize the potential for impact from running water to damage the sediment pond embankment. An analysis of the Crandall Creek flow and pond protection measures indicates that these measures are adequate for a return period in excess of 10,000 years (Section 7.42.22). A slope stability analysis has also been performed on the pond embankment, indicating it meets the required slope-stability safety factors (Chapter 7, Table 7-7).

R645-301-728.200 Basis for Determination

The PHC Determination for this operation is based on baseline hydrologic, geologic, and other information gathered specifically for this site and the surrounding area by the permittee. This includes information from the South Crandall Lease area and from the U-68082 lease mod area. Additionally, regional information has been provided through various published reports as noted in the plan.

Specific groundwater information is provided in Section 7.24.1 and Appendices 7-16, 7-17, 7-18, 7-19, 7-21, 7-24, 7-40, 7-41, 7-43, 7-46, 7-47, and 7-48 of Chapter 7. Surface water data is presented in Section 7.24.2 and Appendices 7-14, 7-23, 7-25, 7-26, 7-27 through 7-39, 7-43, 7-44, 7-45, and 7-48 of Chapter 7. Geologic information is provided in Chapter 6 and Section 7.24.3, while climatic information is provided in Section 7.24.4.

R645-301-728.300 Findings

7.28.310

Chapter 7, Sections 7.24.1 and 7.24.2, indicate the potential for adverse impacts to the hydrologic balance to be minimal in both the existing permit area and in the South Crandall Lease area, and in the U-68082 lease mod area. The basis for this determination is through extensive studies, past and on-going groundwater and surface water monitoring, past history, and performance of the on-going operation, and various protection plans for operations and reclamation. A summary of potential impacts is provided in Table 1 of this PHC.

7.28.320

Waste rock is produced in limited quantities on a very infrequent basis during mining operations. When incidental quantities of rock are encountered, the rock is left in the mine and will not be removed in the future. These conditions, coupled with the fact that the waste rock does not have acid or toxic characteristics indicate that little potential exists for any impacts from toxic- or acid-forming materials.

Further, handling plans have been implemented for earth, refuse, and acid-toxic forming materials, which, if needed, will prevent or control discharge of pollutants to the hydrologic system (Section 7.31.1). This will be accomplished using the best technology currently available.

7.28.330

The following are expected impacts from the coal mining and reclamation operation:

7.28.331

Sediment yield does naturally increase on a temporary basis from areas disturbed for the operation. However, the majority of the disturbed area runoff is directed to the sediment pond. The pond is designed with a total storage volume of 0.98 acre feet, which allows for complete containment of sediment. The 7 small areas which do not drain to the sediment pond, as shown on Plate 7-5, are treated through the use of sediment traps, straw bale dikes, silt fences, and vegetation.

Genwal, in cooperation with the U.S. Forest Service, is conducting detailed sedimentation and erosion studies in the Blind Canyon watershed to determine the exact impact of mining and subsidence. To date, negative impacts to intermittent and perennial streams by sediment loading and increased turbidity has not been observed in the permit area.

7.28.332

Water quality parameters, including acidity, total suspended solids and total dissolved solids, are not expected to be impacted by the mining or reclamation operations. This determination is based on information provided in Chapter 7, Sections 7.24.1 and 7.24.2, and by results of the on-going water monitoring program detailed in Section 7.31.2.

It is unlikely that groundwater quality or quantity will be affected by the underground mining operation (as discussed in Section 7.24.1 and associated appendices, and Section 7.28.100). There exists a potential for impacts to the surface water. However, these potential impacts are expected to be minimal for the following reasons:

(1) Sediment controls are in place and maintained to minimize sediment loading to drainages;

(2) All discharges from the sediment pond (or mine) are conducted in accordance with requirements of a U.P.D.E.S. Permit;

(3) Historical data from this site (which is summarized in the Annual Report and Appendices 7-16, 7-17, 7-18, 7-19, 7-21, 7-24, 7-40, 7-41, 7-43, 7-46, 7-47, and 7-48) show no indication of mine related impacts on the hydrology of the area;

(4) The water monitoring program will continue to be followed as described in Chapter 7, Section 7.31.2. Results will continue to be analyzed and any problem areas noted will be corrected to prevent further impacts to the hydrology.

<u>728.333</u>

The potential for flooding of the surface facilities is minimized by the design and installation of adequately sized diversions, sediment pond and velocity control structures as described in Chapter 7, Section 7.40.

<u>728.334</u>

The Crandall Canyon Mine is expected to have little impact on groundwater. As mentioned earlier, the mine does not appear to have any hydrologic connection to surface water above the mine nor any connection to groundwater in the Star Point Sandstone below.

Monitoring of in-mine and surface monitoring wells drilled within and adjacent to the Crandall Canyon Mine, and completed in the regional Blackhawk-Starpoint aquifer indicate the potentiometric surface of this aquifer generally lies 50 to 60 feet below the top of the Star Point Formation in all but the westernmost portion of the mine. Thus, mining of the Hiawatha Coal Seam at the base of the Blackhawk Formation, overlying the Star Point Formation, will not intersect and drain any water from the regional aquifer. Nor would water from underground mining enter the Star Point Sandstone due to the relatively impermeable shale zone that lies between the Hiawatha seam and the sandstone below.

There may be some potential for impact to seeps and springs through subsidence. Genwal is currently monitoring the water flow rates and quality of the water rights associated with seeps and springs within and adjacent to the current mine permit area. No evidence of impacts have been identified; however, an alternative water source plan has been developed in the event any water rights or springs/seeps are adversely affected by the mining operation or reclamation activities.

The groundwater system that supports discharge at Little Bear Spring will not be subsided. As discussed above, the groundwater discharging from the spring is NOT derived from a regional Star Point aquifer. Rather, it is recharged from surface-water and alluvial groundwater losses in Mill Fork Canyon outside of the permit area. The significant fracture in the Star Point Sandstone from which the spring discharges serves primarily as a conduit for the conveyance of the Mill Fork water to the spring. Groundwater in the Star Point Sandstone that is not within the fracture system does not contribute appreciable quantities of groundwater to the spring. For these reasons, the potential for impacts to Little Bear Spring resulting from mining operations in GENWAL's permit area is considered extremely unlikely..

Impacts to the surface water quality and quantity are minimized through the installation and maintenance of surface runoff and sediment control structures, and a commitment (Section 7.24.2) to not pump from Crandall Creek at a rate that will cause the in-stream flow to decrease below the minimum required rate.

In addition, groundwater and surface water quantity and quality are monitored on a quarterly basis to determine seasonal flow conditions for the permit and adjacent areas. Further, handling plans have been implemented for earth, refuse, and acid-toxic forming materials, which will prevent or control discharge of pollutants to the hydrologic system. Implementation of these plans will be accomplished using the best technology currently available.

Based on the above, there is some potential for the operation to have an impact on the groundwater and surface water resources of the area; however, the impacts are expected to be minimal due to natural geologic and hydrologic conditions, and the implementation of control and protection systems. Therefore, the "Probable Hydrologic Consequences" of this operation are expected to be minimal, if not negligible.

7.28.335

Additional information will be provided if deemed necessary by the Division.

R645-301-728.340 N/A

This is an underground operation.

R645-301-728-400 Updated PHC

This document is provided as an up-dated PHC for the permit renewal in accordance with the State of Utah R645-Coal Mining Rules.

TABLE 1
POTENTIAL HYDROLOGIC IMPACTS

POTENTIAL IMPACT	POTENTIAL EFFECT	POTENTIAL MAGNITUDE OF IMPACT	PROBABILITY OF OCCURRENCE	MITIGATION MEASURES
Leaching of acid or toxic forming materials	Degradation of surface and groundwater quality	Low (no such materials present)	Low	Monitoring materials handled by approved methods
Groundwater Availability	Decrease in spring flow due to subsidence	Low to moderate depending on location	Low (No history of impact)	Monitoring
Groundwater Availability	Interception of groundwater by mine workings	Low	Low (on-going)	Monitoring
Groundwater Availability	Removal of water with coal	Low	Moderate (on-going)	Monitoring
Groundwater Quality	Decrease in quality due to hydrocarbons	Low	Low	SPCC Plan, monitoring inspections and maintenance
Sediment Yield	Increase in TSS	Moderate	Low	Sediment pond, diversions, sediment control, monitoring
Flooding	Damage to downstream area	Low	Low	Sediment ponds, diversions, and monitoring
Streamflow Alteration	Damage to streams due to subsidence	Low	Low	Protection of perennial streams, monitoring
Surface Water Quality	Decrease in quality due to hydrocarbons	Low	Low	SPCC plan, inspections, monitoring, maintenance
Surface Water Quality	Increase in TSS due to coal fines and dust	Low	Low	Sweeping of access road and pads, misting of coal
Surface Water Quantity	Decrease in flow in Crandall Creek below mine	Moderate	Low	Monitoring, maintaining baseflow

APPENDIX 7-50

CONSTRUCTION SEQUENCE - 72" CULVERT

4/97 Revised 5/97

Appendix 7-50
Construction Sequence

Installation of a 72" culvert and construction of earthwork pads for the expansion of surface facilities at the Crandall Canyon Mine is described in outline and in detail below. All construction described below will be done in a manner which produces the absolute minimum sedimentation to Crandall Creek.

A. Construct of Temporary Silt Fences in Stream Bed

B. Start Placing Stream Channel Drain System at Outlet End

   1. Install geotextile fabric on stream channel surface
   2. Place drain rock
   3. Install drain pipe
   4. Place drain rock around and above pipe
   5. Install geotextile on top of drain rock bed
   6. Place marker material on top of geotextile
   7. Place layer of earth fill on top of marker material

C. Construct of Permanent Rip-Rapped Stream Channel at Outlet

D. Continue Stream Channel Drain System Upstream

E. Install and Backfill 72" Culvert

F. Install Inlet Section and Trash Rack. Turn Water into 72" Culvert

G. Begin Pond Construction

H. Begin Pad Construction

Work on the 72" culvert installation will not be initiated until after the peak runoff has subsided and stream flows in Crandall Creek have dropped off to manageable levels (e.g. approximately 10 cfs or less. *Refer to Appendix 7-4 for design calculations*).

Prior to any work in the stream, two silt fences will be constructed by hand across the stream channel at the eastern (downstream) end of the project. ***A silt fence will also be constructed across the work area (construction pad) after the eastern toe has been established, to control sediment runoff from the site.*** Access will be maintained to the silt fence so that sediment trapped during construction can be cleaned out as needed. *See attached calculations for silt fence.* ***The silt fences will be constructed according to the "post and mesh" method commonly used by UDOT. This method utilizes a non-rotting filter fabric stretched across the stream flow, backed by a wire-mesh fence material, which in turn is supported by a series of steel posts anchored into the streambed. Steel fence posts, 5' in length, will be installed on 2'-3' centers across the entire width of the stream channel and up along either bank for an additional 4'-6'. These posts will be securely anchored into the stream bed/bank, either by being driven firmly into the ground or by being placed in holes dug into the ground and tightly backfilled with course rock. If additional strength is needed to adequately withstand the lateral force of the flowing water, the fence posts will be individually supported with angled back-bracing located on the down-stream side and firmly anchored into the streambed. After the fence posts (and bracing) have been installed across the channel, a layer of steel wire-mesh fencing will be attached to the upstream side of the posts to serve as a backing for the filter fabric. The wire-mesh fencing will be 14 gauge minimum, 6" x 6" openings maximum, and will be attached to the fence posts with metal tie wire or clips. The fencing will be installed so that it fits tightly to the bottom of the channel with no gaps in between. If necessary, the channel will be worked with hand tools to assure a tight fit for the bottom of the fence into the stream bed. A row of rock boulders will be placed behind the fence on the downstream side to provide additional support to the fence bottom in the areas between the fence post supports. The fence post/wire-mesh structure will be tethered on either end (at each bank) to maintain adequate tension to support the top edge of the fence.***

After the wire-mesh fence has been installed, the filter fabric silt fencing material (filter cloth) will be installed. This filter cloth will be installed on the upstream side of the wire-mesh back fence and will be attached with metal tie wire or clips. The toe of the filter cloth will be imbedded (anchored) in a trench dug across the channel (and up the bankslopes). This toe-trench will be located several feet upstream from the fence in order to not interfere with the fence post anchors. The toe of filter cloth will be laid into the toe-trench and backfilled with rock material of sufficient size to prevent the trench from being scoured and to prevent the filter cloth from being lifted up by the force of the flowing water.

Prior to installing the main 72" culvert an underdrain must first be constructed within the existing streambed below the main culvert. The purpose of the underdrain is five fold:

a) to handle the in-stream flow during installation of the main 72" CMP culvert

b) to handle any unplanned seepage from the 72" culvert during the operational life of the mine

c) to handle any naturally occurring groundwater flow which may continue to recharge into the existing stream channel during the operational life of the mine

d) to handle any naturally occurring seeps along the hillside which may be covered with fill during the expansion project, and

e) to handle the in-stream flow during final reclamation when the 72" CMP is finally being removed

The purpose of the geotextile is to protect the existing stream bank material in its present in-place condition, and to provide a barrier between the in-place topsoil and the imported fill material. The marker material (earth material of a different color) will also serve as a visual aid to assist reclamation efforts in the future. By using the geotextile and marker material the existing topsoil located on the steeper hillside can be left in place. During final reclamation the fill material will be removed, along with the marker material and the geotextile, to re-expose the existing topsoil.

As the underdrain system is being installed, all trees and brush will first be removed from along the sides of the stream channel. Trees will be cut approximately 3" to 5" above the ground with the roots left intact to help hold the soils along the stream bank. Cut trees and brush will be temporarily placed out of the way along the bank side until after installation of the drain system and the 72" culvert has been completed.

Installation of the drain system in the stream channel is the next step (Refer to Figure 12, Appendix 7-4, for detail of the under drain system; enclosed herein for easy reference). This procedure will start at the proposed outlet (downstream) area. A ramp will be constructed down from the existing sedimentation pond embankment to provide access to the stream bed. A geotextile fabric will be placed by hand in the stream channel, across the bed and five feet beyond the edges of the channel. A layer of clean 2" drain rock gravel will then be placed on top of the fabric to form a bed for the drain pipe (18" perforated cmp culvert). After installing the drain pipe, another layer of drain rock will be placed around and on top of the pipe. Another layer of geotextile will be placed on top of the drain rock and will be covered by a 6" minimum layer of different colored earthen marker material. Finally, a layer of 2" x 0" granular earthfill several feet thick will be placed on top of the marker layer to serve as a bedding material for the culvert installation which will follow later. This layer placement of geotextile/drain pipe/drain rock/geotextile/marker bed/bedding material will then proceed upstream in an orderly fashion in consecutive 20' increments. As construction of the underdrain progresses upstream, the stream water will flow through the drain pipe/drain rock and construction equipment can operate freely on the earth fill on top of the newly construction drain system. Much of the sediment stirred up by hand placement of the geotextile will be filtered out within the newly installed bed of drain rock.

As soon as equipment can adequately operate on top of the drain system located at the bottom of the ramp (i.e. after the 2" x 0" culvert bedding material is in place), rip-rap will be placed in and along side the stream channel in the downstream area where the culvert outlet will eventually be located. The rip-rapped area will be designed and constructed to serve as an effective energy dissipater once the 72" culvert is installed permanently. (Refer to Figure 11 Appendix 7-4 for detail of the rip rap structures; enclosed herein for easy reference). In the meantime, flow from the outlet of the drain pipe will be routed onto the newly installed rip-rap field to help minimize sedimentation during the remainder of construction. It should be noted that according to engineering recommendations, as presented in Appendix 7-4, the rip rap apron should be 30' long and 18' wide. **This rip rap configuration has been determined to be adequate to slow the exit velocity of a 100 year, 6 hour flow event to less than the velocity of the existing natural stream channel during similar flow conditions. In order to ensure maximum protection to the existing channel, Genwal will extend the length of the rip rap apron to 35-40' and widen the outlet of the apron to 20-25'. Also, the engineering calculations for the flow velocity across the apron assume a conservative roughness coefficient for the rip rap which is the same as for the natural channel. In reality, the roughness of the rip rap apron will be greater than the natural channel which should result in an even lower exit velocity. Fortunately, there are a number of larger boulders presently existing in the area adjacent to the proposed culvert outlet which can be used for construction of the rip rap apron. These boulders are generally larger than the boulder sizes specified for the apron according to the engineering determinations referenced in Appendix 7-4. Therefore, utilization of these larger boulders for the rip rap apron will serve to provide an even greater measure of energy dissipation and lower exit velocities..**

After the outlet rip-rap has been completed, additional silt fences (or straw bale dikes) will be installed across the lower (downstream) end of the new earthwork fill to prevent siltation in case of a rain storm event during the remaining construction of the underdrain and the 72" culvert. **Refer to Chapter 7 Figures, Figure 7-11 and Figure 7-12 for typical installation of the silt fence and straw bale sediment treatment.**

Construction of the drain system will progress upstream until the area adjacent to the existing loadout is reached. At this location a second access ramp will be constructed from the road down to the stream. This will become the primary access route for the remainder of the drain/culvert construction. The relatively flat area at the bottom of the ramp (on the south side of the creek) can then be used as a temporary central staging area for construction materials and equipment.

With the primary access ramp now in place, construction can continue upstream as described previously on two fronts: a) construction of the underdrain system will continue upstream, in consecutive 20' increments, as described previously and; b) installation of the 72" CMP will begin at the downstream outlet (rip-rap) end and proceed upstream.

As the main culvert is being laid in place, 36" CMP risers will be installed at the upper end of the lower pad and near the reclaim tunnel exit. These risers will be designed to daylight at the as-built surface and will be used to facilitate inspection and maintenance of the main

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In general, the culvert will follow the existing stream bed alignment as closely as practicable while still keeping the culvert as straight as possible for optimum flow characteristics. Angled joints will be kept to 15° or less to promote smooth flow. Culvert alignment may be altered slightly in some areas in order to complement the overall facility design in the area of the reclaim tunnel, the crusher building foundation and the sediment pond.

After the drain installation has proceeded upstream, installation and backfilling of the 72" culvert will follow. Work will progress as quickly as possible on the underdrain and the 72" culvert to keep exposure time to an absolute minimum. Once the main culvert has been extended to the upstream end of the upper yard, the inlet will be fitted with a standard inlet end-section equipped with a trash rack. The underdrain pipe will then be capped and the full flow of the stream will be routed into the main culvert. The head wall above and around the culvert inlet (free board) will be rip-rapped at this time. (Refer to Figure 10 of Appendix 7-4 for culvert inlet detail; enclosed herein for easy reference). An additional freestanding trash rack will also be installed upstream from the inlet at a location convenient for maintenance and cleanup. The culvert should be fully functional at this time.

As soon as possible after the main culvert has been installed in the vicinity of the designated topsoil salvage area and backfilled sufficiently to allow equipment to cross over, topsoil will be salvaged from the topsoil area. An estimated 3,000 cubic yards of topsoil will be removed from this area and transported to the existing storage area located at the mouth of Crandall Canyon. However, a soil scientist will be on site during this time and will direct additional topsoil recovery if there is more than 3,000 cubic yards in existence.

The pad construction can now begin in earnest. Prior to placing fill material for the pad, the south side slope will have the trees and brush removed with stumps and roots left in place to help stabilize the soil as described earlier. Utmost care will be used to ensure that existing topsoil resources along the slope are protected during this process. All cut trees and brush will be removed from the site and disposed of in an approved manner. After the hillside has been cleared, the slope will then be covered with a geotextile fabric (refer to **Figure 12** for details). The purpose of this geotextile is to provide a separation barrier between the existing topsoil (which is to remain in place) and the imported fill. Placing of the geotextile will be done in lifts as the pad is built up. In addition, a 6"-12" layer of colored marker material will be placed between the geotextile and the fill material serve as a visual boundary for equipment operators during final reclamation. Geotextile and marker material is to be applied to the designated area shown on Plate 5-20 but not for areas from which topsoil has been previously salvaged.

Pad construction will start at the lower end of the property. The fill material (8"x 0) will be hauled from an approved borrow area which has been certified as weed free by the Utah State Agriculture Department and tested to assure soil is non-toxic and nonhazardous. It will be placed on the pad, graded and compacted in appropriate lifts to meet compaction and stability requirements. Compaction must be maintained at a minimum of 90%. Fill material will be an 8" x 0" granular borrow product with specified size gradation to allow 90-95% compaction for a structural fill of 3,000 psf minimum. In structural areas such as around the culvert, reclaim tunnel, escape tube, stacking lane extension, and structural foundations (loadout, crusher structural fill of 3,000 psf minimum. In structural areas such as around the culvert, reclaim tunnel, escape tube, stacking lane extension, and structural foundations (loadout, crusher building, conveyor bents, etc.), compaction will be maintained at 95% with a load bearing capacity of 3,000 psf. Fill will be placed in layers, graded and compacted to meet all necessary structural requirements. Placement and compaction of all fill will be under the direction of registered, professional engineers. As the lower pad is being constructed, silt fences and/or straw bales will be maintained **across the entire** downstream end of the construction site to provide additional interim sedimentation protection.

When construction of the lower pad reaches the floor elevation of the sediment pond, construction of the new pond embankment can then begin. The existing spillways and piezometer hole will be left in place. The additional embankment will be constructed south across the newly installed culvert and will abut the slope of the south hillside. This pond embankment will have a 2:1 outslope and a 3:1 in-slope. This stable design will thereby eliminate the need for pond lining. Once the new embankment is securely keyed into the opposite hillside, the remaining (existing) embankment of the old pond will be removed, leaving a new enlarged impoundment in its place. (Note: In areas where the fill slopes are required to be keyed into the existing hillside, in order to assure adequate geotechnical stability, all available topsoil will first be salvaged.)

After the pond embankment is constructed, and sedimentation controls leading into the pond are adequately in place, earthwork activities will remain focused on the lower pad in order to accommodate the most expedient construction schedule for the new loadout facilities, namely the reclaim tunnel, the crusher building, and the loadout structure.

A naturally occurring seep exists on the south slope near the location of the proposed crusher building. A french drain system will be installed within the lower pad as it is being built up which will connect this seep to the main underdrain system located beneath the 72" culvert. **A perforated pipe bedded in 2" drain rock will be installed in a trench dug from the seep area to the main underdrain. The pipe and gravel will be wrapped in geotextile material to prevent clogging of the drain system.**

After the lower pad has been completed to finish grade (approximately 7,800' elevation), work will continue in preparation of the permanent coal storage area. Topsoil will be removed from a small area of the adjacent slope near the location of the future stacking tube where the southern flank of the coalpile will rest against the existing hillside. This topsoil will be salvaged under the direction of a soils scientist to assure optimum recovery of the soil resource in this area. The soil will be stockpiled off-site at an approved storage location until it is re-used during final reclamation.

After the lower pad is completed sufficiently to allow foundation work to begin, construction of the upper pad can begin. Special emphasis will be given to widening the existing road from the loadout to the truck turnaround. This widening will be done as part of an overall effort to reestablish the Forest Service road as a two-lane roadway through the minesite to the Forest Service trailhead parking Area. This will be accomplished by the following:

a) The existing roadway from the loadout up to the truck turnaround area will be widened by approximately 15 feet. This will result in an additional (third) lane which **will** be used by the trucks as a stacking lane as they wait to enter the loadout to be loaded. This will free up the existing road for unobstructed two-way, two lane traffic to facilitate public use of the road for Forest related activities.

b) The turn-around area will also be widened to allow the trucks to turn in a standard counter-clockwise direction and thereby eliminate the present practice of clockwise cross traffic turnarounds.

c) The existing oil storage shed will be rehabilitated and the roadway will be widened, regraded and repaved in this area.

d) After the new loadout facilities are completed, the existing loadout facilities will be removed and cleaned up and the road will be widened, realigned, and repaved through this area. Also, the existing truckscales and exit ramp will be removed from the middle of the road and the roadway will be re-established and repaved in this area.

e) Construction of the high speed, high efficiency truck loadout will in and of itself help minimize the congested conditions which now exist within the mine site. Presently trucks are often forced to stop along the Forest Service road while waiting to be loaded. The expanded coal storage capabilities and the new high-speed truck loading facilities will allow the trucks to be loaded in a continuous, uninterrupted basis, thereby eliminating the major cause of tie-ups and congestion.

The old truck loadout will be dismantled once the new loadout facility has become operational. The loadout structures will be removed and the excess coal around the area will be cleaned up and hauled to the new coal stockpile area. Once the structures have been removed, this area will provide a place to store material as well as snow and salt in the winter time.

After the new loadout facilities have been constructed, the existing loadout area will be removed and the area will be rehabilitated and cleaned up. These rehabilitation measures shall include the following:

a) The existing loadout facilities will be dismantled and removed from the site, including the coal bin, crushers, scalehouse and loading chute.

b) The existing truck scale will be removed from the middle of the road and the roadway will be regraded and repaved.

c) The existing oil shed will be rehabilitated and the roadway will be regraded

and repaved in this area.

d) **The existing coal pile/storage area will be totally cleaned up. All coal and coal products will be removed. The area will then be swept and vacuumed.**

e) **The hillside below the coal storage area will be dressed up. The mine discharge waterlines will be relocated in a more orderly fashion. Coal products will be vacuumed from the hillside.**

After the upper and lower pads have been constructed to the proper elevations, surface drainage ditches, culverts, and rip-rap will be installed as shown on Plate 7-5C. All newly installed surface drainage culverts (buried and overland) shall be 30" minimum and fitted with inlet end sections. Rip-rap shall be installed within the sediment pond below the culvert outlets to prevent scouring of the pond bottom.

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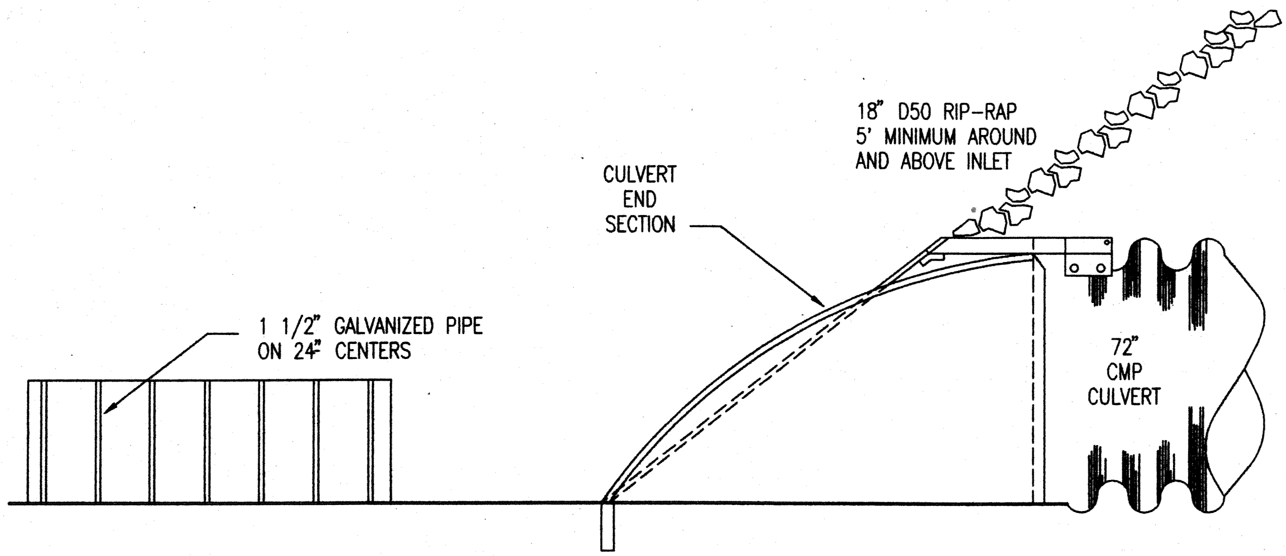
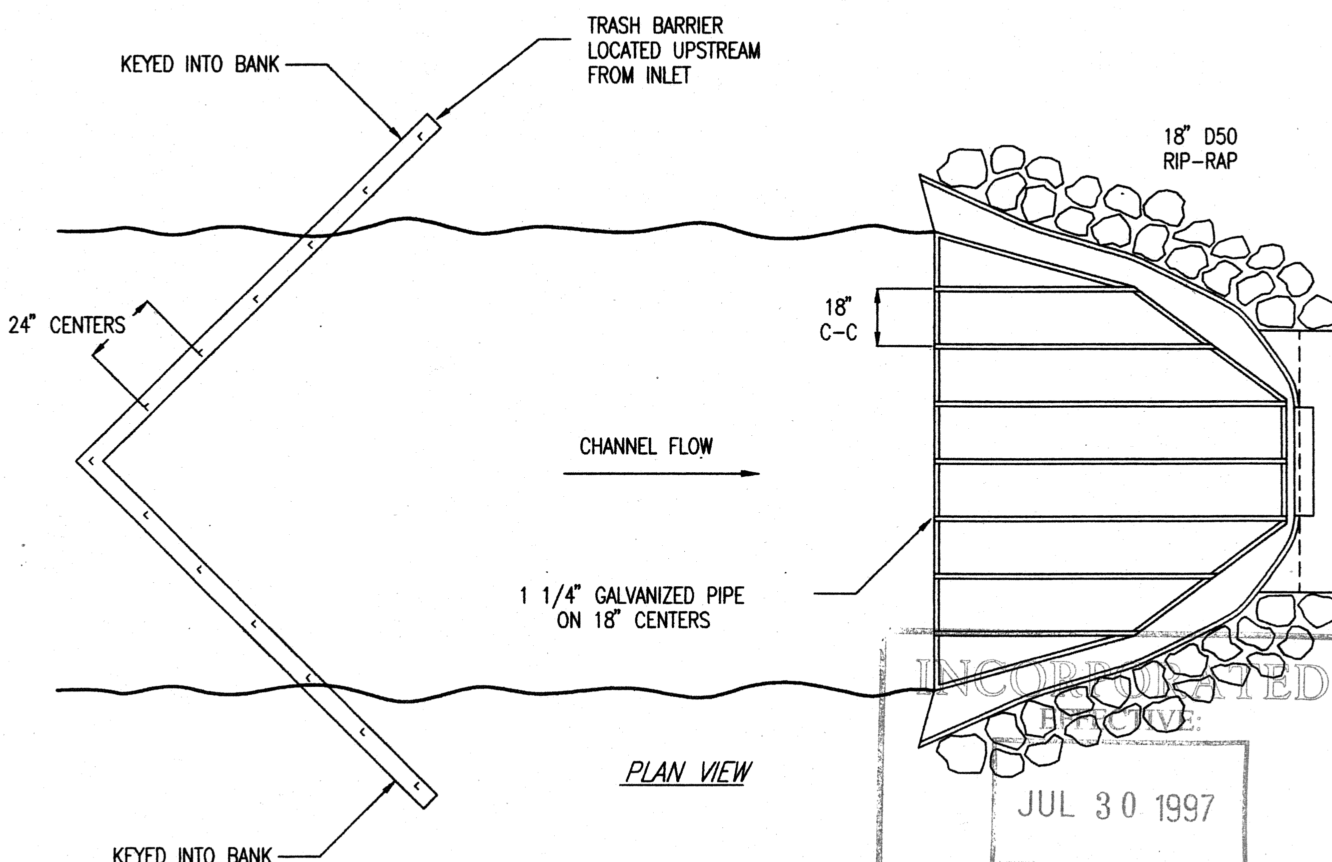
MAIN CULVERT INLET AND TRASH BARRIERS



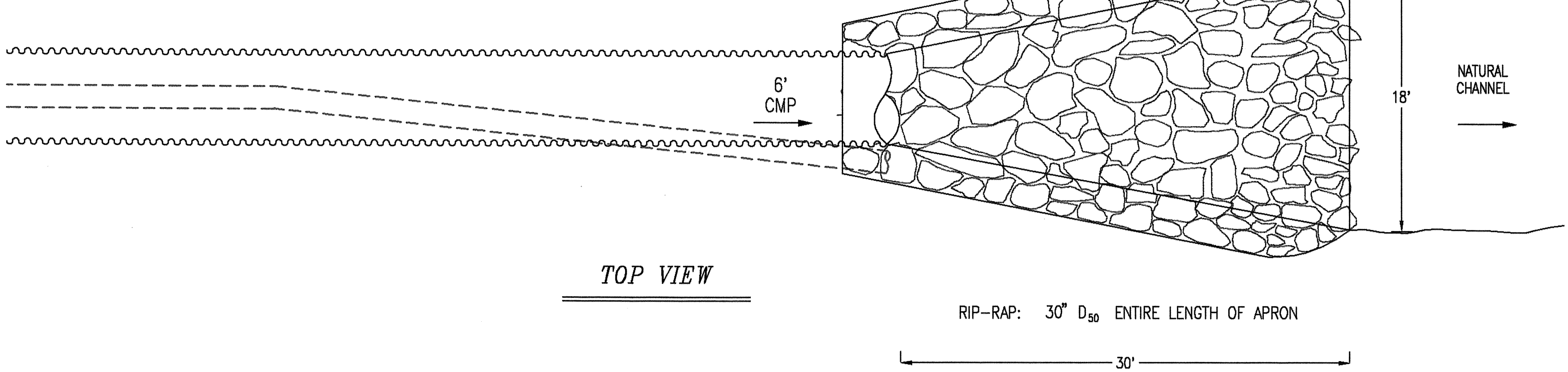
SIDE VIEW



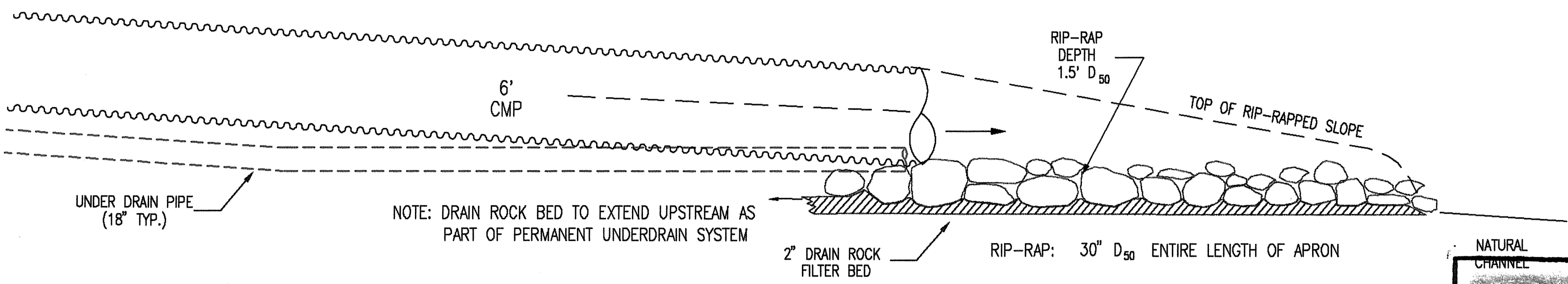
PLAN VIEW

FIGURE 10

MAIN CANYON
CULVERT OUTLET



TOP VIEW



SECTION VIEW

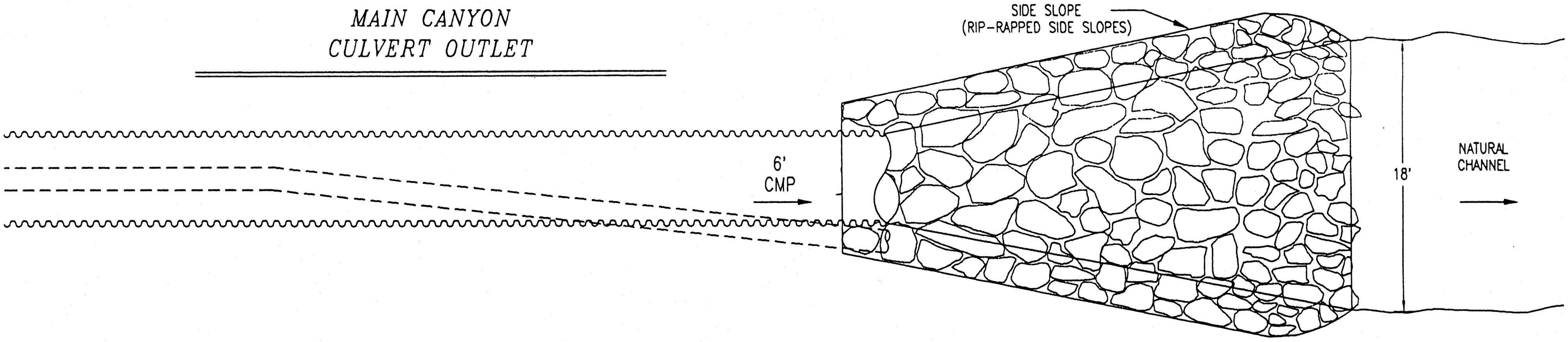
* DESIGN BASED ON FIGURE 7-26, DESIGN OF OUTLET PROTECTION – MAXIMUM TAILWATER CONDITION, "APPLIED HYDROLOGY AND SEDIMENTOLOGY FOR DISTURBED AREAS", BARFIELD, WARNER & HAAN, 1983.

SCALE: 1" = 10'

FIGURE 11

ACAD REF: FIGURE11A

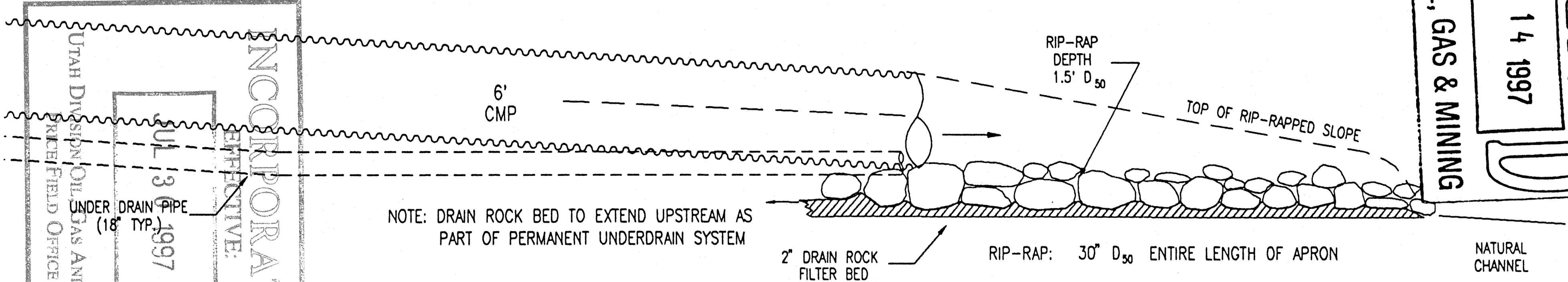
MAIN CANYON CULVERT OUTLET



TOP VIEW

RIP-RAP: 30" D_{50} ENTIRE LENGTH OF APRON

30'



RIP-RAP: 30" D_{50} ENTIRE LENGTH OF APRON

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SECTION VIEW

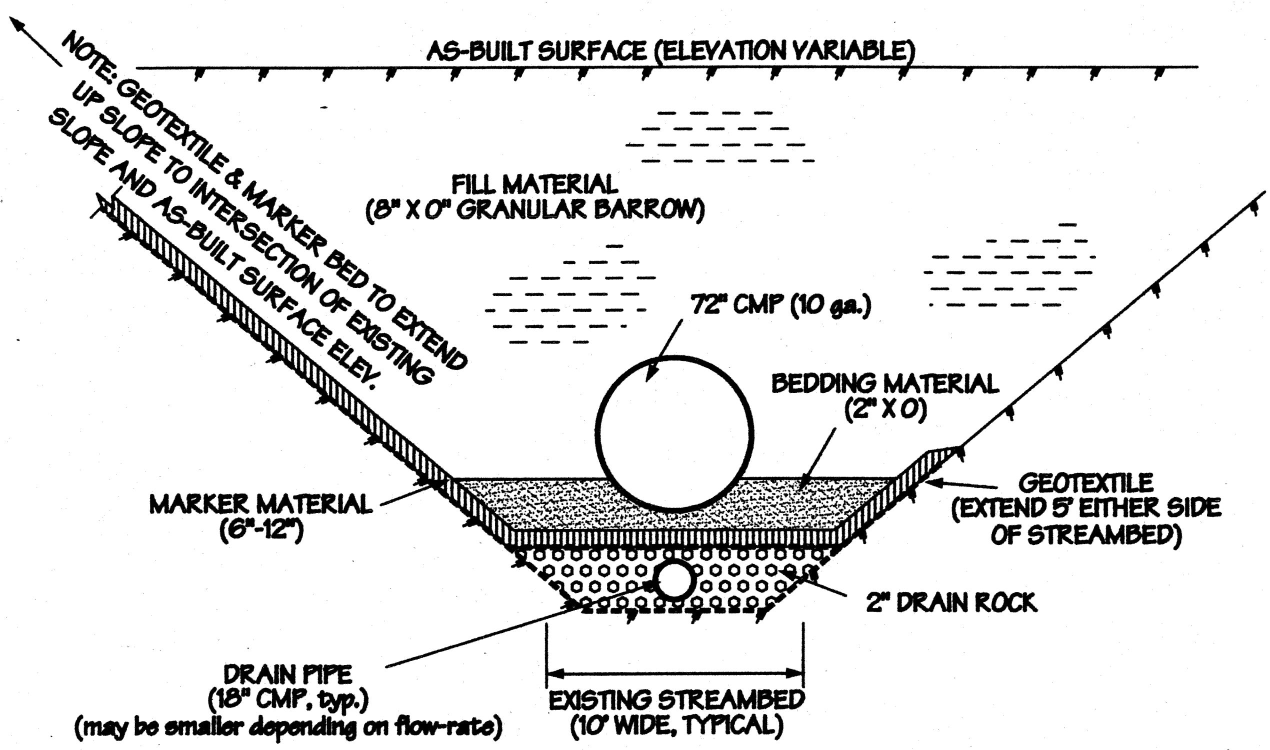
* DESIGN BASED ON FIGURE 7-26, DESIGN OF OUTLET PROTECTION - MAXIMUM TAILWATER CONDITION, "APPLIED HYDROLOGY AND SEDIMENTOLOGY FOR DISTURBED AREAS", BARFIELD, WARNER & HAAN, 1983.

SCALE: 1" = 10'

FIGURE 11

ACAD REF: FIGURE11A

TYPICAL UNDERDRAIN CONSTRUCTION



SCALE: 1" = 15'

Note: Culvert installation will generally follow the existing stream alignment, but may vary slightly to accommodate accepted engineering and installation standards.

FIGURE 12

ATTACHMENT 1

SILT FENCE CALCULATIONS

STEFFEN ROBERTSON AND KIRSTEN
Consulting Engineers and Scientists

TECHNICAL MEMORANDUM

TO: Mr. Gary Gray, GENWAL Resources, Inc.

FROM: Pete Kowalewski, SRK

DATE: June 4, 1997

SUBJECT: Crandall Canyon Silt Fence Evaluation (SRK #94401)

1.0 INTRODUCTION

GENWAL Resources, Inc. (GENWAL) will be constructing an earth fill pad across the creek in Crandall Canyon during the 1997 construction season. The pad will cover approximately 4 acres and will be constructed of common earth fill. A 72-inch culvert will be placed in the creek beneath the pad to pass the creek flow.

Steffen Robertson and Kirsten (U.S.), Inc. (SRK) has been retained by GENWAL to evaluate the use of silt fences during construction activities in Crandall Canyon using the SEDCAD+ computer program. The purpose of the analyses is to assess the possible benefits of using silt fences to reduce the amount of sediment continuing down the creek during construction activities. After construction at the site is completed, stormwater runoff from the newly completed pad site will be routed to an existing sediment pond.

The SEDCAD+ computer program was developed by Dr. Richard Warner of the University of Kentucky and Ms. Pamela Schwab of Civil Software Design. The program was developed to assist in the design and evaluation of stormwater, erosion, and sediment control techniques. Major components encompass design aspects of hydrology, hydraulics, erosion, sediment control, and sedimentation. The program is used to evaluate sediment generation and delivery due to a single storm event on a catchment area. The latest version of SEDCAD+ (Version 3.1) was used to perform the analyses.

2.0 METHODOLOGY

The Crandall Canyon catchment area upstream of the proposed construction was subdivided into seven sub-catchment areas for use in the SEDCAD+ program. In addition, the disturbed area created by the construction of the pad was sub-divided into

6 sub-catchment areas based on the ground slopes on the constructed pad. The ground slope of each area will be the primary controlling factor with respect to sediment generation from each area. Figure 1 presents the sub-catchment areas defined on the USGS topographic map. Figure 2 contains the cross-section of the constructed pad area provided by GENWAL used to define catchment areas for the disturbed area.

Three different models were analyzed using the SEDCAD+ program; a pre-construction model, a construction model without the use of silt fences, and a construction model with the use of silt fences. In all of the models, sediment generation and delivery due to the 10-year 24-hour storm at the Crandall Canyon site was evaluated.

3.0 SEDCAD+ INPUT PARAMETERS

The SEDCAD+ program uses the Soil Conservation Service (SCS) curve number method for determining rainfall excess. Runoff curve numbers (CN) are assigned to each sub-catchment area to determine the amount of runoff originating from each catchment area. The curve numbers used in the analyses are listed below:

Table 1 - SCS Runoff Curve Numbers Used in the Analyses

Catchment Area	SCS Runoff Curve Number (CN)
South Side of Canyon	54
North Side of Canyon	69
Disturbed Area	65-80[1]
Note: [1] - CN varies depending upon slope	

Runoff curve numbers are based on soil type, slope, and vegetative cover present within each catchment area. The curve numbers assigned to each area were based on previous analyses performed for sites within the canyon and engineering judgment.

In addition to the runoff curve number, the time of concentration (t_C) needs to be input to allow the generation of runoff hydrographs (distribution of runoff through time). The SEDCAD+ program calculates the time of concentration for each sub-catchment area using the SCS Upland Curve Method. The program requires the slope and hydraulic length for each sub-catchment to be input to calculate t_C. Representative slopes, lengths, and areas were measured from the United States Geological Survey (USGS) Rilda Canyon 7.5-minute quadrangle (Scale 1:24000). The following is a summary of the values used in the analyses:

Table 2 - Hydrologic Parameters Used in the Analyses

Catchment Area	Area (acres)	Hydraulic Length (ft)	Slope (%)
1[1]	112.6 (110.6[2])	4750	40.4%
2	186.5 (184.5[2])	6750	32.7%
D (disturbed area)			
D1	0.20	70	48.6%
D2	0.40	140	14.3%
D3	0.52	180	7.2%
D4	1.06	370	1.08%
D5	0.29	100	43.0%
D6	1.39	485	1.65%
3	313.1	7000	24.6%
4	140.9	6000	26.9%
5	374.3	7000	29.7%
6	784.2	10500	22.9%
7	1191.3	10000	22.6%

Note: [1] - Area reporting to existing sediment pond is not included in this area
[2] - Areas reduced due to construction of pad

The SEDCAD+ program provides the option of using the Modified Universal Soil Loss Equation (MUSLE), the Revised Universal Soil Loss Equation (RUSLE), or the Soil LOSS routine (SLOSS) to determine sediment generation. The Revised Universal Soil Loss Equation was used in these analyses.

The Revised Universal Soil Loss Equation requires the input of several parameters for the determination of sediment generation from each sub-catchment area including the soil erodibility factor (k), the eroded soil grain size distribution, the length-slope factor (LS), and the control practice factor (CP). The SEDCAD+ program calculates the LS factor based on the input of a representative slope length and slope for each sub-catchment. These values do not necessarily correspond with the slope length and slope input for the hydrologic calculations. The following is a summary of the values used in the analyses:

Table 3 - RUSLE Input Parameters Used in the Analyses

Catchment Area	Soil Erodibility Factor K	Slope Length (ft)	Slope (%)	C-Factor	P-Factor
1	0.15	1700	47.0%	0.006[1]	1.00
2	0.15	1400	62.8%	0.003[2]	1.00
D (disturbed area)					
D1	0.15	70	48.6%	1.000	0.72[3]/0.36[4]
D2	0.15	140	14.3%	1.000	0.72[3]/0.36[4]
D3	0.15	180	7.2%	1.000	0.72[3]/0.36[4]
D4	0.15	370	1.08%	1.000	0.72[3]/0.36[4]
D5	0.15	100	43.0%	1.000	0.72[3]/0.36[4]
D6	0.15	485	1.65%	1.000	0.72[3]/0.36[4]
3	0.15	1300	43.1%	0.006	1.00
4	0.15	2300	53.0%	0.003	1.00
5	0.15	1800	46.7%	0.003	1.00
6	0.15	2300	53.0%	0.006	1.00
7	0.15	2500	39.2%	0.003	1.00

Notes: [1] - Value from Soil Conservation Service (1977) (Barfield, Warner, and Haan) for Undisturbed Woodland, 20-35% Canopy

[2] - Value from Soil Conservation Service (1977) (Barfield , Warner, and Haan) for Undisturbed woodland, 40-70% Canopy

[3] - Value from HDI (1991) for combination of rough irregular surface (P = 0.90) and use of straw bale barrier (P = 0.80)

[4] - Value from HDI (1991) for combination of rough irregular surface, use of straw bale barrier, and silt fence (P = 0.50)

In all of the cases, it was assumed a similar eroded grain size would be produced (no variation in eroded particle size from the fill or native soil was used). It is assumed that fill materials for the pad construction will be borrowed locally and thus will have a similar grain size to the native soils.

4.0 ASSUMPTIONS

The following is a summary of the assumptions made during the analyses:

- Sediment generation was calculated due to the 10-year 24-hour storm only;
- The 10-year 24-hour storm depth of rainfall for the Crandall Canyon site is 2.5 inches (from previous analyses);

- The Soil Erodibility Factor (k) for both native soils and fill materials was assumed to be 0.15 (typical for a sand or loamy sand, value used in previous analyses);
- The pad was assumed to be 125 feet wide;
- Stormwater flows from the constructed pad area are discharged directly to the creek (i.e. no stormwater flows were routed to the existing sediment pond);
- Straw bales are placed at the downstream toe of the constructed pad fill;
- When silt fences are used they are placed downstream of the hay bales;
- Final ("Ultimate") constructed slopes and slope lengths for the pad were used in the sediment generation analyses; and
- A base flow of 10 cfs and sediment concentration of 3 mg/l was used for the creek flow in all of the cases.

5.0 RESULTS OF SEDCAD+ ANALYSES

The following are the results obtained using the SEDCAD+ program:

Case	Peak Sediment Concentration (mg/l)	% Increase Over Pre-Construction Sediment Load
Pre-Construction (Existing)	7535	n/a
Construction (No Silt Fence)	11039	46.5%
Construction (w/ Silt Fence)	7543	0.1%

Case	Tonnage of Eroded Sediment	Peak Settleable Concentration (ml/l)	24-hour Volume Weighted Average Settleable Concentration (ml/l)	24-hour Arithmetic Average Settleable Concentration (ml/l)
Pre-Construction (Existing)	434.5	5.11	2.92	1.87
Construction (No Silt Fence)	443.1[1]	7.50	2.99	1.98
Construction (w/ Silt Fence)	438.4[2]	5.12	2.95	1.92

Notes: [1] - Construction disturbance contributes 8.6 tons of sediment out of the total
[2] - Construction disturbance contributes 3.9 tons of sediment out of the total

Output from the SEDCAD+ program in included in Appendix A.

6.0 CONCLUSIONS

The results of the SEDCAD+ analyses show the use of the combination of the silt fence and the hay bale barriers reduces the peak sediment concentration by approximately 30% as compared to the use of hay bale barriers alone. In addition, the tonnage of sediment eroded from the pad area is significantly reduced (3.9 tons versus 8.6 tons). The use of the combination of the silt fence and the hay bale barrier will result in a negligible increase in peak sediment concentration over the existing (non-disturbed) condition of only 0.1% if the 10-year 24-hour storm occurs during the construction of the pad. The exposure time for the sediment generation from the pad surface will be limited as the upper portion of the pad will be paved with asphalt at the end of the construction process. The paving will reduce the area contributing sediment by approximately 33%. In addition, as soon as the final pad configuration has been constructed, stormwater flows can be routed to the sediment pond.

7.0 REFERENCES

Barfield, B.J., Warner, R.C., and C.T. Haan (1981); Applied Hydrology and Sedimentology for Disturbed Areas; Oklahoma Technical Press, Stillwater OK.

Fifield, J.S.; (1992); Course Notes, *Practical Approaches for Effective Erosion and Sediment Control*; Denver, CO.

Gray, Gary (1997); Personal Communication, GENWAL Resources, Huntington, UT.

Warner, R.C., and P.J. Schwab (1992); SEDCAD+ Version 3 Training Manual; Civil Software Design, Ames, IA.

RILDA CANYON QUAD.

SCALE 1"-2000'

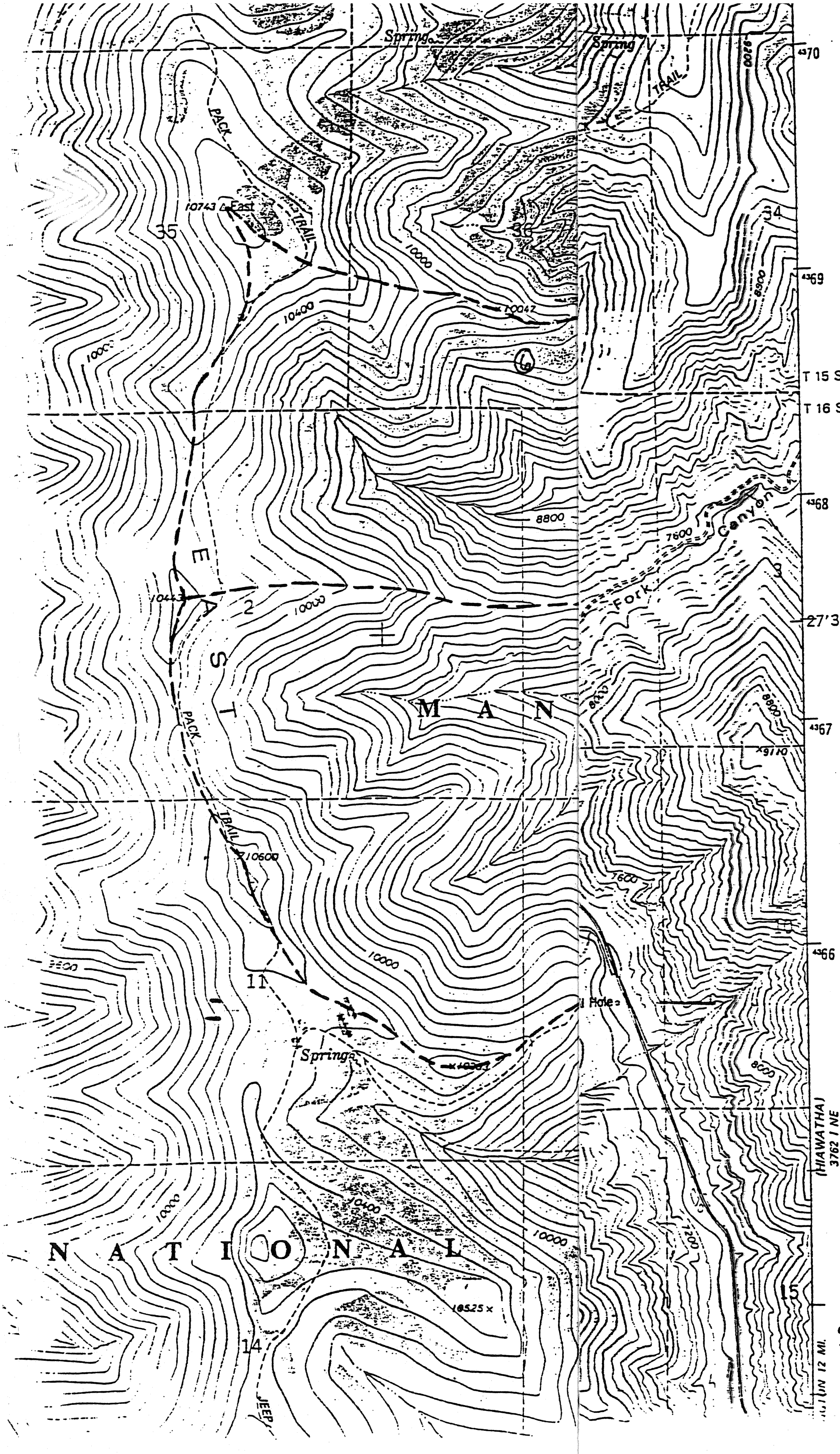
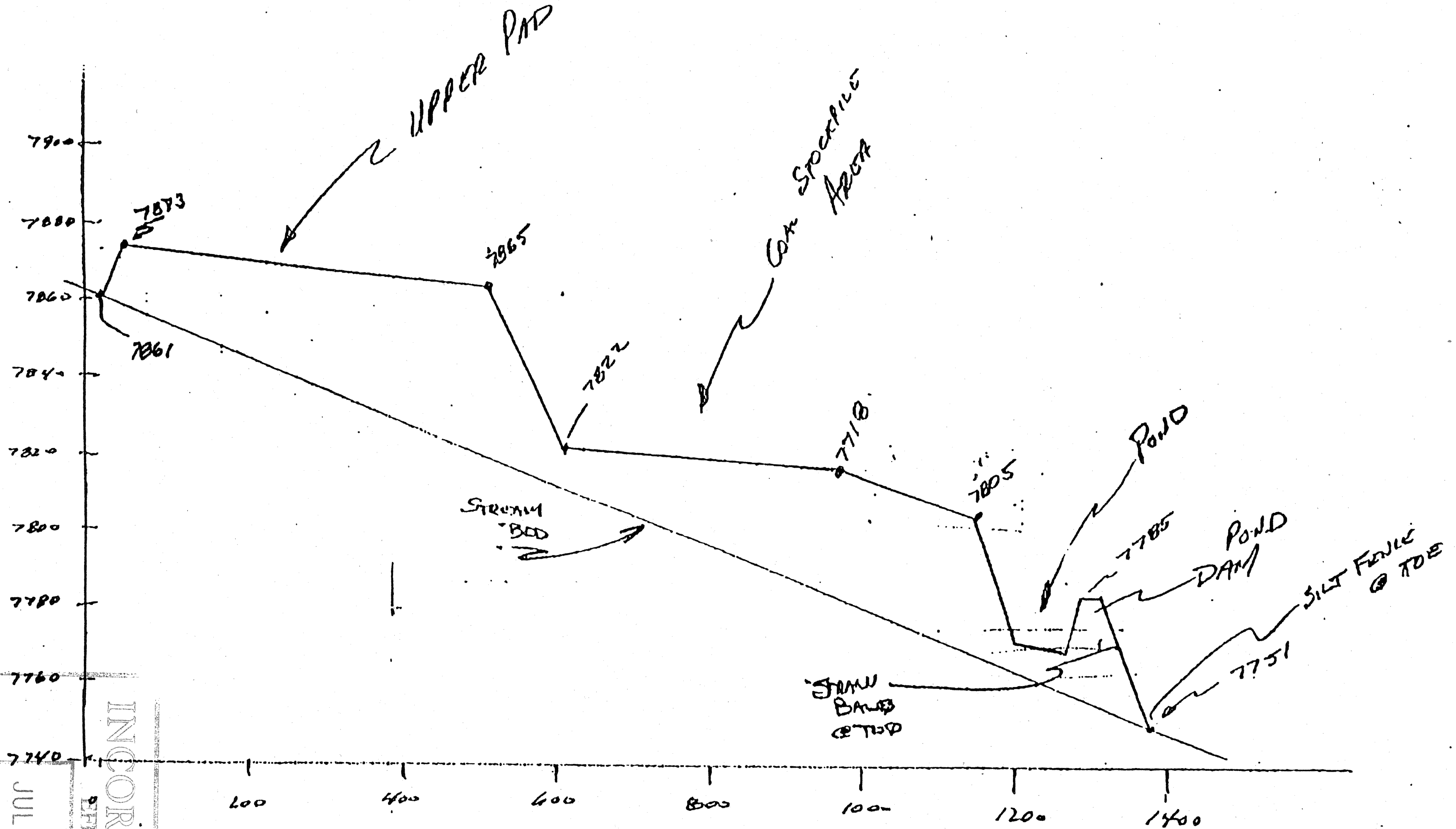


FIGURE 1
SUB-CATCHMENT AREAS
USED IN SEDCAD+
ANALYSES

PAD PROFILE



1" = 200'

NOTE: ASSUMING PAD WIDTH = 125 FT.

FIGURE 2
PAD CROSS-SECTION
(PROVIDED BY GENWAL)

APPENDIX A

SEDCAD+ OUTPUT

SEDCAD+
PRE-CONSTRUCTION (EXISTING) MODEL

CIVIL SOFTWARE DESIGN

SEDCAD+ Version 3

CRANDALL CANYON - EXISTING SEDIMENT DUE TO 10-YR 24-HR STORM (2.5")

by

Name: PETE KOWALEWSKI

Company Name: STEFFEN, ROBERTSON, KIRSTEN

File Name: C:\SEDCAD3\GENWAL1A

Date: 06-04-1997

Civil Software Design -- SEDCAD+ Version 3.1

Company Name: STEFFEN, ROBERTSON, KIRSTEN
Filename: C:\SEDCAD3\GENWAL1A User: PETE KOWALEWSKI
Date: 06-04-1997 Time: 08:15:35
CRANDALL CANYON - EXISTING SEDIMENT DUE TO 10-YR 24-HR STORM (2.5")
Storm: 2.50 inches, 10 year-24 hour, SCS Type II
Hydrograph Convolution Interval: 0.1 hr

GENERAL INPUT TABLE

Specific Gravity: 2.50
Submerged Bulk Specific Gravity: 1.25

Particle Size Distribution(s):

Size (mm)	FILL SOIL % Finer
1.0000	95.00
0.5000	75.00
0.2500	50.00
0.1000	25.00
0.0500	10.00
0.0100	5.00
0.0050	3.00
0.0010	0.00

Detailed Between Structure Routing:

J B S	To Seg. #	Land Flow Condition	Distance (ft)	Slope (%)	Velocity (fps)	Segment Time (hr)	Muskingum K (hr)	X
2 1 1	1	8	4889.77	7.79	8.37	0.16	0.161	0.415
3 1 1	1	8	2267.23	12.40	10.56	0.06	0.059	0.430
4 1 1	1	8	50.38	12.40	10.56	0.00	0.001	0.430

Civil Software Design -- SEDCAD+ Version 3.1

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Date: 06-04-1997 Time: 08:15:35
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Storm: 2.50 inches, 10 year-24 hour, SCS Type II
Hydrograph Convolution Interval: 0.1 hr

SUBWATERSHED/STRUCTURE INPUT/OUTPUT TABLE

-Hydrology-

JBS	SWS	Area (ac)	CN	UHS	Tc (hrs)	K (hrs)	X	Base-Flow (cfs)	Runoff Volume (ac-ft)	Peak Discharge (cfs)
111	1	784.20	69	M	2.409	0.000	0.000	0.0	27.50	51.27
111	2	1191.30	54	M	2.309	0.000	0.000	0.0	6.76	7.15
	Type: Nonerodible Channel Label: UPPER CREEK SECTION									
111	Structure	1975.50							34.26	
111	Total IN/OUT	1975.50							34.26	54.38
211	1	313.10	69	M	1.549	0.000	0.000	0.0	10.98	27.19
211	2	140.90	54	M	1.270	0.000	0.000	0.0	0.80	0.95
211	3	374.30	54	M	1.410	0.000	0.000	0.0	2.12	2.48
	Type: Nonerodible Channel Label: MIDDLE CREEK SECTION									
211	Structure	828.30							48.16	
211	Total IN/OUT	2803.80							48.16	78.68
111 to 211	Routing					0.161	0.415			
311	1	112.60	69	M	0.820	0.000	0.000	10.0	3.95	14.71
311	2	186.50	54	M	1.296	0.000	0.000	0.0	1.06	1.25
	Type: Nonerodible Channel Label: LOWER CREEK SECTION									
311	Structure	299.10							53.17	
311	Total IN/OUT	3102.90							53.17	96.91
211 to 311	Routing					0.059	0.430			
	Type: Nonerodible Channel Label: LOWER CREEK SECTION									
411	Structure	299.10							53.17	
411	Total IN/OUT	3102.90							53.17	96.91
311 to 411	Routing					0.001	0.430			

SUBWATERSHED/STRUCTURE INPUT/OUTPUT TABLE

-Sedimentology-

SED: Sediment
SCp: Peak Sediment Concentration
SSp: Peak Settleable Concentration
24VW: Volume Weighted Average Settleable Concentration - Peak 24 hours
24AA: Arithmetic Average Settleable Concentration - Peak 24 hours

	JBS	SWS	K	L (ft)	S (%)	CP	Tt (hrs)	PS #	SED (tons)	SCp (mg/l)	SSp (ml/l)	24VW (ml/l)	24AA (ml/l)
R	111	1	0.15	2300.0	53.0	0.006	0.000	1	296.0				

```
R 111  2   0.15 2500.0  39.2 0.003  0.000 1   17.9
            Type: Nonerodible Channel   Label: UPPER CREEK SECTION
  111 Structure                                314.0
  -----------------------------------------------------------------------------
  111 Total IN/OUT                             314.0   10493   7.04   4.50   2.69
  =============================================================================
R 211  1   0.15 1300.0  43.1 0.006  0.000 1   73.5
R 211  2   0.15 2300.0  53.0 0.003  0.000 1    2.2
R 211  3   0.15 1800.0  46.7 0.003  0.000 1    5.0
            Type: Nonerodible Channel   Label: MIDDLE CREEK SECTION
  211 Structure                                394.7
  -----------------------------------------------------------------------------
  211 Total IN/OUT                             394.7    9095   6.14   4.05   2.42
  =============================================================================
  111 to 211 Routing                 0.161
  =============================================================================
R 311  1   0.15 1700.0  47.0 0.006  0.000 1   37.3 (Base Conc.      3 mg/l)
R 311  2   0.15 1400.0  62.8 0.003  0.000 1    2.5
            Type: Nonerodible Channel   Label: LOWER CREEK SECTION
  311 Structure                                434.5
  -----------------------------------------------------------------------------
  311 Total IN/OUT                             434.5    7535   5.11   2.92   1.87
  =============================================================================
  211 to 311 Routing                 0.059
  =============================================================================
            Type: Nonerodible Channel   Label: LOWER CREEK SECTION
  411 Structure                                434.5
  -----------------------------------------------------------------------------
  411 Total IN/OUT                             434.5    7535   5.11   2.92   1.87
  =============================================================================
  311 to 411 Routing                 0.001
  =============================================================================
```

Civil Software Design -- SEDCAD+ Version 3.1

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Date: 06-04-1997 Time: 08:15:35
CRANDALL CANYON - EXISTING SEDIMENT DUE TO 10-YR 24-HR STORM (2.5")
Storm: 2.50 inches, 10 year-24 hour, SCS Type II
Hydrograph Convolution Interval: 0.1 hr

DETAILED SUBWATERSHED INPUT/OUTPUT TABLE

J	B	S	SWS	Seg. #	Land Flow Condition	Distance (ft)	Slope (%)	Velocity (fps)	Segment Time (hr)	Time Conc. (hr)	Muskingum K (hr)	X
1	1	1	1	-a	1	10500.00	22.90	1.21	2.41	2.409		
1	1	1	2	-a	1	10000.00	22.60	1.20	2.31	2.309		
2	1	1	1	-a	1	7000.00	24.60	1.25	1.55	1.549		
2	1	1	2	-a	1	6000.00	26.90	1.31	1.27	1.270		
2	1	1	3	-a	1	7000.00	29.70	1.38	1.41	1.410		
3	1	1	1	-a	1	4750.00	40.40	1.61	0.82	0.820		
3	1	1	2	-a	1	6750.00	32.70	1.45	1.30	1.296		

Civil Software Design -- SEDCAD+ Version 3.1

Company Name: STEFFEN, ROBERTSON, KIRSTEN
Filename: C:\SEDCAD3\GENWAL1A User: PETE KOWALEWSKI
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CRANDALL CANYON - EXISTING SEDIMENT DUE TO 10-YR 24-HR STORM (2.5")
Storm: 2.50 inches, 10 year-24 hour, SCS Type II
Hydrograph Convolution Interval: 0.1 hr

NON-POND STRUCTURE INPUT/OUTPUT TABLE

J1, B1, S1
UPPER CREEK SECTION

Drainage Area from J1, B1, S1, SWS(s)1-2: 1975.5 acres
Total Contributing Drainage Area: 1975.5 acres

MATERIAL: NATURAL CREEK BED
Trapezoidal Nonerodible Channel

Design Discharge (cfs)	Bottom Width (ft)	ZLeft	ZRight	Slope (%)	Manning's n
54.38	25.0	2.0:1	2.0:1	7.8	0.040

	Depth (ft)	Velocity (fps)	Top Width (ft)	Hydraulic Radius	Froude Number
	0.39	5.41	26.6	0.376	1.55
w/ Freeboard:	0.39		26.6		

	Runoff Volume (ac-ft)	Peak Discharge (cfs)	Sediment (tons)	Peak Sediment Concentration (mg/l)	Peak Settleable Concentration (ml/l)	24VW (ml/l)	24AA (ml/l)
IN/OUT	34.26	54.38	314.0	10493	7.04	4.50	2.69

****

J2, B1, S1
MIDDLE CREEK SECTION

Drainage Area from J2, B1, S1, SWS(s)1-3: 828.3 acres
Total Contributing Drainage Area: 2803.8 acres

MATERIAL: NATURAL CREEK BED
Trapezoidal Nonerodible Channel

Design Discharge (cfs)	Bottom Width (ft)	ZLeft	ZRight	Slope (%)	Manning's n
78.68	25.0	2.0:1	2.0:1	12.4	0.040

	Depth (ft)	Velocity (fps)	Top Width (ft)	Hydraulic Radius	Froude Number
	0.42	7.20	26.7	0.406	1.98
w/ Freeboard:	0.42		26.7		

	Runoff Volume (ac-ft)	Peak Discharge (cfs)	Sediment (tons)	Peak Sediment Concentration (mg/l)	Peak Settleable Concentration (ml/l)	24VW (ml/l)	24AA (ml/l)
IN/OUT	48.16	78.68	394.7	9095	6.14	4.05	2.42

J3, B1, S1
LOWER CREEK SECTION

Drainage Area from J3, B1, S1, SWS(s)1-2: 299.1 acres
Total Contributing Drainage Area: 3102.9 acres

MATERIAL: NATURAL CREEK BED
Trapezoidal Nonerodible Channel

Design Discharge (cfs)	Bottom Width (ft)	ZLeft	ZRight	Slope (%)	Manning's n
96.91	25.0	2.0:1	2.0:1	12.4	0.040

	Depth (ft)	Velocity (fps)	Top Width (ft)	Hydraulic Radius	Froude Number
	0.48	7.79	26.9	0.458	2.02
w/ Freeboard:	0.48		26.9		

	Runoff Volume (ac-ft)	Peak Discharge (cfs)	Sediment (tons)	Peak Sediment Concentration (mg/l)	Peak Settleable Concentration (ml/l)	24VW (ml/l)	24AA (ml/l)
IN/OUT	53.17	96.91	434.5	7535	5.11	2.92	1.87

J4, B1, S1
LOWER CREEK SECTION

Drainage Area from J4, B1, S1 299.1 acres
Total Contributing Drainage Area: 3102.9 acres

MATERIAL: NATURAL CREEK BED
Trapezoidal Nonerodible Channel

Design Discharge (cfs)	Bottom Width (ft)	ZLeft	ZRight	Slope (%)	Manning's n
96.91	25.0	2.0:1	2.0:1	12.4	0.040

	Depth (ft)	Velocity (fps)	Top Width (ft)	Hydraulic Radius	Froude Number
	0.48	7.79	26.9	0.458	2.02
w/ Freeboard:	0.48		26.9		

	Runoff Volume (ac-ft)	Peak Discharge (cfs)	Sediment (tons)	Peak Sediment Concentration (mg/l)	Peak Settleable Concentration (ml/l)	24VW (ml/l)	24AA (ml/l)
IN/OUT	53.17	96.91	434.5	7535	5.11	2.92	1.87

SEDCAD+
CONSTRUCTION MODEL
(NO SILT FENCE)

CIVIL SOFTWARE DESIGN

SEDCAD+ Version 3

CRANDALL CANYON - SEDIMENT GENERATION 10-YR 24-HR STORM- NO SILT FENCE

by

Name: PETE KOWALEWSKI

Company Name: STEFFEN, ROBERTSON, KIRSTEN

File Name: C:\SEDCAD3\GENWAL2A

Date: 06-04-1997

Civil Software Design -- SEDCAD+ Version 3.1

Company Name: STEFFEN, ROBERTSON, KIRSTEN
Filename: C:\SEDCAD3\GENWAL2A User: PETE KOWALEWSKI
Date: 06-04-1997 Time: 08:18:16
CRANDALL CANYON - SEDIMENT GENERATION 10-YR 24-HR STORM- NO SILT FENCE
Storm: 2.50 inches, 10 year-24 hour, SCS Type II
Hydrograph Convolution Interval: 0.1 hr

GENERAL INPUT TABLE

Specific Gravity: 2.50
Submerged Bulk Specific Gravity: 1.25

Particle Size Distribution(s):

Size (mm)	FILL SOIL % Finer
1.0000	95.00
0.5000	75.00
0.2500	50.00
0.1000	25.00
0.0500	10.00
0.0100	5.00
0.0050	3.00
0.0010	0.00

Detailed Between Structure Routing:

J B S	To S	Seg. #	Land Flow Condition	Distance (ft)	Slope (%)	Velocity (fps)	Segment Time (hr)	Muskingum K (hr)	X
2 1	1	1	8	4889.81	7.80	8.38	0.16	0.161	0.415
3 1	1	1	8	2267.23	12.40	10.56	0.06	0.059	0.430
4 1	1	1	8	50.38	12.40	10.56	0.00	0.001	0.430

Civil Software Design -- SEDCAD+ Version 3.1

Company Name: STEFFEN, ROBERTSON, KIRSTEN
Filename: C:\SEDCAD3\GENWAL2A User: PETE KOWALEWSKI
Date: 06-04-1997 Time: 08:18:16
CRANDALL CANYON - SEDIMENT GENERATION 10-YR 24-HR STORM- NO SILT FENCE
Storm: 2.50 inches, 10 year-24 hour, SCS Type II
Hydrograph Convolution Interval: 0.1 hr

SUBWATERSHED/STRUCTURE INPUT/OUTPUT TABLE

-Hydrology-

JBS	SWS	Area (ac)	CN	UHS	Tc (hrs)	K (hrs)	X	Base-Flow (cfs)	Runoff Volume (ac-ft)	Peak Discharge (cfs)
111	1	784.20	69	M	2.409	0.000	0.000	0.0	27.50	51.27
111	2	1191.30	54	M	2.309	0.000	0.000	0.0	6.76	7.15
	Type: Nonerodible Channel Label: UPPER CREEK SECTION									
111	Structure	1975.50							34.26	
111	Total IN/OUT	1975.50							34.26	54.38
211	1	313.10	69	M	1.549	0.000	0.000	0.0	10.98	27.19
211	2	140.90	54	M	1.270	0.000	0.000	0.0	0.80	0.95
211	3	374.30	54	M	1.410	0.000	0.000	0.0	2.12	2.48
	Type: Nonerodible Channel Label: MIDDLE CREEK SECTION									
211	Structure	828.30							48.16	
211	Total IN/OUT	2803.80							48.16	78.68
111 to 211 Routing						0.161	0.415			
311	1	110.60	69	M	0.820	0.000	0.000	10.0	3.88	14.45
311	2	184.50	54	M	1.296	0.000	0.000	0.0	1.05	1.24
311	3	0.20*	65	M	0.002	0.000	0.000	0.0	0.00	0.06
311	4	0.40*	77	M	0.010	0.002	0.401	0.0	0.02	0.33
311	5	0.52*	77	M	0.018	0.013	0.370	0.0	0.03	0.43
311	6	1.06*	75	M	0.098	0.031	0.346	0.0	0.06	0.77
311	7	0.29*	80	M	0.004	0.130	0.296	0.0	0.02	0.28
311	8	1.39*	75	M	0.104	0.132	0.302	0.0	0.08	1.01
	Type: Nonerodible Channel Label: LOWER CREEK SECTION									
311	Structure	298.96							53.30	
311	Total IN/OUT	3102.76							53.30	96.97
211 to 311 Routing						0.059	0.430			
	Type: Nonerodible Channel Label: LOWER CREEK SECTION									
411	Structure	298.96							53.30	
411	Total IN/OUT	3102.76							53.30	96.97
311 to 411 Routing						0.001	0.430			

SUBWATERSHED/STRUCTURE INPUT/OUTPUT TABLE

-Sedimentology-

SED: Sediment
SCp: Peak Sediment Concentration
SSp: Peak Settleable Concentration
24VW: Volume Weighted Average Settleable Concentration - Peak 24 hours
24AA: Arithmetic Average Settleable Concentration - Peak 24 hours

	JBS	SWS	K	L (ft)	S (%)	CP	Tt (hrs)	PS #	SED (tons)	SCp (mg/l)	SSp (ml/l)	24VW (ml/l)	24AA (ml/l)
R	111	1	0.15	2300.0	53.0	0.006	0.000	1	296.0				
R	111	2	0.15	2500.0	39.2	0.003	0.000	1	17.9				
			Type: Nonerodible Channel				Label: UPPER CREEK SECTION						
	111 Structure								314.0				
	111 Total IN/OUT								314.0	10493	7.04	4.50	2.69
R	211	1	0.15	1300.0	43.1	0.006	0.000	1	73.5				
R	211	2	0.15	2300.0	53.0	0.003	0.000	1	2.2				
R	211	3	0.15	1800.0	46.7	0.003	0.000	1	5.0				
			Type: Nonerodible Channel				Label: MIDDLE CREEK SECTION						
	211 Structure								394.7				
	211 Total IN/OUT								394.7	9095	6.14	4.05	2.42
	111 to 211 Routing						0.161						
R	311	1	0.15	1700.0	47.0	0.006	0.000	1	36.6	(Base Conc.		3 mg/l)	
R	311	2	0.15	1400.0	62.8	0.003	0.000	1	2.5				
R	311	3	0.15	70.0	48.6	0.720	0.000	1	0.7				
R	311	4	0.15	140.0	14.3	0.720	0.002	1	1.9				
R	311	5	0.15	180.0	7.2	0.720	0.013	1	1.1				
R	311	6	0.15	370.0	1.1	0.720	0.031	1	0.4				
R	311	7	0.15	100.0	43.0	0.720	0.130	1	4.4				
R	311	8	0.15	485.0	1.6	0.720	0.132	1	0.8				
			Type: Nonerodible Channel				Label: LOWER CREEK SECTION						
	311 Structure								443.1				
	311 Total IN/OUT								443.1	11039	7.50	2.99	1.98
	211 to 311 Routing						0.059						
			Type: Nonerodible Channel				Label: LOWER CREEK SECTION						
	411 Structure								443.1				
	411 Total IN/OUT								443.1	11039	7.50	2.99	1.98
	311 to 411 Routing						0.001						

Civil Software Design -- SEDCAD+ Version 3.1

Company Name: STEFFEN, ROBERTSON, KIRSTEN
Filename: C:\SEDCAD3\GENWAL2A User: PETE KOWALEWSKI
Date: 06-04-1997 Time: 08:18:16
CRANDALL CANYON - SEDIMENT GENERATION 10-YR 24-HR STORM- NO SILT FENCE
Storm: 2.50 inches, 10 year-24 hour, SCS Type II
Hydrograph Convolution Interval: 0.1 hr

DETAILED SUBWATERSHED INPUT/OUTPUT TABLE

J	B	S	SWS	Seg. #	Land Flow Condition	Distance (ft)	Slope (%)	Velocity (fps)	Segment Time (hr)	Time Conc. (hr)	Muskingum K (hr)	X
1	1	1	1	-a	1	10500.00	22.90	1.21	2.41	2.409		
1	1	1	2	-a	1	10000.00	22.60	1.20	2.31	2.309		
2	1	1	1	-a	1	7000.00	24.60	1.25	1.55	1.549		
2	1	1	2	-a	1	6000.00	26.90	1.31	1.27	1.270		
2	1	1	3	-a	1	7000.00	29.70	1.38	1.41	1.410		
3	1	1	1	-a	1	4750.00	40.40	1.61	0.82	0.820		
3	1	1	2	-a	1	6750.00	32.70	1.45	1.30	1.296		
3	1	1	3	-a	5	70.00	48.60	6.97	0.00	0.002		
3	1	1	4	-a	5	140.00	14.30	3.78	0.01	0.010		
3	1	1	4	-1	5	77.83	48.60	6.97	0.00		0.002	0.401
3	1	1	5	-a	5	180.00	7.20	2.68	0.02	0.018		
3	1	1	5	-1	5	141.42	14.30	3.78	0.01			
				-2	5	77.83	48.60	6.97	0.00		0.013	0.370
3	1	1	6	-a	5	370.00	1.08	1.04	0.10	0.098		
3	1	1	6	-1	5	180.47	7.20	2.68	0.02			
				-2	5	141.42	14.30	3.78	0.01			
				-3	5	77.83	48.60	6.97	0.00		0.031	0.346
3	1	1	7	-a	5	100.00	43.00	6.56	0.00	0.004		
3	1	1	7	-1	5	370.02	1.08	1.04	0.10			
				-2	5	180.47	7.20	2.68	0.02			
				-3	5	141.42	14.30	3.78	0.01			
				-4	5	77.83	48.60	6.97	0.00		0.130	0.296
3	1	1	8	-a	5	485.00	1.65	1.28	0.10	0.104		
3	1	1	8	-1	5	108.85	43.00	6.56	0.00			
				-2	5	370.02	1.08	1.04	0.10			
				-3	5	180.47	7.20	2.68	0.02			
				-4	5	141.42	14.30	3.78	0.01		0.132	0.302

Civil Software Design -- SEDCAD+ Version 3.1

Company Name: STEFFEN, ROBERTSON, KIRSTEN
Filename: C:\SEDCAD3\GENWAL2A User: PETE KOWALEWSKI
Date: 06-04-1997 Time: 08:18:16
CRANDALL CANYON - SEDIMENT GENERATION 10-YR 24-HR STORM- NO SILT FENCE
Storm: 2.50 inches, 10 year-24 hour, SCS Type II
Hydrograph Convolution Interval: 0.1 hr

NON-POND STRUCTURE INPUT/OUTPUT TABLE

J1, B1, S1
UPPER CREEK SECTION

Drainage Area from J1, B1, S1, SWS(s)1-2: 1975.5 acres
Total Contributing Drainage Area: 1975.5 acres

MATERIAL: NATURAL CHANNEL BED
Trapezoidal Nonerodible Channel

Design Discharge (cfs)	Bottom Width (ft)	ZLeft	ZRight	Slope (%)	Manning's n
54.38	25.0	2.0:1	2.0:1	7.8	0.040

	Depth (ft)	Velocity (fps)	Top Width (ft)	Hydraulic Radius	Froude Number
	0.39	5.41	26.6	0.376	1.55
w/ Freeboard:	0.39		26.6		

	Runoff Volume (ac-ft)	Peak Discharge (cfs)	Sediment (tons)	Peak Sediment Concentration (mg/l)	Peak Settleable Concentration (ml/l)	24VW (ml/l)	24AA (ml/l)
IN/OUT	34.26	54.38	314.0	10493	7.04	4.50	2.69

J2, B1, S1
MIDDLE CREEK SECTION

Drainage Area from J2, B1, S1, SWS(s)1-3: 828.3 acres
Total Contributing Drainage Area: 2803.8 acres

MATERIAL: NATURAL CHANNEL BED
Trapezoidal Nonerodible Channel

Design Discharge (cfs)	Bottom Width (ft)	ZLeft	ZRight	Slope (%)	Manning's n
78.68	25.0	2.0:1	2.0:1	12.4	0.040

	Depth (ft)	Velocity (fps)	Top Width (ft)	Hydraulic Radius	Froude Number
	0.42	7.20	26.7	0.406	1.98
w/ Freeboard:	0.42		26.7		

	Runoff Volume (ac-ft)	Peak Discharge (cfs)	Sediment (tons)	Peak Sediment Concentration (mg/l)	Peak Settleable Concentration (ml/l)	24VW (ml/l)	24AA (ml/l)
IN/OUT	48.16	78.68	394.7	9095	6.14	4.05	2.42

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J3, B1, S1
LOWER CREEK SECTION

Drainage Area from J3, B1, S1, SWS(s)1-8: 299.0 acres
Total Contributing Drainage Area: 3102.8 acres

MATERIAL: NATURAL CHANNEL BED
Trapezoidal Nonerodible Channel

Design Discharge (cfs)	Bottom Width (ft)	ZLeft	ZRight	Slope (%)	Manning's n
96.97	25.0	2.0:1	2.0:1	12.4	0.040

	Depth (ft)	Velocity (fps)	Top Width (ft)	Hydraulic Radius	Froude Number
	0.48	7.80	26.9	0.458	2.02
w/ Freeboard:	0.48		26.9		

	Runoff Volume (ac-ft)	Peak Discharge (cfs)	Sediment (tons)	Peak Sediment Concentration (mg/l)	Peak Settleable Concentration (ml/l)	24VW (ml/l)	24AA (ml/l)
IN/OUT	53.30	96.97	443.1	11039	7.50	2.99	1.98

****

J4, B1, S1
LOWER CREEK SECTION

Drainage Area from J4, B1, S1 299.0 acres
Total Contributing Drainage Area: 3102.8 acres

MATERIAL: NATURAL CHANNEL BED
Trapezoidal Nonerodible Channel

Design Discharge (cfs)	Bottom Width (ft)	ZLeft	ZRight	Slope (%)	Manning's n
96.97	25.0	2.0:1	2.0:1	12.4	0.040

	Depth (ft)	Velocity (fps)	Top Width (ft)	Hydraulic Radius	Froude Number
	0.48	7.80	26.9	0.458	2.02
w/ Freeboard:	0.48		26.9		

	Runoff Volume (ac-ft)	Peak Discharge (cfs)	Sediment (tons)	Peak Sediment Concentration (mg/l)	Peak Settleable Concentration (ml/l)	24VW (ml/l)	24AA (ml/l)
IN/OUT	53.30	96.97	443.1	11039	7.50	2.99	1.98

****

SEDCAD+
CONSTRUCTION MODEL
(WITH SILT FENCE)

CIVIL SOFTWARE DESIGN

SEDCAD+ Version 3

CRANDALL CANYON - SEDIMENT GENERATION 10-YR 24-HR STORM- W/ SILT FENCE

by

Name: PETE KOWALEWSKI

Company Name: STEFFEN, ROBERTSON, KIRSTEN
File Name: C:\SEDCAD3\GENWAL3A

Date: 06-04-1997

Civil Software Design -- SEDCAD+ Version 3.1

Company Name: STEFFEN, ROBERTSON, KIRSTEN
Filename: C:\SEDCAD3\GENWAL3A User: PETE KOWALEWSKI
Date: 06-04-1997 Time: 08:18:20
CRANDALL CANYON - SEDIMENT GENERATION 10-YR 24-HR STORM- W/ SILT FENCE
Storm: 2.50 inches, 10 year-24 hour, SCS Type II
Hydrograph Convolution Interval: 0.1 hr

GENERAL INPUT TABLE

Specific Gravity: 2.50
Submerged Bulk Specific Gravity: 1.25

Particle Size Distribution(s):

Size (mm)	FILL SOIL % Finer
1.0000	95.00
0.5000	75.00
0.2500	50.00
0.1000	25.00
0.0500	10.00
0.0100	5.00
0.0050	3.00
0.0010	0.00

Detailed Between Structure Routing:

J B S	To Seg. #	Land Flow Condition	Distance (ft)	Slope (%)	Velocity (fps)	Segment Time (hr)	Muskingum K (hr)	X
2 1 1	1	8	4889.81	7.80	8.38	0.16	0.161	0.415
3 1 1	1	8	2267.23	12.40	10.56	0.06	0.059	0.430
4 1 1	1	8	50.38	12.40	10.56	0.00	0.001	0.430

Civil Software Design -- SEDCAD+ Version 3.1

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Date: 06-04-1997 Time: 08:18:20
CRANDALL CANYON - SEDIMENT GENERATION 10-YR 24-HR STORM- W/ SILT FENCE
Storm: 2.50 inches, 10 year-24 hour, SCS Type II
Hydrograph Convolution Interval: 0.1 hr

SUBWATERSHED/STRUCTURE INPUT/OUTPUT TABLE

-Hydrology-

JBS	SWS	Area (ac)	CN	UHS	Tc (hrs)	K (hrs)	X	Base-Flow (cfs)	Runoff Volume (ac-ft)	Peak Discharge (cfs)
111	1	784.20	69	M	2.409	0.000	0.000	0.0	27.50	51.27
111	2	1191.30	54	M	2.309	0.000	0.000	0.0	6.76	7.15
	Type: Nonerodible Channel Label: UPPER CREEK SECTION									
111	Structure	1975.50							34.26	
111	Total IN/OUT	1975.50							34.26	54.38
211	1	313.10	69	M	1.549	0.000	0.000	0.0	10.98	27.19
211	2	140.90	54	M	1.270	0.000	0.000	0.0	0.80	0.95
211	3	374.30	54	M	1.410	0.000	0.000	0.0	2.12	2.48
	Type: Nonerodible Channel Label: MIDDLE CREEK SECTION									
211	Structure	828.30							48.16	
211	Total IN/OUT	2803.80							48.16	78.68
111 to 211 Routing						0.161	0.415			
311	1	110.60	69	M	0.820	0.000	0.000	10.0	3.88	14.45
311	2	184.50	54	M	1.296	0.000	0.000	0.0	1.05	1.24
311	3	0.20*	65	M	0.002	0.000	0.000	0.0	0.00	0.06
311	4	0.40*	77	M	0.010	0.002	0.401	0.0	0.02	0.33
311	5	0.52*	77	M	0.018	0.013	0.370	0.0	0.03	0.43
311	6	1.06*	75	M	0.098	0.031	0.346	0.0	0.06	0.77
311	7	0.29*	80	M	0.004	0.130	0.296	0.0	0.02	0.28
311	8	1.39*	75	M	0.104	0.132	0.302	0.0	0.08	1.01
	Type: Nonerodible Channel Label: LOWER CREEK SECTION									
311	Structure	298.96							53.30	
311	Total IN/OUT	3102.76							53.30	96.97
211 to 311 Routing						0.059	0.430			
	Type: Nonerodible Channel Label: LOWER CREEK SECTION									
411	Structure	298.96							53.30	
411	Total IN/OUT	3102.76							53.30	96.97
311 to 411 Routing						0.001	0.430			

SUBWATERSHED/STRUCTURE INPUT/OUTPUT TABLE

-Sedimentology-

SED: Sediment
SCp: Peak Sediment Concentration
SSp: Peak Settleable Concentration
24VW: Volume Weighted Average Settleable Concentration - Peak 24 hours
24AA: Arithmetic Average Settleable Concentration - Peak 24 hours

	JBS	SWS	K	L (ft)	S (%)	CP	Tt (hrs)	PS #	SED (tons)	SCp (mg/l)	SSp (ml/l)	24VW (ml/l)	24AA (ml/l)
R	111	1	0.15	2300.0	53.0	0.006	0.000	1	296.0				
R	111	2	0.15	2500.0	39.2	0.003	0.000	1	17.9				
			Type: Nonerodible Channel				Label: UPPER CREEK SECTION						
	111 Structure								314.0				
	111 Total IN/OUT								314.0	10493	7.04	4.50	2.69
R	211	1	0.15	1300.0	43.1	0.006	0.000	1	73.5				
R	211	2	0.15	2300.0	53.0	0.003	0.000	1	2.2				
R	211	3	0.15	1800.0	46.7	0.003	0.000	1	5.0				
			Type: Nonerodible Channel				Label: MIDDLE CREEK SECTION						
	211 Structure								394.7				
	211 Total IN/OUT								394.7	9095	6.14	4.05	2.42
	111 to 211 Routing						0.161						
R	311	1	0.15	1700.0	47.0	0.006	0.000	1	36.6	(Base Conc.		3 mg/l)	
R	311	2	0.15	1400.0	62.8	0.003	0.000	1	2.5				
R	311	3	0.15	70.0	48.6	0.360	0.000	1	0.4				
R	311	4	0.15	140.0	14.3	0.360	0.002	1	1.0				
R	311	5	0.15	180.0	7.2	0.360	0.013	1	0.5				
R	311	6	0.15	370.0	1.1	0.360	0.031	1	0.2				
R	311	7	0.15	100.0	43.0	0.360	0.130	1	2.2				
R	311	8	0.15	485.0	1.6	0.360	0.132	1	0.4				
			Type: Nonerodible Channel				Label: LOWER CREEK SECTION						
	311 Structure								438.4				
	311 Total IN/OUT								438.4	7543	5.12	2.95	1.92
	211 to 311 Routing						0.059						
			Type: Nonerodible Channel				Label: LOWER CREEK SECTION						
	411 Structure								438.4				
	411 Total IN/OUT								438.4	7543	5.12	2.95	1.92
	311 to 411 Routing						0.001						

Civil Software Design -- SEDCAD+ Version 3.1

Company Name: STEFFEN, ROBERTSON, KIRSTEN
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Date: 06-04-1997 Time: 08:18:20
CRANDALL CANYON - SEDIMENT GENERATION 10-YR 24-HR STORM- W/ SILT FENCE
Storm: 2.50 inches, 10 year-24 hour, SCS Type II
Hydrograph Convolution Interval: 0.1 hr

DETAILED SUBWATERSHED INPUT/OUTPUT TABLE

J	B	S	SWS	Seg. #	Land Flow Condition	Distance (ft)	Slope (%)	Velocity (fps)	Segment Time (hr)	Time Conc. (hr)	Muskingum K (hr)	Muskingum X
1	1	1	1	-a	1	10500.00	22.90	1.21	2.41	2.409		
1	1	1	2	-a	1	10000.00	22.60	1.20	2.31	2.309		
2	1	1	1	-a	1	7000.00	24.60	1.25	1.55	1.549		
2	1	1	2	-a	1	6000.00	26.90	1.31	1.27	1.270		
2	1	1	3	-a	1	7000.00	29.70	1.38	1.41	1.410		
3	1	1	1	-a	1	4750.00	40.40	1.61	0.82	0.820		
3	1	1	2	-a	1	6750.00	32.70	1.45	1.30	1.296		
3	1	1	3	-a	5	70.00	48.60	6.97	0.00	0.002		
3	1	1	4	-a	5	140.00	14.30	3.78	0.01	0.010		
3	1	1	4	-1	5	77.83	48.60	6.97	0.00		0.002	0.401
3	1	1	5	-a	5	180.00	7.20	2.68	0.02	0.018		
3	1	1	5	-1	5	141.42	14.30	3.78	0.01			
				-2	5	77.83	48.60	6.97	0.00		0.013	0.370
3	1	1	6	-a	5	370.00	1.08	1.04	0.10	0.098		
3	1	1	6	-1	5	180.47	7.20	2.68	0.02			
				-2	5	141.42	14.30	3.78	0.01			
				-3	5	77.83	48.60	6.97	0.00		0.031	0.346
3	1	1	7	-a	5	100.00	43.00	6.56	0.00	0.004		
3	1	1	7	-1	5	370.02	1.08	1.04	0.10			
				-2	5	180.47	7.20	2.68	0.02			
				-3	5	141.42	14.30	3.78	0.01			
				-4	5	77.83	48.60	6.97	0.00		0.130	0.296
3	1	1	8	-a	5	485.00	1.65	1.28	0.10	0.104		
3	1	1	8	-1	5	108.85	43.00	6.56	0.00			
				-2	5	370.02	1.08	1.04	0.10			
				-3	5	180.47	7.20	2.68	0.02			
				-4	5	141.42	14.30	3.78	0.01		0.132	0.302

Civil Software Design -- SEDCAD+ Version 3.1

Company Name: STEFFEN, ROBERTSON, KIRSTEN
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Date: 06-04-1997 Time: 08:18:20
CRANDALL CANYON - SEDIMENT GENERATION 10-YR 24-HR STORM- W/ SILT FENCE
Storm: 2.50 inches, 10 year-24 hour, SCS Type II
Hydrograph Convolution Interval: 0.1 hr

NON-POND STRUCTURE INPUT/OUTPUT TABLE

J1, B1, S1
UPPER CREEK SECTION

Drainage Area from J1, B1, S1, SWS(s)1-2: 1975.5 acres
Total Contributing Drainage Area: 1975.5 acres

MATERIAL: NATURAL CHANNEL BED
Trapezoidal Nonerodible Channel

Design Discharge (cfs)	Bottom Width (ft)	ZLeft	ZRight	Slope (%)	Manning's n
54.38	25.0	2.0:1	2.0:1	7.8	0.040

	Depth (ft)	Velocity (fps)	Top Width (ft)	Hydraulic Radius	Froude Number
	0.39	5.41	26.6	0.376	1.55
W/ Freeboard:	0.39		26.6		

	Runoff Volume (ac-ft)	Peak Discharge (cfs)	Sediment (tons)	Peak Sediment Concentration (mg/l)	Peak Settleable Concentration (ml/l)	24VW (ml/l)	24AA (ml/l)
IN/OUT	34.26	54.38	314.0	10493	7.04	4.50	2.69

****

J2, B1, S1
MIDDLE CREEK SECTION

Drainage Area from J2, B1, S1, SWS(s)1-3: 828.3 acres
Total Contributing Drainage Area: 2803.8 acres

MATERIAL: NATURAL CHANNEL BED
Trapezoidal Nonerodible Channel

Design Discharge (cfs)	Bottom Width (ft)	ZLeft	ZRight	Slope (%)	Manning's n
78.68	25.0	2.0:1	2.0:1	12.4	0.040

	Depth (ft)	Velocity (fps)	Top Width (ft)	Hydraulic Radius	Froude Number
	0.42	7.20	26.7	0.406	1.98
W/ Freeboard:	0.42		26.7		

	Runoff Volume (ac-ft)	Peak Discharge (cfs)	Sediment (tons)	Peak Sediment Concentration (mg/l)	Peak Settleable Concentration (ml/l)	24VW (ml/l)	24AA (ml/l)
IN/OUT	48.16	78.68	394.7	9095	6.14	4.05	2.42

****

J3, B1, S1
LOWER CREEK SECTION

Drainage Area from J3, B1, S1, SWS(s)1-8: 299.0 acres
Total Contributing Drainage Area: 3102.8 acres

MATERIAL: NATURAL CHANNEL BED
Trapezoidal Nonerodible Channel

Design Discharge (cfs)	Bottom Width (ft)	ZLeft	ZRight	Slope (%)	Manning's n
96.97	25.0	2.0:1	2.0:1	12.4	0.040

	Depth (ft)	Velocity (fps)	Top Width (ft)	Hydraulic Radius	Froude Number
	0.48	7.80	26.9	0.458	2.02
w/ Freeboard:	0.48		26.9		

	Runoff Volume (ac-ft)	Peak Discharge (cfs)	Sediment (tons)	Peak Sediment Concentration (mg/l)	Peak Settleable Concentration (ml/l)	24VW (ml/l)	24AA (ml/l)
IN/OUT	53.30	96.97	438.4	7543	5.12	2.95	1.92

****

J4, B1, S1
LOWER CREEK SECTION

Drainage Area from J4, B1, S1 299.0 acres
Total Contributing Drainage Area: 3102.8 acres

MATERIAL: NATURAL CHANNEL BED
Trapezoidal Nonerodible Channel

Design Discharge (cfs)	Bottom Width (ft)	ZLeft	ZRight	Slope (%)	Manning's n
96.97	25.0	2.0:1	2.0:1	12.4	0.040

	Depth (ft)	Velocity (fps)	Top Width (ft)	Hydraulic Radius	Froude Number
	0.48	7.80	26.9	0.458	2.02
w/ Freeboard:	0.48		26.9		

	Runoff Volume (ac-ft)	Peak Discharge (cfs)	Sediment (tons)	Peak Sediment Concentration (mg/l)	Peak Settleable Concentration (ml/l)	24VW (ml/l)	24AA (ml/l)
IN/OUT	53.30	96.97	438.4	7543	5.12	2.95	1.92

****

APPENDIX 7-64

BASELINE INFORMATION FOR THE U-68082 LEASE MOD AREA

Petersen Hydrologic

04 October 2004

Mr. Dave Shaver
GENWAL Resources, Inc.
P.O. Box 1077
Price, Utah 84501

Dave,

At your request, we have performed a hydrologic investigation of the No-Name canyon and surrounding area adjacent to the Crandall Canyon Mine permit area. The results of this investigation are summarized in the following letter report.

Introduction

GENWAL Resources, Inc. has operated the Crandall Canyon #1 Mine since 1984. The mine surface facilities are located in Crandall Canyon, approximately 15 miles northwest of Huntington, Utah. GENWAL is currently considering the potential for mining coal reserves located east of and contiguous with their existing permit area. The coal reserves in consideration are located beneath the No-Name and Blind Canyon drainages in the western part of Section 32, Township 15 South, Range 7 East (Figure 1). Coal mining of these reserves would likely involve the undermining of the stream channel in No-Name Canyon. The Blind Canyon stream channel would not be undermined. The purpose of this investigation is to characterize the groundwater and surface-water resources in the proposed mining and surrounding area.

Including this introduction, this report contains the following sections:

Introduction
Methods of Study
Climatic conditions
Geologic conditions
Characterization of Groundwater Systems
Characterization of Surface-water Systems
Annotated Photographs

2695 N. 600 E. Lehi, Utah 84043 (801) 766-4006

Methods of Study

Existing groundwater and surface-water discharge and water-quality data were obtained from GENWAL Resources and compiled into electronic format. During May and June of 2004, the No-Name and Blind Canyon drainages and the intervening highland areas were traversed and surveyed. During July 2004, the No Name Canyon drainage was again surveyed from the upper forks to the confluence with Huntington Creek. All of the springs and seeps identified in the study area during previous spring and seep surveys were visited and monitored. At each spring or seep where groundwater discharge was observed, discharge and water-quality measurements were performed, GPS locations were obtained, and the site was digitally photographed. Stream discharge and water-quality measurements in No-Name Canyon were also performed. Spring and stream discharge measurements were performed using an appropriate calibrated container and stopwatch. Water-quality measurements were performed in the field using regularly calibrated pH, specific conductivity, and dissolved oxygen meters. Temperature measurements were performed with a calibrated digital thermometer. GPS locations were obtained using a hand-held Garmin GPS. Monitoring site details are presented in Table 1. Discharge and water-quality data for springs and streams in the study area are presented in Table 2. Annotated photographs of selected springs, seeps, and surface-water monitoring sites are included at the end of this report.

Climatic conditions

Climatic conditions in the study area are depicted graphically in a plot of the Palmer Hydrologic Drought Index (PHDI) for Utah Region 4 (Figure 2). Region 4 encompasses the south-central mountains of Utah, which includes the Crandall Canyon Mine area. The PHDI is a monthly value generated by the National Climatic Data Center using a variety of hydrologic parameters that indicates wet and dry spells. The PHDI is calculated from several hydrologic parameters including precipitation, temperature, evapotranspiration, soil water recharge, soil water loss, and runoff. Consequently, it is a useful tool for evaluating the relationship between climate and groundwater and surface- water discharge data. The PHDI is useful for determining whether variations in spring and stream discharge rates are the result of climatic variability or whether they are the result of other factors.

As indicated by the PHDI (Figure 2), the region has experienced periods of extreme drought and periods of extreme wetness in addition to periods of near normal climatic conditions. The climatic conditions the area was experiencing during hydrologic data collection are important to consider when evaluating the data discussed in this report. It is apparent in Figure 2 that, beginning in mid-2000, the region entered a period of moderate to severe drought that continues to the present.

Geologic Conditions

The Blackhawk Formation is exposed at the land surface over essentially all of the area that will potentially be undermined. The Castlegate Sandstone overlies the Blackhawk Formation in a small area along the ridgeline between Blind and No-Name Canyons. The Blackhawk Formation consists primarily of interbedded sandstones, siltstones, shales, and coal beds. Much of the sandstone in the Blackhawk Formation occurs as sandstone paleochannels that are usually not continuous over large distances and are encased both vertically and horizontally in low-permeability shale units. The Blackhawk Formation is underlain by the Star Point Sandstone, which consists of three prominent, cliff-forming sandstone members that are interbedded with low-permeability marine shales of the underlying Mancos Shale. The approximate location of the top of the Star Point Sandstone is depicted in Figure 1.

Characterization of Groundwater Systems

Groundwater discharge has been identified in the study area from both the Blackhawk Formation and the Star Point Sandstone. As summarized in Table 1, of the 17 springs and seeps identified in the study area, eight discharge from the Blackhawk Formation and nine discharge from the Star Point Sandstone. Maximum discharge rates for springs in the Blackhawk Formation range from 6 gpm to a seep (Table 1). Minimum discharge in Blackhawk Formation springs and seeps ranges from no discharge to a seep. Maximum discharge for springs and seeps in the Star Point Sandstone range from 10 gpm to a seep. Minimum discharge from springs in the Star Point Sandstone range from no discharge to a seep (Table 1). Specific conductance values for springs in the Blackhawk Formation and Star Point Sandstone are generally similar, averaging 566 µS. The average of all specific conductance measurements for Star Point Sandstone springs (632 µS) is slightly higher than that of the Blackhawk Formation Springs (526µS), likely a result of groundwater interacting with the Mancos Shale tongues in the Star Point Sandstone. Temperature and pH measurements for the Blackhawk Formation and Star Point Sandstone springs are generally similar (Table 2).

It is particularly noteworthy that of the 17 springs and seeps in the study area, all but 4 have at times been completely dry. The other four springs have at times only discharged as a seep. Most of the highest flows measured at the springs occurred during the historic extreme wet spell of the early 1980's (Figure 2; Table 2). None of the springs have discharge characteristics indicative of discharge from a significant groundwater system. The lack of significant baseflow component to the discharge from springs and seeps in the Blackhawk Formation indicates that there is not a deep, drought-resistant groundwater system that supports discharge at the springs in the study area. Rather, springs in the study area are likely supported in the spring and early summer months by annual snowmelt recharge. As the snowpack melts and the seasonal recharge is flushed through the groundwater system, the springs dry-up. Consequently, during dry years when the annual snowmelt recharge is meager, there is commonly no discharge from many of the springs in the study area.

Characterization of Surface-Water Systems

Surface waters in the southern portion of the study area drain into No-Name Canyon. No-Name Canyon, a tributary to Huntington Creek, drains an area of approximately 0.54 square miles. Discharge and water-quality measurements at No-Name Canyon were performed during the high-flow period (May and June) of 2004. Measurements were performed on the upper left and upper right forks, and at a location approximately 150 feet above the confluence with Huntington Creek. A water sample was collected for laboratory baseline water-quality analyses at the lower creek monitoring site on 21 May 2004. The results of the laboratory analyses are attached to this letter report. The creek water is of the calcium-magnesium-bicarbonate chemical type with a TDS concentration of 696 mg/l.

When the No-Name Canyon drainage was visited on 21 May 2004, discharge at the upper right fork was meager (1.69 gpm). The upper right fork drainage above the confluence of the two forks was dry in all but a few locations. In a few locations (near SP-22) there was minimal seepage (dripping) of surface water in the channel (<0.1 gpm). Discharge in the upper left fork was considerably greater (24.4 gpm). Most of the water in the upper left fork originated from seepage into the stream channel in several locations in a debris/snow-covered section of the creek near SP-15. There was snow melting in the drainage above and below SP-15. Above this location, the creek was dry. Visual observations in the lower trunk of the drainage suggested that the discharge in this reach was fairly constant from the confluence of the upper forks to near the confluence with Huntington Creek. In the lowermost approximately 200 feet of the drainage above the confluence with Huntington Creek it was apparent that some of the flow was infiltrating into the alluvial sediments underlying the stream channel. The discharge measured at this location was 17.8 gpm, which represents a loss of approximately 8 gpm relative to that measured at the upper forks.

When the No-Name drainage was again visited approximately 4 weeks later on 17 June 2004, discharge in the drainage was appreciably less. On the afternoon of 16 June 2004 the region experienced thundershowers. On 17 June 2004 there was a near-constant moderate rain shower occurring in the drainage. On 17 June 2004 discharge in the upper right fork at the surface was absent near the confluence of the two forks. Discharge in the upper left fork was measured at 5.76 gpm, which is less than ¼ that measured during May 2004. Similarly, the discharge measured near the confluence with Huntington Creek was only 2.48 gpm, which is less than 15% of that measured in May. The meager discharge measured at the lower site infiltrated entirely into the subsurface within approximately 50 feet downstream. No surface water flowed into Huntington Creek from No-Name Canyon.

When the No-Name Canyon drainage was again visited on 14 July 2004 the creek was dry. Based on the discharge characteristics observed during 2004, the creek would not be considered a perennial stream.

Please feel free to contact me should you have any questions in this regard.

Sincerely,

Erik C. Petersen, P.G.
Principal Hydrogeologist
Utah PG #5373615-2250

C:/GENWAL/No Name Canyon letter report.doc

Table 1 Monitoring site information for springs and creeks in the No-Name Canyon area.

Spring	Formation	UTM coordinates		Q_{max}	Q_{min}	Comments
Springs						
SP-1	Star Point Sandstone			seep	dry	Discharges from the Star Point Sandstone over Mancos Shale
SP-2	Star Point Sandstone			seep	dry	Discharges from the Star Point Sandstone over Mancos Shale
SP-3	Star Point Sandstone	486315	4369554	4	dry	
SP-4	Blackhawk Formation			6	seep	Discharges from colluvium at head of landslide in Blackhawk Formation
SP-5	Blackhawk Formation			seep	dry	Discharges from colluvium at head of landslide in Blackhawk Formation
SP-6	Blackhawk Formation			5	dry	
SP-15	Blackhawk Formation	485608	4368847	seep	dry	
SP-16	Blackhawk Formation	485672	4368903	1.7	dry	
SP-17	Blackhawk Formation	485677	4368904	3	dry	
SP-18	Star Point Sandstone	485737	4368968	10	seep	
SP-19	Star Point Sandstone			5	seep	
SP-20	Star Point Sandstone			seep	dry	
SP-21	Star Point Sandstone	486271	4369204	2	dry	
SP-22	Blackhawk Formation	485484	4369148	4	dry	
SP-23	Blackhawk Formation			5	seep	
SP-24	Star Point Sandstone			10	dry	
SP-25	Star Point Sandstone			<1	dry	
Streams						
No-Name Canyon						
Upper R. Fork		485775	4369074			
Upper L. Fork		485786	4369050			
Lower		486545	4369280			

Table 2 Discharge and water-quality data for springs and creeks in the No-Name Canyon area.

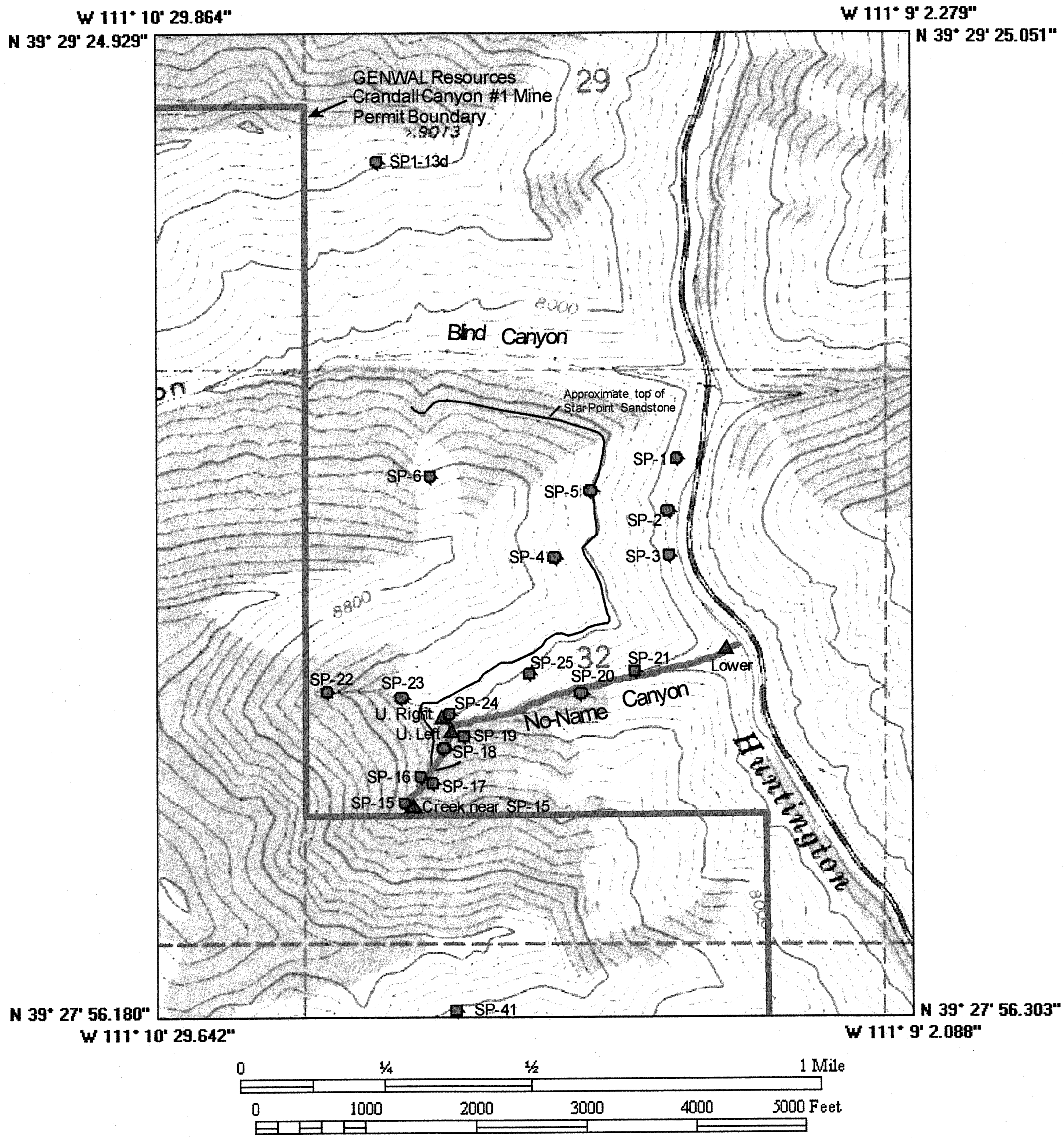
	Date	discharge (gpm)	T (°C)	pH	Cond. (µS)	Comments
Springs						
SP-1	Jun-85	seep				
	Oct-85	dry				
	Sep/Oct 93	dry				
	22-May-04	dry				
SP-2	Jun-85	seep				
	Oct-85	dry				
	Sep/Oct 93	dry				
	22-May-04	dry				
SP-3	Jun-85	4	17	8.12	730	
	Oct-85	dry				
	Sep/Oct 93	dry				
	22-May-04	seep				Melting snow in drainage above seep area
SP-4	Jun-85	6	10	7.86	660	
	Oct-85	seep				
	Sep/Oct 93	seep				
	22-May-04	dry				
SP-5	Jun-85	seep				
	Oct-85	dry				
	Sep/Oct 93	seep				
	22-May-04	dry				
SP-6	Jun-85	5				
	Oct-85	dry				
	Jun-93	seep				
	Sep/Oct 93	dry				
	22-May-04	dry				
SP-15	Jun-85	seep				
	Oct-85	dry				
	Jun-93	seep				
	Sep/Oct 93	seep				
	21-May-04	seep	7.4	8.09	622	Melting snow in drainage above spring area
SP-16	Jun-85	dry	14.5	8.34	560	
	Oct-85	dry				
	Jun-93	0.2	0.2	8.35	462	
	Sep/Oct 93	seep				
	21-May-04	1.72	5.4	7.73	708	Landslide movement occurred since 1993

SP-17	Jun-85	2	10	7.71	460
	Oct-85	dry			
	Jun-93	3	10	8.48	407
	Sep/Oct 93	dry			
	21-May-04	dry			
SP-18	Jun-85	10	7	7.42	500
	Oct-85	2	3	8.15	450
	Jun-93	<0.125	8	8.5	447
	Sep/Oct 93	seep			
	21-May-04	0.27	4.6	8.24	583
SP-19	Jun-85	5	6.5	7.6	620
	Oct-85	1	3.5	8.27	530
	Jun-93	seep			
	Sep/Oct 93	seep			
	21-May-04	dry			
SP-20	Jun-85	seep			
	Oct-85	dry			
	Sep/Oct 93	dry			
	21-May-04	dry			
	14-Jul-04	dry			
SP-21	Jun-85	2	13.5	8.53	820
	Oct-85	dry			
	Sep/Oct 93	dry			
	21-May-04	seep			
	14-Jul-04	dry			
SP-22	Jun-85	4	3.5	8.05	230
	Oct-85	1	3.5	7.32	350
	Jun-93	seep			
	Sep/Oct 93	dry			
	21-May-04	0.1	7.2	8.13	567
SP-23	Jun-85	5	6	8.02	550
	Oct-85	2	3.5	8.08	670
	Jun-93	0.5	10	8.19	498
	Sep/Oct 93	seep			
	21-May-04	dry			
SP-24	Jun-85	2	6	7.35	790
	Oct-85	dry			
	Jun-93	10	8	8.54	555
	Sep/Oct 93	seep			
	21-May-04	dry			
SP-25	Jun-85	<1	10	6.8	820
	Oct-85	dry			
	Sep/Oct 93	dry			
	21-May-04	dry			

Streams

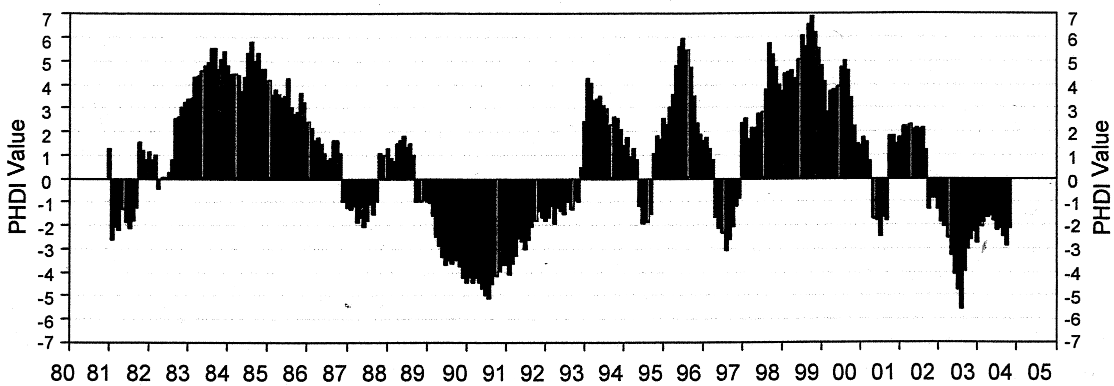
No-Name Canyon

Upper R. Fork					
21-May-04	1.69	7.6	8.18	641	Dissolved oxygen = 6.53 mg/l
17-Jun-04	dry				
14-Jul-04	dry				
Upper L. Fork					
21-May-04	24.4	5.2	8.54	537	Dissolved oxygen = 7.67 mg/l
17-Jun-04	5.76	7.6	8.43	554	Dissolved oxygen = 8.46 mg/l
14-Jul-04	Damp				Monitored during rain storm, slow drip over rocks
Headwaters of L. Fork near SP-15					
21-May-04	4.48	6.3	8.30	542	Dissolved oxygen = 7.48 mg/l
Lower					
21-May-04	17.8	6.9	8.45	561	Dissolved oxygen = 7.41 mg/l
17-Jun-04	2.48	8.0	8.53	655	Surface flow ceased approx. 50 feet below site
14-Jul-04	dry				



Petersen Hydrologic
Consultants in Hydrogeology

Figure 1 Locations of springs and stream monitoring sites in the No-Name Canyon area.



-1 to -2	Mild Drought	1 to 2	Mild Wet Spell
-2 to -3	Moderate Drought	2 to 3	Moderate Wet Spell
-3 to -4	Severe Drought	3 to 4	Severe Wet Spell
-4 to -5	Extreme Drought	4 to 5	Extreme Wet Spell

Figure 2 Plot of Palmer Hydrologi c Drought Index for Utah Region 4.

SGS

June 11, 2004

GENWAL RESOURCES, INC.
P.O. BOX 1077
PRICE UTAH 84501

Sample identification by
Genwal Resources

ID:No Name Canyon

Kind of sample reported to us: Water

Sample taken at: Genwal Resources

Sample taken by: E.Peterson

Date sampled: May 21, 2004

Date received: May 25, 2004

RECEIVED 1000
SAMPLED 1840
FIELD MEASUREMENTS
H2SO4 BOTTLE PRESERVED @ LAB
DIS.METALS
FILTERED @ LAB

Page 1 of 2

Analysis report no. 59-26364

Parameter	Result	MRL	Units		Method	Analyzed Date/Time/Analyst
Acidity	<5	5	mg/l	as $CaCO_3$	D1067-92	05-25-2004 1100 JJ
Alkalinity, Bicarbonate	273	5	mg/l	as $CaCO_3$	EPA 310.1	05-27-2004 0915 JJ
Alkalinity, Carbonate	11	5	mg/l	as $CaCO_3$	EPA 310.1	05-27-2004 0915 JJ
Alkalinity, Total	284	5	mg/l	as $CaCO_3$	EPA 310.1	05-27-2004 0915 JJ
Aluminum, Dissolved	<0.03	0.030	mg/l		EPA 200.7	05-28-2004 1704 DI
Anions	6.9	----	meq/l		---------	06-10-2004 1330 SJ
Arsenic, Dissolved	<0.010	0.010	mg/l		EPA 200.7	05-28-2004 1704 DI
Boron, Dissolved	0.03	0.010	mg/l		EPA 200.7	05-28-2004 1704 DI
Cadmium, Dissolved	<0.001	0.001	mg/l		EPA 200.7	05-28-2004 1704 DI
Calcium, Dissolved	54.40	0.03	mg/l		EPA 200.7	05-28-2004 1704 DI
Cations	7.0	----	meq/l		---------	06-10-2004 1330 SJ
Chloride	5	1	mg/l		EPA 300.0	06-04-2004 1828 DI
Copper, Dissolved	<0.01	0.010	mg/l		EPA 200.7	05-28-2004 1704 DI
Hardness, Total	334	----	mg/l	as $CaCO_3$	SM2340-B	06-10-2004 1330 SJ
Iron, Dissolved	<0.03	0.030	mg/l		EPA 200.7	05-28-2004 1704 DI
Iron, Total	0.21	0.050	mg/l		EPA 200.7	05-26-2004 1404 JJ
Lead, Dissolved	<0.01	0.010	mg/l		EPA 200.7	05-28-2004 1704 DI
Magnesium, Dissolved	48.00	0.01	mg/l		EPA 200.7	05-28-2004 1704 DI
Manganese, Total	0.004	0.002	mg/l		EPA 200.7	05-26-2004 1404 JJ
Manganese, Dissolved	<0.002	0.002	mg/l		EPA 200.7	05-28-2004 1704 DI
Mercury, Dissolved	<0.2	0.2	ug/l		EPA 245.1	06-08-2004 0900 BLP
Molybdenum, Dissolved	<0.005	0.005	mg/l		EPA 200.7	05-28-2004 1704 DI
Nickel, Dissolved	<0.001	0.001	mg/l		EPA 200.7	05-28-2004 1704 DI
Nitrogen, Ammonia	0.1	0.1	mg/l	as N	EPA 350.3	06-07-2004 0830 JJ

MEMBER ACIL

Respectfully submitted,
SGS NORTH AMERICA INC.

Huntington Laboratory

SGS

June 11, 2004

GENWAL RESOURCES, INC.
P.O. BOX 1077
PRICE UTAH 84501

Sample identification by
Genwal Resources

ID:No Name Canyon

RECEIVED 1000
SAMPLED 1840
FIELD MEASUREMENTS
H2SO4 BOTTLE PRESERVED @ LAB
DIS.METALS
FILTERED @ LAB

Page 2 of 2

Kind of sample reported to us: Water

Sample taken at: Genwal Resources

Sample taken by: E.Peterson

Date sampled: May 21, 2004

Date received: May 25, 2004

Analysis report no. 59-26364

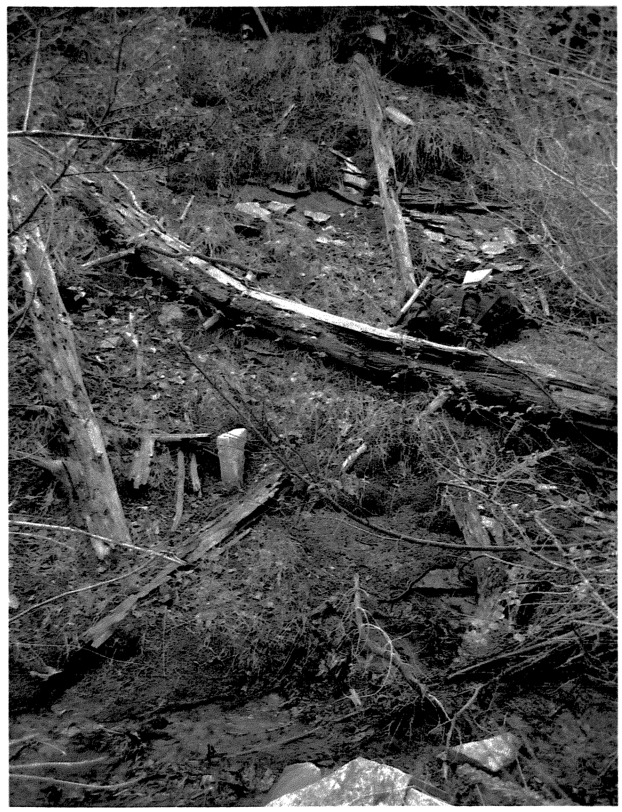
Parameter	Result	MRL	Units	Method	Analyzed Date/Time/Analyst
Oil & Grease	<2	2	mg/l	EPA 413.1	05-26-2004 1000 DI
Potassium, Dissolved	1.57	0.14	mg/l	EPA 200.7	05-28-2004 1704 DI
Selenium, Dissolved	0.03	0.020	mg/l	EPA 200.7	05-28-2004 1704 DI
Sodium, Dissolved	6.31	0.09	mg/l	EPA 200.7	05-28-2004 1704 DI
Solids, Total Dissolved	696	30	mg/l	EPA 160.1	05-25-2004 0900 DI
Solids, Total Suspended	<5	5	mg/l	EPA 160.2	05-25-2004 0900 DI
Sulfate	51	1	mg/l	EPA 300.0	06-04-2004 1828 DI
Zinc, Dissolved	<0.004	0.004	mg/l	EPA 200.7	05-25-2004 1704 DI
Cation/Anion Balance	0.7	----	%		06-10-2004 1330 SJ

MEMBER ACIL

Respectfully submitted,
SGS NORTH AMERICA INC.

Huntington Laboratory

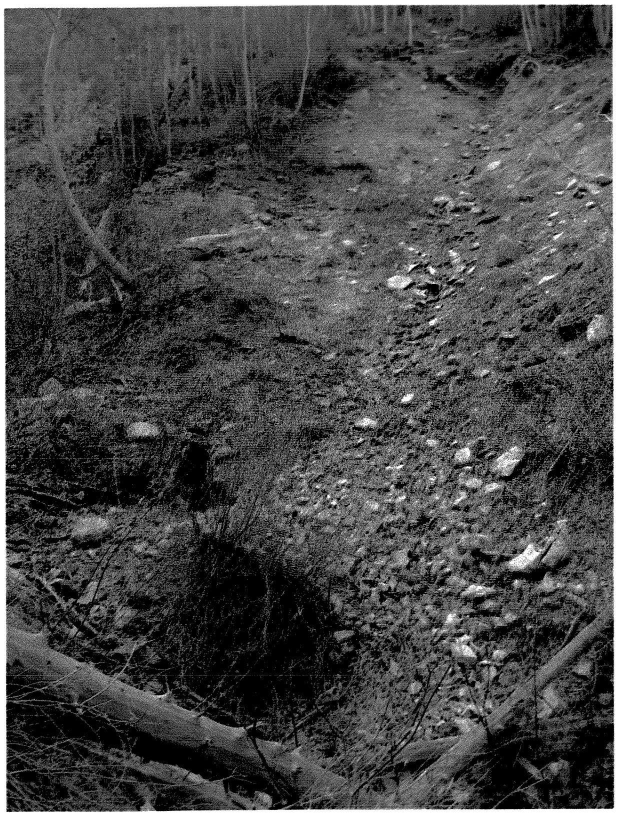
SP-3, 21 May 2004, groundwater discharge
at contact of colluvium over Star Point Sandstone ledge



SP-21, 21 May 2004, groundater discharge
on south side of canyon near creek

Confluence of upper forks of No-Name Canyon,
21 May 2004

SP-18, 21 May 2004



SP-16, 21 May 2004, Note recent movement of landslide at spring location

SP-17 (background), SP-16 (foreground), 21 May 2004

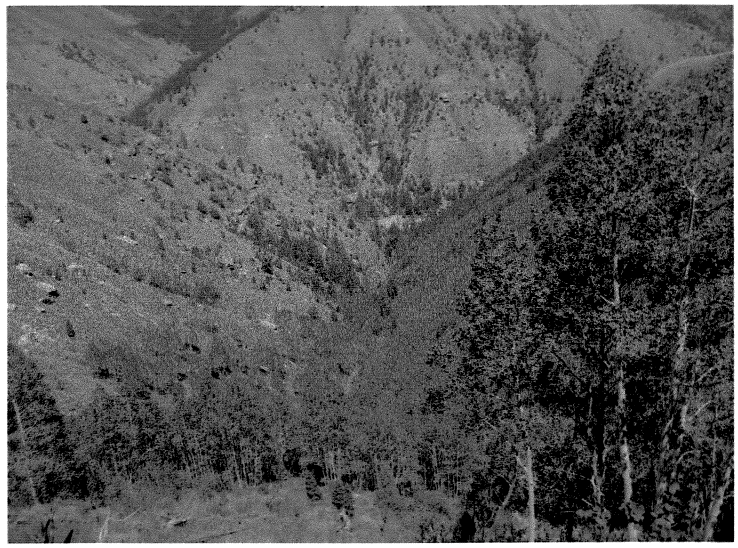
SP-15, 21 May 2004

Creek near SP-15, 21 May 2004, note debris-covered stream channel

Lower No-Name Canyon creek, 21 May 2004

View looking at upland area between Blind and No-Name Canyons, 21 May 2004

Snow-covered creek near SP-15, 21 May 2004



View looking down No-Name Canyon from ridge between upper right and left forks, 21 May 2004

SP-22, 21 May 2004

Sandstone ledge in upper right fork just above confluence with upper left fork, note minimal flow over ledge, 21 May 2004

APPENDIX 7-51

LITTLE BEAR SPRING WATER REPLACEMENT AGREEMENT

1/23/95 revised 4/97

WATER TREATMENT PLANT AGREEMENT

LITTLE BEAR SPRING, HUNTINGTON CANYON

THIS WATER TREATMENT PLANT AGREEMENT ("Agreement") made and entered into this 29 day of April, 2004, by and between Castle Valley Special Service District ("CVSSD"), having an address P.O. Box 877, Castle Dale, UT 84513; PacifiCorp, an Oregon corporation ("PacifiCorp"), having an address c/o Energy West Mining Company, P.O. Box 310, Huntington, UT 84528 ("Energy West") and GENWAL Resources, Inc., a Utah corporation, having an address at P.O. Box 1077, Price, Utah 84501 ("GENWAL").

RECITALS

WHEREAS, CVSSD is a political subdivision of the state of Utah organized as a special service district; and

WHEREAS, CVSSD was legally created in 1977 for the purpose of providing water, sewer, drainage and road-related services for the cities and towns of Huntington, Elmo, Cleveland, Castle Dale, Orangeville, Ferron, and Emery, and the town of Clawson was added to CVSSD in 1999; and

WHEREAS, CVSSD has entered into interlocal governmental agreements with the ities of Huntington, Elmo, and Cleveland (the "Cities")whereby CVSSD has assumed responsibility for the operation and maintenance of the culinary and secondary water systems for the Cities including any treatment facilities and transmission facilities; and

WHEREAS, CVSSD and the Cities obtain a substantial portion of their water from a developed spring located in the SW1/4 of Section 9, Township 16 South, Range 7 East, SLB&M known as the Little Bear Spring; and

WHEREAS, CVSSD is authorized by the various interlocal governmental agreements identified above to make and enter into an agreement with the mining companies conducting coal mining operations in the area of the Little Bear Springs regarding the mitigation of any potential impact such mining operations might have upon the Little Bear Spring; and

WHEREAS, Huntington City owns an existing water treatment plant that is operated and maintained by CVSSD.

WHEREAS, CVSSD has entered into an Agreement dated February 5, 2004 with the North Emery Water Users Special Service District, having to do with the construction of enlarged water treatment units which shall not become effective until such time as this Agreement has become effective among the parties; and

WHEREAS, PacifiCorp conducts coal mining operations in the state of Utah by and through its wholly owned subsidiary, Energy West; and

WHEREAS, one of the general permit conditions imposed upon PacifiCorp and Energy West in connection with the permit issued by the state of Utah, Division of Oil, Gas and Mining, is a requirement that PacifiCorp and Energy West enter into an appropriate agreement to mitigate the potential impact mining might have in connection with the Little Bear Spring; and

WHEREAS, GENWAL conducts coal mining operations in the state of Utah in the vicinity of Little Bear Spring on behalf of ANDALEX Resources, Inc. ("ANDALEX") and the Intermountain Power Agency ("IPA") as the co-owners of the Crandall Canyon Project; and

WHEREAS, ANDALEX and IPA have recently acquired a coal lease from the United States of America, acting through the Bureau of Land Management sometimes identified as the "South Crandall Lease" having lease number UTU-78953; and

WHEREAS, Stipulation #17 attached to the South Crandall Lease requires that in order to adequately protect flow from Little Bear Spring, the Lessee must "enter into a written agreement with the Castle Valley Special District ("CVSSD") to assure an uninterrupted supply of culinary water equivalent to historical flows from the Spring"; and

WHEREAS, CVSSD, PacifiCorp and GENWAL are desirous of entering into an Agreement as to the mitigation measures to be undertaken by Energy West and GENWAL in the event that either or both of their coal mining operations have an impact on the quality and/or quantity of the water coming from the Little Bear Spring, Emery County, Utah as more particularly identified in Energy West's permit and GENWAL'S Special Stipulation #17 to the South Crandall Lease.

WITNESSETH:

NOW THEREFORE, for and in consideration of the promises, the mutual covenants and agreements of the parties hereto, and the consideration in favor of CVSSD described below, the parties hereto agree as follows:

1. The "Recitals" as set forth above are an integral part of this Agreement and are incorporated into the body of this Agreement by this reference.

2. Definitions. The following definitions shall apply to this agreement:

"Companies" shall mean PacifiCorp, Energy West, GENWAL, ANDALEX and IPA either individually or collectively as their interests appear.

"CVSSD Water" shall mean any and all water and/or water rights CVSSD administers, maintains, treats and/or distributes for the cities of Huntington, Cleveland and Elmo, whether at the Little Bear Spring, the Huntington Canyon Water Treatment Plant or otherwise.

"GENWAL Water" shall mean any and all water and/or water rights to which GENWAL, ANDALEX and/or IPA have an interest of any kind whether by ownership, lease or otherwise.

"Little Bear Spring" shall mean and have reference to that certain developed spring area located in the SW1/4, Section 9, Township 16 South, Range 7 East, SLB&M.

"PacifiCorp Water" shall mean any and all water and/or water rights to which PacifiCorp and/or Energy West have an interest of any kind whether by ownership, lease or otherwise.

"Plant Site" and/or "Huntington Canyon Water Treatment Plant" shall mean the existing and proposed new addition to the Huntington Canyon Water Treatment Plant owned by Huntington City and operated and maintained by CVSSD, located about four and one-half miles north of Huntington in Section 8, Township 17 South, Range 8 East SLB&M, including the existing structures and facilities together with any and all additions and/or improvement thereto.

"Existing Plant Site" shall mean the Plant Site as it exists on the date of this Agreement.

"Water Treatment Plant" shall mean the new "water treatment facility o be constructed at the Plant Site pursuant to this Agreement, for CVSSD, as more particularly described in the materials prepared by Bowen Collins & Associates as contained in a two volume set labeled "Contract Documents for the Construction of the Huntington Water Treatment Plant." Volume 1 of 2 is identified as "Specifications" and Volume 2 of 2 is identified as "Drawings." Said materials are referred to herein as the "Contract Documents." The Contract Documents are incorporated herein and are made a part of this Agreement by this reference.

3. Consideration and Release. CVSSD agrees that the Companies performance of the terms and conditions of this Agreement shall constitute the full and complete consideration for the full release, and discharge of the Companies and any or all of its (or their) officers, directors, shareholders, parent or affiliated corporations, agents, attorneys, and assigns, and all other persons, firms, and corporations whomsoever of and from any and all actions, claims, demands, damages, costs, expenses and compensation on account of or in any way growing out of any and all known and unknown claims which CVSSD, and any claiming by, through or under it may now have or may hereafter have resulting from, arising out of, or in any way connected to impacts, on the quantity and/or quality of the

CVSSD Water from the Little Bear Spring as a result of or in any way related to the mining operations of the Companies.

4. Permitting and Enforcement. CVSSD agrees that upon execution of this Agreement and so long as CVSSD continues to receive, subject to anticipated seasonal and climatic variations, the quantity and quality of water from the Huntington Canyon drainage area historically experienced at all times in the future, its comments, both written and verbal, to the various regulatory agencies including, but not limited to, the State of Utah Division of Oil, Gas & Mining tthe Bureau of Land Management, the Office of Surface Mining Reclamation and Enforcement, the United States Forest Service, and the State Engineer of the State of Utah regarding both permitting and enforcement of permits and leases, including but not limited to PacifiCorp's Deer Creek Mine permit application package, the GENWAL Mine permit application package (together with the related Stipulation #17) and all similar or related permits of the Companies, regarding mining within the Mill Fork Canyon area and the Huntington Canyon area, will reflect the fact that PacifiCorp, GENWAL and CVSSD have developed effective mitigation measures, which address potential mining related impacts to the CVSSD Water including, but not limited to, the water of the Little Bear Spring. The comments may include the status of said mitigation measures. CVSSD agrees the Companies permit application packages may be approved or renewed as necessary so long as the Companies have fulfilled their obligations under this Agreement. CVSSD agrees that it will make a good faith effort to resolve any questions or concerns related to this Agreement or mining operations with the Companies prior to any contacts with a regulatory authority.

5. Water Treatment Plant. Energy West and GENWAL, on behalf of the Companies, shall construct, or cause to be constructed, the Water Treatment Plant to treat CVSSD Water. The technical design is included in the Contract Documents. Upon Water Treatment Plant completion, ownership and operation and maintenance of the Water Treatment

Plant will be the responsibility of CVSSD. The final type, design and construction of the Water Treatment Plant will be subject to the advice and approval of CVSSD. CVSSD will provide to Energy West, GENWAL, Bowen Collins & Associates and the contractor ultimately selected to construct the Water Treatment Plant any and all access rights and permissions necessary or convenient for the constructions of the Water Treatment Plant at the Plant Site.

6. Waters to be Treated. The Water Treatment Plant shall utilize water from the Little Bear Spring, Huntington River, other CVSSD Water, and such other water sources as CVSSD may legally utilize in the Water Treatment Plant. The Water Treatment Plant will not utilize PacifiCorp Water or GENWAL Water unless authorized by separate agreement.

This Agreement contemplates that the Cities will transfer water rights in Huntington Cleveland Irrigation Company from one approved diversion point (Little Bear Spring) to another approved diversion point (Water Plant Diversion), both within the Huntington Cleveland Irrigation Company's water right area. In the event that this anticipated transfer is contested or otherwise not approved by Huntington Cleveland Irrigation Company, the Companies agree to provide a sufficient number of their water shares, on a temporary basis, for use by the Cities and District, until the dispute is resolved and a permanent transfer of the Cities water rights is achieved.

7. Water Monitoring. The Companies, after notification to CVSSD, have the right to collect and analyze samples of the Little Bear Spring. Analytical results of all samples obtained by any Party, used for determination of water quality and quantity, will be made available to the other Parties.

8. Water Treatment Plant - Design, Construction and Completion. Energy West and GENWAL will assume the responsibility for the construction of the Water Treatment

Plant and the Companies, by separate agreement among them will provide all funds necessary to complete the construction in accordance with the Contract Documents. CVSSD and the Companies hereby accept the Contract Documents as constituting the final engineering and facility design and as being complete and accurate. The Parties by their execution of this Agreement and the Cities by their acceptance of this Agreement acknowledge that the Water Treatment Plant, as designed and to be constructed, is acceptable to all Parties with respect to both facility design and operating parameters. Upon completion of the Water Treatment Plant, CVSSD, in cooperation with the Companies, will temporarily operate the Water Treatment Plant and have it tested to verify that it meets the design criteria contained in the Contract Documents. Upon completion of the necessary testing, CVSSD shall provide to the Companies a notarized letter, signed by the Board Chairperson, verifying in writing that CVSSD concurs that the design criteria previously agreed to by the Parties have been satisfied and indicating its willingness to accept the Water Treatment Plant in accordance with the terms of this Agreement.

9. Water Treatment Plant Transfer. No deed transfers are required to comply with the terms of this Agreement. Upon the receipt of the notarized letter specified in the preceding paragraph, the Water Treatment Plant will be owned by Huntington City and operated and maintained by CVSSD in accordance with the existing interlocal governmental agreements referred to in this Agreement.

10. Operation and Maintenance Expense. CVSSD agrees that it shall be responsible for operation and maintenance of the Water Treatment Plant from and after the date of the signed, notarized acceptance letter, sent to the Companies. At the time of delivery of the notarized acceptance letter, Energy West shall pay to CVSSD, by its check the lump sum payment of Fifty Thousand Dollars ($50,000) and GENWAL shall pay to CVSSD, by its check, the lump sum payment of Fifty Thousand Dollars ($50,000). Payment of said amounts shall constitute the one time payment by the Companies of the full and complete

contribution of the Companies to the future operation and maintenance costs of the Huntington Canyon Water Treatment Plant (Operation and Maintenance Expense Analysis is included as Exhibit "A") for the life of the facility. No additional operation and maintenance expenses will be owed by the Companies at any time in the future because of their mining operations.

11. Indemnification. During the period of time beginning with the date the contractor engaged to construct the Water Treatment Plant first enters the existing Plant Site and continuing until the date the Companies receive the notarized acceptance letter specified above the Companies shall indemnify and hold harmless CVSSD from and against any and all claims, losses, costs, suits, damages or causes of action including costs and attorney's fees, for and on account of injury, bodily or personal, or death of persons, damage to or destruction of property belonging to CVSSD, its directors, officers, employees, and agents in any way related to this Agreement. Upon delivery of the said notarized acceptance letter and thereafter for the life of the Huntington Canyon Water Treatment Plant, CVSSD shall likewise indemnify, defend, and hold harmless the Companies, their boards of directors, officers, employees, and agents against and from any and all claims, losses, costs, suits, damages or causes of action including costs and attorneys' fees, for and on account of injury, bodily or personal, or death of persons, damage to or destruction of property belonging to the Companies their directors, officers, employees, and agents in any way related to this Agreement.

12. Construction Warranties. In connection with the construction of the Water Treatment Plant, Energy West and GENWAL will obtain the warranties and representations more fully set out in the Contract Documents. The Parties agree that the representations and warranties contained in the Contract Documents are adequate for the purposes of this Agreement and Energy West and GENWAL shall be under no obligation to obtain additional or further warranties and representations from the parties constructing the Water Treatment Plant.

13. Water Rights. The waters treated in the Water Treatment Plant shall be waters owned, rented or otherwise acquired by the cities of Huntington, Cleveland and Elmo, administered by CVSSD. CVSSD shall be solely responsible to ensure that the cities of Huntington, Cleveland and Elmo have adequate water rights for use in connection with the Water Treatment Plant. CVSSD shall take such action as is necessary in accordance with the laws of the State of Utah to ensure that the CVSSD Water may be utilized in connection with the terms of this Agreement. The PacifiCorp Water and the GENWAL Water shall not be utilized in any way in connection with the performance of this Agreement and, the Companies shall be under no obligation or duty to supply water or water rights in connection with the operation and maintenance of the Water Treatment Plant unless authorized by separate agreement.

This Agreement contemplates that the Cities will transfer water rights in Huntington Cleveland Irrigation Company from one approved diversion point (Little Bear Spring) to another approved diversion point (Water Plant Diversion), both within the Huntington Cleveland Irrigation Company's water right area. In the event that this anticipated transfer is contested or otherwise not approved by Huntington Cleveland Irrigation Company, the Companies agree to provide a sufficient number of their water shares, on a temporary basis, for use by the Cities and District, until the dispute is resolved and a permanent transfer of the Cities water rights is achieved.

14. Representations and Warranties. With respect to this Agreement, the Parties hereby represent and warrant to each other as follows:

a. That there are no outstanding conveyances, assignments or agreements granting preferential rights to CVSSD subject to this Agreement in anyone claiming by, through or under the party making this Agreement.

b. That each Party has all of the rights and powers required to enable it to enter into this Agreement and perform the covenants and obligations on its part to be kept and performed hereunder; that the execution and delivery of this Agreement and the performance of the covenants and obligations to be kept and performed hereunder are not contrary to and do not constitute a default under any agreement, either oral or written, to which the party executing this Agreement is a party or by which it is bound.

c. That the Parties making this Agreement have not violated any federal, state or local law, statute, regulations, rule or order applicable to the subject matter of this Agreement and that the parties making this Agreement have complied in all material respects with all applicable federal, state and local laws, statutes, regulations, rules and orders relating to this Agreement.

The above-described representations and warranties shall be applicable at the time of the execution of this Agreement and until the completion of the construction of the Water Treatment Plant.

15. Taxes and Rentals. All rentals, taxes and assessments accrued during construction of the Water Treatment Plant, including design, shall be paid by the Companies. All subsequent rentals, taxes and assessments shall be paid by CVSSD.

16. Survival. Each and every representation, warranty, covenant and agreement of the Parties contained in this Agreement shall survive the completion of the transactions contemplated by this Agreement to take place on the date of this Agreement or subsequent thereto.

17. Successors and Assigns. All of the terms, covenants and conditions of this Agreement shall inure to the benefit of and be binding upon the respective successors, legal representatives and assigns of the Parties. Any assignee of this Agreement, by accepting such assignment, agrees to be bound by all the terms, covenants and conditions of this Agreement or such assignment shall be void and of no effect.

18. Notices. Any notice given under this Agreement shall be in writing and shall be delivered personally or sent by certified mail, return receipt requested. If notice is given by mail, it shall be deemed received seventy-two (72) hours following the time of deposit to the United States mail as evidenced by the postmark on such notice, and such time shall be the effective time of the notice for the purpose of commuting any time periods provided herein. Any such notice shall be delivered or mailed to the following addresses:

If to CVSSD:

Castle Valley Special Service District
c/o Chairman Paul Crawford
P.O. Box 877
Castle Dale, UT 84513

If to PacifiCorp:

PacifiCorp
c/o Energy West Mining Company
Attn: Dee Jense, President and General Manager
P.O. Box 310
Huntington, UT 84528

If to GENWAL:

GENWAL Resources, Inc.
ATTN: Laine Adair, General Manager
P.O. Box 1077
Price, Utah 84501

Any Party may, by the giving of written notice as provided hereunder, change the address to which notices given hereunder are to be directed.

19. Miscellaneous.

a. This Agreement and all other instruments executed in furtherance of the transactions contemplated hereby and the rights and obligations of the parties hereunder and under such other instruments shall be governed in accordance with the laws of the State of Utah.

b. The invalidity or unenforceability of any portion or provisions of this Agreement shall in no way affect the validity or enforceability of any other portion or provision of this Agreement.

c. This Agreement may not be amended or modified in any respect except by written agreement signed by a duly authorized representative of each of the Parties.

d. With respect to the subject matter hereof, this Agreement supersedes all previous negotiations, understandings and agreements, whether written or oral, between the Parties or their representatives and constitutes the entire agreement of the Parties.

e. The captions preceding each paragraph of the Agreement are utilized for the convenience of the Parties, but the captions shall not be used to modify, change or interpret the substantive content of this Agreement.

f. The waiver by any Party of a breach of any term or condition in this Agreement shall not be deemed a waiver of any further breach of said term and condition, nor shall such a waiver constitute or affect any other term or condition. Any waiver must be in writing signed by the Party against whom such waiver is asserted.

g. Any Party may, with the consent of the others, which shall not unreasonably be withheld, assign its interests, rights and obligations hereunder to a successor in interest to the business operated by the Party in connection with this Agreement, but in doing so the assignee under such an assignment shall, in writing, expressly assume all obligations hereunder of the assigning Party, and the assigning Party shall not be relieved of such interests, rights and obligations until the non-assigning Party has been furnished with a signed copy of such assumption.

h. This Agreement may be executed in two or more counterparts, each of which shall be deemed an original, but all of which together shall constitute one and the same agreement.

i. The parties agree from time to time to execute such additional documents as are necessary to effect the intent of the Parties as manifested by this Agreement.

20. Approvals. This Agreement shall not be binding on any Party until such time as it has been approved by the CVSSD board, the Cities and the Companies.

IN WITNESS WHEREOF, the parties have caused this Agreement to be executed as of the day and year first above written.

CASTLE VALLEY SPECIAL SERVICE DISTRICT
By: Paul Crawford
Its: ____________________

PACIFICORP
By: ____________________
Its: President Energy West Mining Co.

GENWAL Resources, Inc.
By: Jaime Adair
Its: General Manager

STATE OF UTAH)
:ss.
COUNTY OF EMERY)

On the 26 day of April, 2004, personally appeared before me Paul Crawford the Chairman of Castle Valley Special Service District, who is the signer of the forgoing instrument and who duly acknowledged to me that he executed the same.

NOTARY PUBLIC
STATE OF UTAH
My Commission Expires
September 18, 2006
C. PAULENE CARR
90 South 100 East
Castle Dale, Utah 84513

C. Paulene Carr
NOTARY PUBLIC

INCORPORATED
APR 15 2005
DIV OF OIL GAS & MINING

My Commission Expires:
9-18-06

STATE OF UTAH)
:ss.
COUNTY OF SALT LAKE)

On the 28 day of APRIL, 2004, personally appeared before me DEE W. JENSE, the PRESIDENT of ~~PacifiCorp~~ ENERGY WEST MINING COMPANY, who is the signer of the forgoing instrument and who duly acknowledged to me that he executed the same.

NOTARY PUBLIC
JOYCE SORENSEN
201 South Main, #2000
Salt Lake City, Utah 84140
My Commission Expires
May 23, 2005
STATE OF UTAH

Joyce Sorensen
NOTARY PUBLIC

My Commission Expires:
May 23, 2005

STATE OF UTAH)
:ss.
COUNTY OF EMERY)

On the 29th day of April, 2004, personally appeared before me Laine W. Adair the General Manager of GENWAL Resources, Inc., who is the signer of the forgoing instrument and who duly acknowledged to me that he executed the same.

Rada J. Rogers
NOTARY PUBLIC

My Commission Expires:
10/2/06

RADA J. ROGERS
NOTARY PUBLIC • STATE of UTAH
2150 N. LUNDY LANE
CLEVELAND, UT 84518
COMM. EXPIRES 10-2-2006

INCORPORATED
APR 15 2005
DIV OF OIL GAS & MINING

APPENDIX 7-52

SUPPLEMENTAL HYDROGEOLOGIC INFORMATION

FOR LBA 11

1/23/95 revised 4/97

Supplemental Hydrogeologic Information For LBA 11

Genwal Resources, Inc. Huntington, Utah

18 March 1997

Mayo and Associates
Consultants in Hydrogeology

Supplemental Hydrogeologic Information For LBA 11

Genwal Resources, Inc. Huntington, Utah

18 March 1997

Prepared by:

Alan L. Mayo, Ph.D.
California Registered Geologist #3265

Erik C. Petersen,
Senior Hydrogeologist

Mayo and Associates
710 East 100 North
Lindon, Utah 84042

Mayo and Associates
Consultants in Hydrogeology

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INTRODUCTION

Genwal Resources, Inc. is currently in the process of acquiring baseline information for LBA 11, a coal lease tract offered by the U.S. Bureau of Land Management. Lease LBA 11 is located immediately south of and contiguous to Genwal's current mining lease area in Crandall Canyon (Figure 1). The U.S. Forest Service (USFS) is currently conducting an environmental assessment (EA) of coal mining in LBA 11. Genwal Resources, Inc. has the opportunity to provide information to the USFS for consideration in the EA. The purpose of this investigation is to provide additional technical analysis to assist the USFS in the preparation of the EA. The scope of our investigation is limited to four specific issues raised by the USFS. These issues are:

1. The potential effects of mining on Little Bear Spring.
2. The potential effects of mining on the recharge to the Rilda Canyon water collection system, particularly subsidence related effects.
3. Groundwater flow associated with the Joes Valley Fault.
4. The potential effects of mining on springs located above LBA 11.

The conclusions presented in this study are based on 1) a limited stable and unstable isotopic investigation of groundwater systems in the vicinity of the mine area carried out by Mayo and Associated as part of this study, 2) an analysis of existing chemical, flow-rate, and piezometric data collected by Genwal Resources, Inc over the past several years, 3) analysis of existing scientific reports dealing with the hydrogeology in the vicinity of the mine area, and 4) integration of the knowledge and experience Mayo and Associates has gained in many similar investigations carried out at other coal mines in the Wasatch Plateau.

BACKGROUND

A brief description of the physiography, geology and structure of the region in vicinity of the Crandall Canyon Mine is presented below. This is not intended as a complete description, but is included to provide background information for the discussion of the specific concerns dealt with in this report.

Location

The Genwal lease areas are located in the central Wasatch Plateau region of central Utah. The region is bounded on the west by Joes Valley and on the east by Huntington Canyon.

Mayo and Associates
Genbase.cdr 11 March 1997

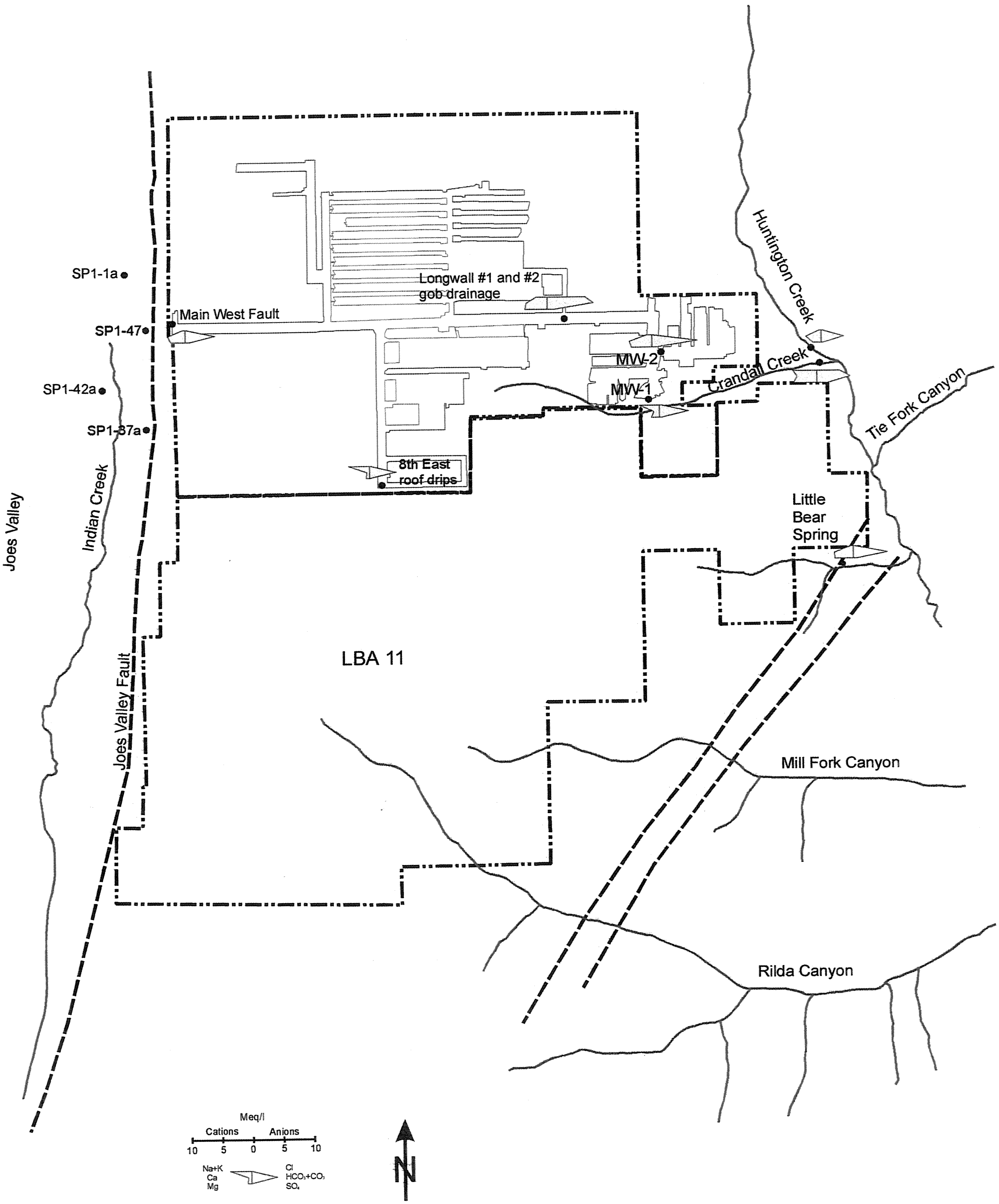

Figure 1 Location of the Genwal study area with Stiff diagrams representing solute compositions of groundwaters and surface waters.

Elevations in the study area range from approximately 7,000 feet in Huntington Canyon to over 10,700 feet on East Mountain. Most of the surface drainage in the lease areas is toward the east into Huntington Creek, which drains into the San Rafael River. A small area in the extreme western portion of the lease areas drains into Indian Creek in Joes Valley. Generally, the land surface in the lease areas is extremely steep and rugged, and is not easily accessable.

Stratigraphy
Seven bedrock formations, all Cretaceous or Tertiary in age, outcrop in the vicinity of the Genwal lease areas. These formations are briefly described below.

Flagstaff Limestone (Tertiary)
The Flagstaff Limestone is a freshwater limestone which typically forms a prominent cliff atop the Wasatch Plateau. It is only present in the uppermost elevations of East Mountain in LBA 11. A thickness of 105 feet was measured on Trail Mountain south of the lease areas (Davis and others, 1977).

North Horn Formation (Tertiary-Cretaceous)
The North Horn Formation is composed primarily of shale with thin interbeds of sandstone, limestone, and conglomerate, and typically forms slopes on the upper surfaces of the Wasatch Plateau. Lenticular sandstone channels exist throughout the formation. The lower two-thirds of the formation consists primarily of bentonitic mudstones. The thickness of the formation averages from 750 to 800 feet in the area.

Price River Formation (Cretaceous)
The Price River formation is made up of sandstone with interbedded shale and some conglomerate. It typically forms alternating ledges and slopes of resistant and non-resistant layers.

Castlegate Sandstone (Cretaceous)
The Castlegate Sandstone consists of coarse-grained fluvial sandstones with some siltstone, claystone, and conglomerate. It forms a prominent cliff above the underlying Blackhawk Formation.

Blackhawk Formation (Cretaceous)
The Blackhawk Formation consists of interbedded sandstones, mudstones, and shales and contains the mineable coal deposits in the Wasatch Plateau. The coal mined at the Crandall Canyon Mine, and the coal to be mined in LBA 11, is from the Hiawatha seam of the Blackhawk Formation. The Hiawatha seam is separated from the underlying Star Point Sandstone by a thin layer (~0-15' thick) of shaley lagoonal deposits. Individual rock layers in the Blackhawk Formation are lenticular and discontinuous with abundant shaley interbeds. Sandstone paleochannels are present in the formation, particularly in its upper portion. The thickness in the area ranges from 625 to 800 feet.

Star Point Sandstone (Cretaceous)
The Star Point Sandstone forms a prominent cliff beneath the Blackhawk Formation and consists of three main massive sandstone layers with interbedded siltstone, shale, and sandstone. The three sandstone members are (from top to bottom) the Spring Canyon, the Storrs, and the Panther members. The sandstone members intertongue with the underlying Masuk member of the Mancos Shale.

Masuk Member of the Mancos Shale
The Masuk Member of the Mancos Shale consists of calcareous, gypsiferous and carbonaceous marine shale. It is approximately 1,300 feet thick.

Structure
The western edge of the Genwal lease areas is constrained by the north-south trending Joes Valley Fault system. Two parallel faults have been mapped by Genwal which trend northeast-southwest and lie immediately to the southeast of LBA 11. No other major faults are known to exist in the lease areas. Northwest-southeast trending faults with displacements on the order of 10 feet have been identified adjacent to Little Bear Spring.

PRESENTATION OF DATA

Methods of Study

On February 3, 1997, Mayo and Associates collected samples for stable and unstable isotopic compositions from one in-mine Blackhawk Formation roof-drip, two wells completed in the Star Point Sandstone beneath the mine workings, one location on the Joes Valley Fault system within the mine, and two samples from Huntington and Crandall Creeks. A single sample of in-mine process water (a mixture of water from natural in-mine drainage and Crandall Creek water pumped from the surface) was collected from an in-mine sump. The information from this sample is not useful for the purposes of this investigation. Additionally, Little Bear Spring was sampled in October 1995 and September 1996 by the Castle Valley Special Services District. The solute and isotopic compositions of these samples are listed in Table 1. Sample locations are plotted on Figure 1. The solute compositions of these waters are presented graphically as Stiff (1951) diagrams on Figure 1.

Isotopic samples for δ^2H, $\delta^{18}O$, and ^3H analyses were collected and preserved in appropriate sealed glass or HDPE plastic bottles. Isotopic samples for $\delta^{13}C$, $\delta^{34}S$, and ^{14}C were precipitated with $BaCl_2 \cdot 2H_2O$.

Stable isotopic analyses for δ^2H, $\delta^{18}O$, $\delta^{13}C$, and $\delta^{34}S$ compositions and unstable ^{14}C contents were performed by Geochron Laboratories, Cambridge, Massachusetts. ^3H analyses were performed by the Tritium Laboratory, University of Miami, Florida using electrolytic enrichment and low level counting methods.

Table 1 Solute and isotopic composition of surface waters and groundwaters in the vicinity of the Crandall Canyon Mine.

genchem.xls 11 March 1997

	T	pH	Cond.	Ca^{2+}	Mg^{2+}	Na^+	K^+	HCO_3^-	CO_3^-	Cl^-	SO_4^{2-}	δ^2H	$\delta^{18}O$	$\delta^{13}C$	^{14}C	^3H
	°C		umhos/cm	mg/L								‰			pmc	TU
Springs and Creeks																
Little Bear Spring	8.9	7.6	556	62	37	7	1	341	0	7	29	-124	-16.8	-9.7[1]	71.12[1]	22.00[1]
Crandall Creek	2.5	8.6	1120	66	47	89	5	326	0	130	85	-126	-17.2	-7.2	62.74	9.3
Huntington Creek	0.6	8.7	387	51	17	5	0	225	0	8	15	-123	-16.8	-10.2	73.22	11.5
Blackhawk Formation																
8th East roof drips	11.9	8.4	407	10	7	77	3	264	0	5	0	-134	-18.2	-8.4	8.41	0.02
Main West fault	9.3	7.95	507	57	28	5	7	304	0	5	32	-130	-17.7	-10.7	40.07	0.06
Star Point Sandstone																
MW-1	12.7	7.95	500	19	16	73	4	293	0	12	18	-134	-18.2	---	---	---
MW-2	10.9	7.3	731	74	41	14	5	456	0	5	39	-133	-18.2	-11.2	5.79	0.03

[1] Samples collected Oct. 95 and Sept. 96 by Castle Valley Special Services District

Groundwater mineral saturation indices were calculated using the computer program WATEQF (Plummer and others, 1976).

Tritium (^3H) and Carbon-14 (^{14}C)
In this investigation, two unstable isotopes, tritium (^3H) and carbon-14 (^{14}C) have been used to evaluate mean residence times. Using methods described by Pearson (1970), Mook (1980), and Fontes (1979), mean groundwater residence times were calculated for the six samples which were analyzed for ^{14}C (Table 2). The concept of groundwater age is difficult to define because water arriving at a well or spring seldom travels via pure piston flow. Instead, it is commonly a mixture of water molecules which recharged at different locations and at different times, thus water typically has no unique age. It is, therefore, best to think of groundwater age as the *mean residence time* of the individual water molecules sampled at the well, spring, or stream.

Tritium is a qualitative tool indicating if groundwater has a component of water which recharged since about 1954. Groundwater which recharged prior to about 1954 will contain essentially no tritium. Carbon-14 provides information regarding the number of years which have elapsed since the groundwater became isolated from soil zone gasses and near-surface waters.

δ^2H and $\delta^{18}O$
The δ^2H and $\delta^{18}O$ composition of a water molecule falling as precipitation is determined by the temperature at which nucleation of the water droplet occurs. Precipitation which occurs under cold conditions will plot more negative than precipitation which occurs under warmer conditions. The δ^2H and $\delta^{18}O$ composition of a non-thermal groundwater is determined at the time of recharge and is not subject to change during its residence in the groundwater system. The δ^2H and $\delta^{18}O$ composition of both in-mine groundwaters and groundwaters from springs and creeks in the vicinity of the lease area are plotted on Figure 2. All groundwaters in the study area plot near the meteoric water line (MWL) suggesting a meteoric recharge origin (i.e. rain and snow). It is apparent that groundwaters from the Blackhawk Formation and Star Point Sandstone plot more negatively than do waters from Huntington Creek and Little Bear Spring. This is may be indicative of cooler paleoclimatic conditions at the time of recharge of the older groundwaters. Crandall Creek, which contains about 25% mine discharge water (Personal communication; Gary Gray, 1997), plots slightly lower than do the other surface waters because of the influence of the Blackhawk Formation component of water from the mine.

DISCUSSION

Each of the four primary areas of concern in this investigation are discussed below.

M   nd Associates
geniso.spw 11 March 1997

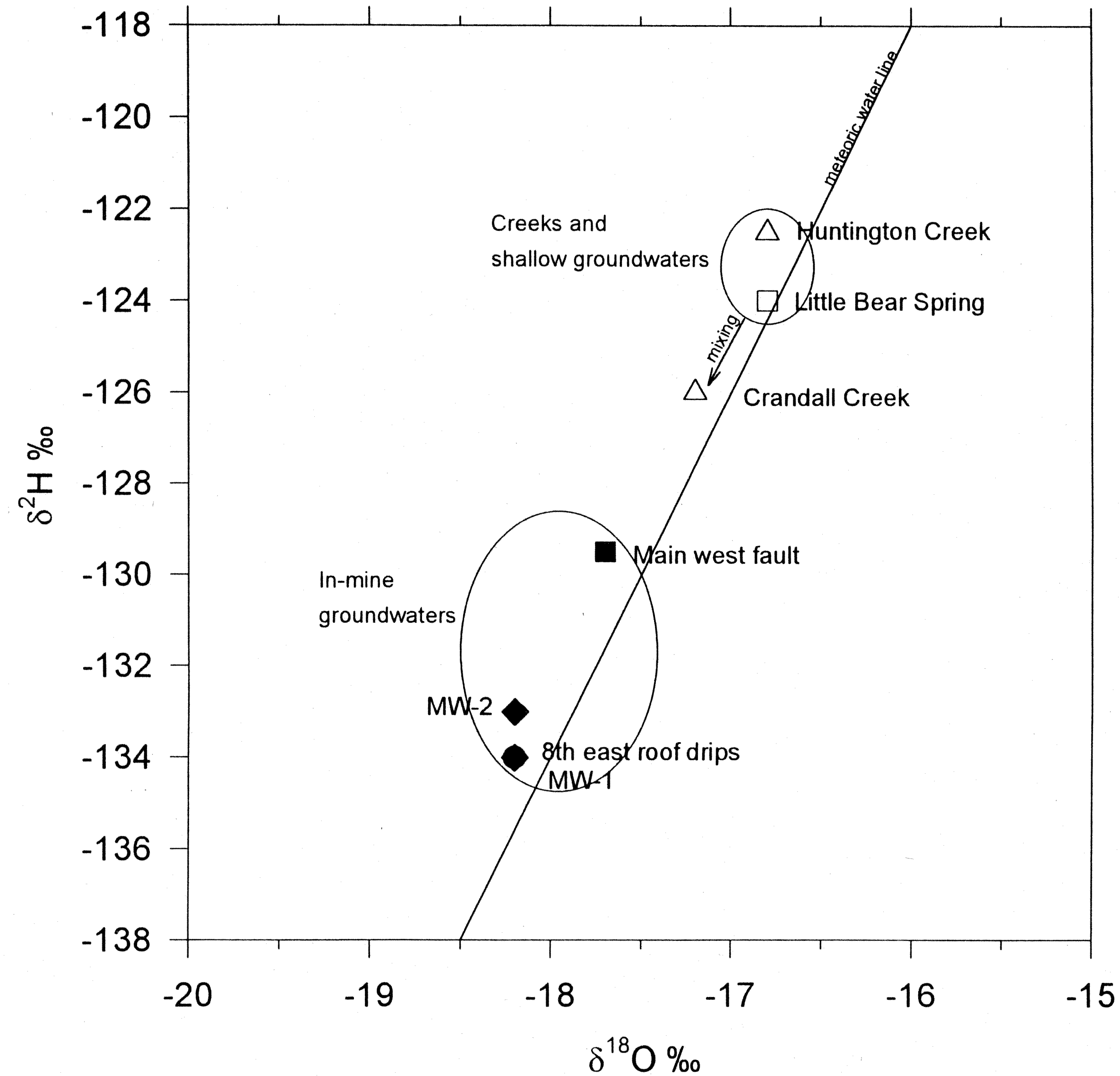

Figure 2 Deuterium and oxygen-18 plot of groundwaters and surface waters in the vicinity of the Crandall Canyon Mine.

Mayo and Associates
Consultants in Hydrogeology

Table 2 Calculated ^{14}C - ^{3}H mean groundwater residence times for the Genwal Mine area.

genage.xls 11 Mar 1997

	Mean residence time (years)								
	$\delta^{13}C$ = -20‰ (gas) assumption			$\delta^{13}C$ = -18‰ (gas) assumption					
	Pearson Model	Mooks Model	Fontes Model	Pearson Model	Mooks Model	Fontes Model	^{14}C pmc	$\delta^{13}C$ ‰	^{3}H TU
Creeks and springs									
Little Bear Spring	modern	modern	modern	modern	modern	modern	71.12	-9.7	22.00
Huntington Creek	modern	modern	modern	modern	modern	modern	73.22	-10.2	11.50
Crandall Creek	modern	modern	modern	modern	modern	modern	62.74	-7.2	9.30
Spring SP1-1a	---	---	---	---	---	---	---	---	29.20
Spring SP1-47	---	---	---	---	---	---	---	---	38.20
Spring SP1-37	---	---	---	---	---	---	---	---	33.30
Spring SP1-42a	---	---	---	---	---	---	---	---	19.20
Blackhawk Formation									
8th East roof drips	13,300	14,800	14,800	14,200	14,800	14,800	8.41	-8.4	0.02
Main West fault	2,400	2,100	2,100	3,600	2,100	2,100	40.07	-10.7	0.06
Starpoint Sandstone									
MW-2	18,800	18,800	18,800	19,600	18,800	18,800	5.79	-11.2	0.03

Assumptions used in all calculations:

$\delta^{13}C$ mineral = 0‰

Activity ^{14}C gas = 100 pmc

Activity ^{14}C mineral = 0 pmc

Potential Effects of Mining on Little Bear Spring

A determination of the precise recharge locations and mechanisms for Little Bear Spring is beyond the scope of this investigation. However, based on stable and unstable isotopic information, stream and spring hydrographs, and geologic information, several important conclusions regarding the relationship between groundwaters encountered in the mine and groundwaters issuing from Little Bear Spring can be drawn:

1) The groundwater discharging from Little Bear Spring is modern (i.e. it has recharged in the last 50 years). The spring water, sampled during low-flow (base-flow) conditions, contains abundant tritium (22.0 TU) and anthropogenic ^{14}C (71.1 pmc). The fact that the base-flow component of the spring is modern water greatly diminishes the likelihood that there is any significant component of old water discharging from the spring. By contrast, the groundwater systems encountered in the mine (i.e. Blackhawk Formation roof drips, Star Point Sandstone wells beneath the mine, and Joes Valley Fault water) discharge water which is thousands of years old. Each of the in-mine samples contain no tritium (Table 2) which suggests that there is no component of modern water.

2) The stable isotopic δ^2H and $\delta^{18}O$ composition of base-flow discharge from Little Bear Spring is very similar to surface water discharging in Huntington Creek, and similar to flow from Crandall Creek (Figure 2). As discussed previously, Crandall Creek contains approximately 25% mine discharge water, which shifts its plotting position in Figure 2 downward relative to the other modern surface waters. The stable isotopic compositions of each of the four in-mine samples plot significantly more negative than do the above ground samples in Figure 2, clearly distinguishing them from the modern, near-surface waters. It is likely that the lower plotting positions of the older, in-mine groundwaters are the result of recharge under cooler, paleoclimatic conditions.

3) There is significant data to suggest that the recharge for Little Bear Spring is closely tied to shallow, seasonal groundwater systems. The discharge hydrograph of Little Bear Spring shows large annual discharge fluctuations and the hydrograph shows response to climatic variability. There is also correlation between stream-flows in Huntington Creek and discharge in the spring.

It is likely that the recharge to Little Bear Spring is closely tied to stream flow in Huntington and/or Crandall Creeks. Groundwater recharge may enter the Star Point Sandstone at nearby up-gradient locations where the creeks flow across exposed, fractured outcrops. However, there is presently insufficient data to completely substantiate this idea. In contrast, seasonal variations in groundwater inflow rates into the mine workings (away from cliff faces and shallow cover) are not observed in the Crandall Canyon Mine (Personal communication, Gary Gray, 1997), nor are they observed in other coal mines in the Wasatch Plateau. This suggests that the groundwater systems encountered within the mine workings are not in hydraulic communication with the groundwater system from which Little Bear Spring discharges.

4) The isolated, perched groundwater systems encountered in the Crandall Canyon Mine workings are hydraulically isolated from the lower sandstones of the Star Point Sandstone from which Little Bear Spring discharges. Many layers of interbedded shale, claystone, and mudstone separate these two systems. Groundwater in the Blackhawk Formation above the mine occurs in isolated sandstone horizons within the mine and is not in hydraulic communication with the underlying groundwaters.

Potential Effects of Mining on the Recharge to the Rilda Canyon Collection System, Particularly Subsidence Related Effects

The Rilda Canyon collection system is operated by the North Emery County Water Users Association and the Castle Valley Special Services District for the purpose of collecting shallow alluvial groundwaters in Rilda Canyon for use as cullinary water. The collection system is not located within the Genwal lease areas, although the uppermost reaches of the Rilda Canyon drainage are within LBA 11. The North Horn Formation is continuously exposed at the surface over the entire reach of Rilda Canyon Creek in LBA 11.

The U.S. Bureau of Mines (Kadnuck, 1994) conducted research at the Deer Creek and Cottonwood Mines located immediately south of LBA 11 and found little or no detrimental effect on North Horn Formation springs which were undermined using longwall mining techniques. The work of the USBM in the central Wasatch Plateau was in agreement with a study by Tieman and Rauch (1986) in Appalachian coal fields which found that springs occurring above longwall panels where the ratio of overburden to panel width was greater than 1 were not adversely impacted by mining operations. The overburden-to-panel width ratio in LBA 11 beneath the Rilda Canyon drainage ranges from 1.8 to 2.8 and, thus, no adverse effects on the shallow groundwater systems or ephemeral drainage are anticipated there.

A relationship was developed by Peng (1992) in Appalachian coal fields which estimates the maximum vertical propagation of fracturing and caving of the overburden above longwall mining to be 30 times the mining thickness. Using this relationship, a maxium vertical fracture propagation of less than 200 feet is calculated beneath the Rilda Canyon drainage in LBA 11. The minimum projected overburden thickness beneath Rilda Canyon in LBA 11 is approximately 1,500 feet, which indicates that there will be a thick sequence of unfractured, low permeability rock between the shallow alluvial deposits of upper Rilda Canyon and the uppermost subsidence fractures. If any subsidence related fractures were to somehow propagate to the surface, the abundant hydrophylic clays present in the underlying Price River and North Horn Formations would swell when wetted and rapidly seal the fractures, impeding the downward migration of groundwaters (Kadnuck 1994; EarthFax Engineering, 1992).

The low permeability shale of the North Horn Formation upon which the Rilda Canyon drainage is developed serves as an effective barrier to the downward migration of groundwaters into underlying formations. The shales also have a tendency to deform plastically rather than fracture when stresses are applied.

A determination of the specific recharge locations and mechanisms for the alluvial groundwater systems associated with the Rilda Canyon collection system is beyond the scope of this investigation. However, it is our opinion that if a potential recharge location was determined to be within LBA 11, the likelihood of any adverse impacts to the shallow groundwater systems in upper Rilda Canyon due to underground mining operations would be negligible.

Nature of the Groundwater Flow Associated with the Joes Valley Fault

Sufficient data is not presently available to completely characterize of the nature of groundwater flow related to the Joes Valley Fault system in the vicinity of Genwal's lease areas. However, based on solute and isotopic data obtained as part of this investigation and available information from investigations carried out by other researchers, several important conclusions may be drawn.

A single sample of groundwater from the Joes Valley Fault system was collected within the Crandall Canyon Mine at the west end of the west mains where the mine workings have intersected the fault system. Groundwater along the fault at this location is physically upwelling through the fractured coal in the floor of the mine workings. Groundwater slowly seeps through the floor along the entire exposed reach of the fault in the mine. The upwelling water does not appear to be under great confining pressure.

A mean ^{14}C "age" of 2,100 years was calculated for the fault system groundwater encountered in the mine (Table 2). No tritium was detected in the sample, indicating that there is no component of modern (post 1954) water associated with the water in the fault. The stable δ^2H and $\delta^{18}O$ composition of groundwater from the fault system has an affinity for other groundwaters encountered in the Blackhawk Formation and in wells in the Star Point Sandstone beneath the mine (Figure 2). The isotopic composition is dissimilar to waters encountered at the surface (i.e. Little Bear Spring, Huntington and Crandall Creeks).

EarthFax Engineering (1992) conducted a tritium and geochemical analysis of groundwaters discharging from springs near the Joes Valley Fault system and from the western slope of East Mountain. The purpose of the investigation was to determine whether there was a detectable component of discharge from Joes Valley Fault contributing water to the springs at the surface. The results of the tritium analysis (Table 2) strongly suggest that the water is of modern origin. Tritium concentrations of the four samples ranged from19.2 to 38.2 TU (Table 2). Carbon-14 data is not available for these samples. It is unlikely that the Joes Valley Fault system is contributing any significant flow to these springs. A low-flow sampling of these springs would help confirm this idea.

In August 1996, Mayo and Associates conducted stream gaging on Indian Creek between the Indian Creek Campground and the confluence with Lowry Water as part of an investigation for Energy West Mining. We found no significant measurable increases in flow over this reach of the creek, suggesting that the Joes Valley Fault system is not contributing any measureable groundwater to the creek flow in this location. Similar findings were reported by Lines (1985).

An in-mine drilling program is currently being conducted by Genwal to better define the residence times and hydraulic characteristics of groundwaters in the Star Point Sandstone below the mine in the vicinity of the Joes Valley Fault system. Stable and unstable isotopic sampling of groundwater in the Spring Canyon tongue of the Star Point Sandstone will be performed as part of the program.

In summary, we can conclude that 1) the groundwater in the Joes Valley Fault system within the Crandall Canyon Mine is thousands of years old, with no component of modern water, 2) the fault system groundwater has a stable isotopic affinity for other groundwaters encountered within the mine, suggesting that the recharge source for the fault waters is different from the recharge source for modern, shallow groundwaters and surface waters, 3) no expression of groundwater discharge from the fault system into springs and creeks at the surface in the vicinity of the Genwal lease area was identified, suggesting that groundwater discharge at the surface is either minimal or non-existent, and 4) groundwaters are upwelling from beneath the mine along the fault system, and do not appear to be under great confining pressure.

Potential Effects of Mining on Springs Located Above LBA 11

A complete determination of the probable hydrologic consequences of mining on springs located within LBA 11 is beyond the scope of this investigation. No chemical or isotopic sampling of the springs in LBA 11 was performed due to the timing of this project and the inaccessibility of the springs due to heavy winter snows. However, some general statements can be made based on our experiences at other coal mines in the Wasatch Plateau.

Our experience at other mines in the area leads us to believe that the groundwater systems occurring in the Flagstaff Limestone, North Horn Formation, Price River Formation, and Castlegate Sandstones occur primarily as perched systems and are not part of "regional aquifers" in the traditional sense. These groundwater systems, almost without exception, discharge "modern" groundwaters which have recharged since about 1954. These groundwaters typically show strong and rapid response to both seasonal changes in precipitation as well as longer term climatic cycles (i.e. periods of above normal precipitation and periods of drought).

As we have demonstrated in previous sections of this report, all of the groundwaters encountered in the mine (Blackhawk Formation roof drips, Star Point Sandstone wells, and

Joes Valley Fault system waters) are thousands of years old and contain no tritium, suggesting that there is not a mixed component of modern water associated with the in-mine groundwaters. The groundwaters encountered in the roof of the mine during mining operations are not part of a regional aquifer, but typically occur as isolated pockets of water in permeable sandstone units, usually within sandstone paleochannels. Typically, much of the sandstone above the mine roof is unsaturated when it is encountered during mining.

As has been the case at other mines in the Wasatch Plateau, the groundwater systems in the formations overlying the horizon to be mined are likely not in communication with the deeper in-mine groundwaters. Hundreds of feet of interbedded sandstone, mudstone, and shale separate these systems and prevent the downward migration of groundwater from the shallow, near-surface groundwater systems.

As was demonstrated in a previous section, detrimental effects on overlying springs and creeks due to subsidence from longwall mining techniques are not anticipated.

SUMMARY

Based on existing hydrologic information, and the new information collected as part of this investigation, we conclude that there is a strong likelihood that mining will not have significant detrimental impacts on shallow groundwater systems in the vicinity of LBA 11.

Little Bear Spring discharges modern water and responds to seasonal changes in precipitation. There appears to be correlation between flow in Little Bear Spring and stage fluctuations in Huntington Creek. The waters discharging from Little Bear Spring are isotopically different from groundwaters encountered in the mine and from groundwaters in the Star Point Sandstone beneath the mine. Discharge from Little Bear Spring does not appear to be related to groundwater flow systems encountered in the mine.

The shallow groundwater systems which support the Rilda Canyon water collection system are hydraulically isolated from deeper, underlying groundwater systems by a thick sequence of interbedded siltstones, mudstones, shales, and hydrophyllic clays. Subsidence fractures which might effect spring or creek discharges in the Rilda Canyon area are not predicted.

Groundwater encountered in the Joes Valley Fault within the Crandall Canyon Mine is approximately 2,100 years old, with no component of modern (post 1954) water. No surface expression of fault water discharging in Joes Valley was identified.

The groundwaters encountered in the Crandall Canyon Mine are thousands of years old and are not in hydraulic communication with adjacent shallow groundwater systems. Our experience at other mines in the Wasatch Plateau leads us to believe that groundwaters which discharge from springs directly overlying LBA 11 are likely hydraulically isolated from groundwater systems encountered within the mine.

REFERENCES

Davis, F.D., and Doelling, H.H., 1977, Coal drilling at Trail Mountain, North Horn Mountain, and Johns Peak areas, Wasatch Plateau, Utah: Utah Geological and mineral Survey Bulletin 112, 90 p.

EarthFax Engineering, Inc., 1992, Mineralogy of the Crandall Canyon Mine overburden, implications for healing of fractures resulting from retreat mining, consulting report prepared for Genwal Coal Company, Inc., Emery County, Utah.

Fontes, J.C., 1980, Environmental isotopes in groundwater hydrology, Chapter 3 in Handbook of environmental isotope geochemistry, v. 1, eds. P. Fritz and J.C. Fontes: New York, Elsevier, p. 75-140.

Kadnuck, L.L.M, 1994, Response of springs to longwall mining at the Deer Creek and Cottonwood mines, Wasatch Plateau, UT, United States Department of the Interior, USBM IC 9405.

Lines, G.C., 1985, The ground-water system and possible effects of underground mining in the Trail Mountain area, central Utah, U.S. Geol. Surv. Water-supply paper 2259.

Mattson, L., and Magers, J.A., Proceedings of the Joseph B. Poland Symposium on Land Subsidence, Association of Engineering Geologists, Annual meeting, Sacramento, California, October 1995.

Mooke, W.G., 1980, Carbon-14 in hydrogeologic studies, in: Handbook of environmental isotope hydrogeochemistry, vol. 1: The terrestrial environment, P. Fritz & J. C. Fontes, 49-74, Elsevier, Amsterdam.

Pearson, F.J., Jr, ands Hanshaw, B.B., 1970, Sources of dissolved carbonate species in groundater and their effects on carbon-14 dating. Isotope Hydrogeology: Vienna, Internat. Atomic Energy Agency, p. 271-286.

Peng, S.S., 1992, Surface Subsidence Engineering, SME, 161 p.

Plummer, L.N., Jones, B.F., and Truesdell, A.H., 1976, WATEQF - A FORTRAN IV version of WATEQF, a computer program for calculating chemical equilibrium of natural waters: USGS Water Resources Investigation, 76-13, 61p.

Stiff, A.H., Jr., 1951, The interpretation of chemical water analyses by means of patterns: Journal of Petroleum Techniques, Technical Note 84, p. 15-17.

Tieman, G.E., and Rauch, H.W., 1986, Study of dewatering effects at an underground longwall mine site in the Pittsburgh Seam of the Northern Appalachian Coalfield, Paper in Eastern Coal Mine Geomechanics, Proceedings: Bureau of Mines Technology Transfer Seminar, Pittsburgh, PA, USBM IC 9137.

APPENDICES

Chemical and Isotopic Laboratory Reporting Sheets

GEOCHRON LABORATORIES a division of KRUEGER ENTERPRISES, INC.

711 CONCORD AVENUE ✦ CAMBRIDGE, MASSACHUSETTS 02138 ✦ U.S.A
TELEPHONE: (617) 876-3691 TELEFAX: (617) 661-0148

STABLE ISOTOPE RATIO ANALYSES — REPORT OF ANALYTICAL WORK

Submitted by: Erik C. Petersen
Mayo and Associates
710 East 100 North
Lindon, UT 84042

Date Received: 02/05/97
Date Reported: 02/20/97
Your Reference: Letter of Feb. 4, 1997 Genwal

Our Lab. Number	Your Sample Number	Description	δD*	$\delta^{18}O$*
HOR-92254	MW-2	Water	-133	-18.2
HOR-92255	#1 and 2 longwall gob water	Water	-129	-17.6
HOR-92256	Main West Fault	Water	-130 -129 **	-17.7
HOR-92257	8th East roof drips	Water	-134	-18.2
HOR-92258	Huntington Creek above C.K.	Water	-122 -123 **	-16.8 -16.8 **
HOR-92259	MW-1	Water	-134	-18.2
HOR-92260	Crandall Creek	Water	-126	-17.2
HOR-92261	Little Bear Spring	Water	-124	-16.8

** Duplicate preparations and analyses.

*Unless otherwise noted, analyses are reported in ‰ notation and are computed as follows:

$$\delta R_{sample}‰ = \left[\frac{R_{sample}}{R_{standard}} - 1 \right] \times 1000$$

Where:

D/H standard is SMOW
$^{18}O/^{16}O$ standard is SMOW

And:

$D/H_{standard}$ = 0.000316**
$^{18}O/^{16}O_{standard}$ = 0.0039948**

**Double atom ratio

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RADIOCARBON AGE DETERMINATION **REPORT OF ANALYTICAL WORK**

Our Sample No. GX-22800-PRI Date Received: 02/05/97

Your Reference: letter of 02/04/97 Date Reported: 02/11/97

Submitted by: Mr. Erik C. Petersen
Mayo & Associates
710 East 100 North
Lindon, Utah 84042

Sample Name: MW-2
groundwater precipitate

AGE = 22,890 +/- 1,270 C-14 years BP (C-13 corrected).
(5.79 +/- 0.91) % of the modern (1950) C-14 activity.

Description: Sample of groundwater precipitate.

Pretreatment: The barium salt precipitate was rapidly vacuum filtered and immediately hydrolyzed, under vacuum to recover carbon dioxide from the barium carbonates for the analysis. C-13 analysis was made on a small portion of the same evolved gas.

Comment:

$\delta^{13}C_{PDB}$ = -11.2 ‰

Y = 89795

Notes: This date is based upon the Libby half life (5570 years) for ^{14}C. The error stated is $\pm 1\sigma$ as judged by the analytical data alone. Our modern standard is 95% of the activity of N.B.S. Oxalic Acid.
The age is referenced to the year A.D. 1950.

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RADIOCARBON AGE DETERMINATION

REPORT OF ANALYTICAL WORK

Our Sample No. GX-22802-PRI

Date Received: 02/05/97

Your Reference: letter of 02/04/97

Date Reported: 02/11/97

Submitted by: Mr. Erik C. Petersen
Mayo & Associates
710 East 100 North
Lindon, Utah 84042

Sample Name: Main West Fault
groundwater precipitate

AGE = 7,350 +/- 310 C-14 years BP (C-13 corrected).
(40.07 +/- 1.54) % of the modern (1950) C-14 activity.

Description: Sample of groundwater precipitate.

Pretreatment: The barium salt precipitate was rapidly vacuum filtered and immediately hydrolyzed, under vacuum to recover carbon dioxide from the barium carbonates for the analysis. C-13 analysis was made on a small portion of the same evolved gas.

Comment: Very small sample; approximately 0.6 grams carbon.

$\delta^{13}C_{PDB}$ = -10.7 ‰

- -

Notes: This date is based upon the Libby half life (5570 years) for ^{14}C. The error stated is $\pm 1\sigma$ as judged by the analytical data alone. Our modern standard is 95% of the activity of N.B.S. Oxalic Acid.
The age is referenced to the year A.D. 1950.

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RADIOCARBON AGE DETERMINATION — REPORT OF ANALYTICAL WORK

Our Sample No. GX-22801-PRI

Date Received: 02/05/97

Your Reference: letter of 02/04/97

Date Reported: 02/11/97

Submitted by: Mr. Erik C. Petersen
Mayo & Associates
710 East 100 North
Lindon, Utah 84042

Sample Name: #1 and #2 longwall gob water
groundwater precipitate

AGE = 15,700 +/- 510 C-14 years BP (C-13 corrected).
(14.17 +/- 0.91) % of the modern (1950) C-14 activity.

Description: Sample of groundwater precipitate.

Pretreatment: The barium salt precipitate was rapidly vacuum filtered and immediately hydrolyzed, under vacuum to recover carbon dioxide from the barium carbonates for the analysis. C-13 analysis was made on a small portion of the same evolved gas.

Comment:

$\delta^{13}C_{PDB}$ = - 7.7 ‰

- -

Notes: This date is based upon the Libby half life (5570 years) for ^{14}C. The error stated is $\pm 1\sigma$ as judged by the analytical data alone. Our modern standard is 95% of the activity of N.B.S. Oxalic Acid. The age is referenced to the year A.D. 1950.

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RADIOCARBON AGE DETERMINATION — REPORT OF ANALYTICAL WORK

Our Sample No. GX-22803-PRI — Date Received: 02/05/97

Your Reference: letter of 02/04/97 — Date Reported: 02/11/97

Submitted by: Mr. Erik C. Petersen
Mayo & Associates
710 East 100 North
Lindon, Utah 84042

Sample Name: 8th East roof drips
groundwater precipitate

AGE = 19,890 +/- 1,140 C-14 years BP (C-13 corrected).
(8.41 +/- 1.19) % of the modern (1950) C-14 activity.

Description: Sample of groundwater precipitate.

Pretreatment: The barium salt precipitate was rapidly vacuum filtered and immediately hydrolyzed, under vacuum to recover carbon dioxide from the barium carbonates for the analysis. C-13 analysis was made on a small portion of the same evolved gas.

Comment:

$\delta^{13}C_{PDB}$ = - 8.4 ‰

- -

Notes: This date is based upon the Libby half life (5570 years) for ^{14}C. The error stated is $\pm 1\sigma$ as judged by the analytical data alone. Our modern standard is 95% of the activity of N.B.S. Oxalic Acid.
The age is referenced to the year A.D. 1950.

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RADIOCARBON AGE DETERMINATION

REPORT OF ANALYTICAL WORK

Our Sample No. GX-22804-PRI

Date Received: 02/05/97

Your Reference: letter of 02/04/97

Date Reported: 02/11/97

Submitted by: Mr. Erik C. Petersen
Mayo & Associates
710 East 100 North
Lindon, Utah 84042

Sample Name: Huntington Creek above C.K.
groundwater precipitate

AGE = 2,505 +/- 170 C-14 years BP (C-13 corrected).
(73.22 +/- 1.56) % of the modern (1950) C-14 activity.

Description: Sample of groundwater precipitate.

Pretreatment: The barium salt precipitate was rapidly vacuum filtered and immediately hydrolyzed, under vacuum to recover carbon dioxide from the barium carbonates for the analysis. C-13 analysis was made on a small portion of the same evolved gas.

Comment: Small sample; approximately 0.60 grams carbon.

$\delta^{13}C_{PDB}$ = -10.2 ‰

Notes: This date is based upon the Libby half life (5570 years) for ^{14}C. The error stated is $\pm 1\sigma$ as judged by the analytical data alone. Our modern standard is 95% of the activity of N.B.S. Oxalic Acid.

The age is referenced to the year A.D. 1950.

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RADIOCARBON AGE DETERMINATION **REPORT OF ANALYTICAL WORK**

Our Sample No. GX-22904 Date Received: 02/25/97

Your Reference: letter of 02/24/97 Date Reported: 03/07/97

Submitted by: Mr. Erik C. Petersen
Mayo & Associates
710 East 100 North
Lindon, Utah 84042

Sample Name: Crandall Creek, 21 Feb 97
groundwater precipitate

AGE = 3,745 +/- 155 C-14 years BP (C-13 corrected).
(62.74 +/- 1.22) % of the modern (1950) C-14 activity.

Description: Sample of groundwater precipitate.

Pretreatment: The barium salt precipitate was rapidly vacuum filtered and immediately hydrolyzed, under vacuum to recover carbon dioxide from the barium carbonates for the analysis. C-13 analysis was made on a small portion of the same evolved gas.

Comment:

$\delta^{13}C_{PDB}$ = - 7.2 ‰

Notes: This date is based upon the Libby half life (5570 years) for ^{14}C. The error stated is $\pm 1\sigma$ as judged by the analytical data alone. Our modern standard is 95% of the activity of N.B.S. Oxalic Acid.
The age is referenced to the year A.D. 1950.

Client: MAYO and ASSOCIATES - GENWAL SAMPLES   Purchase Order: 97-101
Recvd : 97/02/06   Contact: E. Petersen, K. Payne, 801/796-0211
Job# : 927   710 East 100 North (F)/785-2387
Final :   Preliminary Results   Lindon, Utah 84042

Cust	LABEL INFO	JOB.SX	REFDATE	QUANT	ELYS	TU	eTU
MAYO-	MW-2	927.01	970203	1000	275	0.03	0.09
MAYO-	1, 2 LONGWALL GOB WATER	927.02	970203	1000	275	4.68	0.15
MAYO-	MAIN WEST FAULT	927.03	970203	1000	275	0.06	0.09
MAYO-	8TH EAST ROOF DRIPS	927.04	970203	1000	276	0.02	0.09
MAYO-	HUNTINGTON CRK	927.05	970203	1000	274	11.5	0.4

Client: EARTHFAX ENGINEERING
Recvd : 92/06/17
Job# : 409
Final : 92/07/08

Purchase Order: CHECK
Contact: Brent Bovee 801/561-1555
7324 SOUTH 1300 EAST STE 100
MIDVALE UT 84047

Cust LABEL INFO	JOB.SX	REFDATE	QUANT	ELYS	TU	eTU
EARTHFAX- 1	409.01	920611	1000	161	29.2	1.0
EARTHFAX- 2	409.02	920611	1000	157	38.2	1.3
EARTHFAX- 3	409.03	920611	1000	275	33.3	1.1
EARTHFAX- 4	409.04	920611	1000	273	19.2	0.6

COMMERCIAL TESTING & ENGINEERING CO.
GENERAL OFFICES: 1919 SOUTH HIGHLAND AVE., SUITE 210-B, LOMBARD, ILLINOIS 60148 • TEL: 708-953-9300 FAX: 708-953-9306
SINCE 1908
SGS Member of the SGS Group (Société Générale de Surveillance)

PLEASE ADDRESS ALL CORRESPONDENCE TO:
P.O. BOX 1020, HUNTINGTON, UT 84528
TEL: (801) 653-2311
FAX: (801) 653-2436

February 26, 1997

GENWAL RESOURCES, INC.
P.O. BOX 1420
HUNTINGTON UTAH 84528

Sample identification by
GENWAL COAL CO.

ID: Huntington Creek

Rec'd 1115 hr.
Sampled 1635 hr.

Kind of sample reported to us Water

Sample taken at Genwal

Sample taken by Genwal

Date sampled February 3, 1997

Date received February 4, 1997

Field Measurements

pH	8.7
DO	11.2
Conductivity	387
Temperature	0.6°C

NOTE: Dissolved Iron filtered at lab!

Analysis report no. 59-16965

Parameter	Result	MRL	Units	Method	Analyzed Date/Time/Analyst
Alkalinity, Bicarbonate	225	5	mg/l as HCO_3	SM2320-B	02-10-1997 1100 SW
Alkalinity, Carbonate	<5	5	mg/l as CO_3	SM2320-B	02-10-1997 1100 SW
Alkalinity, Total	184	5	mg/l as $CaCO_3$	EPA 310.1	02-10-1997 1100 SW
Anions	4.2	----	meq/l	----------	02-25-1997 1100 RJ
Calcium, Total	51	1	mg/l	EPA 215.1	02-12-1997 1030 MK
Cations	4.2	----	meq/l	----------	02-25-1997 1100 RJ
Chloride	8	1	mg/l	SM4500-Cl-B	02-10-1997 1030 SW
Conductivity	380	1	umhos/cm	SM2510-B	02-05-1997 1230 SW
Hardness, Total	197	----	mg/l as $CaCO_3$	SM2340-B	02-25-1997 1100 RJ
Iron, Total	0.3	0.1	mg/l	EPA 236.1	02-12-1997 0730 MK
Iron, Dissolved	<0.1	0.1	mg/l	EPA 236.1	02-12-1997 0730 MK
Magnesium, Total	17	1	mg/l	EPA 242.1	02-12-1997 1100 MK
Manganese, Total	<0.1	0.1	mg/l	EPA 243.1	02-12-1997 0800 MK
pH	8.35	----	pH units	EPA 150.1	02-04-1997 1245 MK
Potassium, Total	<1	1	mg/l	EPA 258.1	02-12-1997 0830 MK
Sodium, Total	5	1	mg/l	EPA 273.1	02-12-1997 0900 MK
Solids, Total Dissolved	189	10	mg/l	EPA 160.1	02-06-1997 0700 JC
Solids, Total Suspended	11	5	mg/l	EPA 160.2	02-06-1997 0700 JC
Sulfate	15	5	mg/l	EPA 375.4	02-24-1997 1230 SW
Cation/Anion Balance	-0.8	----	%		02-25-1997 1100 RJ

Respectfully submitted,
COMMERCIAL TESTING & ENGINEERING CO.

Larry Stout

FEB-26-97 14:51 FROM: ANDALEX RES INC ID: 8016378860 PAGE

FEB-26-'97 15:22 ID:CT E HUNTINGTON UTAH TEL NO:801 653-2436

COMMERCIAL TESTING & ENGINEERING CO.

GENERAL OFFICES: 1919 SOUTH HIGHLAND AVE., SUITE 210-B, LOMBARD, ILLINOIS 60148 • TEL.: 708-953-9300 FAX: 708-953-9306

SINCE 1908

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PLEASE ADDRESS ALL CORRESPONDENCE TO:
P.O. BOX 1020, HUNTINGTON, UT 84528
TEL: (801) 653-2311
FAX: (801) 653-2436

February 26, 1997

GENWAL RESOURCES, INC.
P.O. BOX 1420
HUNTINGTON UTAH 84528

Sample identification by
GENWAL COAL CO.

ID: Huntington Creek

Kind of sample reported to us: Water

Sample taken at: Genwal

Sample taken by: Genwal

Date sampled: February 3, 1997

Date received: February 4, 1997

Rec'd 1115 hr.
Sampled 1635 hr.

Field Measurements
pH 8.7
DO 11.2
Conductivity 387
Temperature 0.6°C

NOTE: Dissolved Iron filtered at lab!

Analysis report no. 59-16965

Parameter	Result	MRL	Units	Method	Analyzed Date/Time/Analyst
Alkalinity, Bicarbonate	225	5	mg/l as HCO_3	SM2320-B	02-10-1997 1100 SW
Alkalinity, Carbonate	<5	5	mg/l as CO_3	SM2320-B	02-10-1997 1100 SW
Alkalinity, Total	184	5	mg/l as $CaCO_3$	EPA 310.1	02-10-1997 1100 SW
Anions	4.2	----	meq/l	---------	02-25-1997 1100 RJ
Calcium, Total	51	1	mg/l	EPA 215.1	02-12-1997 1030 MK
Cations	4.2	----	meq/l	---------	02-25-1997 1100 RJ
Chloride	8	1	mg/l	SM4500-Cl H	02-10-1997 1030 SW
Conductivity	380	1	umhos/cm	SM2510-B	02-05-1997 1230 SW
Hardness, Total	197	----	mg/l as $CaCO_3$	SM2340-D	02-25-1997 1100 RJ
Iron, Total	0.3	0.1	mg/l	EPA 236.1	02-12-1997 0730 MK
Iron, Dissolved	<0.1	0.1	mg/l	EPA 236.1	02-12-1997 0730 MK
Magnesium, Total	17	1	mg/l	EPA 242.1	02-12-1997 1100 MK
Manganese, Total	<0.1	0.1	mg/l	EPA 243.1	02-12-1997 0800 MK
pH	8.35	----	pH units	EPA 150.1	02-04-1997 1245 MK
Potassium, Total	<1	1	mg/l	EPA 258.1	02-12-1997 0830 MK
Sodium, Total	5	1	mg/l	EPA 273.1	02-12-1997 0900 MK
Solids, Total Dissolved	189	10	mg/l	EPA 160.1	02-06-1997 0700 J
Solids, Total Suspended	11	5	mg/l	EPA 160.2	02-06-1997 0700 J
Sulfate	15	5	mg/l	EPA 375.4	02-24-1997 1230 S
Cation/Anion Balance	-0.8	----	%		02-25-1997 1100 R

Respectfully submitted,
COMMERCIAL TESTING & ENGINEERING CO.

Larry Stout

Huntington Laboratory

COMMERCIAL TESTING & ENGINEERING CO.
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TEL: (801) 653-2311
FAX: (801) 653-2436

February 26, 1997

GENWAL RESOURCES, INC.
P.O. BOX 1420
HUNTINGTON UTAH 84528

Sample identification by
GENWAL COAL CO.

ID: Main West Fault

Kind of sample reported to us: Water

Sample taken at: Genwal

Sample taken by: Genwal

Date sampled: February 3, 1997

Date received: February 4, 1997

Rec'd 1115 hr.
Sampled 1325 hr.

Field Measurements

pH	7.95
DO	8.7
Conductivity	507
Temperature	9.3°C

Analysis report no. 59-16961

Parameter	Result	MRL	Units	Method	Analyzed Date/Time/Analyst
Potassium, Total	7	1	mg/l	EPA 258.1	02-12-1997 0830 MK
Potassium, Dissolved	xxxx	1	mg/l	EPA 258.1	- -
Selenium, Total	xxxx	0.01	mg/l	EPA 270.2	- -
Selenium, Dissolved	xxxx	0.01	mg/l	EPA 270.2	- -
Silica	xxxx	1	mg/l	SM4500-Si B	- -
Sodium, Total	5	1	mg/l	EPA 273.1	02-12-1997 0900 MK
Sodium, Dissolved	xxxx	1	mg/l	EPA 273.1	- -
Solids, Settleable	xxxx	0.5	ml/l	EPA 160.5	- -
Solids, Total Dissolved	252	10	mg/l	EPA 160.1	02-06-1997 0700 JC
Solids, Total Suspended	6385	5	mg/l	EPA 160.2	02-06-1997 0700 JC
Sulfate	32	1	mg/l	EPA 375.4	02-24-1997 1230 SW
Sulfide	xxxx	0.1	mg/l	EPA 376.1	- -
Turbidity	xxxx	0.1	NTU	EPA 180.1	- -
Zinc, Total	xxxx	0.01	mg/l	EPA 289.1	- -
Zinc, Dissolved	xxxx	0.01	mg/l	EPA 289.1	- -
Cation/Anion Balance	xxxx	----	%		

Respectfully submitted,
COMMERCIAL TESTING & ENGINEERING CO.

Huntington Laboratory

COMMERCIAL TESTING & ENGINEERING CO.
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FAX: (801) 653-2436

February 26, 1997

GENWAL RESOURCES, INC.
P.O. BOX 1420
HUNTINGTON UTAH 84528

Sample identification by
GENWAL COAL CO.

ID: MW-1

Rec'd 1115 hr.
Sampled 1610 hr.

Kind of sample reported to us Water

Sample taken at Genwal

Sample taken by Genwal

Date sampled February 3, 1997

Date received February 4, 1997

Field Measurements

pH	7.95
DO	7.8
Conductivity	500
Temperature	12.7°C

NOTE:Dissolved Iron filtered at lab!

Analysis report no. 59-16966

Parameter	Result	MRL	Units	Method	Analyzed Date/Time/Analyst
Alkalinity, Bicarbonate	293	5	mg/l as HCO_3	SM2320-B	02-10-1997 1100 SW
Alkalinity, Carbonate	<5	5	mg/l as CO_3	SM2320-B	02-10-1997 1100 SW
Alkalinity, Total	240	5	mg/l as $CaCO_3$	EPA 310.1	02-10-1997 1100 SW
Anions	5.5	----	meq/l	---------	02-25-1997 1100 RJ
Calcium, Total	19	1	mg/l	EPA 215.1	02-12-1997 1030 MK
Cations	5.5	----	meq/l	---------	02-25-1997 1100 RJ
Chloride	12	1	mg/l	SM4500-Cl-B	02-10-1997 1030 SW
Conductivity	517	1	umhos/cm	SM2510-B	02-05-1997 1230 SW
Hardness, Total	113	----	mg/l as $CaCO_3$	SM2340-B	02-25-1997 1100 RJ
Iron, Total	0.8	0.1	mg/l	EPA 236.1	02-12-1997 0730 MK
Iron, Dissolved	<0.1	0.1	mg/l	EPA 236.1	02-12-1997 0730 MK
Magnesium, Total	16	1	mg/l	EPA 242.1	02-12-1997 1100 MK
Manganese, Total	<0.1	0.1	mg/l	EPA 243.1	02-12-1997 0800 MK
pH	7.96	----	pH units	EPA 150.1	02-04-1997 1245 MK
Potassium, Total	4	1	mg/l	EPA 258.1	02-12-1997 0830 MK
Sodium, Total	73	1	mg/l	EPA 273.1	02-12-1997 0900 MK
Solids, Total Dissolved	244	10	mg/l	EPA 160.1	02-06-1997 0700 JC
Solids, Total Suspended	<5	5	mg/l	EPA 160.2	02-06-1997 0700 JC
Sulfate	18	5	mg/l	EPA 375.4	02-24-1997 1230 SW
Cation/Anion Balance	0.2	----	%		02-25-1997 1100 RJ

Respectfully submitted,
COMMERCIAL TESTING & ENGINEERING CO.

COMMERCIAL TESTING & ENGINEERING CO.

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TEL: (801) 653-2311
FAX: (801) 653-2436

February 26, 1997

GENWAL RESOURCES, INC.
P.O. BOX 1420
HUNTINGTON UTAH 84528

Sample identification by
GENWAL COAL CO.

ID: Main West Fault

Rec'd 1115 hr.
Sampled 1325 hr.

Ca^{2+} & Mg^{2+} will be retested

Kind of sample reported to us: Water

Sample taken at: Genwal

Sample taken by: Genwal

Date sampled: February 3, 1997

Date received: February 4, 1997

Field Measurements

pH	7.95
DO	8.7
Conductivity	507
Temperature	9.3°C

Analysis report no. 59-16961

Parameter	Result	MRL	Units		Method	Analyzed Date/Time/Analyst
Acidity	xxxx	10	mg/l	as $CaCO_3$	D1067-92	- -
Alkalinity, Bicarbonate	304	5	mg/l	as HCO_3	SM2320-B	02-10-1997 1100 SW
Alkalinity, Carbonate	<5	5	mg/l	as CO_3	SM2320-B	02-10-1997 1100 SW
Alkalinity, Total	249	5	mg/l	as $CaCO_3$	EPA 310.1	02-10-1997 1100 SW
Aluminum, Total	xxxx	1	mg/l		EPA 202.1	- -
Aluminum, Dissolved	xxxx	1	mg/l		EPA 202.1	- -
Anions	xxxx	----	meq/l		---------	- -
Arsenic, Total	xxxx	0.01	mg/l		EPA 206.2	- -
Arsenic, Dissolved	xxxx	0.01	mg/l		EPA 206.2	- -
Barium, Total	xxxx	1	mg/l		EPA 208.1	- -
Barium, Dissolved	xxxx	1	mg/l		EPA 208.1	- -
Boron, Total	xxxx	0.1	mg/l		EPA 212.3	- -
Boron, Dissolved	xxxx	0.1	mg/l		EPA 212.3	- -
Cadmium, Total	xxxx	0.01	mg/l		EPA 213.1	- -
Cadmium, Dissolved	xxxx	0.01	mg/l		EPA 213.1	- -
Calcium, Total	600	1	mg/l		EPA 215.1	02-12-1997 1030 MK
Calcium, Dissolved	xxxx	1	mg/l		EPA 215.1	- -
Cations	xxxx	----	meq/l		---------	- -
Chloride	5	1	mg/l		SM4500-Cl-B	02-10-1997 1030 SW
Chromium, Total	xxxx	0.1	mg/l		EPA 218.1	- -
Chromium, Dissolved	xxxx	0.1	mg/l		EPA 218.1	- -
Conductivity	516	1	umhos/cm		SM2510-B	02-05-1997 1230 SW
Copper, Total	xxxx	0.1	mg/l		EPA 220.1	- -
Copper, Dissolved	xxxx	0.1	mg/l		EPA 220.1	- -

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To CRIK	From John
Co.	Co.
Dept.	Phone #
Fax # 801/789-2387	Fax #

Respectfully submitted,
COMMERCIAL TESTING & ENGINEERING CO.

Huntington Laboratory

COMMERCIAL TESTING & ENGINEERING CO.

GENERAL OFFICES: 1919 SOUTH HIGHLAND AVE., SUITE 210-B, LOMBARD, ILLINOIS 60148 • TEL: 708-953-9300 FAX: 708-953-9306
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P.O. BOX 1020, HUNTINGTON, UT 84528
TEL: (801) 653-2311
FAX: (801) 653-2436

February 26, 1997

GENWAL RESOURCES, INC.
P.O. BOX 1420
HUNTINGTON UTAH 84528

Sample identification by
GENWAL COAL CO.

ID: Main West Fault

Kind of sample reported to us: Water

Sample taken at: Genwal

Sample taken by: Genwal

Date sampled: February 3, 1997

Date received: February 4, 1997

Rec'd 1115 hr.
Sampled 1325 hr.

Field Measurements
pH 7.95
DO 8.7
Conductivity 507
Temperature 9.3°C

Analysis report no. 59-16961

Parameter	Result	MRL	Units	Method	Analyzed Date/Time/Analyst
Fluoride	xxxx	0.01	mg/l	SM4500-F-C	- -
Hardness, Total	xxxx	----	mg/l as $CaCO_3$	SM2340-B	- -
Iron, Total	54.0	0.1	mg/l	EPA 236.1	02-12-1997 0730 MK
Iron, Dissolved	0.1	0.1	mg/l	EPA 236.1	02-12-1997 0730 MK
Lead, Total	xxxx	0.1	mg/l	EPA 239.1	- -
Lead, Dissolved	xxxx	0.1	mg/l	EPA 239.1	- -
Magnesium, Total	244	1	mg/l	EPA 242.1	02-12-1997 1100 MK
Magnesium, Dissolved	xxxx	1	mg/l	EPA 242.1	
Manganese, Total	1.4	0.1	mg/l	EPA 243.1	02-12-1997 0800 MK
Manganese, Dissolved	<0.1	0.1	mg/l	EPA 243.1	02-12-1997 0800 MK
Mercury, Total	xxxx	0.2	ug/l	EPA 245.1	- -
Mercury, Dissolved	xxxx	0.2	ug/l	EPA 245.1	- -
Molybdenum, Total	xxxx	0.1	mg/l	EPA 246.1	- -
Molybdenum, Dissolved	xxxx	0.1	mg/l	EPA 246.1	-
Nickel, Total	xxxx	0.1	mg/l	EPA 249.1	- -
Nickel, Dissolved	xxxx	0.1	mg/l	EPA 249.1	- -
Nitrogen, Ammonia	xxxx	0.5	mg/l as N	EPA 350.3	- -
Nitrogen, Nitrate-Nitrite	xxxx	0.1	mg/l as N	EPA 353.3	- -
Nitrogen, Nitrite	xxxx	0.01	mg/l as N	EPA 354.1	- -
Oil & Grease	xxxx	2	mg/l	SM5520-B	- -
Oxygen, Dissolved	xxxx	----	mg/l	EPA 360.1	- -
pH	7.92	----	pH units	EPA 150.1	02-04-1997 1245 MK
Phosphorous, Ortho-PO_4	xxxx	0.01	mg/l as P	SM4500-P-E	- -
Phosphorous, Total	xxxx	0.05	mg/l as P	SM4500-P-B,E	- -

Respectfully submitted,
COMMERCIAL TESTING & ENGINEERING CO.

Huntington Laboratory

Due to a positive interference's from high settleable matter in the sample, dissolved calcium and dissolved magnesium were ran. This was done so the calculate cation/anion charge balance be with in ± 10.

Larry Stout
RG

COMMERCIAL TESTING & ENGINEERING CO.

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P.O. BOX 1020, HUNTINGTON, UT 84528
TEL: (801) 653-2311
FAX: (801) 653-2436

March 5, 1997

GENWAL RESOURCES, INC.
P.O. BOX 1420
HUNTINGTON UTAH 84528

Sample identification by
GENWAL COAL CO.

ID: Main West Fault

Kind of sample reported to us: Water

Sample taken at: Genwal

Sample taken by: Genwal

Date sampled: February 3, 1997

Date received: February 4, 1997

Rec'd 1115 hr.
Sampled 1325 hr.

Field Measurements
pH 7.95
DO 8.7
Conductivity 507
Temperature 9.3°C

Dissolved Fe, Mg & Cl filtered at lab!

Analysis report no. 59-16961

Parameter	Result	MRL	Units		Method	Analyzed Date/Time/Analyst		
Alkalinity, Bicarbonate	304	5	mg/l	as HCO_3	SM2320-B	02-10-1997	1100	SW
Alkalinity, Carbonate	<5	5	mg/l	as CO_3	SM2320-B	02-10-1997	1100	SW
Alkalinity, Total	249	5	mg/l	as $CaCO_3$	EPA 310.1	02-10-1997	1100	SW
Anions	5.8	----	meq/l		---------	03-05-1997	0900	RJ
Calcium, Total	600	10	mg/l		EPA 215.1	02-12-1997	1030	MK
Calcium, Dissolved	57	1	mg/l		EPA 215.1	03-05-1997	0730	MK
Cations	5.6	----	meq/l		---------	03-05-1997	0900	RJ
Chloride	5	1	mg/l		SM4500-Cl B	02-10-1997	1030	SW
Conductivity	516	1	umhos/cm		SM2510-B	02-05-1997	1230	SW
Hardness, Total	263	----	mg/l	as $CaCO_3$	SM2340-B	03-05-1997	0900	RJ
Iron, Total	54.0	10.0	mg/l		EPA 236.1	02-12-1997	0730	MK
Iron, Dissolved	0.1	0.1	mg/l		EPA 236.1	02-12-1997	0730	MK
Magnesium, Total	244	10	mg/l		EPA 242.1	02-12-1997	1100	MK
Magnesium, Dissolved	28	1	mg/l		EPA 242.1	03-05-1997	0745	MK
Manganese, Total	1.4	0.1	mg/l		EPA 243.1	02-12-1997	0800	MK
pH	7.92	----	pH units		EPA 150.1	02-04-1997	1245	MK
Potassium, Total	7	1	mg/l		EPA 258.1	02-12-1997	0830	MK
Sodium, Total	5	1	mg/l		EPA 273.1	02-12-1997	0900	MK
Solids, Total Dissolved	252	10	mg/l		EPA 160.1	02-06-1997	0700	JC
Solids, Total Suspended	6385	5	mg/l		EPA 160.2	02-06-1997	0700	JC
Sulfate	32	10	mg/l		EPA 375.4	02-24-1997	1230	SW
Cation/Anion Balance	+1.3	----	%			03-05-1997	0900	RJ

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To ERIK	From JEAN
Co.	Co.
Dept.	Phone #
Fax # 801/785-2387	Fax #

Respectfully submitted,
COMMERCIAL TESTING & ENGINEERING CO.

Larry [signature]

Huntington Laboratory RJ

Due to a positive interference's from high settleable matter in the sample, dissolved calcium and dissolved magnesium were ran. This was done so the calculate cation/anion charge balance be with in ± 10.

Larry Stout
RS

COMMERCIAL TESTING & ENGINEERING CO.

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TEL: (801) 653-2311
FAX: (801) 653-2436

March 5, 1997

GENWAL RESOURCES, INC.
P.O. BOX 1420
HUNTINGTON UTAH 84528

Sample identification by
GENWAL COAL CO.

ID: MW-2

Kind of sample reported to us: Water

Sample taken at: Genwal

Sample taken by: Genwal

Date sampled: February 3, 1997

Date received: February 4, 1997

Rec'd 1115 hr.
Sampled 1520 hr.

Field Measurements
pH 7.3
DO 8.5
Conductivity 731
Temperature 10.9°C

Dissolved Iron filtered at lab!

Analysis report no. 59-16962

Parameter	Result	MRL	Units	Method	Analyzed Date/Time/Analyst
Alkalinity, Bicarbonate	456	5	mg/l as HCO_3	SM2320-B	02-10-1997 1100 SW
Alkalinity, Carbonate	<5	5	mg/l as CO_3	SM2320-B	02-10-1997 1100 SW
Alkalinity, Total	374	5	mg/l as $CaCO_3$	EPA 310.1	02-10-1997 1100 SW
Anions	8.4	----	meq/l	---------	03-05-1997 0900 RJ
Calcium, Total	109	1	mg/l	EPA 215.1	02-12-1997 1030 MK
Calcium, Dissolved	74	1	mg/l	EPA 215.1	03 05 1997 0730 MK
Cations	7.8	----	meq/l	---------	03-05-1997 0900 RJ
Chloride	5	1	mg/l	SM4500-Cl-B	02-10-1997 1030 SW
Conductivity	748	1	umhos/cm	SM2510-B	02-05-1997 1230 SW
Hardness, Total	354	----	mg/l as $CaCO_3$	SM2340 B	03-05-1997 0900 RJ
Iron, Total	4.5	0.1	mg/l	EPA 236.1	02-12-1997 0730 MK
Iron, Dissolved	<0.1	0.1	mg/l	EPA 236.1	02-12-1997 0730 MK
Magnesium, Total	60	1	mg/l	EPA 242.1	02-12-1997 1100 MK
Magnesium, Dissolved	41	1	mg/l	EPA 242.1	03 05-1997 0745 MK
Manganese, Total	<0.1	0.1	mg/l	EPA 243.1	02-12-1997 0800 MK
pH	7.29	----	pH units	EPA 150.1	02-04-1997 1245 MK
Potassium, Total	5	1	mg/l	EPA 258.1	02-12-1997 0830 MK
Sodium, Total	14	1	mg/l	EPA 273.1	02-12-1997 0900 MK
Solids, Total Dissolved	413	10	mg/l	EPA 160.1	02-06-1997 0700 JC
Solids, Total Suspended	136	5	mg/l	EPA 160.2	02-06-1997 0700 JC
Sulfate	39	50	mg/l	EPA 375.4	02 24 1997 0900 SW
Cation/Anion Balance	-3.8	----	%		03-05-1997 0900 RJ

Respectfully submitted,
COMMERCIAL TESTING & ENGINEERING CO.

Larry Stout

Huntington Laboratory

COMMERCIAL TESTING & ENGINEERING CO.
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February 26, 1997

GENWAL RESOURCES, INC.
P.O. BOX 1420
HUNTINGTON UTAH 84528

Sample identification by
GENWAL COAL CO.

ID: Crandall Creek

Rec'd 1115 hr.
Sampled 1625 hr.

Field Measurements
pH 8.6
DO 11.7
Conductivity 1120
Temperature 2.5°C

NOTE: Dissolved Iron filtered at lab!
NOTE: Dissolved Mang. filtered at lab!

Kind of sample reported to us: Water

Sample taken at: Genwal

Sample taken by: Genwal

Date sampled: February 3, 1997

Date received: February 4, 1997

Analysis report no. 59-16964

Parameter	Result	MRL	Units	Method	Analyzed Date/Time/Analyst
Alkalinity, Bicarbonate	326	5	mg/l as HCO_3	SM2320-B	02-10-1997 1100 SW
Alkalinity, Carbonate	<5	5	mg/l as CO_3	SM2320-B	02-10-1997 1100 SW
Alkalinity, Total	267	5	mg/l as $CaCO_3$	EPA 310.1	02-10-1997 1100 SW
Anions	10.8	----	meq/l	---------	02-25-1997 1100 RJ
Calcium, Total	66	1	mg/l	EPA 215.1	02-12-1997 1030 MK
Cations	11.2	----	meq/l	---------	02-25-1997 1100 RJ
Chloride	130	1	mg/l	SM4500-Cl-B	02-10-1997 1030 SW
Conductivity	1073	1	umhos/cm	SM2510-B	02-05-1997 1230 SW
Hardness, Total	358	----	mg/l as $CaCO_3$	SM2340-B	02-25-1997 1100 RJ
Iron, Total	0.3	0.1	mg/l	EPA 236.1	02-12-1997 0730 MK
Iron, Dissolved	<0.1	0.1	mg/l	EPA 236.1	02-12-1997 0730 MK
Magnesium, Total	47	1	mg/l	EPA 242.1	02-12-1997 1100 MK
Manganese, Total	<0.1	0.1	mg/l	EPA 243.1	02-12-1997 0800 MK
pH	8.35	----	pH units	EPA 150.1	02-04-1997 1245 MK
Potassium, Total	5	1	mg/l	EPA 258.1	02-12-1997 0830 MK
Sodium, Total	89	1	mg/l	EPA 273.1	02-12-1997 0900 MK
Solids, Total Dissolved	601	10	mg/l	EPA 160.1	02-06-1997 0700 JC
Solids, Total Suspended	18	5	mg/l	EPA 160.2	02-06-1997 0700 JC
Sulfate	85	20	mg/l	EPA 375.4	02-24-1997 1230 SW
Cation/Anion Balance	1.7	----	%		02-25-1997 1100 RJ

Respectfully submitted,
COMMERCIAL TESTING & ENGINEERING CO.

Larry Stout

Huntington Laboratory RJ

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February 26, 1997

GENWAL RESOURCES, INC.
P.O. BOX 1420
HUNTINGTON UTAH 84528

Sample identification by
GENWAL COAL CO.

ID: Little Bearspring

Kind of sample reported to us Water

Sample taken at Genwal

Sample taken by Genwal

Date sampled February 3, 1997

Date received February 4, 1997

Rec'd 1115 hr.
Sampled 1005 hr.

Field Measurements
pH 7.6
DO 3.6
Conductivity 556
Temperature 8.9°C

NOTE: pH expired when received!
NOTE: Dissolved Iron filtered at lab!

Analysis report no. 59-16960

Parameter	Result	MRL	Units	Method	Analyzed Date/Time/Analyst
Alkalinity, Bicarbonate	341	5	mg/l as HCO_3	SM2320-B	02-10-1997 1100 SW
Alkalinity, Carbonate	<5	5	mg/l as CO_3	SM2320-B	02-10-1997 1100 SW
Alkalinity, Total	279	5	mg/l as $CaCO_3$	EPA 310.1	02-10-1997 1100 SW
Anions	6.4	----	meq/l	---------	02-25-1997 1030 RJ
Calcium, Total	62	1	mg/l	EPA 215.1	02-12-1997 1030 MK
Cations	6.5	----	meq/l	---------	02-25-1997 1030 RJ
Chloride	7	1	mg/l	SM4500-Cl-B	02-10-1997 1030 SW
Conductivity	580	1	umhos/cm	SM2510-B	05-05-1997 1230 SW
Hardness, Total	307	----	mg/l as $CaCO_3$	SM2340-B	02-25-1997 1030 RJ
Iron, Total	<0.1	0.1	mg/l	EPA 236.1	02-12-1997 0730 MK
Iron, Dissolved	<0.1	0.1	mg/l	EPA 236.1	02-12-1997 0730 MK
Magnesium, Total	37	1	mg/l	EPA 242.1	02-12-1997 1100 MK
Manganese, Total	<0.1	0.1	mg/l	EPA 243.1	02-12-1997 0800 MK
pH	7.52	----	pH units	EPA 150.1	02-04-1997 1245 MK
Potassium, Total	1	1	mg/l	EPA 258.1	02-12-1997 0830 MK
Sodium, Total	7	1	mg/l	EPA 273.1	02-12-1997 0900 MK
Solids, Total Dissolved	306	10	mg/l	EPA 160.1	02-06-1997 0700 JC
Solids, Total Suspended	<5	5	mg/l	EPA 160.2	02-06-1997 0700 JC
Sulfate	29	5	mg/l	EPA 375.4	02-24-1997 0900 RJ
Cation/Anion Balance	0.6	----	%		02-25-1997 1030 RJ

Respectfully submitted,
COMMERCIAL TESTING & ENGINEERING CO.

Larry Scott

Huntington Laboratory RO

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February 26, 1997

GENWAL RESOURCES, INC.
P.O. BOX 1420
HUNTINGTON UTAH 84528

Sample identification by
GENWAL COAL CO.

ID: LW 1 & 2 Gob Water

Rec'd 1115 hr.
Sampled 1450 hr.

Field Measurements
pH 7.4
DO 7.9
Conductivity 752
Temperature 10.9°C

Kind of sample reported to us: Water

Sample taken at: Genwal

Sample taken by: Genwal

Date sampled: February 3, 1997

Date received: February 4, 1997

Analysis report no. 59-16963

Parameter	Result	MRL	Units	Method	Analyzed Date/Time/Analyst
Alkalinity, Bicarbonate	457	5	mg/l as HCO_3	SM2320-B	02-10-1997 1100 SW
Alkalinity, Carbonate	<5	5	mg/l as CO_3	SM2320-B	02-10-1997 1100 SW
Alkalinity, Total	375	5	mg/l as $CaCO_3$	EPA 310.1	02-10-1997 1100 SW
Anions	8.7	----	meq/l	----------	02-25-1997 1300 RJ
Calcium, Total	70	1	mg/l	EPA 215.1	02-12-1997 1030 MK
Cations	8.9	----	meq/l	----------	02-25-1997 1300 RJ
Chloride	219	1	mg/l	SM4500-Cl-B	02-10-1997 1030 SW
Conductivity	788	1	umhos/cm	SM2510-B	02-05-1997 1230 SW
Hardness, Total	356	----	mg/l as $CaCO_3$	SM2340-B	02-25-1997 1300 RJ
Iron, Total	<0.1	0.1	mg/l	EPA 236.1	02-12-1997 0730 MK
Iron, Dissolved	<0.1	0.1	mg/l	EPA 236.1	02-12-1997 0730 MK
Magnesium, Total	44	1	mg/l	EPA 242.1	02-12-1997 1100 MK
Manganese, Total	<0.1	0.1	mg/l	EPA 243.1	02-12-1997 0800 MK
Manganese, Dissolved	<0.1	0.1	mg/l	EPA 243.1	02-12-1997 0800 MK
pH	7.39	----	pH units	EPA 150.1	02-04-1997 1245 MK
Potassium, Total	10	1	mg/l	EPA 258.1	02-12-1997 0830 MK
Sodium, Total	36	1	mg/l	EPA 273.1	02-12-1997 0900 MK
Solids, Total Dissolved	444	10	mg/l	EPA 160.1	02-06-1997 0700 JC
Solids, Total Suspended	<5	5	mg/l	EPA 160.2	02-06-1997 0700 JC
Sulfate	49	50	mg/l	EPA 375.4	02-24-1997 0900 RJ
Cation/Anion Balance	1.3	----	%		02-25-1997 1300 RJ

Respectfully submitted,
COMMERCIAL TESTING & ENGINEERING CO.

Larry Stout

Huntington Laboratory RJ

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February 26, 1997

GENWAL RESOURCES, INC.
P.O. BOX 1420
HUNTINGTON UTAH 84528

Sample identification by
GENWAL COAL CO.

ID: MW-1

Kind of sample reported to us: Water

Rec'd 1115 hr.
Sampled 1610 hr.

Sample taken at: Genwal

Sample taken by: Genwal

Date sampled: February 3, 1997

Date received: February 4, 1997

Field Measurements
pH 7.95
DO 7.8
Conductivity 500
Temperature 12.7°C

NOTE: Dissolved Iron filtered at lab!

Analysis report no. 59-16966

Parameter	Result	MRL	Units	Method	Analyzed Date/Time/Analyst
Alkalinity, Bicarbonate	293	5	mg/l as HCO_3	SM2320-B	02-10-1997 1100 SW
Alkalinity, Carbonate	<5	5	mg/l as CO_3	SM2320-B	02-10-1997 1100 SW
Alkalinity, Total	240	5	mg/l as $CaCO_3$	EPA 310.1	02-10-1997 1100 SW
Anions	5.5	----	meq/l	---------	02-25-1997 1100 RJ
Calcium, Total	19	1	mg/l	EPA 215.1	02-12-1997 1030 MK
Cations	5.5	----	meq/l	---------	02-25-1997 1100 RJ
Chloride	12	1	mg/l	SM4500-Cl-B	02-10-1997 1030 SW
Conductivity	517	1	umhos/cm	SM2510-B	02-05-1997 1230 SW
Hardness, Total	113	----	mg/l as $CaCO_3$	SM2340-B	02-25-1997 1100 RJ
Iron, Total	0.8	0.1	mg/l	EPA 236.1	02-12-1997 0730 MK
Iron, Dissolved	<0.1	0.1	mg/l	EPA 236.1	02-12-1997 0730 MK
Magnesium, Total	16	1	mg/l	EPA 242.1	02-12-1997 1100 MK
Manganese, Total	<0.1	0.1	mg/l	EPA 243.1	02-12-1997 0800 MK
pH	7.96	----	pH units	EPA 150.1	02-04-1997 1245 MK
Potassium, Total	4	1	mg/l	EPA 258.1	02-12-1997 0830 MK
Sodium, Total	73	1	mg/l	EPA 273.1	02-12-1997 0900 MK
Solids, Total Dissolved	244	10	mg/l	EPA 160.1	02-06-1997 0700 JC
Solids, Total Suspended	<5	5	mg/l	EPA 160.2	02-06-1997 0700 JC
Sulfate	18	5	mg/l	EPA 375.4	02-24-1997 1230 SW
Cation/Anion Balance	0.2	----	%		02-25-1997 1100 RJ

Respectfully submitted,
COMMERCIAL TESTING & ENGINEERING CO.

Larry Stout

Huntington Laboratory RP

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FAX: (801) 653-24

February 26, 1997

GENWAL RESOURCES, INC.
P.O. BOX 1420
HUNTINGTON UTAH 84528

Sample identification by
GENWAL COAL CO.

ID: 8th East Roof Drips

Rec'd 1115 hr.
Sampled 1155 hr.

Field Measurements
pH 8.4
DO 4.7
Conductivity 407
Temperature 11.9°C

NOTE: pH expired when received!
NOTE: Dissolved Iron filtered at lab!

Kind of sample reported to us: Water

Sample taken at: Genwal

Sample taken by: Genwal

Date sampled: February 3, 1997

Date received: February 4, 1997

Analysis report no. 59-16959

Parameter	Result	MRL	Units	Method	Analyzed Date/Time/Analyst
Alkalinity, Bicarbonate	264	5	mg/l as HCO_3	SM2320-B	02-10-1997 1100 SW
Alkalinity, Carbonate	<5	5	mg/l as CO_3	SM2320-B	02-10-1997 1100 SW
Alkalinity, Total	218	5	mg/l as $CaCO_3$	EPA 310.1	02-10-1997 1100 SW
Anions	4.5	----	meq/l	---------	02-25-1997 1030 RJ
Calcium, Total	10	1	mg/l	EPA 215.1	02-12-1997 1030 MK
Cations	4.5	----	meq/l	---------	02-25-1997 1030 RJ
Chloride	5	1	mg/l	SM4500-Cl-B	02-10-1997 1030 SW
Conductivity	415	1	umhos/cm	SM2510-B	02-05-1997 1230 SW
Hardness, Total	54	----	mg/l as $CaCO_3$	SM2340-B	02-25-1997 1030 RJ
Iron, Total	0.8	0.1	mg/l	EPA 236.1	02-12-1997 0730 MK
Iron, Dissolved	<0.1	0.1	mg/l	EPA 236.1	02-12-1997 0730 MK
Magnesium, Total	7	1	mg/l	EPA 242.1	02-12-1997 1100 MK
Manganese, Total	<0.1	0.1	mg/l	EPA 243.1	02-12-1997 0800 MK
pH	8.14	----	pH units	EPA 150.1	02-04-1997 1245 MK
Potassium, Total	3	1	mg/l	EPA 258.1	02-12-1997 0830 MK
Sodium, Total	77	1	mg/l	EPA 273.1	02-12-1997 0900 MK
Solids, Total Dissolved	226	10	mg/l	EPA 160.1	02-06-1997 0700 JC
Solids, Total Suspended	<5	5	mg/l	EPA 160.2	02-06-1997 0700 JC
Sulfate	<5	5	mg/l	EPA 375.4	02-24-1997 0900 RJ
Cation/Anion Balance	0.4	----	%		02-25-1997 1030 RJ

Bottle

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COMMERCIAL TESTING & ENGINEERING CO.
Larry Stott
Huntington Laboratory RJ

APPENDIX 7-53

SUMMARY OF NEW ISOTOPIC INFORMATION

FOR LBA 11

1/23/95 revised 4/97

Summary of New Isotopic Information for LBA 11

Genwal Resources, Inc., Huntington, Utah

07 November 1997

Mayo and Associates, LC
Consultants in Hydrogeology

Summary of New Isotopic Information for LBA 11

Genwal Resources, Inc., Huntington, Utah

07 November 1997

Prepared by:

Erik C. Petersen
Senior Hydrogeologist

Alan L. Mayo, Ph.D.
California Registered Geologist #3265

Mayo and Associates, LC
710 East 100 North
Lindon, Utah 84042

Mayo and Associates, LC
Consultants in Hydrogeology

SUMMARY OF NEW ISOTOPIC INFORMATION FOR LBA 11

INTRODUCTION

As part of the collection of baseline information for LBA 11, Genwal Resources, Inc. is currently conducting an extensive water isotopic data collection program. Samples have been collected from springs and streams within LBA 11 and the existing Genwal lease area, and from groundwaters within the existing Crandall Canyon Mine. These samples have been analyzed for stable δ^2H and $\delta^{18}O$ compositions, and for unstable ^3H (tritium) and ^{14}C compositions. The locations of these samples are shown in Figure 1. The solute chemistries are represented as Stiff diagrams on Figure 1. The results of the isotopic analyses are presented in Table 1. The computed mean residence times are given in Table 2. The stable δ^2H and $\delta^{18}O$ compositions are plotted in Figure 2. The purpose of this document is to convey the preliminary findings of this ongoing investigation to date.

Since Mayo and Associates released its report *Supplemental Hydrogeologic Information for LBA 11* (18 March 1997) Genwal has installed five new wells inside the Crandall Canyon Mine. Each of the wells are constructed with 1.25 inch I.D. PVC pipe, and are plugged with bentonite and sealed to the surface with cement. Two of these new wells, MW-6A and MW-8, are completed in the Spring Canyon Member of the Star Point Sandstone. Well MW-6 is completed in the Panther Member of the Star Point Sandstone. Well UDH 46-97 was drilled upward into the Blackhawk Formation above the coal seam. Well MW-7 is completed approximately 200 feet from the Joes Valley Fault system in the Spring Canyon Member of the Star Point Sandstone. Additionally, a sample of groundwater was collected from new mine workings which encountered the Joes Valley Fault system in 5th West (5th West fault). The results of the isotopic analyses for these locations are discussed below.

RESULTS

Spring Canyon Sandstone

MW-6A

MW-6A was drilled to a depth of approximately 105 feet to the Spring Canyon Sandstone Member of the Star Point Sandstone just north of an east-west trending igneous dike. The water from MW-6 is of the Ca^{2+}-Mg^{2+}-HCO_3^- chemical type which is similar to most other waters within the mine. The ^{14}C content of MW-6A is 8.75 pmc (percent modern carbon), which, when modeled using Pearsons, Mooks, and Fontes models, yields a mean groundwater residence time of between 14,500 and 15,400 years. The tritium (^3H) content of the water (0.20 TU) is near the laboratory detection limit. The stable isotopic δ^2H and $\delta^{18}O$ composition of this water (δ^2H = -130‰, $\delta^{18}O$ = -17.4‰) is similar to that of the other in-mine groundwater samples.

MW-8

MW-8 was drilled to a depth of approximately 105 feet to the Spring Canyon Member of the Star Point Sandstone just south of the igneous dike. The water from MW-8 is also of the Ca^{2+}-Mg^{2+}-HCO_3^- chemical type. Groundwater from MW-8 has a significantly greater residence time than does MW-6A. The ^{14}C content of 4.90 pmc yields a mean groundwater age of between 18,300 and 19,500 years. The ^3H content (0.10 TU) is near the laboratory detection limit. The stable isotopic δ^2H and $\delta^{18}O$ composition of this water (δ^2H = -131‰, $\delta^{18}O$ = -17.3‰) is similar to that of the other in-mine groundwater samples.

Panther Sandstone

MW-6

A single well, MW-6, was completed in the Panther Sandstone Member of the Star Point Sandstone to a depth of 352 feet. The well is located adjacent to MW-6A near an altered mafic igneous dike. The solute chemistry of the groundwater from MW-6 is different from that of other groundwater samples from the Star Point Sandstone in the area. The laboratory analysis indicates that the water is of the Ca^{2+} - OH^- type. We believe that the areal extent of this groundwater is probably limited and that its chemical composition is related to the adjacent igneous dike. An investigation of the chemical origin of the MW-6 groundwater was completed by David Tingey Analytical Consulting (DTAC). David Tingey of DTAC has extensive experience with the chemistry and history of Igneous Dikes in the Wasatch Plateau. DTAC concluded that the unusually high pH and elevated TDS of the water are the result of serpentization of olivine minerals in the igneous dike in a relatively inactive groundwater flow system. We agree with their findings. The ^{14}C content of the groundwater in this well (30.39 pmc) indicates a mean groundwater residence time of 6,000 to 6,900 years. The ^3H content of 0.43 TU is near the laboratory detection limit. The stable isotopic δ^2H and $\delta^{18}O$ composition of this water (δ^2H = -131‰, $\delta^{18}O$ = -17.2‰) is similar to that of the other in-mine groundwater samples.

Blackhawk Formation

UDH 46-97

A vertical drill hole (UDH 46-97) was drilled upward from the mine workings into the overlying Blackhawk Formation. This hole is open over its entire extent except for 4 feet of surface casing. During drilling, no water was encountered in the Cottonwood coal seam (approximately 50 feet above the Hiawatha seam). Water was encountered in the Blind Canyon seam at approximately 94 feet. The groundwater drainage from this hole is minimal. At the time of sampling, discharge was only 0.1 gpm. The groundwater discharging from

UHD 46-97 is of the Ca^{2+}-Mg^{2+}-HCO_3^- type. The measured ^{14}C content of the groundwater discharging from this drill hole (9.65 pmc) yields a mean groundwater age of between 12,300 and 13,800 years. The ^{3}H content was near the laboratory detection limit at 0.00 TU. The stable isotopic δ^2H and $\delta^{18}O$ composition of this water (δ^2H = -132‰, $\delta^{18}O$ = -17.4‰) is similar to that of the other in-mine groundwater samples.

Joes Valley Fault System

MW-7

Well MW-7 was drilled into the Spring Canyon Member of the Star Point Sandstone approximately 200 feet from the Joes Valley Fault system. The groundwater in MW-7 is of the Ca^{2+}-Mg^{2+}-HCO_3^- type. The ^{14}C composition of the groundwater from MW-7 (31.85 pmc) yields a mean groundwater residence time of between 4,200 and 5,200 years. The ^{3}H content of 0.01 TU is near the laboratory detection limit. This calculated groundwater age is similar to that of groundwaters taken directly from the fault system, but is much younger than that of groundwaters taken from the Spring Canyon Member away from the fault. The stable isotopic δ^2H and $\delta^{18}O$ composition of this water (δ^2H = -131‰, $\delta^{18}O$ = -17.3‰) is similar to that of the other in-mine groundwater samples.

5th West Fault

Recently, the mine workings in the 5th West area in the northwestern portion of the existing lease encountered the Joes Valley Fault system. Water discharging from the fault at the mining face was sampled and analyzed. The groundwater discharging from the Joes Valley Fault at this location is of the Ca^{2+}-Mg^{2+}-HCO_3^- type. A ^{14}C content of 34.99 pmc was measured which yields a mean groundwater age of between 3,200 and 4,600 years. This age is similar to that calculated for Joes Valley Fault system water encountered previously at the western end of the West Mains. The stable isotopic δ^2H and $\delta^{18}O$ composition of this water (δ^2H = -131‰, $\delta^{18}O$ = -17.5‰) is similar to that of the other in-mine groundwater samples. The ^{3}H content of this water sample is 0.95 TU.

SUMMARY

The findings of this most recent round of isotopic sampling support the conclusions of the previous report by Mayo and Associates *Supplemental Hydrogeologic Information for LBA 11* (18 March 1997).

All of the ^{3}H contents of groundwaters from within the mine are less than 1 TU. Groundwaters from the Blackhawk Formation and Spring Canyon Sandstone Member of the Star Point Sandstone have radiocarbon ages between about 13,000 and 20,000 years. Groundwater from a single well in the Panther Sandstone Member of the Star Point Sandstone is between 6,000 and 6,900 radiocarbon years. Groundwater in the Joes Valley Fault system has a mean radiocarbon age between about 2,000 and 5,000 years. The water discharging from Little Bear Spring is unquestionably of modern origin. Previous investigations conducted by Mayo and Associates in the Wasatch Plateau and the Book Cliffs coal districts have shown that the overwhelming majority of springs discharge modern water. In Figure 3, mean groundwater residence times are plotted against ^3H compositions of samples collected by Mayo and Associates from springs and creeks, and from within coal mines in the Wasatch Plateau and Book Cliffs coal fields. It is readily apparent that the waters are partitioned into modern waters (most springs, creeks, and wells) which contain abundant tritium, and very old waters (mostly in-mine samples) which contain essentially no tritium. The stable δ^2H and $\delta^{18}O$ compositions of the groundwaters from within the mine cluster together in the lower portions of the plot in Figure 2. The creek samples and Little Bear Spring sample cluster together in the upper portion of the plot. This suggests dissimilar origins for the in-mine waters and the modern, near-surface waters. The groundwater from the Panther Sandstone Member of the Star Point Sandstone beneath the mine (MW-6) has a pH and a solute chemical composition which is entirely different from that which discharges from the Panther Sandstone at Little Bear Spring. Clearly, the water discharging from Little Bear Spring is not derived from the water beneath the mine near MW-6. All of this information strongly suggests that the in-mine waters are hydrologically isolated from the shallowly circulating modern waters in overlying springs and creeks. The modern groundwater discharging from Little Bear Spring is not related to the groundwater encountered in the mine and, thus, should not be impacted by future mining operations.

Mayo and Associates
Genbase.cdr 11 March 1997

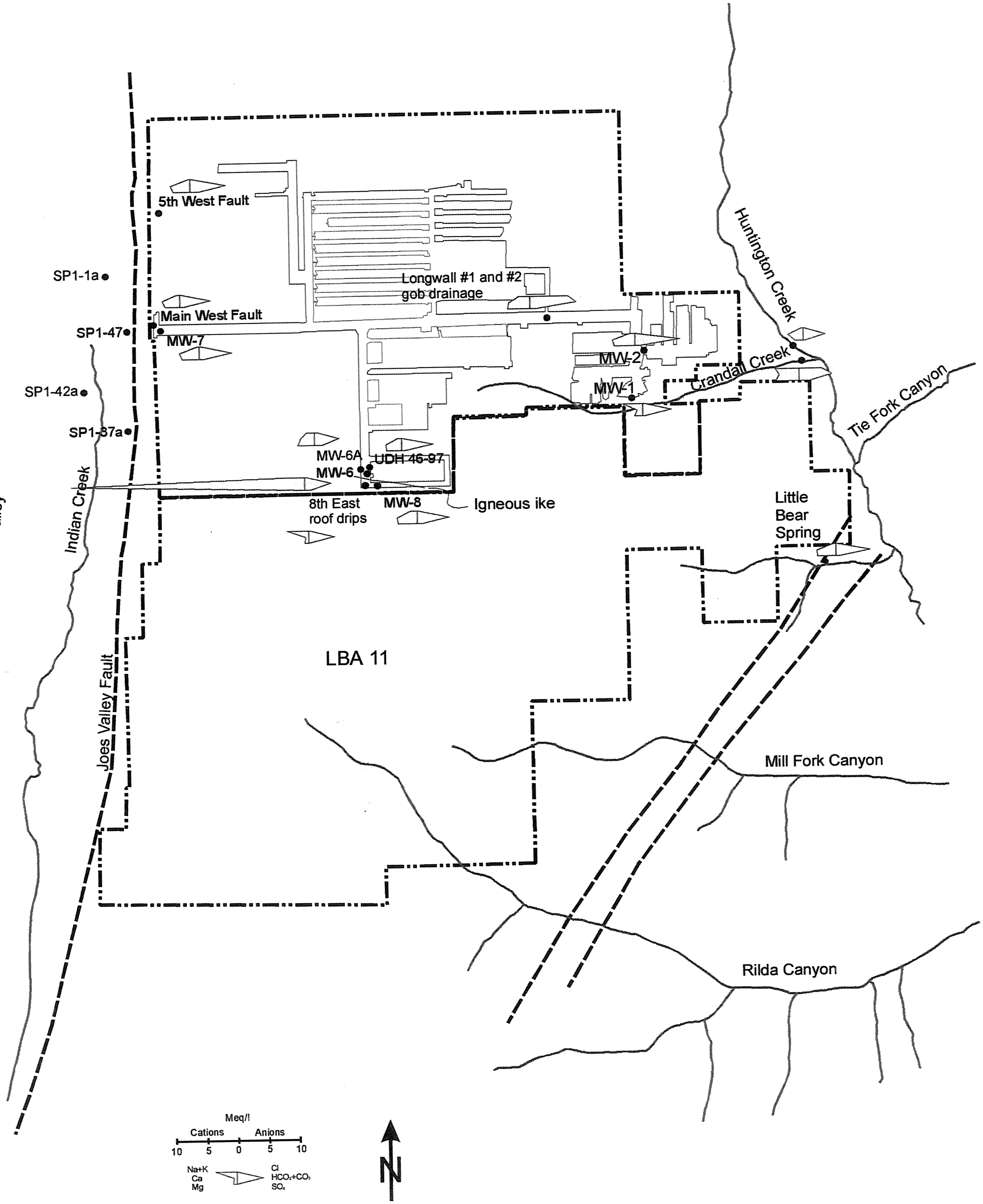

Figure 1 Location of the Genwal study area with Stiff diagrams representing solute compositions of groundwaters and surface waters.

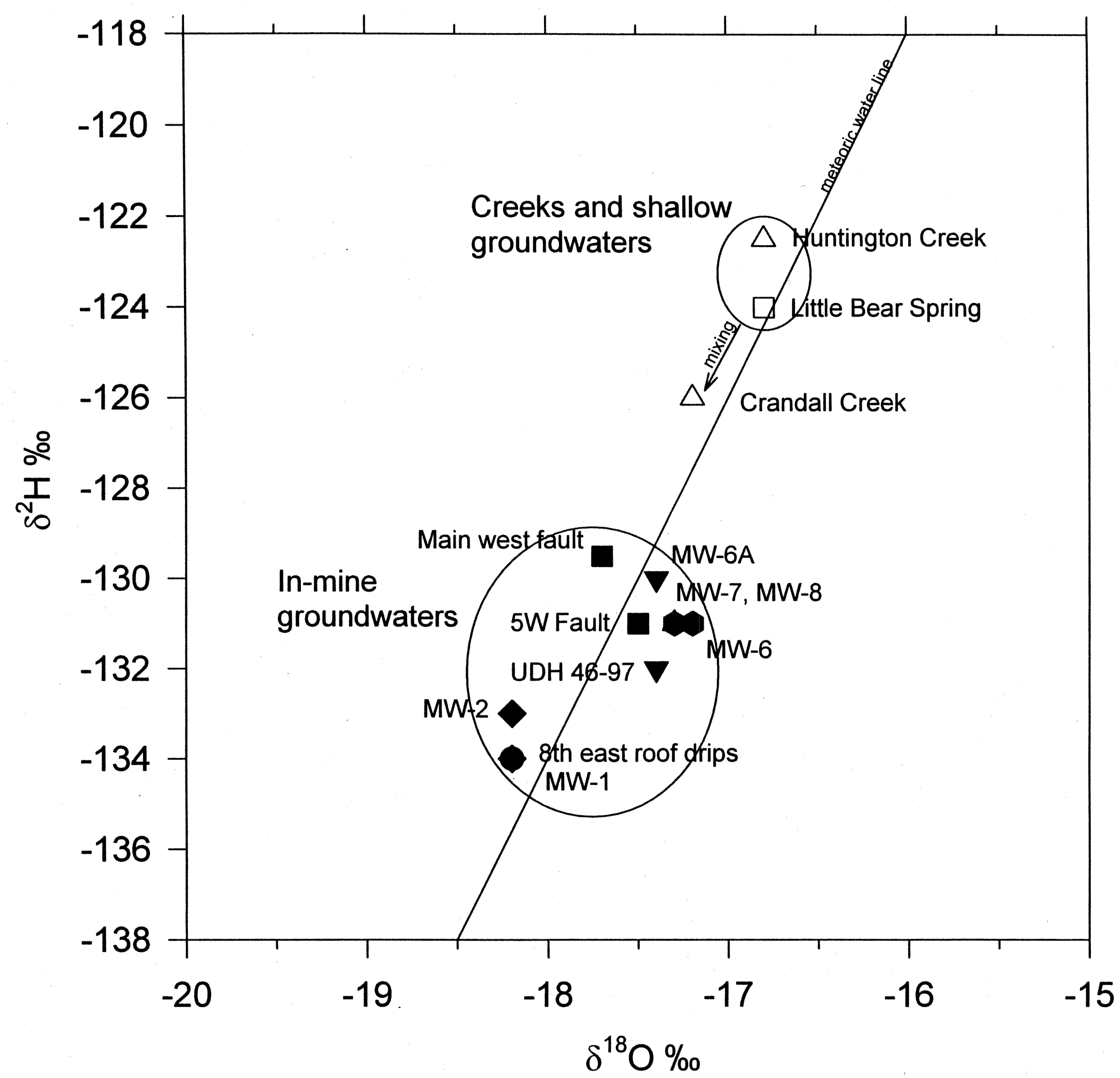

Figure 2 Deuterium and oxygen-18 plot of groundwaters and surface waters in the vicinity of the Crandall Canyon Mine.

(coal1.spt 3/5/97)

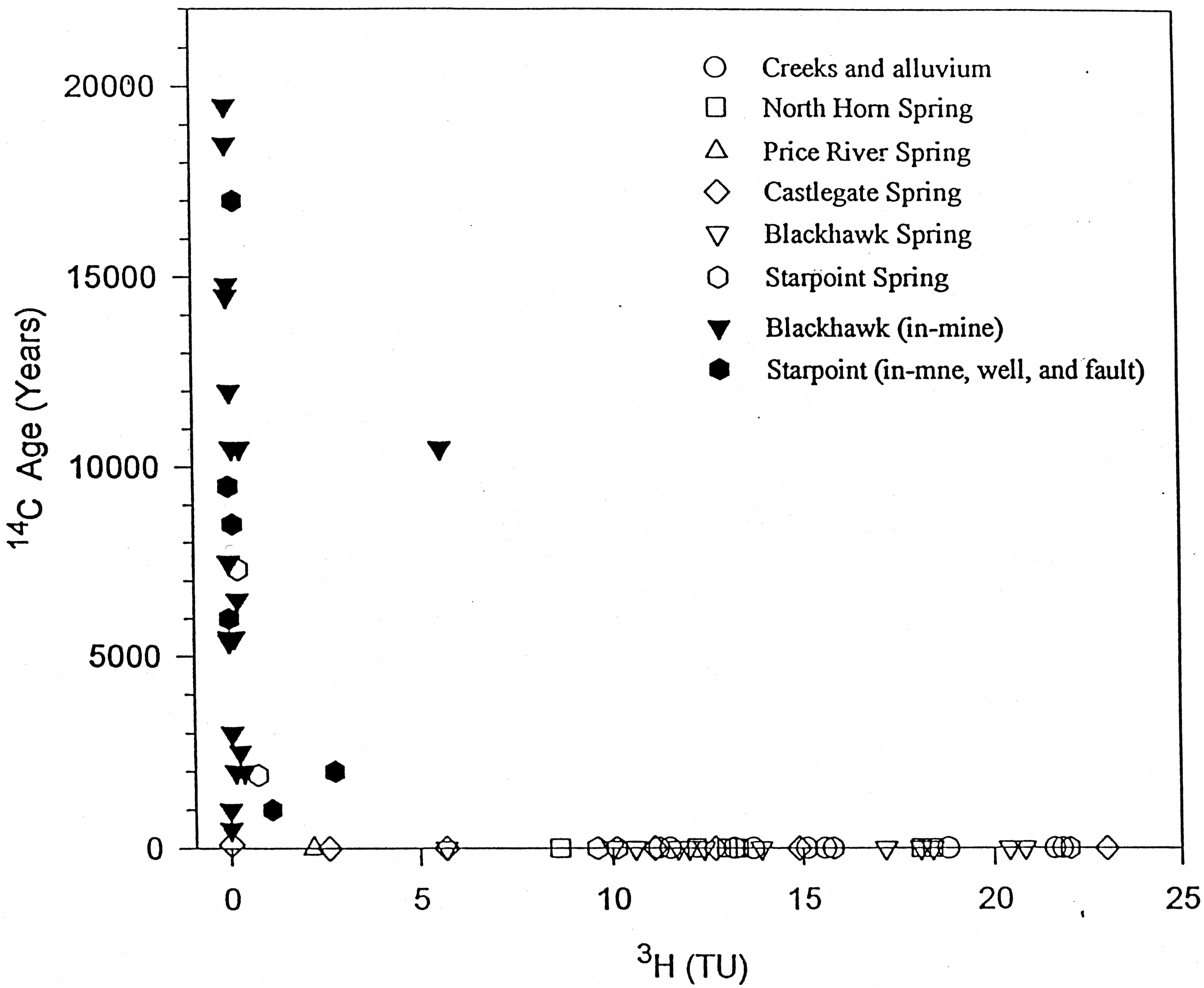

Figure 3 Mean groundwater residence time of springs, creeks, wells, and in-mine samples from the Wasatch Plateau and Book Cliffs coal districts plotted against tritium concentrations.

Table 1 Solute and isotopic composition of surface waters and groundwaters in the vicinity of the Crandall Canyon Mine.

genchem.xls 07 November 1997

		T	pH	Cond.	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	HCO_3^-	CO_3^-	Cl^-	SO_4^{2-}	δ^2H	$\delta^{18}O$	$\delta^{13}C$	^{14}C	^3H
		°C		υmhos/cm	mg/L								‰			pmc	TU
Springs																	
Little Bear Spring	10/95 and 9/96[1]	8.9	7.6	556	62	37	7	1	341	0	7	29	-124	-16.8	-9.7[1]	71.12[1]	22.00[1]
Creeks																	
Crandall Creek	3-Feb-97	2.5	8.6	1120	66	47	89	5	326	0	130	85	-126	-17.2	-7.2	62.74	9.3
Huntington Creek	3-Feb-97	0.6	8.7	387	51	17	5	0	225	0	8	15	-123	-16.8	-10.2	73.22	11.5
Blackhawk Formation																	
8th East roof drips	3-Feb-97	11.9	8.4	407	10	7	77	3	264	0	5	0	-134	-18.2	-8.4	8.41	0.02
UDH 46-97	5-Jun-97	10.7	8.1	504	50	29	15	4	316	0	5	26	-132	-17.4	-8.5	9.65	0
Joes Valley Fault system																	
Main West fault	3-Feb-97	9.3	7.95	507	57	28	5	7	304	0	5	32	-130	-17.7	-10.7	40.07	0.06
5th West Fault	5-Jun-97	11.1	8	520	62	32	3	2	346	0	6	67	-131	-17.5	-11	34.99	0.95
MW-7	5-Jun-97	12.1	7.7	511	62	32	4	2	319	0	10	33	-131	-17.3	-10.8	31.85	0.01
Star Point Sandstone																	
Spring Canyon Sandstone																	
MW-1	3-Feb-97	12.7	7.95	500	19	16	73	4	293	0	12	18	-134	-18.2	---	---	---
MW-2	3-Feb-97	10.9	7.3	731	74	41	14	5	456	0	5	39	-133	-18.2	-11.2	5.79	0.03
MW-8	5-Jun-97	14.1	7.8	547	64	37	17	6	317	0	8	40	-131	-17.3	-9	4.9	0.1
MW-6A	5-Jun-97	14.2	8.2	544	46	32	22	12	243	0	17	61	-130	-17.4	-10.1	8.75	0.2
Panther Sandstone																	
MW-6	5-Jun-97	13.3	12.6	6170	742	5	62	24	0	128	13	48	-131	-17.2	-12.6	30.39	0.43

[1] Samples collected Oct. 95 and Sept. 96 by Castle Valley Special Services District

Mayo and Associates
Consultants in Hydrogeology

Table 2 Calculated ^{14}C - ^{3}H mean groundwater residence times for the Genwal Mine area.

genage.xls 28 Jul 1997

	Mean residence time (years)								
	$\delta^{13}C$ = -20‰ (gas) assumption			$\delta^{13}C$ = -18‰ (gas) assumption					
	Pearsons Model	Mooks Model	Fontes Model	Pearsons Model	Mooks Model	Fontes Model	^{14}C pmc	$\delta^{13}C$ ‰	^{3}H TU
Creeks and springs									
Little Bear Spring	modern	modern	modern	modern	modern	modern	71.12	-9.7	22.00
Huntington Creek	modern	modern	modern	modern	modern	modern	73.22	-10.2	11.50
Crandall Creek	modern	modern	modern	modern	modern	modern	62.74	-7.2	9.30
Spring SP1-1a	---	---	---	---	---	---	---	---	29.20
Spring SP1-47	---	---	---	---	---	---	---	---	38.20
Spring SP1-37	---	---	---	---	---	---	---	---	33.30
Spring SP1-42a	---	---	---	---	---	---	---	---	19.20
Joes Valley Fault system									
Main West fault	2,400	2,100	2,100	3,600	2,100	2,100	40.07	-10.7	0.06
5th West fault	3,700	3,000	3,000	4,600	3,000	3,000	34.99	-11.0	0.95
MW-7	4,400	4,200	4,200	5,200	4,200	4,200	31.85	-10.8	0.01
Blackhawk Formation									
8th East roof drips	13,300	14,800	14,800	14,200	14,800	14,800	8.41	-8.4	0.02
UDH 46-97	12,300	13,800	13,800	13,100	13,800	13,800	9.65	-8.5	0.00
Starpoint Sandstone									
Spring Canyon Sandstone									
MW-2	18,800	18,800	18,800	19,600	18,800	18,800	5.79	-11.2	0.03
MW-6A	14,500	14,500	14,500	15,400	14,500	14,500	8.75	-10.1	0.20
MW-8	18,300	19,500	19,500	19,200	19,500	19,500	4.90	-9.0	0.10
Panther Sandstone									
MW-6	6,000	---	---	6,900	---	---	30.39	-12.6	0.43

Assumptions used in all calculations:
$\delta^{13}C$ mineral = 0‰
Activity ^{14}C gas = 100 pmc
Activity ^{14}C mineral = 0 pmc

DTAC *David Tingey Analytical Consulting*
1824 East 750 South, Springville, Utah 84663
phone: (801) 489-4577

Client: Mayo and Associates
710 East 100 North
Lindon, Utah 84042
(801) 796-0211
requested by: Erik Peterson

Date: October 23, 1997

Project: Genwal Resources Inc., water MW-6 investigation

Summary of conclusions: The chemical data reported by Commercial Testing and Engineering Co. (CTE) is reasonably accurate. Water from well MW-6 has an unusual calcium-hydroxide (Ca^{2+}-OH^{-})-type composition, yet it is naturally occurring. This unusual composition originated from the addition of calcium oxide (CaO) and the consumption of hydrogen ion (H^{+}) in the water as a result of serpentinitzation (alteration) of olivine minerals in an ultramafic igneous dike located approximately 300 feet south of the MW-6 wellhead. The stratigraphy below the Genwal Resources Inc., Crandall Canyon #1 Mine, Hiawatha Seam is interpreted to have contributed to the formation of this unusual water by causing a stagnant bounded water system in the Panther Sandstone that is dammed by the dike. Neither mining operations in the Crandall Canyon #1 Mine nor drilling of the MW-6 well have adversely affected the water composition.

Problem: Water sampled from well MW-6 has an unusually high pH (12.6 field). Chemical data reported by Commercial Testing and Engineering Co. Huntington office (CTE) has a cation/anion balance error of 75.7% (CTE data for MW-6 included at the end of paper). Errors over 5% are generally considered suspect and an indication of an inaccurate chemical analysis. The lab reported that the water sample has high hydroxide alkalinity which was not reported. The presence of hydroxide in high concentrations balances the cations and would correct the error balance. Is this data accurate and if so how does a natural water of this composition originate?

Methods: Field reconnaissance to determine the geologic setting and to inspect the well construction; chemical analysis of the water sample by: Atomic Absorption Spectrometery (AA), Ion Chromatography (IC), and wet chemistry titration; analysis of solid residue after evaporation of the water by: X-ray Fluorecence Spectrometery (XRF), X-ray Diffraction (XRD), and chemical tests; laboratory experiments to synthesize a water of similar composition.

Data: Well MW-6 was drilled in the floor of Genwal Resources Inc., Crandall Canyon #1 Mine. The mine is located in the Hiawatha Seam which sits on the Spring Canyon member of the Star Point Sandstone. All indications are that the well was constructed using conventional techniques with PVC pipe casing. Gary Gray's field notes document that the well bottomed out in the Panther Sandstone member and is screened at this horizon. Above the screen horizon, conventional techniques were used to seal around the casing with bentonite pellets and concrete. The well stem is approximately 3 feet tall and had a well-purge pipe extending down the well which also capped the well. The well has been purged several times, likely displacing a volume of water sufficient to remove any contamination which might have been introduced during well construction. A second, shallower well is located approximately 10 feet east of the MW-6 well. Erik Peterson from Mayo and Associates said that analysis of water from this shallower well is normal and similar to water sampled from other wells in the area. Gary Gray indicated that the two wells were drilled at the same time using the same techniques.

Located approximately 300 feet south of the MW-6 wellhead, the Hiawatha coal seam is cut by a 3 foot wide, vertical, N80°W-striking ultramafic minette dike. Within the coal seam the dike is extremely altered to calcite and clay. The only primary mineral remaining is a trace of phlogopite (mica). The dike, which cuts the Hiawatha coal seam in the Crandall Canyon #1 mine, is part of a more extensive swarm of dikes located in the Wasatch Plateau. Several dikes in the swarm with N80°W orientations have been dated by K-Ar methods and indicate these dikes were emplaced 24 million years ago during the Miocene (Tingey and others, 1991). Fresh unaltered minette dikes are minerallogically composed of phlogopite, olivine, and pyroxene.

Chemical analysis in our laboratory of water MW-6 using standard EPA methods has shown that the analysis completed by Commercial Testing and Engineering Co., Huntington Office (CTE) is reasonably accurate (see CTE data). I measured a pH of 12.3 and determined that the water had high concentrations of calcium as the primary cation and low concentrations of the anions bicarbonate, carbonate, chloride and sulfate. Titration of the water with dilute HCl indicated that the water has a high hydroxide alkalinity as reported by CTE. Hydroxide (OH^-) with a concentration of approximately 575 mg/L would balance the cations present in water MW-6. Qualitative XRF analysis for elements heavier than atomic number 13 indicates that the residue is composed of calcium (Ca) with lesser amounts of sulfur (S), chlorine (Cl), potassium (K), phosphorous (P), and strontium (Sr). XRD analysis of the residue showed that it is composed of calcium oxide (CaO) and lesser amounts of calcite ($CaCO_3$).

Laboratory experiments were set up to synthesize a water of similar composition to MW-6. Measured amounts of CaO, $CaCO_3$, and Portland Cement were added to three beakers of ultrapure DI water (filtered to 0.2 micron and processed through a Millipore water purification system). The amount of reagent added was calculated to give a calcium concentration similar to that measured in water MW-6. Portland cement was investigated as a possible contaminant introduced during well construction. The results of these experiments indicate that the addition of CaO produced a water chemistry similar to that of water MW-6 with a pH of 11.7 and similar chemical properties during titration. The addition of $CaCO_3$, and Portland Cement produced water chemistries unlike MW-6 and can be ruled out as possible explanations for this unusual water chemistry.

Discussion and Conclusions:

The chemical data for water sample MW-6 reported by Commercial Testing and Engineering Co. (CTE) is reasonably accurate and agrees with the data collected in our laboratory. Water from the MW-6 well can best be described as naturally- occurring, having an unusual calcium-hydroxide (Ca^{2+}-OH^{-})-type composition. Mining operations in the Crandall Canyon #1 Mine or the drilling of well MW-6 have had no impact on the water composition.

Meteoric water with unusally high pH and a calcium-hydroxide (Ca2+-OH-)-type composition which are associated with utramafic rocks have been reported by Barnes and others, (1967) for several locations in California, and by Maksimovic and others, (1995) in Serbia. Waters from Red Mountain Stanislaus County, and Santa Clara County, California have a pH of 11.78 and 12.01 with calcium as the primary cation, low magnesium concentration and no detectable bicarbonate and carbonate (Barnes and others, 1967). These unusual hydroxide- balanced waters are attributed to serpentinization of olivine in ultramafic rocks which contributes CaO to the water. In the U.S. Geological Survey Water-Supply paper 2254, (Hem, 1992) the formation of these unusually-high pH waters associated with ultramafic rocks is attributed to reactions consuming H^{+} at a higher rate than the influx of carbon dioxide species. Calcium oxide (CaO) released into the water disassociates in the following reaction: $CaO + H^{+} \leftrightharpoons Ca^{2+} + OH^{-}$. As the H^{+} ions are consumed the pH goes up. In order for this unusual water to be formed these conditions must also include the lack of carbon dioxide (CO_2) species being added to the system. If CO_2 is added to the system, carbonic acid forms and calcite ($CaCO_3$) precipatates from the water, causing the pH to drop.

The structural relationship between the vertical N80°W- striking ultramafic igneous dike, the Panther sandstone, and the low permeable shales above and below the Panther sandstone have contributed to the formation of this unusual water. The local gentle dip of the Panther sandstone towards the ultramafic dike, combined with the bounding shales, creates a stagnant water system dammed by the dike. These conditions within the Panther sandstone allowed time for this unsual water to form from the slow chemical reactions taking place as the olivine minerals within the dike serpentinized, releasing calcium oxide (CaO). Low water flow rates have also contributed by keeping an influx of carbon dioxide from entering the water system.

References:

Barnes, I., LaMarche, V.C., Jr., and Himmelberg, G., 1967, Geochemical evidence of present-day serpentinitzation. Science, v. 156, pages 830-832.

Hem, J.D., 1992, Study and Interpretation of the Chemical Characteristics of Natural Water. U.S. Geological Survey Water-Supply Paper, 264 pages.

Maksimovic, Z.J., Jovanovic, T., Rsumovic, M., 1995, Magnesium bicarbonate- and calcium hydroxide-type waters from ultramafic rocks in Serbia and the curative uses. Special Publications of the Geological Society of Greece, 4, part 3, pages 898-902, Geological Society of Greece.

Tingey, D.G., Christiansen, E.H., Best, M.G., Ruiz, J., Lux D. R., 1991, Tertiary Minette and Melanephelinite Dikes, Wasatch Plateau, Utah: Records of Mantle Heterogeneities and Changing Tectonics. Journal of Geophysical Research, vol. 96, No. B8, pages 13,529-13,544.

COMMERCIAL TESTING & ENGINEERING CO.
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SINCE 1908
SGS Member of the SGS Group (Société Générale de Surveillance)

PLEASE ADDRESS ALL CORRESPONDENCE TO:
P.O. BOX 1020, HUNTINGTON, UT 84528
TEL: (801) 653-2311
FAX: (801) 653-2436

July 8, 1997

GENWAL RESOURCES, INC.
P.O. BOX 1420
HUNTINGTON UTAH 84528

Sample identification by
GENWAL COAL CO.

ID: MW-6
Rec'd 0900 hr.
Sampled 1605 hr.

Kind of sample reported to us: Water

Sample taken at: Genwal

Sample taken by: Genwal

Date sampled: June 5, 1997

Date received: June 6, 1997

Field Measurements
pH 12.6
DO 11.2
Conductivity 6170
Temperature 13.3°C

NOTE: Dissolved Iron filtered at lab!
NOTE: Charge balance greater than 10 due to high Hydroxide Alkalinity in sample!

Analysis report no. 59-17276

Parameter	Result	MRL	Units	Method	Analyzed Date/Time/Analyst
Alkalinity, Bicarbonate	<50	50	mg/l as HCO_3	SM2320-B	06-16-1997 1700 RJ
Alkalinity, Carbonate	128	50	mg/l as CO_3	SM2320-B	06-16-1997 1700 RJ
Alkalinity, Total	1405	50	mg/l as $CaCO_3$	EPA 310.1	06-16-1997 1700 RJ
Anions	5.6	----	meq/l	---------	07-07-1997 0800 RJ
Calcium, Total	742	5	mg/l	EPA 215.1	06-27-1997 1145 MK
Cations	40.7	----	meq/l	---------	07-07-1997 0800 RJ
Chloride	13	1	mg/l	SM4500-Cl-B	06-30-1997 1100 RJ
Conductivity	5890	1	umhos/cm	SM2510-B	06-10-1997 1400 SW
Hardness, Total	1873	----	mg/l as $CaCO_3$	SM2340-B	07-07-1997 0800 RJ
Iron, Total	1.6	0.1	mg/l	EPA 236.1	06-27-1997 0745 MK
Iron, Dissolved	<0.1	0.1	mg/l	EPA 236.1	06-27-1997 0745 MK
Magnesium, Total	5	1	mg/l	EPA 242.1	06-27-1997 1215 MK
Manganese, Total	0.2	0.1	mg/l	EPA 243.1	06-27-1997 0830 MK
Oxygen, Dissolved	2.0	----	mg/l	EPA 360.1	06-06-1997 0915 MK
pH	11.86	----	pH units	EPA 150.1	06-06-1997 1000 MK
Potassium, Total	24	1	mg/l	EPA 258.1	06-27-1997 0845 MK
Sodium, Total	62	1	mg/l	EPA 273.1	06-27-1997 1030 MK
Solids, Total Dissolved	1390	10	mg/l	EPA 160.1	06-09-1997 0700 JC
Solids, Total Suspended	71	5	mg/l	EPA 160.2	06-12-1997 0700 JC
Sulfate	48	1	mg/l	EPA 375.4	06-27-1997 0830 SC
Cation/Anion Balance	75.7	----	%		07-07-1997 0800 RJ

Post-it® Fax Note 7671	Date 7-8-97 pgs 3
To Jean Semborski	From LAURA
Co./Dept.	Co. CTE
Phone #	Phone #
Fax # 637-8860	Fax #

Respectfully submitted,
COMMERCIAL TESTING & ENGINEERING CO.

Larry Scovil

Huntington Laboratory

GEOCHRON LABORATORIES a division of
KRUEGER ENTERPRISES, INC.
711 CONCORD AVENUE ✦ CAMBRIDGE, MASSACHUSETTS 02138 ✦ U.S.A
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RADIOCARBON AGE DETERMINATION — REPORT OF ANALYTICAL WORK

Our Sample No. GX-23181-PRI

Date Received: 06/23/97

Your Reference: letter of 06/17/97

Date Reported: 06/27/97

Submitted by: Mr. Erik Petersen
Mayo and Associates
710 East 100 North
Lindon, Utah 84042

Sample Name: MW-6A

AGE = 19,570 +/- 1,510 C-14 years BP (C-13 corrected).
(8.75 +/- 1.63) % of the modern (1950) C-14 activity.

Description: Sample of groundwater precipitate.

Pretreatment: The barium salt precipitate was rapidly vacuum filtered and immediately hydrolyzed, under vacuum to recover carbon dioxide from the barium carbonates for the analysis. C-13 analysis was made on a small portion of the same evolved gas.

Comment:

$\delta^{13}C_{PDB} = -10.1$ ‰

Notes: This date is based upon the Libby half life (5570 years) for ^{14}C. The error stated is $\pm 1\sigma$ as judged by the analytical data alone. Our modern standard is 95% of the activity of N.B.S. Oxalic Acid. The age is referenced to the year A.D. 1950.

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RADIOCARBON AGE DETERMINATION — REPORT OF ANALYTICAL WORK

Our Sample No. GX-23182-PRI

Date Received: 06/23/97

Your Reference: letter of 06/17/97

Date Reported: 06/27/97

Submitted by: Mr. Erik Petersen
Mayo and Associates
710 East 100 North
Lindon, Utah 84042

Sample Name: 5th West Fault

AGE = 8,440 +/- 270 C-14 years BP (C-13 corrected).
(34.99 +/- 1.17) % of the modern (1950) C-14 activity.

Description: Sample of groundwater precipitate.

Pretreatment: The barium salt precipitate was rapidly vacuum filtered and immediately hydrolyzed, under vacuum to recover carbon dioxide from the barium carbonates for the analysis. C-13 analysis was made on a small portion of the same evolved gas.

Comment:

$\delta^{13}C_{PDB}$ = -11.0 ‰

Notes: This date is based upon the Libby half life (5570 years) for ^{14}C. The error stated is $\pm 1\sigma$ as judged by the analytical data alone. Our modern standard is 95% of the activity of N.B.S. Oxalic Acid.
The age is referenced to the year A.D. 1950.

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RADIOCARBON AGE DETERMINATION — REPORT OF ANALYTICAL WORK

Our Sample No. GX-23155-PRI

Date Received: 06/10/97

Your Reference: letter of 06/06/97

Date Reported: 06/17/97

Submitted by: Mr. Erik Petersen
Mayo and Associates
710 East 100 North
Lindon, Utah 84042

Sample Name: MW-8 (05 June 1997)

AGE = 24,200 +/- 3,400 C-14 years BP (C-13 corrected).
(4.90 +/- 1.67) % of the modern (1950) C-14 activity.

Description: Sample of groundwater precipitate.

Pretreatment: The barium salt precipitate was rapidly vacuum filtered and immediately hydrolyzed, under vacuum to recover carbon dioxide from the barium carbonates for the analysis. C-13 analysis was made on a small portion of the same evolved gas.

Comment: Small sample; approximately 0.51 grams carbon.

$\delta^{13}C_{PDB}$ = - 9.0 ‰

- -

Notes: This date is based upon the Libby half life (5570 years) for ^{14}C. The error stated is $\pm 1\sigma$ as judged by the analytical data alone. Our modern standard is 95% of the activity of N.B.S. Oxalic Acid.
The age is referenced to the year A.D. 1950.

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RADIOCARBON AGE DETERMINATION — REPORT OF ANALYTICAL WORK

Our Sample No. GX-23157-AMS

Date Received: 06/10/97

Your Reference: telefax rec'd 06/25/97

Date Reported: 07/22/97

Submitted by: Mr. Erik Petersen
Mayo and Associates
710 East 100 North
Lindon, Utah 84042

Sample Name: MW-6

AGE = 9,570 +/- 60 C-14 years BP (C-13 corrected).
(30.39 +/- 0.20) % of the modern (1950) C-14 activity.

Description: Sample of groundwater precipitate.

Pretreatment: The barium salt precipitate was rapidly vacuum filtered and immediately hydrolyzed, under vacuum to recover carbon dioxide from the barium carbonates for the analysis. C-13 analysis was made on a small portion of the same evolved gas.

The sample was very small and analysis by accelerator mass spectrometry (AMS) was required.

Comment:

$\delta^{13}C_{PDB} = -12.6$ ‰

Notes: This date is based upon the Libby half life (5570 years) for ^{14}C. The error stated is $\pm 1\sigma$ as judged by the analytical data alone. Our modern standard is 95% of the activity of N.B.S. Oxalic Acid.

The age is referenced to the year A.D. 1950.

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RADIOCARBON AGE DETERMINATION — REPORT OF ANALYTICAL WORK

Our Sample No. GX-23156-PRI

Date Received: 06/10/97

Your Reference: letter of 06/06/97

Date Reported: 06/17/97

Submitted by: Mr. Erik Petersen
Mayo and Associates
710 East 100 North
Lindon, Utah 84042

Sample Name: UDH 46-97 (05 June 1997)

AGE = 18,780 +/- 1,140 C-14 years BP (C-13 corrected).
(9.65 +/- 1.28) % of the modern (1950) C-14 activity.

Description: Sample of groundwater precipitate.

Pretreatment: The barium salt precipitate was rapidly vacuum filtered and immediately hydrolyzed, under vacuum to recover carbon dioxide from the barium carbonates for the analysis. C-13 analysis was made on a small portion of the same evolved gas.

Comment: Small sample; approximately 0.67 grams carbon.

$\delta^{13}C_{PDB}$ = - 8.5 ‰

- -

Notes: This date is based upon the Libby half life (5570 years) for ^{14}C. The error stated is $\pm 1\sigma$ as judged by the analytical data alone. Our modern standard is 95% of the activity of N.B.S. Oxalic Acid.
The age is referenced to the year A.D. 1950.

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RADIOCARBON AGE DETERMINATION | **REPORT OF ANALYTICAL WORK**

Our Sample No. GX-23154-PRI

Date Received: 06/10/97

Your Reference: letter of 06/06/97

Date Reported: 06/17/97

Submitted by: Mr. Erik Petersen
Mayo and Associates
710 East 100 North
Lindon, Utah 84042

Sample Name: MW-7 (05 June 1997)

AGE = 9,190 +/- 260 C-14 years BP (C-13 corrected).
(31.85 +/- 1.02) % of the modern (1950) C-14 activity.

Description: Sample of groundwater precipitate.

Pretreatment: The barium salt precipitate was rapidly vacuum filtered and immediately hydrolyzed, under vacuum to recover carbon dioxide from the barium carbonates for the analysis. C-13 analysis was made on a small portion of the same evolved gas.

Comment: Relatively small sample; approximately 0.96 grams carbon.

$\delta^{13}C_{PDB}$ = -10.8 ‰

Notes: This date is based upon the Libby half life (5570 years) for ^{14}C. The error stated is $\pm 1\sigma$ as judged by the analytical data alone. Our modern standard is 95% of the activity of N.B.S. Oxalic Acid.

The age is referenced to the year A.D. 1950.

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STABLE ISOTOPE RATIO ANALYSES

REPORT OF ANALYTICAL WORK

Submitted by: Erik C. Petersen
Mayo and Associates
710 East 100 North
Lindon, UT 84042

Date Received: 06/10/97
Date Reported: 07/14/97
Your Reference: Letter of June 6, 1997 Genwal

Our Lab. Number	Your Sample Number	Description	δD*	δ¹⁸O*
HOR-94048	MW-7	Water	-131 -131 **	-17.3
HOR-94049	MW-8	Water	-131	-17.3
HOR-94050	UDH 46-97	Water	-132 -131 **	-17.4 -17.4 *
HOR-94051	MW-6	Water	-131	-17.2

** Duplicate analyses on separate aliquots of original sample.

*Unless otherwise noted, analyses are reported in ‰ notation and are computed as follows:

$$\delta R_{sample} ‰ = \left[\frac{R_{sample}}{R_{standard}} - 1 \right] \times 1000$$

Where:

D/H standard is SMOW
$^{18}O/^{16}O$ standard is SMOW

And:

$D/H_{standard}$ = 0.000316**
$^{18}O/^{16}O_{standard}$ = 0.0039948**

**Double atom ratio

GEOCHRON LABORATORIES a division of
KRUEGER ENTERPRISES, INC.

711 CONCORD AVENUE ✦ CAMBRIDGE, MASSACHUSETTS 02138 ✦ U.S.A
TELEPHONE: (617) 876-3691 TELEFAX: (617) 661-0148

STABLE ISOTOPE RATIO ANALYSES

REPORT OF ANALYTICAL WORK

Submitted by:
Erik Petersen
Mayo and Associates
710 East 100 North
Lindon, UT 84042

Date Received: 06/23/97
Date Reported: 07/14/97
Your Reference: Genwal Resources
Gary Gray

Our Lab. Number	Your Sample Number	Description	δD*	$\delta^{18}O$*
HOR-94183	MW-6A 5 JUNE 1997	Water	-130	-17.4
HOR-94184	5th West Fault 5 JUNE 1997	Water	-131	-17.5 -17.4 *

** Duplicate analyses on separate aliquots of original sample.

*Unless otherwise noted, analyses are reported in ‰ notation and are computed as follows:

$$\delta R_{sample}‰ = \left[\frac{R_{sample}}{R_{standard}} - 1 \right] \times 1000$$

Where:

D/H standard is SMOW
$^{18}O/^{16}O$ standard is SMOW

And:

$D/H_{standard}$ = 0.000316**
$^{18}O/^{16}O_{standard}$ = 0.0039948**

**Double atom ratio

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STABLE ISOTOPE RATIO ANALYSES

REPORT OF ANALYTICAL WORK

Submitted by: Erik C. Petersen
Mayo and Associates
710 East 100 North
Lindon, UT 84042

Date Received: 06/10/97
Date Reported: 09/02/97
Your Reference: Letter of June 6, 1997 Genwal

Our Lab. Number	Your Sample Number	Description	$\delta^{34}S$*
SR-94052	MW-7	$BaSO_4$	+17.1
SR-94053	MW-8	$BaSO_4$	+18.6 +18.7 **
SR-94054	UDH 46-97	$BaSO_4$	+26.9
SR-94055	MW-6	$BaSO_4$	+13.0 +9.8 ***

** Duplicate analyses on separate aliquots of original sample.

*** Due to small amount of $BaCO_3$, two sample bottles of MW-6 were received and prepared on different dates. Difference in results are most likely due to inhomogeneity between the two sample bottles.

*Unless otherwise noted, analyses are reported in ‰ notation and are computed as follows:

$$\delta^{34}S_{sample}‰ = \left[\frac{^{34}S/^{32}S_{sample}}{^{34}S/^{32}S_{standard}} - 1 \right] \times 1000$$

Where:

$^{34}S/^{32}S$ standard is Cañon Diablo troilite

And:

$^{34}S/^{32}S = 0.0450045$

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STABLE ISOTOPE RATIO ANALYSES

REPORT OF ANALYTICAL WORK

Submitted by: Erik Petersen
Mayo and Associates
710 East 100 North
Lindon, UT 84042

Date Received: 06/23/97
Date Reported: 09/02/97
Your Reference: Genwal Resources
Gary Gray

Our Lab. Number	Your Sample Number	Description	$\delta^{34}S$*
SR-94181	MW-6A 5 JUNE 1997	$BaSO_4$	+15.0 +15.2 **
SR-94182	5th West Fault 5 JUNE 1997	$BaSO_4$	+12.5

** Duplicate analyses on separate aliquots of original sample.

*Unless otherwise noted, analyses are reported in ‰ notation and are computed as follows:

$$\delta^{34}S_{sample}‰ = \left[\frac{{}^{34}S/{}^{32}S_{sample}}{{}^{34}S/{}^{32}S_{standard}} - 1\right] \times 1000$$

Where:

${}^{34}S/{}^{32}S$ standard is Cañon Diablo troilite

And:

${}^{34}S/{}^{32}S = 0.0450045$

Client: MAYO and ASSOCIATES - GENWAL
Recvd : 97/06/10
Job# : 960
Final : 97/07/08

Purchase Order: 97-103, 97-104
Contact: K. Payne 801/796-0211
710 E. 100 North, (F) 785-2387
Lindon, UT 84042

Cust	LABEL INFO	JOB.SX	REFDATE	QUANT	ELYS	TU	eTU
MAYO-	MW-7	960.01	970605	1000	275	0.01	0.09
MAYO-	MW-8	960.02	970605	1000	275	0.10	0.09
MAYO-	UDH46-97	960.03	970605	1000	275	-0.07	0.09
MAYO-	MW-6	960.04	970605	1000	275	0.43*	0.09
MAYO-	MW-6A	960.05	970605	1000	275	0.20	0.09
MAYO-	5TH WEST FAULT	960.06	970611	1000	275	1.25	0.09

* Average of duplicate runs

Client: MAYO and ASSOCIATES - GENWAL
Recvd : 97/09/11
Job# : 991
Final : 97/10/01

Purchase Order: 97-109
Contact: K. Payne 801/796-0211
710 E. 100 North, (F) 785-2387
Lindon, UT 84042

Cust LABEL INFO	JOB.SX	REFDATE	QUANT	ELYS	TU	eTU
MAYO-GENWAL-5TH WEST FAULT	991.01	970820	1000	275	0.95	0.09

COMMERCIAL TESTING & ENGINEERING CO.
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SINCE 1908
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PLEASE ADDRESS ALL CORRESPONDENCE TO:
P.O. BOX 1020, HUNTINGTON, UT 84528
TEL: (801) 653-2311
FAX: (801) 653-2436

July 24, 1997

GENWAL RESOURCES, INC.
P.O. BOX 1420
HUNTINGTON UTAH 84528

Sample identification by
GENWAL COAL CO.

ID: MDH-46-97

Rec'd 0900 hr.
Sampled 1530 hr.

Kind of sample reported to us: Water

Sample taken at: Genwal

Sample taken by: Genwal

Date sampled: June 5, 1997

Date received: June 6, 1997

Field Measurements

pH	8.1
DO	12.8
Flow	0.3 gpm
Conductivity	504
Temperature	10.7°C

NOTE: Dissolved iron filtered at lab!

Analysis report no. 59-17279

Parameter	Result	MRL	Units	Method	Analyzed Date/Time/Analyst		
Alkalinity, Bicarbonate	316	5	mg/l as HCO_3	SM2320-B	06-16-1997	1700	RJ
Alkalinity Carbonate	<5	5	mg/l as CO_3	SM2320-B	06-16-1997	1700	RJ
Alkalinity, Total	259	5	mg/l as $CaCO_3$	EPA 310.1	06-16-1997	1700	RJ
Anions	5.9	----	meq/l	----------	07-07-1997	0800	RJ
Calcium, Total	50	1	mg/l	EPA 215.1	06-27-1997	1145	MK
Cations	5.6	----	meq/l	----------	07-07-1997	0800	RJ
Chloride	5	1	mg/l	SM4500-Cl-B	06-30-1997	1100	RJ
Conductivity	515	1	umhos/cm	SM2510-B	06-30-1997	0340	RJ
Hardness, Total	244	----	mg/l as $CaCO_3$	SM2340-B	07-07-1997	0800	RJ
Iron, Total	<0.1	0.1	mg/l	EPA 236.1	06-27-1997	0745	MK
Iron, Dissolved	<0.1	0.1	mg/l	EPA 236.1	06-27-1997	0745	MK
Magnesium, Total	29	1	mg/l	EPA 242.1	06-27-1997	1215	MK
Manganese, Total	0.2	0.1	mg/l	EPA 243.1	06-27-1997	0830	MK
Oxygen, Dissolved	6.5	----	mg/l	EPA 360.1	06-06-1997	0915	MK
pH	7.51	----	pH units	EPA 150.1	06-06-1997	1000	MK
Potassium, Total	4	1	mg/l	EPA 258.1	06-27-1997	0845	MK
Sodium, Total	15	1	mg/l	EPA 273.1	06-27-1997	1030	MK
Solids, Total Dissolved	280	10	mg/l	EPA 160.1	06-09-1997	0700	JC
Solids, Total Suspended	<5	5	mg/l	EPA 160.2	06-12-1997	0700	JC
Sulfate	36	1	mg/l	EPA 375.4	06-27-1997	0830	SC
Cation/Anion Balance	-2.0	----	%		07-07-1997	0800	RJ

Respectfully submitted,
COMMERCIAL TESTING & ENGINEERING CO

Huntington Laboratory

COMMERCIAL TESTING & ENGINEERING CO.

GENERAL OFFICES: [illegible] SOUTH HIGHLAND AVE., SUITE 210-B, LOMBARD, ILLINOIS [illegible] • TEL: [illegible] FAX: [illegible]

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TEL: [illegible]
FAX: [illegible]

July 8, 1997

GENWAL RESOURCES, INC.
P O BOX 1420
HUNTINGTON UTAH 84528

Sample identification by
GENWAL COAL CO.

ID: MW-8

Kind of sample reported to us: Water

Sample taken at: Genwal

Sample taken by: Genwal

Date sampled: June 5, 1997

Date received: June 6, 1997

Rec'd 0900 hr.
Sampled 1410 hr.

Field Measurements

pH	7.8
DO	11.7
Flow	0
Conductivity	547
Temperature	14.1°C

NOTE: Dissolved Iron filtered at lab!

Analysis report no. 59-17270

Parameter	Result	MRL	Units	Method	Analyzed Date/Time/Analyst
Alkalinity, Bicarbonate	317	50	mg/l as HCO_3	SM2320-B	06-16-1997 1700 260
Alkalinity, Carbonate	<5	50	mg/l as CO_3	SM2320-B	06-16-1997 1700 260
Alkalinity, Total	260	50	mg/l as $CaCO_3$	EPA 310.1	06-16-1997 1700 260
Anions	6.3	----	meq/l	----------	07-07-1997 0800 RJ
Calcium, Total	64	5	mg/l	EPA 215.1	06-27-1997 1145 MK
Cations	7.1	----	meq/l	----------	07-07-1997 0800 RJ
Chloride	8	1	mg/l	SM4500-Cl-B	06-30-1997 1100 RJ
Conductivity	567	1	umhos/cm	SM2510-B	06-30-1997 0340 RJ
Hardness, Total	312	----	mg/l as $CaCO_3$	SM2340-B	07-07-1997 0800 RJ
Iron, Total	3.7	0.1	mg/l	EPA 236.1	06-27-1997 0745 MK
Iron, Dissolved	<0.1	0.1	mg/l	EPA 236.1	06-27-1997 0745 MK
Magnesium, Total	37	1	mg/l	EPA 242.1	06-27-1997 1215 MK
Manganese, Total	<0.1	0.1	mg/l	EPA 243.1	06-27-1997 0830 MK
Oxygen, Dissolved	4.0	----	mg/l	EPA 360.1	06-06-1997 0915 MK
pH	7.49	----	pH units	EPA 150.1	06-06-1997 1000 MK
Potassium, Total	6	1	mg/l	EPA 258.1	06-27-1997 0845 MK
Sodium, Total	17	1	mg/l	EPA 273.1	06-27-1997 1030 MK
Solids, Total Dissolved	340	10	mg/l	EPA 160.1	06-09-1997 0700 JC
Solids, Total Suspended	282	5	mg/l	EPA 160.2	06-12-1997 0700 JC
Sulfate	40	1	mg/l	EPA 375.4	06-27-1997 0830 SC
Cation/Anion Balance	6.6	----	%		07-07-1997 0800 RJ

Respectfully submitted,
COMMERCIAL TESTING & ENGINEERING CO.

COMMERCIAL TESTING & ENGINEERING CO.
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TEL: (801) 653-2311
FAX: (801) 653-2436

July 24, 1997

GENWAL RESOURCES, INC.
P.O. BOX 1420
HUNTINGTON UTAH 84528

Sample identification by
GENWAL COAL CO.

ID: 5TH W FAULT

Rec'd 1320 hr.
Sampled 1030 hr.

Field Measurements
pH 8.45
DO 14.0
Flow 5 gpm
Conductivity 545
Temperature 9.2°C

Kind of sample reported to us Water

Sample taken at Genwal

Sample taken by Genwal

Date sampled June 11, 1997

Date received June 11, 1997

NOTE: Dissolved Iron filtered at lab!

Analysis report no. 59-17304

Parameter	Result	MRL	Units	Method	Analyzed Date/Time/Analyst		
Alkalinity, Bicarbonate	397	5	mg/l as HCO_3	SM2320-B	06-16-1997	1700	RJ
Alkalinity, Carbonate	<5	5	mg/l as CO_3	SM2320-B	06-16-1997	1700	RJ
Alkalinity, Total	326	5	mg/l as $CaCO_3$	EPA 310.1	06-16-1997	1700	RJ
Anions	7.3	----	meq/l	---------	07-16-1997	1400	RJ
Calcium, Total	74	1	mg/l	EPA 215.1	07-11-1997	1130	MK
Cations	7.0	----	meq/l	---------	07-16-1997	1400	RJ
Chloride	6	1	mg/l	SM4500-Cl B	07-02-1997	0730	RJ
Conductivity	561	1	umhos/cm	SM2510-B	06-30-1997	0340	RJ
Hardness, Total	337	----	mg/l as $CaCO_3$	SM2340-B	07-16-1997	1400	RJ
Iron, Total	1.0	0.1	mg/l	EPA 236.1	07-11-1997	0900	MK
Iron, Dissolved	<0.1	0.1	mg/l	EPA 236.1	07-11-1997	0900	MK
Magnesium, Total	37	1	mg/l	EPA 242.1	07-11-1997	1200	MK
Manganese, Total	<0.1	0.1	mg/l	EPA 243.1	07-11-1997	0930	MK
Oxygen, Dissolved	6.4	----	mg/l	EPA 360.1	06-11-1997	1520	RJ
pH	7.62	----	pH units	EPA 150.1	06-11-1997	1510	RJ
Potassium, Total	2	1	mg/l	EPA 258.1	07-11-1997	1000	MK
Sodium, Total	4	1	mg/l	EPA 273.1	07-11-1997	1030	MK
Solids, Total Dissolved	340	10	mg/l	EPA 160.1	06-12-1997	0700	JC
Solids, Total Suspended	27	5	mg/l	EPA 160.2	06-12-1997	0700	JC
Sulfate	29	125	mg/l	EPA 375.4	07-02-1997	0715	SC
Cation/Anion Balance	-2.2	----	%		07-16-1997	1400	RJ

Respectfully submitted,
COMMERCIAL TESTING & ENGINEERING CO.

Huntington Laboratory

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TEL: (801) 653-2311
FAX: (801) 653-2436

March 5, 1997

GENWAL RESOURCES, INC.
P.O. BOX 1420
HUNTINGTON UTAH 84528

Sample identification by
GENWAL COAL CO.

ID: MW-2

Kind of sample reported to us: Water

Sample taken at: Genwal

Sample taken by: Genwal

Date sampled: February 3, 1997

Date received: February 4, 1997

Rec'd 1115 hr.
Sampled 1520 hr.

Field Measurements
pH 7.3
DO 8.5
Conductivity 731
Temperature 10.9°C

Dissolved Iron filtered at lab!

Analysis report no. 59-16962

Parameter	Result	MRL	Units	Method	Analyzed Date/Time/Analyst
Alkalinity, Bicarbonate	456	5	mg/l as HCO_3	SM2320-B	02-10-1997 1100 SW
Alkalinity, Carbonate	<5	5	mg/l as CO_3	SM2320-B	02-10-1997 1100 SW
Alkalinity, Total	374	5	mg/l as $CaCO_3$	EPA 310.1	02-10-1997 1100 SW
Anions	8.4	----	meq/l	---------	03-05-1997 0900 RJ
Calcium, Total	109	1	mg/l	EPA 215.1	02-12-1997 1030 MK
Calcium, Dissolved	74	1	mg/l	EPA 215.1	03-05-1997 0730 MK
Cations	7.8	----	meq/l	---------	03-05-1997 0900 RJ
Chloride	5	1	mg/l	SM4500-Cl-B	02-10-1997 1030 SW
Conductivity	748	1	umhos/cm	SM2510-B	02-05-1997 1230 SW
Hardness, Total	354	----	mg/l as $CaCO_3$	SM2340-B	03-05-1997 0900 RJ
Iron, Total	4.5	0.1	mg/l	EPA 236.1	02-12-1997 0730 MK
Iron, Dissolved	<0.1	0.1	mg/l	EPA 236.1	02-12-1997 0730 MK
Magnesium, Total	60	1	mg/l	EPA 242.1	02-12-1997 1100 MK
Magnesium, Dissolved	41	1	mg/l	EPA 242.1	03-05-1997 0745 MK
Manganese, Total	<0.1	0.1	mg/l	EPA 243.1	02-12-1997 0800 MK
pH	7.29	----	pH units	EPA 150.1	02-04-1997 1245 MK
Potassium, Total	5	1	mg/l	EPA 258.1	02-12-1997 0830 MK
Sodium, Total	14	1	mg/l	EPA 273.1	02-12-1997 0900 MK
Solids, Total Dissolved	413	10	mg/l	EPA 160.1	02-06-1997 0700 JC
Solids, Total Suspended	136	5	mg/l	EPA 160.2	02-06-1997 0700 JC
Sulfate	39	50	mg/l	EPA 375.4	02-24-1997 0900 SW
Cation/Anion Balance	-3.8	----	%		03-05-1997 0900 RJ

Respectfully submitted,
COMMERCIAL TESTING & ENGINEERING CO.

Larry Stout

Huntington Laboratory 20

COMMERCIAL TESTING & ENGINEERING CO.

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TEL: (801) [illegible]
FAX: (801) [illegible]

July 8, 1997

GENWAL RESOURCES, INC.
P.O. BOX 1420
HUNTINGTON UTAH 84528

Sample identification by
GENWAL COAL CO.

ID: MW-6
Rec'd 0900 hr.
Sampled 1605 hr

Kind of sample reported to us: Water

Sample taken at: Genwal

Sample taken by: Genwal

Date sampled: June 5, 1997

Date received: June 6, 1997

Field Measurements
pH 12.6
DO 11.2
Conductivity 6170
Temperature 13.3°C
NOTE: Dissolved Iron filtered at lab!
NOTE: Charge balance greater than 10 due to High Hydroxide Alkalinity in sample!

Analysis report no. 59-17276

Parameter	Result	MRL	Units		Method	Analyzed Date/Time/Analyst		
Alkalinity, Bicarbonate	<50	50	mg/l	as HCO_3	SM2320-B	06-16-1997	1700	BJ
Alkalinity, Carbonate	128	50	mg/l	as CO_3	SM2320-B	06-16-1997	1700	BJ
Alkalinity, Total	1405	50	mg/l	as $CaCO_3$	EPA 310.1	06-16-1997	1700	BJ
Anions	5.6	----	meq/l		----------	07-07-1997	0800	BJ
Calcium, Total	742	5	mg/l		EPA 215.1	06-27-1997	1145	MK
Cations	40.7	----	meq/l		----------	07-07-1997	0800	BJ
Chloride	13	1	mg/l		SM4500-Cl-B	06-30-1997	1100	BJ
Conductivity	5890	1	umhos/cm		SM2510-B	06-10-1997	1400	SW
Hardness, Total	1873	----	mg/l	as $CaCO_3$	SM2340-B	07-07-1997	0800	BJ
Iron, Total	1.6	0.1	mg/l		EPA 236.1	06-27-1997	0745	MK
Iron, Dissolved	<0.1	0.1	mg/l		EPA 236.1	06-27-1997	0745	MK
Magnesium, Total	5	1	mg/l		EPA 242.1	06-27-1997	1215	MK
Manganese, Total	0.2	0.1	mg/l		EPA 243.1	06-27-1997	0810	MK
Oxygen, Dissolved	2.0	----	mg/l		EPA 360.1	06-06-1997	0915	MK
pH	11.86	----	pH units		EPA 150.1	06-06-1997	1000	MK
Potassium, Total	24	1	mg/l		EPA 258.1	06-27-1997	0845	MK
Sodium, Total	62	1	mg/l		EPA 273.1	06-27-1997	1030	MK
Solids, Total Dissolved	1390	10	mg/l		EPA 160.1	06-09-1997	0700	JC
Solids, Total Suspended	71	5	mg/l		EPA 160.2	06-12-1997	0700	JC
Sulfate	48	1	mg/l		EPA 375.4	06-27-1997	0830	MC
Cation/Anion Balance	75.7	----	%			07-07-1997	0800	BJ

Post-it® Fax Note 7671	Date 7-28-97 pages 3
To Jean Semborski	From LAURA
Co./Dept.	Co. CTE
Phone #	Phone #
Fax # 637-8860	Fax #

Respectfully submitted,
COMMERCIAL TESTING & ENGINEERING CO.

Larry Sword

Huntington Laboratory

COMMERCIAL TESTING & ENGINEERING CO.

GENERAL OFFICES: 1919 SOUTH HIGHLAND AVE., SUITE 210-B, LOMBARD, ILLINOIS [illegible] • TEL: [illegible] FAX: [illegible]

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TEL: [illegible]
FAX: [illegible]

July 8, 1997

GENWAL RESOURCES, INC.
P.O BOX 1420
HUNTINGTON UTAH 84528

Sample identification by
GENWAL COAL CO.

ID: MW-7

Rec'd 0900 hr.
Sampled 1315 hr.

Kind of sample reported to us: Water

Sample taken at: Genwal

Sample taken by: Genwal

Date sampled: June 5, 1997

Date received: June 6, 1997

Field Measurements

pH	7.7
DO	14.0
Flow	0.2 gpm
Conductivity	511
Temperature	12.1°C

NOTE: Dissolved Iron filtered at lab!

Analysis report no. 59-17277

Parameter	Result	MRL	Units	Method	Analyzed Date/Time/Analyst
Alkalinity, Bicarbonate	319	50	mg/l as HCO_3	SM2320-B	06-16-1997 1700 BJ
Alkalinity, Carbonate	<5	50	mg/l as CO_3	SM2320-B	06-16-1997 1700 BJ
Alkalinity, Total	262	50	mg/l as $CaCO_3$	EPA 310.1	06-16-1997 1700 BJ
Anions	6.2	----	meq/l	---------	07-07-1997 0800 BJ
Calcium, Total	62	5	mg/l	EPA 215.1	06-27-1997 1145 MK
Cations	6.2	----	meq/l	---------	07-07-1997 0800 BJ
Chloride	10	1	mg/l	SM4500-Cl-B	06-30-1997 1100 BJ
Conductivity	527	1	umhos/cm	SM2510-B	06-10-1997 1400 GW
Hardness, Total	287	----	mg/l as $CaCO_3$	SM2340-B	07-07-1997 0800 BJ
Iron, Total	0.2	0.1	mg/l	EPA 236.1	06-27-1997 0745 MK
Iron, Dissolved	<0.1	0.1	mg/l	EPA 236.1	06-27-1997 0745 MK
Magnesium, Total	32	1	mg/l	EPA 242.1	06-27-1997 1215 MK
Manganese, Total	<0.1	0.1	mg/l	EPA 243.1	06-27-1997 0830 MK
Oxygen, Dissolved	3.0	----	mg/l	EPA 360.1	06-06-1997 0915 MK
pH	7.16	..	pH units	EPA 150.1	06-06-1997 1000 MK
Potassium, Total	2	1	mg/l	EPA 258.1	06-27-1997 0845 MK
Sodium, Total	4	1	mg/l	EPA 273.1	06-27-1997 1030 MK
Solids, Total Dissolved	310	10	mg/l	EPA 160.1	06-09-1997 0700 JC
Solids, Total Suspended	<5	5	mg/l	EPA 160.2	06-13-1997 0700 JC
Sulfate	33	1	mg/l	EPA 375.4	06-27-1997 0830 SC
Cation/Anion Balance	2.0	----	%		07-07-1997 0800 BJ

Respectfully submitted,
COMMERCIAL TESTING & ENGINEERING CO.

COMMERCIAL TESTING & ENGINEERING CO.

GENERAL OFFICES: 1919 SOUTH HIGHLAND AVE., SUITE 210-B, LOMBARD, ILLINOIS 60148 • TEL: 708-953-9300 FAX: 708-953-9306

SINCE 1908

SGS Member of the SGS Group (Société Générale de Surveillance)

PLEASE ADDRESS ALL CORRESPONDENCE TO:
P.O. BOX 1020, HUNTINGTON, UT 84528
TEL: (801) 653-2311
FAX: (801) 653-2436

JUL 24, 1997

GENWAL RESOURCES, INC.
P.O. BOX 1420
HUNTINGTON UTAH 84528

Sample identification by
GENWAL COAL CO.

ID: MW-6A

Rec'd 1150 hr.
Sampled 1500 hr.

Field Measurements
pH 8.2
DO 15.2
Conductivity 544
Temperature 14.2°C

Kind of sample reported to us Water

Sample taken at Genwal

Sample taken by Genwal

Date sampled June 6, 1997

Date received June 9, 1997

NOTE: Dissolved Iron filtered at lab!

Analysis report no. 59-17280

Parameter	Result	MRL	Units	Method	Analysed Date/Time/Analyst	
Alkalinity, Bicarbonate	243	5	mg/l as HCO_3	SM2320-B	06-16-1997 1700	RJ
Alkalinity, Carbonate	<5	5	mg/l as CO_3	SM2320-B	06-16-1997 1700	RJ
Alkalinity, Total	199	5	mg/l as $CaCO_3$	EPA 310.1	06-16-1997 1700	RJ
Anions	5.7	----	meq/l	---------	07-07-1997 0800	RJ
Calcium, Total	46	1	mg/l	EPA 215.1	06-27-1997 1145	MK
Cations	5.7	----	meq/l	---------	07-07-1997 0800	RJ
Chloride	17	1	mg/l	SM4500-Cl-B	06-30-1997 1100	RJ
Conductivity	656	1	umhos/cm	SM2510-B	06-30-1997 0340	RJ
Hardness, Total	247	----	mg/l as $CaCO_3$	SM2340-B	07-07-1997 0800	RJ
Iron, Total	0.8	0.1	mg/l	EPA 236.1	06-27-1997 0745	MK
Iron, Dissolved	<0.1	0.1	mg/l	EPA 236.1	06-27-1997 0745	MK
Magnesium, Total	32	1	mg/l	EPA 242.1	06-27-1997 1215	MK
Manganese, Total	0.4	0.1	mg/l	EPA 243.1	06-27-1997 0830	MK
pH	7.85	----	pH units	EPA 150.1	06-09-1997 1530	RJ
Potassium, Total	12	1	mg/l	EPA 258.1	06-27-1997 0845	MK
Sodium, Total	22	1	mg/l	EPA 273.1	06-27-1997 1030	MK
Solids, Total Dissolved	320	10	mg/l	EPA 160.1	06-09-1997 0700	JC
Solids, Total Suspended	29	5	mg/l	EPA 160.2	06-12-1997 0700	JC
Sulfate	61	1	mg/l	EPA 375.4	06-27-1997 0830	SC
Cation/Anion Balance	+3.9	----	%		07-07-1997 0800	RJ

Respectfully submitted,
COMMERCIAL TESTING & ENGINEERING CO.

Huntington Laboratory

APPENDIX 7-54

RESULTS OF IN-MINE SLUG TESTS

1/23/95 revised 4/97

Results of In-Mine Slug Tests on the Star Point Sandstone, Genwal Resources, Crandall Canyon Mine

Genwal Resources, Inc., Huntington, Utah

07 November 1997

Mayo and Associates, LC
Consultants in Hydrogeology

Results of In-Mine Slug Tests on the Star Point Sandstone, Genwal Resources, Crandall Canyon Mine

Genwal Resources, Inc., Huntington, Utah

07 November 1997

Prepared by:

Erik C. Petersen,
Senior Hydrogeologist

Alan L. Mayo, Ph.D.
California Registered Geologist #3265

Mayo and Associates, LC
710 East 100 North
Lindon, Utah 84042

Mayo and Associates, LC
Consultants in Hydrogeology

Results of In-Mine Slug Tests
On the Star Point Sandstone

Genwal Resources
Crandall Canyon Mine

Conducted August and September, 1997

7 November 1997

Introduction

During August and September 1997, Mayo and Associates personnel conducted slug and recovery tests on four monitoring wells in the Crandall Canyon Mine. The wells tested included MW-2, MW-7, and MW-6a completed in the Spring Canyon member of the Star Point Sandstone and Well MW-6 completed in the Panther member of the Star Point Sandstone. The locations of these wells are shown on Figure 1.

Methodology

Each of the wells tested, with the exception of MW-2, were constructed in early 1997. The wells were cased with 1.25" I.D. PVC pipe. The screened intervals were packed with silica sand. The annulus of each well was plugged with Bentonite and back-filled to the surface with concrete. Well MW-2 was constructed at an earlier time and is not cased. Well logs for these wells are included as an attachment to this report.

The tests on wells MW-2, MW-6a, and MW-6 were performed by rapidly removing a volume of water from the well casing. A slug of water was rapidly removed from wells MW-2 and MW-6a using a nitrogen gas driven air lift system. Water from well MW-6 was removed by rapidly removing a long plastic bailer. Well test recoveries were logged using automated electronic pressure transducers and data loggers obtained from In-Situ Incorporated of Laramie, Wyoming. The hydraulic head at well MW-7 is above ground surface and a shut-in recovery test was required. Well recovery measurements were made on this well using a pressure gage and a stop watch. The time-recovery data for each of the slug tests are included as an attachment to this report.

The time-recovery data for each well were plotted electronically. Values of hydraulic conductivity were calculated for each well using both computer methods and conventional manual calculations. The results of the slug tests are given in Table 1 below.

Table 1 Slug test results

Well	Formation	Type of test	Hydraulic Conductivity (feet/second)
MW-2	Spring Canyon	Slug recovery	4.8×10^{-8} to 4.9×10^{-8}
MW-6A	Spring Canyon	Slug recovery	4.4×10^{-8} to 5.9×10^{-8}
MW-7	Spring Canyon	Shut-in recovery	7.4×10^{-8}
MW-6	Panther	Slug recovery	6.2×10^{-8} to 7.4×10^{-8}

Interpretation

The values of hydraulic conductivity calculated for the Star Point Sandstone are low. These values are consistent with the antiquity of the groundwater contained in the sandstone.

Mayo and Associates
Genbase.cdr 11 March 1997

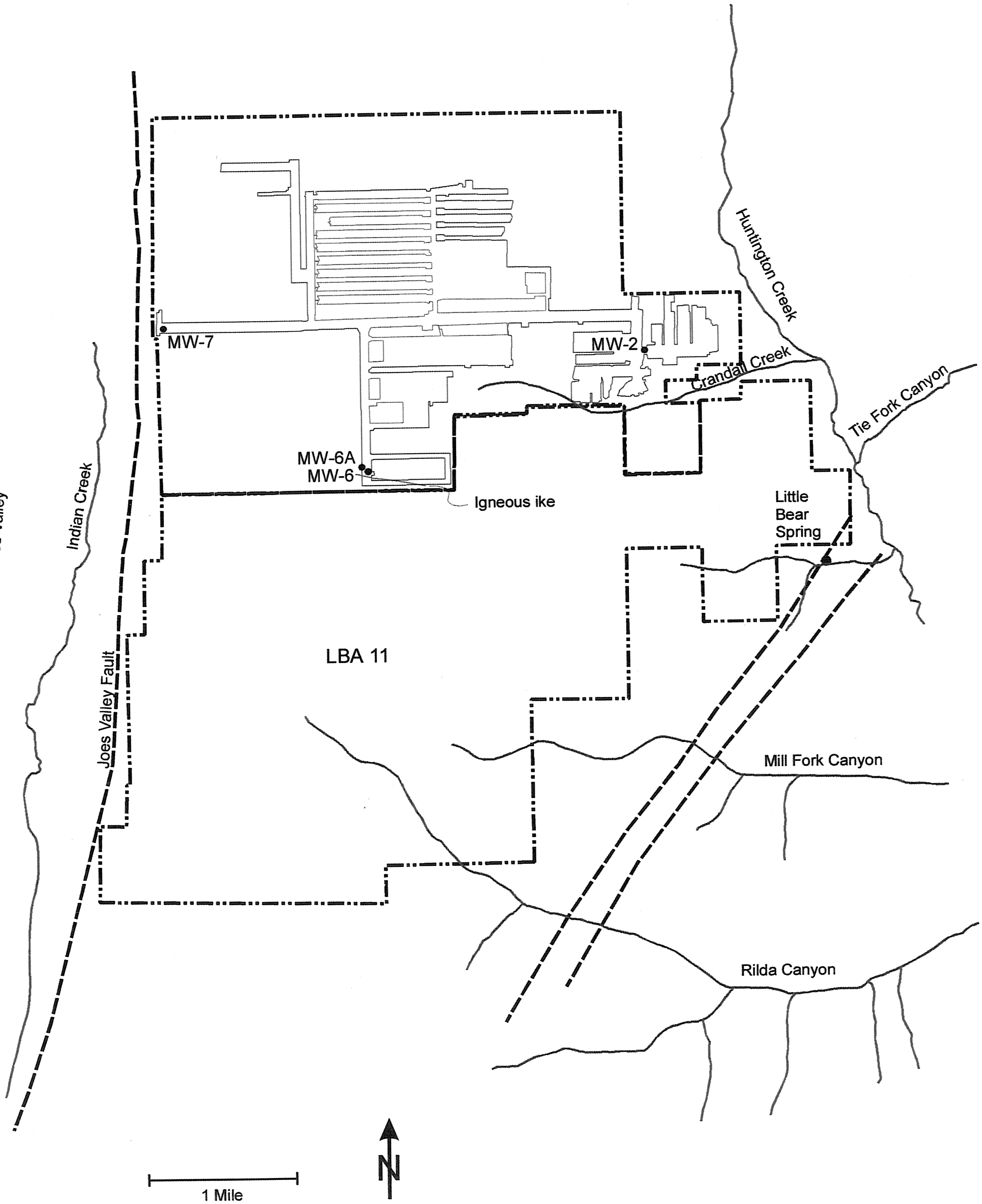


Figure 1 Map showing location of wells slug tested in the Crandall Canyon Mine.

MW-2 slug test

Time (minutes)	Depth to water
0	13.109
0.2	13.093
0.4	13.093
0.6	13.078
0.8	13.062
1	13.062
1.2	13.062
1.4	13.046
1.6	13.062
1.8	13.03
2	13.03
2.2	13.014
2.4	13.014
2.6	12.998
2.8	12.998
3	12.998
3.2	12.982
3.4	12.982
3.6	12.967
3.8	12.967
4	12.967
4.2	12.951
4.4	12.951
6.4	12.903
8.4	12.856
10.4	12.792
12.4	12.745
14.4	12.681
16.4	12.618
18.4	12.57
20.4	12.523
22.4	12.475
24.4	12.428
26.4	12.364
28.4	12.317
30.4	12.269
32.4	12.222
34.4	12.174
36.4	12.127
38.4	12.079
40.4	12.047
42.4	11.984
44.4	11.936
46.4	11.905
48.4	11.841
50.4	11.81
52.4	11.746
54.4	11.699

MW-2 slug test

Time (minutes)	Depth to water
56.4	11.651
58.4	11.604
60.4	11.556
62.4	11.509
64.4	11.477
66.4	11.429
68.4	11.382
70.4	11.334
72.4	11.287
74.4	11.255
76.4	11.207
78.4	11.16
80.4	11.112
82.4	11.081
84.4	11.033
86.4	10.986
88.4	10.954
90.4	10.906
92.4	10.843
94.4	10.827
114.4	10.383
134.4	10.003
154.4	9.623
174.4	9.242
194.4	8.893
214.4	8.561
234.4	8.275
254.4	7.974
274.4	7.705
294.4	7.467
314.4	7.198
334.4	6.96
354.4	6.738
374.4	6.516
394.4	6.31
414.4	6.088
434.4	5.898
454.4	5.708
474.4	5.533
494.4	5.327
514.4	5.153
534.4	4.995
554.4	4.852
574.4	4.662
594.4	4.535
614.4	4.392
634.4	4.234
654.4	4.107

MW-2 slug test

Time (minutes)	Depth to water
674.4	3.948
694.4	3.853
714.4	3.711
734.4	3.584
754.4	3.489
774.4	3.346
794.4	3.235
814.4	3.14
834.4	3.061
854.4	2.95
874.4	2.855
894.4	2.775
914.4	2.664
934.4	2.601
954.4	2.49
974.4	2.427
994.4	2.348

MW-6 slug test

Time (minutes)	Depth to water
0	6.02
0.2	5.973
0.4	5.926
0.6	5.895
0.8	5.847
1	5.832
1.2	5.8
1.4	5.785
1.6	5.769
1.8	5.737
2	5.706
2.2	5.69
2.4	5.659
2.6	5.643
2.8	5.612
3	5.596
3.2	5.565
3.4	5.549
3.6	5.533
3.8	5.502
4	5.486
4.2	5.47
4.4	5.439
4.6	5.423
4.8	5.392
5	5.376
5.2	5.36
5.4	5.345
5.6	5.313
5.8	5.298
6	5.266
6.2	5.25
6.4	5.235
6.6	5.203
6.8	5.188
7	5.172
7.2	5.156
7.4	5.14
7.6	5.109
7.8	5.093
8	5.077
8.2	5.062
8.4	5.03
8.6	5.015
8.8	4.999
10.8	4.81
12.8	4.637
14.8	4.464

MW-6 slug test

Time (minutes)	Depth to water
16.8	4.292
18.8	4.135
20.8	3.977
22.8	3.836
24.8	3.71
26.8	3.569
28.8	3.443
30.8	3.317
32.8	3.207
34.8	3.082
36.8	2.956
38.8	2.877
40.8	2.783
42.8	2.688
44.8	2.579
46.8	2.5
48.8	2.406
50.8	2.327
52.8	2.249
54.8	2.186
56.8	2.107
58.8	2.029
60.8	1.966
62.8	1.903
64.8	1.856
66.8	1.777
68.8	1.73
70.8	1.667
72.8	1.636
74.8	1.589
76.8	1.526
78.8	1.494
80.8	1.432
82.8	1.4
84.8	1.368
86.8	1.321
88.8	1.29
90.8	1.243
92.8	1.211
94.8	1.18
96.8	1.164
98.8	1.133
118.8	0.897
138.8	0.724
158.8	0.63
178.8	0.551

MW-6A slug test

Time (minutes)	Depth to water
0	67.575
0	68.534
0	68.581
0	67.921
0.1	66.962
0.1	66.443
0.1	65.798
0.1	65.39
0.1	64.525
0.2	64.478
0.2	64.226
0.2	63.754
0.2	63.298
0.2	63.361
0.2	63.377
0.3	63.267
0.3	63.125
0.3	62.999
0.3	62.78
0.3	62.544
0.3	62.229
0.4	61.93
0.4	61.632
0.4	61.38
0.6	58.911
0.8	57.59
1	56.615
1.2	55.845
1.4	55.231
1.6	54.728
1.8	54.304
2	53.942
2.2	53.628
2.4	53.345
2.6	53.109
2.8	52.889
3	52.684
3.2	52.511
3.4	52.338
3.6	52.165
3.8	52.008
4	51.851
4.2	51.709
4.4	51.568
4.6	51.426
4.8	51.285
5	51.143
5.2	51.017

MW-6A slug test

Time (minutes)	Depth to water
5.4	50.891
5.6	50.766
5.8	50.64
6	50.514
6.2	50.388
6.4	50.262
6.6	50.152
6.8	50.026
7	49.916
7.2	49.791
7.4	49.681
7.6	49.555
7.8	49.445
8	49.319
8.2	49.209
8.4	49.083
8.6	48.973
8.8	48.847
9	48.737
9.2	48.627
9.4	48.501
11.4	47.416
13.4	46.394
15.4	45.387
17.4	44.412
19.4	43.453
21.4	42.525
23.4	41.613
25.4	40.716
27.4	39.835
29.4	38.986
31.4	38.137
33.4	37.319
35.4	36.517
37.4	35.715
39.4	34.944
41.4	34.189
43.4	33.45
45.4	32.726
47.4	32.019
49.4	31.327
51.4	30.635
53.4	29.974
55.4	29.329
57.4	28.7
59.4	28.071
61.4	27.473
63.4	26.875

MW-6A slug test

Time (minutes)	Depth to water
65.4	26.293
67.4	25.726
69.4	25.177
71.4	24.626
73.4	24.106
75.4	23.588
77.4	23.084
79.4	22.597
81.4	22.109
83.4	21.637
85.4	21.181
87.4	20.724
89.4	20.284
91.4	19.86
93.4	19.435
95.4	19.01
97.4	18.617
99.4	18.224
119.4	14.731
139.4	11.742
159.4	9.382
179.4	7.557
199.4	6.125
219.4	4.993
239.4	4.096
259.4	3.372
279.4	2.774
299.4	2.286
319.4	1.893
339.4	1.562
359.4	1.279
379.4	1.059
399.4	0.886
419.4	0.729
439.4	0.603
459.4	0.509
479.4	0.414
499.4	0.351
519.4	0.304
539.4	0.257
559.4	0.226
579.4	0.194
599.4	0.178
619.4	0.162
639.4	0.131
659.4	0.131
679.4	0.131
699.4	0.115

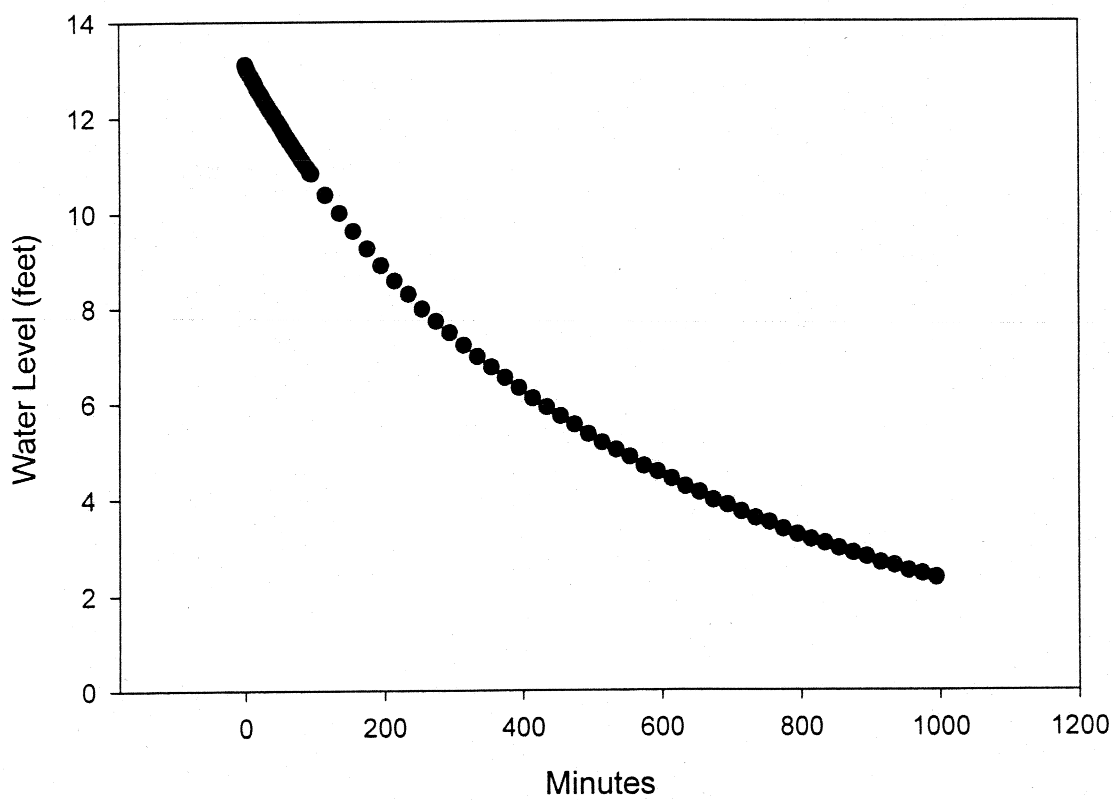
MW-6A slug test

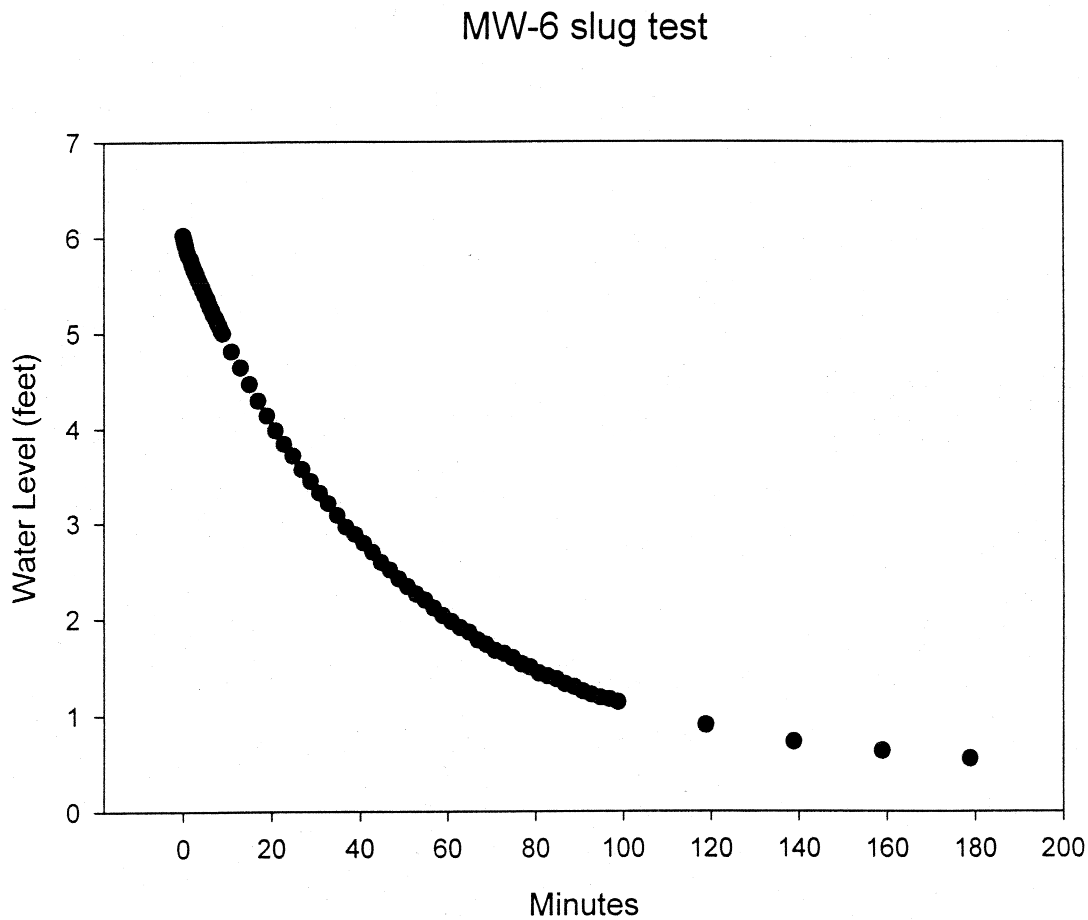
Time (minutes)	Depth to water
719.4	0.115
739.4	0.115
759.4	0.099
779.4	0.099
799.4	0.099
819.4	0.099
839.4	0.099
859.4	0.099
879.4	0.099
899.4	0.099
919.4	0.099
939.4	0.099
959.4	0.084
979.4	0.084
999.4	0.084
1199.4	0.052

MW-7 Pressure Test

Time	Psi	Feet
00:00:00	0.0	0.00
00:00:30	11.5	26.57
00:01:00	12.0	27.72
00:01:30	12.7	29.34
00:02:00	13.0	30.03
00:02:30	13.5	31.19
00:03:00	13.8	31.88
00:03:30	14.0	32.34
00:04:00	14.0	32.34
00:04:30	14.3	33.03
00:05:00	14.5	33.50
00:05:30	14.8	34.19
00:06:00	14.9	34.42
00:06:30	15.0	34.65
00:07:00	15.2	35.11
00:07:30	15.3	35.34
00:08:00	15.4	35.57
00:08:30	15.5	35.81
00:09:00	15.6	36.04
00:09:30	15.8	36.50
00:10:00	15.9	36.73
00:10:30	15.9	36.73
00:11:00	16.0	36.96
00:11:30	16.0	36.96
00:12:30	16.2	37.42
00:13:30	16.4	37.88
00:14:30	16.5	38.12
00:15:30	16.7	38.58
00:16:30	16.8	38.81
00:17:30	16.9	39.04
00:18:30	17.0	39.27
00:19:30	17.1	39.50
00:21:30	17.5	40.43
00:23:30	17.7	40.89
00:25:30	17.9	41.35
00:27:30	18.1	41.81
00:29:30	18.2	42.04
02:35:30	21.5	49.67
03:08:30	22.0	50.82

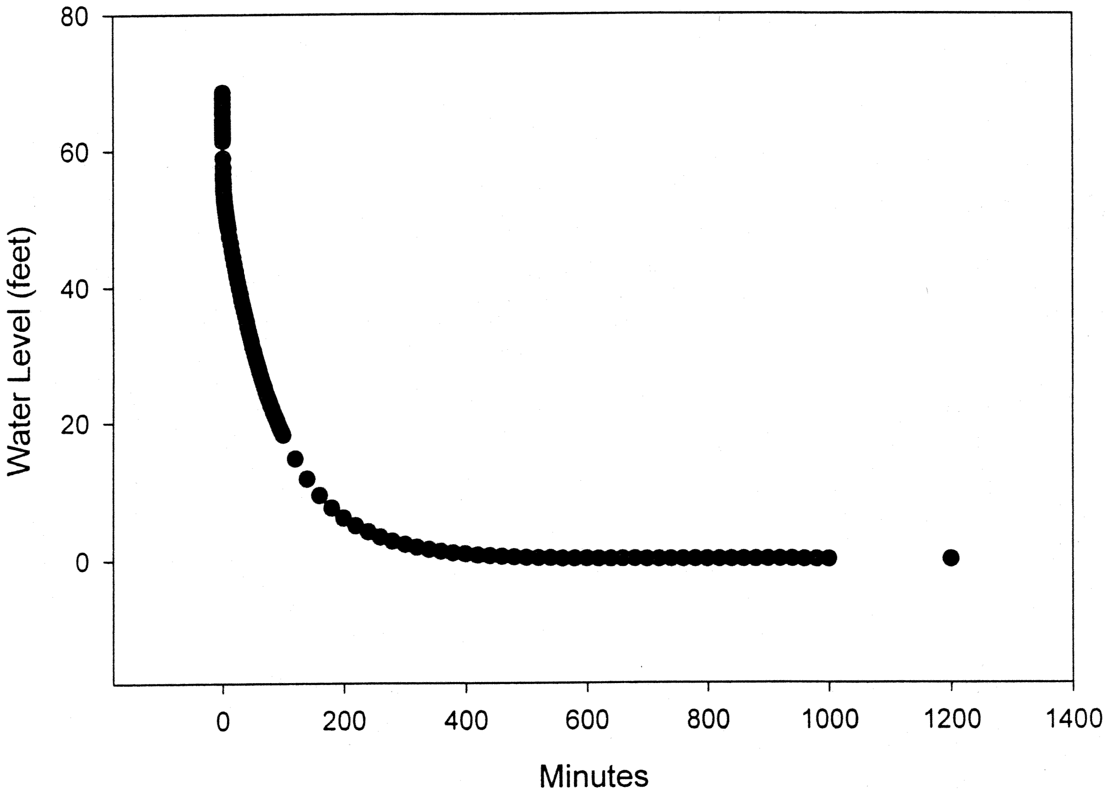
MW-2 slug test

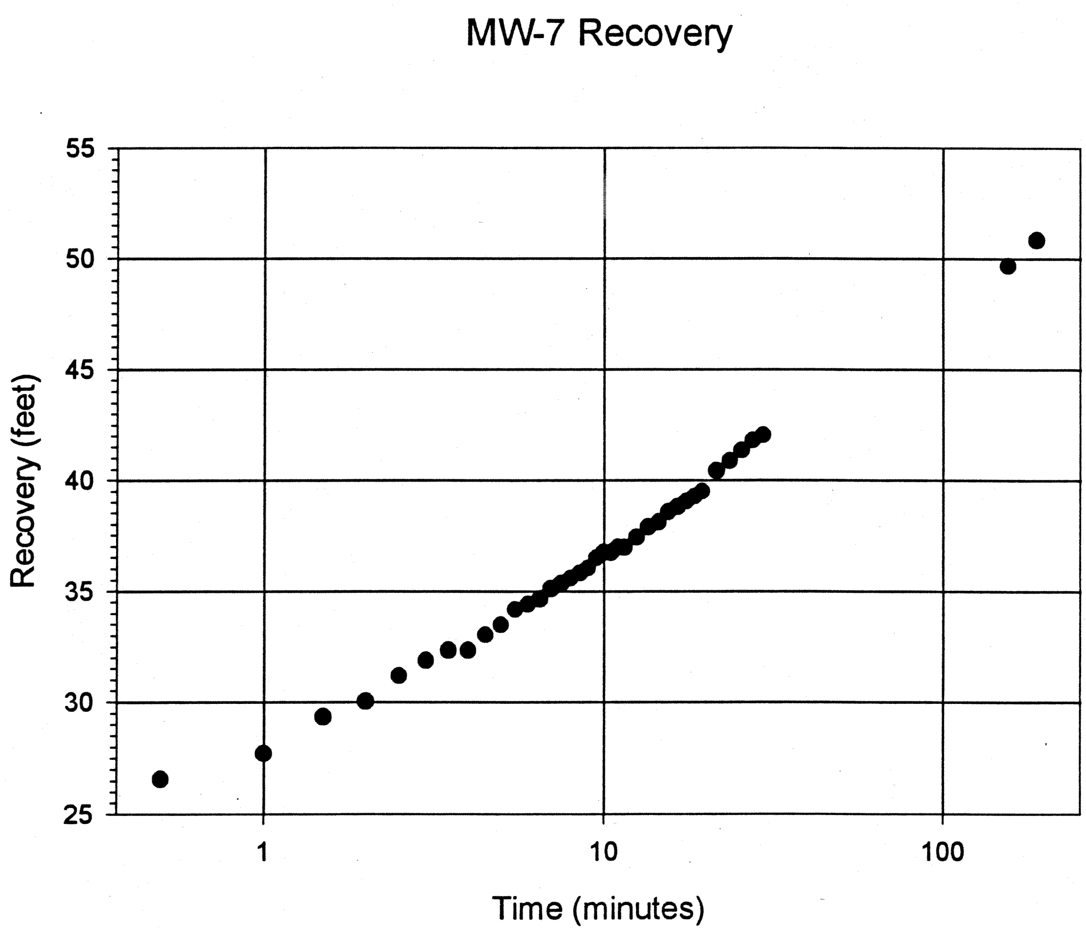




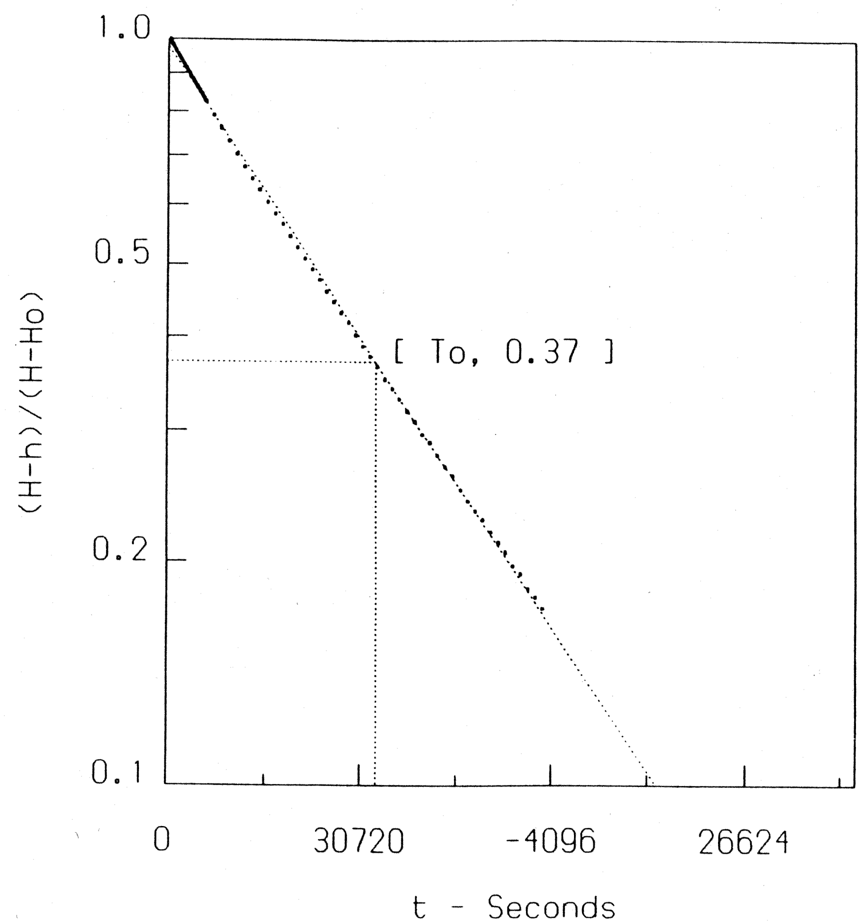
MW-6 slug test
Water Level (feet)
0
1
2
3
4
5
6
7
0
20
40
60
80
100
120
140
160
180
200
Minutes

MW-6A slug test





MW-7 Recovery
Recovery (feet)
55
50
45
40
35
30
25
1
10
100
Time (minutes)



Well I.D. = MW-2

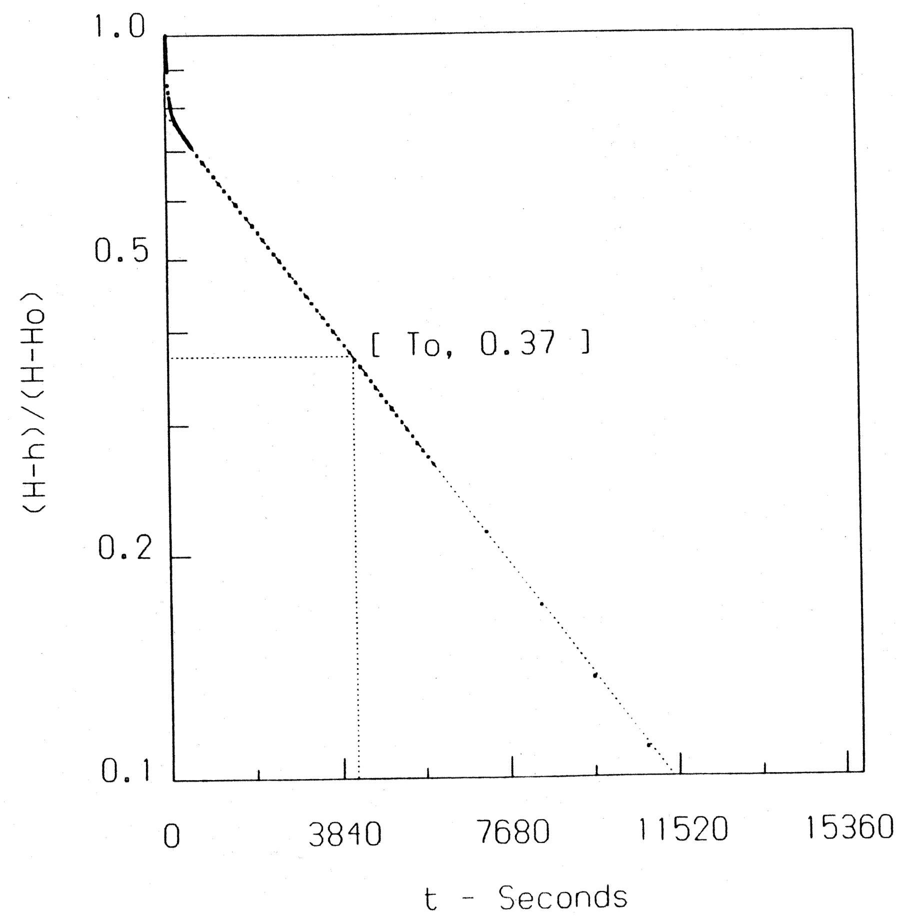
Well radius = 0.1667 ft

Intake radius = 0.1667 ft

Intake length = 50.0000 ft

To = 33342.45 sec.

K = 0.0000000475 ft/s



Well I.D. = MW-6a

Well radius = 0.0520 ft

Intake radius = 0.1250 ft

Intake length = 30.0000 ft

To = 4158.64 sec.

K = 0.0000000594 ft/s

WRI

WELL DRILLER'S REPORT

State of Utah
Division of Water Rights

For additional space, use "Additional Well Data Form" and attach

Well Identification MONITOR WELL: 97-93-001-M-01

Owner *Note any changes*
Genwal Resource Inc.
P.O. Box 1420
Huntington, UT 84528

Contact Person/Engineer: GARY GRAY / GENWAL RESOURCES

Well Location *Note any changes*
NORTH 400 feet WEST 300 feet from the SE Corner of
SECTION 2, TOWNSHIP 16S, RANGE 6E, SLB&M.

Location Description: (address, proximity to buildings, landmarks, ground elevation, local well #) MW -7

Drillers Activity Start Date: 3-13-97 Completion Date: 4-4-97

Check all that apply:
[X] New [ ] Repair [ ] Deepen [ ] Abandon [ ] Replace [ ] Public Nature of Use:

DEPTH (feet) FROM	TO	BOREHOLE DIAMETER (in)	DRILLING METHOD	DRILLING FLUID
0	100	3	FLUID ROTARY	WATER

Well Log

DEPTH (feet) FROM	TO	WATER	PERMEABLE high	PERMEABLE low	UNCONSOLIDATED CLAY	SILT	SAND	GRAVEL	COBBLES	BOULDER	OTHER	CONSOLIDATED ROCK TYPE	COLOR	DESCRIPTIONS AND REMARKS (include comments on *water quality* if known.)
0	100										X			SANDSTONE / CLAYSTONE

Static Water Level

Date 4-3-97 Water Level 0 feet Flowing? [X] Yes [ ] No

Method of Water Level Measurement WCI If Flowing, Capped Pressure [1] PSI

Point to Which Water Level Measurement was Referenced GROUND LEVEL

Height of Water Level reference point above ground surface 0 feet Temperature N/A [ ] °C [ ] °F

Construction Information

DEPTH (feet)		CASING			DEPTH (feet)		SCREEN ☒ PERFORATIONS ☐		
FROM	TO	CASING TYPE AND MATERIAL/GRADE	WALL THICK (in)	NOMINAL DIAM. (in)	FROM	TO	SLOT SIZE OR PERF SIZE (in)	SCREEN DIAM. OR PERF LENGTH (in)	SCREEN TYPE OR NUMBER PERF (per round/interval)
0	53	1 1/4" SCH 40 PVC		1 1/4	53	93	.010	1 1/4	

Well Head Configuration: FLUSH MOUNT Access Port Provided? ☒ Yes ☐ No

Casing Joint Type: FLUSH Perforator Used: ______

DEPTH (feet)		FILTER PACK / GROUT / PACKER / ABANDONMENT MATERIAL		
FROM	TO	ANNULAR MATERIAL, ABANDONMENT MATERIAL and/or PACKER DESCRIPTION	Quantity of Material Used (if applicable)	GROUT DENSITY (lbs./gal.,# bag mix, gal./sack etc.)
0	1	CONCRETE	1	
1	40	CEMENT BENTONITE MIXTURE	2	
40	50	3/8" BENTONITE PELLETS	1	
50	100	16-40 SILICA SAND	2	

Well Development / Pump or Bail Tests

Date	Method	Yield	Units Check One: GPM	CFS	DRAWDOWN (ft)	TIME PUMPED (hrs & min)

Pump (Permanent)

Pump Description: ______ Horsepower: ______ Pump Intake Depth: ______ feet

Approximate maximum pumping rate: ______ Well disinfected upon completion? ☐ Yes ☐ No

Comments

Description of construction activity, additional materials used, problems encountered, extraordinary circumstances, abandonment / procedures. *Use additional well data form for more space.*

Well Driller Statement

This well was drilled or abandoned under my supervision, according to applicable rules and regulations, and this report is complete and correct to the best of my knowledge and belief.

Name LAYNE CHRISTENSEN COMPANY License No. 626

(~~Person, Firm~~, or Corporation – Print or Type)

Signature [signature] Date 4-10-97

(Licensed Well Driller)

WL1

WELL DRILLER'S REPORT
State of Utah
Division of Water Rights

For additional space, use "Additional Well Data Form" and attach

Well Identification MONITOR WELL: 97-93-001-M-02

Owner *Note any changes*
Genwal Resource Inc.
P.O. Box 1420
Huntington, UT 84528

Contact Person/Engineer: GARY GRAY / GENWAL RESOURCES

Well Location *Note any changes*
NORTH 200 feet EAST 400 feet from the SW Corner of SECTION 35, TOWNSHIP 15S, RANGE 6E, SLB&M.

Location Description: (address, proximity to buildings, landmarks, ground elevation, local well #) MW-8

Drillers Activity Start Date: 3-13-97 Completion Date: 4-4-97

Check all that apply:
[X] New [ ] Repair [ ] Deepen [ ] Abandon [ ] Replace [ ] Public Nature of Use:

DEPTH (feet) FROM	TO	BOREHOLE DIAMETER (in)	DRILLING METHOD	DRILLING FLUID
0	107	3	FLUID ROTARY	WATER

Well Log

DEPTH (feet) FROM	TO	WATER	PERMEABLE high	PERMEABLE low	CLAY	SILT	SAND	GRAVEL	COBBLES	BOULDER	OTHER	ROCK TYPE	COLOR	DESCRIPTIONS AND REMARKS (include comments on *water quality* if known.)
0	107										X			SANDSTONE / CLAYSTONE

(CLAY through OTHER are UNCONSOLIDATED; ROCK TYPE is CONSOLIDATED)

Static Water Level

Date 3-31-97 Water Level 1.4 feet Flowing? [ ] Yes [ ] No

Method of Water Level Measurement WLI If Flowing, Capped Pressure NO PSI

Point to Which Water Level Measurement was Referenced GROUND LEVEL

Height of Water Level reference point above ground surface N/A feet Temperature N/A [ ] °C [ ] °F

Well Log

Construction Information

DEPTH (feet) FROM	TO	CASING: CASING TYPE AND MATERIAL/GRADE	WALL THICK (in)	NOMINAL DIAM. (in)	DEPTH (feet) FROM	TO	SCREEN ☐ PERFORATIONS ☐: SLOT SIZE OR PERF SIZE (in)	SCREEN DIAM. OR PERF LENGTH (in)	SCREEN TYPE OR NUMBER PERF (per round/interval)
0	70	1 1/4"SCH 40 PVC		1 1/4	70	100	.010	1 1/4	

Well Head Configuration: FLUSH MOUNT

Access Port Provided? ☒ Yes ☐ No

Casing Joint Type: FLUSH

Perforator Used: ____

DEPTH (feet) FROM	TO	FILTER PACK / GROUT / PACKER / ABANDONMENT MATERIAL: ANNULAR MATERIAL, ABANDONMENT MATERIAL and/or PACKER DESCRIPTION	Quantity of Material Used (if applicable)	GROUT DENSITY (lbs./gal.,# bag mix, gal./sack etc.)
0	1	CONCRETE	1	
1	50	CEMENT BENTONITE GROUT	2	
50	55	3/8" BENTONITE PELLETS	1	
55	107	16-40	2	

Well Development / Pump or Bail Tests

Date	Method	Yield	Units Check One: GPM	CFS	DRAWDOWN (ft)	TIME PUMPED (hrs & min)

Pump (Permanent)

Pump Description: ____ Horsepower: ____ Pump Intake Depth: ____ feet

Approximate maximum pumping rate: ____ Well disinfected upon completion? ☐ Yes ☐ No

Comments

Description of construction activity, additional materials used, problems encountered, extraordinary circumstances, abandonment / procedures. *Use additional well data form for more space.*

Well Driller Statement

This well was drilled or abandoned under my supervision, according to applicable rules and regulations, and this report is complete and correct to the best of my knowledge and belief.

Name LAYNE CHRISTENSEN COMPANY
(Person, Firm, or Corporation – Print or Type)

License No. 626

Signature ____ (Licensed Well Driller)

Date 4-10-97

WL1

WELL DRILLER'S REPORT
State of Utah
Division of Water Rights

For additional space, use "Additional Well Data Form" and attach

Well Identification MONITOR WELL: 97-93-002-M-02

Owner *Note any changes*
Genwal Resources Inc.
P.O. Box 1420
Huntington, UT 84528

Contact Person/Engineer: GARY GRAY / GENWAL RESOURCES

Well Location *Note any changes*
NORTH 70 feet WEST 300 feet from the SE Corner of
SECTION 2, TOWNSHIP 16S, RANGE 6E, SLB&M.

Location Description: (address, proximity to buildings, landmarks, ground elevation, local well #) MW-6A

Drillers Activity Start Date: 3-28-97 Completion Date: 4-4-97

Check all that apply:
[X] New [ ] Repair [ ] Deepen [ ] Abandon [ ] Replace [ ] Public Nature of Use:

DEPTH (feet) FROM	TO	BOREHOLE DIAMETER (in)	DRILLING METHOD	DRILLING FLUID
0	102	3	FLUID ROTARY	WATER

Well Log

DEPTH (feet) FROM	TO	WATER	PERMEABLE high	PERMEABLE low	UNCONSOLIDATED CLAY	SILT	SAND	GRAVEL	COBBLES	BOULDER	OTHER	CONSOLIDATED ROCK TYPE	COLOR	DESCRIPTIONS AND REMARKS (include comments on *water quality* if known.)
0	102										X			SANDSTONE / CLAYSTONE

Static Water Level

Date 3-28-97 Water Level 2.5 feet Flowing? [ ] Yes [X] No

Method of Water Level Measurement WL1 If Flowing, Capped Pressure NO PSI

Point to Which Water Level Measurement was Referenced GROUND LEVEL

Height of Water Level reference point above ground surface N/A feet Temperature N/A [ ] °C [ ] °F

[redacted] *Well Log* [redacted]

Construction Information

DEPTH (feet) FROM	TO	CASING: CASING TYPE AND MATERIAL/GRADE	WALL THICK (in)	NOMINAL DIAM. (in)	DEPTH (feet) FROM	TO	SCREEN ☒ PERFORATIONS ☐: SLOT SIZE OR PERF SIZE (in)	SCREEN DIAM. OR PERF LENGTH (in)	SCREEN TYPE OR NUMBER PERF (per round/interval)
0	72	1 1/4" SCH PVC		1 1/4	72	102	.010	1 1/4	

Well Head Configuration: FLUSH MOUNT Access Port Provided? ☒ Yes ☐ No

Casing Joint Type: FLUSH Perforator Used:

DEPTH (feet) FROM	TO	FILTER PACK / GROUT / PACKER / ABANDONMENT MATERIAL: ANNULAR MATERIAL, ABANDONMENT MATERIAL and/or PACKER DESCRIPTION	Quantity of Material Used (if applicable)	GROUT DENSITY (lbs./gal., # bag mix, gal./sack etc.)
0	1	CONCRETE	1	
1	70	CEMENT	4	
70	72	3/8 BENTONITE PELLETS	1	
72	102	16-40 SILICA SAND	2	

Well Development / Pump or Bail Tests

Date	Method	Yield	Units Check One: GPM	CFS	DRAWDOWN (ft)	TIME PUMPED (hrs & min)

Pump (Permanent)

Pump Description: Horsepower: Pump Intake Depth: feet

Approximate maximum pumping rate: Well disinfected upon completion? ☐ Yes ☐ No

Comments

Description of construction activity, additional materials used, problems encountered, extraordinary circumstances, abandonment / procedures. *Use additional well data form for more space.*

Well Driller Statement

This well was drilled or abandoned under my supervision, according to applicable rules and regulations, and this report is complete and correct to the best of my knowledge and belief.

Name LAYNE CHRISTENSEN COMPANY License No. 626

(Person, Firm, or Corporation – Print or Type)

Signature [signature] Date 4-10-97

(Licensed Well Driller)

P.O. Box 1420
Huntington, UT 84528

Contact Person/Engineer: GARY GRAY / GENWAL RESOURCES

Well Location *Note any changes*

NORTH ~~620~~ 640 feet WEST ~~290~~ 300 feet from the SE Corner of SECTION 2, TOWNSHIP 16S, RANGE 6E, SLB&M.

Location Description: (address, proximity to buildings, landmarks, ground elevation, local well #) MW-6

Drillers Activity Start Date: 3-28-97 Completion Date: 4-4-97

Check all that apply:
[X] New [ ] Repair [ ] Deepen [ ] Abandon [ ] Replace [ ] Public Nature of Use:

DEPTH (feet) FROM	TO	BOREHOLE DIAMETER (in)	DRILLING METHOD	DRILLING FLUID
0	350	3	FLUID ROTARY	WATER

Well Log

DEPTH (feet) FROM	TO	WATER	PERMEABLE High	PERMEABLE low	UNCONSOLIDATED CLAY	SILT	SAND	GRAVEL	COBBLES	BOULDER	OTHER	CONSOLIDATED ROCK TYPE	COLOR	DESCRIPTIONS AND REMARKS (include comments on *water quality* if known.)
0	350										X			SANDSTONE/CLAYSTONE

Static Water Level

Date 3-28-97 Water Level 2.5 feet Flowing? [ ] Yes [X] No

Method of Water Level Measurement WL1 If Flowing, Capped Pressure NO PSI

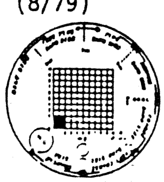
Point to Which Water Level Measurement was Referenced GROUND LEVEL

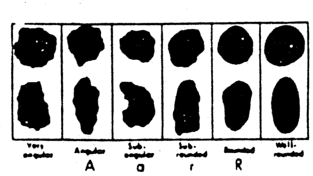
Height of Water Level reference point above ground surface N/A feet Temperature N/A [ ] °C [ ] °F

Well Log

97.2					Note: Water level @: 7:15 A 3/13/97
11				100	2.35' bgL

C - 1857 (8/79)





HOLE NO MW-6

TYPE OF DESCRIPTION	
CUTTINGS	
CORE	X
OUTCROP	

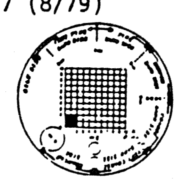
Andalex Resources, Inc.

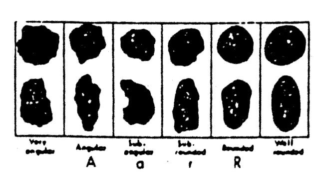
HOLE NO. MW-6

Geologist R. Holland

BOX NO.	SMPL. NO.	DEPTH FROM	DEPTH TO	THICKNESS	STRIP LOG 1" = ___	MEDIAN GRAIN SIZE (VF F M C VC)	ROUNDNESS (A a r R)	SORTING (P M W)	DESCRIPTION & REMARKS
11 107.0	33 Horiz Fract. Bedd.				100				Sandstone, lt to med. gray, fine to very fine, S&P, Quarts graines are dominate clast, Calcareous, v. minor carbonaceous laminae. @ 103 SS as above with carb laminae increasing slightly.
12 116.7	10 Horiz Fract. Bedd.				110				@ 110.5' Sandstone as ab with interbeds of clayey siltstone, dark gray, calcareous, cross laminated. @ 111.15 SS as ab. @ 113.45 SS as ab with siltstone as ab @ 114.1 SS as above.
13 126.6	3 Horiz Fract. Bedd.	123.8	129.2	123.8 5.4'	120				@ 117.5' Sandstone and interbeds of silt st. as ab. Carbonate increased to highly calc. Clay fraction inc. with depth @ 123.8' Sandstone, brown black, fine grained, Carbonaceous, noncalcareous, quartz clast are sub to well rounded, frosted to clear.
14 136.5	3 Horiz. Fract. Bedding		Storrs		130				@ 129.2' Sandstone, lt brown gray to tan, med. to fine grained, noncalc, quartz clast sub to well rounded, frosted to clear, some S&P Note: Hole Purged at 130.6' - water level rose 2.5' in 4 minutes. = .28 gpm 0.17 gpm
15 146.15	0 fractures Bedding				140				Sandstone becoming lighter gray with depth and grain size increasing. white Feldspar(?) common. S&P Sandstone as above fine to med. gray, becoming slightly calcareous, very uniform, very little carb. material, massive bedding.
16 155.7	0 fractures Bedding				150				Sandstone as ab, clean, uniform, massive.
17 165.6	1 fracture				160				@ 160' sandstone, lt gray, fine grained, S&P, uniform, massive, calcareous.
18 175.4	7 Fractures bedding				170				@ 174.8 SS as ab with claystone laminae, dark grey to black, appear noncalcareous.
19 185.2	4 Fractures Bedding				180				@ 175.4 sandstone as above, clay fraction decreased to 0%, SS is uniform, massive. @ 182. and 183 sandstone as ab with silty claystone interbeds to laminae, dark gray to black. Bedding planes occure at zones of high clay content.
20 194.6	5 Fractures Bedding				190				@ 187.85 Interbedded claystone, dark gray to black and sandstone as above. Note: Hole purged @ 5:00 pm 3/13/97 @ 7:15 Am on 3/14/97 water level at 2.5' bgl
21					200				@ 196.5' Claystone fraction increasing claystone is dark gray to black, calc. to non calc., carbonaceous.

C - 1857 (8/79)





Andalex Resources, Inc.

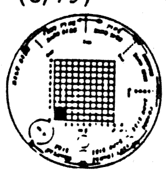
TYPE OF DESCRIPTION	
CUTTINGS	
CORE	X
OUTCROP	

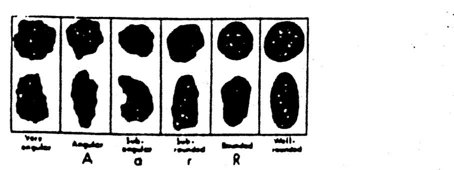
HOLE NO. MW-6

Geologist R. Holland

BOX NO.	SMPL. NO.	DEPTH FROM	DEPTH TO	THICKNESS	STRIP LOG	MEDIAN GRAIN SIZE	ROUNDNESS	SORTING	DESCRIPTION & REMARKS
21 (204.65)	7 Fract. Bedd.				200				@201.1 sandstone, lt gray, vfg to fg, slightly calcareous, well indurated, quartz clast are sub to well rounded, frosted to clear, minor s&p. Note: at 205.7' .49 gpm flow.
22 (214.4)	6 Fract. Bedding				210				@205' Sandstone as ab with some clay laminae - zones of turbation.
23 (224.2)	11 Fract. Bedd. 1 Vertical Fract.				220				@216 well developed cross laminae. Clay fraction inc. with depth. Bedding fractures occure prim. along clay laminae. Coal laminae at 217.5' @222.7' verticle fracture, pyrite common along fracture face.
24 (234.0)	6 Fract. - Bedd. 2 Fract. - vert.				230				@226 verticle fracture with pyrite. Sandstone, lt gray, vfg, calc, clayey laminae common but dec. with depth. @227' sandstone, med to dark gray, vfg, clayey laminae and turbation zones, calcareous. Worm burrows(?) noted.
25 (243.8)	8 Fract.-Bedd. 2 Fract.-vert.				240				Note: since encountering the vertical fract. the drilling fluid returns have decreased. @231.5 core becoming darker gray with increase in clay fraction. Verticle fracture @231 to 235.5'
26 (253.6)	6 Fract. - Bedd.				250				@236.5' hole making 4.22 gpm. @238 verticle fracture with abundant pyrite along fracture face. Core displays bioturbation and clay laminae. Circulation becoming a problem - lost into fr
27 (263.3)	2 Fract.-Bedd 1 Fract.-vert.				260				@242.2 ss, lt gray, vfg to fg, slightly to calcareous, well indurated, massive, minor clay laminae. @246 Artesian flow @1.0 gpm. @248.5 + 251.7 dark gray round spots. @260' verticle fracture with pyrite
28 (273.15)	4 Fract.-Bedd 1 Fract.-vert.	267.2	269.4	2.2	270				Some cross laminae and claystone inclusions. @265.5' pinkish calcite inclusion 1" long. @267' Hydrolic head at 1.9' bgl 3/15/97. @267.2 ss, lt to dark gray, vf to fg, strongly bioturbated, slightly calcareous, base is cross laminated, clayey.
29 (282.9)	0 fractures	269.4	284.9	15.5'	280				@269.4 Sandstone, lt gray, vfg, slightly calc., s&p, uniform. @275 ss as above becoming darker gray and fine grained.
(292.5)	9 Fract.-Bedd.	284.9	292.0	7.1	290				@284.9' Sandstone as ab with clystone bands and inclusions, claystone is dark gray to blk, non to slightly calcareous. - most of the inclusions are prob. ripup clast. @290.5 - 291.7 rounded brown inclusions up to 2" diameter - ss.
		292.0	315.3	23.3	300				@292.0' Sandstone, med gray, fine grained, calc., with abundant clay laminae, carbonaceous. @297.2 Sandstone as ab with interbeds of siltstone, clayey, blk, slightly calc. and clayst, blk, slightly calc.

C - 1857 (8/79)





Andalex Resources, Inc.

TYPE OF DESCRIPTION	
CUTTINGS	
CORE	X
OUTCROP	

HOLE NO. MW-6
PAGE 4 OF 4
Geologist R. Holland

BOX NO.	SMPL. NO.	DEPTH FROM	DEPTH TO	THICKNESS	STRIP LOG
31 302.4	11 Fract-Bedd				300
32 311.15	6 Fract.-Bedding				310
33 321.0	10 Fract.-Bedding	315.3	357.0	35.7	320
34 330.9	5 Fract.-Bedding				330
35 340.7	7 Fract.-Bedding				340
36 351.0	6 Fract.-Bedd 1 Vertical				350

Panther (315.3 – 357.0, thickness 35.7)

TD 351.0

MEDIAN GRAIN SIZE (S F M C C) | ROUNDNESS (A a r R) | SORTING (P M W)

DESCRIPTION & REMARKS

at 301.8 - 302.2 claystone with interbedded SS as ab

@ 307.3' Sandstone, lt to med. gray, vfg to fg, slightly calc., low angle cross bedding.

Calcite inclusions <1" at 310.5'

308.8 - 311.75 SS as above with minor interbeds of claystone, dark gray to blk.

@ 311.75' Purged hole with core barrel — Recharge measured at 1.4 gpm. Blow hole with air compressor for 1.25 hr - hole made 2.9 gpm

@ 312.7 Claystone interbed, blk, silty, non calc, to slightly calc. Clay interbeds increase to 313.8. @ 313.8 sandstone, med to dark gray, cross laminae, coal at 315.2 to 315.3.

@ 315.3' Sandstone, lt to med gray, fine gr., slightly calc., SdP, becoming very uniform with depth. minor clay laminae.

@ 321.5 SS as ab, cross bedded, fine to medium grained

@ 338.8 claystone parting <1" Sandstone as above, cross bedding

@ 344.7 - 345.0 SS as ab with claystone interbeds exhibiting bioturbation.

@ 347.3 Interbedded claystone, siltstone and vfg sandstone, med gray to dark gray to black, calcareous, bioturbation common.

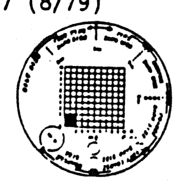
at 350.7' vfg to silty sandstone, dark gray to black when wet.

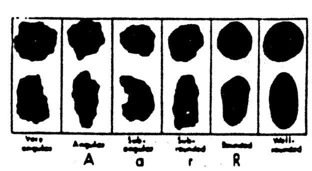
Note: From 347.3 To 351.0 will most likely act as impervious to downward migration of water.

Purged hole, water level rose 10.8' in 35 sec. = 9.6 gpm.

Roger J Holland
3/15/97

C - 1857 (8/79)





HOLE NO. MW-6

Construction Information

DEPTH (feet) FROM	TO	CASING TYPE AND MATERIAL/GRADE	WALL THICK (in)	NOMINAL DIAM. (in)	SCREEN ☒ / PERFORATIONS ☐ DEPTH (feet) FROM	TO	SLOT SIZE OR PERF SIZE (in)	SCREEN DIAM OR PERF LENGTH (in)	SCREEN TYPE OR NUMBER PERF (per round/interval)
0	305	1 1/4" SCH 40 PVC		1 1/4	305	345	.010	1 1/4	
345	350	1 1/4" SCH 40 PVC		1 1/4					

Well Head Configuration: FLUSH MOUNT Access Port Provided? ☒ Yes ☐ No

Casing Joint Type: FLUSH Perforator Used: ____

DEPTH (feet) FROM	TO	FILTER PACK / GROUT / PACKER / ABANDONMENT MATERIAL: ANNULAR MATERIAL, ABANDONMENT MATERIAL and/or PACKER DESCRIPTION	Quantity of Material Used (if applicable)	GROUT DENSITY (lbs./gal., # bag mix, gal./sack etc.)
0	1	CONCRETE	1	
1	290	CEMENT BENTONITE GROUT	14	
290	300	BENTONITE SLURRY	1	
300	350	16-40 SILICA SAND	3.5	

Well Development / Pump or Bail Tests

Date	Method	Yield	Units Check One: GPM	CFS	DRAWDOWN (ft)	TIME PUMPED (hrs & min)

Pump (Permanent)

Pump Description: ____ Horsepower: ____ Pump Intake Depth: ____ feet

Approximate maximum pumping rate: ____ Well disinfected upon completion? ☐ Yes ☐ No

Comments

Description of construction activity, additional materials used, problems encountered, extraordinary circumstances, abandonment / procedures. *Use additional well data form for more space.*

Well Driller Statement

This well was drilled or abandoned under my supervision, according to applicable rules and regulations, and this report is complete and correct to the best of my knowledge and belief.

Name LAYNE CHRISTENSEN COMPANY License No. 626

(Person, Firm, or Corporation – Print or Type)

Signature [signature] Date 4-10-97

(Licensed Well Driller)

APPENDIX 7-55

INVESTIGATION OF ALLUVIAL GROUND WATER SYSTEM

IN MILL FORK CANYON

1/23/95 revised 4/97

Investigation of the Alluvial Groundwater System In Mill Fork Canyon with Implications for Recharge to Little Bear Spring

GENWAL Resources, Inc., Huntington, Utah

24 February 2001

Mayo and Associates, LC
Consultants in Hydrogeology

Investigation of the Alluvial Groundwater System In Mill Fork Canyon with Implications for Recharge to Little Bear Spring

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GENWAL Resources, Inc., Huntington, Utah

24 February 2001

Prepared by:

Erik C. Petersen, P.G.
Associate

Mayo and Associates, LC
710 East 100 North
Lindon, Utah 84042

Mayo and Associates, LC
Consultants in Hydrogeology

Investigation of the Alluvial Groundwater System In Mill Fork Canyon with Implications for Recharge to Little Bear Spring

Introduction

Little Bear Spring is located in the central Wasatch Plateau region, approximately 12 miles northwest of Huntington, Utah (Figure 1). The spring discharges from a northeast-southwest trending fracture system in the Star Point Sandstone. Discharge from the spring varies from about 200 gpm during periods of prolonged drought, to nearly 500 gpm during wetter climatic periods.

Recent hydrogeologic investigations of Little Bear Spring (Mayo and Associates 2001, 1999; WTR, 1999) have concluded that the spring is recharged from surface water and/or alluvial groundwater losses in Mill Fork Canyon, located about 1.5 miles southwest of the spring (Figure 2). Specifically, it has been found that recharge to the spring occurs where the Star Point Sandstone fracture system intersects the base of the alluvial deposits in Mill Fork Canyon.

The purpose of this investigation is 1) to verify that alluvial groundwater in Mill Fork Canyon is lost to the Star Point Sandstone fracture system that supports Little Bear Spring, and 2) to verify that alluvial groundwater loss in Mill Fork Canyon is of sufficient magnitude to sustain the baseflow discharge to Little Bear Spring.

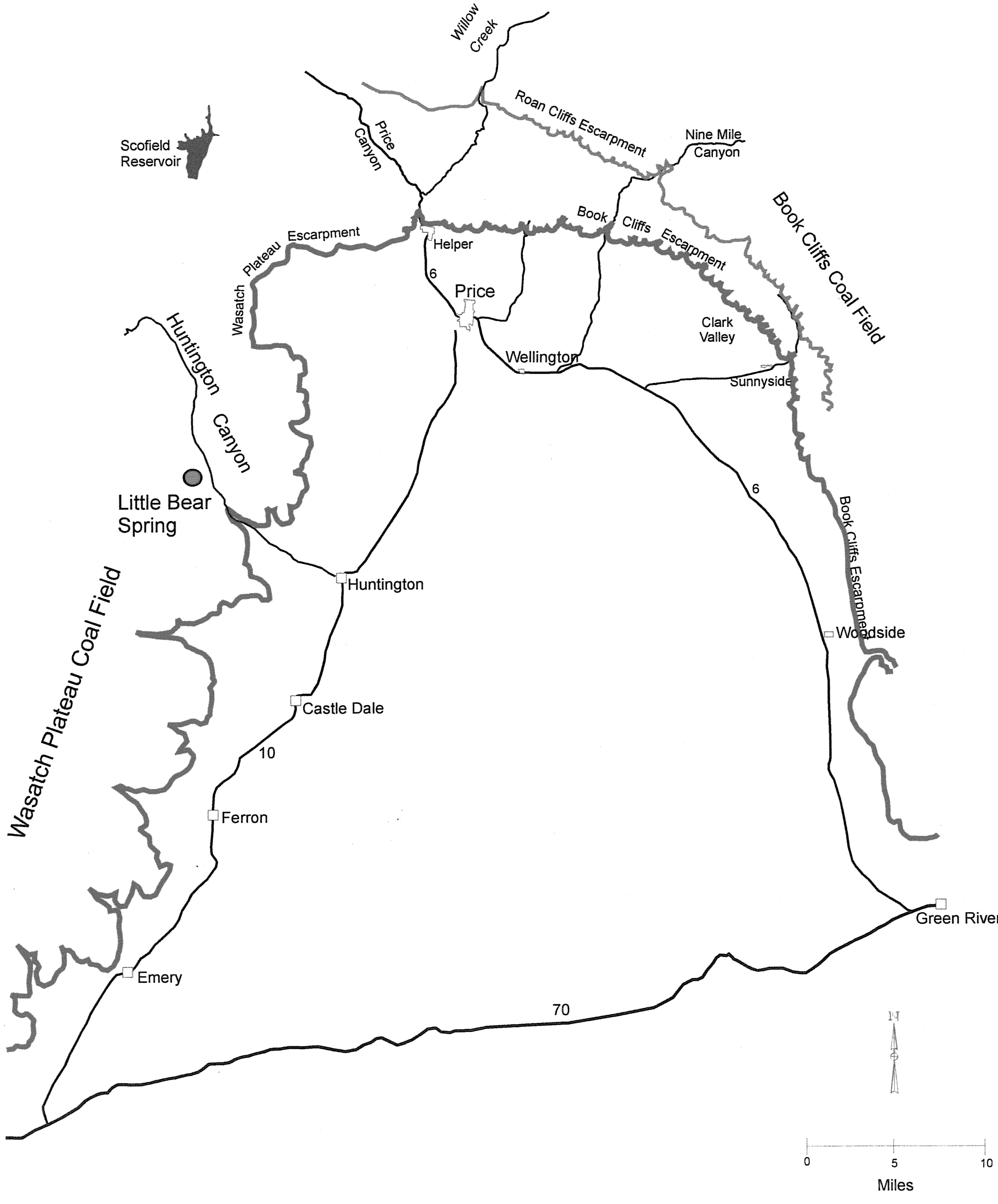

Figure 1 Location map of the Little Bear Spring area.

Mayo & Associates
Fig1 - Regional Map.cdr 13 Jul 99

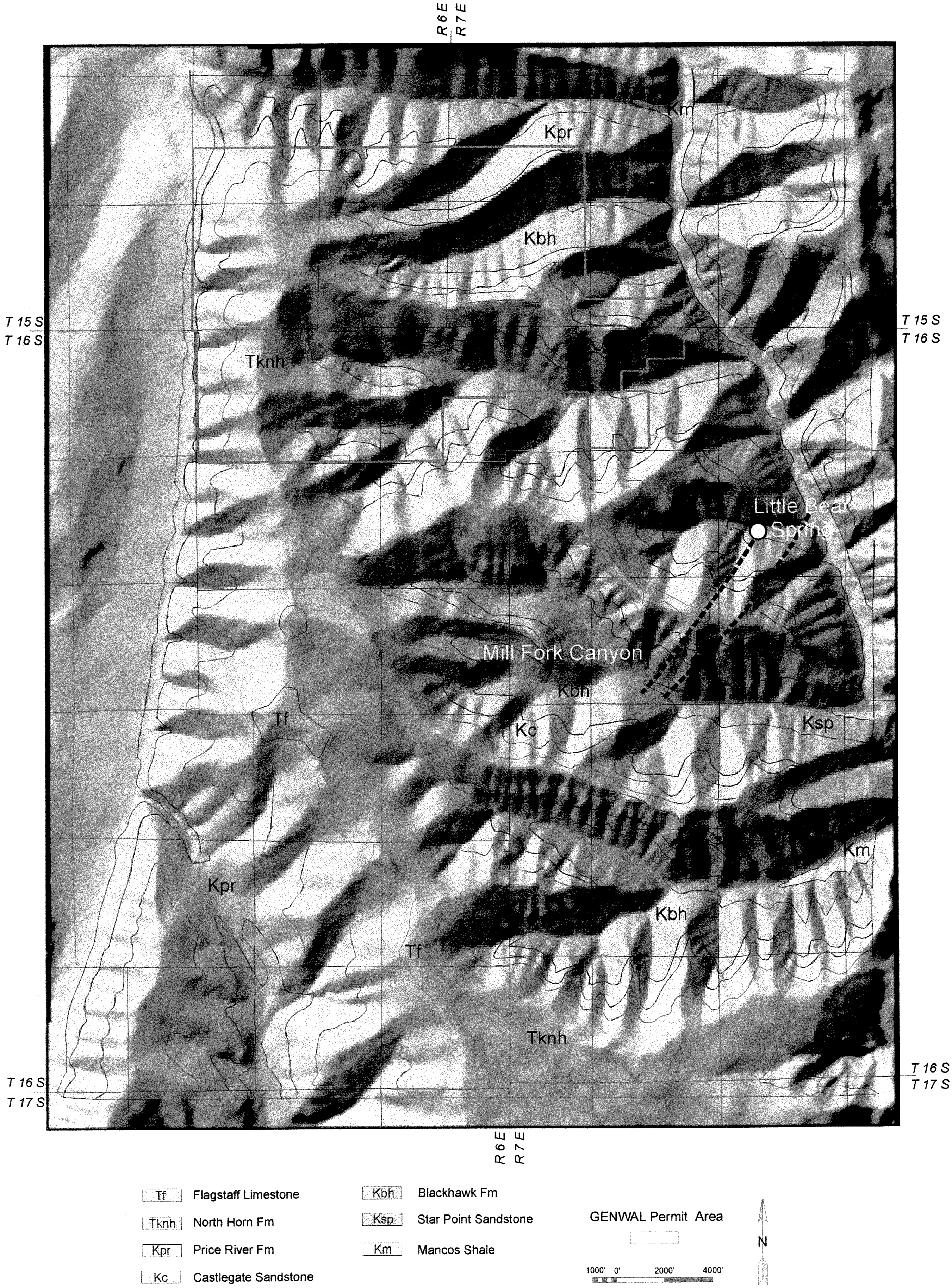

Figure 2 Relief map of the Little Bear Spring area.

Methodology

To verify that the alluvial deposits in Mill Fork Canyon recharge the fracture system from which Little Bear Spring discharges, it is necessary to determine the quantity of groundwater flowing through the Mill Fork alluvial deposits both above and below the fracture system. It is possible to determine the quantity of water flowing through a groundwater system using Darcy's Law, Q=KIA, where Q is the discharge rate, K is the hydraulic conductivity of the alluvial sediments, I is the hydraulic gradient, and A is the cross-sectional area of saturated alluvium. The determination of each of these parameters is discussed below.

Cross-sectional area of saturated alluvium

Sunrise Engineering of Draper, Utah performed a geophysical investigation of the alluvial sediments in Mill Fork Canyon during November 2000. This investigation included two electrical resistivity profiles. The upper profile was located just below the confluence of the upper right and left forks above the fracture zone from which Little Bear Spring discharges (Figure 3). The lower profile was located immediately below the fracture zone at the end of the Forest Service access road (Figure 3). Geophysical interpretations of the resistivity data were provided by Sunrise Engineering. The resistivity cross-sections shown in Figure 3 indicate the geometry of the bedrock/alluvium interface, the thickness of the alluvial deposits, and the cross-sectional area of saturated alluvium (Figure 3). Alluvial thickness measured at the upper profile ranged from 0 to 50 feet, while thicknesses ranged from 0 to 30 feet at the lower profile. The water table at both the upper and lower profiles is near the ground surface. The saturated alluvial thickness at the upper

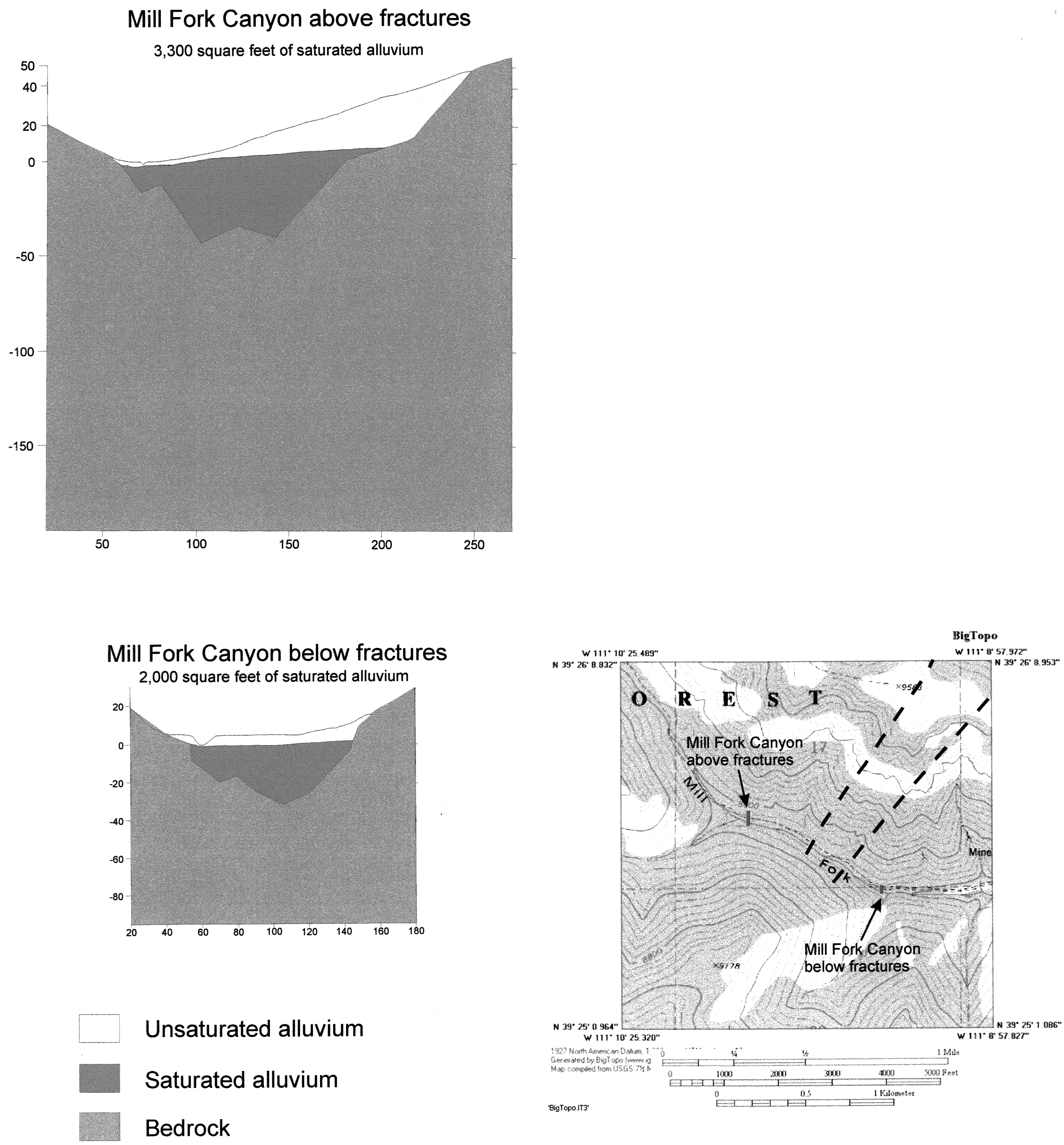

Figure 3 Cross-sections through alluvial sediments above (a) and below (b) the Star Point Sandstone fractures in Mill Fork Canyon. (Geophysical data and interpretation from Sunrise Engineering, 2001).

profile (3,300 square feet) is two-thirds greater than that at the lower profile (2,000 square feet)

Hydraulic Gradients

On 24 January 2001, topographic gradients in the vicinity of the lower resistivity profile were surveyed. Topographic gradients in the vicinity of the upper profile were surveyed on 17 February 2001. The surveys were performed using a hand transit. In this investigation the hydraulic gradient was assumed to be the same as local topographic gradient. This assumption, while not accurate in some geologic settings, is believed to be valid in this steep, mountainous terrain because topography constrains the geometry of the base of the alluvial deposits. Because the water table is essentially at the land surface at both profiles, it follows that the hydraulic gradient will be a reflection of the land surface. The gradient measured in the vicinity of the upper profile (0.132) is appreciably steeper than that at the lower profile (0.043).

Hydraulic conductivity of alluvial sediments

Because site-specific hydraulic conductivity data are not available for the alluvial sediments in upper Mill Fork Canyon it was necessary to estimate the hydraulic conductivity. During field activities in the upper Mill Fork Canyon area it was observed that the near-surface sediments in the stream channel consist primarily of clean sand with some gravel and boulders. There is an overall lack of fine-grained material observed in the stream channel. The makeup of the deeper alluvial sediments has not been investigated. Typical values of hydraulic conductivity for alluvial materials are given in Figure 4. The estimate used in this investigation for both the upper and lower profiles is 1.9×10^{-3} ft/sec, which is in the upper range of silty sand or the middle range of clean sand. The basis for this estimate is described below.

Flow Calculations

As discussed above, values for the saturated cross-sectional area of the alluvial sediments and the hydraulic gradient at both the upper and lower profiles were measured in the field. In order to calculate the flow rates across the upper and lower profiles, it is necessary to estimate the value for the third parameter in Darcy's Law, hydraulic conductivity.

One of the two purposes of this investigation is to verify that the losses from the alluvial groundwater system are on the order of 300 gpm (the baseflow discharge rate of Little Bear Spring). This is accomplished by using Darcy's Law to calculate the flow across the upper and lower profiles. The difference between the discharge in the upper and lower profiles represents the loss from the alluvial groundwater system between the two profiles. If it is assumed that the loss of alluvial water to the fracture system is 300 gpm, it is possible to reverse calculate the value of hydraulic conductivity that corresponds to this flow loss. Using this method, a value for hydraulic conductivity of 1.9×10^{-3} ft/sec is calculated. These calculations are presented in Table 1. As discussed previously, this value, which is consistent with the types of materials observed in Mill Fork Canyon, is reasonable.

Table 2.2 Range of Values of Hydraulic Conductivity and Permeability

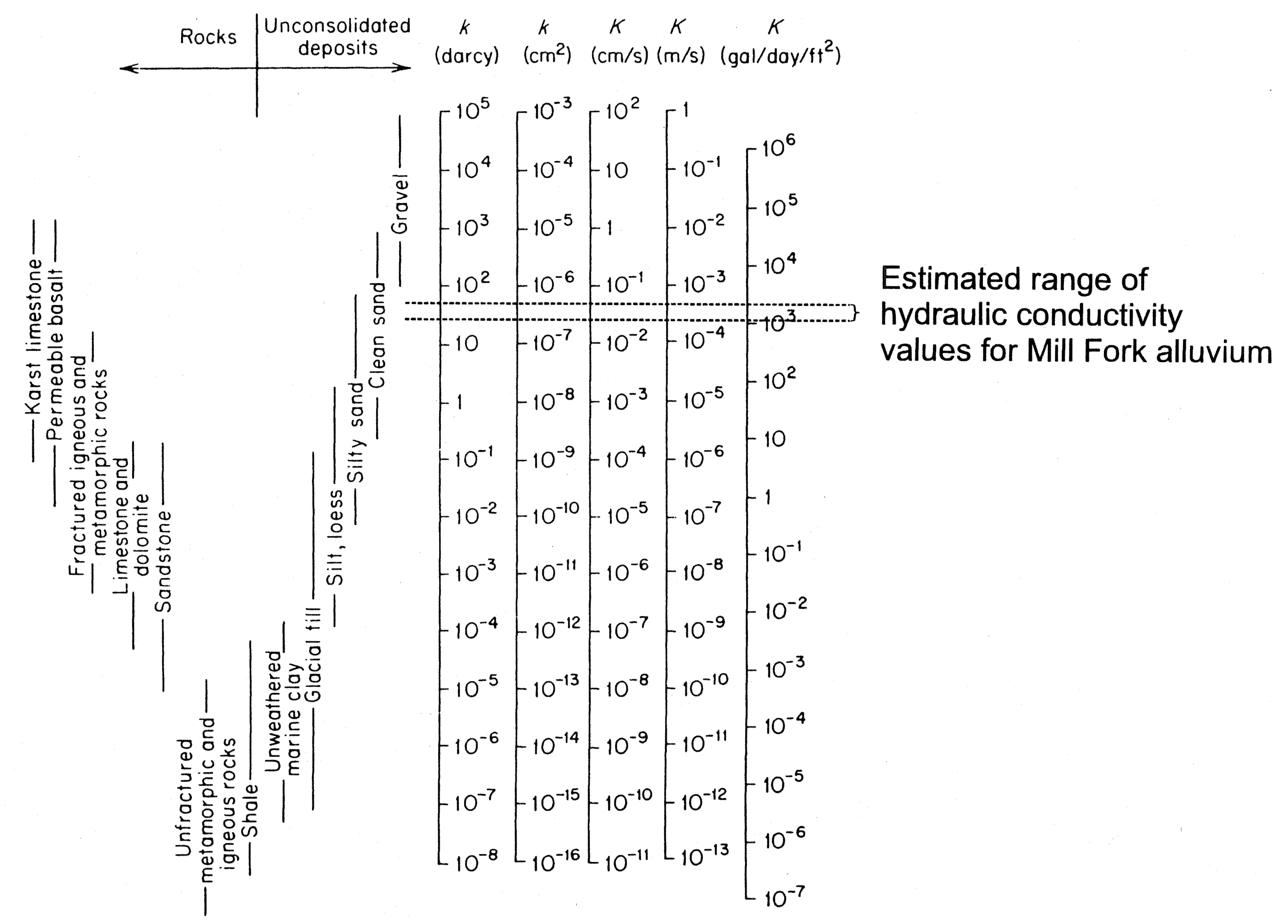

Figure 4 Estimated range of hydraulic conductivity for alluvial sediments in Mill Fork Canyon (Table of K values from Freeze and Cherry, 1979).

Table 1 Listing of parameters used in calculating alluvial groundwater loss in the vicinity of the fracture system from which Little Bear Spring discharges.

Upper cross-section			
K (ft/sec)	0.0019		(approximated)
I	0.132		(surveyed)
A (ft^2)	3300		(calculated from resistivity profile)
Q (cfs)	0.828		(calculated)
Lower cross-section			
K (ft/sec)	0.0019		(approximated)
I	0.043		(surveyed)
A (ft^2)	2000		(calculated from resistivity profile)
Q (cfs)	0.163		(calculated)
Flow difference (cfs)		**0.665**	
Flow difference (gpm)		**298**	

Consideration of three factors suggests that the value of hydraulic conductivity calculated above may be somewhat higher than the actual value. First, any groundwater entering the alluvial groundwater system from the canyon walls in the ½ mile reach between the upper and lower profiles (as suggested by the slope of the water table in both the upper and lower profiles; Figure 3) was not accounted for in the calculations. If this inflow were accounted for, a lower estimate of hydraulic conductivity of the Mill Fork alluvial sediments would result. Second, the alluvial sediments in the lower profile, where the stream gradients are more shallow than in the upper profile, are likely coarser than those in the less steep areas near the lower profile. Consequently, the hydraulic conductivity is likely greater near the upper profile than the lower profile. If the hydraulic conductivity estimate at the upper profile is increased, while the hydraulic conductivity at the lower profile is decreased, a significantly increased flow differential between the upper and lower profiles is calculated. Third, the flow calculations are based on a baseflow discharge rate from Little Bear Spring of 300 gpm. This assumption does not consider any contribution that may occur from delayed release of storage in the rocks between Mill Fork Canyon and the discharge location 1.5 miles distant in Little Bear Canyon (i.e. a gradual draining through the year of water that recharged during the high-flow period). Thus, it is possible that the actual recharge to the fracture system that occurs during the winter months may be significantly less than 300 gpm. The resistivity study was carried out during the driest period of the year when recharge contributions from Mill Fork Canyon are probably at their lowest.

Conclusions

The results of this investigation provide strong support for the idea that alluvial groundwater losses in upper Mill Fork Canyon provide recharge to Little Bear Spring through Star Point Sandstone fracture systems. The results of this investigation clearly indicate that there is more groundwater flowing through the alluvial sediments above the fracture system than below the fracture system. The large loss of water between the upper and lower resistivity profiles strongly support the idea of recharge to the Star Point Sandstone fracture system from the alluvial groundwater system in Mill Fork Canyon.

Although uncertainty regarding the hydraulic conductivity of the alluvial sediments precludes the precise determination of the magnitude of the recharge to Little Bear that occurs in Mill Fork Canyon, a recharge rate on the order of 300 gpm during low-flow conditions is reasonable.

References Cited

Freeze, R.A., and Cherry, J.C., 1979, Groundwater, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 604 p.

Mayo and Associates, 1999, Investigation of groundwater and surface-water systems in the vicinity of GENWAL's existing permit area and the Mill Fork Tract, Emery County, Utah, unpublished consulting report submitted to Genwal Resources, Inc., Huntington, Utah.

Sunrise Engineering, 2001, Resistivity investigation of alluvial thicknesses and bedrock geometry in Mill Fork Canyon, unpublished consulting report.

Water Technology and Research, Inc, 1999, AquaTrack Survey, Little Bear Springs study, unpublished consulting report, 31 p.

APPENDIX 7-56

INVESTIGATION OF POTENTIAL FOR

LITTLE BEAR SPRING RECHARGE

1/23/95 revised 4/97

Investigation of the Potential for Little Bear Spring Recharge in Mill Fork Canyon, Emery County, Utah

GENWAL Resources, Inc., Huntington, Utah

23 February 2001

Mayo and Associates, LC
Consultants in Hydrogeology

Investigation of the Potential for Little Bear Spring Recharge in Mill Fork Canyon, Emery County, Utah

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23 February 2001

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Executive Summary

Little Bear Spring is located in the central Wasatch Plateau region, approximately 12 miles northwest of Huntington, Utah. Discharge rates from Little Bear Spring are unusually large relative to other springs in the Wasatch Plateau, ranging from about 200 to nearly 500 gpm. Discharge from Little Bear Spring, while being responsive to climate and season, is resistant to even prolonged periods of drought. Because of the large quantities of water that consistently discharge from Little Bear Spring, it has been utilized as a culinary water supply for many years. Castle Valley Special Service District currently utilizes the spring to supply drinking water to the towns of Huntington, Cleveland, and Elmo.

Because of the proximity of Little Bear Spring to current and proposed coal mining areas, considerable attention has been given to the hydrogeologic conditions in the vicinity of the spring. Mayo and Associates (1999) suggested that recharge to Little Bear Spring occurs through surface water and/or alluvial groundwater losses in Mill Fork Canyon. Water Technology and Research (1999) performed a geophysical investigation of Little Bear Spring that is in overall agreement with this conclusion. There is currently a general consensus in the local scientific community that Little Bear Spring is likely recharged from the south, probably in Mill Fork Canyon.

Previous investigations (Huntington No. 4 Mine MRP, Mayo and Associates, 1999) have demonstrated that there is commonly no flow in Mill Fork Creek in the vicinity of the fracture system from which Little Bear Spring discharges. The Mill Fork stream channel at the confluence with Huntington Creek is, likewise, commonly dry during much of the year. This condition is anomalous relative to the adjacent Wasatch Plateau drainages both above and below Mill Fork. In nearly all years, discharge persists throughout the year in the Horse Canyon, Blind Canyon, Crandall Canyon, Little Bear Canyon, and Rilda Canyon drainages.

The predicted water yield from Mill Fork Canyon was evaluated using two independent methods to determine if there is sufficient available water in the basin to sustain Little Bear Spring.

Using a comparative basin analysis approach, the discharge from Mill Fork Canyon was compared with the Crandall Canyon discharge. A surrogate basin was used for analysis in order to determine what a typical drainage basin (without a major diversion from the drainage as occurs in Mill Fork) should produce in terms of its annual water yield. The use of Crandall Canyon discharge as a surrogate for Mill Fork was based on the fact that the surface areas of the two adjoining basins are essentially identical (within less than 2%). The aspects, vegetation, and elevation distributions of the two drainages are likewise very similar.

It was determined that, while there is no baseflow discharge in Mill Fork Creek below the fracture system, a baseflow discharge of about 300 gpm persists throughout the year in

Crandall Creek. The alluvial groundwater flowing in Crandall Canyon is not included in this baseflow estimate. An obvious question follows this determination – why is there no baseflow in upper Mill Fork and where did the water go? The assumption that the water that is lost from upper Mill Fork canyon is recharging Little Bear Spring (which has a baseflow discharge of about 300 gpm) is entirely consistent with all of the available data.

The Utah Division of Water Resources (1975) has predicted that up to 4 inches of runoff can be expected from drainage basins in the vicinity of Mill Fork Canyon. Using a conservative estimate of 3.5 inches of runoff, it is calculated that upper Mill Fork should yield about 800 acre-feet of runoff per year, or an average discharge rate of about 500 gpm. This conclusion is in good agreement with that determined using the comparative basin approach.

A conceptual model of groundwater recharge to Little Bear Spring in Mill Fork Canyon has been developed. During the fall and winter months, recharge to the spring occurs as alluvial groundwater is intercepted by the Star Point Sandstone fracture system where it intersects the bottom of the stream channel. During the high-flow season, surface water also contributes to the recharge of Little Bear Spring both directly (through nearby stream losses) and as a result of overall increases in the amount of groundwater flow in the alluvial sediments. This recharge model satisfies all of the physical constraints that must be met for the model to be accepted.

To summarize, it is determined that the upper Mill Fork drainage *is* capable of sustaining the discharge at Little Bear Spring. Moreover, it is difficult to explain the lack of flow in the Mill Fork drainage without taking recharge to Little Bear Spring into account.

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Investigation of the Potential For Little Bear Spring Recharge in Mill Fork Canyon

1. Introduction

Little Bear Spring is located in the central Wasatch Plateau region, approximately 12 miles northwest of Huntington, Utah (Figure 1). Discharge rates from Little Bear Spring are unusually large relative to other springs in the Wasatch Plateau, ranging from about 200 to nearly 500 gpm. Discharge from Little Bear Spring, while being responsive to climate and season, is resistant to even prolonged periods of drought (Figure 2; Table 1). During the severe regional drought of the early 1990s, discharge from Little Bear Spring was continuously greater than 200 gpm (Figure 2).

Because of Little Bear Spring's large discharge rate and good reliability, it has been utilized as a culinary water supply for many years. Castle Valley Special Service District currently utilizes the spring to supply drinking water to the towns of Huntington, Cleveland, and Elmo.

Considerable attention has been given to the hydrogeologic conditions in the vicinity of the spring due to the proximity of the spring to current and proposed coal mining areas. Particular attention has been given to identifying the recharge mechanism and location for the spring because of concerns regarding the potential for mining-related impacts. Mayo and Associates (1999) concluded that recharge to Little Bear Spring occurs through surface water

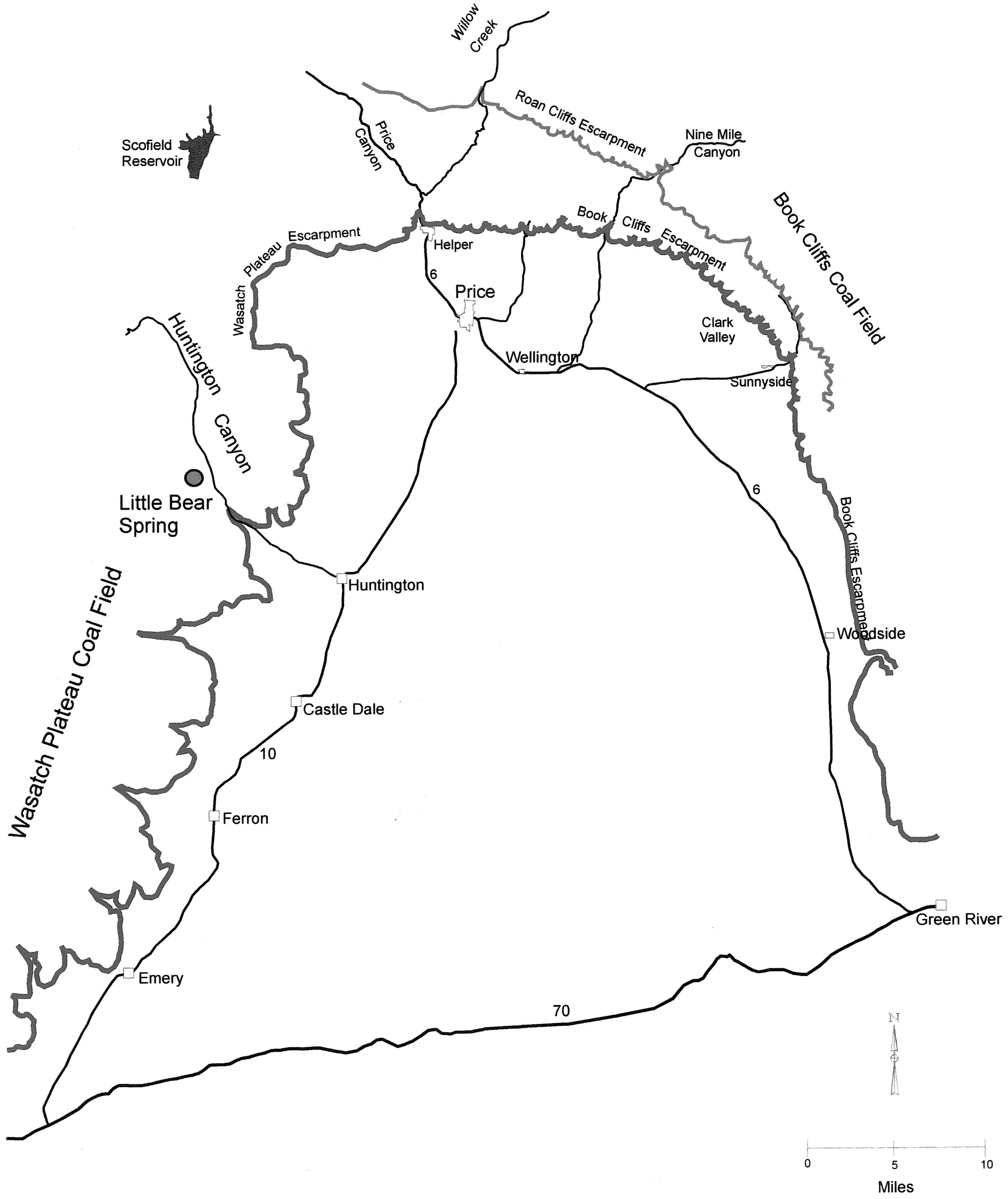


Figure 1 Location map of the Little Bear Spring area.

Mayo & Associates
Fig1 - Regional Map.cdr 13 Jul 99

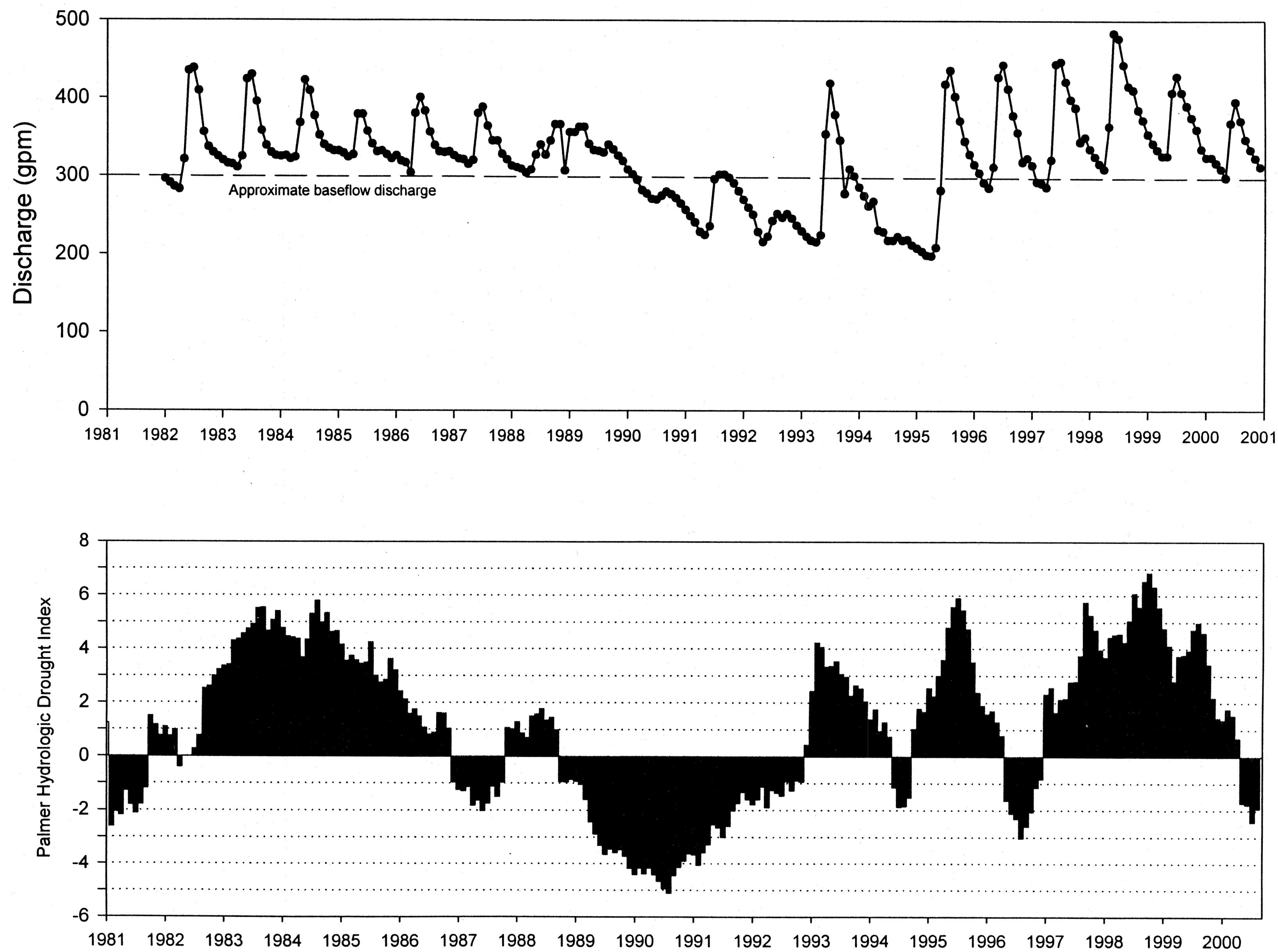


Figure 2 Discharge hydrograph for Little Bear Spring and a plot of the Palmer Hydrologic Drought Index for Utah Region 4.

Table 1 Monthly discharge data for Little Bear Spring (data provided by Castle Valley Special Service District).

LITTLE BEAR SPRING AVERAGE MONTHLY FLOW (gpm)

Year	Jan Avg Flow	Feb Avg Flow	Mar Avg Flow	Apr Avg Flow	May Avg Flow	Jun Avg Flow	Jul Avg Flow	Aug Avg Flow	Sep Avg Flow	Oct Avg Flow	Nov Avg Flow	Dec Avg Flow	Yearly Average
1982	296	291	286	283	321	435	438	409	356	337	330	325	342
1983	320	316	315	311	325	424	430	395	358	339	330	326	349
1984	325	326	322	324	368	423	409	377	352	340	335	332	353
1985	332	329	324	227	379	379	357	341	331	332	327	322	332
1986	326	319	317	304	380	400	383	356	339	331	330	331	343
1987	326	322	321	315	320	380	388	364	345	345	328	321	340
1988	313	311	309	304	308	327	340	327	345	366	366	307	327
1989	256	356	363	363	341	333	332	330	340	334	326	319	333
1990	308	302	295	282	278	271	270	275	280	277	272	265	281
1991	257	249	241	229	225	236	296	302	302	298	291	281	267
1992	270	260	251	229	216*	223*	243	252	247	252	246	237	244
1993	230	223	218	216	225	354	419	379	346	278	309	300	291
1994	286	275	262	268	231	229	218	218	223	218	219	212	238
1995	208	204	199	198	209	282	418	436	402	371	345	328	300
1996	315	304	292	285	312	427	443	412	378	356	318	323	347
1997	314	293	291	286	321	444	447	421	398	388	344	350	358
1998	335	325	316	309	364	484	477	443	415	410	385	372	386
1999	354	342	334	326	326	407	428	407	390	375	360	335	365
2000	324	324	317	309	298	368	395	371	347	334	323	312	
2001													

Note: * Discovered a broken pipe at the lower spring which decreased the flow

Mo. Totals	5695	5671	5573	5368	5531	6603	7131	6815	6494	6281	5761	5586	5796.92
Monthly Ave.	299.7	298.5	293.3	282.5	291.1	347.5	375.3	358.7	360.8	348.9	320.1	310.3	322.05

and/or alluvial groundwater losses in Mill Fork Canyon. Water Technology and Research (WTR; 1999) performed a geophysical investigation of Little Bear Spring that is in general agreement with this conclusion.

The purpose of this investigation is to determine if the Mill Fork drainage can sustain the discharge of Little Bear Spring. Specific objectives are 1) to determine if the annual water yield from the upper Mill Fork drainage is sufficient to sustain the discharge at Little Bear Spring in addition to any surface water discharge from the basin, and 2) to evaluate the physical mechanism whereby surface water from Mill Fork Creek and/or alluvial groundwater may recharge the fracture system that discharges at Little Bear Spring.

Including this introduction, this report contains the following sections:

- Introduction
- Background
- Methods of Study
- Climate
- Geologic and Physiographic Setting
- Water Budget
- Conceptual Recharge Model for Little Bear Spring
- Conclusions

2. Background

Mayo and Associates (1999) investigated groundwaters and surface waters in the vicinity of Little Bear Spring and the surrounding area. This investigation included an evaluation of the potential coal mining impacts to Little Bear and other springs in the area. Mayo and Associates concluded that mining-related impacts to water quality or water quantity at the spring were unlikely. Based on several lines of evidence they also concluded that Little Bear Spring does not originate from the groundwater systems surrounding the coal seams. The evidence included groundwater age dating (the Star Point Sandstone groundwater in the mine is nearly 20,000 years old while Little Bear Spring water is modern), groundwater stable isotopic compositions, potentiometric data, groundwater discharge characteristics and rates, and chemical information.

Previous investigations concluded that the Little Bear Canyon drainage does not receive sufficient precipitation to sustain the discharge from Little Bear Spring (Vaughn Hansen Associates, Beaver Creek Coal Company, Huntington #4 Mine MRP, 1977). They suggested that the recharge location for Little Bear Spring must originate from outside the Little Bear Canyon drainage. Mayo and Associates (1999) concluded that the most likely recharge mechanism for Little Bear Spring was from surface-water or alluvial groundwater losses in a major drainage south of the spring, most likely in Mill Fork Canyon. The fracture system from which Little Bear Spring discharges intersects the bottom of Mill Fork Canyon approximately 1.5 miles southwest of the spring.

WTR (1999), using a proprietary geophysical technique, concluded that the primary recharge to Little Bear Spring originates from the southwest along the same trend as the fracture system from which the spring emanates. They further concluded that Little Bear Spring was likely recharged from losses in Mill Fork Creek.

Although several recharge mechanisms and locations for Little Bear Spring have been proposed through the years, there is now a general consensus among the local scientific community that recharge to the spring most likely occurs to the south or southwest of the spring (Conference on Little Bear Spring at the Manti-La Sal National Forest office, Price, Utah, 26 October 2000).

At the October 2000 meeting, it was concluded that additional data should be collected to verify the conclusion that Little Bear Spring could be recharged from surface water or alluvial groundwater losses in Mill Fork Canyon. Specifically, it was determined that a water budget analysis should be performed to verify that the annual water yield from the upper Mill Fork drainage is sufficient to sustain both the discharge at Little Bear Spring and any surface water flowing out of the drainage.

3. Methods of Study

The hydrology and hydrogeology of the study area have been evaluated by analyzing: 1) surface water and groundwater discharge data, 2) climatological data, and 3) geologic and topographic information. Specific methods of investigation are described below.

3.1 Maps and reports

Existing published and unpublished hydrologic, hydrogeologic, and geologic reports and maps were obtained and reviewed.

3.2 Compilation of historic stream flow data

Historic discharge data for streams in the region were obtained from GENWAL Resources and compiled into electronic format. Additional data were obtained from the Utah Division of Oil, Gas and Mining on-line database and from the U.S. Environmental Protection Agency on-line database (STORET). Historic and recent discharge data for Little Bear Spring were obtained from the Castle Valley Special Service District.

3.3 Stream gauging in Mill Fork Canyon

Prior to the 2000 conference, stream flow measurements were taken on both the main and upper left forks of Mill Fork Creek on 8-9 October 1998. The upper left forks were gauged from approximately the eastern edge of section 13, T16S R6E to the confluence with the main fork near spring MF-3. The main fork was gauged from just above spring MF-7 to the confluence with Huntington Creek. All stream flow measurements were made using a calibrated bucket and a stopwatch. Temperature and electrical conductivity were recorded at each gauging station. Additionally, water samples were collected at each site for stable isotopic analysis.

On 3-4 November 2000, stream flow measurements were again performed on both the main and upper left forks of Mill Fork Creek. Stream flow measurements were made with either a 90° v-notch weir or with a calibrated bucket and stopwatch.

3.4 Drainage basin area calculations

Surface areas for the Mill Fork and Crandall Canyon drainages were calculated from the Rilda Canyon USGS 7.5 minute topographic map. Drainage basin areas were digitized and the areas were electronically determined using AutoCAD™ software.

4. Climate

Precipitation in Crandall Canyon near the mine portal (at an elevation of about 8000 feet) averages 20 inches per year (Crandall Canyon Mine, MRP). The average monthly precipitation at the mine is shown in Figure 3. Because precipitation in the area is highly influenced by topography, regions at significantly higher elevations likely receive more precipitation, whereas the lower-lying areas likely receive less. Most of the precipitation in the area occurs as winter snow between November and March. Significant thunderstorms often occur during the monsoon season in August.

Temperatures in the Crandall Canyon area commonly range from 32 to 90°F (0 to 32°C) in the summer months and from –10 to 40°F (-23 to 4.4°C) during the winter months.

Potential evapotranspiration is 18 and 21 inches per year in the Crandall Canyon area (Crandall Canyon Mine MRP). Potential evapotranspiration is defined as the water loss that will occur if at no time there is a deficiency of water in the soil for the use of plants or

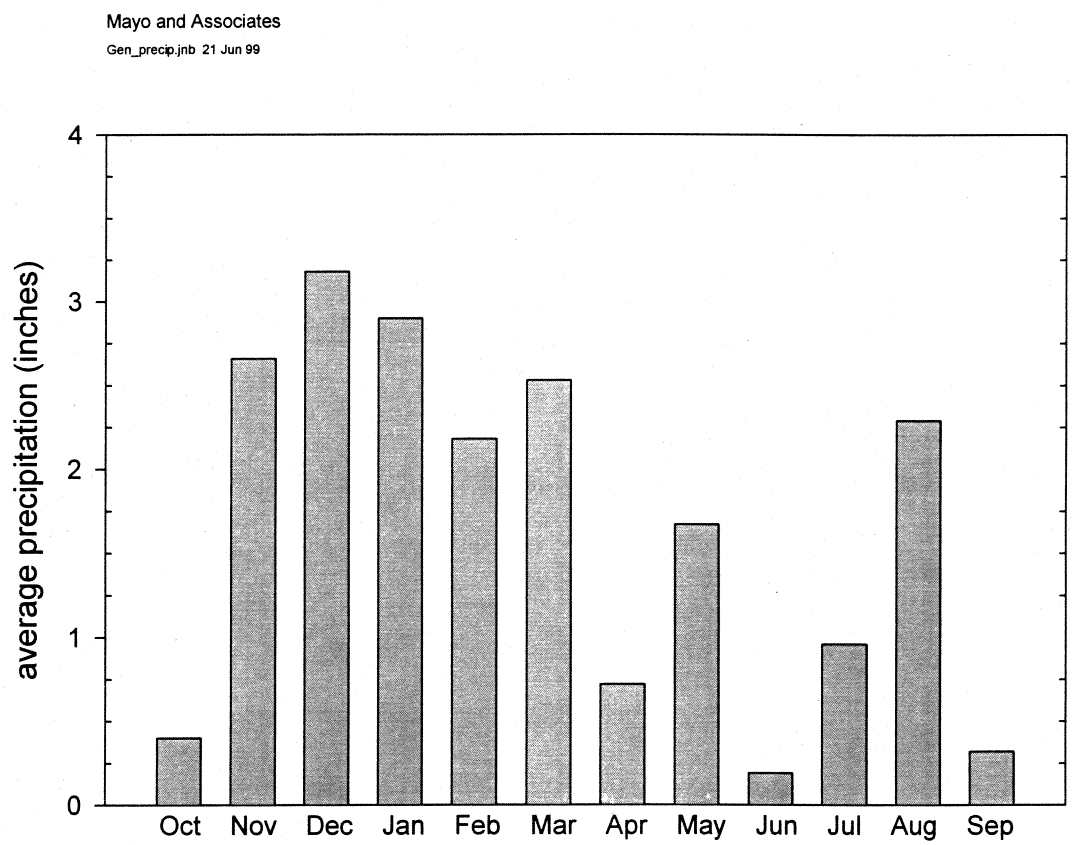


Figure 3 Average monthly precipitation at the Crandall Canyon #1 Mine.

evaporation at the ground surface. Because this condition is not always met, the actual evapotranspiration rate is commonly lower than the potential rate.

The average direction of the prevailing winds is from the west and northwest at an average velocity of 12 mph.

It is believed that climatic conditions in the Mill Fork and Little Bear drainages (at similar elevations) are likely similar to those in the Crandall Canyon area.

A plot of the Palmer Hydrologic Drought Index (PHDI) for Utah Division 4 is shown in Figure 2. The PHDI (NCDC, 1997; Karl, 1986; Guttman, 1991) indicates the long-term climatic trends for the region. The PHDI is a monthly value calculated by the National Climatic Data Center (NCDC) that indicates the severity of a wet or dry spell. The PHDI is based on climatic and hydrologic parameters such as temperature, precipitation, evapotranspiration, soil water recharge, soil water loss, and runoff. Because the PHDI takes into account parameters that affect the balance between moisture supply and moisture demand, the index is a useful tool for evaluating the long-term relationship between climate and groundwater recharge and discharge.

The PHDI is useful for determining if variations in spring or stream discharges are the result of climatic variability or whether they are the result of other factors.

5. Geologic and Physiographic Setting

Seven bedrock formations crop out in the study area. In descending order these formations are the Flagstaff Limestone, North Horn Formation, Price River Formation, Castlegate Sandstone, Blackhawk Formation, Star Point Sandstone, and the Masuk Member of the Mancos Shale. These formations are shown on a geologic map in Figure 4 and on an east-west geologic cross-section in Figure 5. Little Bear Spring discharges from the Panther Tongue of the Star Point Sandstone, which is separated from the overlying coal seams of the Blackhawk Formation by more than 300 feet of mostly low-permeability rock (Beaver Creek Coal Company, 1991).

Geophysical studies conducted in Mill Fork Canyon (Sunrise Engineering, 2001) indicate that an appreciable alluvial system occurs in Mill Fork Canyon. Alluvial thickness measured in the vicinity of the Star Point Sandstone fracture system ranged from about 30 to 45 feet. It was observed that the near-surface sediments in the stream channel in this area consist primarily of clean sand with some gravel and boulders. There was an overall lack of fine-grained material observed in the stream channel. The makeup of the deeper alluvial sediments has not been investigated.

Mayo and Associates (1999) indicated that vertical downward migration of near-surface recharge water through the bedrock formations does not occur in the Little Bear Spring area. This is evidenced by the extremely old Star Point Sandstone groundwaters below the coal mine (nearly 20,000 years old) and the lack of seasonal variations in wells completed in the

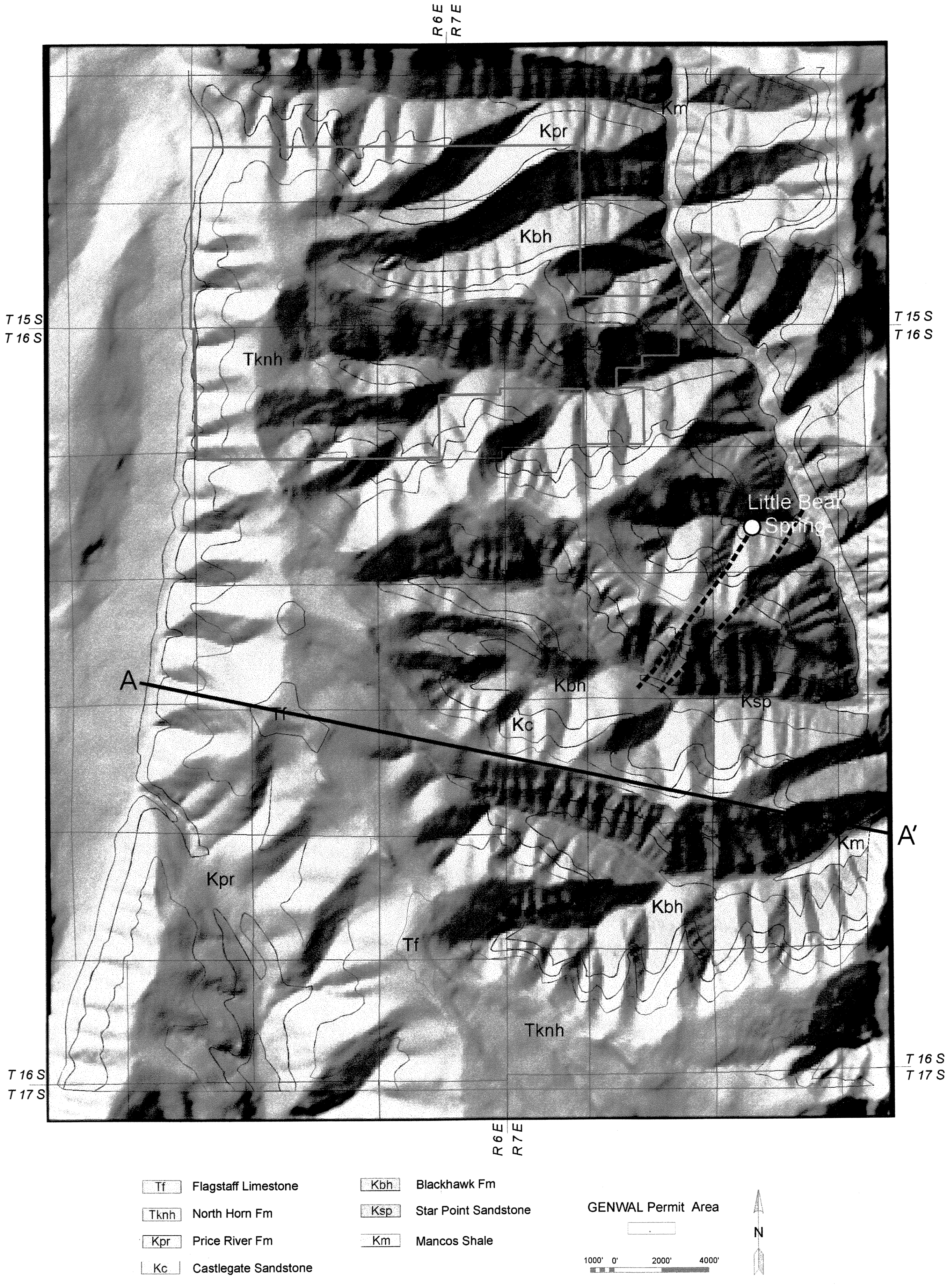


Figure 4 Geologic map of the Little Bear Spring area.

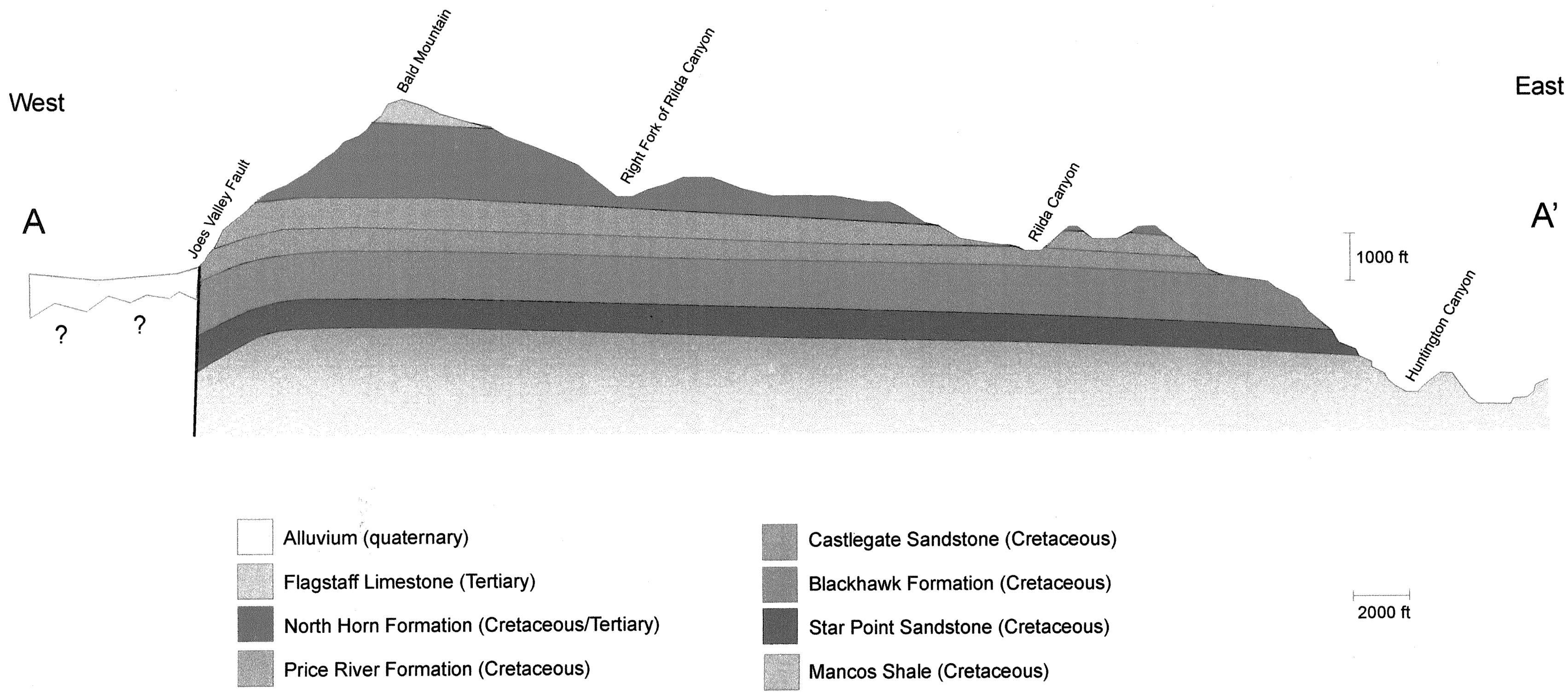


Figure 5 Generalized cross-section A-A'. Cross-section location is shown on Figure 4.

Star Point Sandstone. Likewise, groundwater inflow rates in the mine do not show seasonal variation. In contrast, all of the 23 springs and streams sampled for groundwater age dating had a modern origin (i.e. recharged in the past 50 years). Little Bear Spring shows pronounced seasonal and climatic fluctuations in discharge rate (Figure 2). The annual discharge peak usually occurs during May or June (Table 1). Because of the inability of groundwater to migrate downward in appreciable quantities, the most likely recharge location for Little Bear Spring is where the Star Point Sandstone is exposed at the surface.

Previous investigations examined the nature of surface water discharge in Mill Fork Canyon (Huntington No. 4 Mine, MRP; Mayo and Associates, 1999). The Results of the October 1998 stream gauging at Mill Fork canyon are shown on Figures 6 and are listed in the appendix. The stream gauging locations are shown on Figure 7. Also shown on Figure 7 are the locations of the upper and lower water monitoring stations monitored by the Huntington No. 4 Mine. The results of the stream monitoring indicate that there is usually no flow in Mill Fork canyon in the vicinity of the fracture system from which Little Bear Spring discharges. The Mill Fork stream channel at the confluence with Huntington Creek is likewise commonly dry during much of the year. The only reach of the stream below the fracture system that contained any water during the November 2000 stream survey (27 gpm) occurred at a bedrock high located near the base of the Star Point Sandstone. Within less than a half mile downstream, this meager discharge had infiltrated into the alluvial sediments and surface flow ceased. The general lack of water in the middle and lower reaches of Mill Fork Canyon is anomalous when compared to the adjacent drainages both above and below

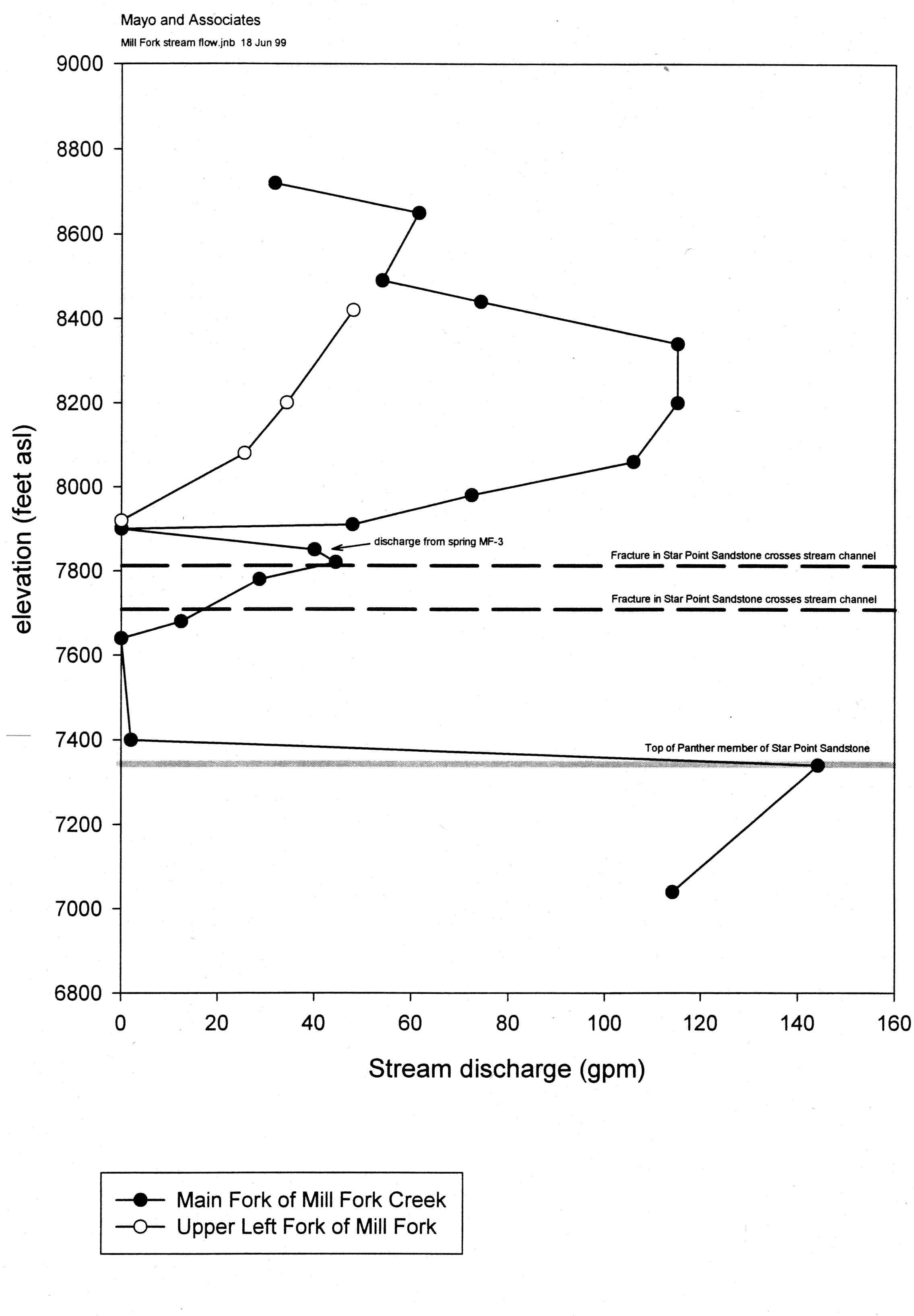


Figure 6 Streamflow measurements from Mill Fork Creek, 8-9 October 1998.

Mayo and Associates, Mill Fork stream gauging locations.cdr 14 Jan 99

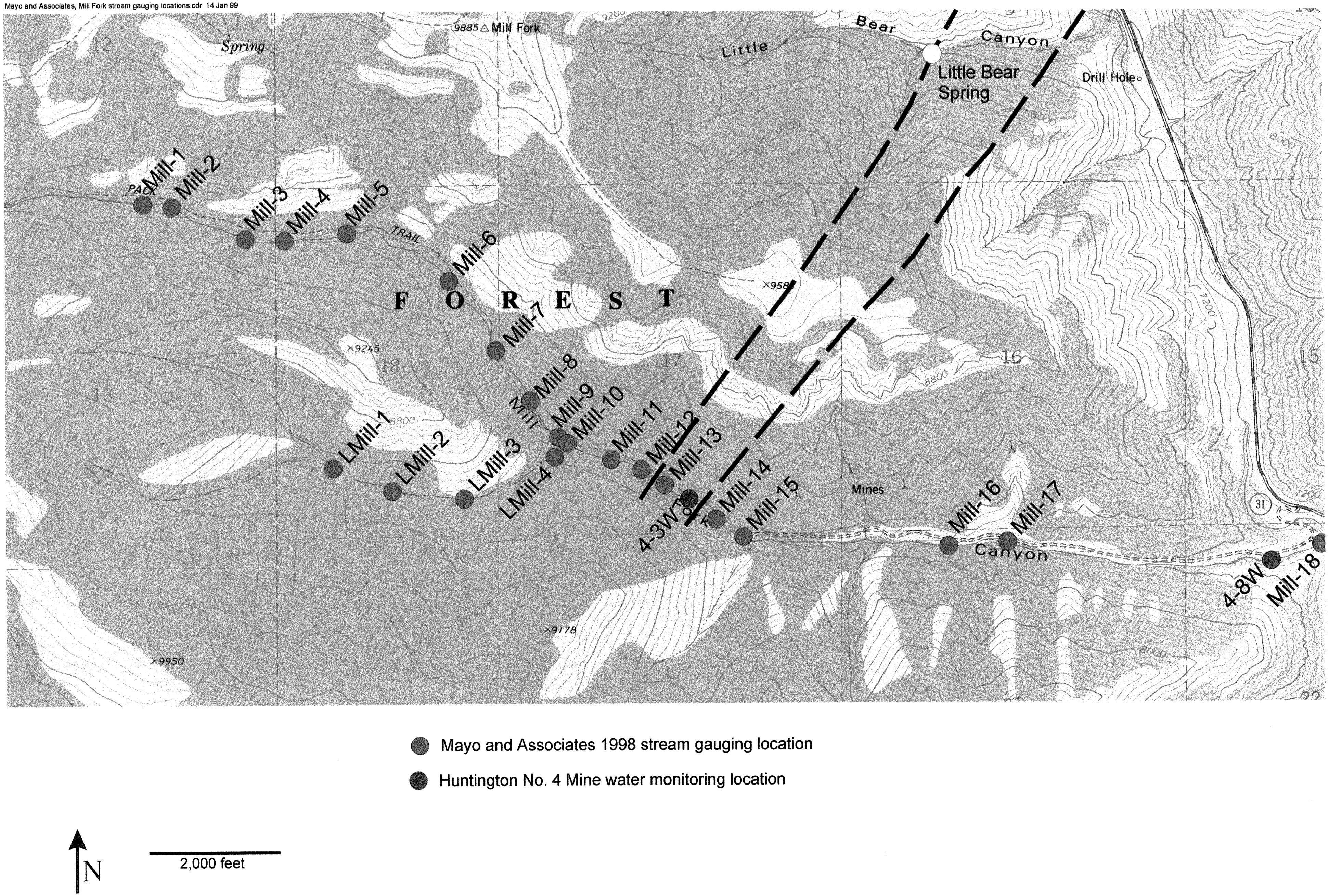


Figure 7 Stream gauging and monitoring stations on Mill Fork Creek.

Mill Fork. In nearly all years, discharge persists throughout the year in the Horse Canyon, Blind Canyon, Crandall Canyon, Little Bear Canyon, and Rilda Canyon drainages.

6. Water Budget

The annual water yield from Mill Fork Canyon has been evaluated using two independent methods: 1) a comparative basin analysis using Crandall Canyon as a surrogate for Mill Fork Canyon, and 2) an area-based projected yield investigation. The results of the water yield determinations using these two methods are described below.

6.1 Comparative basin analysis

Using a comparative basin approach, the discharge from Mill Fork Canyon is compared with the Crandall Canyon discharge. A surrogate basin was used for this analysis in order to establish the approximate magnitude of the annual water yield that would be anticipated from Mill Fork Canyon were there no major surface-water or groundwater diversions from the drainage (i.e., recharge to Little Bear Spring). This approach is favorable because 1) the physical characteristics of the upper Crandall Canyon drainage are in most respects remarkably similar to those of the adjacent upper Mill Fork drainage (Figure 8), and 2) there is a large amount of available historical discharge data from the Crandall Canyon drainage.

It is apparent in Figure 8 that the overall physical characteristics of the upper Mill Fork drainage and the upper Crandall Canyon drainage are very comparable. The area of the upper Mill Fork drainage (above the intersection of the fracture zone) was calculated as 4.29 square miles. The area of the Crandall Canyon drainage above the GENWAL Resources upper flume was calculated as 4.36 square miles, which is less than 2% greater than that of upper Mill Fork. Likewise, the elevation distribution of the surface area is similar between the two basins, with the Mill Fork drainage having only slightly less surface area in the highest elevation zones (Figure 8). The aspects of the two adjoining drainages are also comparable and there are no apparent differences in the surrounding land topography that might result in orographic variations in precipitation. Vegetation in both drainages is similar, with dense conifer or aspen forests dominating the north-facing slopes, while the south facing slopes are much less heavily vegetated.

Discharge hydrographs for the Mill Fork drainage are shown in Figure 9. In Figure 10, the discharge from the upper Mill Fork drainage (4-3W) is plotted together with the discharge from upper Crandall Creek (UPF-1). Based on the similarities between these two basins, it is anticipated that the annual water yield from these drainages should be similar. However, as shown in Figure 10, both the baseflow and springtime peak flows from the basins are strikingly disparate. Upper Crandall Creek has a historic baseflow discharge of about 300 gpm that persists throughout the year (Figure 10). The alluvial groundwater flowing in Crandall Canyon is not included in this baseflow estimate. In contrast, there is no baseflow discharge in Mill Fork Creek in the vicinity of the fracture system from which Little Bear Spring discharges. An obvious question follows this observation – why is there no baseflow discharge in upper Mill Fork Creek, and where did the water go?

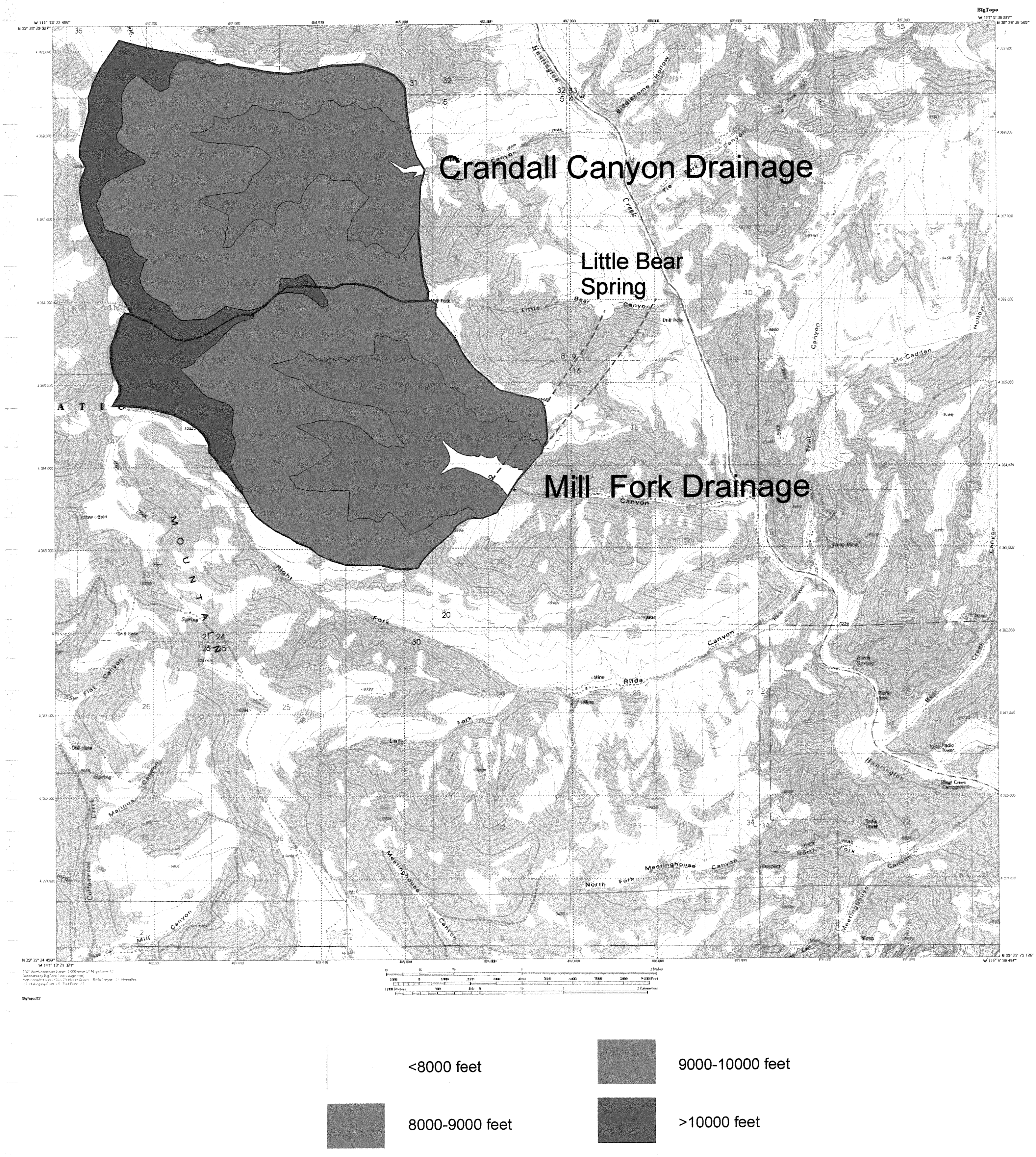


Figure 8 Comparison of Mill Fork and Crandall Canyon drainages.

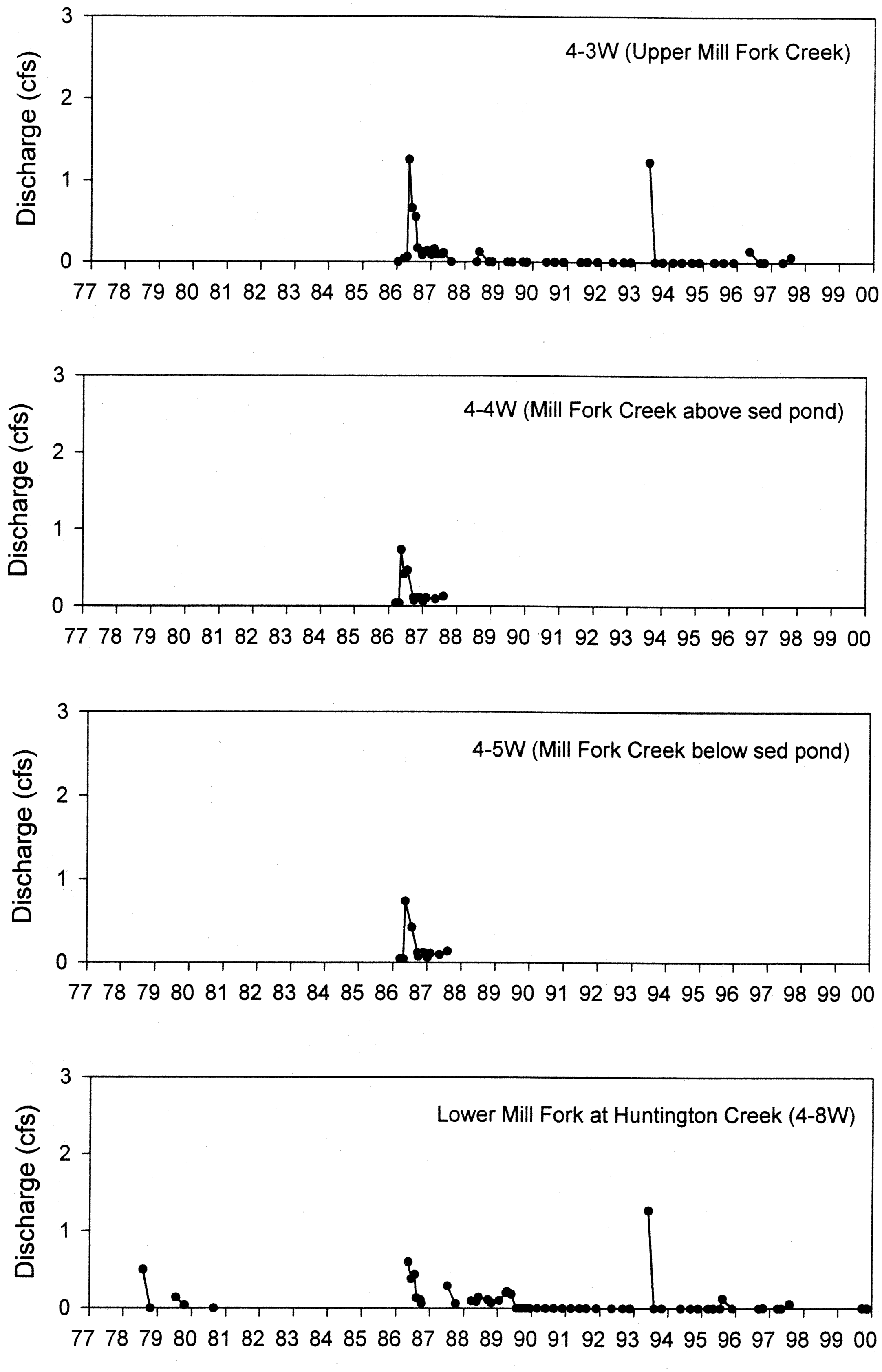
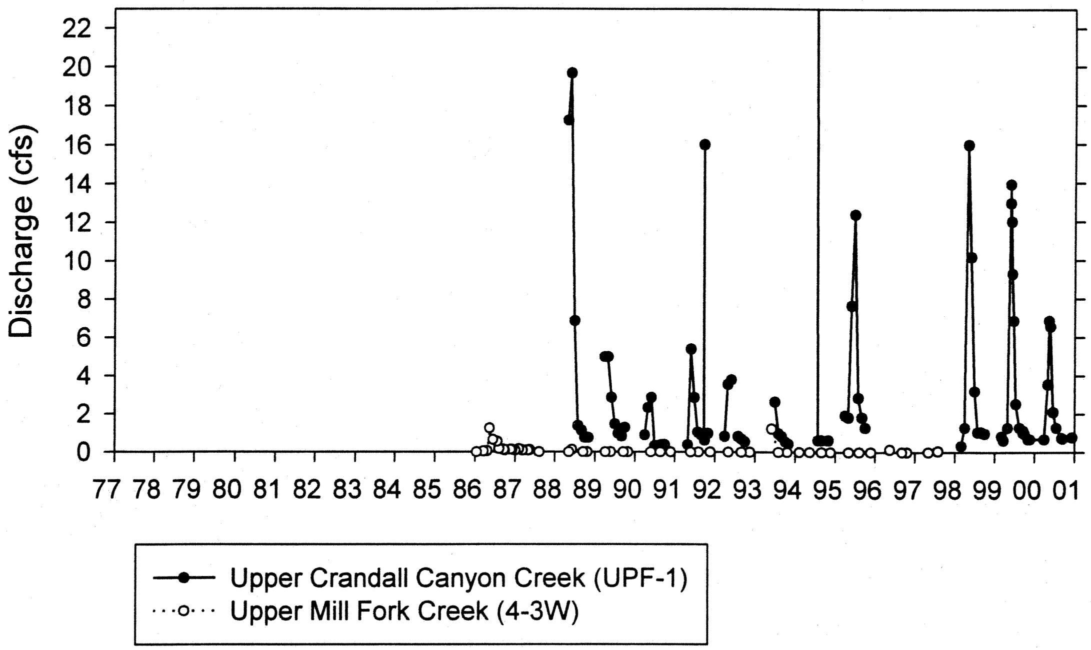


Figure 9 Discharge hydrographs showing available data for Mill Fork Creek (1978-2000).

a)



b)

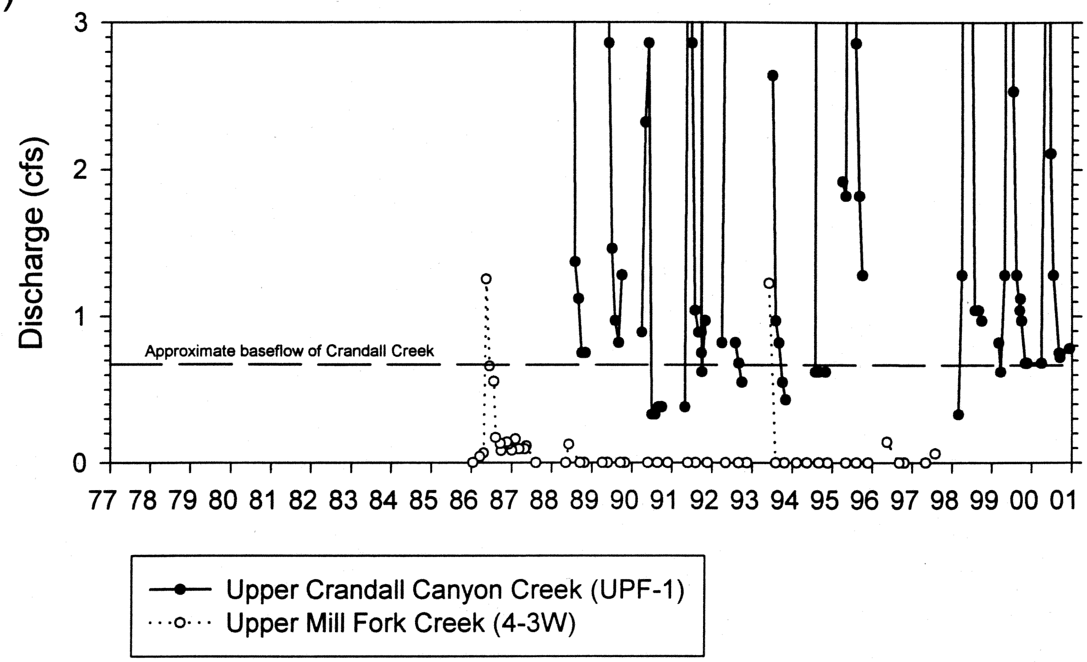


Figure 10 Discharge hydrographs for upper Mill Fork Creek and upper Crandall Canyon Creek. a) plot showing relative magnitudes of yearly discharges from the creeks, b) enlargment of lower range of graph to compare baseflow discharge rates.

The upper Mill Fork Drainage should produce approximately 300 gpm of baseflow discharge during normal water years. The fact that there is none suggests that approximately 300 gpm of discharge during baseflow conditions have been removed from the basin. That this water is recharging Little Bear Spring is entirely consistent with all of the available data.

6.2 Area-based projected yield

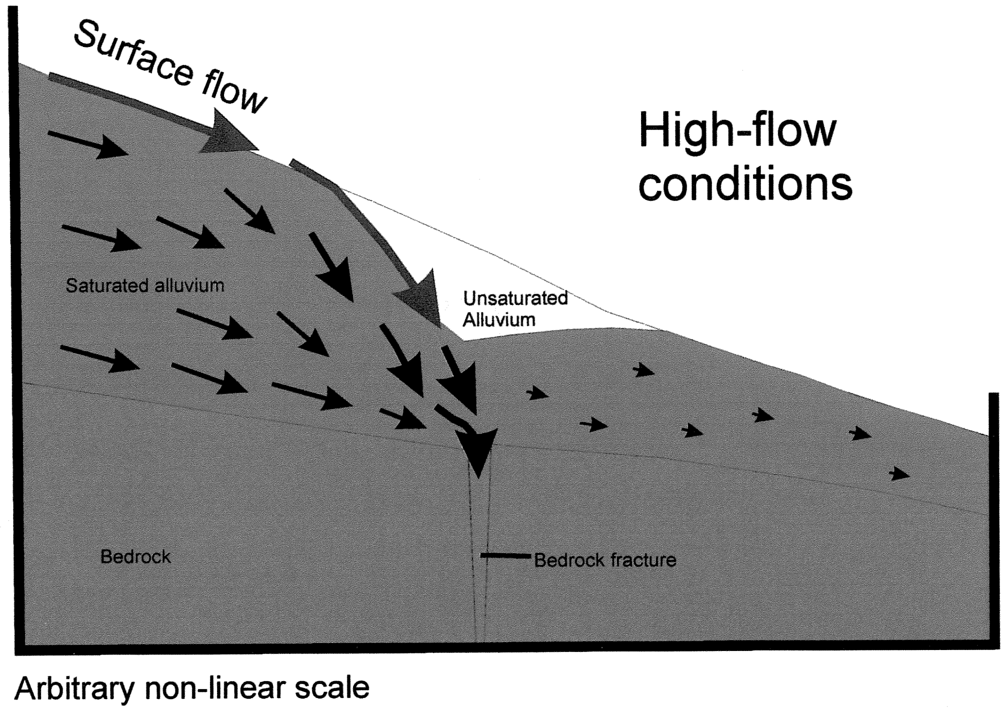
A determination of the annual water yield for upper Mill Fork Canyon has also been made using empirical data on basin yield provided by the Utah Division of Water Resources (1975). The Utah Division of Water Resources (1975) has predicted that up to 4 inches of runoff can be expected from drainage basins similar to and in the vicinity of Mill Fork Canyon.

It should be noted that Crandall Canyon, which is physically similar to Mill Fork, has historically had annual yields that are significantly greater than 4 inches per year. During 1998, for example (a relatively wet year for which daily average discharge data for the ice-free period are available), upper Crandall Creek discharged approximately 1,525 acre-feet, which equates with a yield of 6.56 inches per year as expressed over the 4.36 square mile drainage. During that same year, the discharge from Little Bear Spring totaled 623 acre-feet, which equates with a yield in upper Mill Fork Canyon of only 2.72 inches. This suggests that even after recharging Little Bear Spring, there is a significant surplus of water in the drainage.

Using a conservative estimate of 3.5 inches of runoff for the upper Mill Fork drainage, it is calculated that on average the drainage should yield about 800 acre-feet of runoff per year from the 4.29 square miles of the drainage. This equates with an average discharge rate from upper Mill Fork Canyon of about 500 gpm, which exceeds the yearly average discharge rate from Little Bear Spring (about 322 gpm) by more than 50%. Given the fact that only relatively small amounts of surface water leave Mill Fork Canyon during the year, the conclusion that much of the annual yield of the upper Mill Fork drainage provides recharge to Little Bear Spring seems reasonable. This conclusion is in good agreement with the comparative basin analysis result discussed previously.

7. Conceptual recharge model for Little Bear Spring

Based on the findings of this and previous investigations, a conceptual model for the recharge of Little Bear Spring in Mill Fork Canyon has been developed. The conceptual model is graphically depicted in Figure 11. A regional geologic cross-section along the trace of the Star Point Sandstone fracture system is shown on Plate 1. Recharge to Little Bear Spring occurs as alluvial groundwater in Mill Fork Canyon is intercepted by the Star Point Sandstone fractures where they intersect the base of the alluvial deposits. During the low-flow season, the spring is sustained primarily by losses of alluvial groundwater into the fracture system. During the high-flow season in the springtime and early summer, surface water also contributes to the recharge of Little Bear Spring both directly (through stream losses near the fractures) and as a result of overall increases in the amount of groundwater flow in the alluvial sediments.



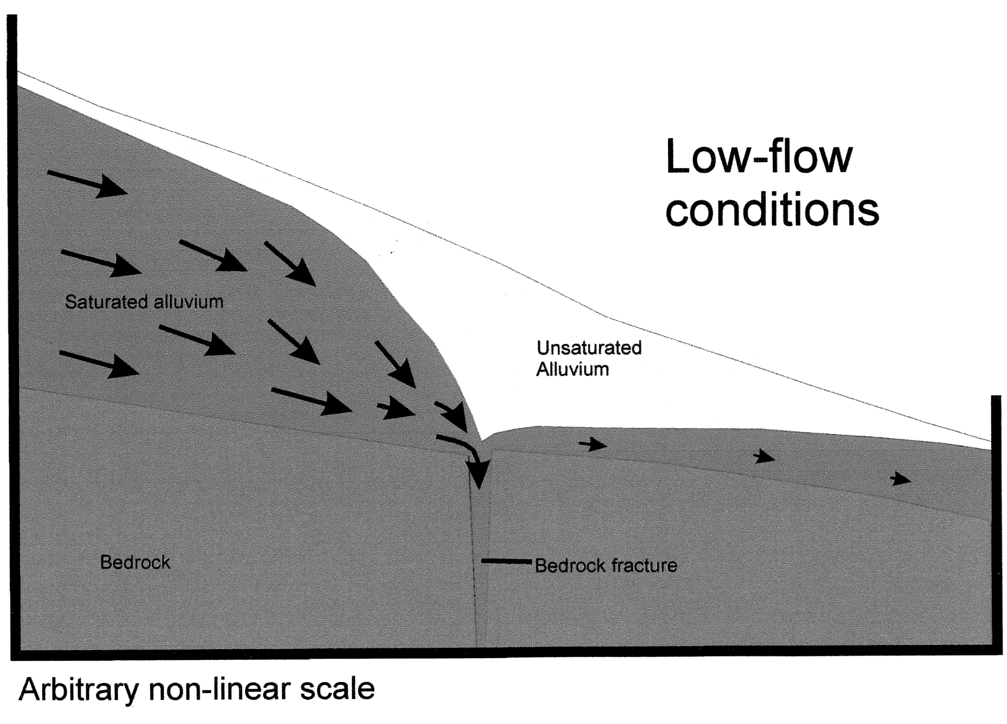


Figure 11 Cartoon showing the conceptual recharge model for Little Bear Spring.

There are several constraints that must be satisfied in order for any proposed recharge model for Little Bear Spring to be accepted. Each of these constraints is listed in Table 2 below.

Table 2 Acceptability constraints for the proposed Little Bear Spring recharge model.

Constraint	Proposed Mill Fork recharge model
There must be sufficient available water in the basin to supply at least 200 gpm of recharge continuously to the spring.	As discussed above, the upper Mill Fork drainage is believed to have more than adequate capacity to sustain Little Bear Spring. Moreover, it is difficult to explain the lack of baseflow in the drainage without taking Little Bear Spring recharge into account.
The recharge location must be located topographically above the elevation of Little Bear Spring (about 7475 feet) to provide the driving head to cause the spring to discharge.	The fracture system from which Little Bear Spring discharges intersects the Mill Fork drainage at an elevation of approximately 7710 to 7790 feet.
The water recharging Little Bear Spring must be of modern origin as evidenced by the modern water encountered in Little Bear Spring (Mayo and Associates, 1999).	Surface waters in the region have been demonstrated to discharge modern water (Mayo and Associates, 1999). Groundwater discharge into the Mill Fork drainage was sampled in three locations (MF-3, MF-7, and MF-20). All of these groundwaters were found to be of modern origin.
The recharge water must respond to season and climate.	Surface waters in the region have been demonstrated to respond to season and climate. The alluvial groundwater system in Mill Fork Canyon is also responsive to climate and season.
The chemical quality of the recharge water must be of similar or higher quality relative to Little Bear Spring discharge water.	The water quality in Mill Fork Canyon is of the same chemical type and approximate TDS concentration as that discharging from Little Bear Spring (Mayo and Associates, 1999)
Because of the inability of recharge water to migrate downward through the relatively impermeable bedrock formations in the region, the recharge will most likely occur where the Star Point Sandstone outcrops at the surface	The fracture system from which Little Bear Spring discharges intersects the bottom of the alluvial deposits in the Star Point Sandstone.

As described above, the proposed recharge location and mechanism is able to satisfy all of the required constraints.

8. Conclusions

- The upper Mill Fork drainage *is* capable of sustaining the discharge at Little Bear Spring. Moreover, it is difficult to explain the lack of flow in the Mill Fork drainage without taking recharge to Little Bear Spring into account.

- The proposed model of recharge to Little Bear Spring satisfies all of the physical constraints required for the model to be accepted.

9. References Cited

Beaver Creek Coal Company, 1981, Star Point Sandstone cross sec. Little Bear to Mill Fork Canyon, Plate 6-8.

Conference onLittle Bear Spring, Manti-La Sal National Forest, Price, Utah, 26 October 200. Conferees: Richard White, EarthFax Engineering; David Hansen, Hansen, Allen, and Luce; Peter Nielson, Nielsen Consulting; Erik Petersen, Mayo and Associates; Liane Mattson, U.S. Forest Service; Jerry and Rich Montgomery, WTR.

Guttman, N.B., 1991, A sensitivity analysis of the Palmer Hydrologic Drought Index: Water Resources Bulletin, v. 27, n. 5, p. 797-807.

Karl, T.R., 1986, The sensitivity of the Palmer Drought Severity Index and Palmer's Z-Index to their calibration coefficients including potential evapotranspiration: Journal of Climate and Applied Meteorology, v.25, p.77-86

Mayo and Associates, 1999, Investigation of groundwater and surface-water systems in the vicinity of GENWAL's existing permit area and the Mill Fork Tract, Emery County, Utah, unpublished consulting report submitted to Genwal Resources, Inc., Huntington, Utah.

NCDC (National Climatic Data Center), 1998, Online monthly climatic parameters; www.ncdc.noaa.gov

Sunrise Engineering, 2001, Resistivity investigation of alluvial thicknesses and bedrock geometry in Mill Fork Canyon, unpublished consulting report.

Utah Division of Water Resources, 1975, from Beaver Creek Coal Company, Huntington No. 4 Mine MRP.

Vaughn Hansen Associates, 1977, in Beaver Creek Coal Company, Huntington #4 Mine MRP.

Water Technology and Research, Inc, 1999, AquaTrack Survey, Little Bear Springs study, unpublished consulting report, 31 p.

Appendix 1 Mill Fork stream gauging results.

Station #	Flow (gpm) November 2000	Flow (gpm) October 1998	Cond October 1998	Elev. (ft)
Mill-1	0.0	31.7	370	8720
Mill-2	0.0	61.4	450	8650
Mill-3	18.5	54.0	450	8490
Mill-4	---	74.3	460	8440
Mill-5	31.5	115.2	460	8340
Mill-6	12.0	115.2	450	8200
Mill-7	0.0	106.0	430	8060
Mill-8	0.0	72.4	430	7980
Mill-9	0.0	47.9	410	7910
Mill-10	0.0	0.0	---	7900
Mill-11	0.0*	40.0	430	7850
Mill-12	0.0	44.4	430	7820
Mill-13	0.0	28.6	420	7780
Mill-14	0.0	12.4	410	7680
Mill-15	0.0	0.0	---	7640
Mill-16	---	2.0	480	7400
Mill-17	26.6	144.2	540	7340
Mill-18	0.0	114.2	540	7040
L Mill-1	0.0	48.0	340	8420
L-Mill-2	0.0	34.3	340	8200
L-Mill-3	0.0	25.5	340	8080

* Spring MF-3 was discharging at 18.7 gpm during November 2000, but the flow had all infiltrated before Mill-11

APPENDIX 7-57

DETERMINATION OF RECHARGE LOCATION

OF LITTLE BEAR SPRING (DYE TRACING)

1/23/95 revised 4/97

Determination of the Recharge Location Of Little Bear Spring by Means of Fluorescent Dye Tracing

GENWAL Resources, Inc., Price, Utah

20 November 2001

Mayo and Associates, LC
Consultants in Hydrogeology

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20 November 2001

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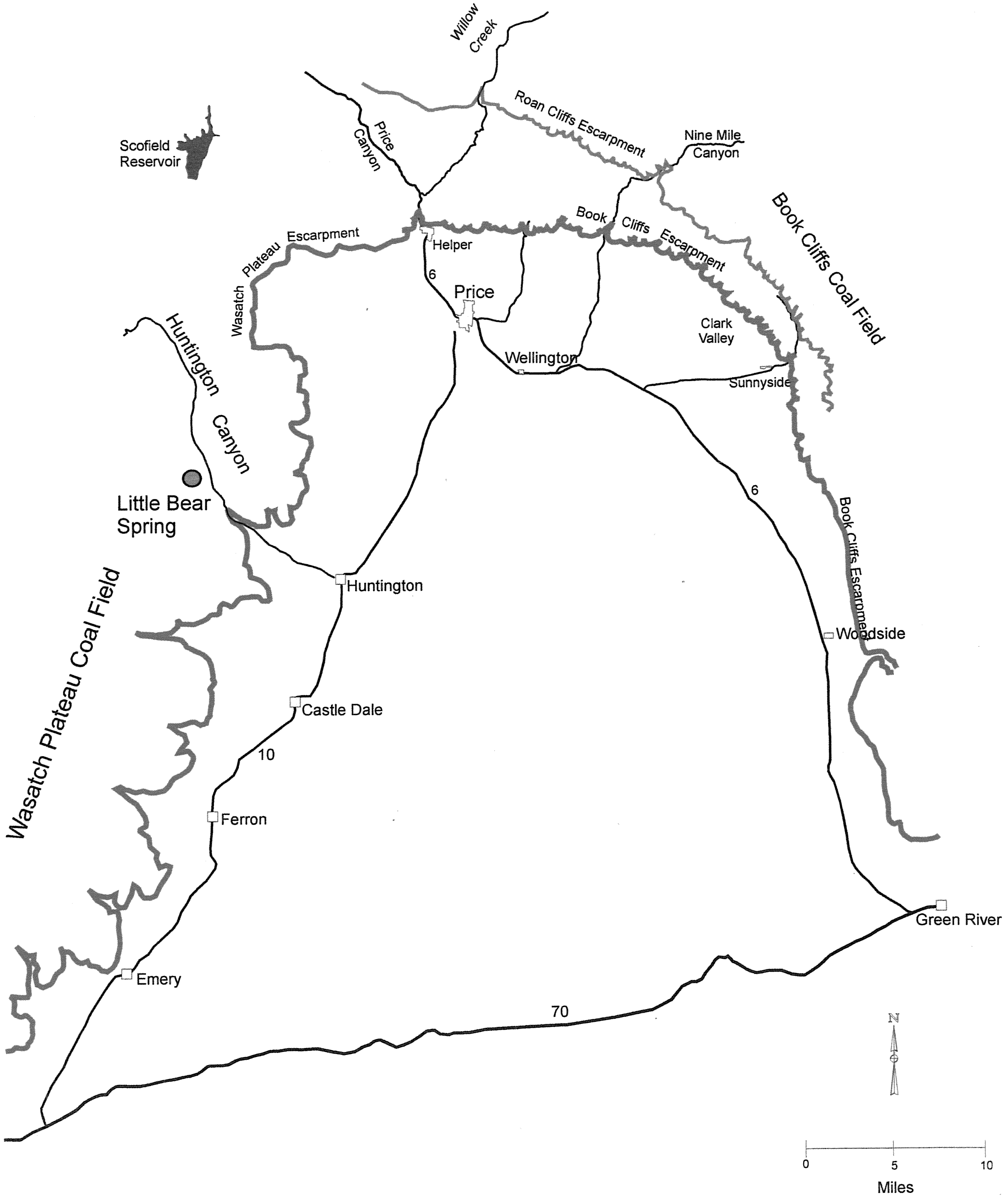


Figure 1 Location map of the Little Bear Spring area.

Mayo & Associates
Fig1 - Regional Map.cdr 13 Jul 99

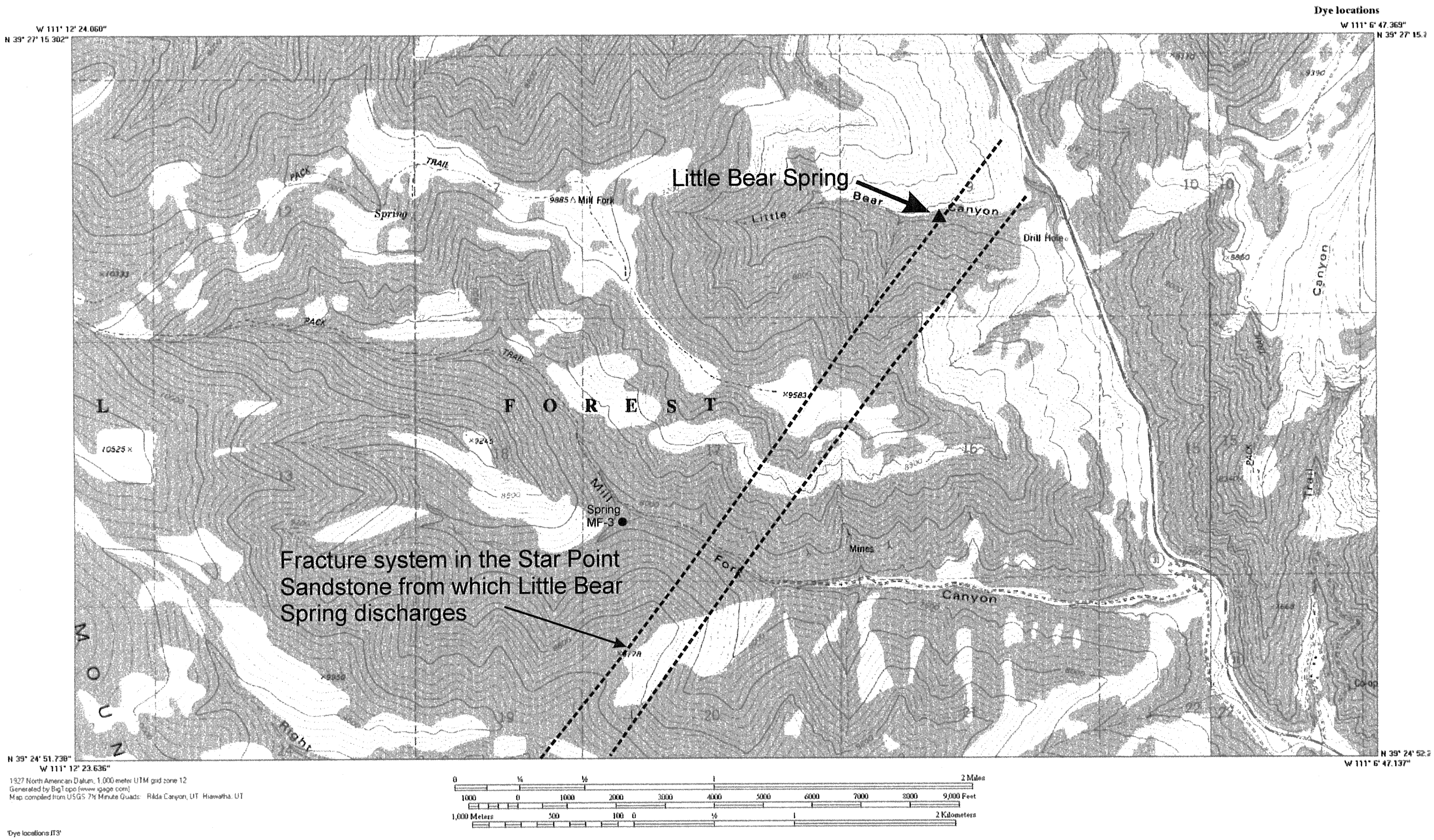


Figure 2 Location of Little Bear Spring and Mill Fork Canyon.

Including this introduction, this report contains the following sections:

1. Introduction
2. Methods of Study
3. Locations and Quantities of Dye Injections and Sampling Locations
4. Results
5. Conclusions
6. References Cited

2. Methods of study

Fluorescent dye selection

The fluorescent dye eosine was selected as the tracer for the Little Bear Spring study. Eosine dye was selected because 1) it has been determined to be safe for use in and around culinary water systems (Aley, 1999; Field and Others, 1995; Smart, 1984), 2) it is detectable in water samples at the laboratory at very low concentrations while it remains non-visible at concentrations higher than other commonly used fluorescent dyes, and 3) it is among the dyes most resistant to adsorption onto organic or clay particles which are thought to be present in the lower Mill Fork alluvial sediments. Eosine dye rapidly decomposes in the presence of sunlight (Aley, 1999).

Dye detection

Analysis for eosine dye was performed on activated carbon samplers by Ozark Underground Laboratory of Protem, Missouri. Activated carbon samplers continuously accumulate dye as long as they remain in the water, which allows for continuous, uninterrupted monitoring for fluorescent dye at the sampling locations. Very low laboratory detection limits are also possible using activated carbon samplers. The determinations of the amounts of dye to be placed in Mill Fork Creek were based on the goal of achieving concentrations at the sampling locations that would be high enough to be detectable in the laboratory but sufficiently low so as not to be visible.

Characterization of Background Fluorescence

Prior to the placement of eosine dye into Mill Fork Creek, a survey of local hydrologic research institutions was conducted to determine whether any recent injections of fluorescent dye had occurred in the Huntington Canyon and surrounding area. After discussions with personnel from the Utah State University Water Research Laboratory, University of Utah, Brigham Young University, United States Geological Survey, United States Forest Service, State of Utah Divisions of Drinking Water and Water Quality, and local hydrologic consulting firms, there was no indication of recently placed dye in the area.

To check for either naturally occurring or human induced background fluorescence in the Mill Fork and Little Bear Spring areas, carbon samplers were placed in upper Mill Fork Creek, lower Mill Fork Creek, and Little Bear Spring approximately one week before the first placement of dye in Mill Fork Creek. Analysis of these samplers indicated no background fluorescence.

Dye Injection Technique

After receiving letters of consent from appropriate agencies (Utah Division of Water Quality, U.S. Forest Service, Castle Valley Special Service District) eosine dye was placed in Mill

Fork Creek. The dye was shipped from Ozark Underground Laboratory of Protem, Missouri in powdered form. The powdered dye was mixed with culinary water (or creek water) in 5-gallon plastic containers prior to being placed in the creek. The dye was transported and placed in the creek by an assistant. At no time did the person or vehicle of the person collecting the dye samples come into contact with the eosine dye.

Sample collection procedures

Carbon samplers were collected and placed in sealed plastic baggies and kept out of sunlight to prevent sample degradation. The person collecting the dye samples wore rubber gloves to minimize the potential for sample contamination. The individual samples were double bagged and shipped to the laboratory in new coolers on "blue ice" to maintain refrigeration. A 100 ml sample of water was also collected during each sampling event at each site for potential direct laboratory analysis. During each sampling event, new carbon samplers were placed in duplicate to accumulate dye until the next sampling. Duplicate samplers were placed in each sampling location to minimize the potential for data loss due to the loss of the carbon samplers. Samplers placed in creeks were located in inconspicuous, shady areas to minimize the potential for vandalism or dye degradation.

As is generally the practice in dye tracer studies, samples for analysis were collected more frequently in the early portion of the test, and less frequently in the latter portion.

3. Locations and Quantities of Dye Injections and Sampling Locations

Phase 1, Dye placed December 2000

Sampling locations for Phase 1 of the dye tracer study are shown on Figure 3. Quantities of dye placed and dye placement locations are also shown on Figure 3. For Phase 1, a total of 4 pounds of eosine dye was placed in three locations in the Mill Fork drainage. During December 2001, with the exception of the discharge from spring MF-3, the Mill Fork drainage above the fracture system was mostly dry and/or frozen for a distance of approximately 1¼ miles above the fracture system. The discharge from MF-3 at that time (approximately 12 gpm) persisted in the stream channel for only about 75 yards before it completely infiltrated into the subsurface. Approximately 1.3 pounds of eosine dye was placed in the MF-3 discharge at 10:00 a.m. on 8 December 2000.

As shown on Figure 3, eosine dye was placed in two additional locations the upper Mill Fork drainage on 8 December 2000 at about 11:30 a.m. Approximately 1.3 pounds of dye was placed at each location in the creek, which was flowing at about 40 gpm at the time.

The purpose of the dye tracer investigation was to determine whether Little Bear Spring is recharged in Mill Fork Canyon. Consequently, the primary dye monitoring location was Little Bear Spring. The entire discharge from Little Bear Spring is captured in a closed collection system and piped down Huntington Canyon. Carbon samplers were placed in a concrete control structure adjacent to the Highway 31 in Huntington Canyon (Figure 3). The control structure is part of the culinary water conveyance system and remained locked at all

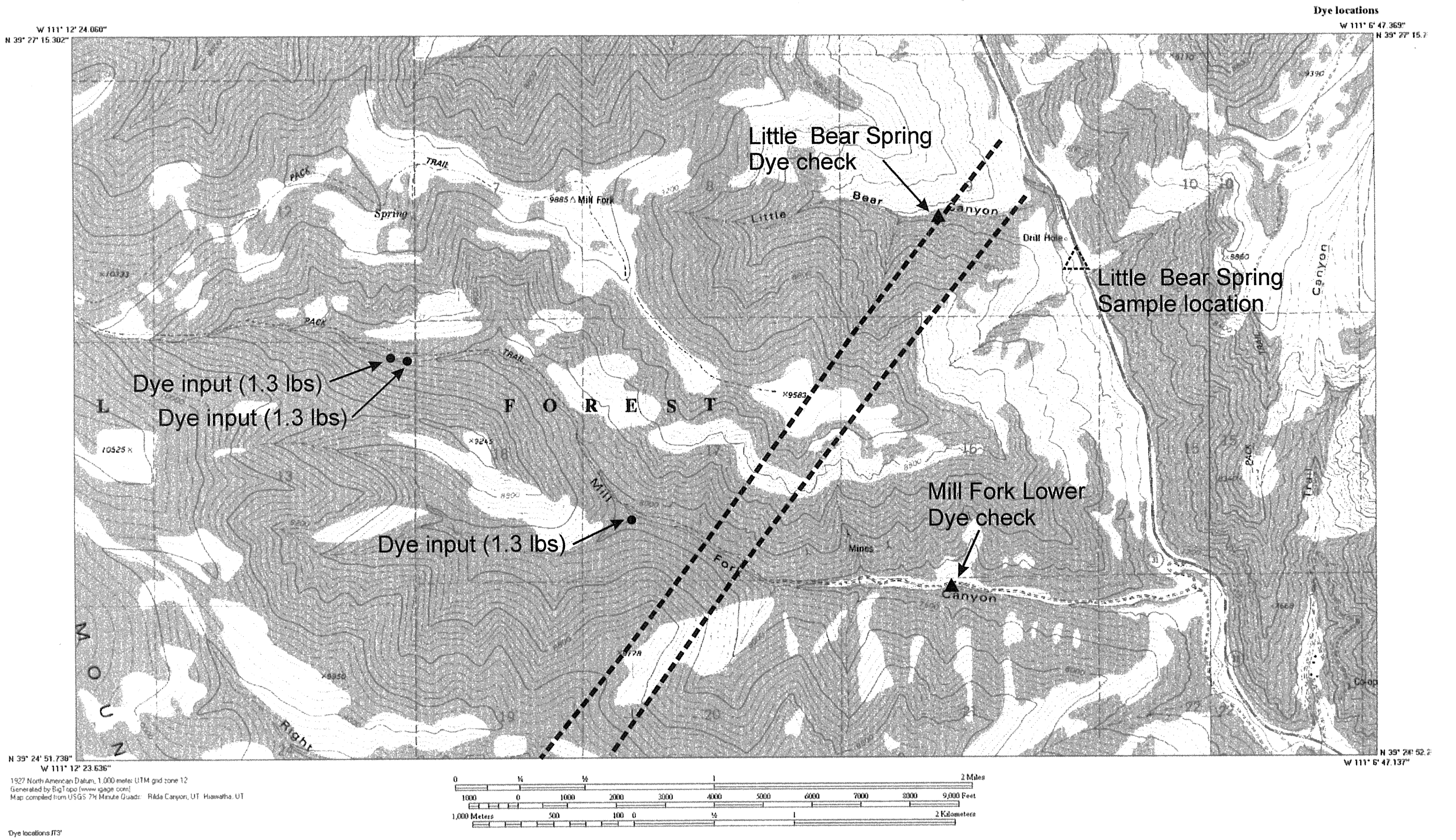


Figure 3 Dye input and monitoring locations, Phase 1. Eosine dye placed on 8 December 2001, 10:00 - 12:00.

times. Carbon samplers were also placed in the lower Mill Fork drainage where water first emerges in the drainage below the fracture system during most of the year (Figure 3). The purpose of monitoring at that location was to determine whether the groundwater that emerges there is hydraulically connected to surface waters in upper Mill Fork.

Phase 2, Dye placed July 2001

Sampling locations, dye placement locations, and dye quantities placed during Phase 2 of the dye tracer study are shown on Figure 4. Although there was appreciably more discharge in Mill Fork Creek during July 2001 than there was during December 2000, significant reaches of dry streambed were present during the Phase 2 dye placement. Six pounds of eosine dye was placed in upper Mill Fork Creek at the lower end of a flowing stream reach. Immediately below the dye placement location, the stream discharge entirely infiltrated into the subsurface. This location is situated approximately two-thirds of a mile above the fracture system from which Little Bear Spring discharges (Figure 4).

A meager discharge was present in the Mill Fork drainage during July 2001 below spring MF-3. The streambed in the Mill Fork drainage below MF-3 and above the fracture system contained water in some reaches and was dry in others. Discharge in the flowing reaches of the stream in these locations ranged from about 1 to 5 gpm. Dye was placed in three locations where surface water was present on 30 July 2001 from 19:00 to 20:30. The amounts of dye placed were 2 pounds at the upper location, 6 pounds in the middle location, and 6 pounds in the lower location (Figure 4).

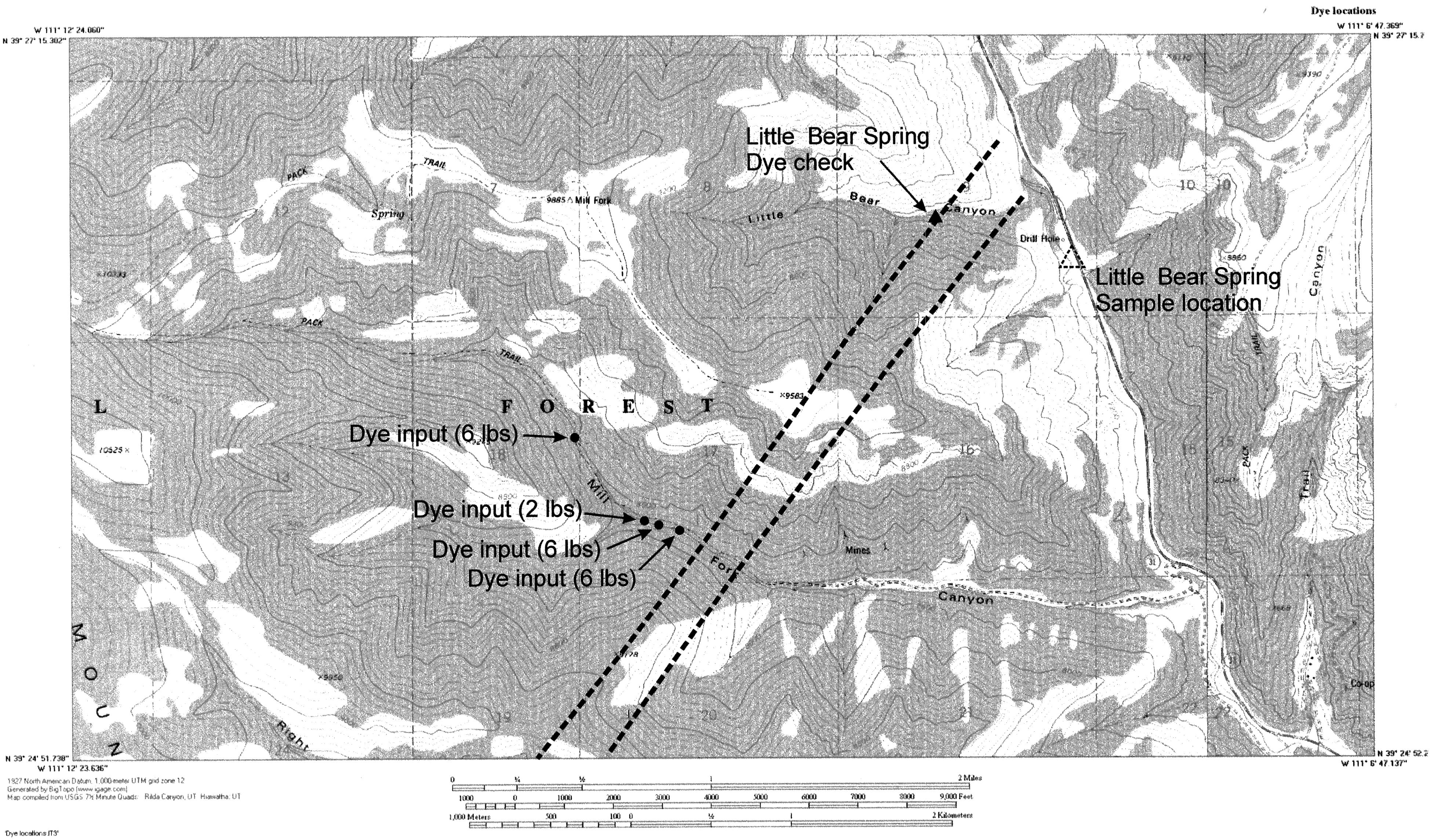


Figure 4 Dye input and monitoring locations, Phase 2. Eosine dye placed on 30 July 2001, 18:30-20:30.

In addition to the dye placed in the flowing reaches of Mill Fork Creek during Phase 2 of the dye tracer study, additional dye was placed in dry sets below the fracture system from which Little Bear Spring discharges. These locations are shown on Figure 5. On 30 July 2001 at 21:00, 2 pounds of eosine was placed in the upper dry set, 2 pounds placed in the middle dry set, and 1 pound placed in the lower dry set. The dry sets consisted of powdered eosine dye in open-topped plastic containers that were placed in the dry streambed and were to be activated when a significant amount of surface water was present in the drainage. When the dry sets were investigated on 28 October 2001, it was found that the dry sets had only partially activated and much or all of the powdered dye remained in the plastic containers. This is an indication that only relatively small surface water flows had occurred in the drainage. Approximately 1 pound of dye had been released from the upper set, approximately 0.25 pounds from the middle set, and approximately 0.25 pounds had been released from the lower set. The residual dye and the dry set containers were removed from the Mill Fork Drainage on 28 October 2001 and disposed of properly.

During Phase 2 of the investigation, monitoring of Little Bear Spring at the concrete control structure continued as during Phase 1. In the period immediately preceding the placement of dye for Phase 2, surface water had been flowing continuously at the surface from the dye placement areas to the confluence with Huntington Creek. Surface waters containing dye that could persist in the drainage from the dye placement area to the lower Mill Fork station would render any information about groundwater transport of dye to the lower Mill Fork station meaningless. Therefore, sampling at the lower Mill Fork site was discontinued for Phase 2 of the investigation.

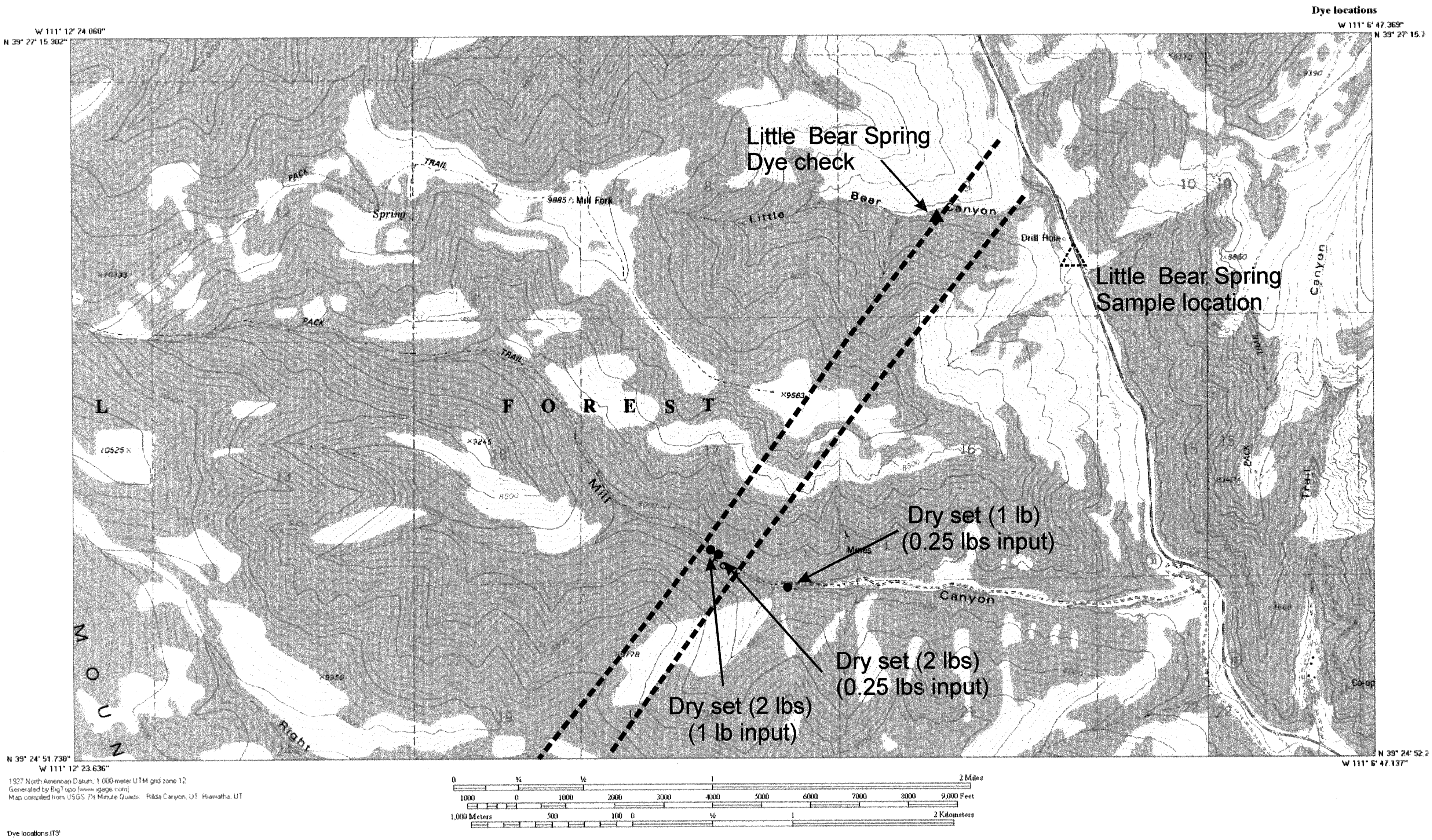


Figure 5 Dry set dye placements, Phase 2. Dry eosine powder placed in dry streambed on 20 July 2001, 21:00.

4. Results

Phase 1

The results of the dye detection analyses are listed in Table 1. Laboratory reporting sheets from Ozark Underground Laboratory are provided in the Appendix. As shown in Table 1, no eosine was detected in either monitoring location for a period of approximately 6 months. On 10 June 2001, a minor amount of eosine was detected at the lower Mill Fork site (Table 1). On the next monitoring event 13 days later, no eosine was detected at the lower Mill Fork site. Mayo and Associated (2001a) predicted that some of the alluvial groundwater in the upper Mill Fork drainage should eventually reach the lower Mill Fork monitoring site. However, the 10 June 2001 sampling event was the first sampling event after the first occurrence of continuous surface water flow in Mill Fork Creek from the headwater areas to below the lower Mill Fork monitoring site. Thus, there is the possibility that eosine dye held in the streambank sediments or shallow alluvial sediments beneath the shady, frozen drainage during the winter months could have been incorporated into the surface flow that reached the lower Mill Fork monitoring site. It is unknown whether the dye detected at the lower Mill Fork station was transported through the alluvial groundwater system in Mill Fork Canyon or whether the dye was transported by the surface water flow that had recently inundated the monitoring site. The latter of these two possibilities seems most likely.

Table 1 Dye sample log and analytical results.

Sample name	Date retrieved from water	Time	Date put in water	Date sent for analysis	Result	Comments
Mill Fork Upper #1	27-Nov-00			29-Nov-00	N.D.	Background check
Mill Fork Upper #2	27-Nov-00			back-up		Background check
Mill Fork Upper water samp	27-Nov-00			reserve		Background check
Mill Fork Lower #1	29-Nov-00	11:00		29-Nov-00	N.D.	Background check
Mill Fork Lower #2	29-Nov-00	11:00		back-up		Background check
Mill Fork Lower water samp	29-Nov-00	11:00		reserve		Background check
Little Bear #1	29-Nov-00	12:00		29-Nov-00	N.D.	Background check
Little Bear #2	29-Nov-00 (lost)	---		---		Background check
Little Bear water samp	29-Nov-00	12:00		reserve		Background check
Phase 1						
Eosine dye (4 lbs) added to Right and Left forks of Mill Fork (8 Dec 00, 10 am - 12 noon)						
Mill Fork Lower #1	9-Dec-00	15:40	29-Nov-00	15-Dec-00	N.D.	
Mill Fork Lower #2	9-Dec-00	15:40	29-Nov-00	back-up		
Mill Fork Lower water samp	9-Dec-00	15:40	---	reserve		
Little Bear #1	9-Dec-00	15:10	29-Nov-00	15-Dec-00	N.D.	
Little Bear #2	9-Dec-00	15:10	29-Nov-00	back-up		
Little Bear water samp	9-Dec-00	15:10	---	reserve		
Mill Fork Lower #1	11-Dec-00	14:45	9-Dec-00	15-Dec-00	N.D.	
Mill Fork Lower #1	11-Dec-00	14:45	9-Dec-00	back-up		
Mill Fork Lower water samp	11-Dec-00	14:45	---	reserve		
Little Bear #1	11-Dec-00	14:10	9-Dec-00	15-Dec-00	N.D.	
Little Bear #2	11-Dec-00	14:10	9-Dec-00	back-up		
Little Bear water samp	11-Dec-00	14:10	---	reserve		
Little Bear #1	14-Dec-00	14:00	11-Dec-00	15-Dec-00	N.D.	Placed 3 carbon samplers in the spring box for emergency backup.
Little Bear #2	14-Dec-00	14:00	11-Dec-00	back-up		
Little Bear water samp	14-Dec-00	14:00	---	reserve		
Mill Fork Lower #1	14-Dec-00	15:00	11-Dec-00	15-Dec-00	N.D.	
Mill Fork Lower #2	14-Dec-00	15:00	11-Dec-00	back-up		
Mill Fork Lower water samp	14-Dec-00	15:00	---	reserve		
Little Bear #1	26-Dec-00	17:00	14-Dec-00	27-Dec-00	N.D.	
Little Bear #2	26-Dec-00	17:00	14-Dec-00	back-up		
Little Bear water samp	26-Dec-00	17:00	---	reserve		
Mill Fork Lower #1	26-Dec-00	18:00	14-Dec-00	27-Dec-00	N.D.	
Mill Fork Lower #2	26-Dec-00	18:00	14-Dec-00	back-up		
Mill Fork Lower water samp	26-Dec-00	18:00	---	reserve		
Little Bear #1	12-Jan-01	15:00	26-Dec-00	15-Jan-01	N.D.	
Little Bear #2	12-Jan-01	15:00	26-Dec-00	back-up		
Little Bear water samp	12-Jan-01	15:00	---	reserve		
Mill Fork Lower #1	12-Jan-01	16:00	26-Dec-00	15-Jan-01	N.D.	
Mill Fork Lower #2	12-Jan-01	16:00	26-Dec-00	back-up		
Mill Fork Lower water samp	12-Jan-01	16:00	---	reserve		
Little Bear #1	24-Jan-01	17:00	12-Jan-01	26-Jan-01	N.D.	
Little Bear #2	24-Jan-01	17:00	12-Jan-01	back-up		
Little Bear water samp	24-Jan-01	17:00	---	reserve		
Mill Fork Lower #1	24-Jan-01	18:00	12-Jan-01	26-Jan-01	N.D.	
Mill Fork Lower #2	24-Jan-01	18:00	12-Jan-01	back-up		
Mill Fork Lower water samp	24-Jan-01	18:00	---	reserve		
Little Bear #1	2-Feb-01	16:00	24-Jan-01	7-Feb-01	N.D.	
Little Bear #2	2-Feb-01	16:00	24-Jan-01	back-up		
Little Bear water samp	2-Feb-01	16:00	---	reserve		
Mill Fork Lower #1	2-Feb-01	17:00	24-Jan-01	7-Feb-01	N.D.	
Mill Fork Lower #2	2-Feb-01	17:00	24-Jan-01	back-up		
Mill Fork Lower water samp	2-Feb-01	17:00	---	reserve		
Little Bear #1	17-Feb-01	13:30	2-Feb-01	23-Feb-01	N.D.	
Little Bear #2	17-Feb-01	13:30	2-Feb-01	back-up		
Little Bear water samp	[illegible]	[illegible]				

Phase 2

No eosine was detected at Little Bear Spring during Phase 1 of the dye tracer investigation. As discussed previously, the amount of eosine placed in the Mill Fork drainage during Phase 1 of the investigation was minimized to mitigate the potential for visible coloration of the water in Little Bear Spring. After conversations with Mr. Tom Aley of the Ozark Underground Laboratory (Personnal Communication, Tom Aley, 2001) it was concluded that there was a reasonable possibility that insufficient eosine dye was placed during Phase 1. It has been estimated that commonly only approximately 1% of the dye injected in a tracer study in fractured, non-soluble rock is recovered at the sampling location (Ozark Underground Laboratory, 1999). This is because fluorescent dye is readily lost to adsorption on clay particles or organic material, or is lost to photo-degradation prior to infiltration. Mr. Aley recommended that for Phase 2 of the dye tracer study, approximately 4 times the amount of eosine dye used for Phase 1 be placed in the drainage. Consequently, a total of 20 pounds of eosine dye was placed in the Mill Fork drainage above the fracture system for Phase 2 of the dye tracer study.

It is not known when the approximately 1.5 pounds of eosine dye in the three dry sets discussed previously was released into the drainage. However, because all of the dry sets were located down gradient of the upper fracture from which Little Bear Spring discharges (Figure 5), it is unlikely that significant amounts of dye from the dry sets ever arrived at Little Bear Spring.

On 9 September 2001 during the first sampling event at Little Bear Spring subsequent to the introduction of dye for Phase 2 of the investigation, eosine dye was detected in the carbon sampler at a concentration of 312 ppb. On the following sampling event on 26 September 2001, dye was again detected at a concentration of 496 ppb.

5. Conclusions

Based on the positive detection of eosine dye in Little Bear Spring, it has been demonstrated that water in the Mill Fork Drainage recharges Little Bear Spring. The travel time from the streambed in Mill Fork Canyon to the spring is 40 days or less. These findings are in complete agreement with previous investigations of Little Bear Spring conducted by Mayo and Associates (2001a, 2001b).

6. References Cited

Aley, T., 1999, Ozark Underground Laboratory groundwater tracing handbook, Ozark Underground Laboratory, Protem, MO, 35 p.

Water Technology and Research, Inc, 1999, AquaTrack Survey, Little Bear Springs study, unpublished consulting report, 31 p.

Field, M.S., Wilhelm, J.F.Q., Quinlan, J.F., and Aley, T.J., 1995, An assessment of the potential adverse properties of fluorescent tracer dyes used for groundwater tracing, Environmental Monitoring and Assessment, 38: 75-96, Kluwer Academic Publishers

Mayo and Associates, 2001a, Investigation of the Potential for Little Bear Spring Recharge in Mill Fork Canyon, Emery County, Utah, unpublished consulting report for GENWAL Resources, Inc, Price, Utah.

Mayo and Associates, 2001b, Investigation of the Alluvial Groundwater System In Mill Fork Canyon with Implications for Recharge to Little Bear Spring, unpublished consulting report for GENWAL Resources, Inc, Price, Utah.

Mayo and Associates, 1999, Investigation of groundwater and surface-water systems in the vicinity of GENWAL's existing permit area and the Mill Fork Tract, Emery County, Utah, unpublished consulting report submitted to Genwal Resources, Inc., Huntington, Utah.

Smart, P.L., 1984, A review of the toxicity of twelve fluorescent dyes used for water tracing, NSS Bulletin 46: 21-33

Appendix

Laboratory Reporting Sheets

Ozark Underground Laboratory

Ozark Underground Laboratory for Mayo & Associates

Date Samples Rec'd at OUL: November 30, 2000
Date Analyzed by OUL: December 6, 2000

Table 1. Results for charcoal background samplers analyzed for the presence of fluorescein, eosine and rhodamine WT (RWT) dyes. Peak wavelengths are reported in nanometers (nm); dye concentrations are reported in parts per billion (ppb).

OUL Lab #	Stn. #	Station Name	Date/Time Placed 2000	Date/Time Collected 2000	Fluorescein		Eosine		RWT	
					Peak	Conc.	Peak	Conc.	Peak	Conc.
K6979	1	Little Bear	NDT	11/29 1200	ND		ND		ND	
K6980		Lab[illegible] C[illegible] Cha[illegible] Blank								
K6981	2	Mill Fork Upper	NDT	11/28 1600	ND		ND		ND	
K6982	3	Mill Fork Lower	NDT	11/29 1130	ND		ND		ND	

FOOTNOTES:

NDT = No date or time given

ND = No dye detected

Ozark Underground Laboratory for Mayo & Associates

Project: Little Bear Springs
Samples collected by: Erik C. Petersen
Samples shipped on: December 15, 2000
Date samples rec'd at OUL: December 18, 2000
Date analyzed by OUL: December 20, 2000

Table 1. Results for charcoal samplers analyzed for the presence of fluorescein, eosine and rhodamine WT (RWT) dyes. Peak wavelengths are reported in nanometers (nm); dye concentrations are reported in parts per billion (ppb).

OUL Lab #	Stn. #	Station Name	Date/Time Placed 2000	Date/Time Collected 2000	Fluorescein		Eosine		RWT	
					Peak	Conc.	Peak	Conc.	Peak	Conc.
K7367	3	Mill Fork Lower # 1	NDT	12/9 1540	ND		ND		ND	
K7368	1	Little Bear # 1	NDT	12/9 1510	ND		ND		ND	
K7369	3	Mill Fork Lower # 1	NDT	12/11 1445	ND		ND		ND	
K7370	1	Little Bear # 1	NDT	12/11 1410	ND		ND		ND	
K7371	3	Mill Fork Lower # 1	NDT	12/14 1500	ND		ND		ND	
K7372	1	Little Bear # 1	NDT	12/14 1400	ND		ND		ND	

FOOTNOTES:

NDT = No date or time given

ND = No dye detected

Ozark Underground Laboratory for Mayo & Associates

Project: Crandall Canyon Mine Project
Samples collected by: Erik C. Petersen
Samples shipped on: December 27, 2000
Date samples rec'd at OUL: December 28, 2000
Date analyzed by OUL: January 4, 2001

Table 1. Results for charcoal samplers analyzed for the presence of fluorescein, eosine and rhodamine WT (RWT) dyes. Peak wavelengths are reported in nanometers (nm); dye concentrations are reported in parts per billion (ppb).

OUL Lab #	Stn. #	Station Name	Date/Time Placed 2000	Date/Time Collected 2000	Fluorescein		Eosine		RWT	
					Peak	Conc.	Peak	Conc.	Peak	Conc.
K7491	1	Little Bear # 1	NDT	12/26 1700	ND		ND		ND	
K7492	3	Mill Fork Lower # 1	NDT	12/26 1800	ND		ND		ND	

FOOTNOTES:

NDT = No date or time given

ND = No dye detected

Ozark Underground Laboratory for Mayo & Associates

Project: Crandall Canyon Mine Project
Samples collected by: Erik C. Petersen
Samples shipped on: January 15, 2001
Date samples rec'd at OUL: January 17, 2001
Date analyzed by OUL: January 22, 2001

Table 1. Results for charcoal samplers analyzed for the presence of fluorescein, eosine and rhodamine WT (RWT) dyes. Peak wavelengths are reported in nanometers (nm); dye concentrations are reported in parts per billion (ppb).

OUL Lab #	OUL Stn. #	Station Name	Date/Time Placed	Date/Time Collected 2001	Fluorescein		Eosine		RWT	
					Peak	Conc.	Peak	Conc.	Peak	Conc.
K7909	1	Little Bear # 1	NDT	1/12 1500	ND		ND		ND	
K7910	3	Mill Fork Lower # 1	NDT	1/12 1600	ND		ND		ND	

FOOTNOTES:

NDT = No date or time given

ND = No dye detected

Ozark Underground Laboratory for Mayo & Associates

Project: GENWAL
Samples collected by: Erik Petersen
Samples shipped on: January 26, 2001
Date samples rec'd at OUL: January 30, 2001
Date analyzed by OUL: January 31, 2001

Table 1. Results for charcoal samplers analyzed for the presence of eosine dye. Peak wavelengths are reported in nanometers (nm); dye concentrations are reported in parts per billion (ppb).

OUL Lab #	OUL Stn. #	Station Name	Date/Time Placed 2001	Date/Time Collected 2001	Eosine	
					Peak	Conc.
K8072	3	Mill Fork Lower # 1	1/12 1600	1/24 1700	ND	
K8073	1	Little Bear # 1	1/12 1500	1/24 1800	ND	

FOOTNOTES:

ND = No dye detected

Ozark Underground Laboratory for Mayo & Associates

Project: GENWAL
Samples collected by: Erik Petersen
Samples shipped on: February 7, 2001
Date samples rec'd at OUL: February 9, 2001
Date analyzed by OUL: February 14, 2001

Table 1. Results for charcoal samplers analyzed for the presence of eosine dye. Peak wavelengths are reported in nanometers (nm); dye concentrations are reported in parts per billion (ppb).

OUL Lab #	OUL Stn. #	Station Name	Date/Time Placed 2001	Date/Time Collected 2001	Eosine	
					Peak	Conc.
K8289	1	Little Bear # 1	1/24 1700	2/2 1600	ND	
K8290	3	Mill Fork Lower # 1	1/24 1800	2/2 1700	ND	

FOOTNOTES:

ND = No dye detected

Ozark Underground Laboratory for Mayo & Associates

Project: GENWAL
Samples collected by: Erik Petersen
Samples shipped on: February 23, 2001
Date samples rec'd at OUL: February 27, 2001
Date analyzed by OUL: March 1, 2001

Table 1. Results for charcoal samplers analyzed for the presence of eosine dye. Peak wavelengths are reported in nanometers (nm); dye concentrations are reported in parts per billion (ppb).

OUL Lab #	OUL Stn. #	Station Name	Date/Time Placed 2001	Date/Time Collected 2001	Eosine	
					Peak	Conc.
K8479	1	Little Bear # 1	2/2 1600	2/17 1330	ND	
K8480		Laboratory control charcoal				
K8481	3	Mill Fork Lower # 1	2/2 1700	2/17 1630	ND	

FOOTNOTES:

ND = No dye detected

Ozark Underground Laboratory for Mayo & Associates

Project: GENWAL - Little Bear
Samples collected by: Erik Petersen
Samples shipped on: March 16, 2001
Date samples rec'd at OUL: March 20, 2001
Date analyzed by OUL: March 23, 2001

Table 1. Results for charcoal samplers analyzed for the presence of eosine dye. Peak wavelengths are reported in nanometers (nm); dye concentrations are reported in parts per billion (ppb).

OUL Lab #	OUL Stn. #	Station Name	Date/Time Placed 2001	Date/Time Collected 2001	Eosine	
					Peak	Conc.
K8870	1	Little Bear # 1	2/17 1330	3/14 1230	ND	
K8871	3	Mill Fork Lower # 1	2/17 1630	3/14 1330	ND	

FOOTNOTES:

ND = No dye detected

Ozark Underground Laboratory for Mayo & Associates

Project: GENWAL
Samples collected by: Erik Petersen
Samples shipped on: April 3, 2001
Date samples rec'd at OUL: April 5, 2001
Date analyzed by OUL: April 6, 2001

Table 1. Results for charcoal samplers analyzed for the presence of eosine dye. Peak wavelengths are reported in nanometers (nm); dye concentrations are reported in parts per billion (ppb).

OUL Lab #	OUL Stn. #	Station Name	Date/Time Placed 2001	Date/Time Collected 2001	Eosine	
					Peak	Conc.
K9049	1	Little Bear # 1	3/14 1230	4/1 1330	ND	
K9050	3	Mill Fork Lower # 1	3/14 1330	4/1 1345	ND	

FOOTNOTES:

ND = No dye detected

Ozark Underground Laboratory for Mayo & Associates

Project: GENWAL
Samples collected by: Erik Petersen
Samples shipped on: April 30, 2001
Date samples rec'd at OUL: May 2, 2001
Date analyzed by OUL: May 10, 2001

Table 1. Results for charcoal samplers analyzed for the presence of eosine dye. Peak wavelengths are reported in nanometers (nm); dye concentrations are reported in parts per billion (ppb).

OUL Lab #	OUL Stn. #	Station Name	Date/Time Placed 2001	Date/Time Collected 2001	Eosine	
					Peak	Conc.
K9427	1	Little Bear # 1	4/1 1330	4/27 1730	ND	
K9428	3	Mill Fork Lower # 1	4/1 1345	4/27 1745	ND	

FOOTNOTES:

ND = No dye detected

Ozark Underground Laboratory for Mayo & Associates

Project: GENWAL
Samples collected by: Erik Petersen
Samples shipped on: May 21, 2001
Date samples rec'd at OUL: May 23, 2001
Date analyzed by OUL: May 31, 2001

Table 1. Results for charcoal samplers analyzed for the presence of eosine dye. Peak wavelengths are reported in nanometers (nm); dye concentrations are reported in parts per billion (ppb).

OUL Lab #	OUL Stn. #	Station Name	Date/Time Placed 2001	Date/Time Collected 2001	Eosine	
					Peak	Conc.
L0107	1	Little Bear # 1	4/27 1715	5/13 1645	ND	
L0108	3	Mill Fork Lower # 1	4/27 1745	5/13 1715	ND	

FOOTNOTES:

ND = No dye detected

Ozark Underground Laboratory for Mayo & Associates

Project: GENWAL
Samples collected by: Erik Petersen
Samples shipped on: May 29, 2001
Date samples rec'd at OUL: May 31, 2001
Date analyzed by OUL: June 7, 2001

Table 1. Results for charcoal samplers analyzed for the presence of eosine dye. Peak wavelengths are reported in nanometers (nm); dye concentrations are reported in parts per billion (ppb).

OUL Lab #	OUL Stn. #	Station Name	Date/Time Placed 2001	Date/Time Collected 2001	Eosine	
					Peak	Conc.
L0484	1	Little Bear # 1	5/13 1645	5/27 1700	ND	
L0485	3	Mill Fork Lower # 1	5/13 1715	5/27 1730	ND	

FOOTNOTES:

ND = No dye detected

Ozark Underground Laboratory for Mayo & Associates

Project: GENWAL
Samples collected by: Erik Petersen
Samples shipped on: June 15 and 25, 2001
Date samples rec'd at OUL: June 19 and 27, 2001
Date analyzed by OUL: June 27, 2001

Table 1. Results for charcoal samplers analyzed for the presence of eosine dye. Peak wavelengths are reported in nanometers (nm); dye concentrations are reported in parts per billion (ppb).

OUL Lab #	OUL Stn. #	Station Name	Date/Time Placed 2001	Date/Time Collected 2001	Eosine	
					Peak	Conc.
L1055	1	Little Bear # 1	5/27 1700	6/10 1645	ND	
L1056	3	Mill Fork Lower # 1	5/27 1730	6/10 1715	536.4	1.26
L1290	1	Little Bear # 1	6/10 1645	6/23 2000	ND	
L1291	3	Mill Fork Lower # 1	6/10 1715	6/23 2030	ND	

FOOTNOTES:

ND = No dye detected

Ozark Underground Laboratory for Mayo & Associates

Project: GENWAL
Samples collected by: Erik Petersen
Samples shipped on: July 9, 2001
Date samples rec'd at OUL: July 11, 2001
Date analyzed by OUL: July 13, 2001

Table 1. Results for charcoal samplers analyzed for the presence of fluorescein and eosine dyes. Peak wavelengths are reported in nanometers (nm); dye concentrations are reported in parts per billion (ppb).

OUL Lab #	OUL Stn. #	Station Name	Date/Time Placed 2001	Date/Time Collected 2001	Fluorescein		Eosine	
					Peak	Conc.	Peak	Conc.
L1658	1	Little Bear #1	6/23 2000	6/27 1330	ND		ND	
L1659	4	Little Bear USFS	NDT	7/8 2000	ND		ND	
L1660	Laboratory Control Charcoal Blank							
L1661	3	Mill Fork Lower #1	6/23 2030	7/8 2030	ND		ND	
L1662	1	Little Bear #1	6/23 2000	7/8 2000	ND		ND	

FOOTNOTES:

ND = No dye detected

Ozark Underground Laboratory for Mayo & Associates

Project: GENWAL
Samples collected by: Erik Petersen
Samples shipped on: July 26, 2001
Date samples rec'd at OUL: July 30, 2001
Date analyzed by OUL: August 1, 2001

Table 1. Results for charcoal sampler analyzed for the presence of fluorescein and eosine dyes. Peak wavelengths are reported in nanometers (nm); dye concentrations are reported in parts per billion (ppb).

OUL Lab #	OUL Stn. #	Station Name	Date/Time Placed 2000	Date/Time Collected 2001	Fluorescein		Eosine	
					Peak	Conc.	Peak	Conc.
L2030	1	Little Bear Backup #1	12/14 1400	6/25 1800	ND		ND	

FOOTNOTES:

ND = No dye detected

Ozark Underground Laboratory for Petersen Hydrologic

Project: GENWAL
Samples collected by: Erik Petersen
Samples shipped on: September 28, 2001
Date samples rec'd at OUL: October 1, 2001
Date analyzed by OUL: October 5, 2001

Table 1. Results for charcoal samplers analyzed for the presence of fluorescein and eosine dyes. Peak wavelengths are reported in nanometers (nm); dye concentrations are reported in parts per billion (ppb).

OUL Lab #	OUL Stn. #	Station Name	Date/Time Placed 2000	Date/Time Collected 2001	Fluorescein		Eosine	
					Peak	Conc.	Peak	Conc.
L3448	1	Little Bear #1	7/25 1800	9/9 1700	ND		538.7	312
L3449	1	Little Bear #1	9/9 1700	9/26 1700	ND		538.8	496

FOOTNOTES:

ND = No dye detected

Table 1 Dye sample log and analytical results.

Sample name	Date retrieved from water	Time	Date put in water	Date sent for analysis	Result	Comments
Mill Fork Upper #1	27-Nov-00			29-Nov-00	N.D.	Background check
Mill Fork Upper #2	27-Nov-00			back-up		Background check
Mill Fork Upper water samp	27-Nov-00			reserve		Background check
Mill Fork Lower #1	29-Nov-00	11:00		29-Nov-00	N.D.	Background check
Mill Fork Lower #2	29-Nov-00	11:00		back-up		Background check
Mill Fork Lower water samp	29-Nov-00	11:00		reserve		Background check
Little Bear #1	29-Nov-00	12:00		29-Nov-00	N.D.	Background check
Little Bear #2	29-Nov-00 (lost)	---		---		Background check
Little Bear water samp	29-Nov-00	12:00		reserve		Background check
Phase 1						
Eosine dye (4 lbs) added to Right and Left forks of Mill Fork (8 Dec 00, 10 am - 12 noon)						
Mill Fork Lower #1	9-Dec-00	15:40	29-Nov-00	15-Dec-00	N.D.	
Mill Fork Lower #2	9-Dec-00	15:40	29-Nov-00	back-up		
Mill Fork Lower water samp	9-Dec-00	15:40	---	reserve		
Little Bear #1	9-Dec-00	15:10	29-Nov-00	15-Dec-00	N.D.	
Little Bear #2	9-Dec-00	15:10	29-Nov-00	back-up		
Little Bear water samp	9-Dec-00	15:10	---	reserve		
Mill Fork Lower #1	11-Dec-00	14:45	9-Dec-00	15-Dec-00	N.D.	
Mill Fork Lower #1	11-Dec-00	14:45	9-Dec-00	back-up		
Mill Fork Lower water samp	11-Dec-00	14:45	---	reserve		
Little Bear #1	11-Dec-00	14:10	9-Dec-00	15-Dec-00	N.D.	
Little Bear #2	11-Dec-00	14:10	9-Dec-00	back-up		
Little Bear water samp	11-Dec-00	14:10	---	reserve		
Little Bear #1	14-Dec-00	14:00	11-Dec-00	15-Dec-00	N.D.	Placed 3 carbon samplers in the spring box for emergency backup.
Little Bear #2	14-Dec-00	14:00	11-Dec-00	back-up		
Little Bear water samp	14-Dec-00	14:00	---	reserve		
Mill Fork Lower #1	14-Dec-00	15:00	11-Dec-00	15-Dec-00	N.D.	
Mill Fork Lower #2	14-Dec-00	15:00	11-Dec-00	back-up		
Mill Fork Lower water samp	14-Dec-00	15:00	---	reserve		
Little Bear #1	26-Dec-00	17:00	14-Dec-00	27-Dec-00	N.D.	
Little Bear #2	26-Dec-00	17:00	14-Dec-00	back-up		
Little Bear water samp	26-Dec-00	17:00	---	reserve		
Mill Fork Lower #1	26-Dec-00	18:00	14-Dec-00	27-Dec-00	N.D.	
Mill Fork Lower #2	26-Dec-00	18:00	14-Dec-00	back-up		
Mill Fork Lower water samp	26-Dec-00	18:00	---	reserve		
Little Bear #1	12-Jan-01	15:00	26-Dec-00	15-Jan-01	N.D.	
Little Bear #2	12-Jan-01	15:00	26-Dec-00	back-up		
Little Bear water samp	12-Jan-01	15:00	---	reserve		
Mill Fork Lower #1	12-Jan-01	16:00	26-Dec-00	15-Jan-01	N.D.	
Mill Fork Lower #2	12-Jan-01	16:00	26-Dec-00	back-up		
Mill Fork Lower water samp	12-Jan-01	16:00	---	reserve		
Little Bear #1	24-Jan-01	17:00	12-Jan-01	26-Jan-01	N.D.	
Little Bear #2	24-Jan-01	17:00	12-Jan-01	back-up		
Little Bear water samp	24-Jan-01	17:00	---	reserve		
Mill Fork Lower #1	24-Jan-01	18:00	12-Jan-01	26-Jan-01	N.D.	
Mill Fork Lower #2	24-Jan-01	18:00	12-Jan-01	back-up		
Mill Fork Lower water samp	24-Jan-01	18:00	---	reserve		
Little Bear #1	2-Feb-01	16:00	24-Jan-01	7-Feb-01	N.D.	
Little Bear #2	2-Feb-01	16:00	24-Jan-01	back-up		
Little Bear water samp	2-Feb-01	16:00	---	reserve		
Mill Fork Lower #1	2-Feb-01	17:00	24-Jan-01	7-Feb-01	N.D.	
Mill Fork Lower #2	2-Feb-01	17:00	24-Jan-01	back-up		
Mill Fork Lower water samp	2-Feb-01	17:00	---	reserve		
Little Bear #1	17-Feb-01	13:30	2-Feb-01	23-Feb-01	N.D.	
Little Bear #2	17-Feb-01	13:30	2-Feb-01	back-up		
Little Bear water samp	17-Feb-01	13:30	---	reserve		
Mill Fork Lower #1	17-Feb-01	16:30	2-Feb-01	23-Feb-01	N.D.	
Mill Fork Lower #2	17-Feb-01	16:30	2-Feb-01	back-up		
Mill Fork Lower water samp	17-Feb-01	16:30	---	reserve		
Little Bear #1	14-Mar-01	12:30	17-Feb-01	16-Mar-01	N.D.	
Little Bear #2	14-Mar-01	12:30	17-Feb-01	back-up		
Little Bear water samp	14-Mar-01	12:30	---	reserve		
Mill Fork Lower #1	14-Mar-01	13:30	17-Feb-01	16-Mar-01	N.D.	
Mill Fork Lower #2	14-Mar-01	13:30	17-Feb-01	back-up		
Mill Fork Lower water samp	14-Mar-01	13:30	---	reserve		
Little Bear #1	1-Apr-01	13:30	14-Mar-01	3-Apr-01	N.D.	
Little Bear #2	1-Apr-01	13:30	14-Mar-01	back-up		
Little Bear water samp	1-Apr-01	13:30		reserve		
Mill Fork Lower #1	1-Apr-01	13:45	14-Mar-01	3-Apr-01	N.D.	
Mill Fork Lower #2	1-Apr-01	13:45	14-Mar-01	back-up		
Mill Fork Lower water samp	1-Apr-01	13:45	---	reserve		
Little Bear #1	27-Apr-01	17:15	1-Apr-01	30-Apr-01	N.D.	
Little Bear #2	27-Apr-01	17:15	1-Apr-01	back-up		
Little Bear water samp	27-Apr-01	17:15	---	reserve		
Mill Fork Lower #1	27-Apr-01	17:45	1-Apr-01	30-Apr-01	N.D.	
Mill Fork Lower #2	27-Apr-01	17:45	1-Apr-01	back-up		
Mill Fork Lower water samp	27-Apr-01	17:45	---	reserve		
Little Bear #1	13-May-01	16:45	27-Apr-01	21-May-01	N.D.	
Little Bear #2	13-May-01	16:45	27-Apr-01	back-up		
Little Bear water samp	13-May-01	16:45	---	reserve		
Mill Fork Lower #1	13-May-01	17:15	27-Apr-01	21-May-01	N.D.	
Mill Fork Lower #2	(not collected)					
Mill Fork Lower water samp	13-May-01	17:15	---	reserve		
Little Bear #1	27-May-01	17:00	13-May-01	29-May-01	N.D.	
Little Bear #2	27-May-01	17:00	13-May-01	back-up		
Little Bear water samp	27-May-01	17:00	---	reserve		
Mill Fork Lower #1	27-May-01	17:30	13-May-01	29-May-01	N.D.	
Mill Fork Lower #2	27-May-01	17:30	27-Apr-01	back-up		
Mill Fork Lower water samp	27-May-01	17:30	---	reserve		
Little Bear #1	10-Jun-01	16:45	27-May-01	15-Jun-01	N.D.	
Little Bear #2	10-Jun-01	16:45	27-May-01	back-up		
Little Bear water samp	10-Jun-01	16:45	---	reserve		
Mill Fork Lower #1	10-Jun-01	17:15	27-May-01	15-Jun-01		
Mill Fork Lower #2	10-Jun-01	17:15	27-May-01	back-up	1.26 ppb	
Mill Fork Lower water samp	10-Jun-01	17:15	---	reserve		
Little Bear #1	23-Jun-01 (damaged)	20:00	10-Jun-01	25-Jun-01	N.D. (possible)	About 2/3 of the carbon leaked out of the bag through a hole in the carbon sampler mesh
Little Bear #2	23-Jun-01 (lost)	20:00	10-Jun-01	---		Carbon sampler separated from the wire holder and was lost
Little Bear water samp	23-Jun-01	20:00	---	reserve		
Mill Fork Lower #1	23-Jun-01	20:30	10-Jun-01	25-Jun-01	N.D.	
Mill Fork Lower #2	23-Jun-01	20:30	10-Jun-01	back-up		
Mill Fork Lower water samp	23-Jun-01	20:30	---	reserve		
Little Bear #1	27-Jun-01	13:30	23-Jun-01	9-Jul-01	N.D.	
Little Bear #2	27-Jun-01	13:30	23-Jun-01	back-up		
Little Bear water samp	27-Jun-01	13:30	---	reserve		
Little Bear USFS	27-Jun-01	13:30	---	9-Jul-01	N.D.	Sampler placed in spring box by Karl Boyer approximately 2 weeks earlier
Little Bear Backup #1	25-Jul-01	18:00	14-Dec-00	26-Jul-01	N.D.	Installed 3 replacement backup samplers
Little Bear Backup #2	25-Jul-01	18:00	14-Dec-00	back-up		
Little Bear Backup #3	25-Jul-01	18:00	14-Dec-00	back-up		
Little Bear water samp	25-Jul-01	18:00	---	reserve		
Phase 2						
Eosine dye (20 lbs) placed in the Mill Fork Drainage above the fracture zone, 20 July 2001. Also 1.5 lbs released from dry sets below fracture.						
Little Bear #1	9-Sep-01	17:00	25-Jul-01	28-Sep-01	312 ppb	
Little Bear #2	9-Sep-01	17:00	25-Jul-01	back-up		
Little Bear #3	9-Sep-01	17:00	25-Jul-01	back-up		
Little Bear water samp	9-Sep-01	17:00	---	reserve		
Little Bear #1	26-Sep-01	17:00	9-Sep-01	28-Sep-01	496 ppb	
Little Bear #2	26-Sep-01	17:00	9-Sep-01	back-up		
Little Bear #3	26-Sep-01	17:00	9-Sep-01	back-up		
Little Bear water samp	26-Sep-01	17:00	---	reserve		

Phase 2

No eosine was detected at Little Bear Spring during Phase 1 of the dye tracer investigation. As discussed previously, the amount of eosine placed in the Mill Fork drainage during Phase 1 of the investigation was minimized to mitigate the potential for visible coloration of the water in Little Bear Spring. After conversations with Mr. Tom Aley of the Ozark Underground Laboratory (Personnal Communication, Tom Aley, 2001) it was concluded that there was a reasonable possibility that insufficient eosine dye was placed during Phase 1. It has been estimated that commonly only approximately 1% of the dye injected in a tracer study in fractured, non-soluble rock is recovered at the sampling location (Ozark Underground Laboratory, 1999). This is because fluorescent dye is readily lost to adsorption on clay particles or organic material, or is lost to photo-degradation prior to infiltration. Mr. Aley recommended that for Phase 2 of the dye tracer study, approximately 4 times the amount of eosine dye used for Phase 1 be placed in the drainage. Consequently, a total of 20 pounds of eosine dye was placed in the Mill Fork drainage above the fracture system for Phase 2 of the dye tracer study.

It is not known when the approximately 1.5 pounds of eosine dye in the three dry sets discussed previously was released into the drainage. However, because all of the dry sets were located down gradient of the upper fracture from which Little Bear Spring discharges (Figure 5), it is unlikely that significant amounts of dye from the dry sets ever arrived at Little Bear Spring.

On 9 September 2001 during the first sampling event at Little Bear Spring subsequent to the introduction of dye for Phase 2 of the investigation, eosine dye was detected in the carbon sampler at a concentration of 312 ppb. On the following sampling event on 26 September 2001, dye was again detected at a concentration of 496 ppb.

5. Conclusions

Based on the positive detection of eosine dye in Little Bear Spring, it has been demonstrated that water in the Mill Fork Drainage recharges Little Bear Spring. The travel time from the streambed in Mill Fork Canyon to the spring is 40 days or less. These findings are in complete agreement with previous investigations of Little Bear Spring conducted by Mayo and Associates (2001a, 2001b).

6. References Cited

Aley, T., 1999, Ozark Underground Laboratory groundwater tracing handbook, Ozark Underground Laboratory, Protem, MO, 35 p.

Water Technology and Research, Inc, 1999, AquaTrack Survey, Little Bear Springs study, unpublished consulting report, 31 p.

Field, M.S., Wilhelm, J.F.Q., Quinlan, J.F., and Aley, T.J., 1995, An assessment of the potential adverse properties of fluorescent tracer dyes used for groundwater tracing, Environmental Monitoring and Assessment, 38: 75-96, Kluwer Academic Publishers

Mayo and Associates, 2001a, Investigation of the Potential for Little Bear Spring Recharge in Mill Fork Canyon, Emery County, Utah, unpublished consulting report for GENWAL Resources, Inc, Price, Utah.

Mayo and Associates, 2001b, Investigation of the Alluvial Groundwater System In Mill Fork Canyon with Implications for Recharge to Little Bear Spring, unpublished consulting report for GENWAL Resources, Inc, Price, Utah.

Mayo and Associates, 1999, Investigation of groundwater and surface-water systems in the vicinity of GENWAL's existing permit area and the Mill Fork Tract, Emery County, Utah, unpublished consulting report submitted to Genwal Resources, Inc., Huntington, Utah.

Smart, P.L., 1984, A review of the toxicity of twelve fluorescent dyes used for water tracing, NSS Bulletin 46: 21-33

Appendix

Laboratory Reporting Sheets

Ozark Underground Laboratory

Ozark Underground Laboratory for Mayo & Associates

Date Samples Rec'd at OUL: November 30, 2000
Date Analyzed by OUL: December 6, 2000

Table 1. Results for charcoal background samplers analyzed for the presence of fluorescein, eosine and rhodamine WT (RWT) dyes. Peak wavelengths are reported in nanometers (nm); dye concentrations are reported in parts per billion (ppb).

OUL Lab #	Stn. #	Station Name	Date/Time Placed 2000	Date/Time Collected 2000	Fluorescein		Eosine		RWT	
					Peak	Conc.	Peak	Conc.	Peak	Conc.
K6979	1	Little Bear	NDT	11/29 1200	ND		ND		ND	
K6980		Lab[illegible] C[illegible] Cha[illegible] Blank								
K6981	2	Mill Fork Upper	NDT	11/28 1600	ND		ND		ND	
K6982	3	Mill Fork Lower	NDT	11/29 1130	ND		ND		ND	

FOOTNOTES:

NDT = No date or time given

ND = No dye detected

Ozark Underground Laboratory for Mayo & Associates

Project: Little Bear Springs
Samples collected by: Erik C. Petersen
Samples shipped on: December 15, 2000
Date samples rec'd at OUL: December 18, 2000
Date analyzed by OUL: December 20, 2000

Table 1. Results for charcoal samplers analyzed for the presence of fluorescein, eosine and rhodamine WT (RWT) dyes. Peak wavelengths are reported in nanometers (nm); dye concentrations are reported in parts per billion (ppb).

OUL Lab #	Stn. #	Station Name	Date/Time Placed 2000	Date/Time Collected 2000	Fluorescein		Eosine		RWT	
					Peak	Conc.	Peak	Conc.	Peak	Conc.
K7367	3	Mill Fork Lower # 1	NDT	12/9 1540	ND		ND		ND	
K7368	1	Little Bear # 1	NDT	12/9 1510	ND		ND		ND	
K7369	3	Mill Fork Lower # 1	NDT	12/11 1445	ND		ND		ND	
K7370	1	Little Bear # 1	NDT	12/11 1410	ND		ND		ND	
K7371	3	Mill Fork Lower # 1	NDT	12/14 1500	ND		ND		ND	
K7372	1	Little Bear # 1	NDT	12/14 1400	ND		ND		ND	

FOOTNOTES:

NDT = No date or time given

ND = No dye detected

Ozark Underground Laboratory for Mayo & Associates

Project: Crandall Canyon Mine Project
Samples collected by: Erik C. Petersen
Samples shipped on: December 27, 2000
Date samples rec'd at OUL: December 28, 2000
Date analyzed by OUL: January 4, 2001

Table 1. Results for charcoal samplers analyzed for the presence of fluorescein, eosine and rhodamine WT (RWT) dyes. Peak wavelengths are reported in nanometers (nm); dye concentrations are reported in parts per billion (ppb).

OUL Lab #	Stn. #	Station Name	Date/Time Placed 2000	Date/Time Collected 2000	Fluorescein		Eosine		RWT	
					Peak	Conc.	Peak	Conc.	Peak	Conc.
K7491	1	Little Bear # 1	NDT	12/26 1700	ND		ND		ND	
K7492	3	Mill Fork Lower # 1	NDT	12/26 1800	ND		ND		ND	

FOOTNOTES:

NDT = No date or time given

ND = No dye detected

Ozark Underground Laboratory for Mayo & Associates

Project: Crandall Canyon Mine Project
Samples collected by: Erik C. Petersen
Samples shipped on: January 15, 2001
Date samples rec'd at OUL: January 17, 2001
Date analyzed by OUL: January 22, 2001

Table 1. Results for charcoal samplers analyzed for the presence of fluorescein, eosine and rhodamine WT (RWT) dyes. Peak wavelengths are reported in nanometers (nm); dye concentrations are reported in parts per billion (ppb).

OUL Lab #	OUL Stn. #	Station Name	Date/Time Placed	Date/Time Collected 2001	Fluorescein		Eosine		RWT	
					Peak	Conc.	Peak	Conc.	Peak	Conc.
K7909	1	Little Bear # 1	NDT	1/12 1500	ND		ND		ND	
K7910	3	Mill Fork Lower # 1	NDT	1/12 1600	ND		ND		ND	

FOOTNOTES:

NDT = No date or time given

ND = No dye detected

Ozark Underground Laboratory for Mayo & Associates

Project: GENWAL
Samples collected by: Erik Petersen
Samples shipped on: January 26, 2001
Date samples rec'd at OUL: January 30, 2001
Date analyzed by OUL: January 31, 2001

Table 1. Results for charcoal samplers analyzed for the presence of eosine dye. Peak wavelengths are reported in nanometers (nm); dye concentrations are reported in parts per billion (ppb).

OUL Lab #	OUL Stn. #	Station Name	Date/Time Placed 2001	Date/Time Collected 2001	Eosine	
					Peak	Conc.
K8072	3	Mill Fork Lower # 1	1/12 1600	1/24 1700	ND	
K8073	1	Little Bear # 1	1/12 1500	1/24 1800	ND	

FOOTNOTES:

ND = No dye detected

Ozark Underground Laboratory for Mayo & Associates

Project: GENWAL
Samples collected by: Erik Petersen
Samples shipped on: February 7, 2001
Date samples rec'd at OUL: February 9, 2001
Date analyzed by OUL: February 14, 2001

Table 1. Results for charcoal samplers analyzed for the presence of eosine dye. Peak wavelengths are reported in nanometers (nm); dye concentrations are reported in parts per billion (ppb).

OUL Lab #	OUL Stn. #	Station Name	Date/Time Placed 2001	Date/Time Collected 2001	Eosine	
					Peak	Conc.
K8289	1	Little Bear # 1	1/24 1700	2/2 1600	ND	
K8290	3	Mill Fork Lower # 1	1/24 1800	2/2 1700	ND	

FOOTNOTES:

ND = No dye detected

Ozark Underground Laboratory for Mayo & Associates

Project: GENWAL
Samples collected by: Erik Petersen
Samples shipped on: February 23, 2001
Date samples rec'd at OUL: February 27, 2001
Date analyzed by OUL: March 1, 2001

Table 1. Results for charcoal samplers analyzed for the presence of eosine dye. Peak wavelengths are reported in nanometers (nm); dye concentrations are reported in parts per billion (ppb).

OUL Lab #	OUL Stn. #	Station Name	Date/Time Placed 2001	Date/Time Collected 2001	Eosine	
					Peak	Conc.
K8479	1	Little Bear # 1	2/2 1600	2/17 1330	ND	
K[illegible]80	Labora[illegible]ontr[illegible]					
K8481	3	Mill Fork Lower # 1	2/2 1700	2/17 1630	ND	

FOOTNOTES:

ND = No dye detected

Ozark Underground Laboratory for Mayo & Associates

Project: GENWAL - Little Bear
Samples collected by: Erik Petersen
Samples shipped on: March 16, 2001
Date samples rec'd at OUL: March 20, 2001
Date analyzed by OUL: March 23, 2001

Table 1. Results for charcoal samplers analyzed for the presence of eosine dye. Peak wavelengths are reported in nanometers (nm); dye concentrations are reported in parts per billion (ppb).

OUL Lab #	OUL Stn. #	Station Name	Date/Time Placed 2001	Date/Time Collected 2001	Eosine	
					Peak	Conc.
K8870	1	Little Bear # 1	2/17 1330	3/14 1230	ND	
K8871	3	Mill Fork Lower # 1	2/17 1630	3/14 1330	ND	

FOOTNOTES:

ND = No dye detected

Ozark Underground Laboratory for Mayo & Associates

Project: GENWAL
Samples collected by: Erik Petersen
Samples shipped on: April 3, 2001
Date samples rec'd at OUL: April 5, 2001
Date analyzed by OUL: April 6, 2001

Table 1. Results for charcoal samplers analyzed for the presence of eosine dye. Peak wavelengths are reported in nanometers (nm); dye concentrations are reported in parts per billion (ppb).

OUL Lab #	OUL Stn. #	Station Name	Date/Time Placed 2001	Date/Time Collected 2001	Eosine	
					Peak	Conc.
K9049	1	Little Bear # 1	3/14 1230	4/1 1330	ND	
K9050	3	Mill Fork Lower # 1	3/14 1330	4/1 1345	ND	

FOOTNOTES:

ND = No dye detected

Ozark Underground Laboratory for Mayo & Associates

Project: GENWAL
Samples collected by: Erik Petersen
Samples shipped on: April 30, 2001
Date samples rec'd at OUL: May 2, 2001
Date analyzed by OUL: May 10, 2001

Table 1. Results for charcoal samplers analyzed for the presence of eosine dye. Peak wavelengths are reported in nanometers (nm); dye concentrations are reported in parts per billion (ppb).

OUL Lab #	OUL Stn. #	Station Name	Date/Time Placed 2001	Date/Time Collected 2001	Eosine	
					Peak	Conc.
K9427	1	Little Bear # 1	4/1 1330	4/27 1730	ND	
K9428	3	Mill Fork Lower # 1	4/1 1345	4/27 1745	ND	

FOOTNOTES:

ND = No dye detected

Ozark Underground Laboratory for Mayo & Associates

Project: GENWAL
Samples collected by: Erik Petersen
Samples shipped on: May 21, 2001
Date samples rec'd at OUL: May 23, 2001
Date analyzed by OUL: May 31, 2001

Table 1. Results for charcoal samplers analyzed for the presence of eosine dye. Peak wavelengths are reported in nanometers (nm); dye concentrations are reported in parts per billion (ppb).

OUL Lab #	OUL Stn. #	Station Name	Date/Time Placed 2001	Date/Time Collected 2001	Eosine	
					Peak	Conc.
L0107	1	Little Bear # 1	4/27 1715	5/13 1645	ND	
L0108	3	Mill Fork Lower # 1	4/27 1745	5/13 1715	ND	

FOOTNOTES:

ND = No dye detected

Ozark Underground Laboratory for Mayo & Associates

Project: GENWAL
Samples collected by: Erik Petersen
Samples shipped on: May 29, 2001
Date samples rec'd at OUL: May 31, 2001
Date analyzed by OUL: June 7, 2001

Table 1. Results for charcoal samplers analyzed for the presence of eosine dye. Peak wavelengths are reported in nanometers (nm); dye concentrations are reported in parts per billion (ppb).

OUL Lab #	OUL Stn. #	Station Name	Date/Time Placed 2001	Date/Time Collected 2001	Eosine	
					Peak	Conc.
L0484	1	Little Bear # 1	5/13 1645	5/27 1700	ND	
L0485	3	Mill Fork Lower # 1	5/13 1715	5/27 1730	ND	

FOOTNOTES:

ND = No dye detected

Ozark Underground Laboratory for Mayo & Associates

Project: GENWAL
Samples collected by: Erik Petersen
Samples shipped on: June 15 and 25, 2001
Date samples rec'd at OUL: June 19 and 27, 2001
Date analyzed by OUL: June 27, 2001

Table 1. Results for charcoal samplers analyzed for the presence of eosine dye. Peak wavelengths are reported in nanometers (nm); dye concentrations are reported in parts per billion (ppb).

OUL Lab #	OUL Stn. #	Station Name	Date/Time Placed 2001	Date/Time Collected 2001	Eosine	
					Peak	Conc.
L1055	1	Little Bear # 1	5/27 1700	6/10 1645	ND	
L1056	3	Mill Fork Lower # 1	5/27 1730	6/10 1715	536.4	1.26
L1290	1	Little Bear # 1	6/10 1645	6/23 2000	ND	
L1291	3	Mill Fork Lower # 1	6/10 1715	6/23 2030	ND	

FOOTNOTES:

ND = No dye detected

Ozark Underground Laboratory for Mayo & Associates

Project: GENWAL
Samples collected by: Erik Petersen
Samples shipped on: July 9, 2001
Date samples rec'd at OUL: July 11, 2001
Date analyzed by OUL: July 13, 2001

Table 1. Results for charcoal samplers analyzed for the presence of fluorescein and eosine dyes. Peak wavelengths are reported in nanometers (nm); dye concentrations are reported in parts per billion (ppb).

OUL Lab #	OUL Stn. #	Station Name	Date/Time Placed 2001	Date/Time Collected 2001	Fluorescein		Eosine	
					Peak	Conc.	Peak	Conc.
L1658	1	Little Bear #1	6/23 2000	6/27 1330	ND		ND	
L1659	4	Little Bear USFS	NDT	7/8 2000	ND		ND	
L1660		Laboratory Control Charcoal Blank						
L1661	3	Mill Fork Lower #1	6/23 2030	7/8 2030	ND		ND	
L1662	1	Little Bear #1	6/23 2000	7/8 2000	ND		ND	

FOOTNOTES:

ND = No dye detected

Ozark Underground Laboratory for Mayo & Associates

Project: GENWAL
Samples collected by: Erik Petersen
Samples shipped on: July 26, 2001
Date samples rec'd at OUL: July 30, 2001
Date analyzed by OUL: August 1, 2001

Table 1. Results for charcoal sampler analyzed for the presence of fluorescein and eosine dyes. Peak wavelengths are reported in nanometers (nm); dye concentrations are reported in parts per billion (ppb).

OUL Lab #	OUL Stn. #	Station Name	Date/Time Placed 2000	Date/Time Collected 2001	Fluorescein		Eosine	
					Peak	Conc.	Peak	Conc.
L2030	1	Little Bear Backup #1	12/14 1400	6/25 1800	ND		ND	

FOOTNOTES:

ND = No dye detected

Ozark Underground Laboratory for Petersen Hydrologic

Project: GENWAL
Samples collected by: Erik Petersen
Samples shipped on: September 28, 2001
Date samples rec'd at OUL: October 1, 2001
Date analyzed by OUL: October 5, 2001

Table 1. Results for charcoal samplers analyzed for the presence of fluorescein and eosine dyes. Peak wavelengths are reported in nanometers (nm); dye concentrations are reported in parts per billion (ppb).

OUL Lab #	OUL Stn. #	Station Name	Date/Time Placed 2000	Date/Time Collected 2001	Fluorescein		Eosine	
					Peak	Conc.	Peak	Conc.
L3448	1	Little Bear #1	7/25 1800	9/9 1700	ND		538.7	312
L3449	1	Little Bear #1	9/9 1700	9/26 1700	ND		538.8	496

FOOTNOTES:

ND = No dye detected

APPENDIX 7-58

SUMMARY OF HYDRO LOGIC BASELINE INFORMATION,

SOUTH CRANDALL LEASE

1/23/95 revised 4/97

PETERSEN HYDROLOGIC

14 September 2003

Mr. Dave Shaver
GENWAL Resources, Inc.
P.O. Box 1077
Price, Utah 84501

Dave,

This appendix summarizes the baseline water monitoring activities in the South Crandall Lease area. Baseline monitoring locations are shown on Figure 1. Discharge and major-ion water quality data from seeps, springs, and streams in the South Crandall Lease area are presented in Table 1. Trace metal and nutrient water quality measurements are presented in Table 2.

Historic monitoring of seeps, springs, and creeks in the South Crandall Lease area has been performed by several entities. The sources from which the hydrologic data in the table were obtained are listed in Tables 1 and 2.

GENWAL Resources, Inc. has collected a large amount of hydrologic data from springs, seeps, and streams in the South Crandall Lease and surrounding area. Beginning in 1985 and continuing to the present, GENWAL has performed a series of spring and seep surveys in the South Crandall Lease and surrounding area. In conjunction with scientific investigations conducted at the Crandall Canyon Mine, GENWAL has also collected a substantial amount of discharge, solute, and isotopic data in the region. Over the past several years, GENWAL also performed baseline monitoring of springs, seeps, and streams in the South Crandall Lease area.

Beaver Creek Coal Company, as part of hydrologic monitoring at the Huntington Canyon #4 Mine, monitored seeps, springs, and streams in the South Crandall Lease and surrounding area. This included monitoring of Little Bear Spring.

The Castle Valley Special Service District operates Little Bear Spring as part of a water supply system that supplies municipal water to adjacent municipalities. In conjunction with these activities, the Castle Valley Special Service District performs routine monitoring of Little Bear Spring. The CVSSD measures monthly average discharge from Little Bear Spring and performs periodic water quality measurements. The monthly average discharge at the spring for the period 1982 to the present is presented in Table 3.

2695 N. 600 E. LEHI, UTAH 84043 (801) 766-4006

Water quality and discharge data from Little Bear Spring collected by the CVSSD are included in Tables 1 and 2.

Data from the South Crandall Lease area has also been collected by governmental agencies. The United States Geologic Survey, in conjunction with various investigations in the Huntington Canyon area, has performed periodic measurements of discharge and water quality from streams, seeps, and springs in the area, including Little Bear Spring. The Utah Department of Health has also monitored water quality at Little Bear Spring. Water quality measurements performed by the USGS and the Utah Department of Health are included in Tables 1 and 2. Discharge data from Little Bear Spring collected by the USGS and CVSSD prior to 1982 are presented in Table 4.

Also included in this appendix is a plot of the Palmer Hydrologic Drought Index. A plot of the PHDI for Utah Region 4 (which includes the South Crandall Lease area) is presented in Figure 2. The PHDI is a monthly value generated by the National Climatic Data Center using a variety of hydrologic parameters that indicates wet and dry spells. The PHDI is calculated from several hydrologic parameters including precipitation, temperature, evapotranspiration, soil water recharge, soil water loss, and runoff. Consequently, it is a useful tool for evaluating the relationship between climate and groundwater and surface water discharge data. The PHDI is useful for determining whether variations in spring and stream discharge rates are the result of climatic variability or whether they are the result of other factors.

As indicated by the PHDI (Figure 2), during the past 20 years, the region has experienced periods of extreme drought and periods of extreme wetness in addition to periods of near normal climatic conditions. The climatic conditions the area was experiencing during baseline monitoring activities at the South Crandall Lease area are important to consider when evaluating the data in this appendix.

Please feel free to contact me should you have any questions in this regard.

Sincerely,

Erik C. Petersen, M.S., P.G.
Principal Hydrogeologist
Utah PG No. 5373615-2250

Table 1 South Crandall Lease baseline monitoring summary
Petersen Hydrologic 14 Sep 03

	Date	Data source	Flow (gpm)	T (C°)	pH (s.u.)	Cond. (µS/cm)	TDS (mg/l)	Ca^{2+} (mg/l)	Mg^{2+} (mg/l)	Na^{+} (mg/l)	K^{+} (mg/l)	HCO_3^- (mg/l)	CO_3^{2-} (mg/l)	SO_4^{2-} (mg/l)	Cl^- (mg/l)	DO (mg/l)	Turbidity (NTU)	Hard. (mg/l)	Acidity (mg/l)	Alkalinity (mg/l CaCO3)	O&G (mg/l)	TSS (mg/l)	Tritium (TU)	^{14}C (pmC)	$\delta^{13}C$ (‰)	$\delta 2H$ (‰)	$\delta^{18}O$ (‰)	$\delta^{34}S$ (‰)
								Major Ions															Isotopes					
Springs																												
LB-1	1993	Genwal	1	6	7.95	478																						
(Castlegate Sandstone)	30-Jun-03	Genwal	dry																									
	24-Aug-03	Genwal	dry																									
LB-2	1993	Genwal	2	4	7.95	495																						
(Castlegate Sandstone)	1994	Genwal	5	7	8.12	375																						
	Jun 24-27,96	Genwal			7.78	415																						
	7-Aug-97	Genwal	10	4.9	8.10	312	290	70		5	1	301	<5	28	5								16.6	94.2	-11	-128	-17	
	30-Jun-03	Genwal	2	5.4	7.93	487	307.0	77.00	27.3	4.64	1.03	315.0	<5	47	5		2.0	305.0	5.0	258		<5						
	24-Aug-03	Genwal	2.15	9.9	8.09	401	275	47.9	28.9	4.81	1.02	227	<5	50	4		2.9	239	<5	186		9						
LB-5	1993	Genwal	1	7	7.73	425																						
(Blackhawk Formation)	30-Jun-03	Genwal	seep																									
	24-Aug-03	Genwal	dry																									
LB-5A	1993	Genwal	Seep	---	---	---																						
(Blackhawk Formation)	Jun 24-27,96	Genwal	15	7	7.98	436																						
	7-Aug-97	Genwal	7	8	8.10	535	480	84	50	7	2	390	<5	107	7								17.1	61.06	-13.0	-128	-17	
	30-Jun-03	Genwal	1.95	8.0	7.56	699	482.0	86.4	50.2	7.94	1.44	378.0	<5	117	6		1.0	422.0	14.0	310		33						
	24-Aug-03	Genwal	2.01	8.9	8.02	682	477	85.5	51.7	6.69	1.5	3667	<5	118	5		1.6	426	<5	301		9						
LB-11	1981	Beaver Ck. Coal	5	9.9	8.1	559																						
(Star Point Sandstone)	30-Jun-03	Genwal	5																									
	24-Aug-03	Genwal	4.69	10.0	8.09	556											7.0											
LB-13	1982	Beaver Ck. Coal	1.5		7.95	291																						
(Castlegate Sandstone)	30-Jun-03	Genwal	dry																									
	24-Aug-03	Genwal	dry																									
LB-14	25-Aug-80	Beaver Ck. Coal			7.6	520	370							57	14.0							12						
(Castlegate Sandstone)	22-Jul-81	Beaver Ck. Coal	1	20	8.3	620	405							36	8.01							32						
	1982	Beaver Ck. Coal	22		7.45	333																						
	30-Jun-03	Genwal	dry																									
	24-Aug-03	Genwal	dry																									
LB-15	1980	Beaver Ck. Coal			7.2	495																						
(Alluvium)	1981	Beaver Ck. Coal			7.65	548																						
	1982	Beaver Ck. Coal	300	16	7.56	491																						
	25-Aug-03	Genwal	0.1	18.2	7.44	1,441											19.7											
LB-16	1980	Beaver Ck. Coal			7.4	500																						
(Star Point Sandstone)	1981	Beaver Ck. Coal			8.76	559																						
	1982	Beaver Ck. Coal	5		7.8	488																						
	30-Jun-03	Genwal	seep																									
	24-Aug-03	Genwal	seep																									
SP-73	Jun-85	Genwal	seep	---	---	---																						
(Blackhawk Formation)	Oct-85	Genwal	dry	---	---	---																						
	Jun-93	Genwal	10	5	8.26	417																						
	30-Jun-03	Genwal	dry	---	---	---																						
	25-Aug-03	Genwal	dry																									

	Date	Data source	Flow (gpm)	T (C°)	pH (s.u.)	Cond. (μS/cm)	TDS (mg/l)	Ca^{2+} (mg/l)	Mg^{2+} (mg/l)	Na^{+} (mg/l)	K^{+} (mg/l)
SP-74											
(Blackhawk Formation)	Jun-85	Genwal	seep	---	---	---					
	Oct-85	Genwal	dry	---	---	---					
	Jun-93	Genwal	dry	---	---	---					
	30-Jun-03	Genwal	dry	---	---	---					
	25-Aug-03	Genwal									
SP-75	Jun-85	Genwal	seep								
(Blackhawk Formation)	Oct-85	Genwal	dry								
	Jun-93	Genwal	dry								
	30-Jun-03	Genwal	dry	---	---	---					
	25-Aug-03	Genwal									
SP-76	Jun-85	Genwal	1	10	7.48	960					
(Blackhawk Formation)	Oct-85	Genwal	1	5	8.35	850					
	30-Jun-03	Genwal	dry	---	---	---					
	25-Aug-03	Genwal	dry								
SP-77	Jun-85	Genwal	seep	---	---	---					
(Blackhawk Formation)	Oct-85	Genwal	dry	---	---	---					
	30-Jun-03	Genwal	dry	---	---	---					
	25-Aug-03	Genwal	dry								
SP-78	Jun-85	Genwal	seep	---	---	---					
(Star Point Sandstone)	Oct-85	Genwal	dry	---	---	---					
	Jun-93	Genwal	dry	---	---	---					
	30-Jun-03	Genwal	seep	---	---	---					
	25-Aug-03	Genwal	seep								
SP-79	Jun-85	Genwal	seep	---	---	---					
(Star Point Sandstone)	Oct-85	Genwal	dry	---	---	---					
	Jun-93	Genwal	dry	---	---	---					
	30-Jun-03	Genwal	0.395	8.9	7.71	870					
	25-Aug-03	Genwal	0.353	10.7	7.84	1,006					
Little Bear Spring	3-Oct-57	Utah Dept. of Health					305	75	25		
(Star Point Sandstone)	25-Jun-70	CVSSD	399								
(upper Little Bear Spring)	8/75 to 2/79 av.	USFS mean	449	5.8	8.9						
(upper Little Bear; 4-1-W)	16-Jul-76	Beaver Ck. Coal			9.3						
	18-Aug-76	USGS, 1981	121	8.3	7.6	530	332	67	38	7.1	1.5
	18-Aug-76	USGS, 1981	117								
	27-Apr-78	USGS, 1981	426								
	29-Aug-78	USGS, 1981	292								
(upper Little Bear; 4-1-W)	15-Sep-78	Beaver Ck. Coal	180		7.10	720	470				
	13-Oct-78	USGS, 1981	256								
	8-Nov-78	USGS, 1981	188								
	4-Nov-77	Utah dept of Health			7.7	492	315	66	36	6	2
(upper Little Bear; 4-1-W)	15-Jun-79	Beaver Ck. Coal			8.4						
(upper Little Bear; 4-1-W)	11-Oct-79	Beaver Ck. Coal			7.80		330				
(upper Little Bear; 4-1-W)	25-Aug-80	Beaver Ck. Coal			7.20	490	350				
(upper Little Bear; 4-1-W)	6-Nov-80	Beaver Ck. Coal			7.20	500	350				
(upper Little Bear; 4-1-W)	4-Jan-81	Beaver Ck. Coal			6.80	557	390				
(upper Little Bear; 4-1-W)	3-Feb-81	Beaver Ck. Coal			7.80	530	350				
(upper Little Bear; 4-1-W)	4-Mar-81	Beaver Ck. Coal			7.40	520	310				
(upper Little Bear; 4-1-W)	9-Apr-81	Beaver Ck. Coal			8.40	580	380				

	Date	Data source	Flow (gpm)	T (C°)	pH (s.u.)	Cond. (µS/cm)	TDS (mg/l)	Major Ions Ca^{2+} (mg/l)	Mg^{2+} (mg/l)	Na^{+} (mg/l)	K^{+} (mg/l)	HCO_3^{-} (mg/l)	CO_3^{2-} (mg/l)	SO_4^{2-} (mg/l)	Cl^{-} (mg/l)	DO (mg/l)	Turbidity (NTU)	Hard. (mg/l)	Acidity (mg/l)	Alkalinity (mg/l CaCO3)	O&G (mg/l)	TSS (mg/l)	Tritium (TU)	Isotopes ^{14}C (pmC)	$\delta^{13}C$ (‰)	δ2H (‰)	$\delta^{18}O$ (‰)	$\delta^{34}S$ (‰)
SP-74																												
(Blackhawk Formation)	Jun-85	Genwal	seep	---	---	---																						
	Oct-85	Genwal	dry	---	---	---																						
	Jun-93	Genwal	dry	---	---	---																						
	30-Jun-03	Genwal	dry	---	---	---																						
	25-Aug-03	Genwal																										
SP-75	Jun-85	Genwal	seep																									
(Blackhawk Formation)	Oct-85	Genwal	dry																									
	Jun-93	Genwal	dry																									
	30-Jun-03	Genwal	dry	---	---	---																						
	25-Aug-03	Genwal																										
SP-76	Jun-85	Genwal	1	10	7.48	960																						
(Blackhawk Formation)	Oct-85	Genwal	1	5	8.35	850																						
	30-Jun-03	Genwal	dry	---	---	---																						
	25-Aug-03	Genwal	dry																									
SP-77	Jun-85	Genwal	seep	---	---	---																						
(Blackhawk Formation)	Oct-85	Genwal	dry	---	---	---																						
	30-Jun-03	Genwal	dry	---	---	---																						
	25-Aug-03	Genwal	dry																									
SP-78	Jun-85	Genwal	seep	---	---	---																						
(Star Point Sandstone)	Oct-85	Genwal	dry	---	---	---																						
	Jun-93	Genwal	dry	---	---	---																						
	30-Jun-03	Genwal	seep	---	---	---																						
	25-Aug-03	Genwal	seep																									
SP-79	Jun-85	Genwal	seep	---	---	---																						
(Star Point Sandstone)	Oct-85	Genwal	dry	---	---	---																						
	Jun-93	Genwal	dry	---	---	---																						
	30-Jun-03	Genwal	0.395	8.9	7.71	870											7.9											
	25-Aug-03	Genwal	0.353	10.7	7.84	1,006																						
Little Bear Spring	3-Oct-57	Utah Dept. of Health					305	75	25			341	1.67	14	7.4					282								
(Star Point Sandstone)	25-Jun-70	CVSSD	399																									
(upper Little Bear Spring)	8/75 to 2/79 av.	USFS mean	449	5.8	8.9									56.7	3.7					244								
(upper Little Bear; 4-1-W)	16-Jul-76	Beaver Ck. Coal			9.3									15.9	3.7													
	18-Aug-76	USGS, 1981	121	8.3	7.6	530	332	67	38	7.1	1.5	346		35	5.3					284								
	18-Aug-76	USGS, 1981	117																									
	27-Apr-78	USGS, 1981	426																									
	29-Aug-78	USGS, 1981	292																									
(upper Little Bear; 4-1-W)	15-Sep-78	Beaver Ck. Coal	180		7.10	720	470							28.0	14							1.00						
	13-Oct-78	USGS, 1981	256																									
	8-Nov-78	USGS, 1981	188																									
	4-Nov-77	Utah dept of Health			7.7	492	315	66	36	6	2	346		32	2					274								
(upper Little Bear; 4-1-W)	15-Jun-79	Beaver Ck. Coal			8.4									97.5														
(upper Little Bear; 4-1-W)	11-Oct-79	Beaver Ck. Coal			7.80		330							58.0	8							1.00						
(upper Little Bear; 4-1-W)	25-Aug-80	Beaver Ck. Coal			7.20	490	350							33.0	14							9.00						
(upper Little Bear; 4-1-W)	6-Nov-80	Beaver Ck. Coal			7.20	500	350							21.0	0.65							1.00						
(upper Little Bear; 4-1-W)	4-Jan-81	Beaver Ck. Coal			6.80	557	390							18.0	4.49							8.00						
(upper Little Bear; 4-1-W)	3-Feb-81	Beaver Ck. Coal			7.80	530	350							18.0	12.3							1.00						
(upper Little Bear; 4-1-W)	4-Mar-81	Beaver Ck. Coal			7.40	520	310								9.00							1.00						
(upper Little Bear; 4-1-W)	9-Apr-81	Beaver Ck. Coal			8.40	580	380							24.0	14.00							2.00						

	Date	Data source	Flow (gpm)	T (C°)	pH (s.u.)	Cond. (µS/cm)	TDS (mg/l)	Major Ions: Ca^{2+} (mg/l)	Mg^{2+} (mg/l)	Na^{+} (mg/l)	K^{+} (mg/l)	HCO_3^{-} (mg/l)	CO_3^{2-} (mg/l)	SO_4^{2-} (mg/l)	Cl^{-} (mg/l)	DO (mg/l)	Turbidity (NTU)	Hard. (mg/l)	Acidity (mg/l)	Alkalinity (mg/l CaCO3)	O&G (mg/l)	TSS (mg/l)	Isotopes: Tritium (TU)	^{14}C (pmC)	$\delta^{13}C$ (‰)	δ2H (‰)	$\delta^{18}O$ (‰)	$\delta^{34}S$ (‰)
	28-Apr-81	Utah dept of Health			8.0	535	308	53	36	12	1	320		35	4					262								
(upper Little Bear; 4-1-W)	13-May-81	Beaver Ck. Coal			7.9	540	350							37.5	12							9.0						
(upper Little Bear; 4-1-W)	11-Jun-81	Beaver Ck. Coal		10	7.7	530	345							36	10							2.0						
(upper Little Bear; 4-1-W)	10-Dec-81	Beaver Ck. Coal			7.6	560	375							18	4.24							14.0						
(upper Little Bear; 4-1-W)	14-Jan-82	Beaver Ck. Coal	265	7	7.2	500	325							30	2.9							4.0						
(upper Little Bear; 4-1-W)	17-Feb-82	Beaver Ck. Coal	269	10	7.8	450	286							6.0	4.6							1.0						
(upper Little Bear; 4-1-W)	Mar-82	Beaver Ck. Coal	265	8	7.4	400	260							27.0	3.8							2						
(upper Little Bear; 4-1-W)	22-Apr-82	Beaver Ck. Coal	305		7.5	590	390							30.0	2.40							14.0						
(upper Little Bear; 4-1-W)	26-May-82	Beaver Ck. Coal			7.6	520	350							24.0	9.9													
(upper Little Bear; 4-1-W)	23-Jun-82	Beaver Ck. Coal			7.7	560	367							21.0	10.1							4.0						
(upper Little Bear; 4-1-W)	21-Jul-82	Beaver Ck. Coal		16.0	1.7	415	276							6.0	13.0							4.0						
(upper Little Bear; 4-1-W)	24-Aug-87	Beaver Ck. Coal					315	52	46	7	2		0	36	5			319	281									
	18-Sep-90	CVSSD			7.20		236	61.8	38.25	6.87	1.70	362	<0.10	34.2	4.3		0.61	430		297		5						
	24-Nov-92	CVSSD			7.4	405	312	48.2	38.2	7.25	1.86	331	0.4	34.9	4.52		0.50	173		272								
	10/95 and 9/96	CVSSD		8.9	7.6	556																	22.0	71.12	-9.7	-124	-17	7
	3-Feb-97	Genwal		8.9	7.6	556	306	62	37	7	1	341	<5	29	7			307		279		<5						
	30-Jun-03	Genwal		8.8	7.37	511	315.0	67.5	35.0	6.74	1.39	340.0	<5	35	4		1.0	313.0	17.0	279		6						
Streams																												
Little Bear Canyon Creek	6/25/1970	CVSSD	126																									
	9-Jul-70	CVSSD	126																									
	24-Aug-70	CVSSD	36																									
	6-Oct-70	CVSSD	40																									
	15-Apr-71	CVSSD	27																									
	27-May-71	CVSSD	90																									
	13-Oct-78	USGS, 1981	108																									
	30-Oct-79	USGS, 1981	108																									
	30-Sep-98	Genwal	49	8.4	8.4	560																						
	2-Nov-98	Genwal	73.2	3.9	8.0	470																						
	30-Jun-03	Genwal	dry																									
	24-Aug-03	Genwal	dry																									
Section 4 Creek	30-Jun-03	Genwal	dry																									
	25-Aug-03	Genwal	dry																									
Section 5 Creek	30-Jun-03	Genwal	0.97	14.7	8.42	462	293	47.7	35.9	6.8	1.61	254	<5	59	5	7.82	1.7	267	<5	215	<2	<5						
	25-Aug-03	Genwal	1.07	10.6	8.12	510	322	47.3	39.9	6.99	1.6	273	<5	57	5	7.04	3.1	282	<5	230	<2	24						
Sec 5. U. Right Creek	30-Jun-03	Genwal	0.233	11.0	8.25	521										6.83	12.1											
	25-Aug-03	Genwal	0.210	13.6	8.40	585										7.09	17.2											
Sec 5 U. Left Creek	30-Jun-03	Genwal	1.55	10.0	8.40	428										7.61	3.1											
	25-Aug-03	Genwal	1.21	10.2	8.28	435										7.55	9.0											
IBC-1	30-Sep-98	Genwal	7.1	7.7	8.3	480	390	49	42	6	2	333	28	50	6													
	2-Nov-98	Genwal	8.93	2.5	8.3	420																						
	30-Jun-03	Genwal	3.26	8.0	8.19	481	330	55.0	39.2	6.61	1.47	299	<5	55	4	8.36	1.2	299	18	249	<2	<5						
	25-Aug-03	Genwal	0.405	9.3	7.89	599	382	63.0	47.2	7.37	1.85	353	<5	61	4	7.85	3.1	352	<5	289	<2	<5						

Table 2 South Crandall Lease baseline monitoring summary

Petersen Hydrologic 14 Sep 03

Station	Date	Data source	Flow (gpm)	T (C°)	pH (s.u.)	Cond. (µS/cm)	TDS (mg/l)	Nutrients NH_4 (mg/l N)	NO_3^- (mg/l N)	NO_2^{2-} (mg/l N)	PO_4 (mg/l P)
Springs											
LB-1	1993	Genwal	1	6	7.95	478					
(Castlegate Sandstone)	30-Jun-03	Genwal	dry								
	24-Aug-03	Genwal	dry								
LB-2	1993	Genwal	2	4	7.95	495					
(Castlegate Sandstone)	1994	Genwal	5	7	8.12	375					
	Jun 24-27,96	Genwal			7.78	415					
	7-Aug-97	Genwal	10	4.9	8.10	312	290				
	30-Jun-03	Genwal	2	5.4	7.93	487	307.0	<0.1	0.08	<0.03	<0.05
	24-Aug-03	Genwal	2.15	9.9	8.09	401	275	<0.1	<0.03	<0.03	<0.05
LB-5	1993	Genwal	1	7	7.73	425					
(Blackhawk Formation)	30-Jun-03	Genwal	seep								
	24-Aug-03	Genwal	dry								
LB-5A	1993	Genwal	Seep	---	---	---					
(Blackhawk Formation)	Jun 24-27,96	Genwal	15	7	7.98	436					
	7-Aug-97	Genwal	7	8	8.10	535	480				
	30-Jun-03	Genwal	1.95	8.0	7.56	699	482.0	<0.1	0.3	<0.03	<0.05
	24-Aug-03	Genwal	2.01	8.9	8.02	682	477	0.3	0.3	<0.03	<0.05
LB-11	1981	Beaver Ck. Coal	5	9.9	8.1	559					
(Star Point Sandstone)	30-Jun-03	Genwal	5								
	24-Aug-03	Genwal	4.69	10.0	8.09	556					
LB-13	1982	Beaver Ck. Coal	1.5		7.95	291					
(Castlegate Sandstone)	30-Jun-03	Genwal	dry								
	24-Aug-03	Genwal	dry								
LB-14	25-Aug-80	Beaver Ck. Coal			7.6	520	370		0.03		
(Castlegate Sandstone)	22-Jul-81	Beaver Ck. Coal	1	20	8.3	620	405		0.33		
	1982	Beaver Ck. Coal	22		7.45	333					
	30-Jun-03	Genwal	dry								
	24-Aug-03	Genwal	dry								
LB-15	1980	Beaver Ck. Coal			7.2	495					
(Alluvium)	1981	Beaver Ck. Coal			7.65	548					
	1982	Beaver Ck. Coal	300	16	7.56	491					
	25-Aug-03	Genwal	0.1	18.2	7.44	1,441					
LB-16	1980	Beaver Ck. Coal			7.4	500					
(Star Point Sandstone)	1981	Beaver Ck. Coal			8.76	559					
	1982	Beaver Ck. Coal	5		7.8	488					
	30-Jun-03	Genwal	seep								
	24-Aug-03	Genwal	seep								
SP-73	Jun-85	Genwal	seep	---	---	---					
(Blackhawk Formation)	Oct-85	Genwal	dry	---	---	---					
	Jun-93	Genwal	10	5	8.26	417					
	30-Jun-03	Genwal	dry	---	---	---					
	25-Aug-03	Genwal	dry								
SP-74	Jun-85	Genwal	seep	---	---	---					
(Blackhawk Formation)	Oct-85	Genwal	dry	---	---	---					
	Jun-93	Genwal	dry	---	---	---					
	30-Jun-03	Genwal	dry	---	---	---					
	25-Aug-03	Genwal									
SP-75	Jun-85	Genwal	seep								
(Blackhawk Formation)	Oct-85	Genwal	dry								
	Jun-93	Genwal	dry								
	30-Jun-03	Genwal	dry	---	---	---					
	25-Aug-03	Genwal									
SP-76	Jun-85	Genwal	1	10	7.48	960					
(Blackhawk Formation)	Oct-85	Genwal	1	5	8.35	850					
	30-Jun-03	Genwal	dry	---	---	---					
	25-Aug-03	Genwal	dry								
SP-77	Jun-85	Genwal	seep	---	---	---					
(Blackhawk Formation)	Oct-85	Genwal	dry	---	---	---					

Station	Date	Trace Constituents Ag (mg/l)	Al (mg/l)	As (mg/l)	Ba (mg/l)	B (mg/l)	Cd (mg/l)	Cr (t) (mg/l)	Cr(VI) (mg/l)	Cu (mg/l)	Cn (mg/l)	F- (mg/l)	Fe(t) (mg/l)	Fe(d) (mg/l)	Hg (mg/l)	Mn (t) (mg/l)	Mn (d) (mg/l)	Mo (mg/l)	Ni (mg/l)	Pb (mg/l)	Se (mg/l)	Si (mg/l SiO2)	Sr (mg/l)	Tl (mg/l)	Zn (mg/l)
LB-2	7-Aug-97												<0.1	<0.1		<0.1									
	30-Jun-03		0.011	<0.005		0.017	<0.003			<0.01			<0.02	<0.005	<0.0002	<0.005	<0.005	<0.005		<0.005	0.014				<0.005
	24-Aug-03		<0.010	<0.005		0.019	<0.003			<0.010			0.02	<0.005	<0.0002	<0.005	<0.005	<0.005		<0.005	0.017				<0.005
LB-5A	7-Aug-97												<0.1	<0.1											
	30-Jun-03		<0.010	<0.005		0.023	<0.003			<0.010			0.033	<0.005	<0.0002	<0.005	<0.005	<0.005		<0.005	0.014				<0.005
	24-Aug-03		<0.010	<0.005		0.015	<0.003			<0.010			0.102	<0.005	<0.0002	<0.005	<0.005	<0.005		<0.005	0.017				<0.005
LB-14	25-Aug-80													0.136			0.032								
	22-Jul-81													0.22			0.03								

								Nutrients				Trace Constituents																							
	Date	Data source	Flow (gpm)	T (C°)	pH (s.u.)	Cond. (µS/cm)	TDS (mg/l)	NH_4 (mg/l N)	NO_3^- (mg/l N)	NO_2^{2-} (mg/l N)	PO_4 (mg/l P)	Ag (mg/l)	Al (mg/l)	As (mg/l)	Ba (mg/l)	B (mg/l)	Cd (mg/l)	Cr (t) (mg/l)	Cr(VI) (mg/l)	Cu (mg/l)	Cn (mg/l)	F- (mg/l)	Fe(t) (mg/l)	Fe(d) (mg/l)	Hg (mg/l)	Mn (t) (mg/l)	Mn (d) (mg/l)	Mo (mg/l)	Ni (mg/l)	Pb (mg/l)	Se (mg/l)	Si (mg/l SiO2)	Sr (mg/l)	Tl (mg/l)	Zn (mg/l)
	30-Jun-03	Genwal	dry	---	---	---
	25-Aug-03	Genwal	dry
SP-78	Jun-85	Genwal	seep	---	---	---
(Star Point Sandstone)	Oct-85	Genwal	dry	---	---	---
	Jun-93	Genwal	dry	---	---	---
	30-Jun-03	Genwal	seep	---	---	---
	25-Aug-03	Genwal	seep
SP-79	Jun-85	Genwal	seep	---	---	---
(Star Point Sandstone)	Oct-85	Genwal	dry	---	---	---
	Jun-93	Genwal	dry	---	---	---
	30-Jun-03	Genwal	0.395	8.9	7.71	870
	25-Aug-03	Genwal	0.353	10.7	7.84	1,006
Little Bear Spring	3-Oct-57	Utah Dept. of Health					305		0.16													0.7	0.25									3.9
(Star Point Sandstone)	25-Jun-70	CVSSD	399
(upper Little Bear Spring)	8/75 to 2/79 av.	USFS mean	449	5.8	8.9				0.185			0.0017		0.002	0.0236			0.0018		0.0051		0.15	0.0914		0.0002		0.017			0.0015	0.0023				0.0099
(upper Little Bear; 4-1-W)	16-Jul-76	Beaver Ck. Coal			9.3				0.180														0.003				0.002
	18-Aug-76	USGS, 1981	121	8.3	7.6	530	332									0.03						0.1		0.04								5.6	0.26
	18-Aug-76	USGS, 1981	117
	27-Apr-78	USGS, 1981	426
	29-Aug-78	USGS, 1981	292
(upper Little Bear; 4-1-W)	15-Sep-78	Beaver Ck. Coal	180		7.10	720	470		0.08														0.210
	13-Oct-78	USGS, 1981	256
	8-Nov-78	USGS, 1981	188
	4-Nov-77	Utah dept of Health			7.7	492	315		0.09						0.04	0.08						0.12	0.17	0.05			0.002					6			0.005
(upper Little Bear; 4-1-W)	15-Jun-79	Beaver Ck. Coal			8.4				0.06														0.182				0.014
(upper Little Bear; 4-1-W)	11-Oct-79	Beaver Ck. Coal			7.80		330		0.08														0.010				0.035
(upper Little Bear; 4-1-W)	25-Aug-80	Beaver Ck. Coal			7.20	490	350		0.19														0.022				0.015
(upper Little Bear; 4-1-W)	6-Nov-80	Beaver Ck. Coal			7.20	500	350		0.26														0.025				0.01
(upper Little Bear; 4-1-W)	4-Jan-81	Beaver Ck. Coal			6.80	557	390		0.12														0.040
(upper Little Bear; 4-1-W)	3-Feb-81	Beaver Ck. Coal			7.80	530	350		0.10														0.020				0.002
(upper Little Bear; 4-1-W)	4-Mar-81	Beaver Ck. Coal			7.40	520	310		0.13																		0.01
(upper Little Bear; 4-1-W)	9-Apr-81	Beaver Ck. Coal			8.40	580	380		0.13
	28-Apr-81	Utah dept of Health			8.0	535	308		0.15		0.20	0.002		0.001	0.06	0.05		0.005		0.01		0.12	0.03		0.0001		0.01		0.01	0.005	0.001	6			0.035
(upper Little Bear; 4-1-W)	13-May-81	Beaver Ck. Coal			7.9	540	350		0.19														0.02				0.01
(upper Little Bear; 4-1-W)	11-Jun-81	Beaver Ck. Coal		10	7.7	530	345		0.15														0.01				0.001
(upper Little Bear; 4-1-W)	10-Dec-81	Beaver Ck. Coal			7.6	560	375		0.27														0.01				0.015
(upper Little Bear; 4-1-W)	14-Jan-82	Beaver Ck. Coal	265	7	7.2	500	325		0.19														0.001				0.011
(upper Little Bear; 4-1-W)	17-Feb-82	Beaver Ck. Coal	269	10	7.8	450	286		0.01														0.03				0.001
(upper Little Bear; 4-1-W)	Mar-82	Beaver Ck. Coal	265	8	7.4	400	260		0.09														0.02				0.01
(upper Little Bear; 4-1-W)	22-Apr-82	Beaver Ck. Coal	305		7.5	590	390		0.16														0.12
(upper Little Bear; 4-1-W)	26-May-82	Beaver Ck. Coal			7.6	520	350																0.05				0.005
(upper Little Bear; 4-1-W)	23-Jun-82	Beaver Ck. Coal			7.7	560	367		0.14														0.09				0.005
(upper Little Bear; 4-1-W)	21-Jul-82	Beaver Ck. Coal		16.0	1.7	415	276		0.18														0.10				0.007
(upper Little Bear; 4-1-W)	24-Aug-87	Beaver Ck. Coal					315																	0.18			<0.02
	18-Sep-90	CVSSD			7.20		236	<0.03	0.22	<0.02		<0.005		<0.001	0.080		<0.010	<0.010		<0.01		0.09	<0.03		<0.0003		<0.01			<0.002	<0.001				<0.01
	24-Nov-92	CVSSD			7.4	405	312	<0.05	0.34	<0.01	<0.10	<0.01		<0.002	0.061	<0.01	<0.004	<0.03	<0.005	<0.03	<0.050	<0.10	0.06	<0.03	<0.0005		<0.002		0.04	<0.001	<0.002	5.96		0.19	0.022
	10/95 and 9/96	CVSSD		8.9	7.6	556
	3-Feb-97	Genwal		8.9	7.6	556	306																<0.1	<0.1		<0.1
	30-Jun-03	Genwal		8.8	7.37	511	315.0	<0.1	0.015	<0.03	<0.05		0.012	<0.005		0.017	<0.003			<0.010			0.023	<0.005	<0.0002	<0.005	<0.005	<0.005		<0.005	0.017				<0.005
Streams
Little Bear Canyon Creek	6/25/1970	CVSSD	126
	9-Jul-70	CVSSD	126
	24-Aug-70	CVSSD	36
	6-Oct-70	CVSSD	40
	15-Apr-71	CVSSD	27
	27-May-71	CVSSD	90
	13-Oct-78	USGS, 1981	108
	30-Oct-79	USGS, 1981	108
	30-Sep-98	Genwal	49	8.4	8.4	560
	2-Nov-98	Genwal	73.2	3.9	8.0	470
	30-Jun-03	Genwal	dry
	24-Aug-03	Genwal	dry
Section 4 Creek	30-Jun-03	Genwal	dry
	25-Aug-03	Genwal	dry
Section 5 Creek	30-Jun-03	Genwal	0.97	14.7	8.42	462	293	<0.1	<0.03	<0.03	<0.05		0.015	<0.005		0.038	<0.003			<0.010			0.021	<0.005	<0.0002	<0.005	<0.005	<0.005		<0.005	0.014				<0.005
	25-Aug-03	Genwal	1.07	10.6	8.12	510	322	0.1	<0.03	<0.03	<0.05		<0.010	<0.005		0.028	<0.003			<0.010			0.096	<0.005	<0.0002	<0.005	<0.005	<0.005		<0.005	0.013				<0.005
Sec 5. U. Right Creek	30-Jun-03	Genwal	0.233	11.0	8.25	521
	25-Aug-03	Genwal	0.210	13.6	8.40	585
Sec 5 U. Left Creek	30-Jun-03	Genwal	1.55	10.0	8.40	428
	25-Aug-03	Genwal	1.21	10.2	8.28	435

	Date	Data source	Flow (gpm)	T (C°)	pH (s.u.)	Cond. (µS/cm)	TDS (mg/l)	Nutrients NH_4 (mg/l N)	NO_3^- (mg/l N)	NO_2^{2-} (mg/l N)	PO_4 (mg/l P)	Trace Constituents Ag (mg/l)	Al (mg/l)	As (mg/l)	Ba (mg/l)	B (mg/l)	Cd (mg/l)	Cr (t) (mg/l)	Cr(VI) (mg/l)	Cu (mg/l)	Cn (mg/l)	F- (mg/l)	Fe(t) (mg/l)	Fe(d) (mg/l)	Hg (mg/l)	Mn (t) (mg/l)	Mn (d) (mg/l)	Mo (mg/l)	Ni (mg/l)	Pb (mg/l)	Se (mg/l)	Si (mg/l SI02)	Sr (mg/l)	Tl (mg/l)	Zn (mg/l)
IBC-1	30-Sep-98	Genwal	7.1	7.7	8.3	480	390																0.1			<0.1									
	2-Nov-98	Genwal	8.93	2.5	8.3	420																													
	30-Jun-03	Genwal	3.26	8.0	8.19	481	330	<0.1	<0.03	<0.03	<0.05		<0.010	<0.005		0.030	<0.003			<0.010			<0.02	<0.005	<0.0002	<0.005	<0.005	<0.005		<0.005	0.017				<0.005
	25-Aug-03	Genwal	0.405	9.3	7.89	599	382	0.1	<0.03	<0.03	<0.05		<0.010	<0.005		0.040	<0.003			<0.010			<0.02	0.009	<0.0002	<0.005	<0.005	<0.005		<0.005	0.019				<0.005

Table 3 Little Bear Spring average monthly flow data from Castle Valley Special Service District 1982-2003.

Month	Flow (gpm)	Month	Flow (gpm)	Month	Flow (gpm)	Month	Flow (gpm)	Month	Flow (gpm)	Month	Flow (gpm)
Jan/1982	296	Jan/1986	326	Jan/1990	308	Jan/1994	286	Jan/1998	335	Jan/2002	287
Feb/1982	291	Feb/1986	319	Feb/1990	302	Feb/1994	275	Feb/1998	325	Feb/2002	279
Mar/1982	286	Mar/1986	317	Mar/1990	295	Mar/1994	262	Mar/1998	316	Mar/2002	274
Apr/1982	283	Apr/1986	304	Apr/1990	282	Apr/1994	268	Apr/1998	309	Apr/2002	263
May/1982	321	May/1986	380	May/1990	278	May/1994	231	May/1998	364	May/2002	257
Jun/1982	435	Jun/1986	400	Jun/1990	271	Jun/1994	229	Jun/1998	484	Jun/2002	250
Jul/1982	438	Jul/1986	383	Jul/1990	270	Jul/1994	218	Jul/1998	477	Jul/2002	240
Aug/1982	409	Aug/1986	356	Aug/1990	275	Aug/1994	218	Aug/1998	443	Aug/2002	232
Sep/1982	356	Sep/1986	339	Sep/1990	280	Sep/1994	223	Sep/1998	415	Sep/2002	237
Oct/1982	337	Oct/1986	331	Oct/1990	277	Oct/1994	218	Oct/1998	410	Oct/2002	234
Nov/1982	330	Nov/1986	330	Nov/1990	272	Nov/1994	219	Nov/1998	385	Nov/2002	228
Dec/1982	325	Dec/1986	331	Dec/1990	265	Dec/1994	212	Dec/1998	372	Dec/2002	231
Jan/1983	320	Jan/1987	326	Jan/1991	257	Jan/1995	208	Jan/1999	354	Jan/2003	227
Feb/1983	316	Feb/1987	322	Feb/1991	249	Feb/1995	204	Feb/1999	342	Feb/2003	195
Mar/1983	315	Mar/1987	321	Mar/1991	241	Mar/1995	199	Mar/1999	334	Mar/2003	217
Apr/1983	311	Apr/1987	315	Apr/1991	229	Apr/1995	198	Apr/1999	326	Apr/2003	214
May/1983	325	May/1987	320	May/1991	225	May/1995	209	May/1999	326	May/2003	210
Jun/1983	424	Jun/1987	380	Jun/1991	236	Jun/1995	282	Jun/1999	407	Jun/2003	255
Jul/1983	430	Jul/1987	388	Jul/1991	296	Jul/1995	418	Jul/1999	428	Jul/2003	284
Aug/1983	395	Aug/1987	364	Aug/1991	302	Aug/1995	436	Aug/1999	407	Aug/2003	271
Sep/1983	358	Sep/1987	345	Sep/1991	302	Sep/1995	402	Sep/1999	390		
Oct/1983	339	Oct/1987	345	Oct/1991	298	Oct/1995	371	Oct/1999	375		
Nov/1983	330	Nov/1987	328	Nov/1991	291	Nov/1995	345	Nov/1999	360		
Dec/1983	326	Dec/1987	321	Dec/1991	281	Dec/1995	328	Dec/1999	335		
Jan/1984	325	Jan/1988	313	Jan/1992	270	Jan/1996	315	Jan/2000	324		
Feb/1984	326	Feb/1988	311	Feb/1992	260	Feb/1996	304	Feb/2000	324		
Mar/1984	322	Mar/1988	309	Mar/1992	251	Mar/1996	292	Mar/2000	317		
Apr/1984	324	Apr/1988	304	Apr/1992	229	Apr/1996	285	Apr/2000	309		
May/1984	368	May/1988	308	May/1992	Broken pipe	May/1996	312	May/2000	298		
Jun/1984	423	Jun/1988	327	Jun/1992	Broken pipe	Jun/1996	427	Jun/2000	368		
Jul/1984	409	Jul/1988	340	Jul/1992	243	Jul/1996	443	Jul/2000	395		
Aug/1984	377	Aug/1988	327	Aug/1992	252	Aug/1996	412	Aug/2000	371		
Sep/1984	352	Sep/1988	345	Sep/1992	247	Sep/1996	378	Sep/2000	347		
Oct/1984	340	Oct/1988	366	Oct/1992	252	Oct/1996	356	Oct/2000	334		
Nov/1984	335	Nov/1988	366	Nov/1992	246	Nov/1996	318	Nov/2000	323		
Dec/1984	332	Dec/1988	307	Dec/1992	237	Dec/1996	323	Dec/2000	312		
Jan/1985	332	Jan/1989	256	Jan/1993	230	Jan/1997	314	Jan/2001	293		
Feb/1985	329	Feb/1989	356	Feb/1993	223	Feb/1997	293	Feb/2001	295		
Mar/1985	324	Mar/1989	363	Mar/1993	218	Mar/1997	291	Mar/2001	286		
Apr/1985	227	Apr/1989	363	Apr/1993	216	Apr/1997	286	Apr/2001	282		
May/1985	379	May/1989	341	May/1993	225	May/1997	321	May/2001	280		
Jun/1985	379	Jun/1989	333	Jun/1993	354	Jun/1997	444	Jun/2001	367		
Jul/1985	357	Jul/1989	332	Jul/1993	419	Jul/1997	447	Jul/2001	373		
Aug/1985	341	Aug/1989	330	Aug/1993	379	Aug/1997	421	Aug/2001	379		
Sep/1985	331	Sep/1989	340	Sep/1993	346	Sep/1997	398	Sep/2001	289		
Oct/1985	332	Oct/1989	334	Oct/1993	278	Oct/1997	388	Oct/2001	314		
Nov/1985	327	Nov/1989	326	Nov/1993	309	Nov/1997	344	Nov/2001	304		
Dec/1985	322	Dec/1989	319	Dec/1993	300	Dec/1997	350	Dec/2001	296		

Table 4 Little Bear Spring flow data 1970-1981

Date	Flow (cfs)	Flow (gpm)	Source
25-Jun-70	0.89	399	CVSSD
9-Jul-70	0.88	395	CVSSD
24-Aug-70	0.61	274	CVSSD
6-Oct-70	0.5	224	CVSSD
15-Apr-71	0.65	292	CVSSD
27-May-71	0.52	233	CVSSD
18-Aug-76	0.26	117	USGS
27-Apr-78	0.95	426	USGS
29-Aug-78	0.65	292	USGS
13-Oct-78	0.57	256	USGS
8-Nov-78	0.42	188	USGS

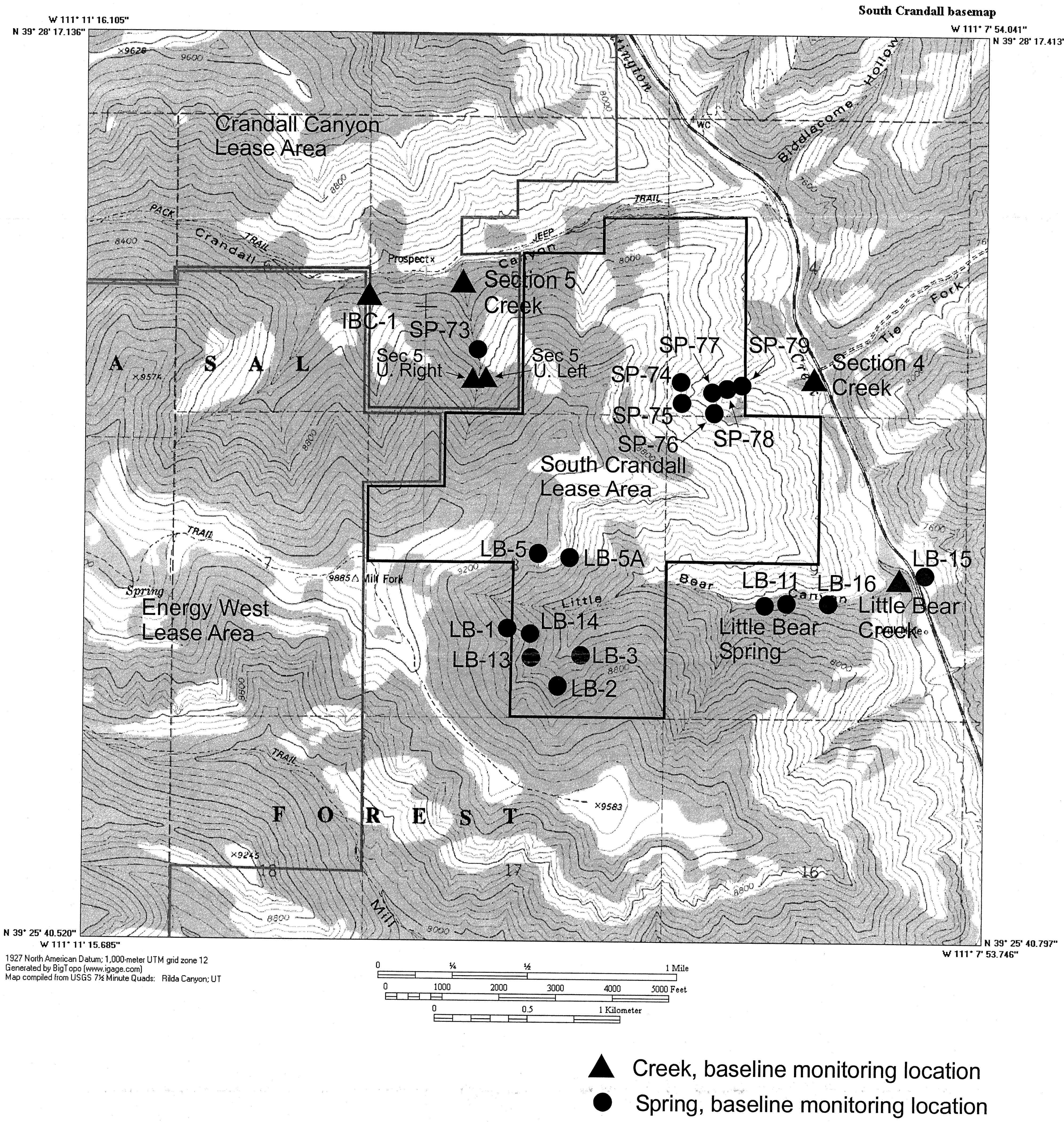
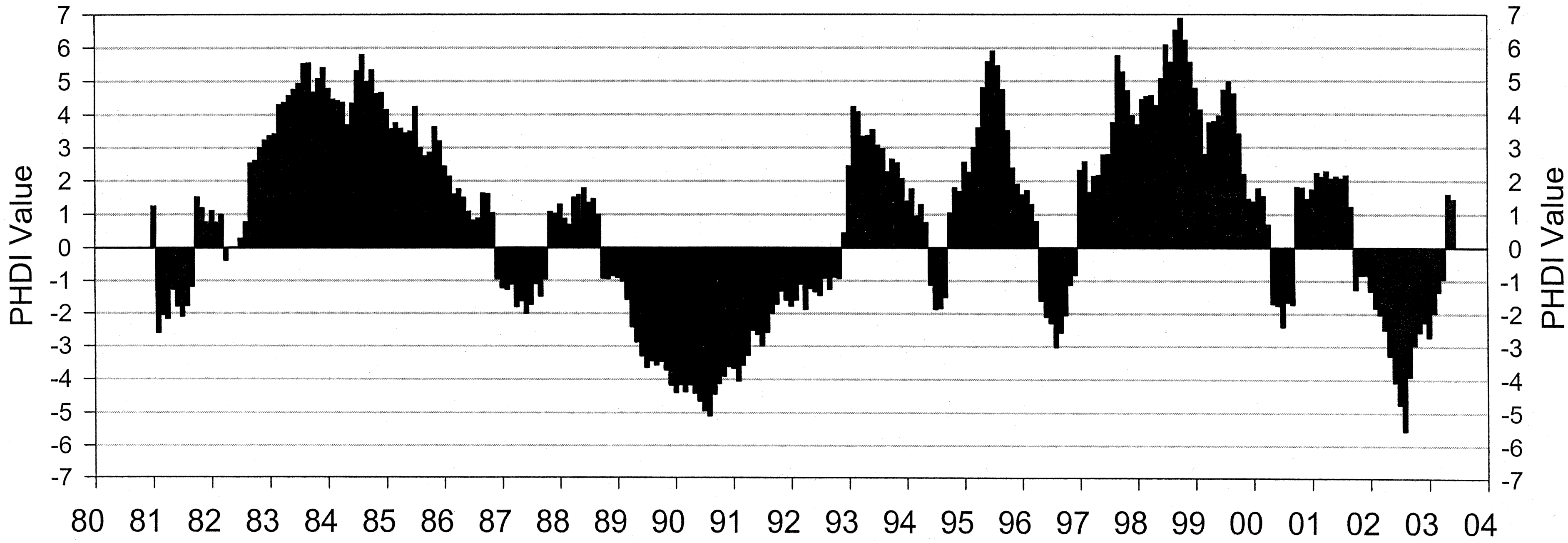


Figure 1 South Crandall Lease baseline monitoring locations



-1 to -2 Mild Drought	1 to 2 Mild Wet Spell
-2 to -3 Moderate Drought	2 to 3 Moderate Wet Spell
-3 to -4 Severe Drought	3 to 4 Severe Wet Spell
-4 to -5 Extreme Drought	4 to 5 Extreme Wet Spell

Figure 2 Plot of Palmer Hydrologic Drought Index for Utah Region 4.

APPENDIX 7-59

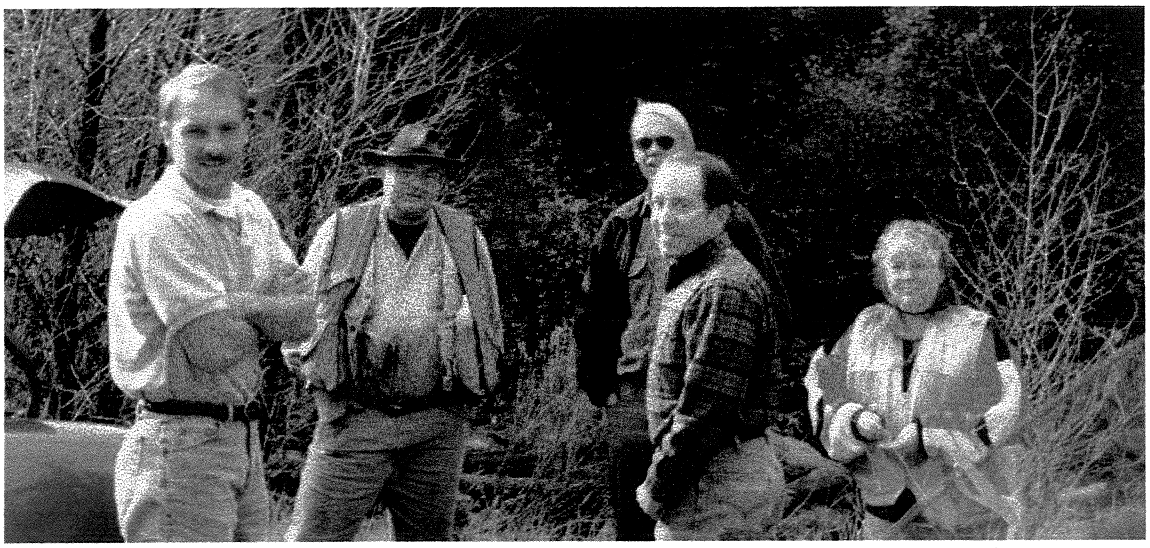
LITTLE BEAR SPRING STUDY (INITIAL STUDY, 1998)

AQUA TRACK

AquaTrack Survey

Little Bear Springs Study

Huntington Canyon, Utah



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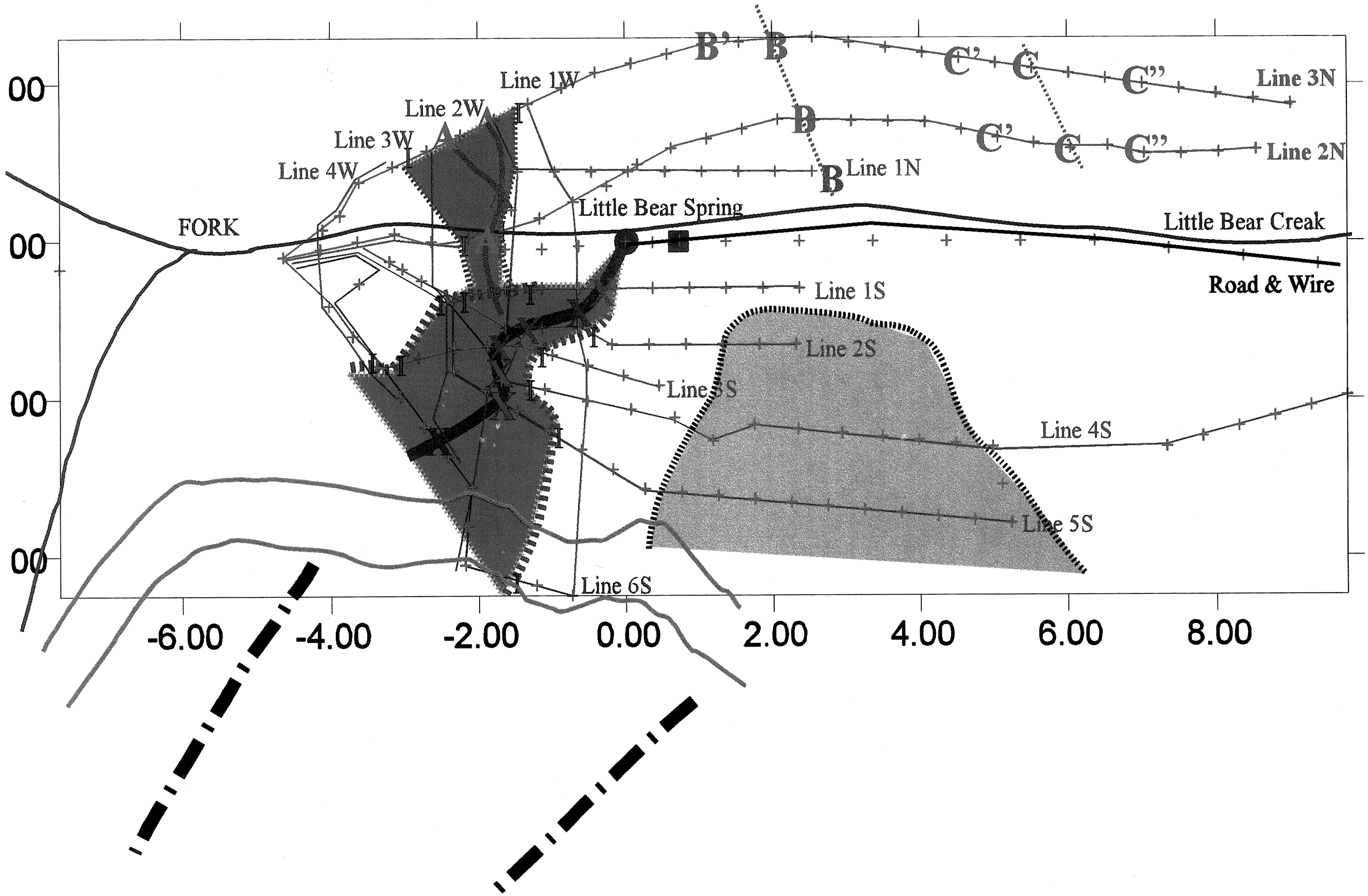
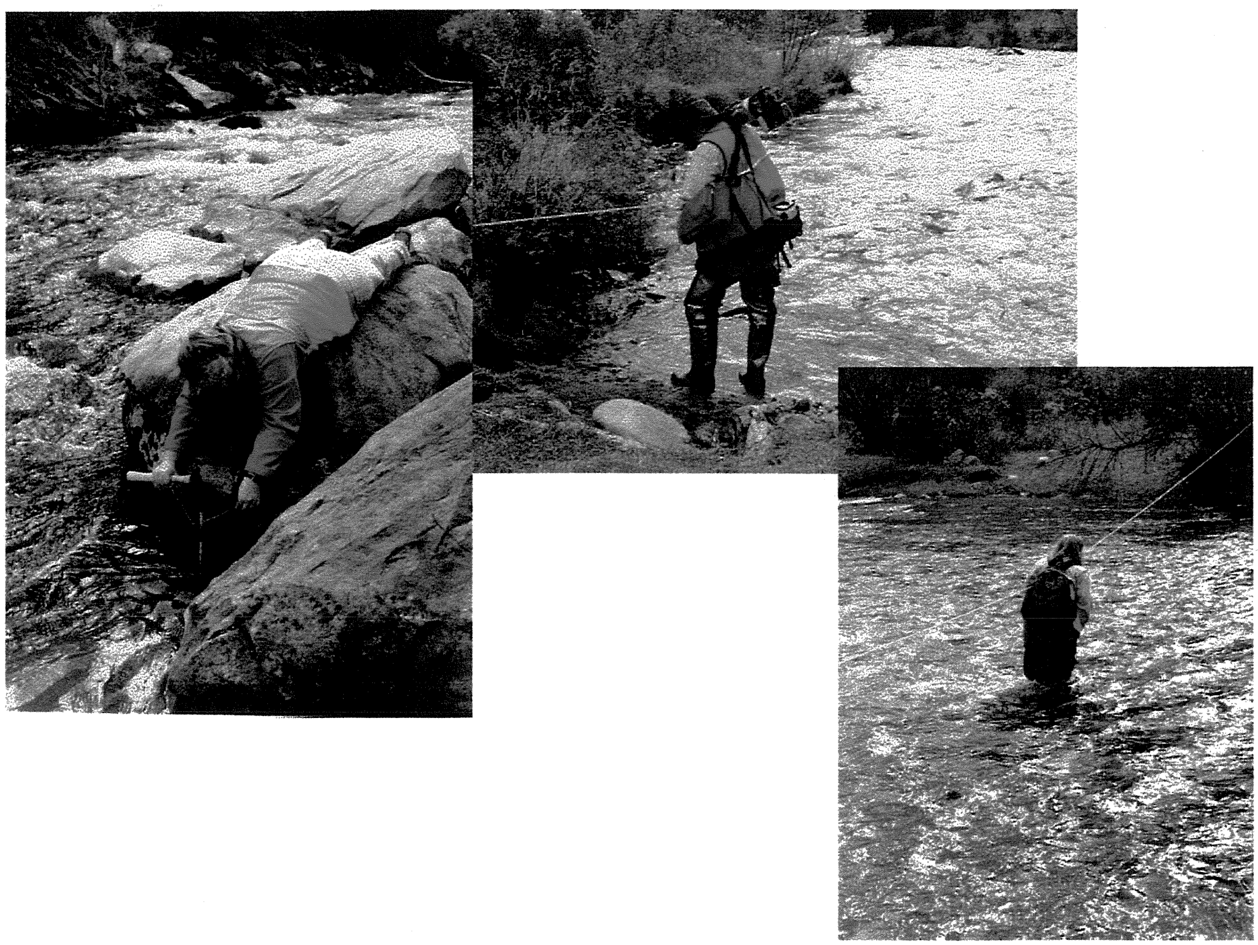

Line 3N
Line 2N
Line 1N
Line 1W
Line 2W
Line 3W
Line 4W
B'
B
C'
C
C''
FORK
Little Bear Spring
Little Bear Creak
Road & Wire
Line 1S
Line 2S
Line 3S
Line 4S
Line 5S
Line 6S
-6.00
-4.00
-2.00
0.00
2.00
4.00
6.00
8.00

AQUATRACK

AquaTrack

AquaTrack uses electromagnetic energy, injected into the groundwater being investigated, to map water and related geologic structures. More specifically the technology can be used to map, track, and monitor: groundwater, groundwater channels, groundwater structures, subsurface pollution plumes. It can also be used to map interconnected fracture or porous zones, map leaks in earthen dams, and maps leaks in drain fields. The technology will also monitor changes in subsurface water flow, changes in ion concentration in groundwater, progress of in situ leaching solution, movement of heap leaching solutions, changes in subsurface redox or reaction fronts, underground chemical reactions, and subterranean bio-reactions. AquaTrack can also be used to check other subsurface waters and related geologic structures. It works best for tracking long continuous conductors of any kind and in the ground this usually is the path of water but underground pipes and wires can cause interference problems.



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SURVEY OBJECTIVES

An AquaTrack survey was conducted at Little Bear Spring to map the subsurface-water feeding the spring located in Little Bear Canyon, a side canyon to Huntington Canyon. The goal of the survey was to identify if possible paths, structures, and sources of groundwater responsible for Little Bear Spring. In this regard, we were asked to provide information on the following:

1. Map the subsurface flow paths in the vicinity of Little Bear Spring.
2. Identify the subsurface path or paths of the groundwater feeding Little Bear Spring.
3. Identify the structure channeling groundwater to Little Bear Spring.
4. Identify the controlling structures for Little Bear Spring.
5. If possible determine the source that is feeding Little Bear Spring.
6. If possible find the source that replenishes Little Bear Spring every year.

CONCLUSIONS:

Results obtained from data procured during this investigation are summarized below.

1. Subsurface flow paths of ground water feeding Little Bear Spring are shown behind the front cover and on page 27. Partial results are shown on pages 16 and 23. For an overlay of this interpretive map on topographic contours see page 29.
2. Groundwater feeding Little Bear Spring come from both sides of Little Bear Canyon.
   a. The groundwater coming from the north is supplying between 30 and 40 percent of the total for Little Bear Spring, see pages 21 and 27. For interpretation of the north side of the canyon see pages 13 thru 16.
   b. The groundwater coming from the south is supplying between 60 and 70 percent of the total for Little Bear Spring, see pages 21 and 27. For interpretation of the south side of the canyon see pages 17 thru 23.
   c. The interpretation as to where and how the two systems connect, see pages 24 thru 26.
   d. There is no groundwater coming down Little Bear Canyon, from the west, that feeds Little Bear Spring, see pages 24 thru 26.
3. The structure that is channeling groundwater to Little Bear Spring is a confluence of two fracture systems. Both of these fractures have been modified by the water flowing through them. They now appear to be sinuous and cave like in nature, see pages 21 thru 23. The cavern like structures provides for three favorable characteristics.
   a. First both systems are probably able to hold a great deal of reserve water.
   b. Second both systems are able to release this water over an extended period of time.

c. Third both systems have probably developed channels that come near the surface that can be replenished every year.

4. There are several structures that combined control the location of Little Bear Spring.

   a. Little Bear Canyon is located in the bottom of a syncline, see pages 30 and 31.

   b. The fracture system in Little Bear Canyon is probably controlled by the syncline. On the south side of the canyon the fractures trend from southwest to northeast, see pages 23, 29, and 30. On the north side of the canyon the fracture trend from northwest to southeast, see pages 16, 30, and 31.

   c. Fractures from each side of the canyon meet just above the spring, see pages 16, 19 and 20.

   d. Just east and down gradient of Little Bear Spring is a very low conductivity zone that indicates very low porosity and/or low permeability. This would force groundwater flowing down gradient toward this area to surface. This zone is down gradient on the syncline, and the fractures. This low conductivity zone would explain the system of seeps and springs that exist along a 500-foot stretch, below Little Bear Spring, see pages 20 thru 22, and 27.

   e. The rock formations in this location can form voids because of weaker cementing of some of the sand in the sandstones. These voids and possibly ruble along fractures, have formed cave like structure(s) along the subsurface channels feeding Little Bear Spring, see pages 21, 22, and 28.

5. Based on the directions of fracture systems when considered in conjunction with structural and topographic bottoms and their relationship to the position of Little Bear Spring, there are three possible sources feeding Little Bear Spring; the south-fork of Little Bear Canyon, Mill Fork Creek, and Crandall Canyon.

6. The same three sources probably makeup in part the replenishment system for Little Bear Spring. The south-fork of Little Bear Canyon, Mill Fork Creek, and Crandall Canyon. This survey was unable to determine the source replenishment of Little Bear Springs.

   a. The south or left fork of Little Bear Canyon is considered one of the three because the fault that projects into the cave system feeding the spring is centered on the south fork, see pages 27 thru 30.

   b. Mill Fork Canyon was surveyed using a more powerful transmitter. One line was run down Mill Fork Canyon , but there was insufficient signal reaching that far with the antenna setup used, see pages 29 and 30. To determine if the water from Mill Fork is feeding into the Little Bear Spring system an antenna system will have to include both, Little Bear Spring and the water in Mill Fork Canyon.

   c. With no signal reaching Mill Fork Canyon no attempt was made to survey Crandall Canyon.

INTERPRETERS NOTE

This section has been included for disclosures and clarification on terms used in this report.

The station spacing used in this survey was 50 feet, thus the accuracy of any point located by the data taken during this survey is ± 25 feet. This implies that the error in locating the channel center is ± 25 feet with a maximum error in the width of the channel of ± 50 feet.

Survey lines (SL), are lines where field data is collection in the survey area. Profiles or lines are the survey lines data after mathematical corrections have been made for objects that influence the data such as drift, noise, power lines, and known utilities. A profile or line can be created by combining stations from different survey lines and data from individual stations. Station refers to a point on a survey line where data were collected. Channel(s) are paths of current flow that can result from electricity following groundwater, utility lines, ore bodies, soil disturbed by past trenching or abandoned manmade structures such as old underground flews, etc.

The coordinate system used in this report defines north and east of point zero as positive numbers on the grid, south and west are negative numbers. For the diagonal lines the negative numbers represent the most southern or western portion of the profile.

The numbers along the bottom of the profiles, charts, and along the edges of plan maps are in hundreds of feet so the distance between -2 and +1 would be 300 feet. For all the profiles the observer is looking west, north, or northwest. In the case of the east/west profiles, profiles north and south of Little Bear Spring, the observer is looking north.

BACKGROUND:

Little Bear Spring is the largest spring in Huntington canyon and is used to supply culinary water to Huntington. Coal mining in the area might threaten the source of water feeding or replenishing the spring. It is important to both the water users and the coal mining companies to know the source of water and also to know the source replenishing Little Bear Spring. The data used in this survey and report were collected in October and November of 1998.

TECHNOLOGY USED- AQUATRACK, How it Works:

AquaTrack uses electricity to follow the groundwater and map it subsurface paths. The best conductors in the ground are water, ore bodies and manmade structures like metal pipes or buried wire. AquaTrack works by directly energizing the groundwater in question. In this survey this was accomplished by energizing Little Bear Spring and using Huntington creek for the return circuit. The electricity flowing in the groundwater generates a magnetic field. By mapping the magnetic field, the flow of electricity in the ground is mapped. The map of current flow thus generates a map of the groundwater.

For a more detailed explanation refer to the appendixes.

EQUIPMENT AND SETUP:

The AquaTrack survey requires the establishment of an electrical circuit which included the groundwater to be mapped. In this case that was Little Bear Spring. At least one direct contact with the water is desirable to establish the circuit. (*It is possible to conduct a survey without a direct contact with water but the results will not be as reliable as the current could potentially follow another conductor in the ground.*) The current takes the best path (*the path of least resistance and generally the shortest*) to the return electrodes, completing the circuit. Most surveys, including this one, utilize only one direct contact point with the water being surveyed. Groundwater is always a significantly better conductor than the surrounding soil or rock, due to waters ability to take ions into solution. These ions and other dissolved solids that are in all ground waters turn the water into an electrolyte.

Survey Area

The survey area covered the area surrounding Little Bear Spring. The primary lines were run parallel to the canyon. There were a sufficient number of station also taken west of Little Bear Spring to determine if the source of the groundwater was coming down Little Bear Canyon. On the hillside directly north of the spring three lines were surveyed. The survey on this side was limited by a continuous set of cliffs. However, there was sufficient room below these cliffs for three survey lines of data. This provided information relating to the groundwater movement north of Little Bear Spring. To the south the hill was steep and moss covered. There was sufficient time before the snow to obtain about six survey lines. Several of these line had to be collected over a period of days because of terrain limitations. There are more lines on the south slope for two reasons, first it appeared in the field data that the majority of the water seemed to be coming from the south side of the spring, and second because cliffs limited our access on the north slope more than the south slope. We would have liked to take a few more survey lines to the south and west of Little Bear Spring but conditions, such as a foot of snow, did not permit. Data stations

SURVEY RESULTS:

At each survey point data was taken to allow the magnitude and direction of the magnetic field produced from the transmitter and antenna to be calculated. The data was analyzed several ways. The magnitude of the magnetic field is used to produce a contour map. The profiles were analyzed individually to gain additional insight into the subsurface chanal configuration. The groundwater channel centers are obvious in this data, however in contour data edges are a little more difficult to identify. The center and edges of groundwater channels are clearer in profile.

The following discussion will first look at the contour data and subsequently the profiles. The two will be used to corroborate each other and help the reader follow the interpretation process. The final map will be a composite of the information obtained from all forms of analyzing the data.

Contours

Figure 2 is copy of a topographic contour map in the vicinity of Little Bear Spring. The spring is shown in the center on this map.

Sedimentary Rocks above and below Little Bear Spring

The geology around the spring is important in attempting to understand how the spring may have formed and what structural influences may have contributed to it creation and location. Little Bear Canyon is located approximately along the bottom of what appears to be a low angle or weak syncline. The cliff forming formations are pock marked with small cave like structures. These are either places where the formation was not well cemented or where the cement was calcite and was at some later time leached away leaving these voids or holes in the cliff forming rock. In the formations stratigraphically directly above Little Bear Spring this phenomena void spaces and holes is particularly prominent. Figure 3 is a generalized geology map of the area. The formations that could possibly directly or indirectly affect Little Bear Springs are briefly described in the following section.

Kpr - Price River Formation (upper cretaceous)-Grayish mixture of conglomerate, sandstone; with minor shale layers. The formation is locally massive and well cemented. The conglomerates contain quartzite, quartz, chert, and a little limestone. The sandstones are fine to coarse grained. The Price River Formation forms steep slopes and low cliffs.

Kc - Castlegate Sandstone (upper cretaceous)-Sandstone and some conglomerate. The formation is irregularly bedded and is massive. The sand grains can be fine or coarse. The Castlegate Sandstone contains some thin, shaly siltstones and some carbonaceous material.

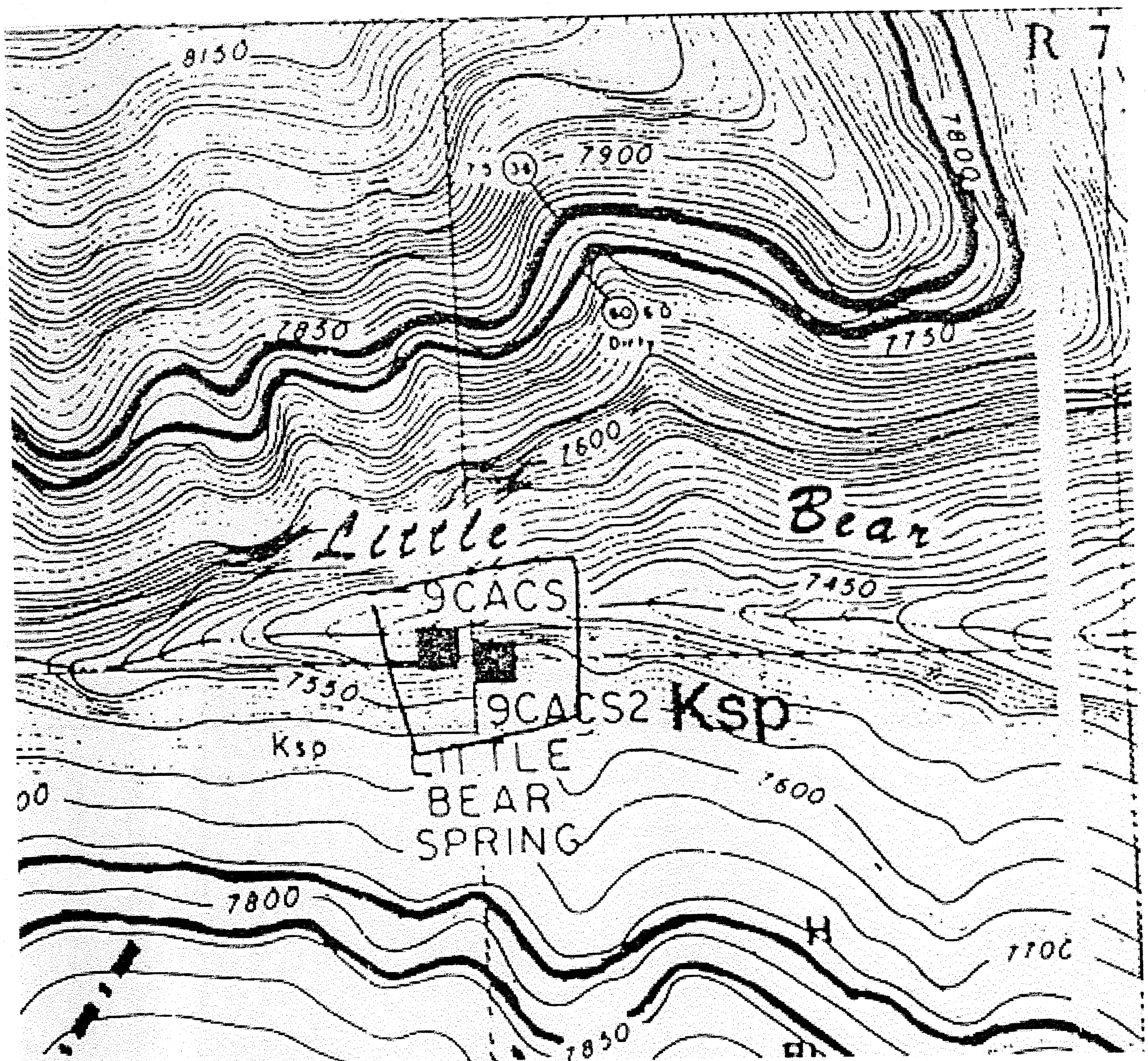


Figure 2 Contour map of the area immediately surrounding Little Bear Spring. Little Bear Spring is in the center of this map and is indicated by a black square. Some of the geology of the area is also shown on this map.

Kbh - Blackhawk Formation (upper cretaceous)-Sandstone, shaly siltstone, shale, carbonaceous shale, and coal. The sandstones are gray to brown, and are thin to medium bedded with some cross bedding. The sand is fine to medium grained. The Blackhawk contains many coal zones with a major thick coal zone at base directly overlies Star Point Sandstone. The Blackhawk Formation is a major coal producer.

Ksp - Star Point Sandstone (upper cretaceous)- This is the formation from which Little Bear Spring flows. Light-brown sandstone, shale, and shaly siltstone. It is thin to medium bedded; and fine to medium grained. The formation consists of three sandstone units. The formation forms that were collected during this survey are shown in Figure 1. They are all located is relation to the Little Bear Spring. Little Bear Spring was the 0,0 point for this survey, and that point is also visible on Figure 1 as a blue dot.

Electrode Placement

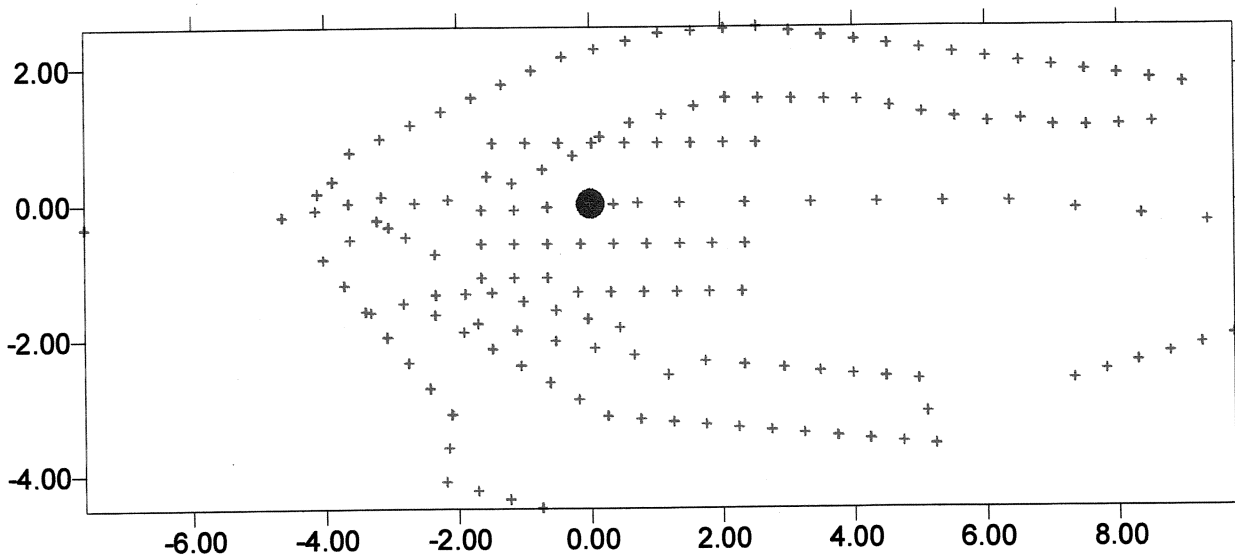


Figure 1 Station locations for the Little Bear Spring AquaTrack survey.

Four injection electrodes where placed into the water to be mapped, Little Bear Spring. A return set of four electrodes where placed in a Huntington Creek to completes the circuit. The connecting wire was run down Little Bear canyon. This was the route that posed the least likelihood of interfering with the survey by masking the subsurface water channel. Huntington Creek was used because it was thought that this would least bias the subsurface current flow path. The electric current followed the groundwater coming to Little Bear Spring as far back into the hill side as it could, slowly bleeding off to find an electrical return path to Huntington Creek.

Grid Location

Because of the terrain a regular grid was impossible to establish. Lines were positioned where the terrain would permit. Whenever possible the lines were kept 100 feet apart. Near the end of the survey a couple of intermediary lines were run to better define the subsurface system. The station spacing was 50 feet along the lines. The base station was located at the 90 degree turn in the road leading to the spring at the mouth of Little Bear Canyon.

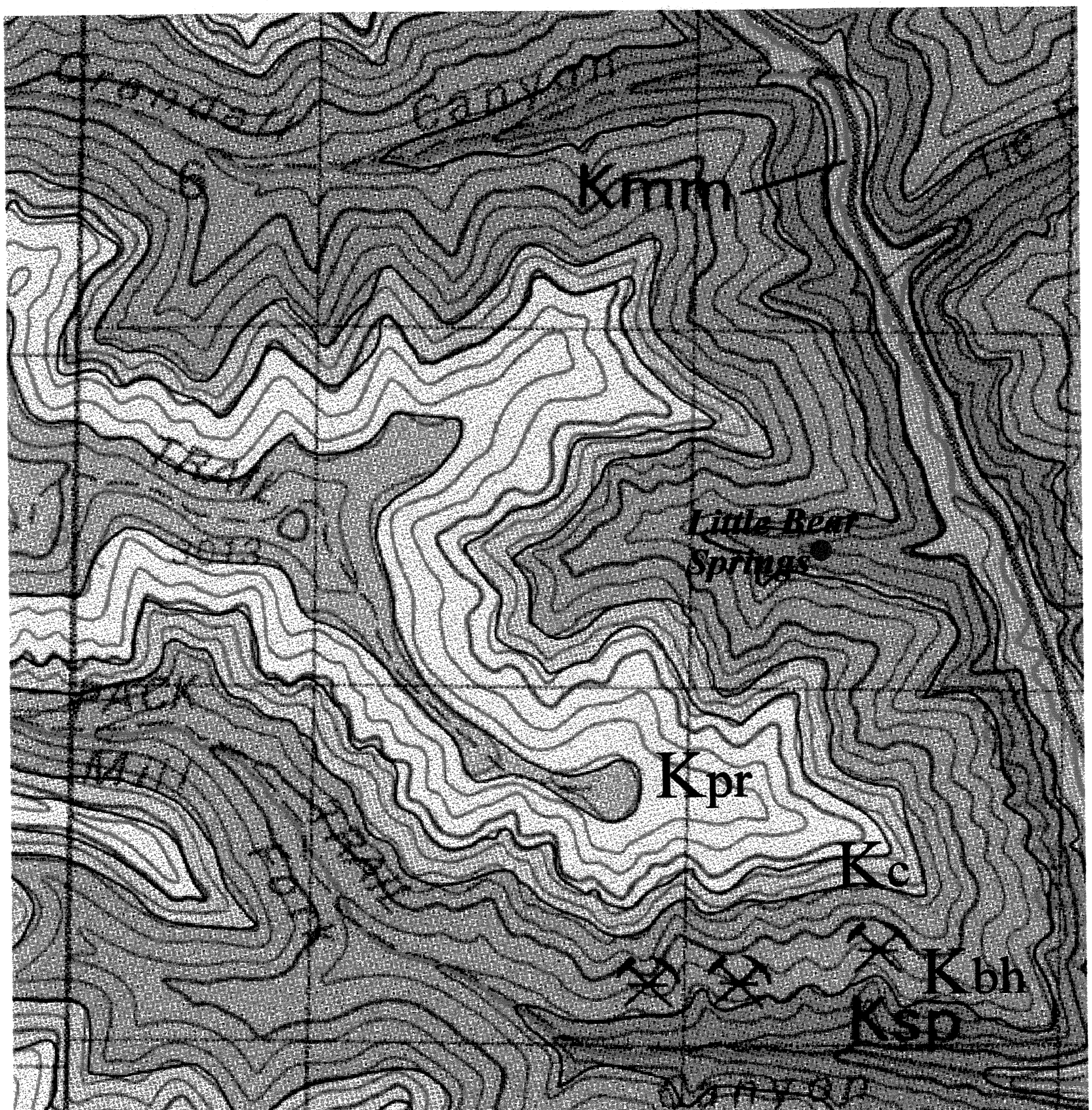


Figure 3 Generalized geology map of the area surrounding Little Bear Spring.

ledges and cliffs. From top to bottom they are the Spring Canyon, Storrs, and Panther Tongues. The sandstone layers are separated by beds of shale and shaly siltstone. The Star Point Sandstone is a fluvial deposit, and in this area is about 110 m (360 ft) thick.

Kmm - Mancos Shale (upper cretaceous)-Consists of five members, however, the only one of import in this area is the Masuk which is composed primarily of shale and silt stone. It is light gray, and in most places just looks like part of the soil. Masuk is located in the bottom of Huntington canyon.

Figure 4 is a plot of the maximum horizontal field. A standard contouring program, "Surfer" was used to generate the map. This program utilized a method known as "Kriging." Stations are marked with a small "+". Computer programs yield ambiguous results where there is no definitive data. This is obvious for this map near the center along 0 NS from 3 to 10 east. The wire was in that area and thus no meaningful data could be collected. Often it is best to ignore the contours in such areas. On the rest of the maps used in this report these contours have been removed.

The stations east of Little Bear Spring along the road were so over whelmed by the signal emitted from the wire that they had no significance and thus were not used in the analysis.

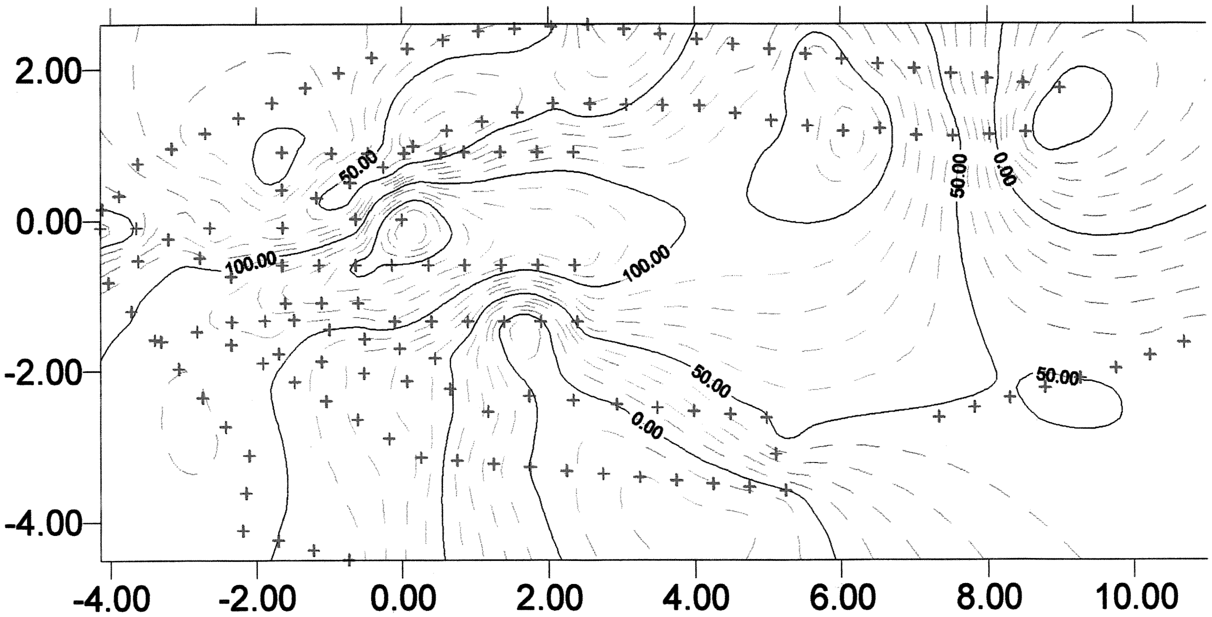


Figure 4 Contour map of the magnetic field created by energizing Little Bear Spring.

The profiles shown in Figure 5 were created from the data set and do not indicate what order or how the data was gathered. The profile are arbitrary and were chosen to provide the details for the structures that needed to be studied. In the following sections the profiles north of the spring will be interpreted first, and the profiles that are south of the springs second.

The different colors used on the line or profiles, in the maps that follow, are to assist the reader. By using the different colors the various profiles can be individually identified where they overlap. On the maps data stations are always in red, and blue is reserved for water and related groundwater structures.

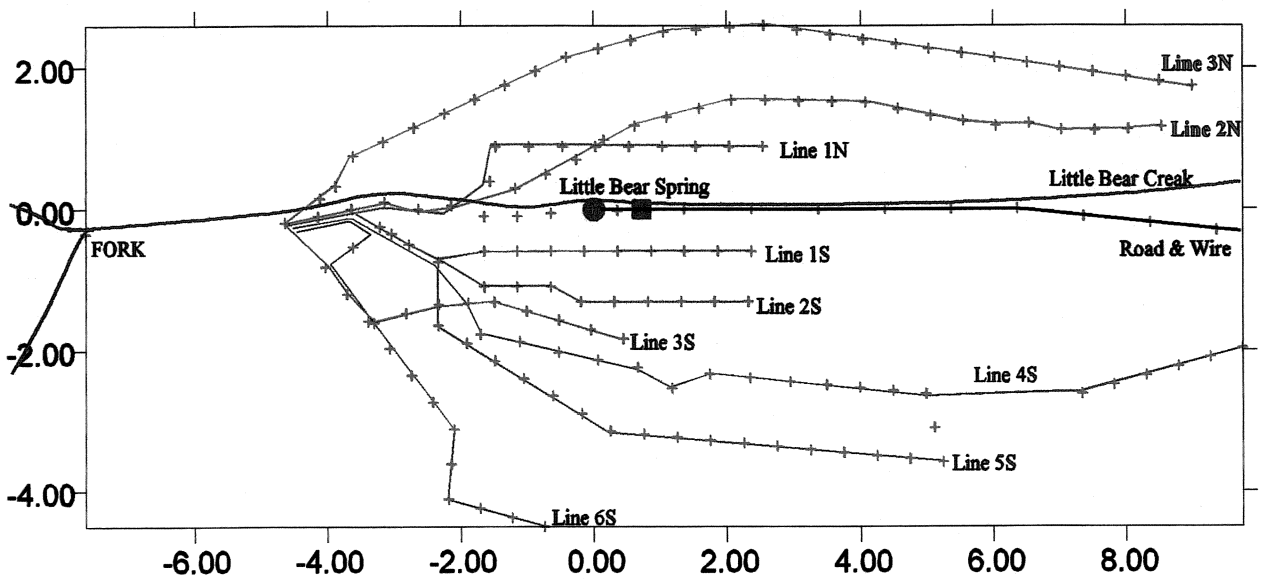


Figure 5 Stations used to create the lines or profile north and south of Little Bear Spring.

The potential profiles west of Little Bear Spring are shown in Figure 6. The profiles created to the west were used to tie the two sides together and show that no groundwater is coming from the west down Little Bear Canyon that contributes to the flow of Little Bear Spring.

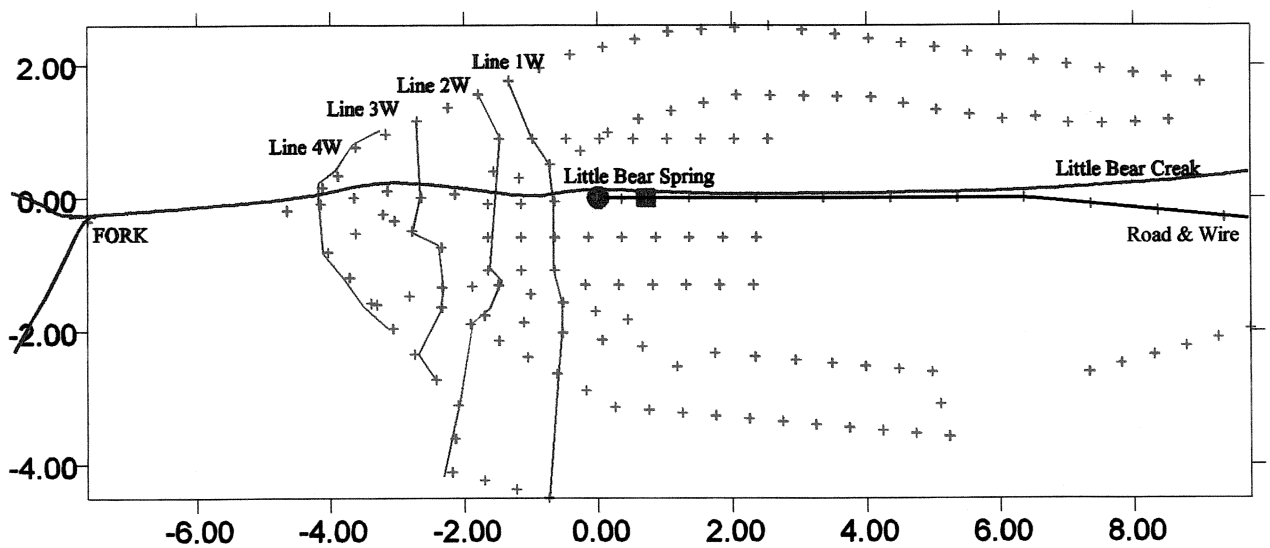


Figure 6 Potential profiles west of Little Bear Spring that can be created from the data.

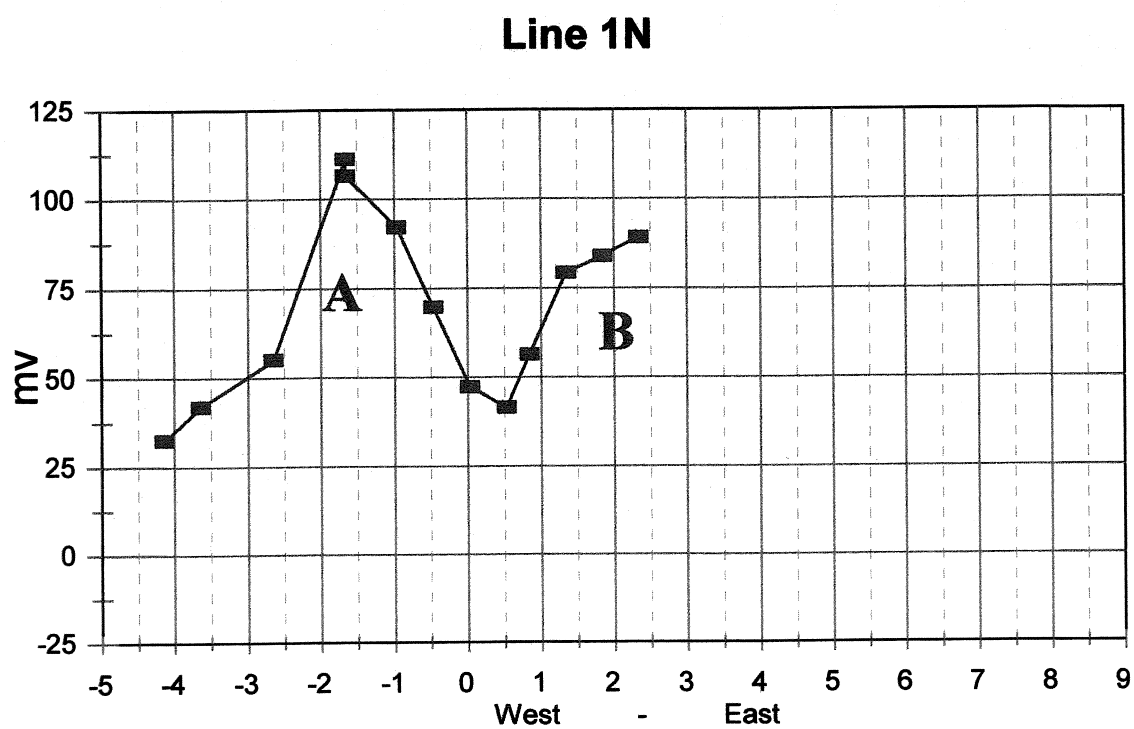


Figure 7 Line 1 N showing the channel center for "A" and "B".

Line 1 N is a short line that is just about is approximately even with the spring until station -1.5 west. At this point the line jogs north. The two stations at about 1.5 north are 40 and 90 feet north of the spring respectively. The rest of the line runs east, west about 90 feet north of the spring. Two anomalies are visible in this data. The first is labeled "A"and the second is labeled "B".

Anomaly "A" is caused by a narrow structure at this point. This is evident from the pointed Christmas tree shape of the anomaly. When comparing this with the next two profiles, what appears to be happening is that there is some type of funneling occurring at this location. This funneling is above Little Bear Spring and appears to probably cross the canyon feeding into the main water supply that feeds Little Bear Spring. This cross over is west the spring, and indicates that Little Bear Spring is being fed by two sources. As will be shown later, "B" is the smaller source but still a significant portion of the water. This double source or conjunction of sources is probably why Little Bear Spring is the biggest spring in the area.

Anomaly "B" is caused by a smaller source than Anomaly "A" , and Anomaly "B"and Anomaly "C" is possibly responsible for a lot of the seeps downstream (east) from Little Bear Spring. The rest are seepage from the Little Bear Spring system.

If the reader keeps in mind that Little Bear Canyon is located at the bottom of a syncline and seems to be the conjunction of several other bedrock features it will provide an understanding of the complex nature of this spring system, and how they **all** play a roll in creating Little Bear Spring.

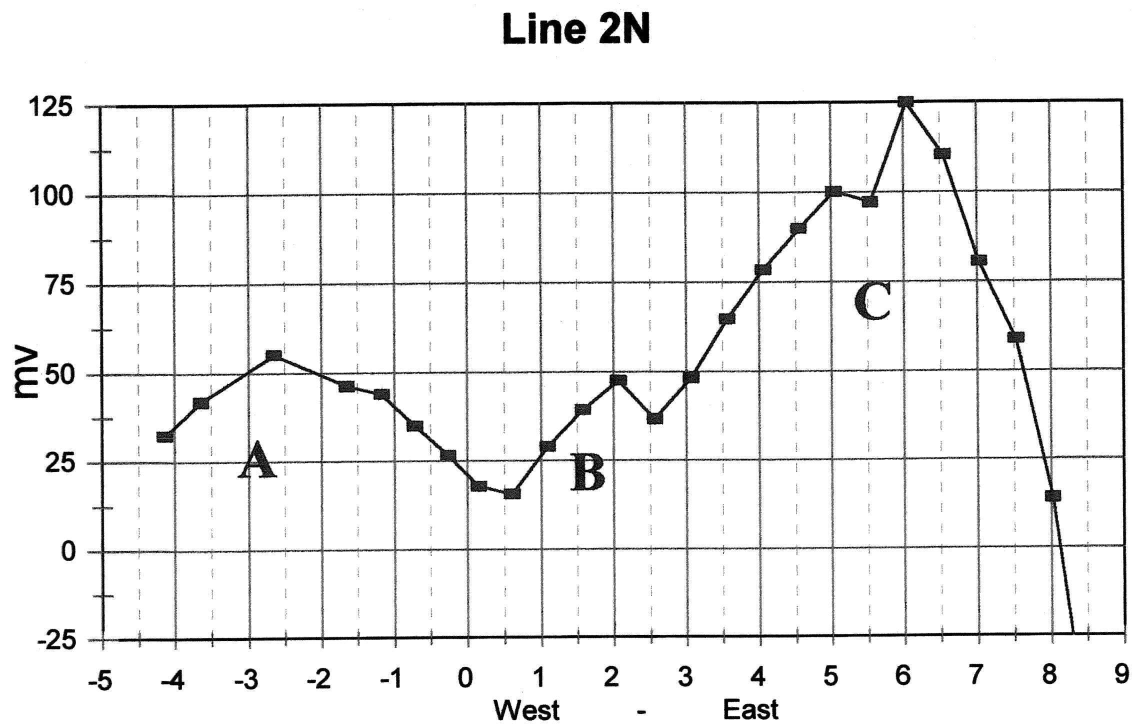


Figure 8 Line 2 N showing the channel center for "A", "B", and "C".

2 N is a long line that runs just above the cliffs located north of the road leading to Little Bear Spring. It uses the same first few stations as line 1 N but deviates cutting at an angle up through the broken cliffs until the profile was above the primary lower cliff structure. The rest of the line averages about 140 feet north of the spring and creek. Three anomalies are visible in this data. The first is labeled "A", the second is labeled "B", and the third is labeled "C".

Anomaly "A" is broader on this profile. This is the result of two phenomena. The first is the angle that the second survey line cut through the anomaly and the second is that the subsurface structure broadens over a very short distance. It should also be noted that anomaly "A" has a lower amplitude on this profile. However the area under the curve, height vs. width, is about the same which indicates that about the same amount of water is involved in creating anomaly a on both lines.

Anomaly "B" is caused by a smaller source than Anomaly "A". Anomaly "B" is now a side feature to Anomaly "C", and anomaly "C" is the strongest feature on this and on Line 3 N. However the shape of anomaly "C" indicates that it is very narrow and extends to a great depth. Again see the pointed Christmas tree shape of the anomaly, with a very long side that is almost straight with little or no curvature at the top..

Anomaly "B"and Anomaly "C" are as stated before probably responsible for most of the seeps downstream, from Little Bear Spring.

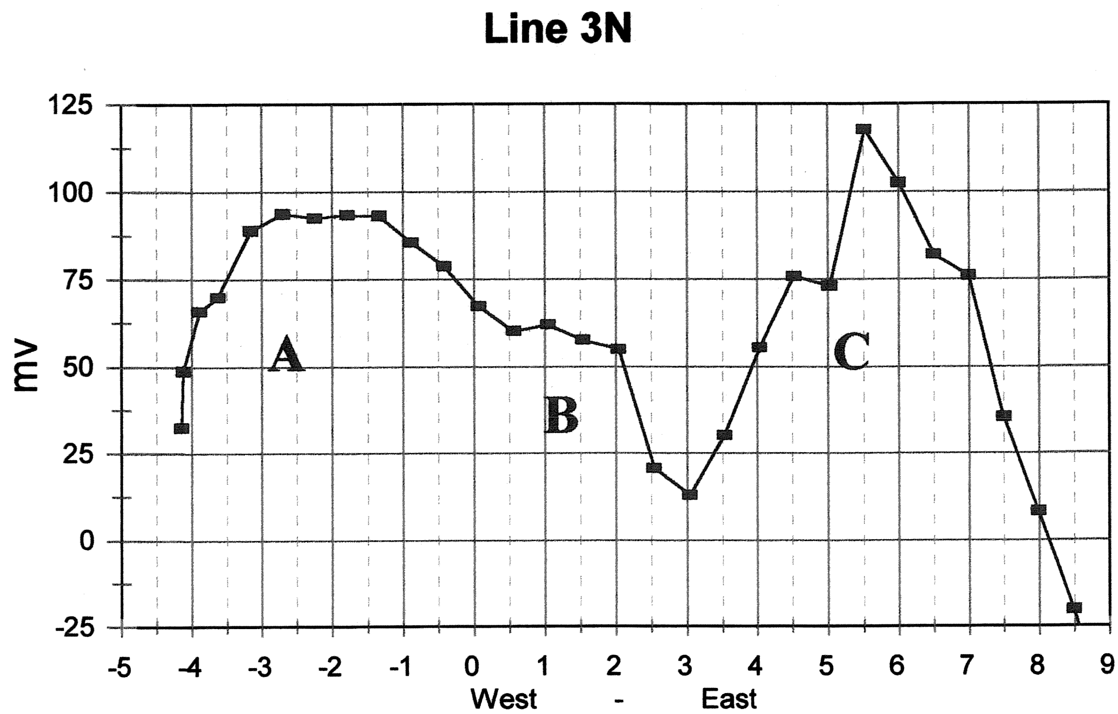


Figure 9 Line 3 N showing the channel center for "A", "B", and "C".

Line 3 N is a long line that runs just below the upper cliffs in Little Bear Canyon. These cliffs are unbroken and there was no way up through them. The only route would have been to follow the creek bottom to where the creek breached this layer. Line 3 N starts with the same first station as line 1 N and 2 N, but cuts up at an angle through the broken cliffs until the profile was at the base of the upper cliffs. After the base of the cliff is reached the rest of the line averages about 225 feet north of the spring and creek. As with Line 2 N three anomalies are visible in this data. The first is labeled "A", the second is labeled "B", and the third is labeled "C".

The ground is getting complicated by crossing of subsurface structure and changes in width and depth of these structures. Anomaly "C" is developing a shoulder on either side. These are probably the result of similar parallel structures that are not as wet. Anomaly "B" is changed from a shoulder on anomaly "C", to a shoulder on anomaly "A". Anomaly "A"has broadened giving the indication that there might be substantial subsurface storage or reservoir capacity behind anomaly "A". The short distance in which the edge of the western portion of this anomaly drops in value after holding the same value for 250 feet indicates not only a voluminous structure but a near the surface structure as well.

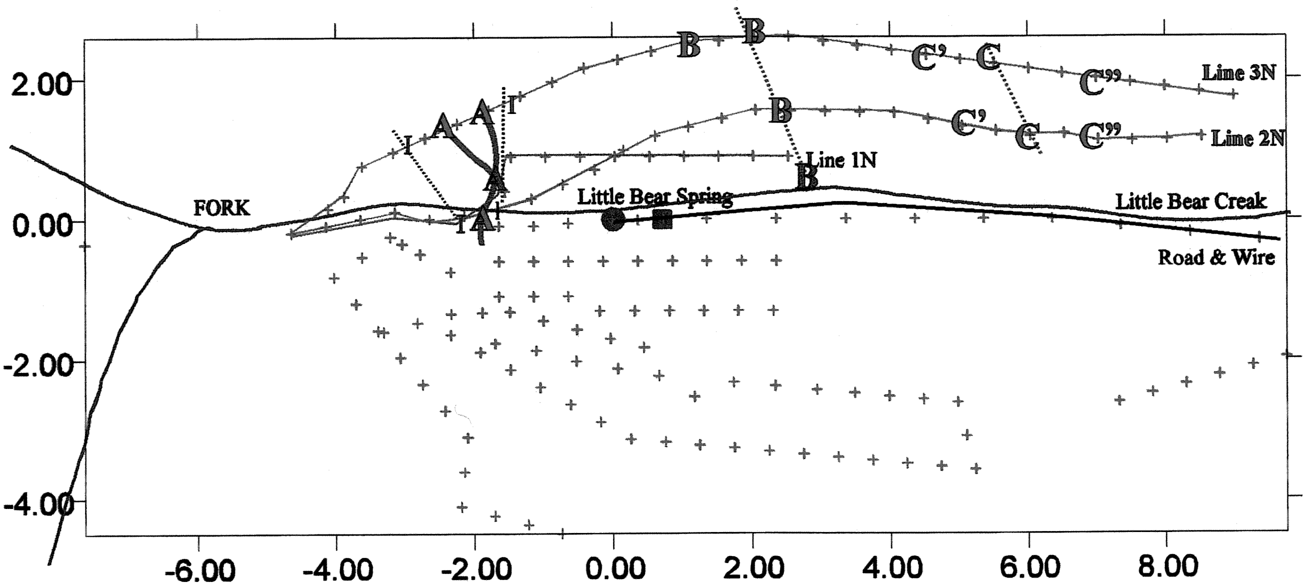


Figure 10 Interpretation of the three profile north of Little Bear Spring.

Anomaly "A" is narrow at the bottom of Little Bear Canyon but broadens to the north on Line 3 N. The data gives every indication that this groundwater source passes under Little Bear Creak and most likely enters the underground system that feeds Little Bear Spring. When the profiles to the west and south of the spring are looked at, and interpreted this will become more evident.

Anomalies "B" and "C" with their side fractures are generally so thin that they probably do not carry much water. They are most likely responsible for all of the small seeps that occur downstream from Little Bear Spring. They are also probably part of a set of fracture or subsurface structures that are also responsible for Anomaly "A". An interesting observation is that this set of fractures are located at about 135 degrees to the fracture system mapped on the south side of Little Bear Creak. This could be an artifact resulting from the slight synclinal structure in this valley or it could be related to larger overall past tectonic condition in the area.

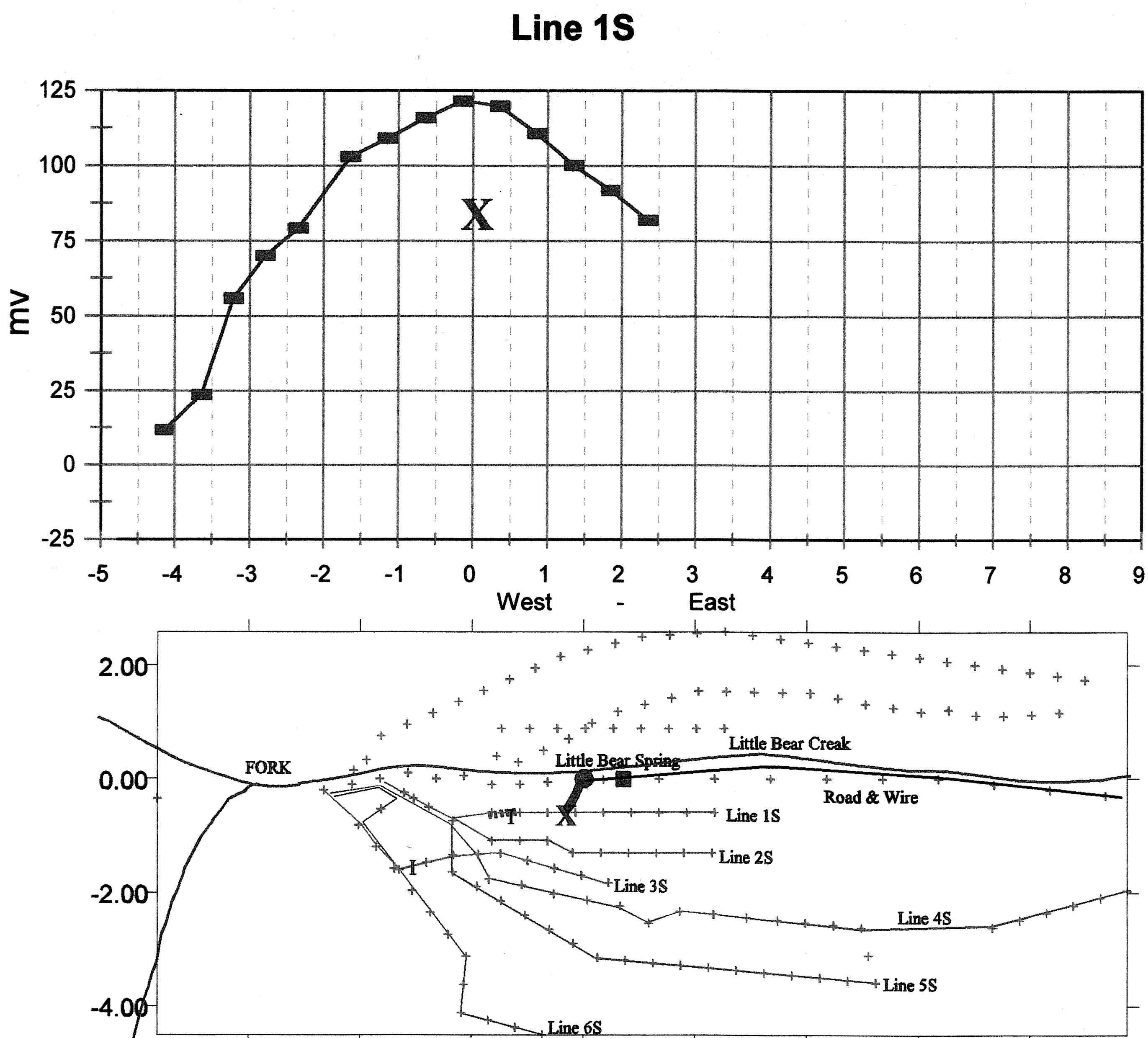


Figure 11 Line 1 S showing the channel center and its position on the plan map.

The magnitude of the anomaly labeled "X" on line 1 S dominates the entire profile. It has two interesting qualities, the first is that the top is not pointed and second the area under the curve is substantial. This anomaly is not to deep at this point and is carrying the majority of the current. In turn this would imply that this anomaly is the primary feed for Little Bear Spring. The "X" marked on the map indicates the center of the channel. The west edge of the channel could be determined but not the east edge. However, the east edge cannot be more than 50 feet east of the channel center. The proximity of the electrodes to this edge, masks the anomaly that it would generate.

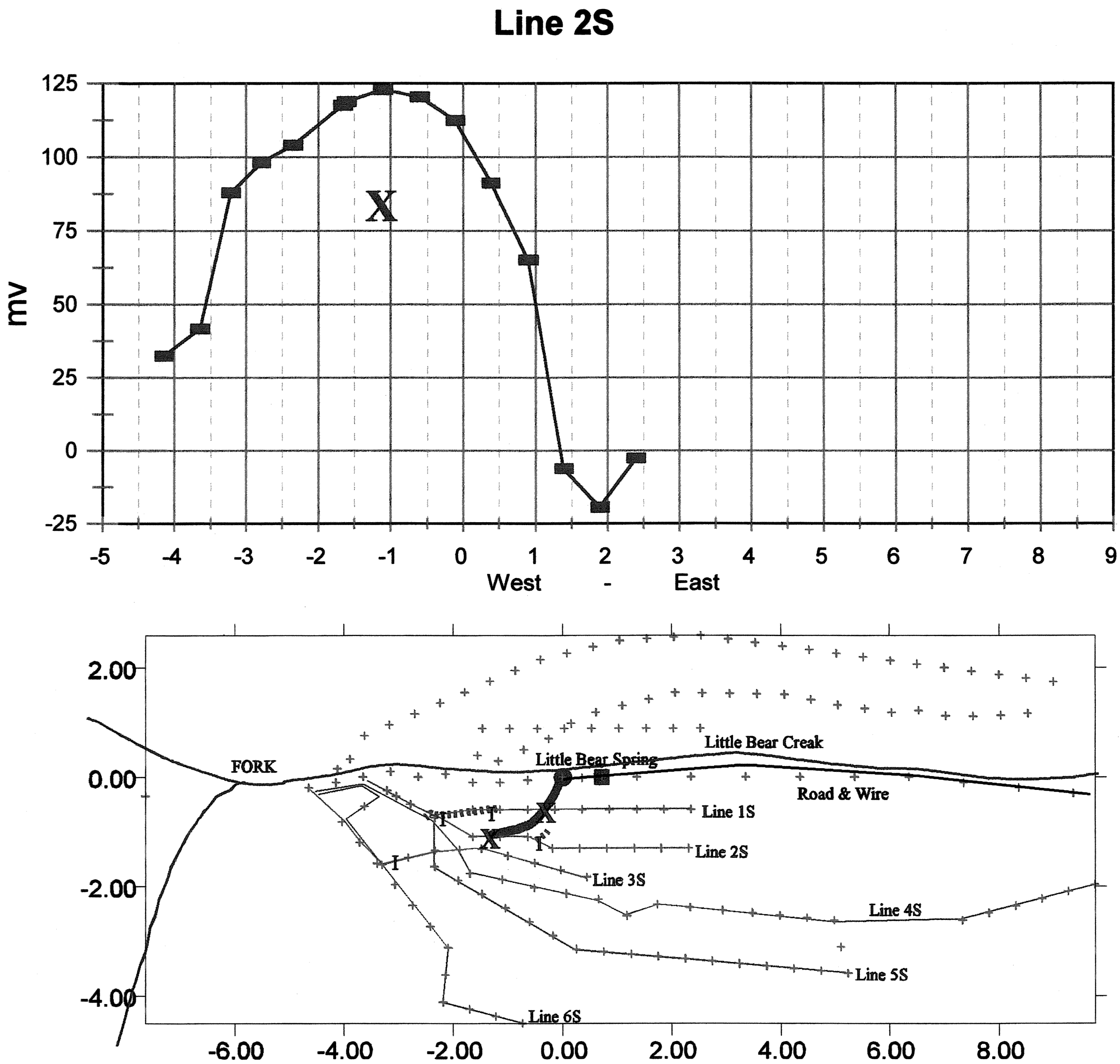


Figure 12 Line 2 S showing the channel center and its position on the plan map.

The anomaly labeled "X" on line 2 S still dominates the entire profile. As before the top is not pointed and the area under the curve is substantial. The sharpness of the edges of this anomaly indicates that it is still not very far from the surface. The edges are easy to identify because of the substantial drop in signal that occurs between coordinates -3.5 and -3 on the west side, and coordinates 1 and 1.5 on the east. The center is located at about -1.25 where on line 1 S the center was about -0.25. The channel center is about 100 feet further south on this profile. The anomaly is still not to deep underground and is carrying the majority of the current, implying that this anomaly is the primary feed for Little Bear Spring. The "X" with the solid blue line marked on the map indicates the center of the channel.

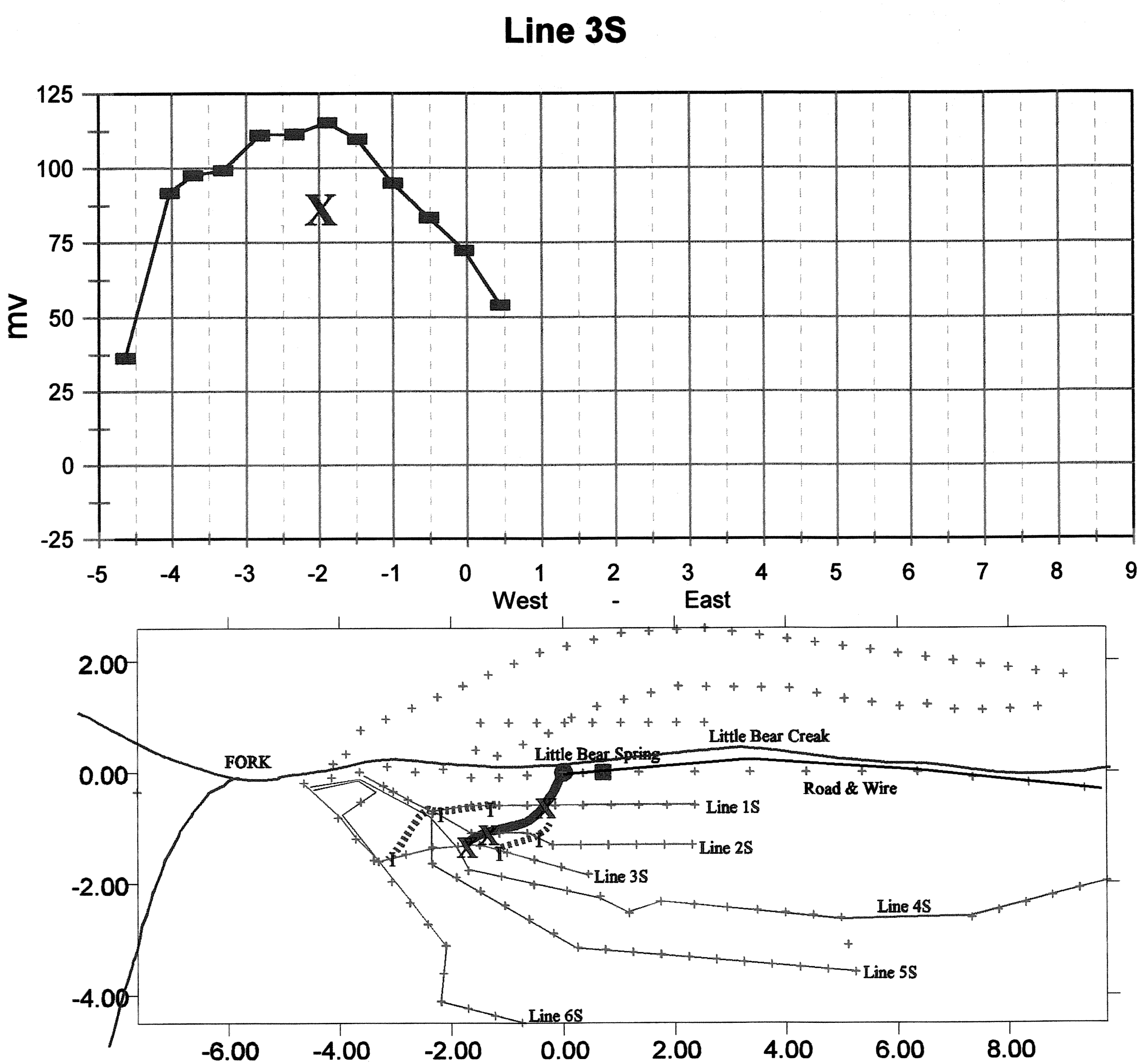


Figure 13 Line 3 S showing the channel center and its position on the plan map.

Line 3 S is short but still contains the center of the channel and a well defined western edge. The channel center is at about -2 and the west edge at about -4.25. It should be noted the a shoulder that was starting to develop on line 2 S is now very prominent on this line. This shoulder is were the water from "A" is entering the Little Bear Spring system. The anomaly labeled "X" on line 3 S still dominates the entire profile. The top of the anomaly is still rounded and as before the area under the curve is substantial. The edge west edge is easy to identify by of the drop in signal that occurs about coordinate -4.25. The center is located at about -2 so the center has moved another 75 feet to the west. The anomaly is still relatively close to the surface and is still carrying the majority of the current. The "X" with the solid blue line marked on the map indicates the center of the channel. The "I" with the dotted blue lines indicate the edges.

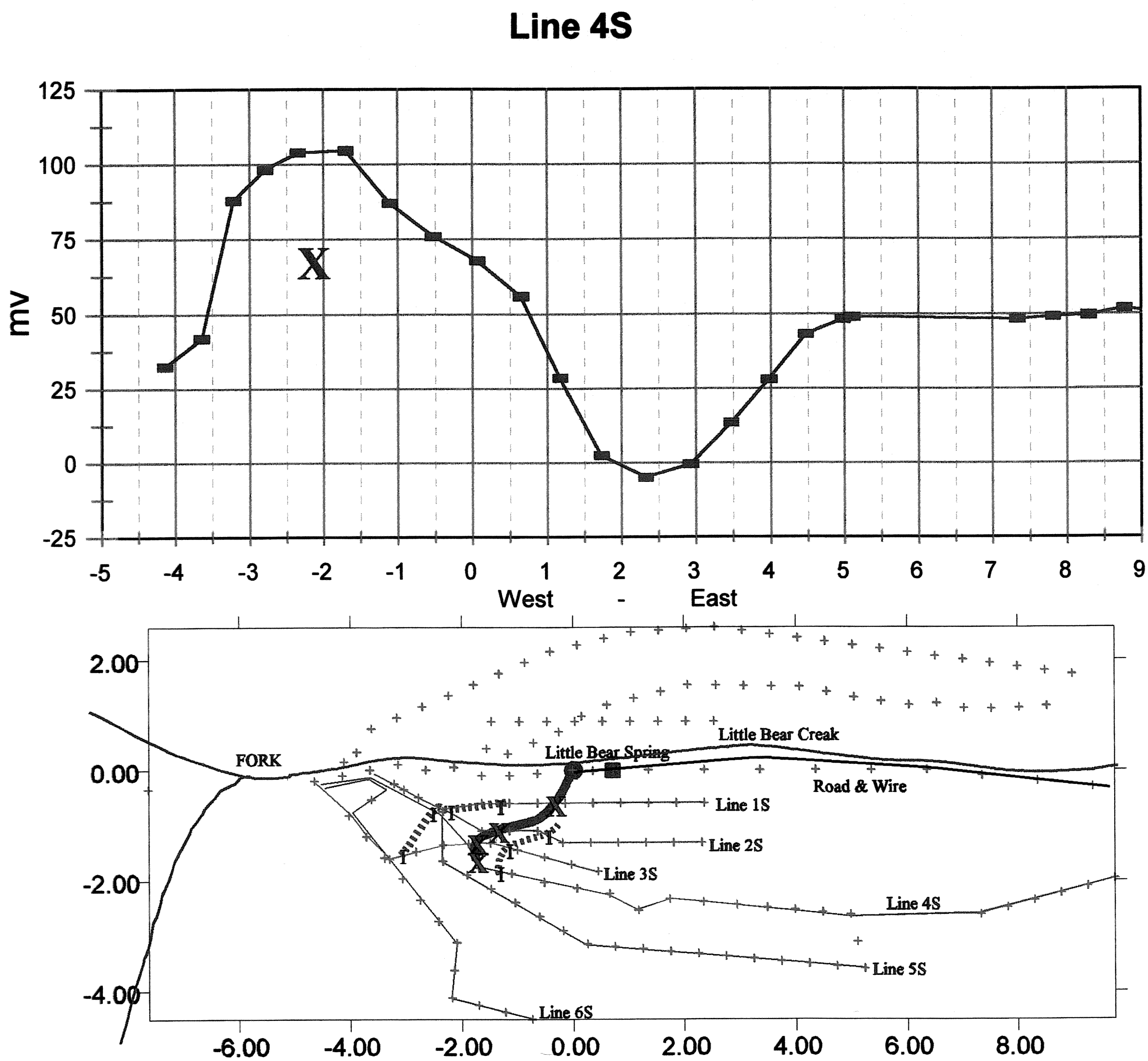


Figure 14 Line 4 S showing the channel center and its position on the plan map.

Line 4 S is a long profile and it provides additional insights into the feeder system for Little Bear Spring. The long tail of data on the east end of line 4 S provides insight into the general back ground value for this type of survey in this are. This constant value at the east end of the line establishes that about 50 mv is probably a good average corrected value for this area. It should be noted that on the west end of all the lines south of the spring the value that the readings approach is about 40 mv. This is for two reasons; first most of the lines ends are using the same stations and second those that don't close in proximity. When the reading on a line approaches 50 mv the readings are reaching background values. The background value is the data value that would be read in the ground if the groundwater was homogeneously distributed throughout the subsurface. Values above this are more wet than normal and values below this are drier than normal for this area.

On line 4 S there is a dominant low centered at 2.5 east. The value of this low is basically zero or slightly negative. The low at 2.5 is indicative of a dry or low conductivity zone. This zone is probably impermeable and does not permit groundwater to move or even slowly percolate to the east. This impervious zone would force groundwater to the surface especially where groundwater in this area is entering the subsurface from both sides of the canyon. The groundwater is not only entering the canyon but it is in essence colliding with this impervious zone. The consequence is that all the groundwater entering this area is forced to surface. Even the small amounts of groundwater, coming from the north in the narrow "B" and "C" zones is forced to the surface. The spring system in Little Bear canyon ends where this low ends, about 500 feet east of Little Bear Spring. It is becoming clear that the confluence of geologic structures is not only responsible for Little Bear Spring but for the whole spring system in this area of Little Bear Canyon.

The groundwater feeding Little Bear Spring is flowing from both north and south of Little Bear Canyon. The ratio for the origins of groundwater for Little Bear Spring can be estimated by the area under the curves on the profiles. Based on these areas calculations it is estimated that about 60 to 70 percent of the groundwater is coming from the south side of the canyon and about 30 to40 percent from the north side.

On line 4 S the west edge of the channel feeding Little Bear Spring is located about -3.25. The channel center at about -2. On line 4 S the channel center is almost due south of the center on line 3 S. The east edge of the channel is located at between 1.75 and 1.25. There is a shoulder in the data between -1 and 1 with and average value of about 60 mv. This is probably the result of some water leakage from the Little Bear Spring system. This leakage moves east until it meets the impervious zone. This leakage probably contributes slightly to the seeps or spring system east of Little Bear Spring.

Line 5 S was also long enough that both the Little Bear Spring and the damming systems are visible in the data. The impervious zone starts about 0.5 east and the east edge of the Little Bear Spring channel is between -1 and -0.5 west.

The channel on line 5 S center is about -2 to -2.25, but still basically south of the last two centers or possibly slightly shifted to the east. The west edge is about -3.5, and as stated the eastern edge is about -.75.

The subsurface system feeding Little Bear Spring is widening, becoming broader, or encompassing more of the subsurface with each additional profile to the south. The system probably is involving void spaces or cave like structures in the subsurface rock. This also could be the result of several subsurface fractures forming some type of expanded reservoir like system. What ever the cause it appears that upstream, underground, the channel or fracture system

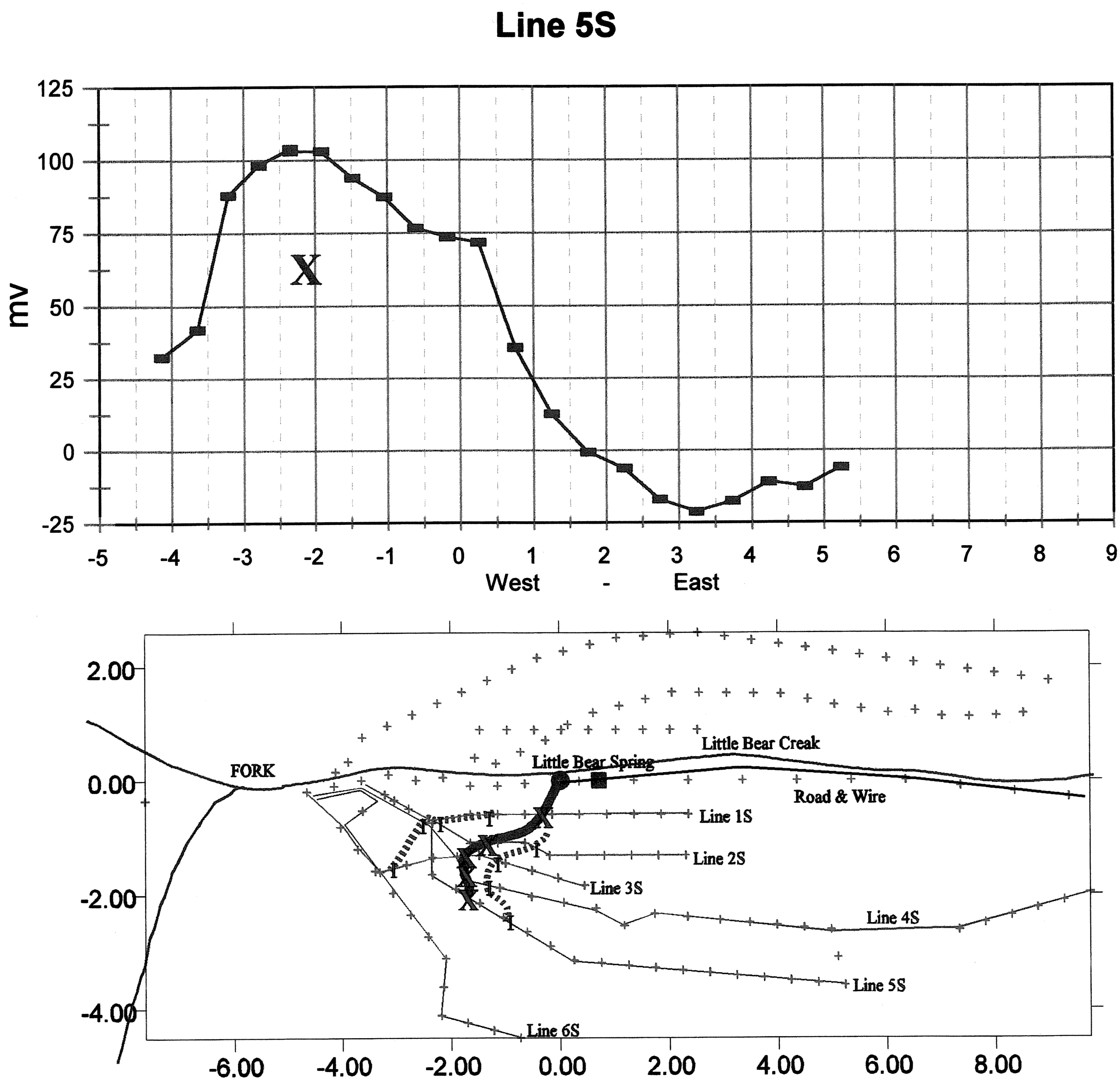


Figure 15 Line 5 S showing the channel center and its position on the plan map.

that is feeding Little Bear Spring is widening. The signature in the data gives every indication that some type of caves or cave like structures are involved. This is because neither the center of the channel nor the edges of the channel or system, whichever it is called, do not form straight lines, but rather have a curved or meandering course.

On line 6 S the sinuous patter becomes even more apparent. The center of the channel has shifted to about -3 which is 100 feet further west than on the previous lines. The western edge is located at about -3.5. The eastern edge

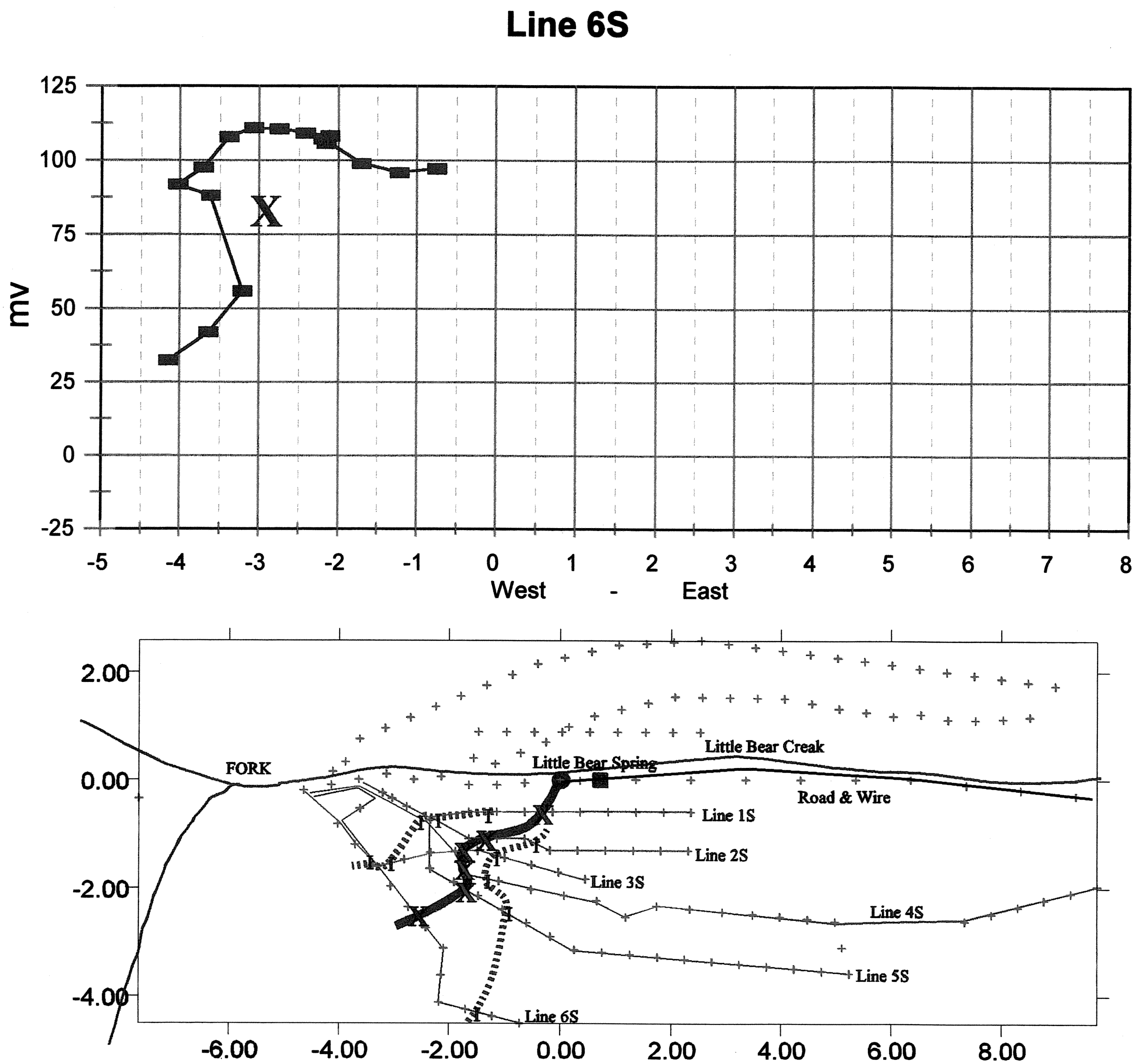


Figure 16 Line 6 S showing the channel center and its position on the plan map.

is controlled by the low conductivity zone, so the channel edge is somewhere between a -1 and zero. The total system is very wide at this location. If the whole system opens up as it penetrates deeper into the mountain it could represent a substantial reservoir that is slowly used during the summer and then replenished during the winter and spring. This would account for the seasonal fluctuations. As the reservoir gets low the pressure drops and the flow of the spring slows down. Then when the reservoir fills the pressure increases, which in turn makes the flow increase.

The general trend direction of the system feeding Little Bear Spring is toward a fault or fracture that follows the left fork of Little Bear Canyon.

Line 1 W, Figure 17, is about 70 feet west of Little Bear Spring. The point where the profile crosses the bottom of the canyon is a low in the values. The value at this point is very near background value. This indicates that the ground is wet above the spring but does not contain a channel that is helping to feeding the spring. The "A" and "X" channels can be seen in this profile, and at this point they are separate.

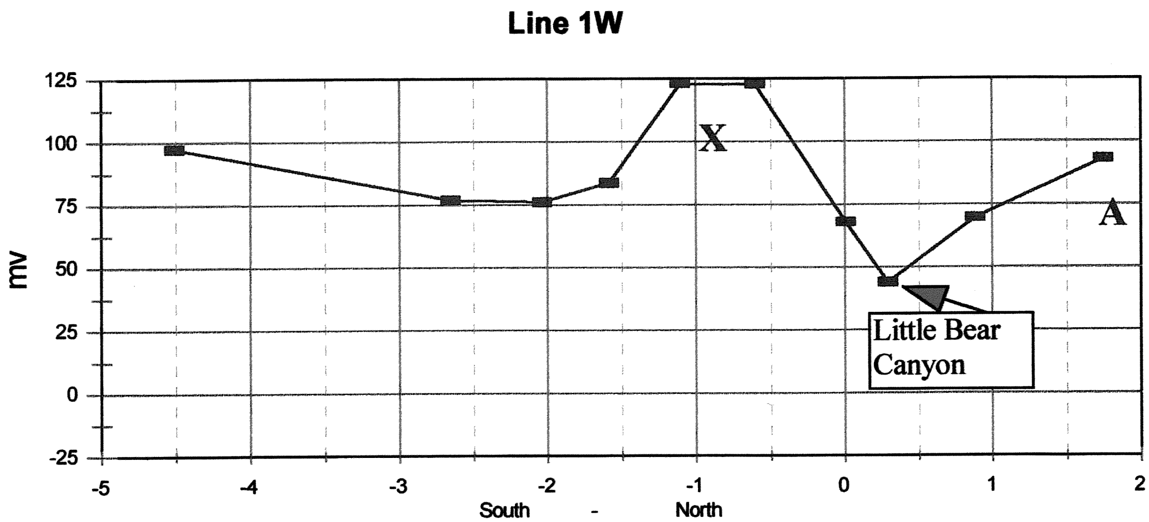


Figure 17 Line 1 W about 70 feet west of Little Bear Spring.

Line 2W, Figure 18, is another 100 feet up the canyon or about 170 feet west of Little Bear Spring. The two channels "A" and "X" are getting closer but they are still separated and no water coming down Little Bear Canyon stream is part of the Little Bear Spring system. The direction that channel "X" follows, places it primarily in the majority of the channel. Even so it is still possible to determine the center of the channel which is about -0.75

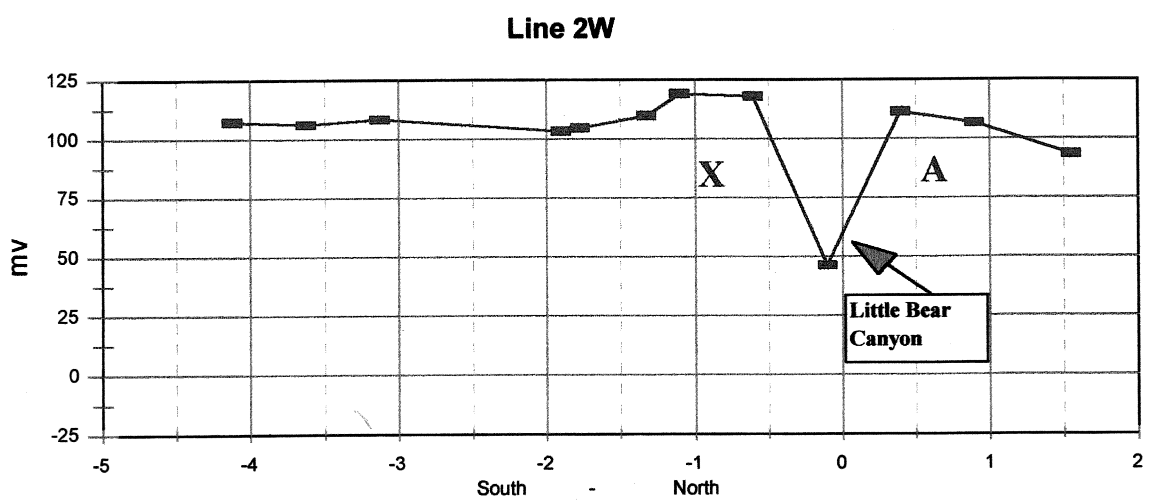


Figure 18 Line 2 W crosses Little Bear Canyon about 170 feet west of Little Bear Spring.

Line 3 W, Figure 19 is a very interesting profile. At first it appears to provide no information because it is so flat. The "X" side is a little higher than the "A" side, also the "X" channel is much broader. This was determined using the profiles north and south of the spring. The most interesting conclusion that can be drawn from this profile is that the survey line follows

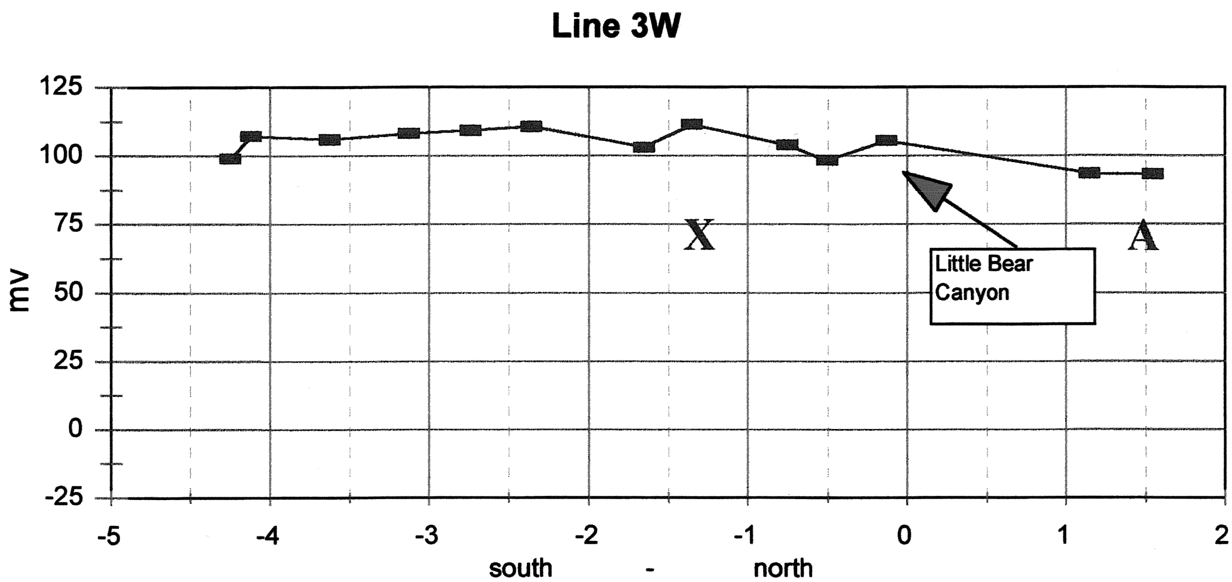


Figure 19 Line 3 W about 270 feet west of Little Bear Spring. There is evidence of a continuous channel along this profile

the channel that brings the "A" groundwater channel into the "X" groundwater channel. This interconnect is proof that Little Bear Spring is being fed from both north and south. Figure 20, Line 4 W again indicates that no water is feeding the springs from the west , and reestablishes the

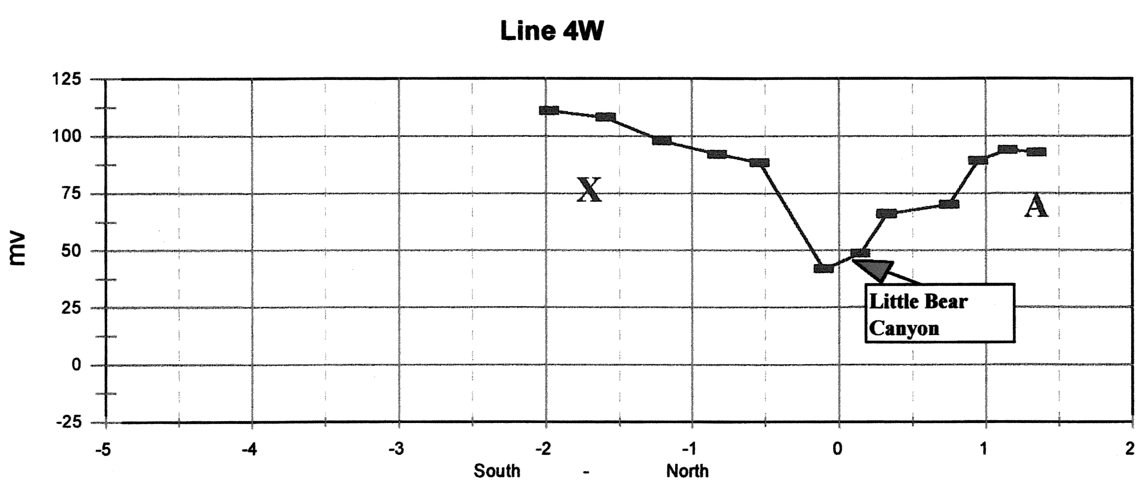


Figure 20 Line 4 W about 425 feet west of Little Bear Spring. The two channels are again evident in the data with a break in the bottom of Little Bear Canyon.

pattern seen in Figures 17 and 18. This shows that the channel under Little Bear Canyon connecting channels "A" and "X" is very narrow.

Figure 21 is an east, west profile constructed from stations in the bottom of Little Bear Canyon, along the creek west of Little Bear Spring. The interconnection point between channels "A" and "X" is visible on this profile, line 0 NS. The center of this interconnection or better said the extension of channel "A" to where it intersects channel "X" is about 250 feet west and up hill

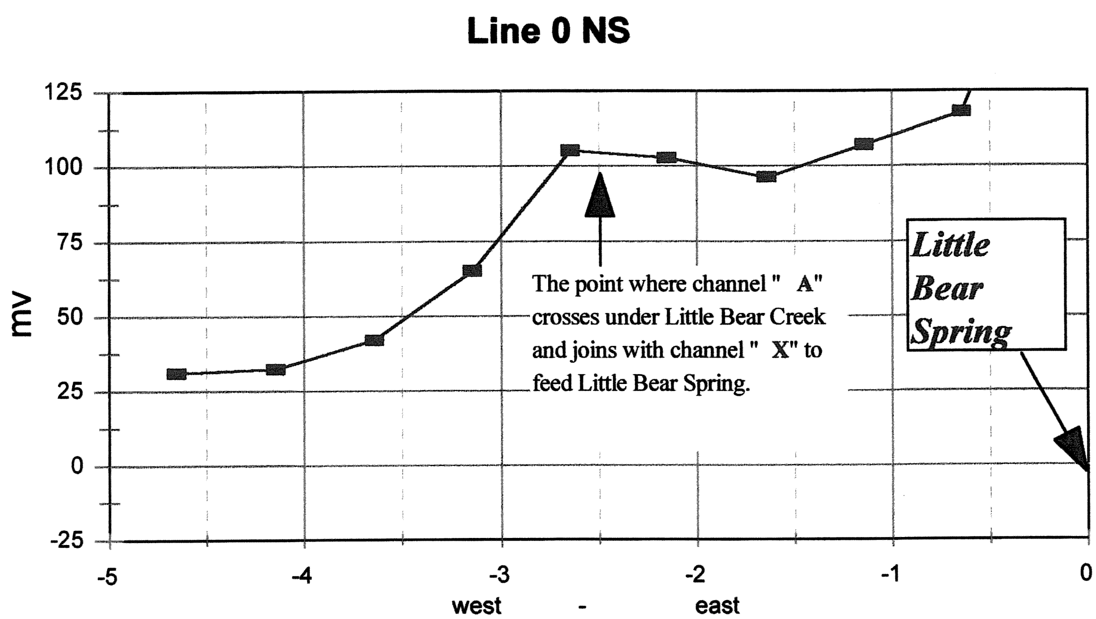


Figure 21 The point were channel "A" crosses under Little Bear Creek is about 250 feet west of Little Bear Spring.

from Little Bear Spring at -2.5 on the graph.

COMBINED RESULTS

When the results of all the data analysis are combined, the results are shown in Figure 22. The light gray area is the low conductivity zone that is most likely forcing the groundwater that is above it to the surface. That is most likely the reason that in addition to little Bear Spring there is a whole complex of springs and seeps in this general part of Little Bear Canyon. The blue indicates high conductivity zones which are usually associated with groundwater.

The ground water feeding Little Bear Springs is coming from two major sources. The one to the south is apparently supplying between 60 - 70 percent, and the one to the north apparently between 30 - 40 percent of the water. The data indicates that the underground system is quite open and extensive. This is indicative of some type of cave system. It could be one that has developed along a series of fractures or faults or it could be the result of deferential cementing that is visible in out crops which are very pock marked. In any case it appears that the system forms some type of reservoir that is constricted by the springs opening and thus supplies a flow all

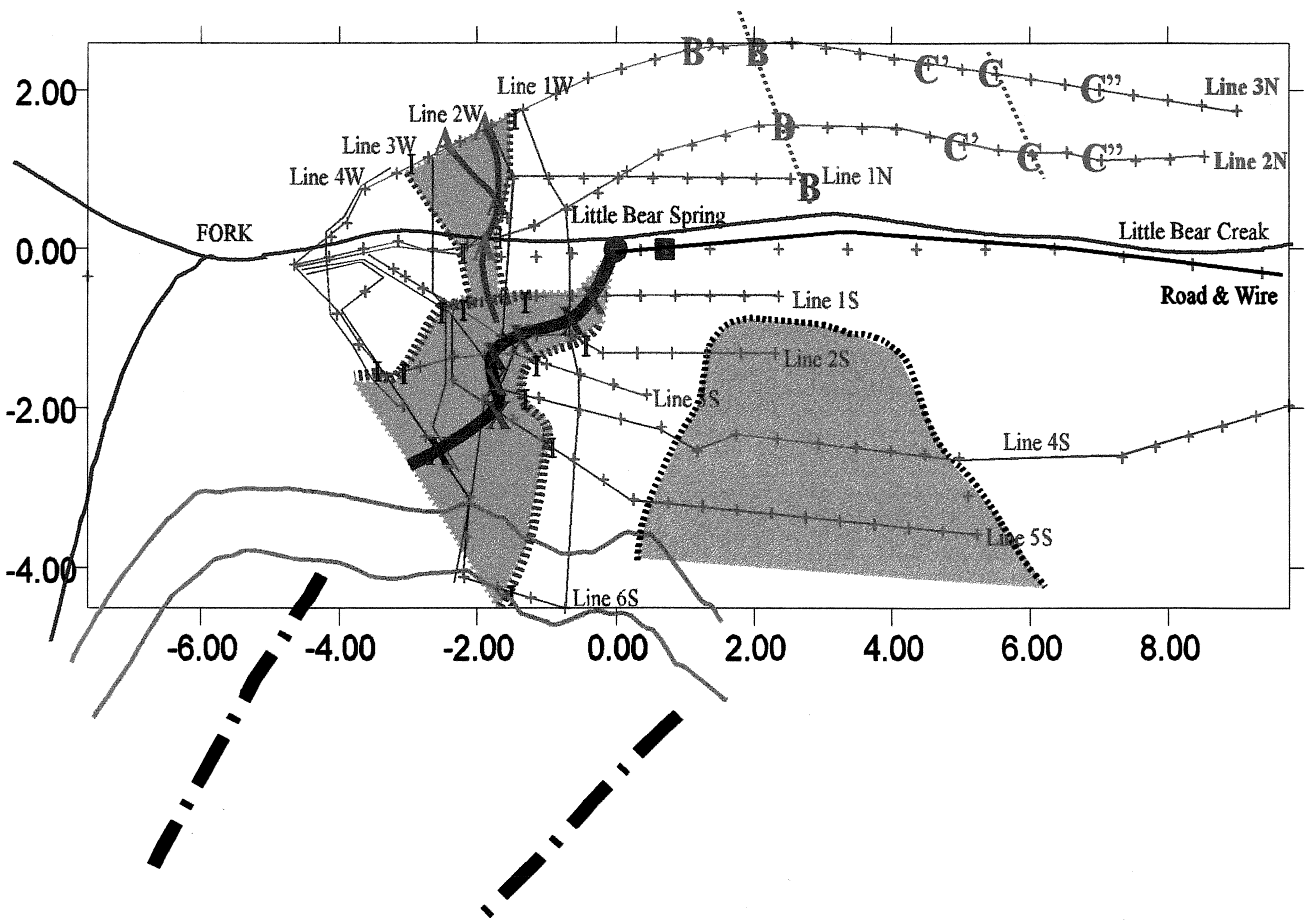


Figure 22 Final interpretation of AquaTrack survey for Little Bear Spring.

Little Bear Spring Monthly Flows

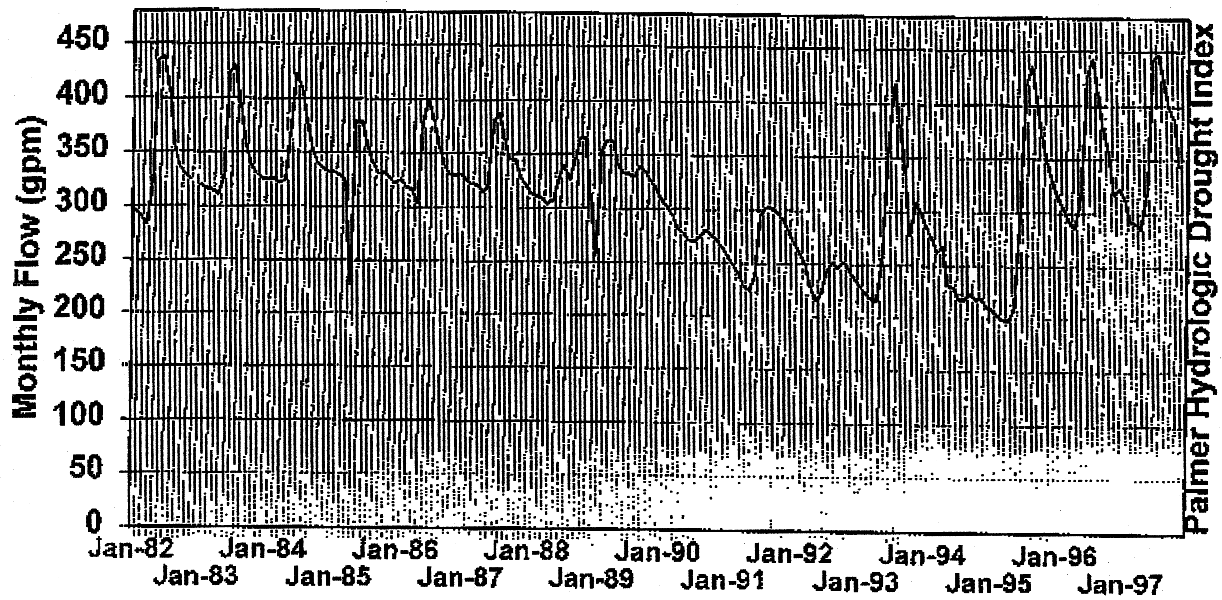


Figure 23 Annual cycles of flow from Little Bear Spring. On average for the last fifteen years the maximum flow occurs in late spring, and gradually tapers of to a minimum flow in the winter.

year.

As can be seen in Figure 23 the flow is not constant but increases and decreases with the seasons. This would indicate that the recharge of the Little Bear Spring system is very dependant on seasonal recharge of the underground reservoir.

In Figure 24 the AquaTrack interpretation has been superimposed on a topographic map of the area. Note that some of the features from the Topographic map have been included in the interpretation map. These include Little Bear Creek, the boundary between the Blackhawk and Starpoint formations and the northern ends of two faults that have apparently been mapped in the Blackhawk but have not been mapped in the Starpoint formation. *An enlargement of the interpretation is also shown just behind the cover page.*

Figure 25 is an smaller scale copy of the topographic and geologic map used in Figure 24. This map is included to show the extent and trends of the faults that seem to terminate just above Little Bear Spring. It also shows two interesting aspects about the fault that is pointed at Little Bear Spring. First that is must be a soft or highly fractured fault because it seems to follow or even be responsible for forming the south fork of Little Bear Creek. The south fork could be just one of the recharge areas. Second, this fault reaches all the way to Mill Fork Canyon, see Figure 26.

Figure 26 is an even smaller scale map. The fault that seems to point right at Little Bear Spring is highlighted in green. On this map the fault extends to Mill Fork Canyon but was not mapped to the bottom of the canyon to Mill Fork Creek. To see if Mill Fork Creek might be contributing to Little Bear Spring a large transmitter was connected to the wire energizing the spring. A line of data was taken along the bottom of Mill Fork Canyon. The larger transmitter was able to supply three times the energy of the first transmitter. However, the canyon was not close enough for the current to reach Mill Fork Canyon and unfortunately bled off into the ground before it traveled that far. Thus, there was no signal measured in Mill Fork Canyon.

This should not be construed to mean no water from Mill Fork is part of the supply for Little Bear Spring it only means a different antenna arrangement is needed to test that hypophysis. The antenna setup was not optimal for testing Mill Fork Canyon. There was neither confirmation or non-confirmation that Mill Fork Canyon supplied water to Little Bear Spring.

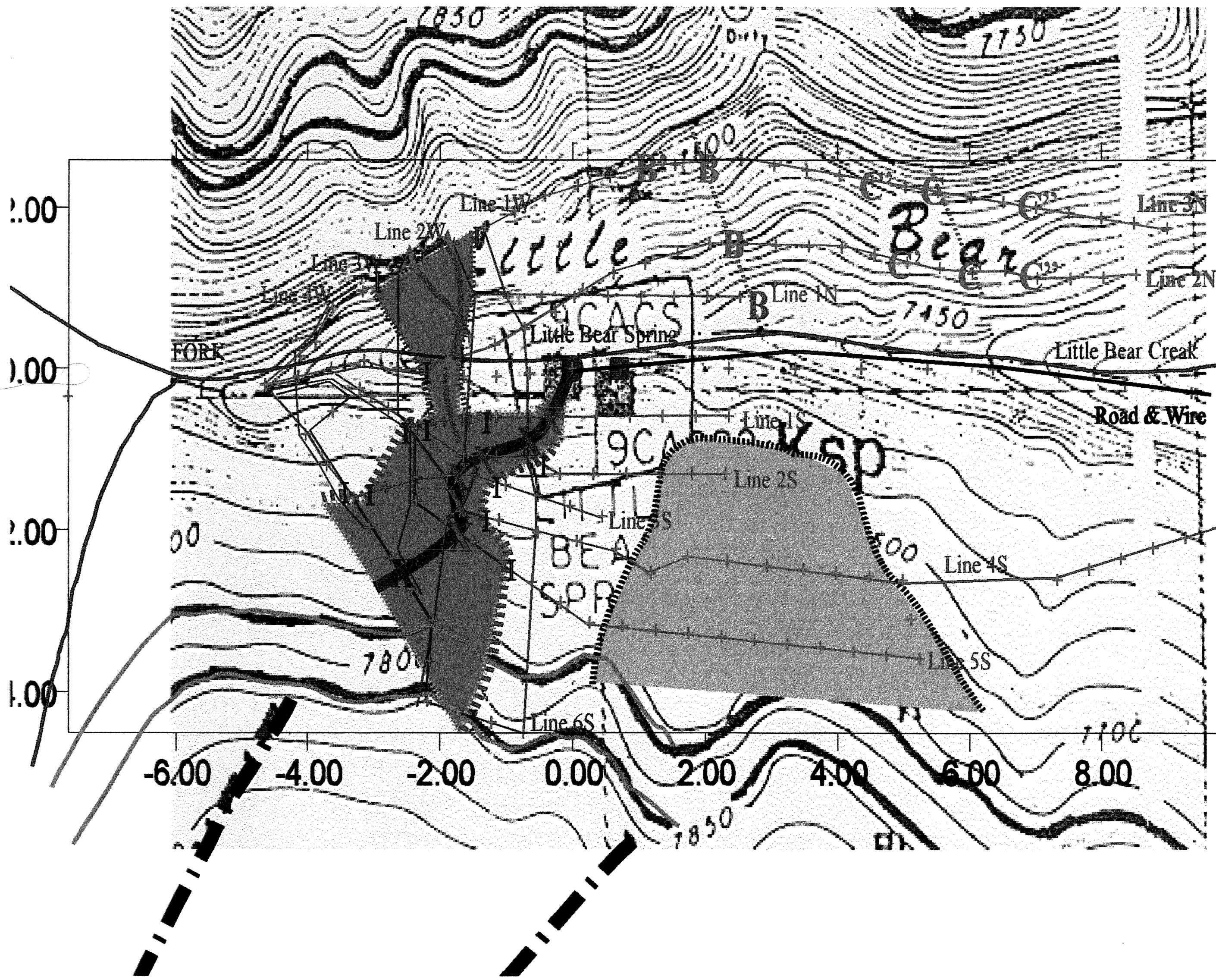


Figure24 Interpretation for Little Bear Spring overlain on a topographic map for the area.

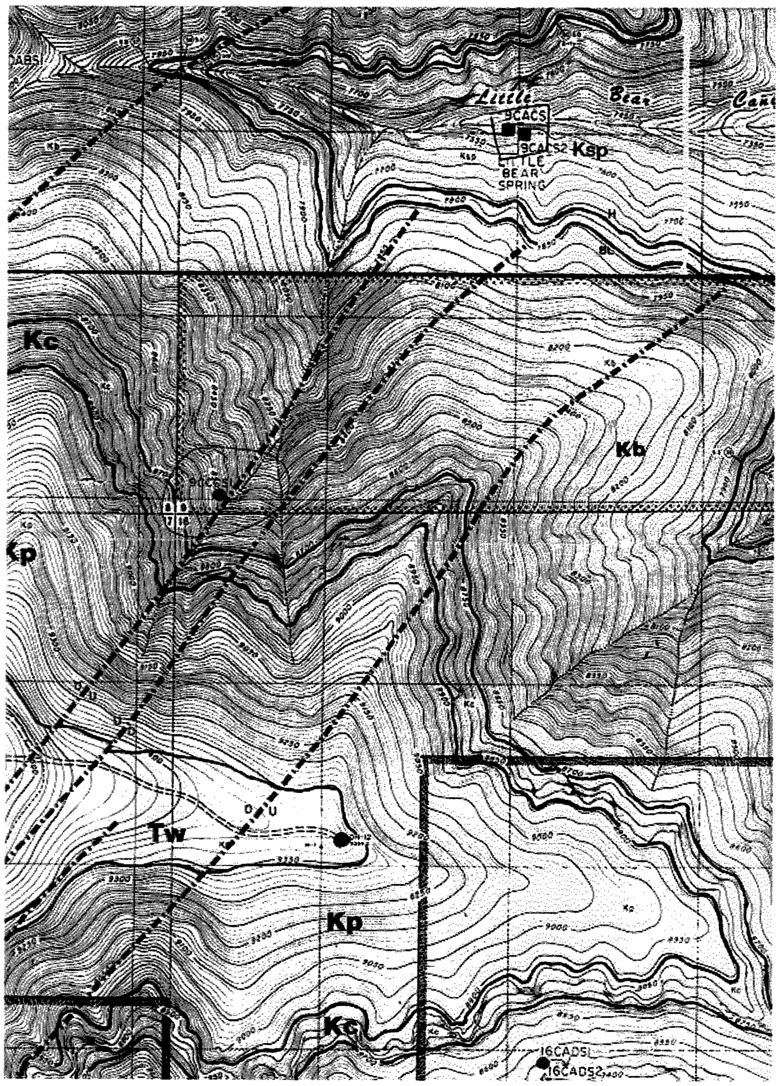


Figure 25 Expanded topographic and geologic coverage of the area around Little Bear Spring. The fault that extend to the southwest are also shown on Figure 22 and 23. On those figures only the very northern most part of the faults are visible.

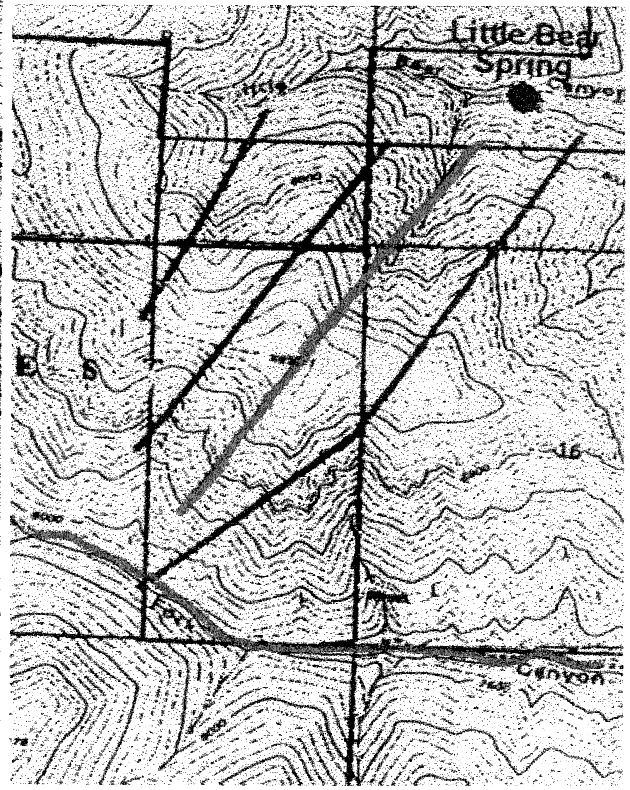


Figure 26 A larger scale map showing where faults extend into Mill Fork Canyon. The green line is the suspected fault. The red line indicates the location of a data line taken in Mill Fork Canyon.

Figure 27 is a combination of topography and geological structural features. It contains two interesting pieces of data. The first is that Little Bear Canyon is formed out of a syncline that is plunging to the west, this is shown in red. Thus, down gradient for all water is to the bottom of Little Bear Canyon. Second, this map indicates that on the northern limb of the syncline the faults are running at approximately 135 degrees to the faults that were shown in Figures 25 and 26, shown in green. The fault direction is the same direction indicated by the AquaTrack survey for structure the water is following on the north side of Little Bear Canyon.

We apologize for the quality of the last figure as we had to scan it from a poor reproduction.

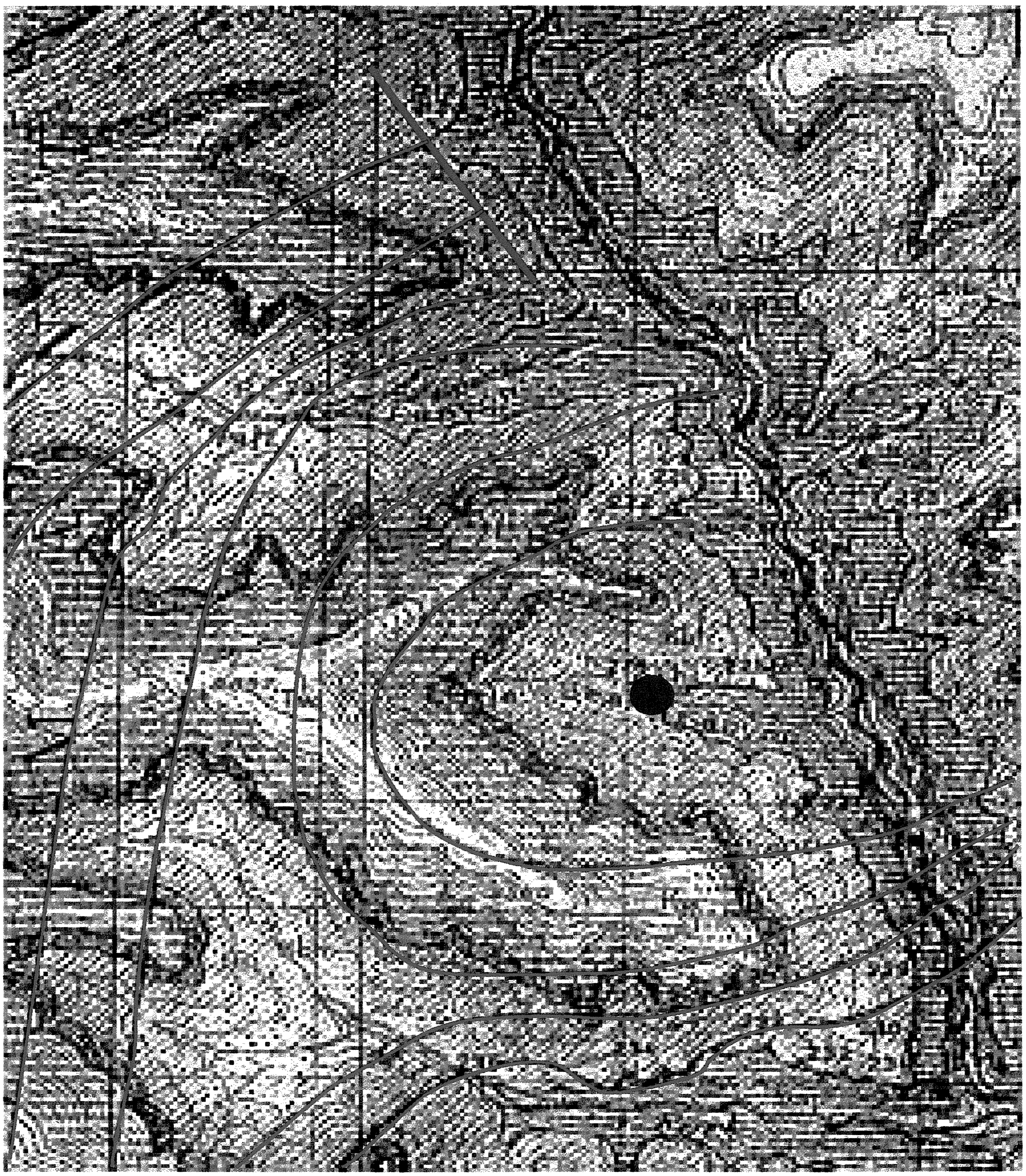


Figure 27 Structural contour near Little Bear Canyon. Little Bear Canyon is centered on a weak syncline, shown in red. Also notice to the north of Little Bear Canyon near the center of the map is a fault that is running northwest to south east, shown in green. This is the same trend as observed on the north side of Little Bear Canyon in the Aqua Track data.

AQUATRACK APPENDIXES

These appendixes are included to provide the reader with an overview of the technology behind AquaTrack. They will assist the reader in understanding the methodology of interpretation. They are not intended to be all inclusive, but are simply intended as an overview to afford appreciation.

Differences between AquaTrack and conventional groundwater tracking technologies

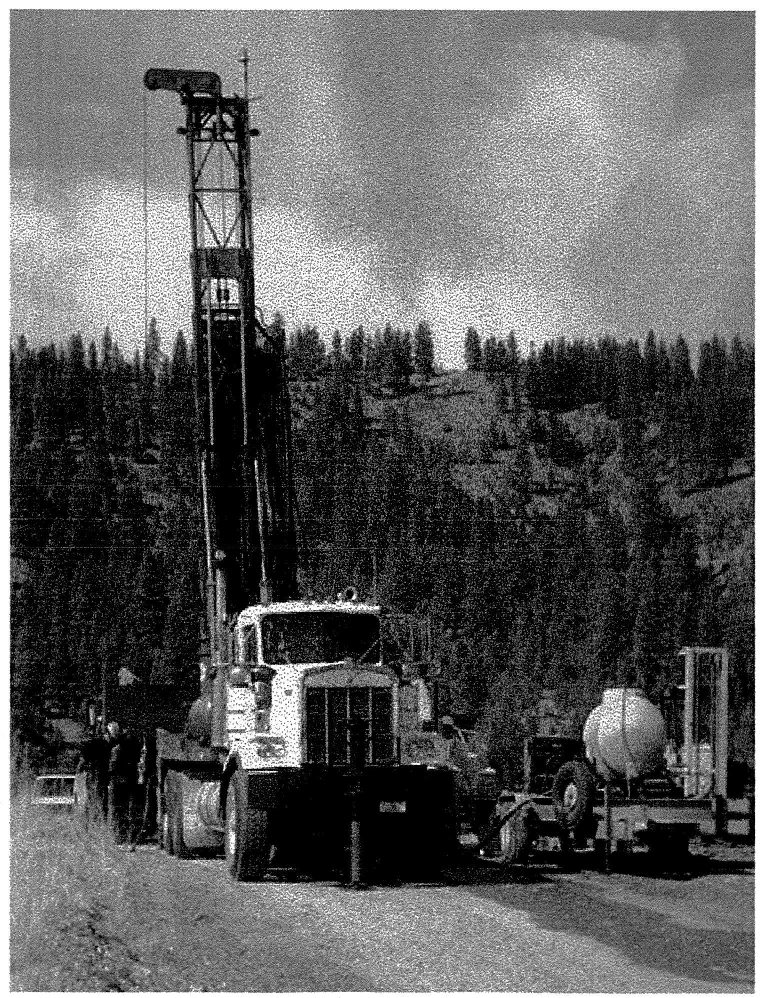
Current groundwater mapping technologies fall into one of the following categories: conventional geophysics, tomography, or monitoring wells using logging technologies or tracers.

Conventional geophysics generally involves indirect energizing and measurements which includes: galvanic resistivity, electromagnetic conductivity, conventional electromagnetic surveys, ground penetrating radar, refraction or reflection seismic surveys, and magnetic surveys. Conventional geophysical technologies do not have the capability of resolving separate subsurface anomalies and confirming that they result from a particular plume or groundwater channel. Detecting groundwater plumes or even resolving plumes at depths greater than about 100 feet is very difficult using conventional geophysics.

The disadvantages of resistivity and conductivity surveys are that they are indirect methods and map low resistivity zones. The zones may or may not be associated with the particular subsurface water in question. The various classical surface electrical resistivity and/or conductivity techniques map resistivity lows or conductivity highs. There is no assurance that the various anomalies are interconnected or just how they relate to the water of interest. There can be two adjacent resistivity anomalies that may or may not be connected because of stratigraphic interference or other problems. Classical resistivity and conductivity technologies energize all subsurface features and average values over a broad area. Thus a particular feature of interest is not isolated and definitively measured. Adjacent features can appear as contiguous features even though they may or may not be connected.

Tomographic type technologies include: electrical resistance tomography, seismic tomography, and radio imaging method. Tomographic technology is a very powerful and sophisticated tool that involves very complicated algorithms to develop models. Resolution is a function of the specific wavelength of the energy source used. The wavelength for seismic tomography is the frequency of the acoustic wave and for electrical resistance tomography, it is the spacing of the electrodes. The drawbacks to tomographic technologies are that they are very time consuming and expensive. In addition, resolution of individual features deteriorates as their depth from the surface increases, especially for small or narrow features.

Monitor wells: The drawback to drilling is that you only identify what is at the location of the drill hole. To establish linkage between holes it is necessary to use tracer solutions or a geophysical continuity test. One geophysical technology used to establish connectivity between holes is to place an electrode in one hole at the horizon of interest and then lower another electrode in the second hole to see if there is a response at the horizon of interest in the second hole. This technique establishes connectivity but does not provide a trace of the subsurface path between the drill holes. With monitor wells it is difficult to confidently map a subsurface water system and be certain that all branches or narrow off shoots have been identified. It is possible to miss narrow channels of groundwater. Wells provide inconclusive and, at times, even misleading results.



Well logging technologies include: thermal logging, gamma logging, neutron logging, acoustic logging, electrical resistivity logging and electromagnetic induction logging. Well logging technologies have a limited range of detection. Generally the detection limits on well logging tool range from a fraction of a meter to just a few meters from the well.

Tracer technologies include: radioactive or non-radioactive tracer methods. Tracers are any substance that can be easily and uniquely identified. Tracers are introduced into the medium being investigated and then wells or leaks are monitored at outlying locations for the appearance of the tracer. This technology requires monitoring wells and relies on intercepting the tracer to detect leaks. Tracers are a powerful technology. However, it takes time for the tracer to move through an aquifer or subterranean system. The aquifer must be continually monitored and sampled to pick up an indication of the tracer which generally requires sophisticated lab analysis to detect the tracer in the minute quantities that make it through. In some situations it may be objectionable to introduce any additional chemicals into a sensitive system.

AquaTrack mimics tracer technologies in that it uses electrons as its tracer and magnetic sensors to monitor the movement of the tracer. Data reduction can be done on a computer spread sheet, and interpretation involves analyzing profiles and contour maps of the magnetic data.

Technology analogous to AquaTrack

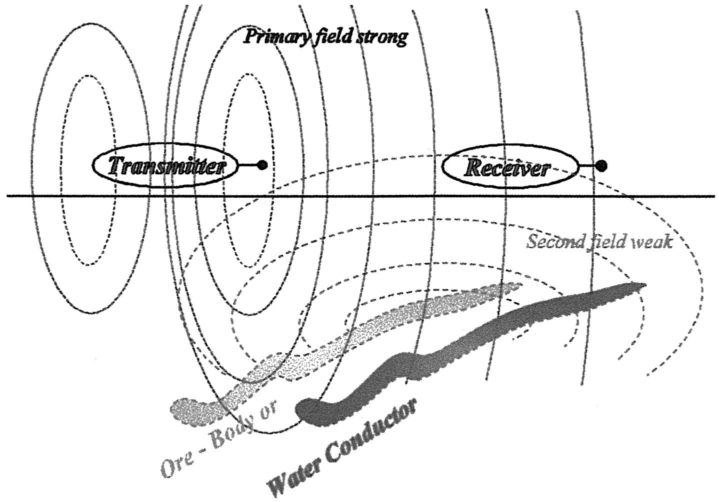
AquaTrack uses the concepts similar to several existing technologies but differs in its execution of the application to tracking water.

The technology is similar to the idea of directly connecting or nearly directly connecting to an ore body as utilized in the Mise-a-la-masse method. Mise-a-la-masse is used to detect mineralization just missed by drilling and in the immediate vicinity of the drill hole.

Another similar technology is used by phone companies to detect wires in walls. They attach a signal generator to the wire and energize it. Then a small loop antenna is used to locate the trace of the wire in the wall.

The location of underground pipes and utilities using Metro Tech tools is also very similar to the technology behind AquaTrack. The closest analogy is a Metro Tech transmitter connected to a pipe and to a grounded electrode. A receiver is used to map the electromagnetic field generated by the current following the pipe. The buried portion of the pipe is located by mapping the magnetic field. When using AquaTrack to track groundwater, underground pipes and wires create noise that must be identified and corrected.

Background

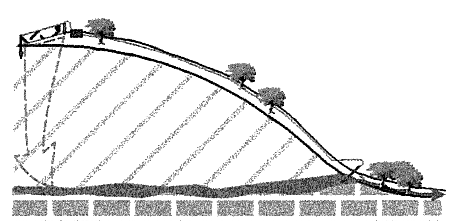


Conventual E.M. surveys

Electromagnetics have long been employed by geophysicists to find minerals and ore deposits. The concept of electromagnetics is straight forward. A fluctuating electrical current in a coil will generate a fluctuating magnetic field. The converse is also true. A fluctuating electric current will be generated in a coil placed in a fluctuating magnetic field. A sub corollary is also true, that any conductor placed in a fluctuating magnetic field will have electric currents circulating in the conductors which in turn will produce their own magnetic field which will oppose the first magnetic field. This secondary magnetic field will be much weaker than the primary magnetic field.

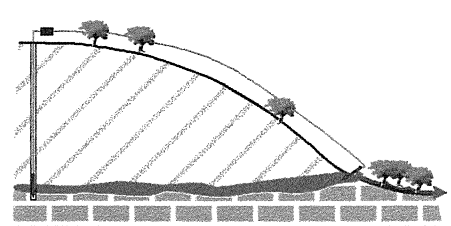
In conventional electromagnetic techniques a transmitter coil is placed on or near the surface. The transmitter coil is energized to create an alternating magnetic field. This alternating magnetic field induces electric current in all the conductors in the area. A second magnetic field is generated by the current flowing in the conductors. The secondary magnetic field interferes with the primary magnetic field and this interference is measured. There are two major problems with this method when mapping subsurface water channels. First, all conductors in the subsurface are energized the same amount and will respond in similar ways and second, the secondary magnetic field is usually much weaker and can be hard to resolve from the primary field.

The technology used to track groundwater uses electromagnetics, but **AquaTrack** combines geophysics and tracer technology. By injecting electricity into the solution being investigated the electrons become tracers. As ions in the groundwater move, they generate a magnetic field. This magnetic field can be measured some distance away from the moving ions thus direct contact with the groundwater is unnecessary. **AquaTrack** creates a primary magnetic field in the conductor of interest and other conductors not of interest generate only a weaker secondary magnetic field. The path followed by the electricity maps the groundwater and related structures. **AquaTrack** is an electromagnetic method developed to track and monitor ground waters.



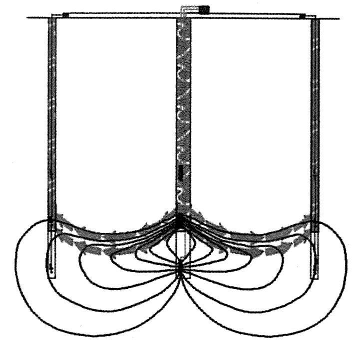
Some of the capabilities of AquaTrack are:

- Mapping subsurface pollution plumes.
- Finding the source of seeps.
- Delineating leaks in earthen dams and drain fields.
- Monitoring changing subsurface ion concentrations or reaction fronts.
- Monitoring leaching solutions.

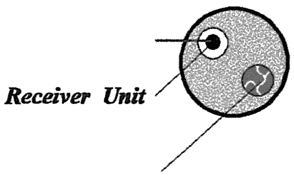


When there is a surface expression of the groundwater of interest such as a seep or spring the best techniques are to place one of the electrodes directly in the seep or spring.

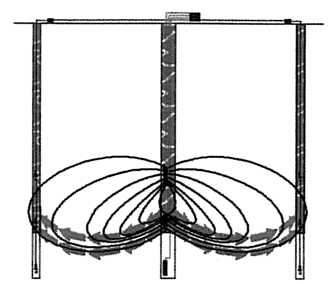
In a drill hole the preferred electrode configuration is to place the return electrode below the energizing electrode. When the return electrode is the upper electrode the current flowing back is closer to the receivers on the surface and thus masks the signal from the groundwater. When the energizing electrode is higher than the return electrode the current in the ground water is closer to the receiver and thus the current following the groundwater creates the stronger signal.



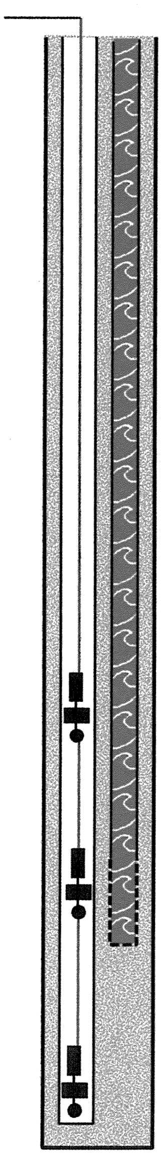
Current Flow bottom & middle electrode



The principle of electrons acting as tracers is utilized so that AquaTrack can actively monitor retainer walls and other subsurface barriers for leaks. This system not only detects leaks in the barrier but identifies the leak location. The leak can then be repaired with a minimal cost.

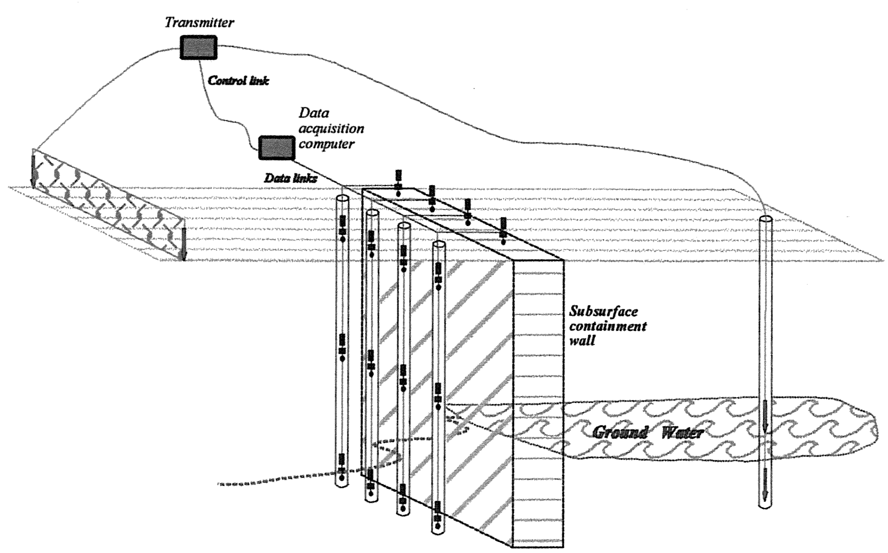


Current Flow top & middle electrode



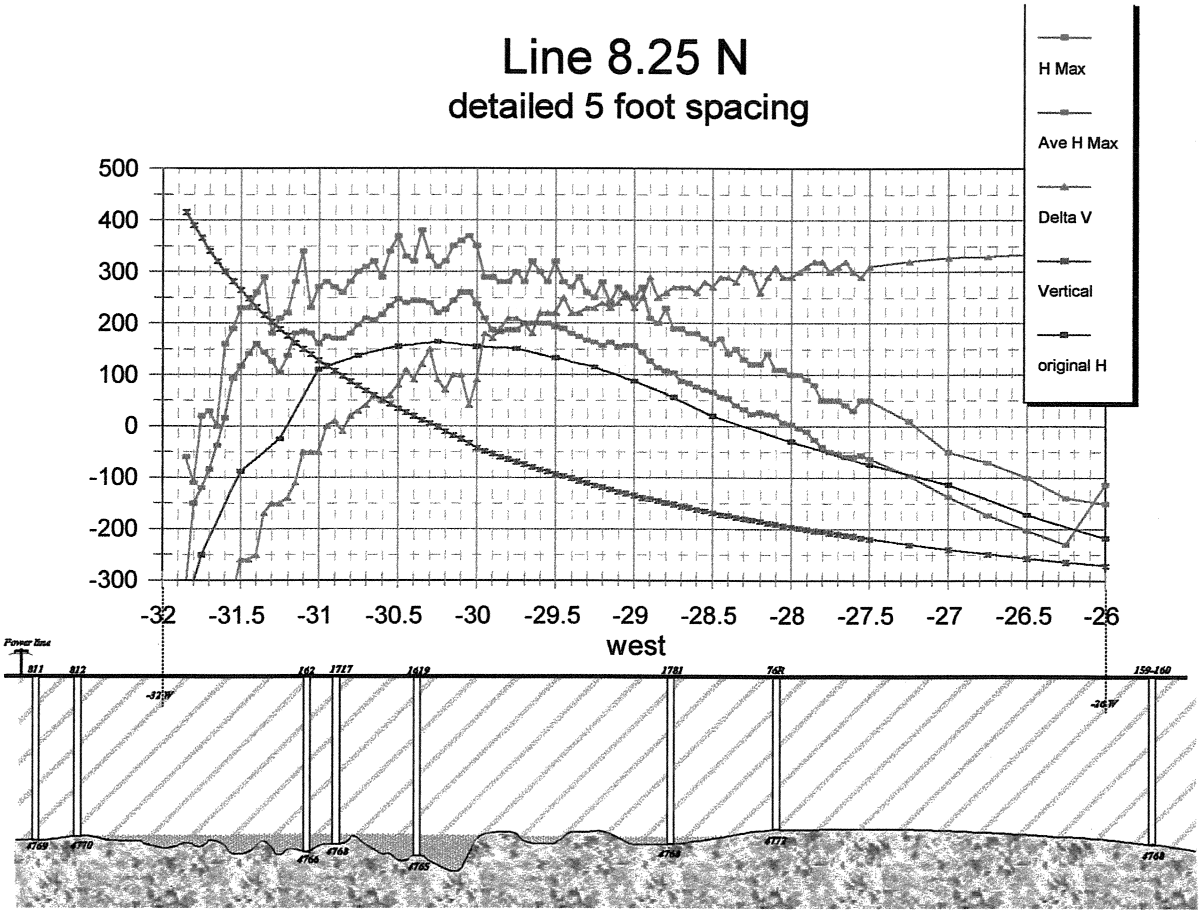
Pure water is not a good conductor, but groundwater is not pure, containing ions from many sources. The more minerals in the water the better a conductor the water will become whether the ions come from natural sources, pollution, or from leach solutions. Ground water is a better conductor than everything in the ground except metals. By directly energizing a stream of ground water, the water acts as a subsurface conductor. The magnetic field generated by the electric current flowing in that conductor can be measured on the surface. Since this is a primary field, it is stronger and much easier to track than the secondary fields used by other electromagnetic technologies. Directly energizing requires at least one point of contact with the water in question.

While AquaTrack is based on sound scientific theory, in practice it can be quite difficult. The water being tracked may be only one of several conductors being energized or partially energized. A clay layer in soils often acts as a weak conductor producing a broad superimposed field.



Subsurface Containment Wall

Power lines or buried cable will produce their own magnetic fields. The depth of the water from the surface may also vary and will cause variations in the field measurements. Other potential influences include changes in water conductivity due to changing ion concentration or a broadening of the water stream (sheet flow verses channel flow). Even the wire that is used to energize the water stream and connects the return electrode will generate a magnetic field. Although the data obtained by AquaTrack usually allows someone with experience to determine these things, it is always prudent to consider all prior knowledge of a site to confirm observations and as a double check for any data interpretation.

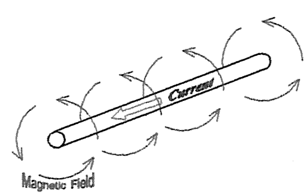


AquaTrack data frequently enhances the value of other types of data that has been collected for the site.

Review of physical principles involved

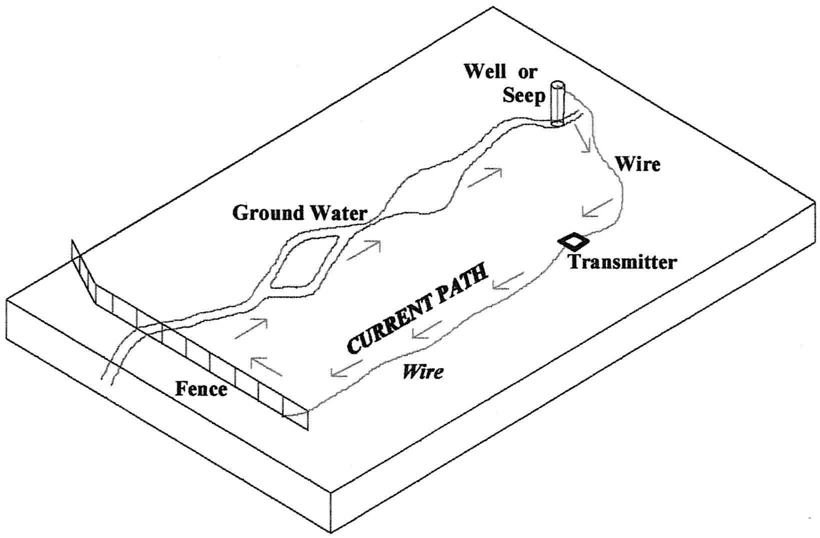
The combination and interplay of several electrical phenomena and adaption of several electromagnetic principles, in combinations not previously used, provides the interpretive foundation. The following is an overview of these principals and, in some cases, examples of how they are used to interpret AquaTrack data.

1. Current flowing in a wire generates a magnetic field that wraps around that wire perpendicular to the flow of current.



If the wire is replaced by another conductor, such as water in a subsurface channel, current following that water will create a magnetic field. By mapping the magnetic field generated by the electric current the water channel can be located.

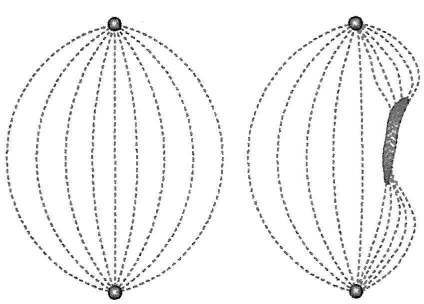
2. Two coils in close proximity are coupled magnetically. A transformer is a special case of two coupled coils. The primary coil is the loop carrying the initial current. The secondary coil has current induced in it by current flowing in the primary coil.



The primary coil of the AquaTrack analogy is created by a large primary loop on and in the ground. The antenna wire forms one part of the primary coil and the subsurface water path forms the other part of the primary coil. The wire portion acts like a single turn coil, but the groundwater portion behaves like a multiple turn coil. A virtual primary transformer loop or turn is created by the antenna wire and groundwater path.

The secondary coil of our hypothetical transformer is the receiver used to map the field of the primary coil. The physical shape of the water portion of the coil will determine whether it exhibits properties of a single wire or simulates multiple windings on a coil. A broad flow will approach the current carrying characteristics of a large number of small wires where a narrow channel, such as in a pipe, will exhibit properties similar to a single wire. The way that the primary and secondary coils couple, and the current generated in the secondary coil is controlled by how many virtual turns, emulated by the groundwater, are inside or outside the position of the secondary coil. Thus theory for transformers and large loops can be used to analyze the resultant magnetic field and infer the shape, location, and path of the channel used by the subsurface water being energized.

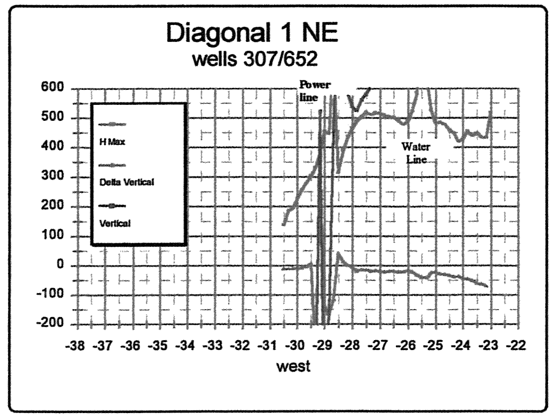
3. A good conductor, such as a metallic object, placed in a moderate conductor will gather current from the moderate conductor into the good conductor.



This is demonstrated by the classical physics experiment where two electrodes are placed at opposite ends of a tray of water. The electric field in the tray is first mapped containing only water. Then different types of conductors or insulators are placed in the tray. Objects with greater conductivity than the water warp the electric field in a way that diverts current through the conductor. This is because the entire metal surface is at the same electrical potential. This changes the gradient which focuses the flow of current through the metal. *Conductors gather current.* Insulators whose resistivity is greater than the water divert the current around the object. *Insulators do not gather current.*

Good conductors in the ground will gather electrical current flowing in the ground. This is referred to in the geophysical literature as *current gathering*. Current flowing in the ground will preferentially follow good conductors in the subsurface. There are three general classes of good conductors in the ground.

■ First are groundwater channels. When current is directly injected into the conductor of interest, the signature of that conductor will be the strongest because the current will preferentially remain in that conductor. Current will disperse from the conductor at a rate that is a function of the resistivity contrast of groundwater channel and surrounding medium.



■ Second types of conductors are man made. These include:

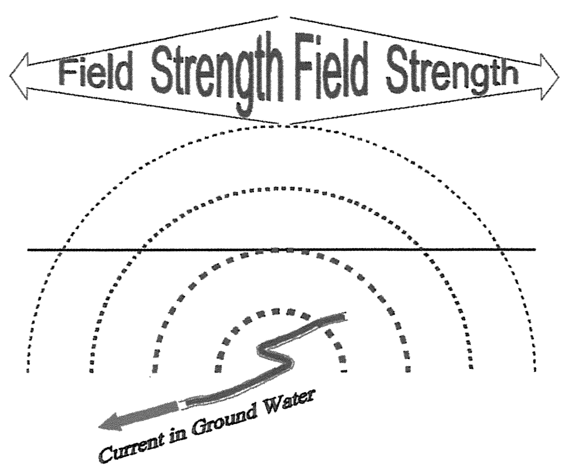
- communication lines,
- overhead power lines, (The effect seen on the profile to the right at station -29 is due to overhead power lines. Pipes and communication lines have similar signatures but not as strong.
- underground metal pipes,
- chain-link or steel stake fences,
- rails or other elongated conductors.

The locations of fences, wires, pipes and conductors are usually known thus they can be accounted when the data is interpreted.

■ Third are mineral deposits such as ore bodies. These are rare and are generally easy to distinguish from other types of conductors.

Application of these principles to AquaTrack

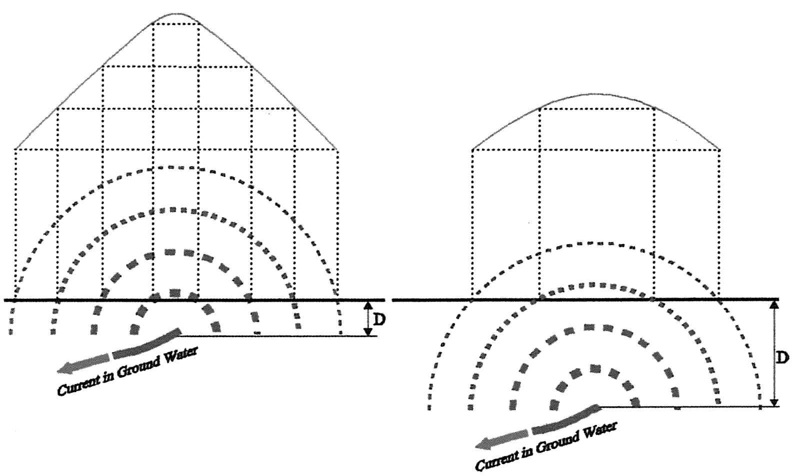
Following are observations of how the magnetic field behaves when using AquaTrack and how this technology is used to map groundwater channels. A loop is formed by the wire and current in the ground. A magnetic field is generated by electrical current following subsurface water. Mapping the components of the magnetic field provides information which can be used to map the electrical ground current, which maps the groundwater.



To examine what is happening we will return to our most elementary model which demonstrates the principle of how this technology works. Consider what happens when electric current flows in a wire. A magnetic field is produced that circles the wire. If a conductive stream of water or solution replaces the wire, a magnetic field will form directly above the water's channel. This field will be horizontal and perpendicular to the conducting zone just as it would be for a wire. A curved conductor will behave the same way. The strongest field strength will be measured directly over the conductor. If measured, the magnetic field traces a path on the surface that follows the path of water, in the ground. To create this current flowing in the groundwater, an electrode is placed in the solution to be studied. In the least complicated situation, a single electrode in the groundwater or site of interest would produce the strongest signal from the underground conductor. However, in the real world there are no mono poles and a second electrode is required.

An important part of this technology is that the groundwater or medium of interest is directly energized. This can be done in several ways but ultimately all achieve the same effect. The electromagnetic signal that is measured at any point in the survey is a compilation of the current flowing in the earth and the field created by the wires leading to the electrodes energizing the groundwater.

The field intensity can vary according to channel depth.



The magnitude of the magnetic field is related to the size of the loop and the current flowing in the loop. The vertical magnetic field inside a loop will be its maximum and is constant when completely inside the loop. The vertical field decreases when crossing any flow paths that short circuit part of the loop flowing in the ground. The vertical magnetic field will have a relative zero (maximum slope) directly over a water channel. If the water channel is confined, the vertical field will change rapidly over a very short distance. When crossing a wide water channel, the vertical field will start to change, decreasing in strength, before the first edge is crossed. It then stabilizes over the channel and decreases abruptly as the second edge is crossed. Outside the loop, the vertical field will decrease moving away from the loop.

The horizontal magnetic field inside the loop will be a minimum. The horizontal field is maximum crossing over any conducting strand of the loop. When moving from inside to outside the loop the horizontal field will decrease and continue to decrease outside the loop when moving away from the virtual loop.

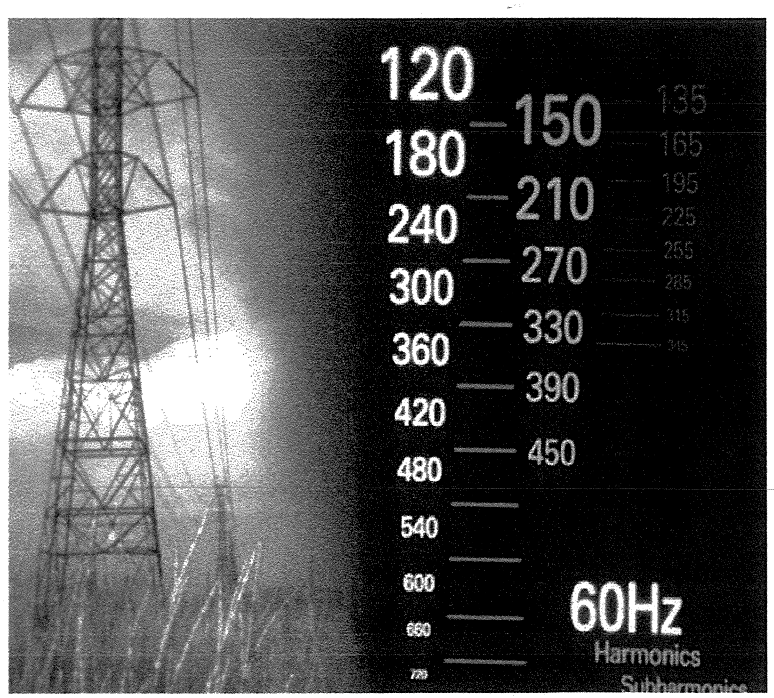
The magnetic field's rate of curvature is proportional to the distance from the water channel carrying the electric current.

The rate that the magnetic field falls off along the water channel is proportional to the resistivity contrast between the water channel and the surrounding media

Noise

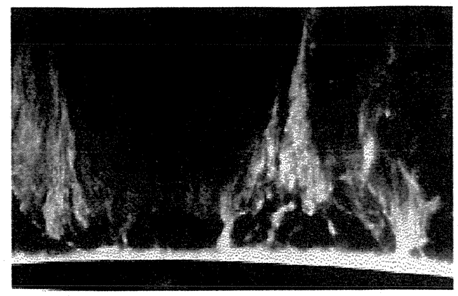
There are three large sources of electrical noise in the ground that must be accounted for when analyzing AquaTrack field measurements.

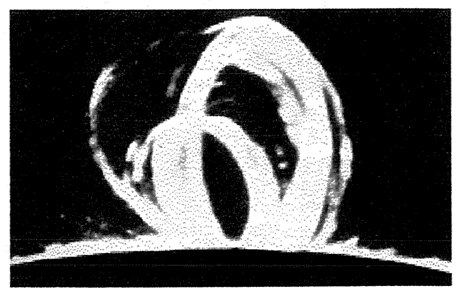
- The first results from power companies which use the earth for their return circuit for all their power distribution. Thus as usage changes during the day the electrical and magnetic field produced by the returned



electrical power will shift and change. These effects are screened by frequency locks between the transmitter and receiver. Corrections are obtained from multiple base station readings used to monitor drifts in the local electromagnetic fields.

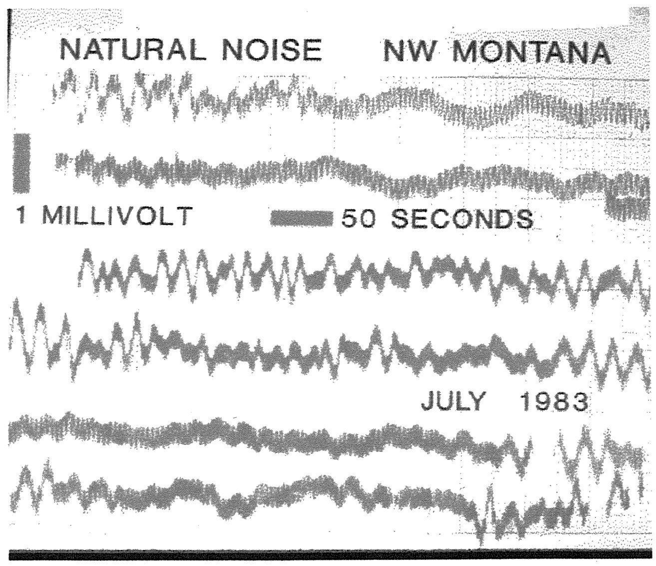
Filters are provided to lock the frequency of the AC current at a precise 400 cycles. Four hundred cycles was selected to eliminate interference from stray 60 cycle current or any harmonics of 60 cycles. Output voltage is controlled to produce the desired current Both the output voltage and output current are measured and recorded during the survey.

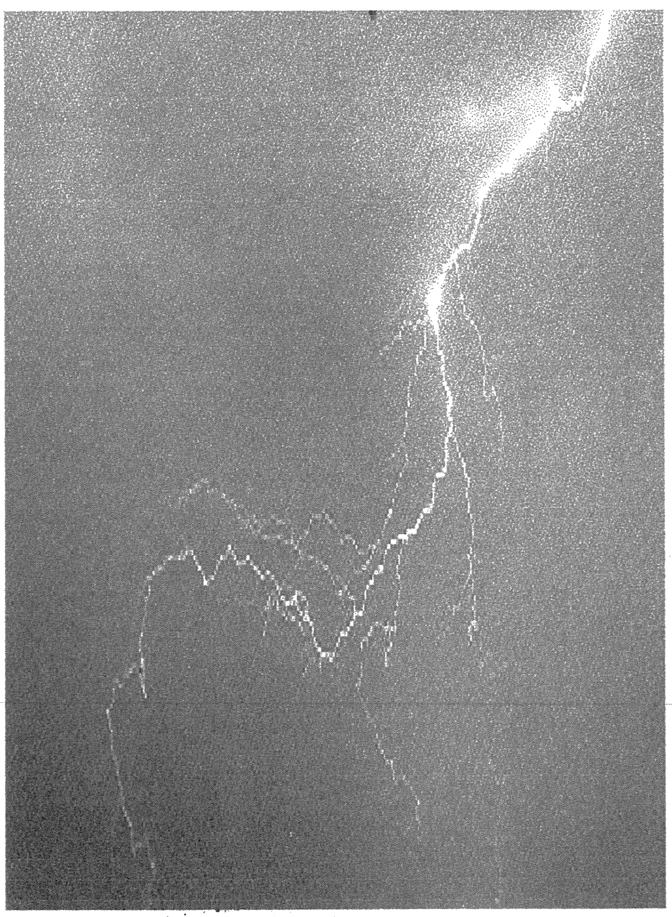




- The second strongest noise source is telluric currents created by the electrical currents that the sun generates in the ionosphere. Multiple readings at a base station help identify and correct for these influences.

The third electrical noise source is distant thunder storms. The electrical static generated by lightning strikes becomes trapped in a wave guide between the ground and the ionosphere. With distance the currents generated begin to blanket the electromagnetic spectrum usable in this technology. Noise from these sources are corrected using a combination of frequency locks and bases station corrections.

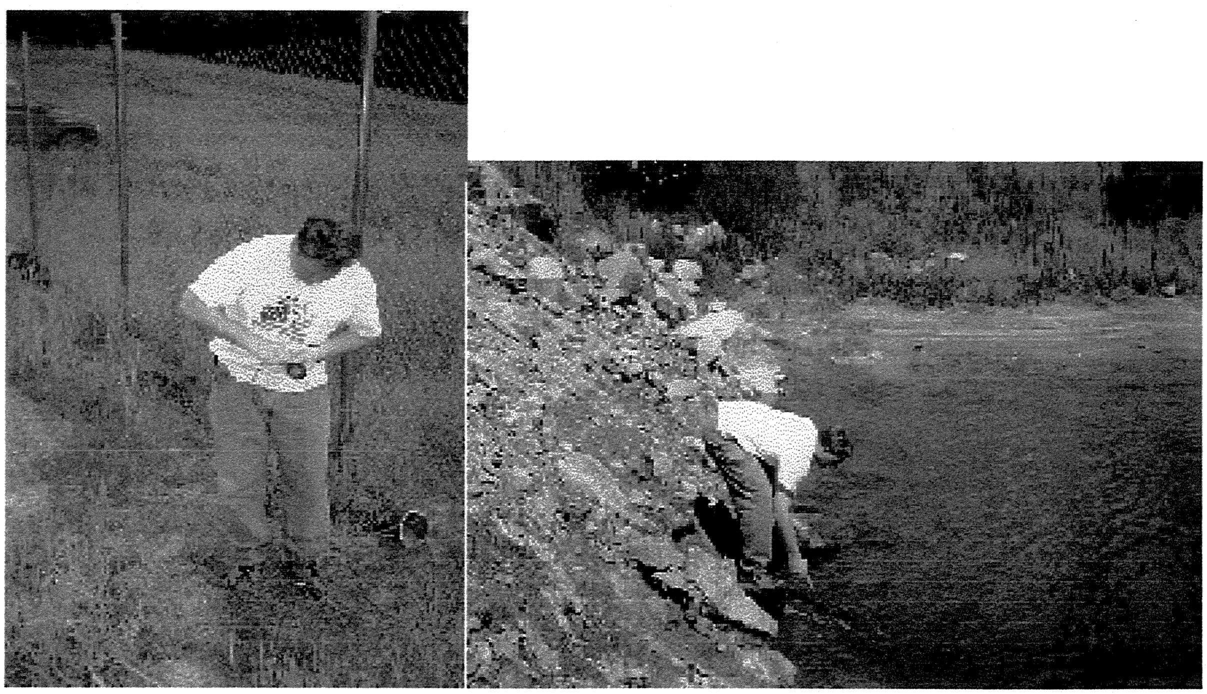




Field procedures

The first step is to provide a path for the current to flow in a large primary loop. The water path to be mapped has to be included as part of this primary loop circuit. This is done by directly connecting an electrode to the water to be mapped. To provide a return path and continuity between the electrodes wire is strung from the primary electrode to the grounded point or points.

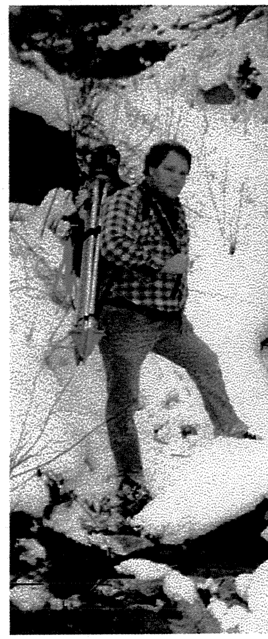
At least one of the electrodes must be in contact with the water being tracked. The second electrode can be in contact with the water to establish the flow path between two points. However if the subsurface path is an unknown then it is better if the return electrode does not bias the flow of electricity in the ground. This is best done by using as the second electrode a broad ground plain such as a chain-link fence or surface water such as a pond or stream.



A controlled AC transmitter is included in the wire portion of the loop. The current is filtered and controlled to provide a locked frequency between the transmitter and receiver. Output voltage and current are controlled, monitored, and recorded during the survey, and corrections are made for any transmitter drift. All readings are locked to a base station and corrected for diurnal drift.

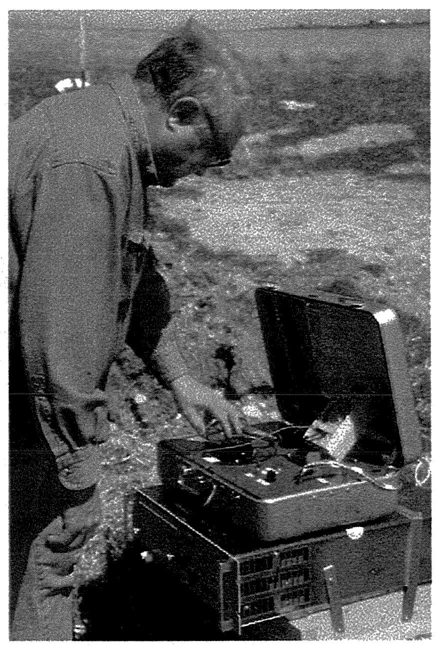
Data is collected at each station using a special receiver. The receiver consists of a coil and a filtered amplifier. The magnetic signal picked up in the coil is correlated with the transmitter signal and filtered for noise. Magnetic field measurements consist of magnitude and direction of the magnetic field components. The minimum field is detected first because it is more definitive. The field direction is obtained using a compass mounted on the receiver coil. The maximum is measured by rotating the coil 90 degrees and recording the voltage induced in the receiving coil. The coil is again rotated 90 degrees in the vertical to measure the vertical component of the field.

Data Reduction

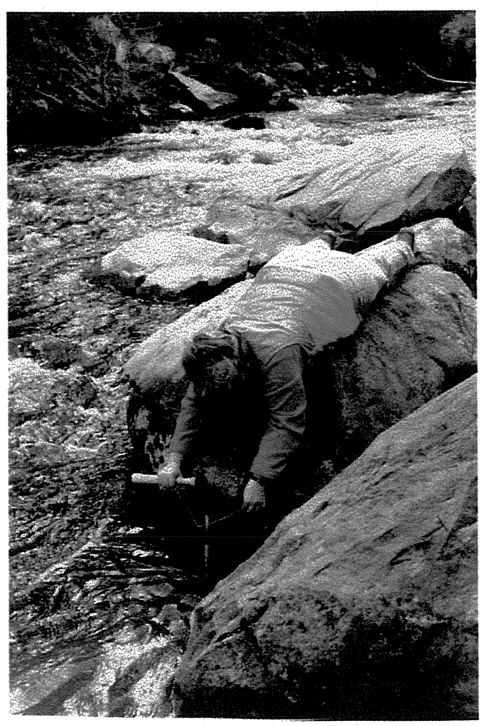


Analysis of the data is a multifaceted process. Voltage and current of the transmitter are controlled, monitored, and recorded using a portable computer during the survey. These recorded readings are used to correct for any transmitter drift. All readings are locked to a base station and corrected for diurnal drift. Both of these corrections are the same as standard linear correction made to all geophysical data.

- A base station reading is taken as often as possible during the day. The drift measured at the base is assumed to be linear and is simply subtracted from the reading. This compensates for instrument drift and some of the spheric variations.
- The transmitter current can be is monitored by taking current readings every minute through the day with a portable computer. Data at individual stations is normalized to a constant current, usually 1 amp.



The data interpretation can be facilitated and enhanced by various treatments. These are standard mathematical manipulations that are applied equally to all data to remove regional and other effects. For example: First, current bleeding from the conductor such as a groundwater channel will cause a gradually reduced signal due to lower current flow. This effect can be adjusted by adding a factor based on the station's distance from the current source. Second, the electrodes, or contact points, can act as electric poles and will create a very predictable field. This field can be calculated and removed mathematically from the data.

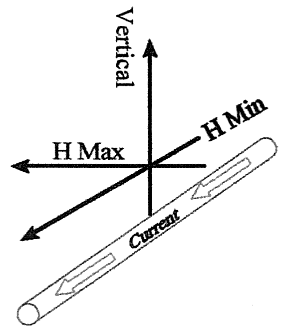


The data can be presented in various forms such as linear or logarithmic. The preferred method is linear but in a few cases where the anomalies are substantial and tend to overwhelm the smaller anomalies, logarithmic is then preferred. All data in this report are linear unless specified otherwise.

Data Interpretation

General guide lines

In the simplest case, such as a wire-like conductor, field strength will be greatest at a point directly over the conductor. If the conductor is straight, field strength measured on a line perpendicular to the conductor will increase until it is directly over the conductor then decrease at the same rate.

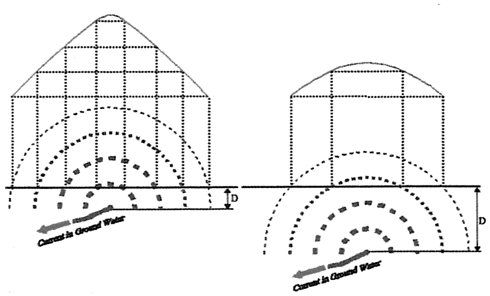


The direction of electrical current flowing in the ground represents the path of the groundwater or channel. Electric current flows in the same direction as the minimum horizontal magnetic field or perpendicular to the maximum horizontal magnetic field. The direction of electric current flow is directly correlatable to the subsurface water channels.

The rate of change of the vertical magnetic field intensity with distance across the anomaly is proportional to the width of the current path or indicates the width of the groundwater channel.

Width of the horizontal magnetic field is proportional to depth and width of the channel.

Correlation of vertical and horizontal data can be used to clarify ambiguities of width and depth.



Specific case examples.

The following examples are how possible features will show up when site data is plotted in a manner similar to that of a contour map. When possible a Figure is show that corresponds:

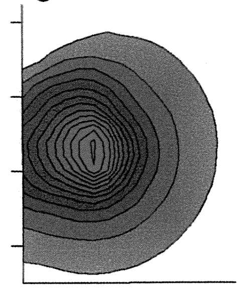
a. A non-perturbed field, where no conductor is energized, would form a contour map composed of concentric circles around the point where the water is energized.

b. Water in a narrow channel will form a V shape in the contours. The shape of the "V" will be sharper the closer to the surface the channel is.

c. A vertical structure such as water flowing along a vertical fault, will also form the "V" contour but with a somewhat lower gradient as fields generated at the lower portions of the fault structure will add to the fields generated closer to the surface.

d. A flat conductor or sheet flow of water will produce a flatter signal than a deep narrow conductor. The gradient will increase toward the edge of the water then level off, only to reduce sharply on the other side, making the edge of the sheet flow more pronounced than a deep narrow conductor.

Figure a.



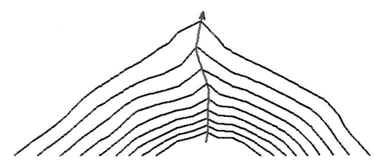


Figure b.

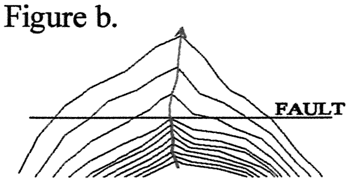
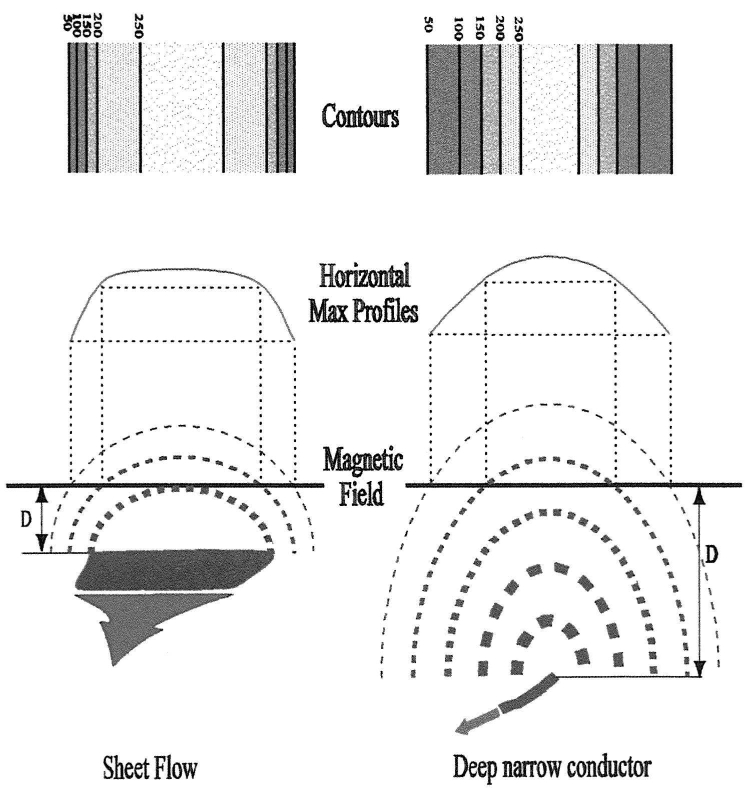


Figure c.

Figure d.



e. Up-welling along a conductor will start with lower values due to the depth of the initial flow then increase and narrow in the area of the up welling.

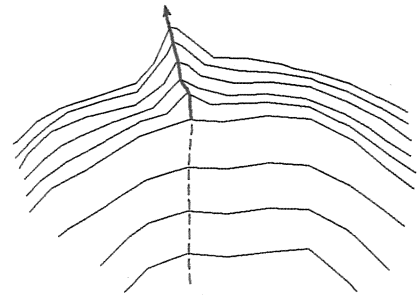


Figure e.

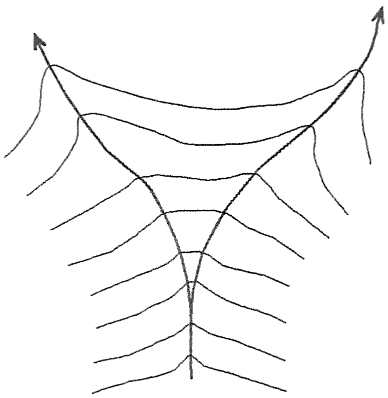


Figure f.

f. Branching in a conductor will show very misleading results in the area of the branch as two or more fields will be measured at one time.

g. If the water becomes less conductive or if the thickness of the water layer thins, this area will change to a lower field strength as less current will be carried. An example would be where relatively fresh water passes through a reaction zone and picks up additional minerals. Measured from the high conductivity side to the low conductivity side, there will appear to be a rapid decrease in conductivity, far more pronounced than could be accounted for by increased distance from the current source. This will look very similar to water flowing along a vertical structure. (see Figure c)

h. Conductors in the surrounding rock or soils, even weakly conductive soils, will cause distortions in the fields measured and may even form secondary fields. These conductors may be a wide variety of things, the most common of which may be power lines, water pipes, or phone lines. These generally produce wide and wild variations in the field and are thus easy to identify.

i. An attached clay lens, such as a repository lining, will tend to mask the field of the conductor being tracked and could produce localized high readings in wet areas as they will act as good conductors and concentrate current. What generally happens over a clay liner is that there is an broad low intensity anomaly that outlines the clay liner and thus this anomaly can by modeled and removed.

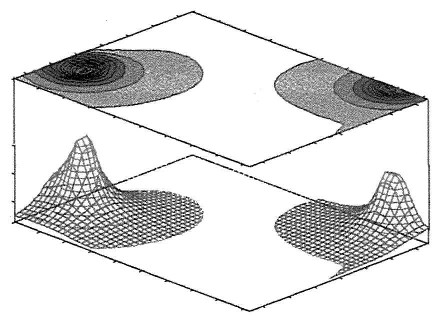


Figure j.

j. Fields in the area of a return electrode show higher values as the current will be collected and concentrated at the electrodes no matter which path it has taken. As shown in Figure j this anomaly is very localized and predictable thus it can generally be accounted for in the data.

k. The rate of change in the horizontal direction of the vertical magnetic field intensity across the anomaly is proportional to the width of the current path and thus can be used to calculate the width of the groundwater channel. The Amplitude is related to the resistivity contrast between the channel and the soil. The (λ) width is related to how well the channel edge is defined. The (Δ) width is related to overall width and sometimes can provide clues as to depth. These are all theoretical calculations and unfortunately more often than not can not be used with field data. The most common reason that this valuable tool can not be used is that the data spacing is to wide. Generally it is not practical to use close station spacing in an area where preliminary data is just outlining the water channels for the first time.

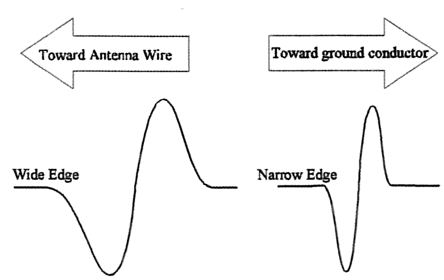


Figure k..

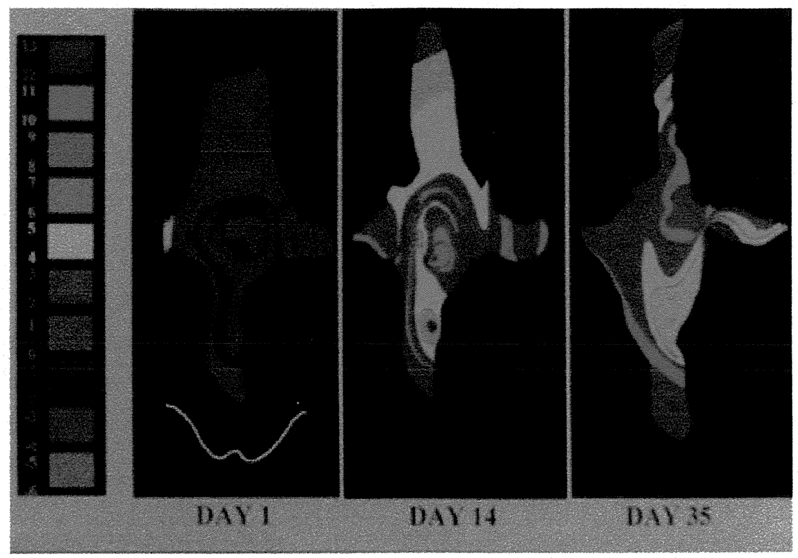
l. Width of the horizontal magnetic field is proportional to depth and width of the channel.

m. Correlation of vertical and horizontal magnetic field data is used to clarify ambiguities of width and depth.

n. Local intensity increases in either of the magnetic fields can indicate chemical or biological activity. Chemical and biological activity translate into the ability to produce ions.

o. A study conducted over time, weeks or months, will show changes in field values and are plotted by taking the difference or ratio of the readings.

p. A study conducted over time, weeks or months, will show changes in field values at the same location due to changes in the flow of water, chemical changes over time (such as oxidation or acid production), or biological activity. Variations from one season to the next would be expected due to variations in seasonal water flows.



Comparing all three surveys shows the increase in conductivity and movement of draw down cone as the result of well pump down test.

q. Comparing changes in the various components of the magnetic field over time provides information relating to fluid movement, change in chemical activity, changes of fluid in an aquifer, changes in subsurface biological activity, movement of chemical or bio reaction fronts, leaching progress and activity relating to in situ mining, progress of subsurface chemical or biological remediation, increases or decreases in subsurface flow, changes in salinity, or any change in the groundwater that affects any of its electrical properties.

r. The direction as the minimum horizontal magnetic field or a direction perpendicular to the maximum horizontal magnetic field indicates the direction of the current or subsurface solution path. This is visible in vector plots of the minimum field direction.

s. As current flows down the groundwater channel, some electrical current leaks into the surrounding medium. The electrical contrast between the channel and host rock can be evaluated by the rate at which the magnetic and electric fields degrade.

t. The dip of the magnetic field is related to depth and dispersion of the ground current that is following the groundwater.

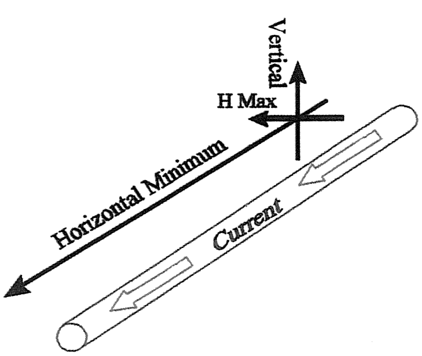


Figure r.

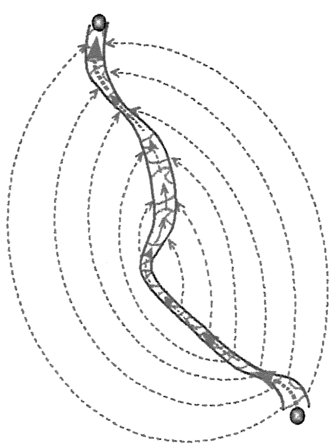


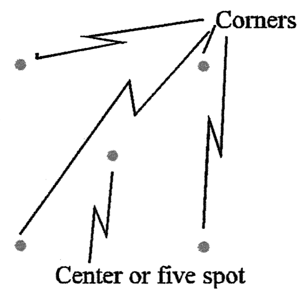
Figure s.

<u>The simple case will rarely exist</u>. Interpretation of the field measurements must therefore include as much information of the site as possible. It is obvious that some field measurements could be interpreted to represent widely different outcomes. Historic data can often be used to eliminate possible explanations. Any known influence on the field must be accounted for and normalized out of the measurements as best as possible. Attempts to overcome this are made preforming a precursory analyzation of data as it is being gathered on the site and confirming the interpretations with further observations, extra diagonal profiles, and by using any historic data about the site.

All possible explanations for the data obtained need to be considered. For example water will flow along the course of least resistance and most likely will not be straight. Its depth from the surface may also change. The channel the water follows may also expand and contract. As is observed in several cases the path of the water may split following several paths. Other conductors may also exist in the area and may be energized. All these things must be taken into consideration during the interpretive phase, and some prejudgment, hopefully correct, during the data gathering phase.

It is possible to prejudice the interpretation if care is not taken and data is not thoroughly analyzed from all possible angles. Dr. Montgomery has over 30 years of experience interpreting geophysical data with proven success.

Data Collection and Analysis



The normal preliminary survey of an area is made by taking magnetic readings at the grid coordinates and at the center of each square or the five spot.

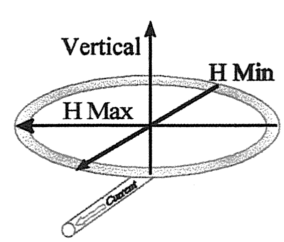
Wells, seeps, springs, or other types of water sources are energized with approximately one amp. Variation in current are corrected by normalizing all the data to one amp to correct any current drift. Drift is calculated by monitoring transmitters output at random intervals.

A second correction is made for diurnal variations. This correcting is calculated by repeated readings at a base station. Base station readings are taken a minimum of three times daily, morning, noon, and evening.

Readings at stations affected by known long continuous conductors are collected but may not be included in the final analysis as they can provide misleading results. These included interference from the wire connecting the electrodes and the fence or row of electrodes. Additionally, sources of interference could be power lines, communication lines, water pipes, and multiple linear sources in the area. Readings that are not obviously associated with known manmade conductors are not excluded from the final presentation.

The values measured at each station are:

1. Location in northing and easting,
2. Minimum magnetic value and bearing,
3. Maximum magnetic value and bearing,
4. Vertical magnetic value,
5. Time, and
6. Any adjacent cultural feature.



Grid Data and Detailed Profiles

The preliminary or regional data is generally gathered on a north-south/ east-west oriented grid with 100 foot spacing. The primary survey is made by taking measurements at the grid points and at the center of each grid square, or the five spot. The reduced maximum horizontal magnetic field values are contoured to determine general location and orientation of the ground-water channel feeding the energized water source. Readings taken over a grid area provide general information related to water flow and preferential direction of channels. Grid data does not provide detailed information defining channels or the edges of channels.

In some surveys rather than using a grid, profiles are used that are oriented with respect to the feature being studied. The profile can be straight or curved. The decision to use straight or curved profiles is generally a decision based on the topography of the area being studied. Flat terrain lends its self to square grids or straight profiles very well. When the topography is steep or rugged the profiles are usually run where there is access.

Detailed profiles taken perpendicular to the path of the channel or water, as determined by the original survey data, provides the information needed for improved accuracy in determining the center of the water channel and the location and type of channel edges. Subsequently, detailed readings may be taken along selected profiles in locations where the initial data indicates the existence of groundwater channels.

For the best results supplemental readings are taken along selected profiles in locations where initial data indicates the existence of groundwater channels. Detailed or supplemental profiles are located by using the initial grid. Data collected along profiles running north-south or east-west are spaced at 25 foot intervals. Diagonal profiles running north-west to south-east or north-east to south-west are spaced using 23.5 foot intervals This spacing was chosen because it was an even division, 1/4 or 1/6th, of the distance between the corners of the square. Thus the corners and the five spot are re-occupied to assure that the magnetic values for the profiles can be correlated with the regional data. This permits the comparison and verification of data. These two spacing intervals provide sufficient information to locate subsurface water-related features to within about 25 feet.

If more precise information is required in one location for planning or engineering information at five foot data spacing can be used. This detailed spacing along a profile will provide details that are relative to approximately five feet. These types of profile must be chosen to run perpendicular to the subsurface channel or groundwater flow to provide the greatest accuracy.

Whenever possible stations in the field are repeated. Thus if a new line crosses an older line the point or station where they cross is re-occupied and a new reading is taken. This assures quality in the data and allows all parts of the survey to be calibrated the same.

APPENDIX 7-60

LITTLE BEAR SPRING STUDY (EXPANDED STUDY, 1999)

AQUA TRACK

File Mill Fork Lease 2820-4

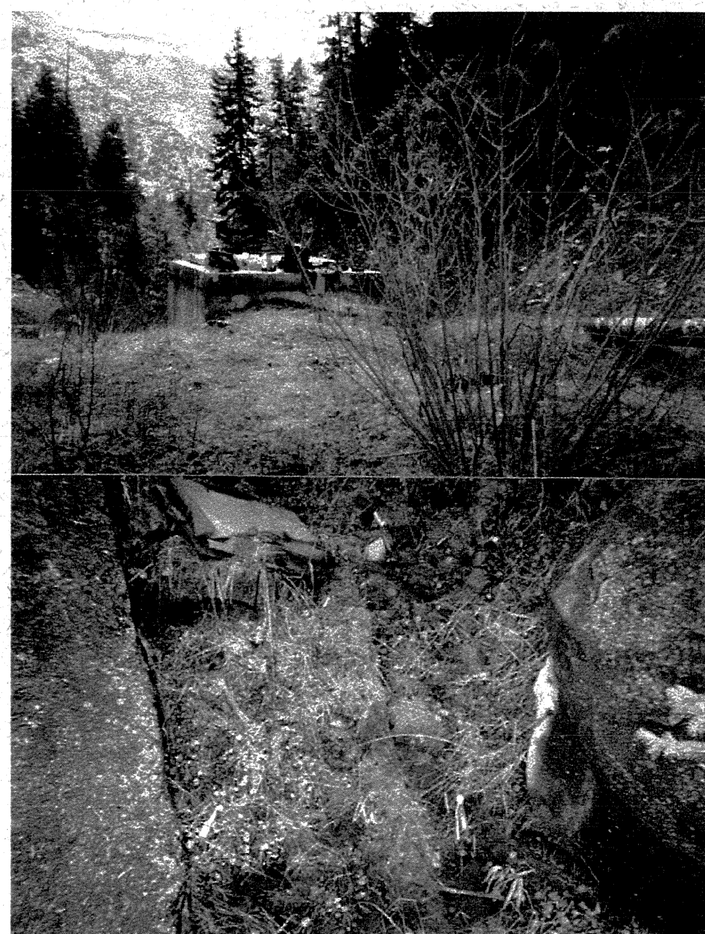
Jeff DeFreest —
Return to Carter

AquaTrack Survey

1999

Little Bear Springs Study

Huntington Canyon, Utah



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AquaTrack

AquaTrack uses electromagnetic energy, injected into the groundwater being investigated, to map water and related geologic structures. More specifically the technology can be used to map, track, and monitor; groundwater, groundwater channels, groundwater structures, subsurface pollution plumes. It can also be used to map interconnected fracture or porous zones, map leaks in earthen dams, and maps leaks in drain fields. The technology will also monitor changes in subsurface water flow, changes in ion concentration in groundwater, progress of in situ leaching solution, movement of heap leaching solutions, changes in subsurface redox or reaction fronts, underground chemical reactions, and subterranean bio-reactions. AquaTrack can also be used to check other subsurface waters and related geologic structures. It works best for tracking long continuous conductors of any kind and in the ground this usually is the path of water but underground pipes and wires are known to cause interference problems.

COMPANIES AND GOVERNMENT AGENCIES WE HAVE WORKED WITH:

Private Companies
ASARCO
Phelps Dodge
Kennecott Copper
Sorenson Development
CH2M HILL
Daniel B. Stephens & Assoc., Inc.
HYDROMETRICS, Inc
Lockheed Martin
Chevron Gas

Government Agencies
U. S. G. S.
U.S. Air Force
Bureau of Indian Affairs
Bureau of Mines
Salt Lake Co. - Flood Control
UT Div. of Oil Gas and Mining
INEEL - DOE - Idaho
Los Alamos - DOE - N.M.

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INDEX

SURVEY OBJECTIVES

Personnel from Water Technology and Research, Inc. (WTR) conducted an AquaTrack survey in Little Bear Canyon, Mill Fork Canyon And on top of the ridge that divides the two canyons. The purpose of the survey was to map the subsurface-water feeding Little Bear Spring in Little Bear Canyon. The goal of the survey was to follow the structure paths feeding Little Bear Spring, and to determine if the path of the ground water source intersected Mill Fork Canyon. In this regard, WTR was asked to provide the information on the following:

1. Expand the map of subsurface flow paths in the vicinity of Little Bear Spring. By Surveying a "U" shaped line the profile wrapped around the south, west and north sides of the 1998 survey area and Little Bear Spring.

2. Continue in identifying the path or route of the groundwater feeding Little Bear Spring.

3. Identify the structure that is controlling the water feeding Little Bear Spring.

4. If possible determine what the source might be that is feeding the spring.

5. If possible find the source of the water that replenishes the spring every year.

6. Find where the structure feeding Little Bear Spring crosses Mill Fork Canyon

CONCLUSIONS:

The results obtained from the AquaTrack data procured during the course of this investigation are summarized below.

1. The expanded survey area in the vicinity of Little Bear Spring is shown along with the results for Little Bear Canyon and Spring on the map of Figures 5, 6 pages 12-13 and Figure 15. Page 25. A cross section profile along the fault controlling the water feeding Little Bear Spring is shown in Figure 19 Page 30.

2. From the 1998 survey the path of the groundwater was found to be following a fault line. Along this fault the data indicates that the groundwater has hollowed out caverns or cave like structures creating a cistern like system in the mountain range south of Little Bear Spring. In the 1999

> The use of the words "caverns or cave like" in this report do not reference the large open system seen in limestone formations. They refer to what develops along a fault such as gaps or spaces between the fault planes, small pockets created by dissolving the calcite between sand grains to form pockets of sand. These sand pockets would be about the same size and shape as the pockets seen in the cliffs in this area.

survey the data upheld this conclusion indicated water is following this fault and structures related to this fault. This was verified by the data from all three areas studied in this years survey, first Little Bear Canyon, second the ridge between Little Bear Canyon and Mill Fork Canyon, and third Mill Fork Canyon.

A secondary structure was also identified which connects Mill Fork Creek water to the dominating fault that controls the Little Bear Spring water system. This secondary structure creating a leg extending from sinks in Mill Fork Canyon to an area under the ridge where the two structures join, see the combined interpretation and Figure 15 Pages 24-25. The first indication of this secondary structure was identified in the ridge top survey. It is expressed as the right leg of the inverted "Y" on Figure 8 Page 15.

3. There is one main fault line that the groundwater is following.

- In Little Bear Canyon the fault line was found to continue south and north of the 1998 survey area see Figure 6, page 13.
- On the ridge top this fault line was identified in the profiles station 5, Figure 9 Page 16. The small leg connects to the fault in this area adding water to the Little Bear Spring system, see Figure 8, page 15.
- In Mill Fork the controlling applicable fault line was identified at station 44, see Figures 11, thru 14 and the accompanying explanation pages.18 thru 23.

For a complete map that is a composite of all three survey areas see Figure 15 page 25.

4. From the 1999 data it was possible to identify a *portion* of the water that yearly replenishing the groundwater. This water source was Mill Fork Creek. This is probably not the main source of water feeding Little Bear Spring, but this water source adds to the total of water coming from Little Bear Spring.

The Small sinks are not the giants that occur in limestone formations. The sinks visible in Mill Fork Creek bottom are about two to three feet in diameter, about a foot deep, and a sorted sand forms the bottom.

The water enters the system where the water disappears into small sink holes in the bottom of Mill Fork Creek near station 21. These sinks were used as the contact points of electrode 2, see Mill Fork Canyon Interpretation and Figures 11-14 pages 18-23. This is where the data indicates that there is a connection from Mill Fork Creek to the Little Bear Spring groundwater system. The data indicates this leg connects to the Little Bear Spring system under the survey area on top of the ridge. The path for this leg and for the main fault line can be seen in Figure 15. The data still indicates that a *portion* of the water is from sources that fills the fault line south and possibly north of Mill Fork Canyon.

5. The groundwater feeding Little Bear Spring comes from multiple sources. The primary direction of flow is probably to the bottom of the syncline of which is Little Bear Canyon's axis.

- First, The part of the water feeding the Little Bear Spring system is one or more unknown sources south of Mill Fork Canyon.
- Second, a portion of the water in the Little Bear Spring system is from Mill Fork Creek. The data indicates that this water is entering the system by small sinks in the bottom of Mill Fork Canyon. The water that enters these small sinks eventually connects to and enters the dominating fault structure that controls primary groundwater feeding Little Bear Spring.
- Third, there is a small possibility that some of the water could be coming from north of Little Bear Spring along this same fault system. The data indicates that the fault structure continues to the north. Two caveats; First, north of the springs, in the direction of the fault, the slope is primarily down gradient except for one short section. Second, because Little Bear Canyon is located on the axis of a syncline that short section of the fault system that is up gradient is immediately north of Little Bear Spring on the north side of Little Bear Canyon. This could be why so much water exits from the fault system at the location of Little Bear Spring. However, the trend of the gradient past this point is down gradient because of the angle of the fault.

6. The dominant fault in the Little Bear Spring system crosses Mill Fork Canyon at our 1999 survey Mill Fork Canyon station 44 seen on Figure 14 page 22. The data indicates that the fault crosses at this point and that there is water in the fault system. This location was identified during the interpretation process, after the field work had been concluded. Thus, no additional data was collected around Mill Fork Canyon station 44. Thus the data does not indicate if water is entering the Little Bear Spring system at this point or if it is just passing under Mill Fork Canyon at this location.

Additional analysis of the data collected in Mill Fork Canyon around station 44 indicates that the underground water surface at station 44 is possible 100 to 200 feet below the surface, see Figure 16 and its explanation on Page 26.

7. A composite of the AquaTrack survey results and Huntington Mine #4 supplied by Utah Oil, Gas, and Mining indicate that the water feeding Little Bear Spring is below the mine workings, see Figures 17-18 Pages 27-29.

INTERPRETERS NOTE

This section has been included for disclosures and clarification on terms used in this report.

The station spacing used in this survey was either 50 feet or 100 feet, thus the accuracy of any point located by the data taken during this survey is ± half the station spacing. This implies that the error in locating the channel center is ± half the station spacing with a maximum error in the width of the channel of the ± station spacing.

Survey lines' (SL), are lines of data collection in the survey area. Profiles are the survey lines' data after mathematical corrections have been made for objects that influence the data such as power lines and known utilities. Line is a survey line of data stations referring to as a profile or SL. Station refers to a point on a survey line where that data were collected. Channel(s) are paths of current flow that can result from groundwater, utility lines, soil disturbed by past trenching or abandoned manmade structures such as old underground flews, etc.

The coordinate system used in this report defines north and east as positive numbers and south and west as negative numbers. The numbers along the bottom of the profile charts are in hundreds of feet so the distance between -2 and +1 would be 300 feet. For all the profiles the observer is looking west or north. In the case of the east/west profiles the observer is looking north.

BACKGROUND:

Little Bear Spring is the largest spring in Huntington Canyon and is used to supply culinary water to Huntington City and other surrounding towns. Coal mining in the area could disrupt the source of water feeding or replenishing the spring. It is important to both the water users and the coal mining companies to know the source of water and also to know the source replenishing Little Bear Spring. The continuation of the field survey for Little Bear Spring was conducted in August and early September of 1999. The last of the wire was picked up October 1 1999. Data reduction and modeling were done in September of 1999, and the interpretation and report was written in October of 1999.

TECHNOLOGY USED- AQUATRACK, How it Works:

AquaTrack uses electricity to follow the groundwater and map its subsurface paths. The best conductors in the ground are water, ore bodies and manmade structures like metal pipes or buried wire. AquaTrack works by directly energizing the groundwater in question. In this survey this was accomplished by energizing Little Bear Springs and using the water in Mill Fork Creek to complete the circuit. The electricity flowing in the groundwater generates a magnetic field. By mapping the magnetic field, the flow of electricity in the ground is mapped. The map of current flow thus generates a map of the groundwater.

For a more detailed explanation refer to the appendixes.

EQUIPMENT AND SETUP:

The AquaTrack survey requires the establishment of an electrical circuit which includes the groundwater to be mapped. In this case that was Little Bear Spring on one end and water in Mill Fork Canyon on the other end of the circuit. The current takes the best path (least resistance and generally the shortest) to the return electrodes, completing the circuit. Most surveys, excluding this one, utilize only one direct contact point with the water being surveyed. However, in this survey an attempt was made to energize both ends of the water. For the 1998 survey Little Bear Springs was energized and the ground was in Huntington Creek. This electrode arrangement did not provide a signal that would reach Mill Fork Canyon. The first electrode setup in Mill Fork Canyon used the re-emergence of Mill Fork Creek as the ground point. Using the first electrode system the survey was unsuccessful in locating where the Little Bear Spring system crosses Mill Fork Canyon. For the second electrode arrangement in Mill Fork Creek a series of small two to three-foot in diameter and a foot deep sinks were used where Mill Fork Creek disappeared into the ground. This second electrode arrangement was located where the Little Bear Spring system crossed Mill Fork Canyon.

Survey Area

The survey area first extended the coverage around Little Bear Spring in Little Bear Canyon; second, it covered a small area on the ridge between the two canyons; and third, several profiles in Mill Fork Canyon were surveyed.

The survey line in Little Bear Canyon was "U" shaped, see Figure 1. The line starts north of the spring extended toward the west around the base of the valley and up a ridge on the

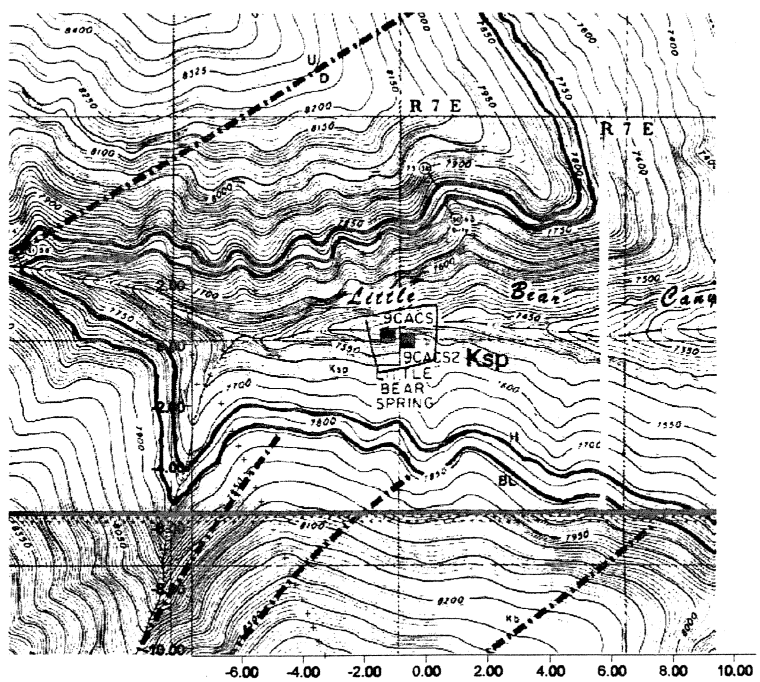


Figure 1 Map for 1999 stations in Little Bear Canyon.

south side of Little Bear Canyon. New data stations are shown with respect to the location of Little Bear Spring, see the blue "+" in Figure 1.

On the ridge top three lines were surveyed. The main line started west of the fault line that was thought to be the structure feeding water to Little Bear Spring, and continued to the east to the ridge point. This line was used to determine if the structure could be identified at the top of the ridge. If it could be identified, then what is the depth of the water in the structure. Once the structure was identified, two shorter lines were surveyed to determine trends and direction of the water structure, and how it runs under the ridge. Data station locations are shown on top of the ridge in Figure 2 as red "+".

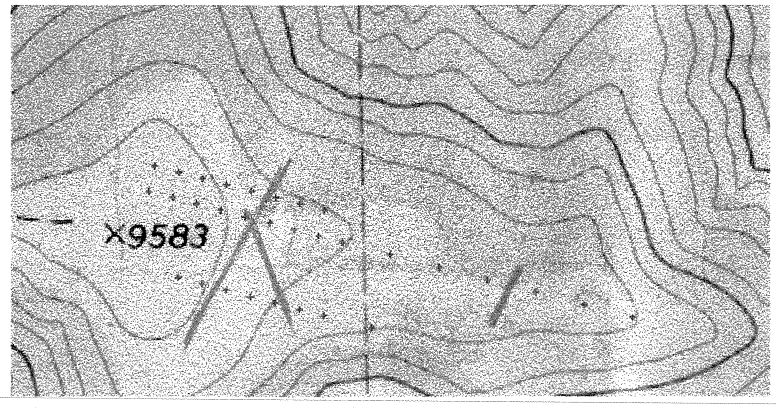


Figure 2 Station on top of the ridge.

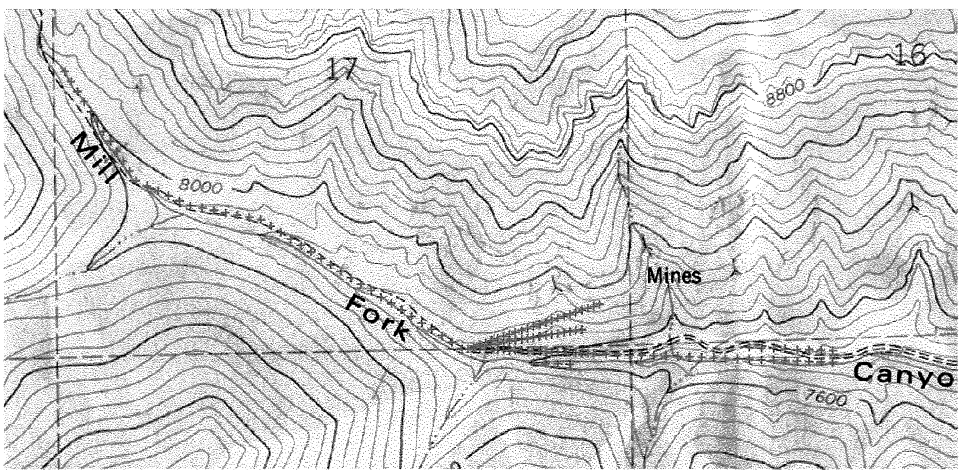


Figure 3 Stations for 1999 in Mill Fork Canyon.

Mill Fork Canyon is the farthest south profile in this survey. In Mill Fork Canyon there were two electrode set ups. The first electrode was set up where the water in Mill Fork Creek started to flow again. The second electrode setup was where the Mill Fork stream disappeared into the ground. Some survey stations were measured twice in Mill Fork Canyon using the different electrode arrangement. Figure 3 shows station locations in Mill Fork Canyon as red "+" .

Electrode Placement

Four electrodes were placed into the water around Little Bear Spring. Return or ground electrodes where placed in Mill Fork Creek to completes the circuit. The connecting wire was run down Little Bear Canyon across Huntington Creek then under the road through a drain pipe to the east side of the highway. The wire was then laid out along the highway to Mill Fork

Canyon where it was again put through a drain pipe to go under the highway. The wire then crossed the river and continued up Mill Fork Canyon to where the electrodes were placed in Mill Fork Creek. The wire was placed on the east side of the highway because there were no campgrounds or pull offs on that side of the highway, so that the likelihood of a camper or fisherman tripping on the wire was minimized. A map indicating wire position is shown as Figure 4.

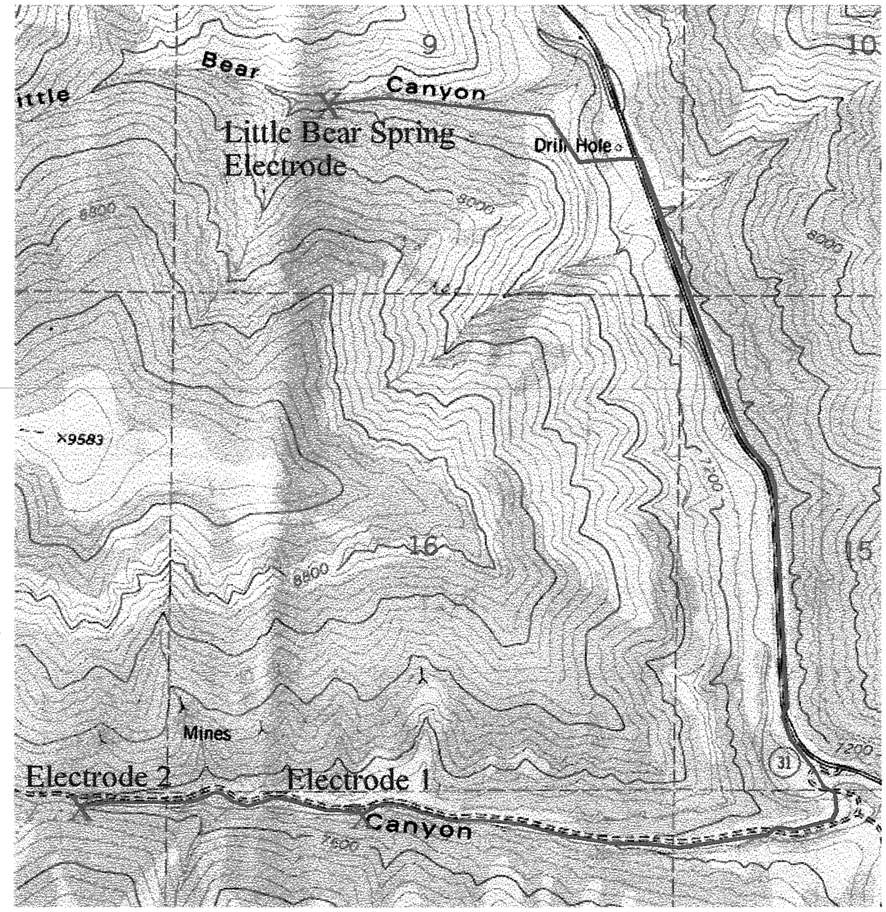


Figure 4 Location of electrodes and wire connecting the electrodes.

The return electrodes were placed in Mill Fork Creek to avoid the problem discovered in the 1998 survey where the signal bled off into Huntington Creek before it reached Mill Fork Canyon. The route described above posed the best antenna to see if the ground water source for Little Bear Spring intersected Mill Fork Canyon.

The first electrode setup in Mill Fork Creek was where the creek starts running again. It was thought that this is where the water resurfaced from where it disappears underground further up Mill Fork. The results of this survey indicated otherwise, and there were some anomalies in Mill Fork Canyon that needed further investigation. A second electrode configuration was needed, thus, the return electrode was moved up the Mill Fork Canyon about 1500 feet to where the water in Mill Fork Creek disappears into several small sinks.

The stations along the main survey line on Mill Fork Canyon road and trail were then re-occupied to obtain a second set of data, using the second electrode configuration, that could be compared to the data from the first electrode arrangement. Using this second set of data or readings, survey lines on the north and south side of the Mill Fork Canyon road were surveyed to obtain additional information about the primary anomalies in Mill Fork Canyon. It was discovered after the data was reduced that the anomaly defining the main Little Bear Spring Structure was overlooked during the field survey. However a secondary source and possibly the only Mill Fork Canyon connection to Little Bear Spring was identified.

Grid Location

Because of the terrain a regular grid was impossible to establish. Lines were positioned where the terrain would permit. Whenever possible the lines were kept 100 feet apart. Near the end of the survey a couple of intermediary lines were run to better define the subsurface system. The station spacing was 50 feet along the line. The base station was located at the beginning of the lines in each canyon and on top of the ridge and then repeated as often as the survey permitted, usually at the beginning and at the end of the day. The station locations are superimposed on topographic maps shown in Figures 1, 2, and 3.

SURVEY RESULTS:

At each survey point, data was taken to allow the magnitude and direction of the magnetic field produced from the transmitter and antenna to be calculated. The data was analyzed using several techniques. The magnitude of the magnetic field is used to produce a contour map. The profiles were analyzed individually to gain additional insight into the subsurface channel configuration. The groundwater channel centers are obvious in this data, however in contour data, edges are a little more difficult to identify. The center and edges of groundwater channels are easier to determine on the profile.

Because of the overall area covered by the survey, there are three main areas that will be discussed individually; first, Little Bear Canyon; second, on top of the ridge; and last is Mill Fork Canyon. In each area the discussion will focus first at the contour data and subsequently the profiles and then vector models if used. The two or three types of interpretation will be used to corroborate each other and help the reader follow the interpretation process. The final map will be a composite of the information obtained from all forms of analyzing the data.

Contours

The contour maps used in this report are based on the maximum horizontal field. A standard contouring program, "Surfer" was used to generate the map. This program utilized a method known as "Kriging." Stations are marked with a small "+". Computer programs yield ambiguous results where there is no definitive data. Often it is best to ignore the contours in such areas. On the maps used in this report these contours have been removed.

Profiles

The profile interpretations in the report were created from the data set and do not indicate what order or how the data was gathered. The profile order is arbitrary, and was chosen to provide the details for the structures that needed to be studied. In the following sections the profiles are analyzed from north to south starting at Little Bear Spring.

The different colors used on the line or profiles in the maps that follow are to assist the reader. By using the different colors the various profiles can be individually identified where they overlap. On the maps data stations are generally shown in red "+". The exception is Little Bear Canyon where the 1998 stations are in red "+" and the new 1999 stations are in blue "+".

Little Bear Canyon

For additional data in Little Bear Canyon one "U" shape line was proposed for the 1999 survey. This line would cover area farther north, west and south of the 1998 survey. The positions on the map of the new 1999 survey stations can be seen in Figure 1 as blue "+". The positions of new stations in relation to last years stations can be seen on the contour map Figure 5 and on Figures 6 and Figure 15 with blue "+' for 1999 stations and red "+" for 1998 stations.

Figure 5 is the contour map of the results obtained in Little Bear Canyon when both surveys are combined. This map shows that the anomaly structure is trending in a southwest direction along the same course as indicated in the 1998 survey interpretation. The profile added in 1999 indicates that the anomaly to the north of the spring trends toward the northeast so that the continuation of source structure is a northeast direction instead of a northwest direction that the 1998 survey data indicated. The earlier interpretation was incomplete due to the inefficient data to the north. So the anomaly and structure to the north of Little Bear Spring is a

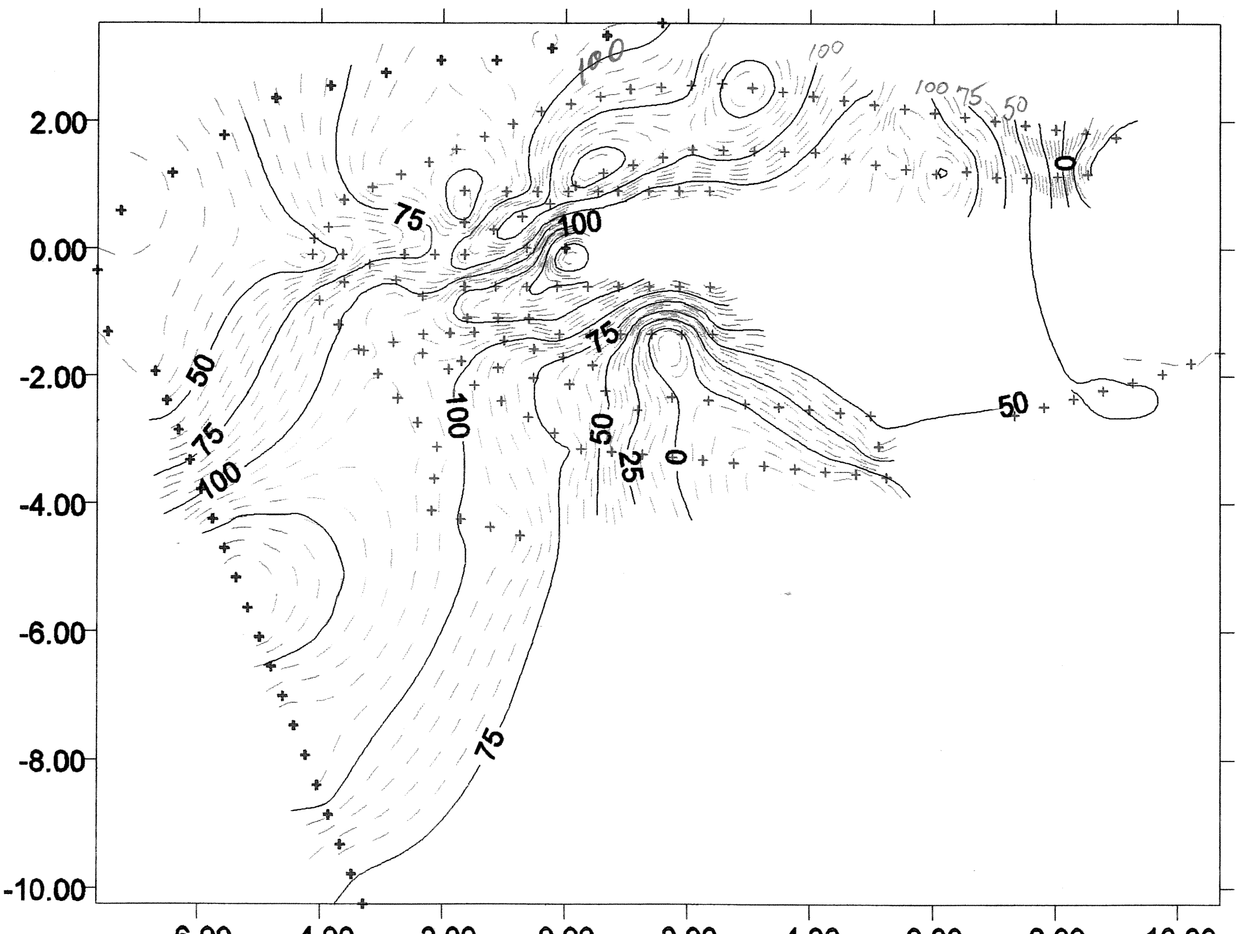


Figure 5 1999 Contour map of Little Bear Canyon. 1999 stations are blue. 1998 stations are red "+".

continuation of the anomaly and structure to the south of Little Bear Spring. Meaning that all the water in the system might not be coming out at Little Bear Spring. Some could be moving farther north along the fault system. An alternative possibility is that south of Little Bear Spring groundwater is moving north to the spring, and north of Little Bear Spring ground water is moving south towards the spring. However, elevations of structures and formations in the area tend to negate this second hypothesizes. The one sure fact is that Little Bear Springs water is coming from the fault system and associated underground structures shown in the final interpretation map at the end of this report.

Figure 6 shows the interpretations of the contour map and the profile data in the immediate vicinity of Little Bear Spring. The yellow dotted line is the projected line of the fault that the groundwater feeding Little Bear Spring is following. The center of the anomaly outlining the groundwater is shown with a dark blue line. The area affected by the groundwater is shown in blue with the affected edges outlined with purple dotted lines. The black dotted lines are the fault lines indicated on geologic maps. The grey lines on Figure 6 are formation contacts. These are used as reference points since they are found on geologic maps and are referred too in the 1998 report. The light brown areas are tight formations with no water. These areas are discussed in the 1998 report.

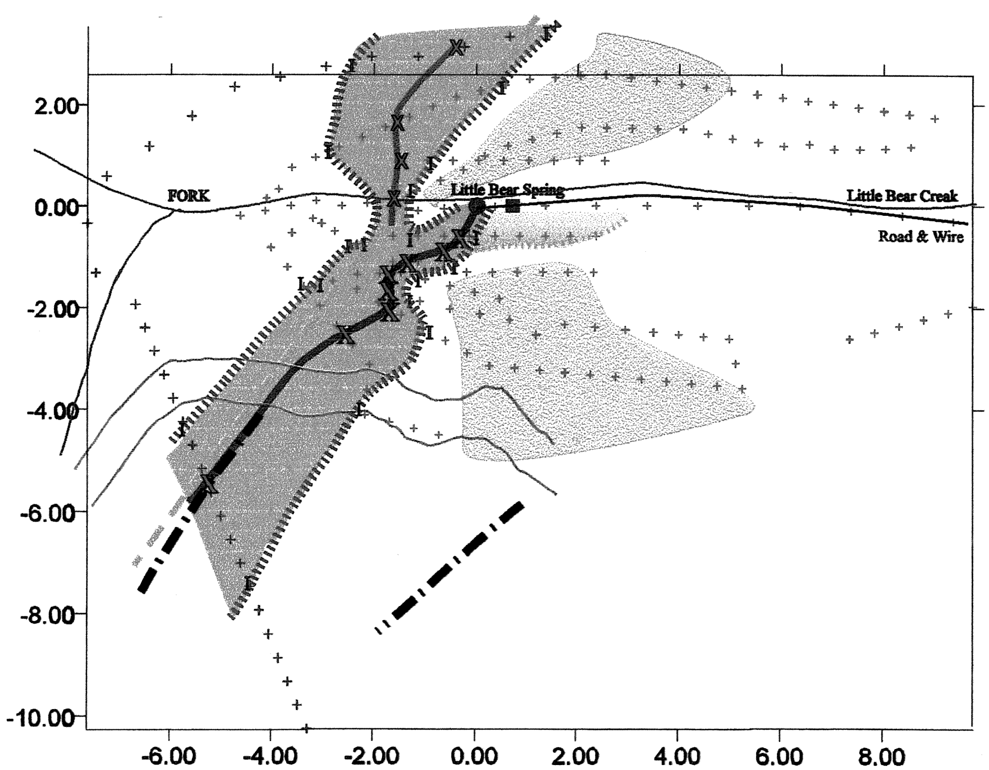


Figure 6 Interpretation of Little Bear Canyon Contour map.

Shown in Figure 6 is the center of the anomaly mapping the groundwater (dark blue line) which follows the fault line projection (yellow dotted line), with the exception of the area around the spring. There is a little detour in the path of the water where the path turns to the east and flows towards the spring.

West of the spring some of the groundwater could turn north and continue along the line of the fault projection. The least likely possibility is that groundwater is feeding Little Bear Spring from both the south and the north, that all the water from both directions comes out of the spring.

Figure 7 is the "U" line profile in Little Bear Canyon. This line starts on the north side of Little Bear Canyon with station 0. The line continues westward to Little Bear Creek. It then ~~across~~ crosses the creek and proceeds up the hill toward the southeast ending at station 22 on the south side of Little Bear Canyon, see Figures 1 and 7. Little Bear Creek is located between stations 9 and 10. This profile shows anomalies in two places. The south side anomaly is between stations 14.5 and 18. The readings show no anomaly to the west of the spring supporting the data gathered in the 1998 survey and the conclusion that none of the water from Little Bear Spring is coming from Little Bear Creek. On the north side of the "U" the readings increase again showing another anomaly. However, when the new data is added to old data, the trend of the anomaly and fault controlling the groundwater on the north side of Little Bear Canyon is in a northeast direction, instead of trending in a northwest direction as the 1998 data indicated. The 1998 data only identified a local structure north and west of the spring. With the addition of the 1999 data, the trend is that the groundwater both north and south of Little Bear Spring is associated with and controlled by a long fault. The southern extent of this fault was previously mapped on the surface. The northern extent of the fault has not been mapped on the surface. It could be that the fault has only a weak surface expression north of Little Bear Spring or the geology has not been mapped in detail north of Little Bear Spring. Thus indications are that primarily the groundwater feeding Little Bear Spring is controlled by a single fault line trending from the north east to the south west. The projected continuation of the fault line through the canyon is shown in Figure 6. The line indicating the center of the anomaly defining Little Bear Spring feeder system overlay the fault zone both in position and direction.

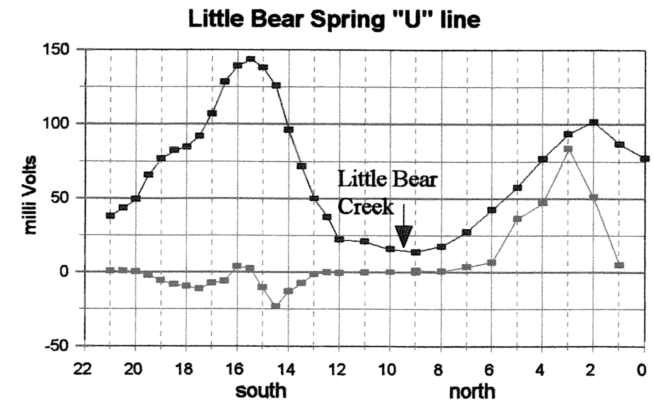


Figure 7 Little Bear Canyon "U" line/profile.

Top of Ridge

Figure 8 is the contour map of the data collected at the top of the ridge in 1999 between Little Bear Canyon and Mill Fork Canyon. The yellow dotted lines in Figure 8 identify the centers of the anomalies. Meaning that at those points the electrical current is flowing directly below these survey lines. There is one main anomaly on the contour map with two additional smaller anomalies. The strengths of the anomalies are partially controlled by where our return electrode was placed. The largest anomaly on this map is the leg of the upside down "Y" starting at station 6 on the bottom of Figure 8. This anomaly trends to where the water disappears into a series of small sinks in Mill Fork Creek. This is the strongest anomaly on this contour map because the return electrode was probably connected to a collateral groundwater source that is feeding Little Bear Spring. This will be further explained in the Mill Fork Canyon interpretation.

The second largest anomaly, by the magnetic reading, is the long leg in the "Y" anomaly in Figure 8. This leg, alines with the mapped fault line indicated in 1998 survey and now in the 1999 survey as the structural source primarily feeding groundwater to Little Bear Spring. This is easily seen on the final interpretation map at the end of the report. On the final interpretation this fault system and the groundwater system feeding Little Bears Spring is indicated by a pink dotted line that traces the fault line. The data defines this path as the main source of the water feeding Little Bear Spring.

The third anomaly is over to the east, starting at station 14 on Figure 8. This anomaly is a separate water feature from the Little Bear Spring. This anomaly is also associated with another mapped fault line. This anomaly has weak magnetic readings indicating it is small, but there is enough current accumulating in this structure from current leakage through the ground that there is some water or moisture associated with this fault.

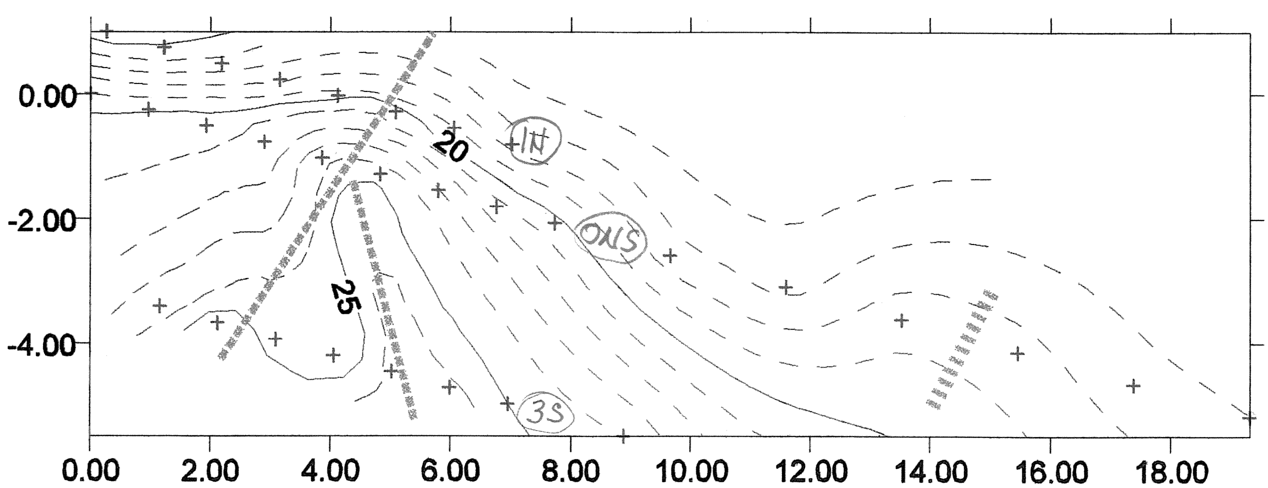


Figure 8 Contour Map of the top of the ridge between Little Bear Canyon and Mill Fork Canyon.

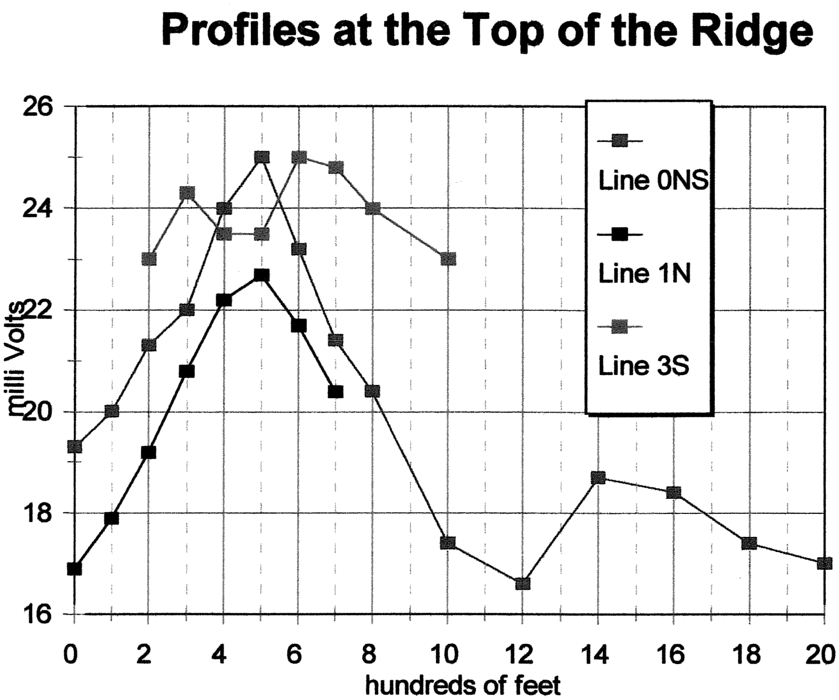


Figure 9 Top of ridge profiles.

Figure 9 is the graph for the profiles on top of the ridge. This graph indicates that on line -3N there are two anomalies close together. One at station 3 and the other between stations 6 and 7. Line 0NS the graph shows two anomalies, however the larger anomaly centered at 5 covers the same area as the two anomalies on line -3S. This anomaly is larger than each of the two on line -3S, this indicates that the two anomalies have become one anomaly at this point. This supports the data seen in the contour map of the "Y" shaped anomaly and gives an angle of the leg of the anomaly at stations 6 and 7 on Line -3S.

The second and smaller anomaly on Line 0NS centered at station 15 lines up with a mapped fault line and shows no indication of being connected to the Little Bear Spring anomaly.

Line 1N supports the conclusion that there is only one anomaly in the area between stations 2 and 7 centered at station 5. One anomaly in this area indicates that the two anomalies in line -3S did merge into one anomaly and that both are feeding groundwater to Little Bear Spring.

Figure 10 is the vector model for the data from on top of the ridge. There

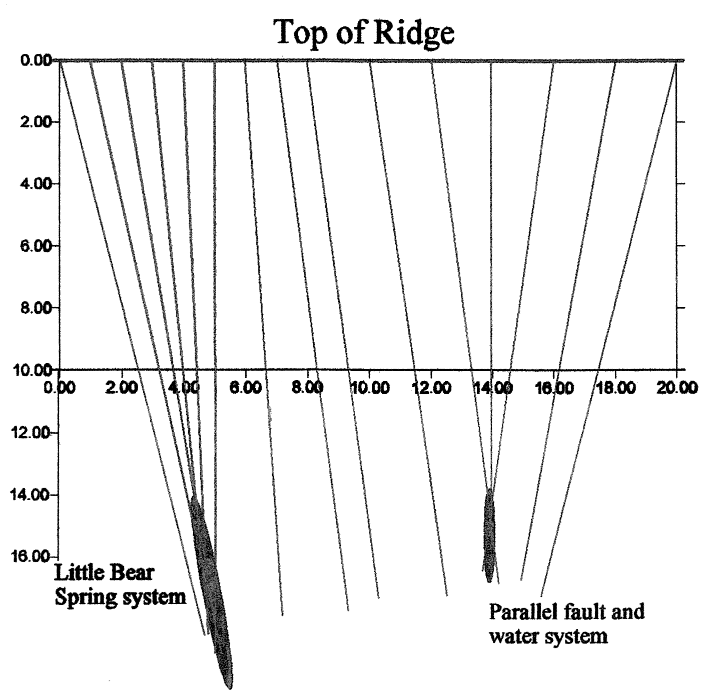


Figure 10 Vector models for the top of the ridge.

was little elevation change along the profile, and the anomalies on top of the ridge were distinctive enough that they lent themselves to vector modeling. This vector model was included in the report to support the profile data that the two fault systems are separate and that the small anomaly seen on line 0NS at 14 is not connected to the large anomaly at station 4, which is the structure feeding Little Bear Spring, in this area of the survey. The vector models also indicate approximately how deep the anomalies are. The top of the ridge is about 9400 feet. The highest point at which the vectors cross on the Little Bear Spring system is 1650 feet below the surface or at an elevation of about 7700 feet. Moving away from the center vector, the other vectors continue to indicate closure at ever increasing values. The range where the vectors cross is between 1650 and 1850 feet, that puts the top of the water just between about 7500-7700 feet in elevation. It should be pointed out that the vector models will indicate an average ~~the~~ depth for structures that are planer in nature, and usually yields values that slightly are deeper than the top of the water. Thus, the depth to the top of the water could be as high as 7800 feet.

Mill Fork Canyon

The data for Mill Fork Canyon was measured using two separate electrodes. The reduction of the data involved two extra mathematical steps so the two sets of data would be compatible. This section will explain each of the procedures and what they were designed to compensate and model.

The first correction is a standard correction that is applied to all data. This correction is to account for the fall off of current as it spreads out from an electrode. In a homogeneous earth the current would spread out evenly and as it is spreading from a point its effect is circular. The larger the circle the more the current is diffused. Thus, to ascertain the true nature of the medium, a circular correction must be made. The circumference of the circle is 2π times the radius. Since the factor 2π is a constant, it does not change regardless of how big the circle is, but the radius is larger for larger circles. Thus, the current is less by a commensurate amount. Therefore, to correct for the spread of the current from a pole, the magnetic field measured at the station must be multiplied by a factor related to the distance the station is from the pole. This is a standard correction that is applied to all such data.

The second and third corrections are only used to combine and correlate data collected at the same stations using two or more separate electrodes. The second correction can be best explained by visualizing what would happen if a current carrying wire was not covered with insulation and was laying on the ground. The electrical current would gradually leak off to the ground. Because the wire is a better conductor, the current does not leak all at once, but rather it would gradually leak off along the length wire until it crossed a good conductor in the ground. At the good conductor all the current would be shorted to ground.

This is what happened in Mill Fork Canyon. The first electrode in Mill Fork Creek was placed in that part of the creek where the water starts to flow again after disappearing under ground further up the canyon. This electrode position is labeled electrode one. It was determined by reducing the data from the electrode one, and during the field survey, that the current from electrode one energized a groundwater for a system that is different than the Little Bear Spring system. However, part of the current followed the groundwater in Mill Fork Creek up the canyon to where it reached a connection with the Little Bear Spring system, so only part of the Little Bear Spring system was mapped. The location of this connection is the small sinks where Mill Fork Creek disappears into the ground. Thus, a second electrode position was established in Mill Fork Creek in these sinks that are about two to three-foot in diameter and about a foot deep where the water disappears into the ground. This electrode setup is and has been referred to as electrode setup two. Electrode two turned out to be in a secondary interconnection to the Little Bear Spring system. The effect of current flowing from these connections is analogous to the bare wire analogy above, and the corrections that need to be made to the data for this situation are straight forward. The correction is the slope of the signal fall off as measured in the data. This represents the rate at which the electrical current is being bled off from the current flowing up Mill Fork Creek's groundwater system. A simple straight line approximation of this slope was thus subtracted from the data to make the second correction see Figure 11.

Figure 11 has been corrected for the radial effects as explained above. The corrections needed for the current bleed off are shown in this figure as sloping lines paralleling long strings of data for both electrode one and electrode two in Mill Fork Canyon. The downward slope of the readings from right to left is caused by signal bleed off. The orange line for electrode two and the brown line for electrode one show the area that needs to be corrected for the far field bleed off effects. The red line on electrode two and the grey line on electrode one show the area where corrections are needed for the near field bleed off. The near bleed off is the area between the electrode and a certain point where the current bleed off is high. Once the current reaches that zone the amount of current bleeding off changes. The current loss is less under these conditions when measured over a given length or distance. The point at which the bleed off changes from near to a far field bleed off is usually associated with an anomaly that represents a high conductive zone.

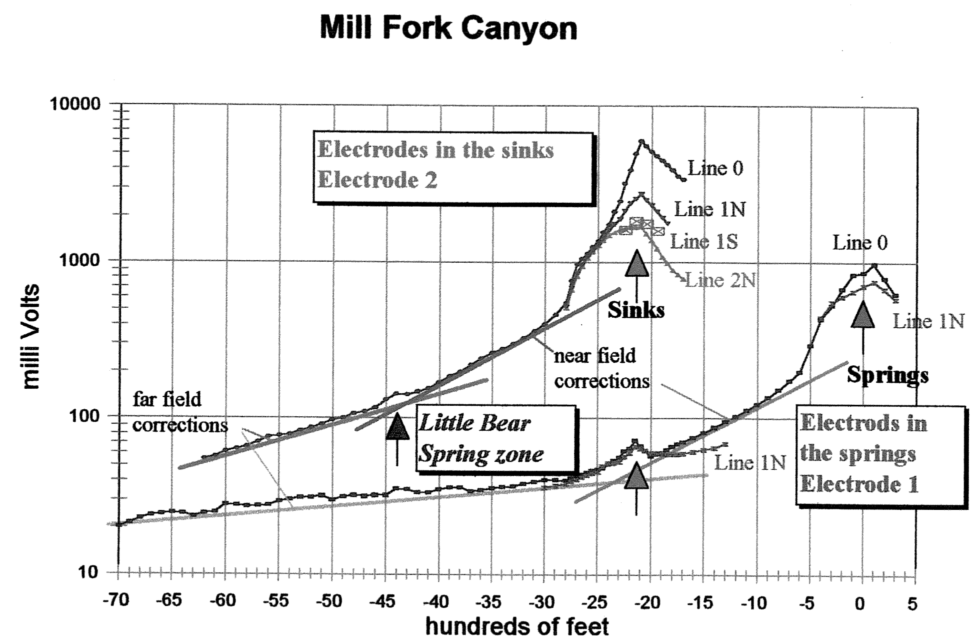


Figure 11 Radial Corrections for Electrode setups 1 and 2.

Figure 12 is the data interpretation for the electrode one setup showing the progression of data as the corrections have been made for the near and far field current bleed off. The electrical current bleed off is the second correction made to data that is explained above. Electrode one setup is when the electrodes were placed in Mill Fork Canyon where the water resurfaced in Mill Fork Creek. All three lines in Figure 11 show the same set of data readings, but are for different corrections; the radial correction, the far fields bleed off correction and the near field bleed off correction.

There are two anomalies seen on Figure 12 the first is at station 3. Notice how once the near field bleed off is corrected for, the anomaly centered at station four nearly disappears. This indicates that this anomaly is not part of the Little Bear Spring system. It still is an anomaly / water source, but if it had been connected to the Little Bear Spring system it would not have drastically changed once the data had been corrected for a near field current bleed off.

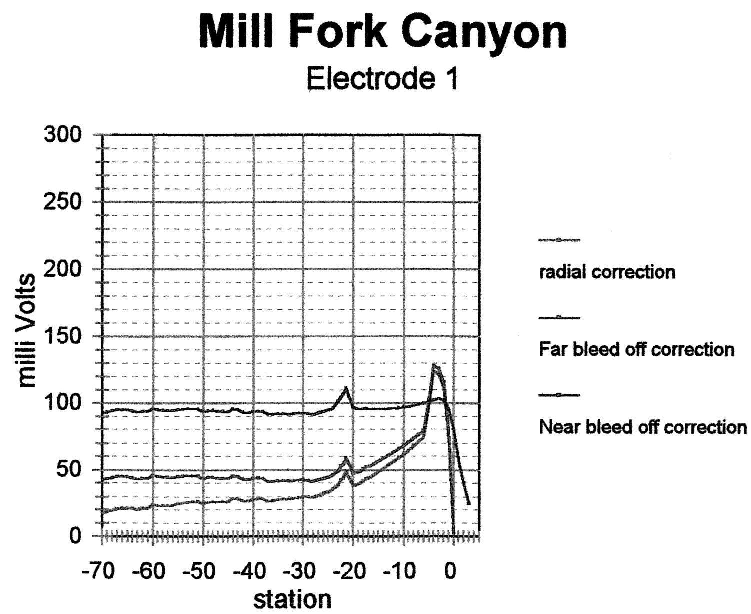


Figure 12 Electrode 1 setup Mill Fork Canyon data

The second anomaly shown for electrode 1 in Figure 12 is a smaller anomaly at station 21. This anomaly is directly connected to the Little Bears Spring system. This is evident in that it did not disappear or decrease in size with all the corrections made. This anomaly is located where the electrodes were moved to for the second electrode setup.

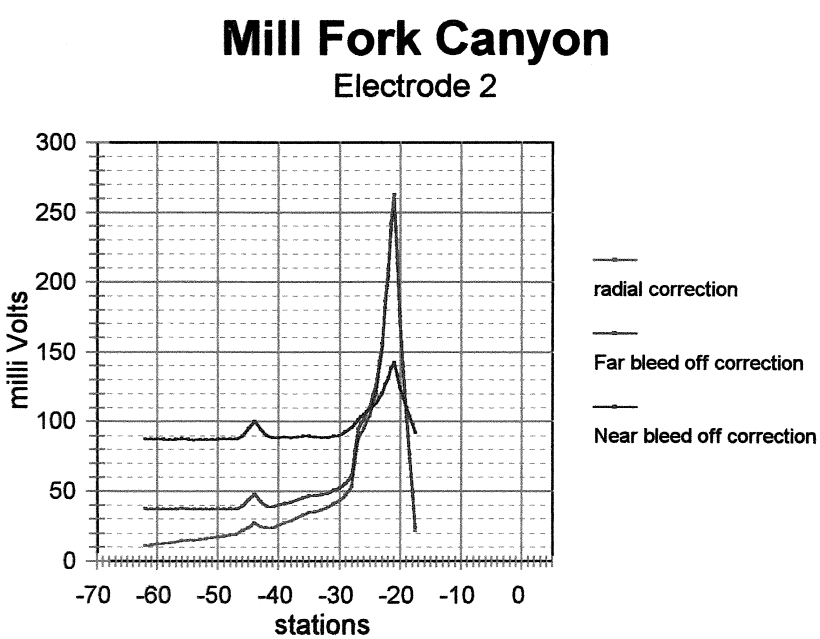


Figure 13 Electrode 2 setup Mill Fork Canyon data

Figure 13 is the data interpretation for the electrode two setup showing the progression of data as the corrections for the near and far current bleed off have been applied. Electrode two setup is where the electrode was moved about 1800 feet west, up Mill Fork Canyon to where the water disappeared into some small sinks in the Mill Fork Creek.

There are two anomalies for the Electrode 2 setup, however there is only one anomaly that is the same from one electrode setup to the next. That anomaly is located at station 21. This anomaly is where Mill Fork Creek disappears into some sinkhole and stops flowing along the creek bed. This anomaly is directly connected to the Little Bear Spring system. This location is the only sure connection that is indicated by the data where Mill Fork Canyon water is feeding Little Bear Spring. However, it is not the only anomaly indicating the system that is feeding Little Bear Spring on the Mill Fork Canyon profiles.

The second anomaly seen in Figure 13 for the Electrode two setup is the Little Bear Spring System. The data indicates two ways that this anomaly is the Little Bear Spring System. The first indication is that this anomaly does not disappear or decrease in size with the bleed off corrections. The second, is that this anomaly lines up on the map with the fault line that is feeding Little Bear Spring.

This smaller anomaly at station 44 indicates where the fault defining the Little Bear Spring System is energized by electrode two. This anomaly was energized by two round-about ways. First, by current leaking through the ground, and second, current following the creek from electrode two through the water to where the smaller anomaly at station 44 connects to the Little Bears Spring system or fault structure. Substantial water may be entering the Little Bear Spring system at or near station 44, or it may not be entering at that point. The fault system is close to the surface but the stream does not stop flowing. There may be only thin cracks or breaks in the rock that impede the flow of water but still sufficient to establish an electrical connection.

The fault system feeding Little Bear Spring is connected to Mill Fork Creek at one known point. This connection is directly under the top of the ridge. This connection point can be seen in the top of the ridge profiles Figure 9 and on the top of the ridge contour map Figure 8.

The third correction had to do with relative signal strength. This was calculated by comparing the maximum signal measured at station -19, the main survey line running along the road of Mill Fork Canyon, for both electrodes after the first two corrections were made. The difference between these two readings was applied as a normalizing factor for the third correction. This normalizing factor was applied to all the data measured in Mill Fork Canyon. This type of correction is referred to in the literature as normalizing. The data values shown in Figure 14 are for the Mill Fork Canyon lines subsequent to the above corrections,

Figure 14 shows only the data along the center profile in Mill Fork Canyon for both electrodes one and two after the normalized correction. Notice that the first unconnected anomaly at station 3 still appears but it is very weak.

In order to normalize the data from electrode one to electrode two the average background value of both profiles had to equal zero. Then a multiplication factor that would make the value of station number 22 for electrode 1 equal to the value of station 22 for electrode 2. This factor

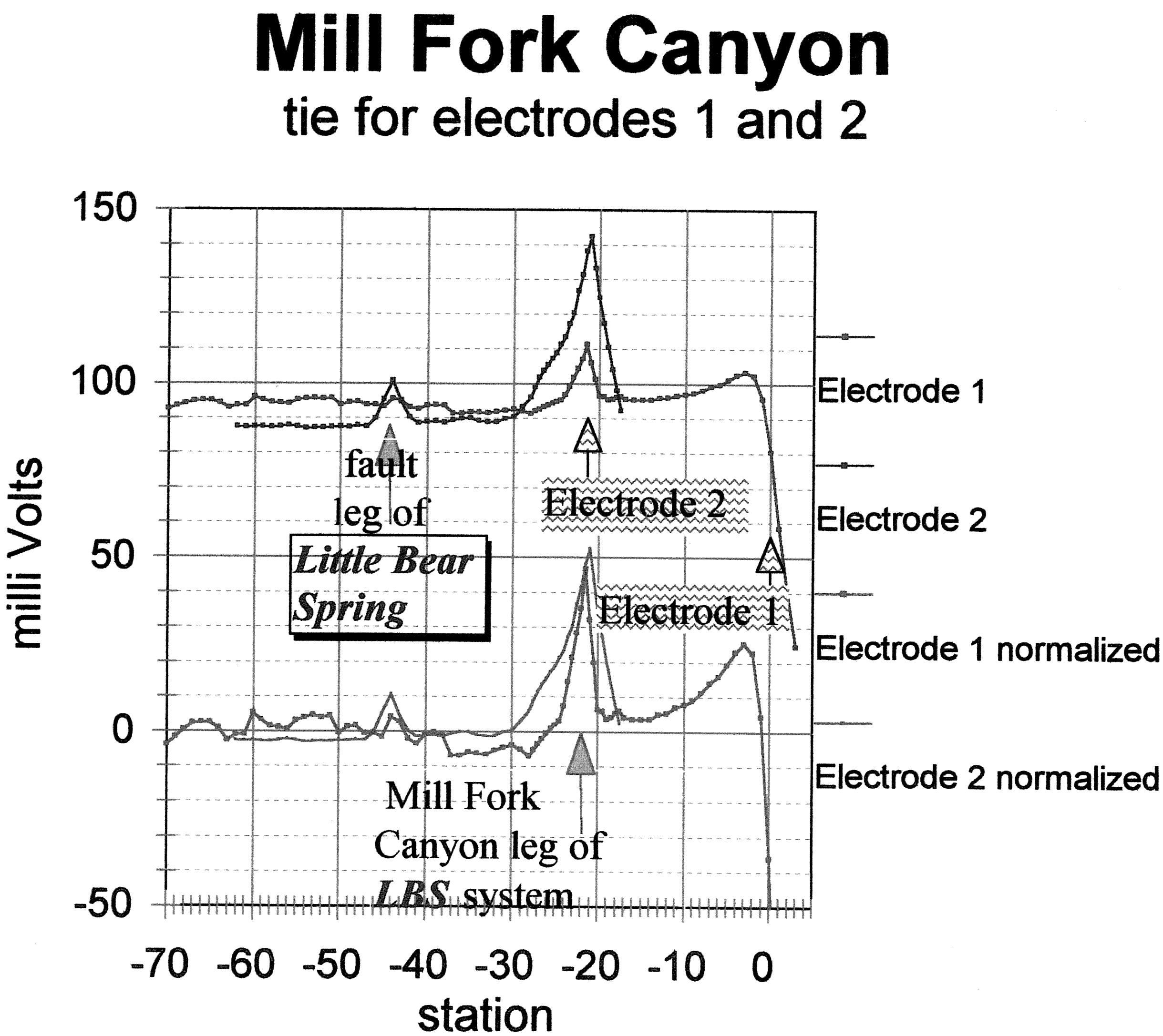


Figure 14 Data normalized for Electrodes setup one and two in Mill Fork Canyon.

was found to be 2.7, which indicates that electrode two has about three times better connectivity to the Little Bear Spring System than electrode one. This would indicate that electrode setup two was connected directly into the Little Bear Spring system where electrode one was not directly connected to the Little Bear Spring system by dispersed groundwater.

The connection of the small sinks in Mill Fork Canyon to the Little Bear Spring system is very strong in both electrode setups. This is because it is possibly the only direct connection in Mill Fork Canyon to the Little Bear Spring system. From the topographic map the elevation of the small sinks in Mill Fork Canyon are about 7600 feet, and the elevation of Little Bear Spring is about 7475 feet.

The normalized data still indicates on Figure 14 the fault controlling the groundwater for Little Bear Spring crosses the Mill Fork Canyon profile at station 44. The data does not indicate a direct connection to Mill Fork Creek at this location. The elevation of Mill Fork Creek where the Little Bear Springs controlling fault crosses at this location is about 7800 feet.

Combined Interpretation

Figure 15 is the interpretation map of all three survey areas combined, Little Bear Canyon, the top of the ridge, and Mill Fork Canyon. Seen on this map is the projected line of the fault that is the dominant and controlling structure for the groundwater feeding Little Bear Spring. This projected line is a dotted pink line which continues past the mapped fault line to the north and follows the fault line to the south. This line indicates where the fault and the Little Bear Spring feeder system passes through Little Bear Canyon, the ridge top, and Mill Fork Canyon.

In Little Bear Canyon this structure is the main water conduit for the spring. The 1999 data supports and strengthens the 1998 data and interpretation. The data collected in 1999 indicates that the fault line continues past Little Bear Spring to the north east. The new data strengthens the hypotheses that this fault structure forms the small cavities, gaps, and other opening along this fault that controls and channels groundwater to Little Bear Spring.

The data taken on the top of the ridge indicates that this fault system is still the primary structure for the groundwater moving to Little Bear Spring. However, there is another structure interconnecting with the fault structure under the ridge that adds groundwater to the Little Bear Spring system. This side leg combined with the main fault structure is seen on Figure 15 as a pink dotted line. Based on anomaly strengths and trend directions, there is a high probability that the water in Mill Fork Canyon disappearing into the small sinks connects and enters the fault controlling the Little Bear Spring groundwater system under the ridge top below where the ridge top survey was conducted.

The most prominent anomaly in Mill Fork Canyon in the field data is located at station 22. This area was thought to be the main connection at the time of the field survey, so survey lines were added on either side of Mill Fork Creek in this area. It was not until all corrections were made to the data that it was realized that the fault structure supplying water to Little Bear Spring crossed under Mill Fork Canyon further to the west. The crossing of Mill Fork Canyon is indicated by the anomaly at station 44. The location of station 44 is concurrent with the continuation of the fault structure supplying water to Little Bear Spring. This would indicate that water is also entering the Little Bear Spring system south of Mill Fork Canyon, and is flowing to Little Bear Spring via this fault system.

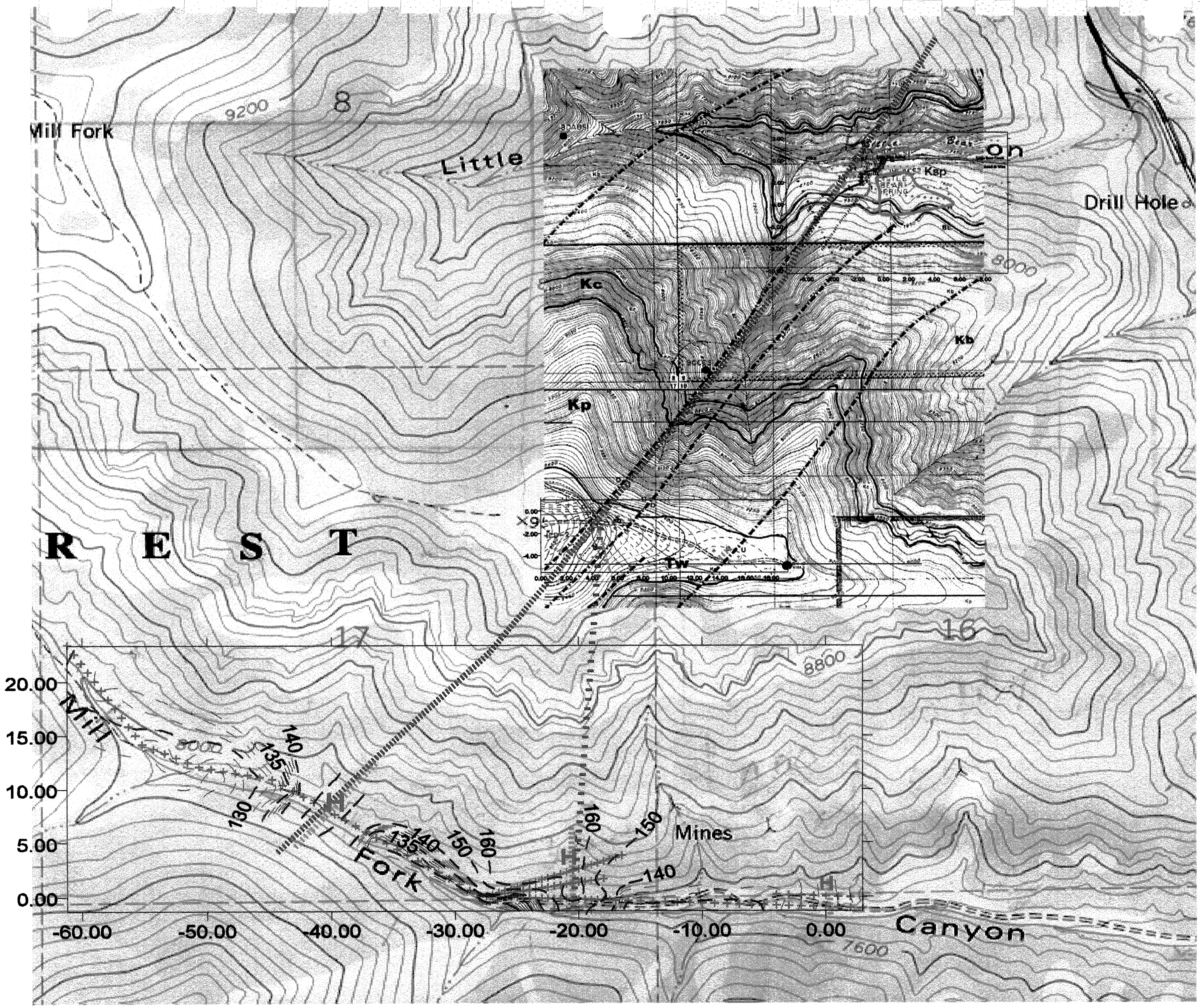
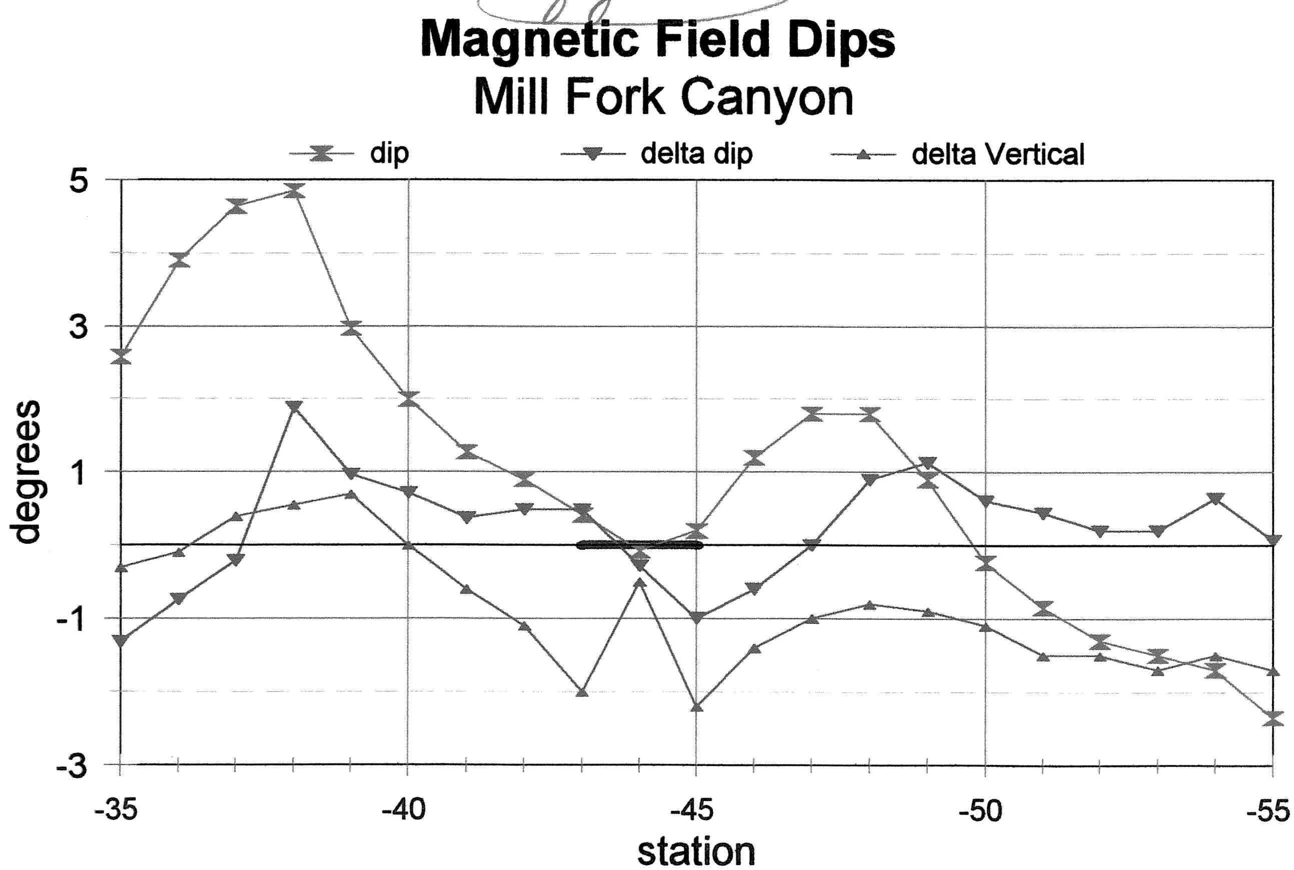


Figure 15 Combined surface interpretation map of the AquaTrack data.

The data in Mill Fork Canyon in the vicinity of station 44 was examined in detail in an attempt to determine the depth to water. The vector model indicated that the station spacing was too large to use this modeling technique. The limits for this type of model are the station spacing plus or minus a half of station spacing. The station spacing was 100 feet, thus the deepest the subsurface water could be at this location is about 150 feet. The model provides no information on how shallow the water might be.

Figure 16 is a plot of the magnetic field dip (dip, orange), rate of change of the dip in the horizontal direction (delta dip, red), and the rate of change of the vertical field along the profile (delta Vertical, green). Each of these indicates a different effect on the magnetic field due to the subsurface conductor. Between stations 38 and 43 the dip is positive indicating that a conductor is ahead, the dip from station 45 to 48 is negative indicating a conductor behind, and the dip at station 45 is zero indicating a conductor below. However, the dip does not show convergence on station 44 from stations 43 and 45. This indicates that the spacing was too large for the depth of the conductor. The delta dip does cross over from positive to negative values as they should if a conductor has been crossed. The delta vertical also starts into a low with a peak in the center of the low as seen at station 44. This is also indicative of a shallow conductor and that station spacing too large to determine the precise depth of the shallow target. The blue line along zero indicates the area within which the fault could cross Mill Fork Canyon, and the highest probability is very close to station 44.

figure 16



Mining in Mill Fork Canyon

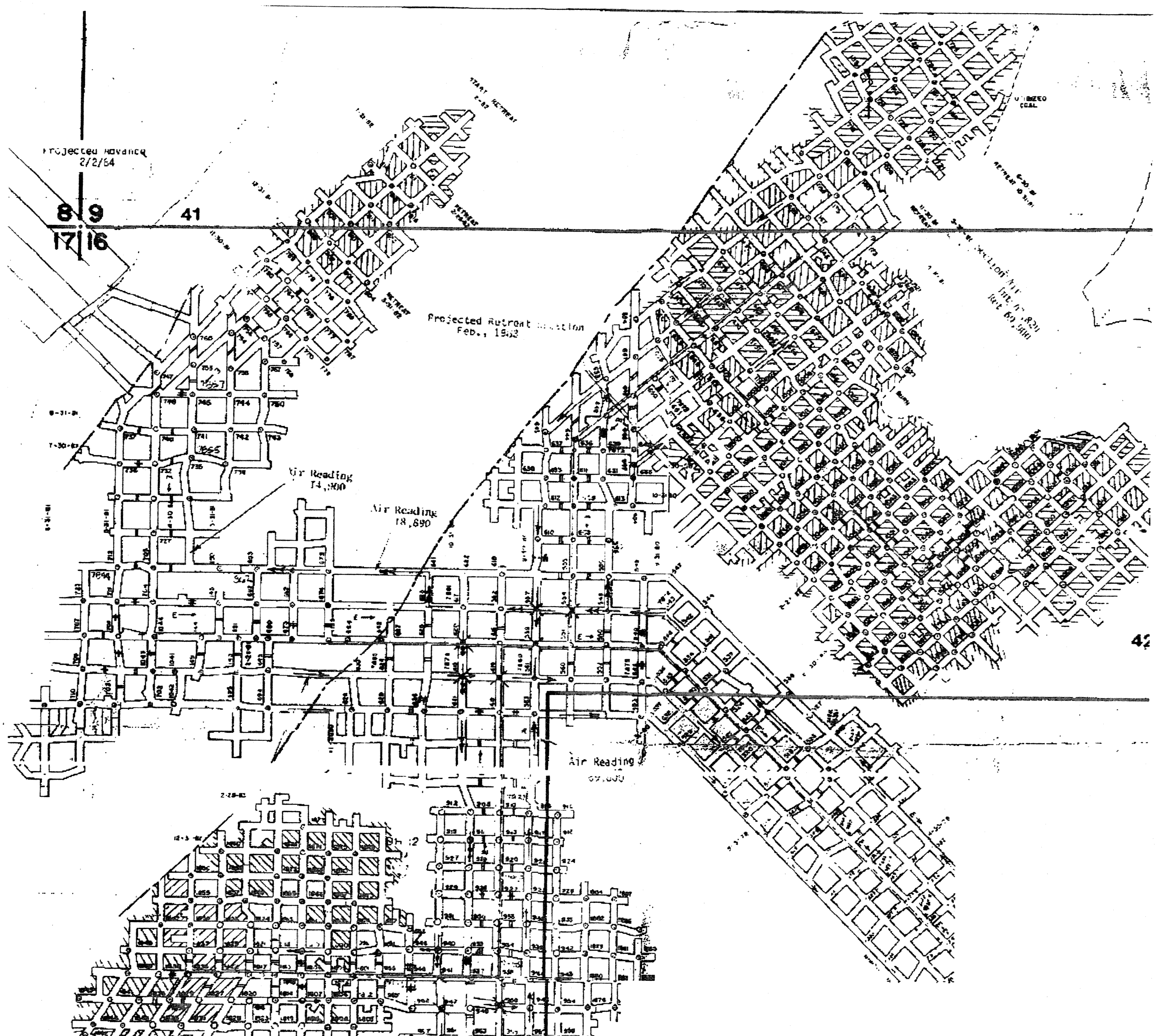
The representative of Pacific Corp. made the observation that this report did not include data from a coal mine that had operated in Mill Fork Canyon. His comments are included in the following box.

> As point in the fall of 1998 (Emery County Public Lands meeting), the preliminary interpretation was hampered by not including historic coal mine data from the Huntington Canyon #4 Mine. The 1999 interpretation again fails to include mining history from the #4 Mine involving the Mill Fork Fault crossing. A review of the mine maps reveal coal horizon (Blind Canyon Seam) at approximately 7840 feet in the area of the Mill Fork fault crossing. As stated by ARCO mine geologist, "only minor occurrences (damp areas) of groundwater were encountered within the Mill Fork Fault system." Mining occurred within approximately 2500 feet of Little Bear Spring without any documented alternations in flow.

As a consequence the data relating to Mine #4 was provided by the Department of Oil, Gas and Mining. Maps of the old workings were provided as well as comments by the Mine Engineer. The box insert below contains comments made by Dan Guy, the Mine Engineer at Huntington Mine #4, to Ken Wyatt the first of February 1999.

> Summary of Notes form February 1, 1999. Discussion of Ken Wyatt with Dan Guy, Mining Engineer, Previously with Beaver Creek Coal Company.
>
> RE: In-mine water at Huntington #4 Mine
>
> **In Mine Water**
>
> I talked with Dan Guy on Feb. 1, 1999 about in mine water interception at the Huntington #4 Mine. He indicated that the mine intercepted very little water as they crossed the first fracture associated with the Mill Fork Graben system. The fractures shown on the maps were derived from exploration drill holes and outcrop data. There were no igneous dikes. Fluvial sand channels were encountered.
>
> As they approached the second fracture in the mine, they did not receive much water but did notice the area was oxidized. Water that was entering the mine came from the floor and not the roof or fluvial sand channels. It was wet enough to make operations messy and they did decide to re-work the sediment pond to receive the extra mine water.
>
> **Mill Fork Creek**
>
> Discussions about Mill Fork Creek. He indicated that there is a losing section of stream. Above the mine the stream "flowed like hell" but 100 yards below the switch back the stream would be dry.

Figure 17 is a portion of the mine working map in the area of interest for this survey. It shows spot elevations and fault locations. These values have been transferred to Figure 18.



Figurer 17 Mine working map of Huntington Canyon Mine #4

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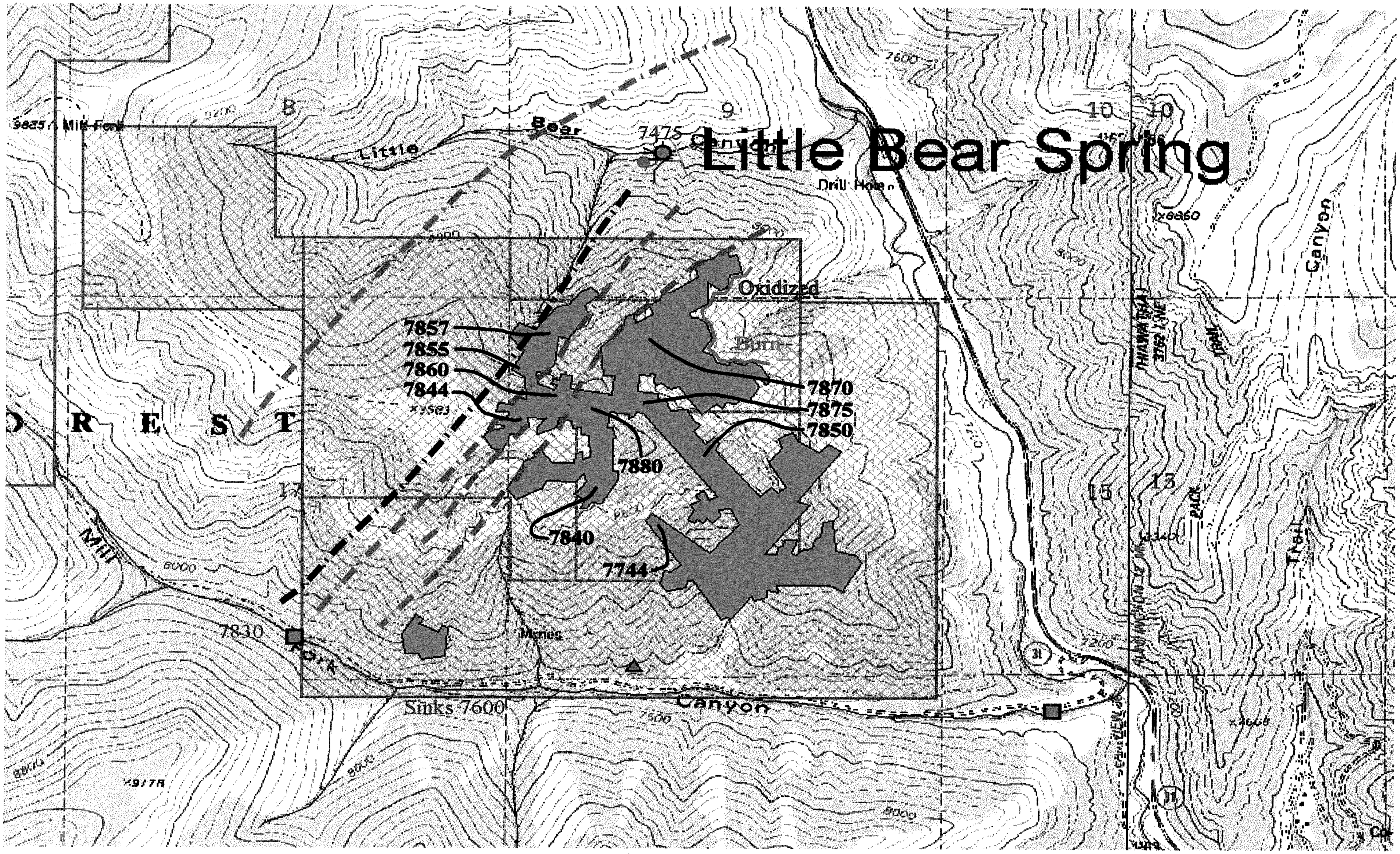

Figure 18 Topographic map showing the mine working for Huntington Canyon #4 Mine with elevations of the old workings.

Figure 18 is a portion of a topographic map between Little Bear Canyon and Mill Fork Canyon. Superimposed on this topographic map is an overlay of the Huntington #4 mine workings (dark green). Also, included are the fault locations. The Faults are shown in gray except for the fault controlling water feeding Little Bear Spring, and that fault is shown in black on Figure 18.

The elevation of Little Bear Spring, the elevations where the fault controlling water feeding Little Bear Spring crosses Mill Fork Canyon, and the elevation of the small sinks into which Mill Fork Creek disappears are shown in dark blue on Figure 18.

The information shown in the previous figures was used to generate a cross sectional view of the system along the fault that controls the water feeding Little Bear Springs. This cross section is Figure 19. The surface is shown as a green line, The location of the mine workings is shown in gray and black. The gray is behind the fault and the black represents that part of the old mine workings that cross the fault.

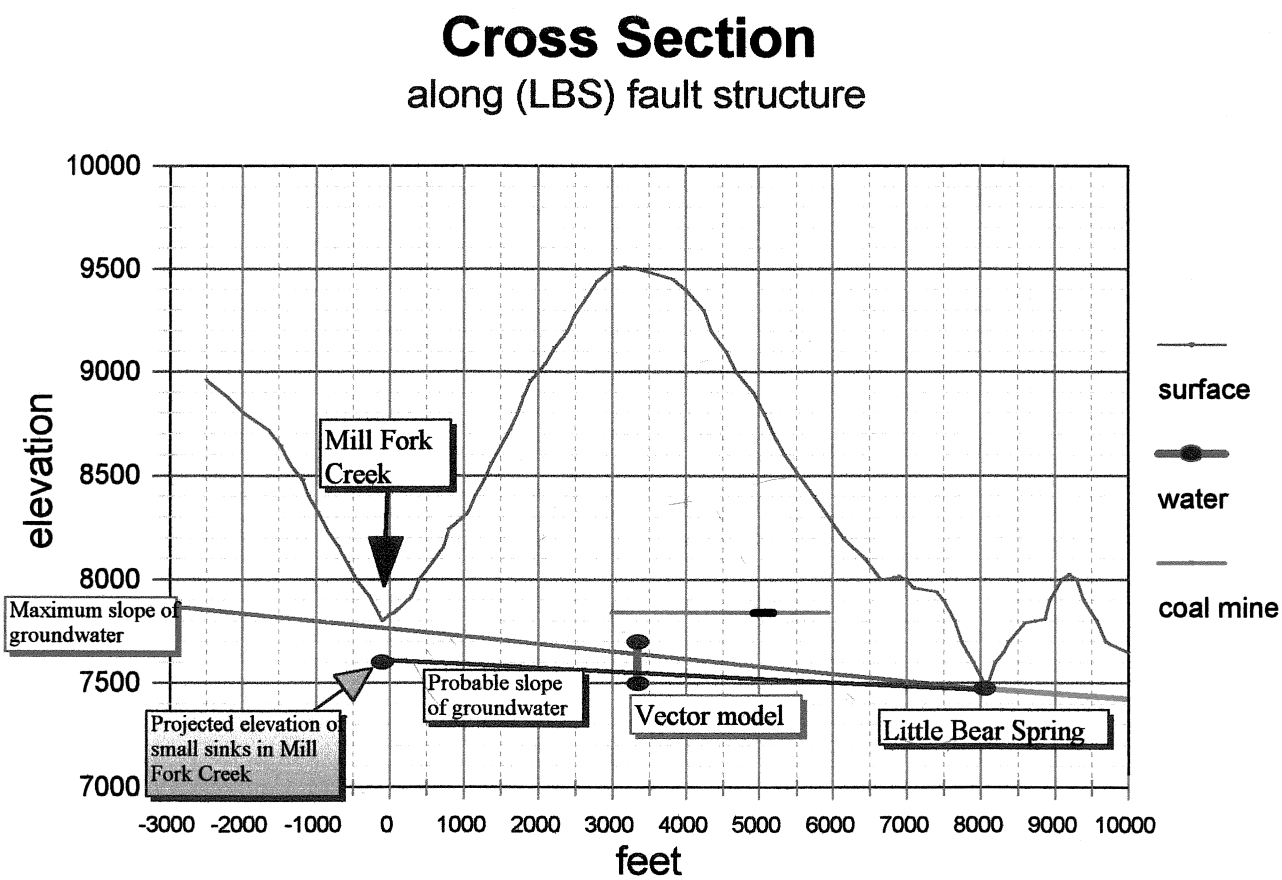

Figure 19 Cross section along the fault that controls the water feeding Little Bear Spring.

Two hydro levels are shown in the cross section. The darker blue is based on the water entering the small sinks, and reemerging at Little Bear Spring. The lighter blue line represents the maximum slope of the hydrostatic head feeding Little Bear Spring. Both of these levels agree with the data from Huntington Mine #4 and the vector model for the top of the ridge. The mine engineer indicated that only a limited amount of water entered the mine when they cross the fault of interest and then what water did enter the mine came from the floor. All these facts indicate that the hydraulic surface is relatively flat dropping a maximum of 150 to 200 feet in 8000 feet horizontally. The rate of flow with this flat of a hydraulic surface would indicate that the entire system is very open with good inter-connectivity. It will be reiterated here that the openings could be called "cave" like but this does not mean large openings. The voids are more on the order of a couple of feet at the most and any void would look very much like the pock marks created by wind and water on the exposed cliffs. The difference would be that the sand would stay in place rather than be removed. Additionally the fault could have elongated places where the walls do not touch. These spacings could range from an inch to a foot or two. But the elongated inter-connected nature of these small openings create a type of cave structure, even though the cavern or open spaces would generally be too small for a human to enter.

If the hydrological surface was sloping greater than the light blue line the water would create a spring in Mill Fork Canyon at about the location of station 44, and possible springs rather than sinks further down Mill Fork Canyon at about station 19 or 20. The dark blue line is the more likely hydrological level, and this would place the water level about 150 feet below Mill Fork Creek at station 44. This provides good agreement with the mine data, the models created by the magnetic data, and what is required hydrologically by where water is entering and exiting the system. The sinks are at about 7600 to 7625 feet and Little Bear Spring is at about 7475 feet for a difference of about 125 to 150 feet. The floor of Mill Fork Canyon where the fault crosses the canyon is about 7830 feet. This is 200 to 225 feet higher than the elevation of the sinks. The ground water at this location could not be deeper that about 150 to 200 feet based on the magnetic data. The water could not be closer to the surface than about 100 to 150 feet or there would be enough head to force water out of the small sinks in Mill Fork Creek. The most logical depth to water in the fault where it crosses under Mill Fork Canyon is about 150 feet plus or minus 50 feet. This yields a slope for the hydrological surface that is an average of the two shown in Figure 19.

RESUME'

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West Valley City, Utah 84120
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EDUCATION

University of Phoenix, Salt Lake City, UT   MBA course   1985 & 1986
Leeds University, Leeds, England.   Geostatistics. March 1974
University of Utah, Salt Lake City, UT.   Ph.D.; Major Geophysics, minor Geology. June 1973.
Weber State College, Ogden, UT.   B.S.; Major Physics, minor Math. Cum Laude. June 1965.

WORK EXPERIENCE

Private Consultant Jan 1999 - Present
Hydrology - groundwater mapping.
Developing new technologies related to subsurface waters.

Water Technologies and Research April 1999 - Present
Chief Scientist
Responsible for all research and development

Weber State University Sept 1997 - Sept 1999
Adjunct Research Professor of Physics

Hydro Geoscience Inc. Sept 1997 - Dec 1998
President and Chief Scientist
Developed and Patented (5,825,188) technology to track groundwater.
Managed Research.
Oversaw Fieldwork.
Directed Interpretive work.

Weber State University Oct 1996 - Sept 1997
Research Professor of Physics
Directed student research and served as PI for research projects.

U.S. Bureau of Reclamation Feb 1996 - Sept 1996
Staff Scientist/Researcher
Developed and built a truck-mounted mechanized device/machine that removed lead from soils.

U.S. Bureau of Mines, Salt Lake City Research Center (SLRC) Dec 1990 - Present
Staff Scientist/Researcher, May 1993 - Feb 1996
Principle Investigator and supervisor of following projects:
Uranium removal from waste water using bacteria in beads.
Bio removal of acetate from spent leach solutions.
Electromagnetic tracking of underground pollution plumes.
Electromagnetic monitoring of subsurface biological processes.
Electromagnetic monitoring of In situ mining.
Technology Transfer Officer, Dec 1990 - May 1993
Coordinated and facilitated the Technology Transfer program.
Created and supervised graphics department for SLRC.
Instituted and supervised the video production department for SLRC.
Supervised computer facilities for SLRC.
Supervised technical library at SLRC.

Weber State College, 1989 - 1993
Adjunct Research Professor of Physics
Directed student research and served as PI for research.

U.S. ARMY, Dugway Proving Grounds, Sept 1986 - Dec 1990

Operations Research Analyst

Contracting Officers Representative for diverse contracts.
Devised unique technique for analyzing time dependent data.
Formulated cold temperature model for agent parameters.
Evaluated composite materials for impact strength and water sorption.

ASARCO Incorporated, Aug 1968 - March 1986

Chief Geophysicist/Manager, Dec 1984 - March 1986

Coordinated geophysical surveys with geologic projects.
Reviewed all papers and reports before publication.
Establish procedures for field and laboratory work.

Computer Manager/Regional Geophysicist, Dec 1979 - Dec 1984

Managed computer department, and supervised staff.
Supervised field projects and crews.
Organized, directed and interpreted geophysical surveys.
Conducted engineering and ground stability studies.
Developed programs to study groundwater pollution (environmental).
Expanded theories to implement improved computer models.

Exploration Geophysicist/Computer Analyst, Jan 1975 - Dec 1979

Directed and interpreted geophysical surveys.
Supervised computer program development for exploration.
Coordinated use of satellite imagery.
Developed interactive graphics modeling programs.
(gravity, magnetics, resistivity and induced polarization)

Theoretical Geophysicist, Aug 1968 - Jan 1975

Developed analysis and computer programs for;
Regionalized statistics, and numerical integration,
Convolution, deconvolution, linear and non-linear filters,
Analyzing and displaying random data, and modeling for theoretical analysis.
Developed and tested new instrumentation.

Weber State College, 1963 - 1965

Physics Lab Instructor for university and engineering physics

OTHER ACTIVITIES

Co-directed construction of Stansbury Park Astronomical Observatory with a 16 inch Newtonian telescope.
Served as Director on the Board of Director for:

Salt Lake Astronomical Society	- four years.
Alta Mining Company	- five years.
Wasatch Martial Arts	- twenty years.
Hydro Geosciences Inc	- two years.

Black Belt 3rd Dan Tae Kwon Do, under a multinational organization *Kyuki-Do*.
Started own school *Wasatch Martial Arts*, Spun off two subsidiary schools.

PUBLICATIONS:

University of Utah . . . . Dissertation, ... plus . . . . 10. spin off publications

Utah Geologic and Mineral Survey . . . . 1. publication

ASARCO Inc. . . . . 182. publications

U.S. ARMY, Dugway Proving Grounds . . . . 8. publications

U.S. Bureau of Mines . . . . 22. publications

U.S. Bureau of Reclamation . . . . 1. publication

AQUATRACK APPENDIXES

These appendixes are included to provide the reader with an overview of the technology behind AquaTrack. They will assist the reader in understanding the methodology of interpretation. They are not intended to be all inclusive. They are simply intended as an overview to afford appreciation.

Differences between AquaTrack and conventional groundwater tracking technologies.

Current groundwater mapping technologies fall into one of the following categories:

- conventional geophysics
- tomography
- monitoring wells using logging technologies or tracers

Older Conventional Technologies

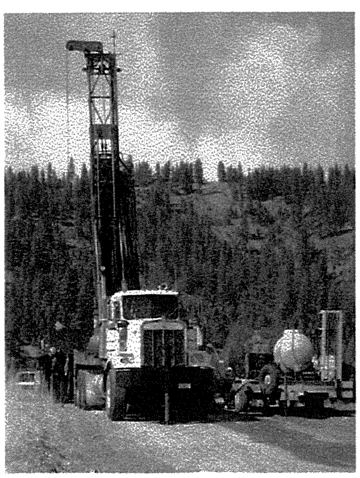
Conventional geophysics generally involves indirect energizing and measurements which includes: galvanic resistivity, electromagnetic conductivity, conventional electromagnetic surveys, ground penetrating radar, and magnetic surveys. Conventional geophysical technologies do not have the capability of resolving separate subsurface anomalies and confirming that they result from a particular plume or groundwater channel. Thus a particular feature of interest is not isolated and definitively measured. Adjacent features can appear as contiguous features even though they may or may not be connected. There is no assurance as to the various anomalies are related. Detecting groundwater plumes or even resolving plumes at depths greater than about 100 feet is very difficult, using conventional geophysics.

Tomographic type technologies include: electrical resistance tomography, seismic tomography, and radio imaging method. Tomographic technology is a very powerful and sophisticated tool that involves very complicated algorithms to develop models. The draw backs to tomographic technologies are that they are very time consuming and expensive.

Monitor wells: The drawback to drilling is that you only identify what is at the location of the drill hole. To establish linkage between holes it is necessary to use tracer solutions or a geophysical continuity test. These techniques establish connectivity but, do not provide a trace of the subsurface path between the drill holes. Using monitor wells it is difficult and requires many wells to map a subsurface water system and be certain that all branches have been identified. It is possible to miss narrow channels of groundwater. Wells provide inconclusive and at times even misleading results.

Well logging technologies include: thermal logging, gamma logging, neutron logging, acoustic logging, electrical resistivity logging, and electromagnetic induction logging. Well logging technologies have limited range of detection. Generally the detection limits on well logging tool range from a fraction of a meter too just a few meters from the well.

Tracer technologies: Tracers are any substance that can be easily and uniquely identified. Tracers are introduced into the medium being investigated and then wells or seeps are monitored for the appearance of the tracer. Tracers are a powerful technology, however, it takes time for the tracer to move through an aquifer. The aquifer must be continually monitored and sampled to pick up and generally require sophisticated lab analysis to detect the tracer. In some situations it may be objectionable to introduce any additional chemicals into a sensitive system.



New Technology

AquaTrack mimics tracer technologies in that it uses electrons as its tracer and magnetic sensors to monitor the movement of the tracer. Thus, not only is continuity established but maps can be made of the subsurface water channels. Data reduction is done on a p.c. computer, and interpretation involves analyzing profiles, creating models and interpreting contour maps of the field data.

Technology analogous to AquaTrack

AquaTrack uses the concepts similar to several existing technologies but differs in the execution of the application to tracking water.

The technology is similar to the idea of directly connecting or nearly directly connecting to an ore body as utilized in the Mise-a-la-masse method. Mise-a-la-masse is used to detect mineralization just missed by drilling and in the immediate vicinity of the drill hole.

Another similar technology is used by the phone company to detect wires in walls. They attach a signal generator to the wire and energize it. Then a small loop antenna is used to locate the trace of the wire in the wall.

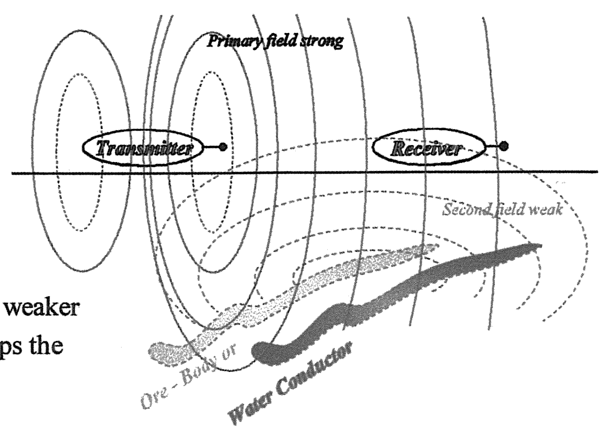
The location of underground pipes and utilities, using Metro Tech tools is also very similar to the technology behind AquaTrack. A Metro Tech transmitter connected to a pipe and to a grounded electrode. A receiver is used to map the electromagnetic field generated by the current following the pipe. The buried portion of the pipe is located by listening for the loudest signal from the receiver. When using AquaTrack to track groundwater, underground pipes and wires create noise that must be identified and corrected for when mapping groundwater.

How AquaTrack Works

Electromagnetics have long been employed by geophysicists to find minerals and ore deposits. A fluctuating electrical current in a coil will generate a fluctuating magnetic field. A conductor placed in a fluctuating magnetic field will have electric currents circulating in the conductors which in turn will produce their own weaker magnetic field.

In conventional electromagnetic techniques a transmitter coil is near the surface is energized to create an alternating magnetic field. This alternating magnetic field induces electric current in all the conductors in the area. A secondary magnetic field is generated by the current flowing in the conductors. The secondary magnetic field interferes with the primary magnetic field and this interference is measured (See illustration above). There are two draw backs. (1) All conductors in the subsurface are energized and will respond in similar ways. (2) Second the secondary magnetic field is much weaker and is hard to resolve.

AquaTrack combines a non conventional electromagnetic geophysical and tracer technologies. By directly energizing the ground water with electricity the ions in the groundwater become tracers. As current flows in the groundwater it generates a magnetic field. This magnetic field can be measured some distance away from the electrical current thus measurement can be made on the surface, above the groundwater. AquaTrack creates the primary magnetic field using the groundwater of interest. Other conductors not of interest generate only a weaker secondary magnetic field. The path followed by the electrical current maps the groundwater and related structures.



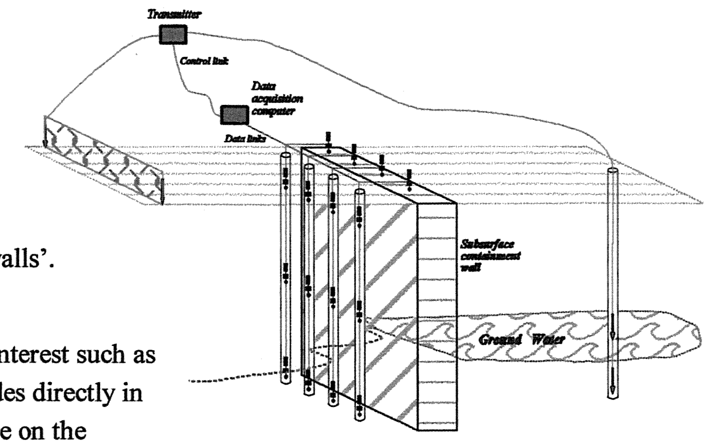
Conventual E.M. surveys

Some of the capabilities of AquaTrack:

The principle of ions acting as tracers is utilized so that AquaTrack can actively:

- Map subsurface pollution plumes.
- Find the source of seeps.
- Delineate leaks in earthen dams and drain fields.
- Monitor changing subsurface ion concentrations or reaction-fronts.
- Monitor surface retainer and subsurface containment walls'.
- Monitor leaching solutions.

When there is a surface expression of the groundwater of interest such as a seep or spring the best technique is to place one of the electrodes directly in the seep or spring. The return electrode can be in a well or fence on the surface (see illustrations to left).

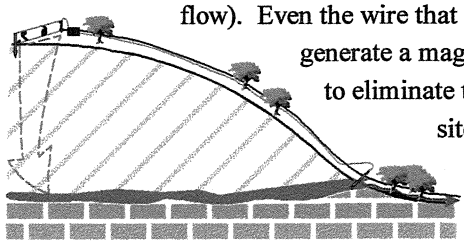


Subsurface Containment Wall

When only a drill hole is used, the preferred electrode configuration is to place the return electrode below the energizing electrode. When the return electrode is the upper electrode the current flowing back is closer to the receivers on the surface and thus masks the signal from the groundwater. When the energizing electrode is higher than the return electrode the current in the ground water is closer to the receiver and thus the current following the groundwater creates the stronger signal (see illustrations below).

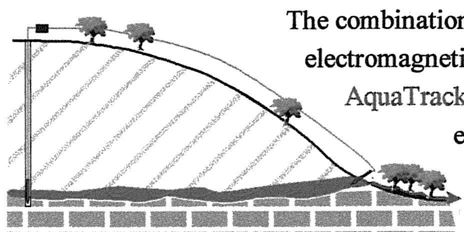
While AquaTrack is based on sound scientific theory, in practice it can be quite difficult. The water being tracked maybe only one of several conductors being energized or partially energized. A clay layer in soils often acts as a weak conductor producing a broad superimposed field.

Power lines or buried cable will produce their own magnetic fields. The depth of the water from the surface may also vary and will cause variations in the field measurements. Other potential influences include changes in water conductivity due to changing ion concentration or a broadening of the water stream (sheet flow verses channel flow). Even the wire that is used to energize the water stream and connects the return electrode will generate a magnetic field. The data obtained by AquaTrack allows someone with experience to eliminate the extraneous effects, it is always prudent to consider all prior knowledge of a site to confirm observations and as a double check for data interpretation. AquaTrack data frequently enhances the value of other types of data that has been colleted for the site.



Review of Physical principles involved

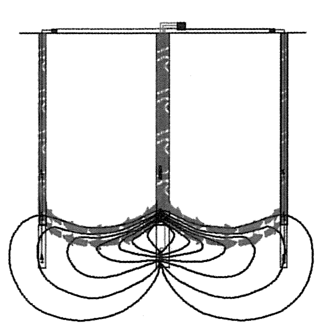
The combination and interplay of several electrical phenomena and adaption of several electromagnetic principles, in combinations not previously used provides the foundation for AquaTrack. The following is an overview of these principals and in some cases' examples of how they are used to interpret AquaTrack data.



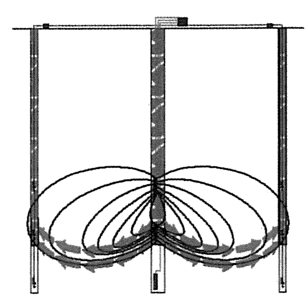
1. Current flowing in a wire generates a magnetic field that wraps around that wire perpendicular to the flow of current.

- In AquaTrack the wire is replaced by groundwater in a subsurface channel, current following that groundwater creates a magnetic field. By mapping the magnetic field the water channel can be located.

2. Two coils in close proximity are coupled magnetically. A transformer is a special case of two

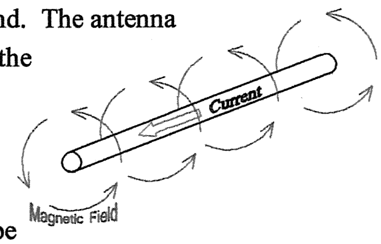


Current Flow bottom & middle electrode

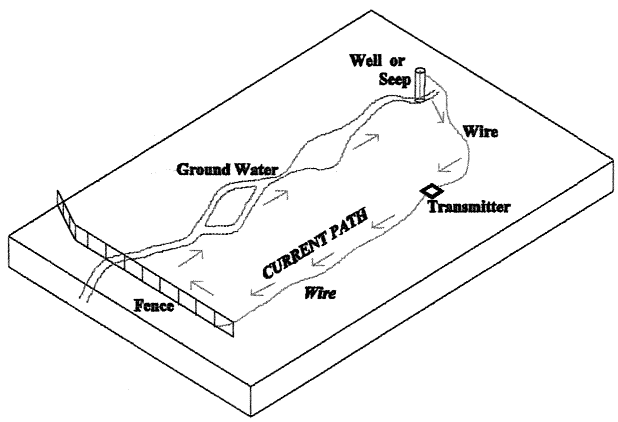


Current Flow top & middle electrode

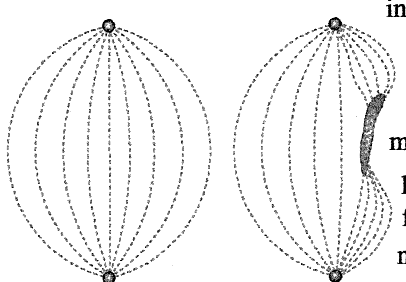
coupled coils. The primary coil is the loop carrying the initial current. The secondary coil has current induced in it by current flowing in the primary coil.



- The primary coil in AquaTrack is created by a large primary loop on and in the ground. The antenna wire forms one part of the loop and the subsurface water path forms the other part of the primary coil. The wire portion behaves like a single turn coil, but the groundwater portion can behave as a single turn or like a multiple turn coil. A virtual primary transformer coil is created by the antenna wire and groundwater path.
- The secondary coil of this hypothetical transformer is the receiver. The physical shape of the groundwater portion of the loop will determine whether it exhibits properties of a single wire or simulates multiple windings. A broad groundwater flow path approach the characteristics of a large number of small wires. A narrow groundwater channel will exhibit properties similar to a single loop. The way that the primary and secondary coils couple, and the current generated in the secondary coil is controlled by how many virtual turns are emulated by the groundwater. Thus transformers and large loop theory can be used to analyze the resultant magnetic field and infer the shape, location, and path of the groundwater channel being energized.



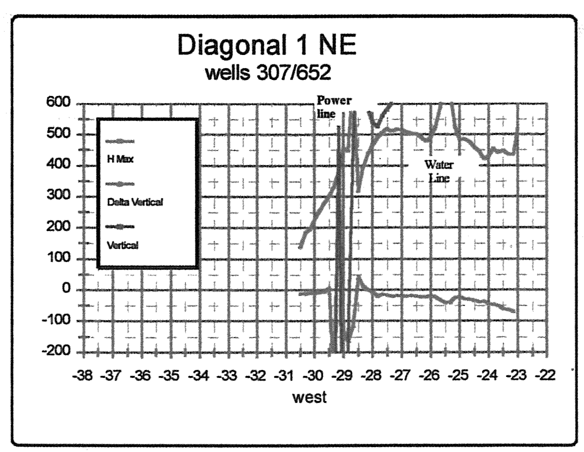
3. A good conductor, such as a metallic object, placed in a moderate conductor will gather current from the moderate conductor into the good conductor.



This is demonstrated by the classical physics experiment where two electrodes are placed at opposite ends of a tray of water. The electric field in the tray is first mapped containing only water. Then different types of conductors or insulators are placed in the tray. Objects with greater conductivity than the water warp the electric field in a way that diverts current through the conductor. This is because the entire metal surface is at the same electrical potential. This changes the gradient which focuses the flow of current through the metal. *Conductors gather current.* Insulators whose resistivity is greater than the water divert the current around the object. *Insulators do not gather current.*

Good conductors in the ground will gather electrical current flowing in the ground. This is referred to in the geophysical literature as *current gathering*. There are three general classes of good conductors in the ground.

■ First are groundwater channels. When current is directly injected into the conductor of interest it is important to remember that the signature of that conductor will be the strongest because the current will preferentially remain in that conductor. Current will disperse from the conductor at a rate that is a function of the resistivity contrast of groundwater channel and surrounding medium.



■ Second types of conductors are man made (refer to Diagonal 1NE diagram to the right), these include:

- communication lines
- over-head power wires. The effect seen on the profile to the right at station -29 is due to overhead power lines. Communication line and pipe have similar signatures but not as strong.

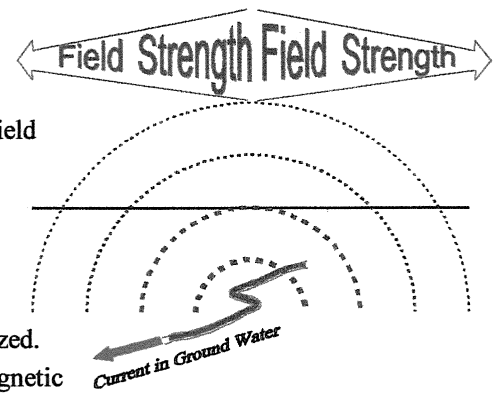
- under-ground metal pipes (at station -25.5 on Diagonal 1 NE).
- chain link or steel stake fences

The locations of fences, wires, pipes and conductors are usually known thus they can be accounted during interpreted.

■ Third are mineral deposits such as ore bodies. These are rare and are generally easy to distinguish from other types of conductors.

Application of these principles to AquaTrack

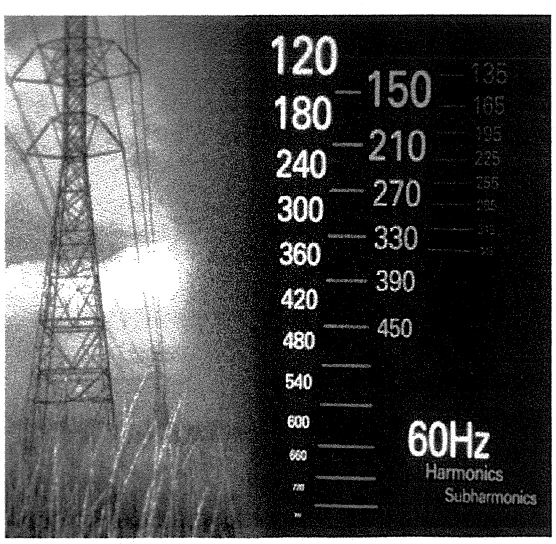
Following are observations of how the magnetic field behaves when using AquaTrack and how this technology is used to map groundwater channels. A loop is formed by the wire and current in the ground. A magnetic field is generated by electrical current following subsurface water.



Consider what happens when electric current flows in a wire. A magnetic field is produced that circles the wire. Replace the wire with groundwater and a magnetic field is generated around the groundwater's channel. On the surface this field will be horizontal and perpendicular to the groundwater. A curved conductor will essentially behave the same way. The strongest horizontal magnetic field will be measured directly over the conductor. The magnetic field traces a path on the surface that follows the path of water, in the ground.

An important part of this technology is that the groundwater is directly energized. This can be done in several ways but ultimately all achieve the same effect. The magnetic signal that is measured at any point in the survey is a compilation of the current flowing in the earth and the field created by the wires leading to the electrodes energizing the groundwater.

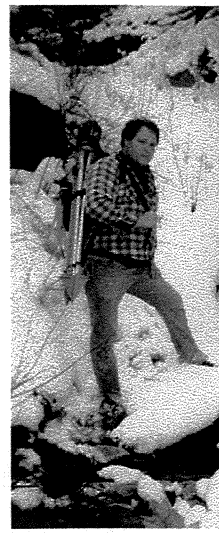
The magnitude of the magnetic field is related to the size of the loop and the current flowing in the loop. The vertical magnetic field inside a loop will be its maximum and is constant when completely inside the loop. The vertical field decreases when crossing any flow paths that short circuit part of the loop flowing in the ground. The vertical magnetic field will have a relative zero (maximum slope) directly over a water channel. If the water channel is confined, the vertical field will change rapidly over a very short distance. When crossing a wide water channel, the vertical field will start to change, decreasing in strength, before the first edge is crossed. It then stabilizes over the channel and decreases abruptly as the second edge is crossed. Outside the loop, the vertical field will decrease away from the loop. The horizontal magnetic field inside the loop will be a minimum. The horizontal field is maximum crossing over any conducting strand of the loop.

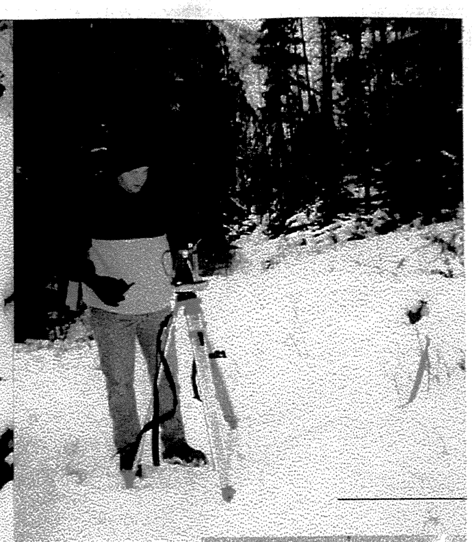


Noise

There are three large sources of electrical noise in the ground that must be accounted for when analyzing AquaTrack field measurements.

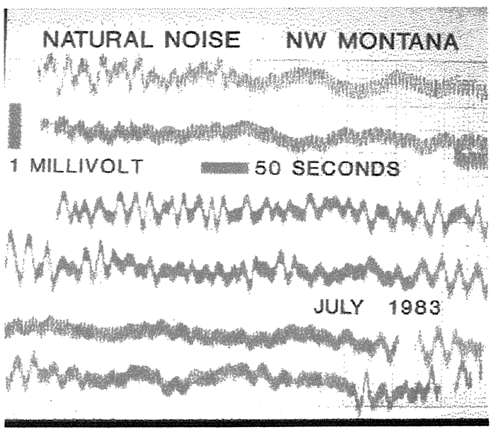
- The first results from power companies which use the earth for their return circuit for all their power distribution. Thus as usage changes during the day the electrical and magnetic field produced by the returned electrical power will shift and change. These effects are screened by frequency locks between the transmitter and receiver. Corrections are made from multiple base station readings used to monitor drifts in the local magnetic field.

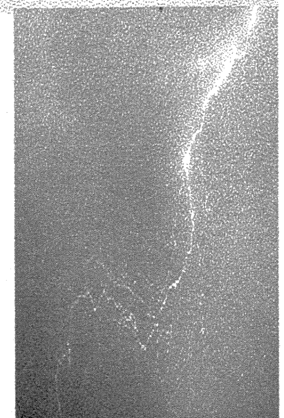




Filters are provided to lock the frequency at a precise 400 cycles. The frequency, 400 cycles, is selected to eliminate interference from stray 60 cycle current or any harmonics of 60 cycles.

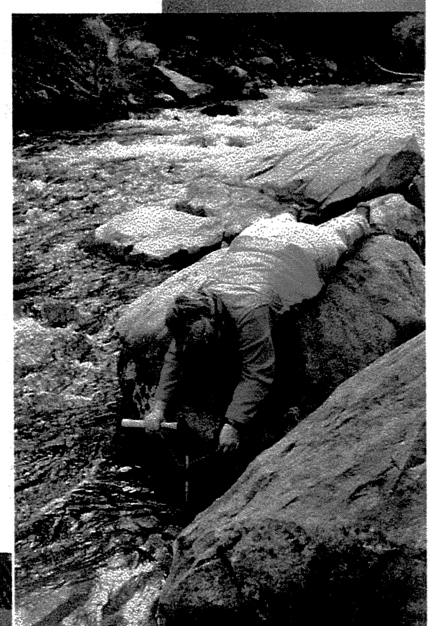
- The second strongest noise source is telluric currents created by the electrical currents that the sun generates in the ionosphere. Multiple readings at a base station help identify and correct for these influences.
- The third electrical noise source is distant thunder storms. The electrical static generated by lightning strikes becomes trapped in a wave guide between the ground and the ionosphere. With distance, the frequencies generated begin to blanket the electromagnetic spectrum usable in this technology. Noise from this source is corrected using a combination of frequency locks and bases station corrections.





Field procedures

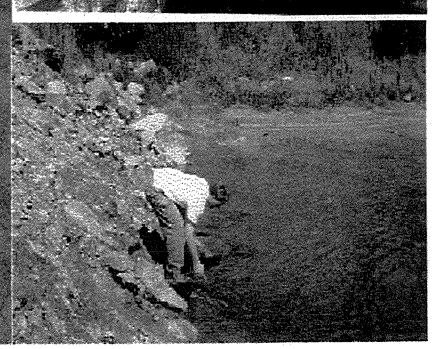
The first step is to provide a path for the current to flow in a large primary loop. As stated the water path to be mapped is included as part of this primary loop circuit. This is done by directly connecting an electrode to the water to be mapped. To provide a return path and continuity between the electrodes wire is strung from the primary electrode to the grounded point or points.



The second electrode can be in contact with the water to establish the flow path between two points. However if the subsurface path is an unknown then it is better if the return electrode does not bias the flow of electricity in the ground. This is best done by using as the second electrode a broad ground plain such as a chain link fence or surface water such as a pond or stream.

A controlled AC transmitter is included in the wire portion of the loop. The frequency is controlled to provide a locked frequency between the transmitter and receiver. Outputs are controlled, monitored, and recorded during the survey, and corrections are made for any transmitter drift.

Data is collected at each station using a special receiver. The receiver consists of a coil and a filtered amplifier. The magnetic signal picked up in the coil is correlated with the transmitter signal and filtered for noise. Magnetic field measurements consist of magnitude and direction of the magnetic field components. The minimum field is detected first because it is more definitive. The field direction is obtained using a compass mounted on the receiver coil. The maximum is measured by rotating the coil 90 degrees and recording the voltage induced in the receiving coil. The coil is again rotated

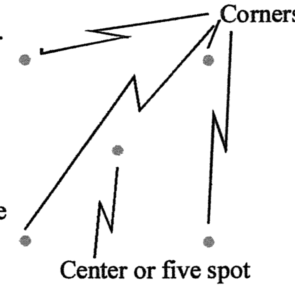


90 degrees in the vertical to measure the vertical component of the field.All readings are locked to a base station and corrected for diurnal drift.

The values measured at each station were:
1. Location in northings and eastings,
2. Minimum magnetic value and bearing,
3. Maximum magnetic value and bearing,
4. vertical magnetic value,
5. time, and
6. any adjacent cultural feature

Grided Data and Detailed Profiles

The preliminary or regional data is generally gathered on a north-south/ east-west oriented grid with 100 foot spacings. The primary survey is made by taking measurements at the grid points and at the center of each grid square, or the five-spot. The reduced maximum horizontal magnetic field values are contoured to determine general location and orientation of the ground-water channel feeding the energized water source. Readings taken over a grid area provide general information related to water flow and preferential direction of channels. Grid data may not provide detailed information defining channels or the edges of channels.



In some surveys rather than use a grid, profiles are used that are oriented perpendicular with respect to the feature being studied. The profile can be straight or curved. The decision to use straight or curved profiles are generally a decision based on the topography of the area being studied. Flat terrain lends its self to square grids or straight profiles very well. When the topography is steep or rugged the profiles are usually run were there is access.

Detailed profiles can be taken perpendicular to the groundwater channel as determined by the original survey data. Detailed data improved accuracy in determining the center of the water channel and the location and type of channel edges. Subsequently detailed readings may be taken along selected profiles in locations where the initial data indicated the existence of groundwater channels. The station spacing for detailed profiles is dictated by the needs of the user.

Whenever possible stations in the field are repeated. Thus if a new line crosses an older line, the point or station where they cross is re-occupied and a new reading is taken. This assure quality in the data and allows all parts of the survey to be calibrated the same.

Data Reduction

Analysis of the data includes correction for drift of both the transmitter and receiver. These corrections are the same as standard correction made to all geophysical data.

The data interpretation includes standard mathematical formulas that are applied equally to all data to remove regional and other effects. For example:

First current bleeding from the conductor, i.e., groundwater channel, will cause a gradually reduced signal due to lower current flow. This effect can be adjusted by adding a factor based on the stations distance from the current source.

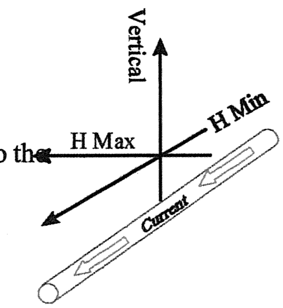
Second, the electrodes, or contact points, can act as electric poles and will create a very predictable field. This field can be calculated and removed mathematically from the data.

The data is presented in various forms such as profiles, contour maps along with various models.

Data Interpretation

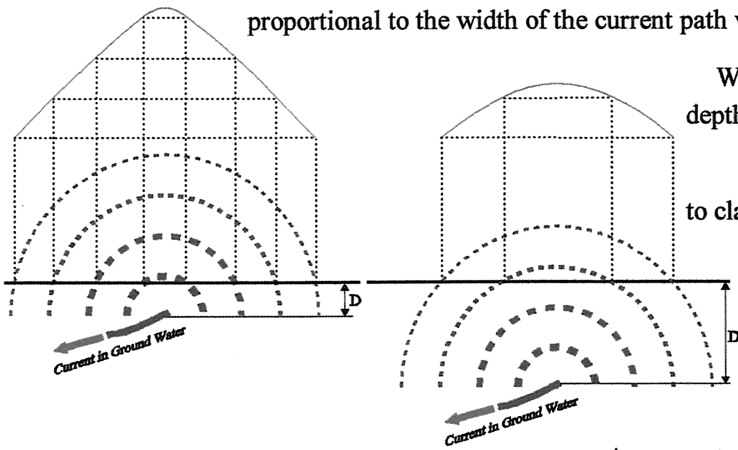
General guide lines

In the simplest case, such as a wire-like conductor, field strength will be greatest at a point directly over the conductor. Horizontal magnetic field strength measured on a line perpendicular to the conductor will increase until it is directly over the conductor then decrease.



The direction of electrical current flowing in the ground, represents the groundwater channel. Electric current flows in the same direction as the minimum horizontal magnetic field which is the direction of the subsurface water channels.

The rate of change of the vertical magnetic field intensity with distance across the anomaly is proportional to the width of the current path which indicates the width of the groundwater channel.



Width of the horizontal magnetic field is proportional to depth and width of the channel.

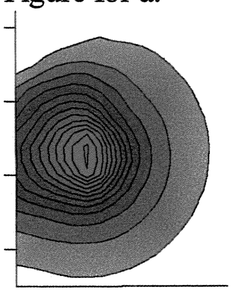
Correlation of vertical and horizontal data can be used to clarify ambiguities of width and depth.

Specific case examples.

The following are examples of how possible features will show up when site data is plotted in a manner similar to that of a contour map:

a. A non perturbed field, where no conductor is energized, would form a contour map composed of concentric circles around the point where the water is energized.

Figure for a.



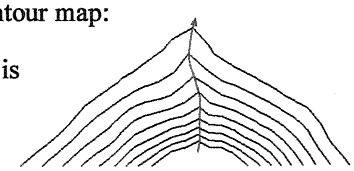


Figure for b.

b. Water in a narrow channel will form a V shape in the contours.
The shape of the "V" will be sharper the closer to the surface the channel is.

c. A vertical structure such as water flowing toward, then flowing down a vertical fault, will also form the "V" contour but with a somewhat lower gradient as fields generated at the deeper portions past the fault structure will add to the fields generated closer to the surface.

d. A flat conductor or sheet flow of water will produce a flatter signal than a deep narrow conductor. The gradient will increase toward the edge of the water, then level off, only to reduce sharply on the other side, making the edge of the sheet flow more pronounced than a deep narrow conductor.

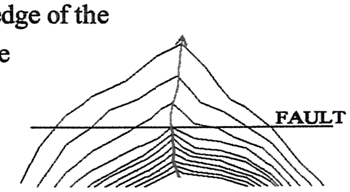


Figure for c.

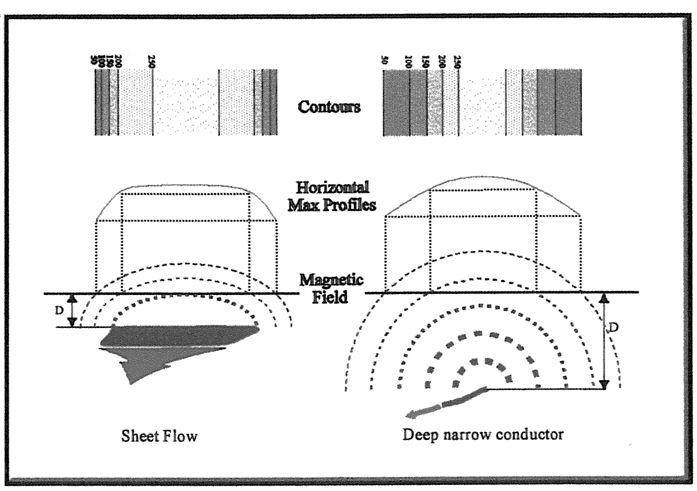


Figure for d.

e. Up welling along a conductor will start with lower values due to the depth of the initial flow then increase and narrow in the area of the up welling.

f. Branching in a conductor will show very misleading results in the area of the branch as two or more fields will be measured at one time.

g. If the water becomes less conductive or if the thickness of the water layer thins, this area will change to a lower field strength as less current will be carried. An example would be where relatively fresh water passes through a reaction zone and picks up additional minerals. Measured from the high conductivity side to the low conductivity side, there will appear to be a rapid decrease in conductivity, far more pronounced than could be accounted for by increased distance from the current source. This will look very similar to water flowing along a vertical structure. (see Figure for c)

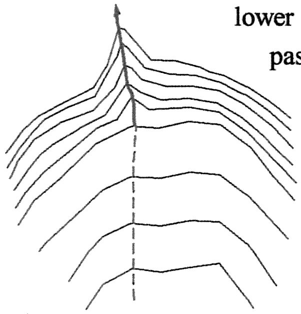


Figure for e.

h. Conductors in the surrounding rock or soils, even weakly conductive soils, will cause distortions in the fields measured and may even form secondary fields. These conductors may be a wide variety of things, the most common of which may be power lines, water pipes, or phone lines. These generally produce wide and wild variations in the field and are thus easy to identify.

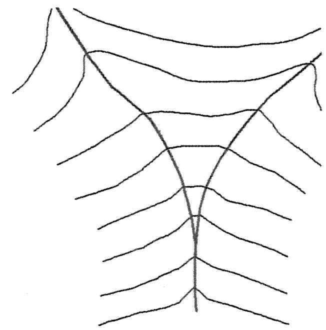


Figure for f.

i. An attached clay lens, such as a repository lining, will tend to mask the field of the conductor being tracked and could produce localized high readings in wet areas as they will act as good conductors and concentrate current. What generally happens over a clay liner is that there is a broad low intensity anomaly that outlines the clay liner and thus this anomaly can be modeled and removed.

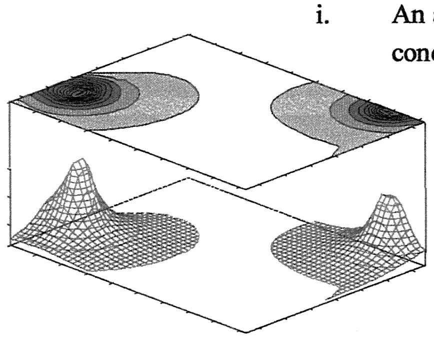


Figure for j.

j. Fields in the area of a return electrode show higher values as the current will be collected and concentrated at the electrodes no matter which path it has taken. As shown in the Figure for j, this anomaly is very localized and predictable thus it can generally be accounted for in the data.

k. The rate of change in the horizontal direction of the vertical magnetic field intensity across the anomaly is proportional to the width of the current path and thus can be used to calculate the width of the groundwater channel. The amplitude is related to the resistivity contrast between the channel and the soil. The (λ) width is related to how well the channel edge is defined. The (Δ) width is related to overall width and sometimes can provide clues as to depth. These are all theoretical calculations and unfortunately more often than not, cannot be used with field data. The most common reason that this valuable tool cannot be used is that the data spacing is too wide. Generally it is not practical to use close station spacing in an area where preliminary data is being used to outlining the water channels for the first time.

l. Width of the horizontal magnetic field is proportional to depth and width of the channel

m. Correlation of vertical and horizontal magnetic field data is used to clarify ambiguities of width and depth.

n. Locale intensity increases in either the magnetic fields can indicate chemical or biological activity. Chemical and biological activity translate into the ability to produce ions.

o. A study conducted over time, weeks or months, will show changes in field values and are plotted by take the difference or ratio of the readings.

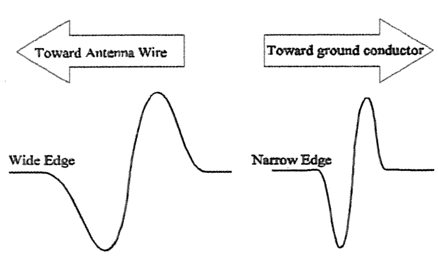


Figure for k.

p. A study conducted over time, weeks or months, will show changes in field values at the same location due to changes in the flow of water, chemical changes over time (such as oxidation or acid production), or biological activity. Variations from one season to the next would be expected due to variations in seasonal water flows.

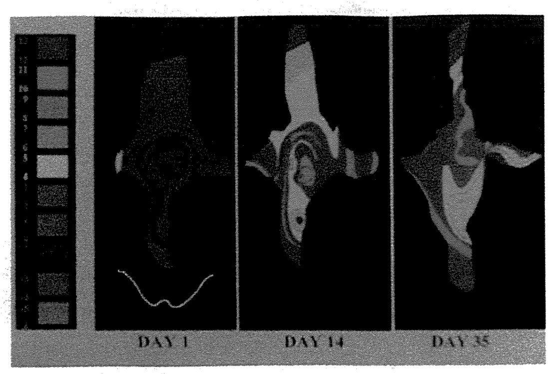


Figure for n, o, p, q. **Comparing all three surveys shows the increase in conductivity and movement of draw down cone as the result of well pump down test.**

q. Comparing changes in the various components of magnetic field over time provide information relating to fluid movement, change in chemical activity, changes of fluid in an aquifer, changes in subsurface biological activity, movement of chemical or bio reaction fronts, leaching progress and activity relating to in situ mining, progress of subsurface chemical or biological remediation, increases or decrease in subsurface flow, changes in salinity, or any change in the groundwater that affects any of its electrical properties.

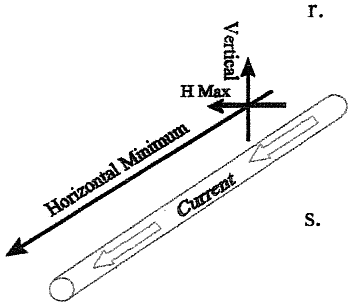


Figure for r.

r. The direction as the minimum horizontal magnetic field or a direction perpendicular to the maximum horizontal magnetic field indicates the direction of the current or subsurface solution path. This is visible in vector plots of the minimum field direction.

s. As current flows down the groundwater channel, some electrical current leaks into the surrounding medium. The electrical contrast between the channel and host rock can be evaluated by the rate at which the magnetic and electric fields degrade.

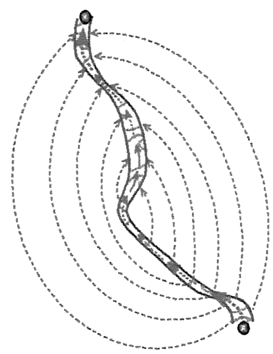
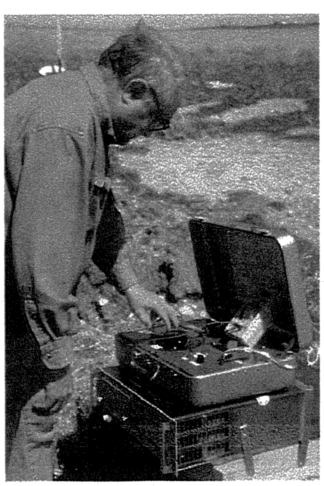


Figure for s.

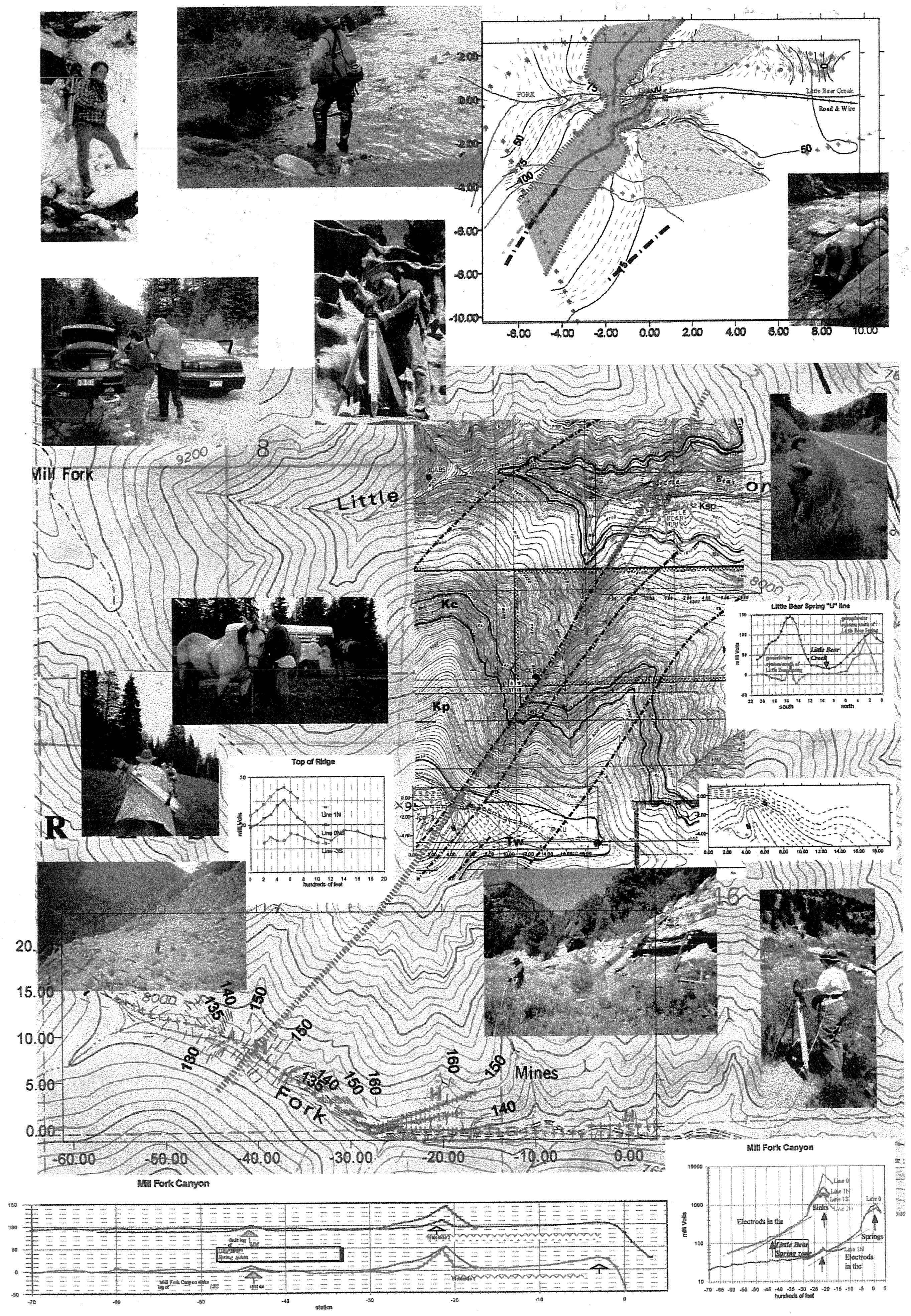
t. The dip of the magnetic field is related to depth and dispersion of the ground current that is following the groundwater.

The simple case will rarely exist. Interpretation of the field measurements must therefor, include as much information of the site as possible. It is obvious that some field measurements could be interpreted to represent widely different outcomes. Historic data can often be used to eliminate possible explanations. Any known influence on the field must be accounted for and normalized out of the measurements as best as possible. Attempts to overcome this are made by performing a precursory analyzing data as it is being gathered on the site and confirming the interpretations with further observations, extra diagonal profiles, and by using any historic data about the site.



All possible explanations for the data obtained need to be considered. For example water will flow along the course of least resistance and most likely will not be straight. Its depth from the surface may also change. The channel the water follows may expand and contract. The path of the water may split following several channels. Other conductors may also exist in the area and may be energized. All these contingencies must be taken into consideration during the interpretive phase, with no prejudgment.

It is possible to prejudice the interpretation if care is not taken and data is not thoroughly analyzed for all possible solutions. Dr. Montgomery has over 30 years of experience interpreting geophysical data with proven success.


Little Bear Creek
Road & Wire
FORK
Mill Fork
Little
Ksp
Kc
Kp
Tw
Mines
Fork
Little Bear Spring "U" line
Top of Ridge
Line 1N
Line 0NS
Line 3S
hundreds of feet
mill Volts
south
north
Mill Fork Canyon
station
Electrods in the
Sinks
Springs
Little Bear Spring zone
hundreds of feet

APPENDIX 7-61

MILL FORK RESISTIVITY STUDY, 2001

AQUA TRACK

RESISTIVITY SURVEY

Sunrise Project No. E9692.48
January 16, 2001

Prepared for:

GENWAL Resources
195 North 100 West
P.O. Box 1410
Huntington, Utah 84528

Prepared by:

Sunrise Engineering, Inc.
12227 South Business Park Drive, Suite 220
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FILLMORE, UT
MESA, AZ
BOISE, ID
AFTON, WY
WASHINGTON, UT
SALT LAKE CITY, UT
BULLHEAD CITY, AZ
PRESCOTT VALLEY, AZ

January 18, 2001

Mr. Dave Shaver
GENWAL Resources
195 North 100 West
Huntington, Utah 84528

RE: Resiitivity Survey
Huntington, Utah
Sunrise Project No. E9692.48

Dear Mr. Shaver:

Enclosed herein is the report for the phase I resistivity survey conducted in Mill Fork Canyon. The information in this report relates only to the study area and should not be extrapolated or construed to apply to other areas. The information, recommendations and conclusions provided herein apply to the study area, as they existed at the time when this report was prepared.

We will be preparing our proposal for the second phase of this study. Phase two consists of an AquaTrack survey above and to the north of Little Bear Spring to determine were the northern extension of the fault is located that feeds into Little Bear Spring. This second phase work can not start until after the spring runoff is over. We plan to submit this second phase proposal to you by the end of February 2001.

We appreciate this opportunity to be of service to you. If you have any questions regarding this report, please feel free to contact us at (801) 523-0100 or (435) 743-6151.

Sincerely,

SUNRISE ENGINEERING, INC.

Calvin Berge For

Jerry R Montgomery, Ph.D.
Senior Geophysicist

Val O. Kofoed

Val Kofoed, P.E.
Principal Engineer

EXECUTIVE SUMMARY

This report presents our findings for phase 1 resistivity survey conducted for GENWAL Resources, Inc. The survey was performed in Mill Fork Canyon near Huntington, Utah. The purpose of this survey was to identify the bedrock/alluvial interface and present cross-sections to show the saturated alluvial zones above the bedrock.

Two cross sections were surveyed and plotted. The first was at the end of the vehicle access road in Mill Fork Canyon. The second was about one mile further up Mill Fork Canyon.

The thickness of the saturated sediments was estimated to range from 0 to 30 feet in the lower study area. In the upper area the thickness of the saturated sediments was determined to range from 0 to 50 feet.

The cross sectional area of the saturated sediments was about 2,000 square feet at the lower resistivity profile and 3,300 square feet at the upper resistivity profile.

The survey also revealed that groundwater in the surveyed profiles flows from the canyon slopes into the canyon creek. Depth to groundwater in the surveyed area ranged from 0-30 feet.

The data indicates that there is an approximately 1,300-square-foot difference in area of saturated sediments between the two surveyed profiles.

TABLE OF CONTENTS

RESISTIVITY SURVEY

Sunrise Project No. E9692.48
January 18, 2001

1.0 INTRODUCTION

This report presents our findings of the first phase resistivity survey conducted for GENWAL Resources, Inc. in Mill Fork Canyon near Huntington, Utah (see **Figure 1**.) A second phase survey will be performed this coming spring/summer in Little Bear Canyon.

A resistivity profiling technique was used in the survey. The purpose of this survey was to estimate the volume of alluvium saturated with groundwater both below and above a fault that is feeding the Little Bear Spring. This study will help estimate the amount of water lost from the alluvium in Mill Fork Canyon through the fault and the amount of water contributing to the Little Bear Spring.

Two resistivity profiles were surveyed. **Figure 2** shows the profile locations in Mill Fork Canyon. **Figure 2** indicates that Mill Fork Canyon is approximately west-east trending in our study area. The surface elevation in the study area is about 8,000 feet above mean sea level.

The fieldwork was conducted during November 27 through December 1, 2000.

Data gathered during the fieldwork was reduced and analyzed. Models were established which show the alluvium profiles and water depths.

2.0 FIELD SURVEY

2.1 Equipment

The equipment used in this survey consisted of two components: a transmitter component and a receiver component.

- The transmitter component consisted of the following four items:

    1. A Honda power 500 watt generator
    2. An Elgar AC power source model 501SL
    3. An impedance matching box, and
    4. An AC to DC converter.

- The receiver was a fluke multi meter with a sensitivity of 0.1 millivolts.

2.2 Setup and Station Location

The stations for the setup of both lower and upper profiles were similar except for the length of the profile. The lower profile #2 was 200 feet long, while the upper profile #1 was 300 feet long. The profile locations are shown in **Figure 2**.

For each survey profile, two transmitting electrodes (one reference transmitting electrode and one roving transmitting electrode) were used.

The lower profile #2 was located at the top of a road (FDR 245, a vehicle accessible road) and extended from the bedrock slope on the north side of the canyon to the bedrock slope on the south side of the canyon. This distance was 200 feet. Readings were taken from both sides of the profile, from north to south then from south to north.

For the 200-foot long profile #2, the reference transmitting electrode was placed at one end of the profile line (200-foot mark) and the roving transmitting electrode was first placed at the 150-foot mark. **Figure 3** (Diagram 2) shows the transmitting electrode setup for profile #2. After the first setup was done, reading from the receiver was then taken for the rest of the profile following specific spacing rules that will be discussed in the next section.

After the reading was taken for the first setting, the roving transmitting electrodes was moved 50 feet and placed at the 100-foot mark while the reference transmitting electrode remained at the 200-foot mark. Readings at the receiver were taken for different survey locations along profile #2.

After readings were taken along the profile under the second setting, the roving transmitting electrode was moved for another 50 feet from the 100-foot mark to the 50-foot mark and readings were taken again.

A reverse setup was then used to take readings again. The first reverse setting was to locate the reference transmitting electrode at the beginning (0) of profile #2 and the roving transmitting electrode at the 50-foot mark; the second and third settings were to move the roving electrode to the 100-foot and 150-foot marks, respectively, while the reference electrode remained at 0. **Figure 4** (Diagram 3)shows the first reverse setting.

The upper profile #1 was approximately one mile further west into Mill Fork Canyon. This profile was also from bedrock on the north to bedrock on the south. The length of this profile was 300 feet from side to side. Readings were taken in both directions from north to south and then from south to north as described for the lower profile. The electrode setup process used on the lower profile #2 was also applied to the upper profile #1.

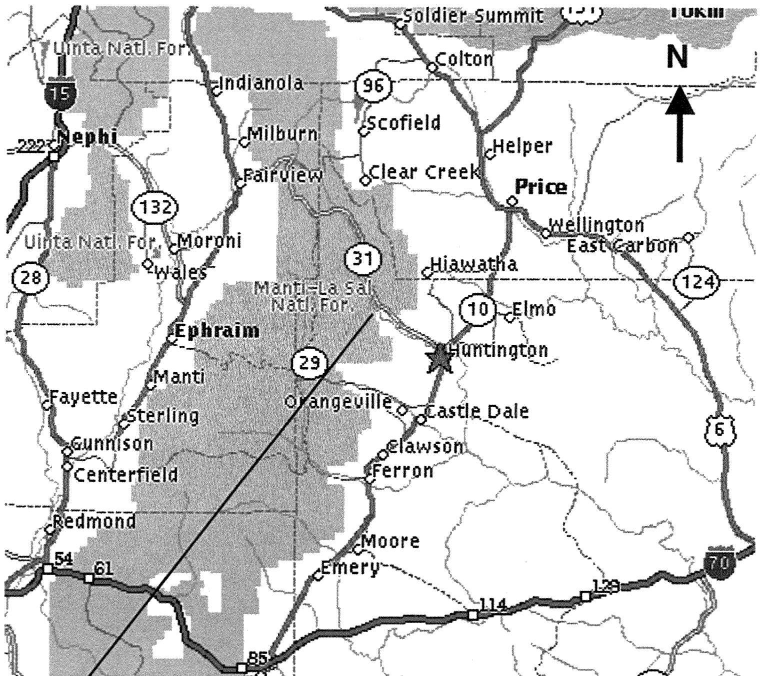


Figure 1. Location Map (Huntington, UT)

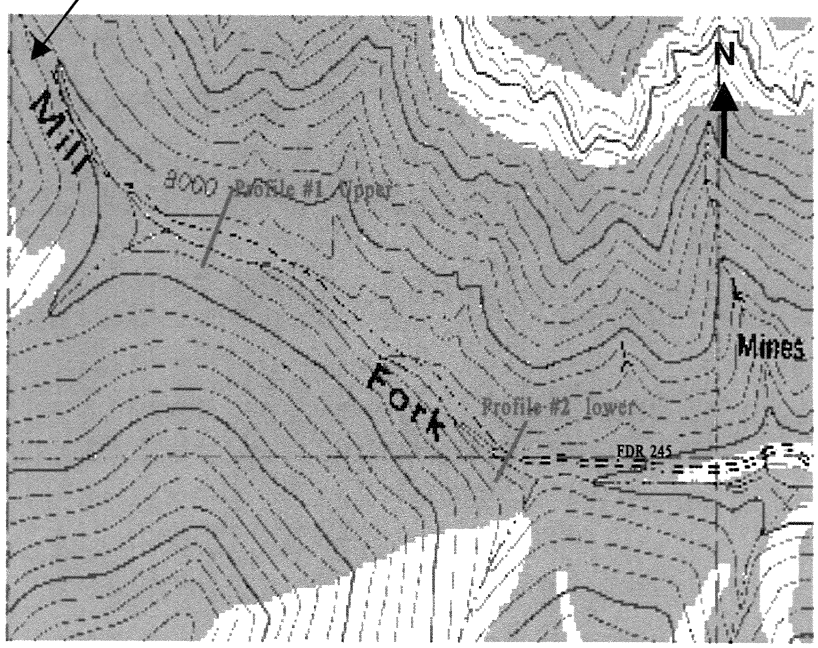


Figure 2. Site Vicinity Map

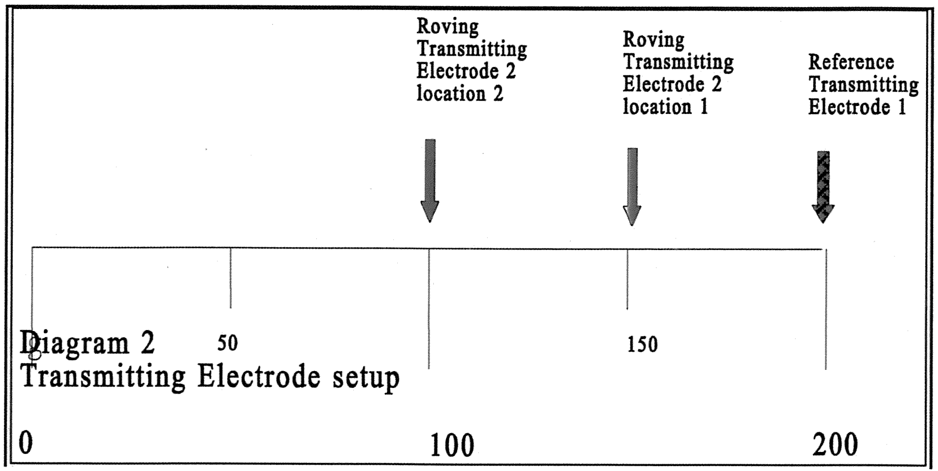


Figure 3. Transmitting Electrode Setup for Profile #2 (Looking West)

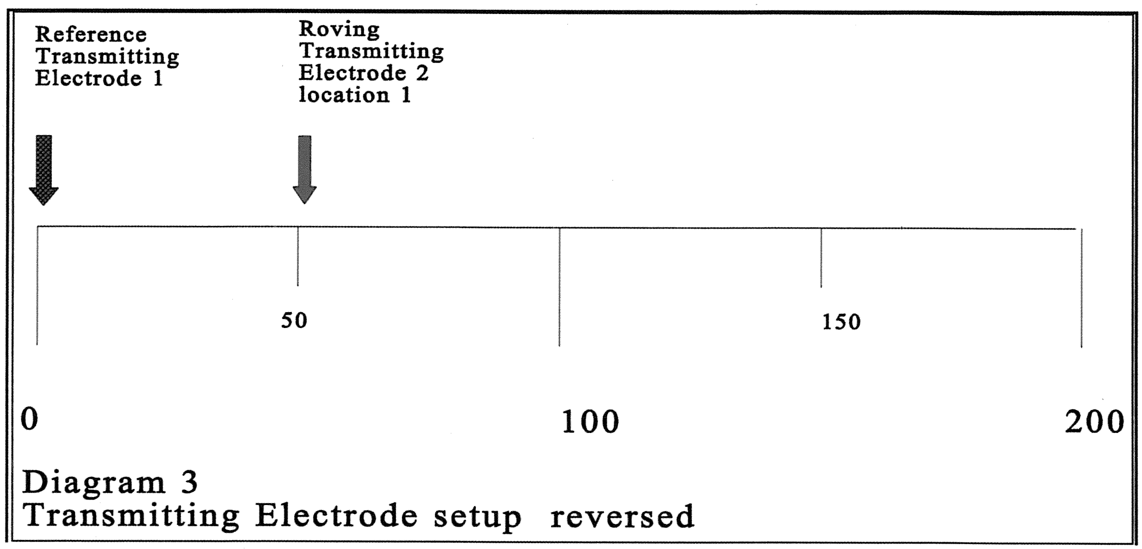


Figure 4. Transmitting Electrode Set Reversed for Profile #2 (Looking West)

2.3 Readings

The readings on profile #2 were conducted by placing a reference receiving (potential) electrode at the opposite end of the line to the reference transmitting electrode. When the transmitting reference electrode had been placed at the 200-foot mark for profile #2, the receiving reference electrode was placed at 0 on the southern side. The roving receiving (potential) electrode was placed on a logarithmic scale starting 5 feet from the roving transmitting electrode or at the 145-foot mark on the profile for the first setting as described in Section 2.2. After the first reading was taken from the 145-foot mark, the roving receiving electrode was moved to the next location. The roving receiving electrode locations for the first setting is shown in **Figure 5** (Diagram 4).

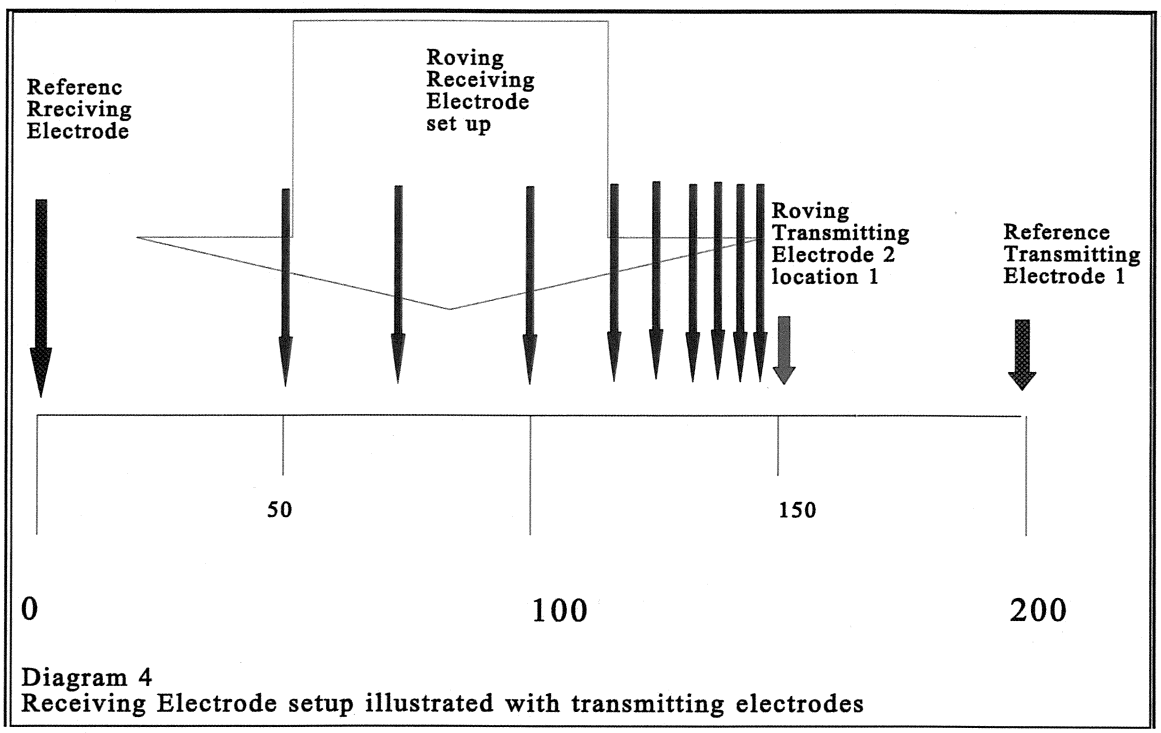


Figure 5. Receiving and Transmitting Electrode Setup for Profile #2 (Looking West)

Readings were taken along the profile in the following sequence of feet from the roving transmitting electrode: 5, 7, 10, 15, 20, 30, 50, 70, 100. These readings were taken from foot marks of 145, 143, 140, 135, 130, 120, 100, 80 and 50 one by one where the roving electrode was located, as shown in **Figure 5**. The maximum number of readings were collected for each roving transmitting electrode setting. Readings were taken until the end of the profile was reached. Thus the distance between the receiving electrodes (reference and roving) becomes progressively smaller while the distance between receiving roving transmitting electrode and the reference transmitting electrodes increased.

After the first set of readings were taken, the roving transmitting electrode was moved to the 100-foot mark as described above and reading were taken again on the same logarithmic scale. Thus, the next reading was taken at the 95-foot mark on the line then at 93, 90, 85, 80, 70, 50, 30. The 30-foot mark was the last reading position prior to bedrock at 0 at the southern end of the profile.

The same procedure was repeated with the roving transmitting electrode at the 50-foot mark. The next reading was taken at the 45-foot mark on the line and then at 43, 40, 35, 30 and 20. The 20-foot mark was the last reading position prior to the bedrock at 0 at the southern end of the profile.

All readings were taken using a Fluke multi-meter. The multi-meter was used to measure the potential difference between its reference potential electrode and the roving potential electrode.

Figure 6 (Diagram 5) illustrates a similar setup for the 300-foot survey profile. This shows the transmitter electrodes set at 300 feet (reference electrode) and 200 feet (roving electrode) and the receiving (potential) electrodes at 0 (reference) and the logarithmic scale from 195 to 50 for the roving receiving (potential) electrode.

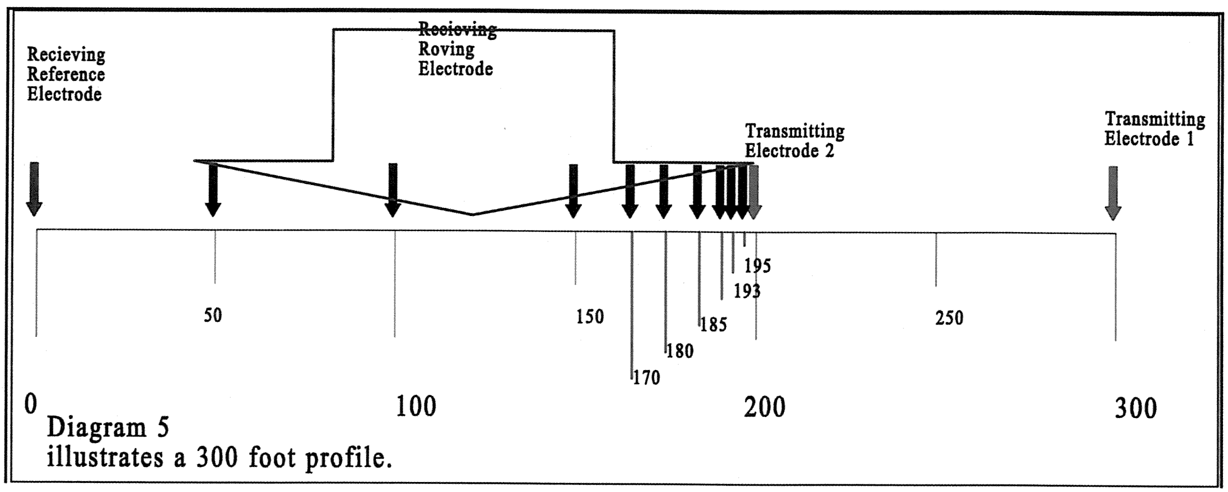


Figure 6. Electrode Setup for Profiled #1 (Looking West)

3.0 DATA ANALYSIS AND INTERPRETATION

The data was reduced using standard equations to determine resistivity based on the current from the transmitter, voltage measured at the receiver, and the geometric configuration of the electrodes.

The values obtained from the reduction of the data were used to develop the models of profiles #1 and #2. The models were developed by plotting the data as cross-sections and depth soundings.

The depth soundings were used to determine the depth to the top of the water table and the depth to bedrock. The depth to these two layers were determined for each fixed electrode positions along both profiles for both directions. This provided depth samples approximately every 50 feet for the entire length of the two profiles.

The data was also plotted in cross sectional form. The interpreted depths obtained from the sounding curves were then superimposed on those cross sections. The cross section and interpretation are included.

Using the cross sectional models obtained from the resistivity data, cross section blocks of saturated alluvium were identified. The area for each of these cross section blocks was calculated and summed to provide a total cross sectional area of saturated sediments for each profile. These calculations are provided in Survey Results.

4.0 SURVEY RESULTS

The two resistivity profiles for Mill Fork Canyon were measured so that both resistivity depth soundings (depth soundings) and cross sectional data would be gathered at the same time. Each depth sounding along the profiles was modeled against standard two- and three-layer sounding curves. The results of these comparisons were superimposed on the data plotted as a cross sectional profile. The resulting models are in **Figures 7 and 8**.

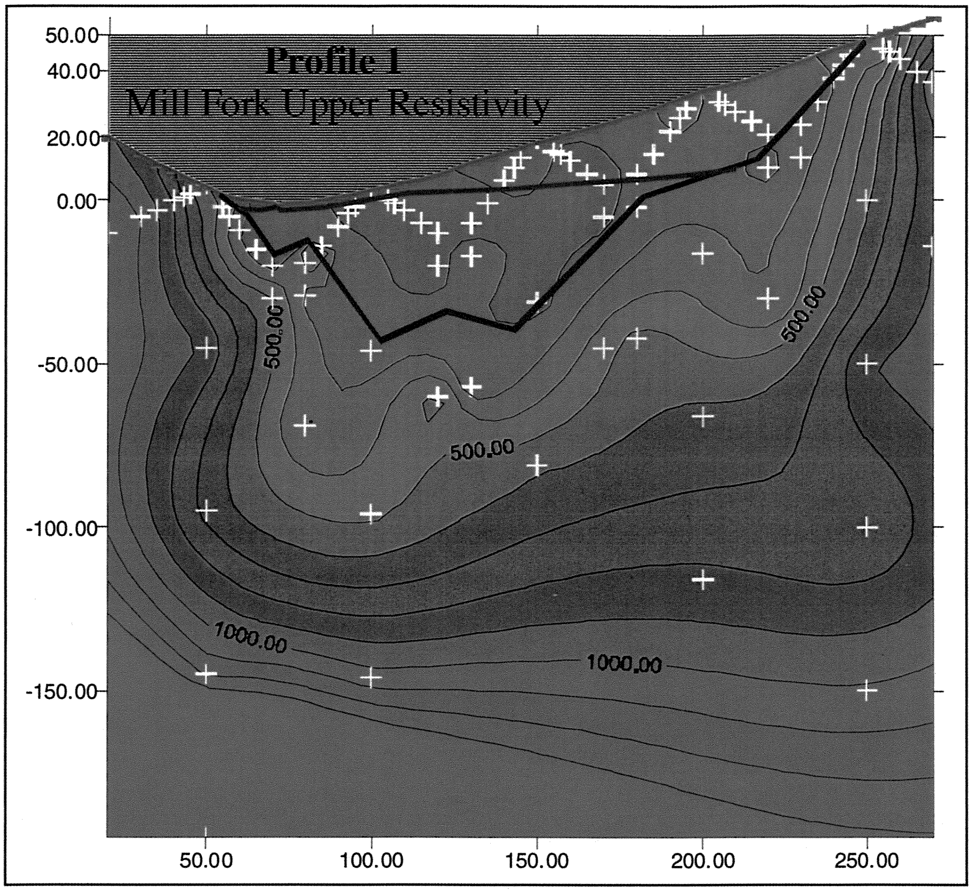


Figure 7. Resistivity Contour Map on Profile #1

Both profiles are plotted looking west with north on the right and south to the left. The coordinate units are in feet and the resistivity is in ohms.

The models are superimposed on the resitivity cross sections and include depth to the bedrock interface and depth to the watertable. The resistivity shown on the map is apparent resistivity. According to the book titled "*Fundamentals of Geophysics*" written by Williams Lowrie in 1997, the apparent resistivity for saturated sediment would be around 300-400 ohms.

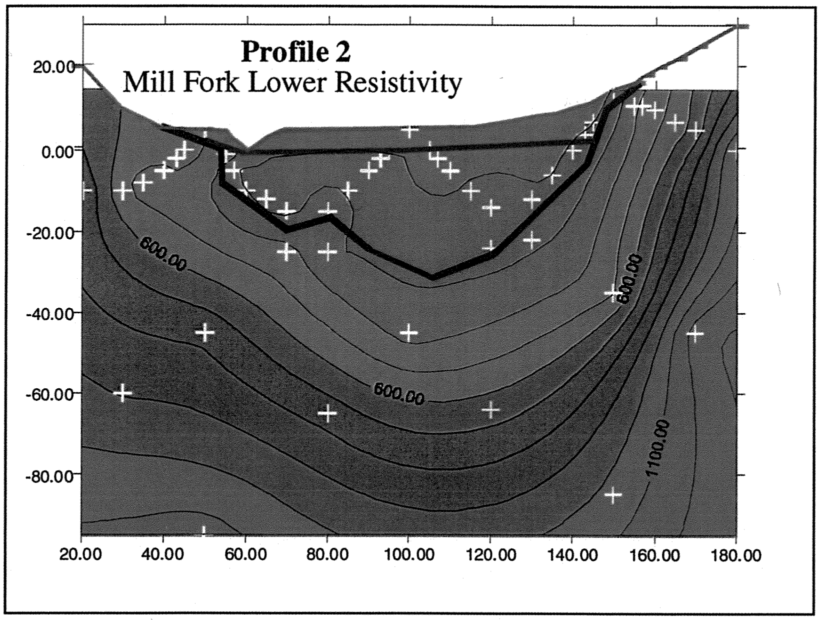


Figure 8. Resistivity Contour Map on Profile #2

In **Figures 7 and 8**, the interface between bedrock and saturated sediments is represented by a red line and the water table a blue line. The two figures indicate that groundwater flows to the canyon creek from both side of the canyon. The depth to water table ranges from 0 at and in the vicinity of the creek and about 30 feet at the foot of the northern slope in profile #1 and about 10 feet at the foot of the northern slope in profile #2. The maximum thickness of the saturated sediments is about 50 feet at profile #1 and roughly 30 feet at profile #2.

The cross sectional area for saturated sediment is estimated to be approximately 3,300 square feet at profile #1 and about 2,000 square feet at profile #2.

5.0 CONCLUSION

This report presents our findings of the resistivity survey conducted for GENWAL Resources, Inc. in Mill Fork Canyon near Huntington, Utah. The survey was performed to map the bedrock alluvial interface and the cross sectional area of the saturated zone.

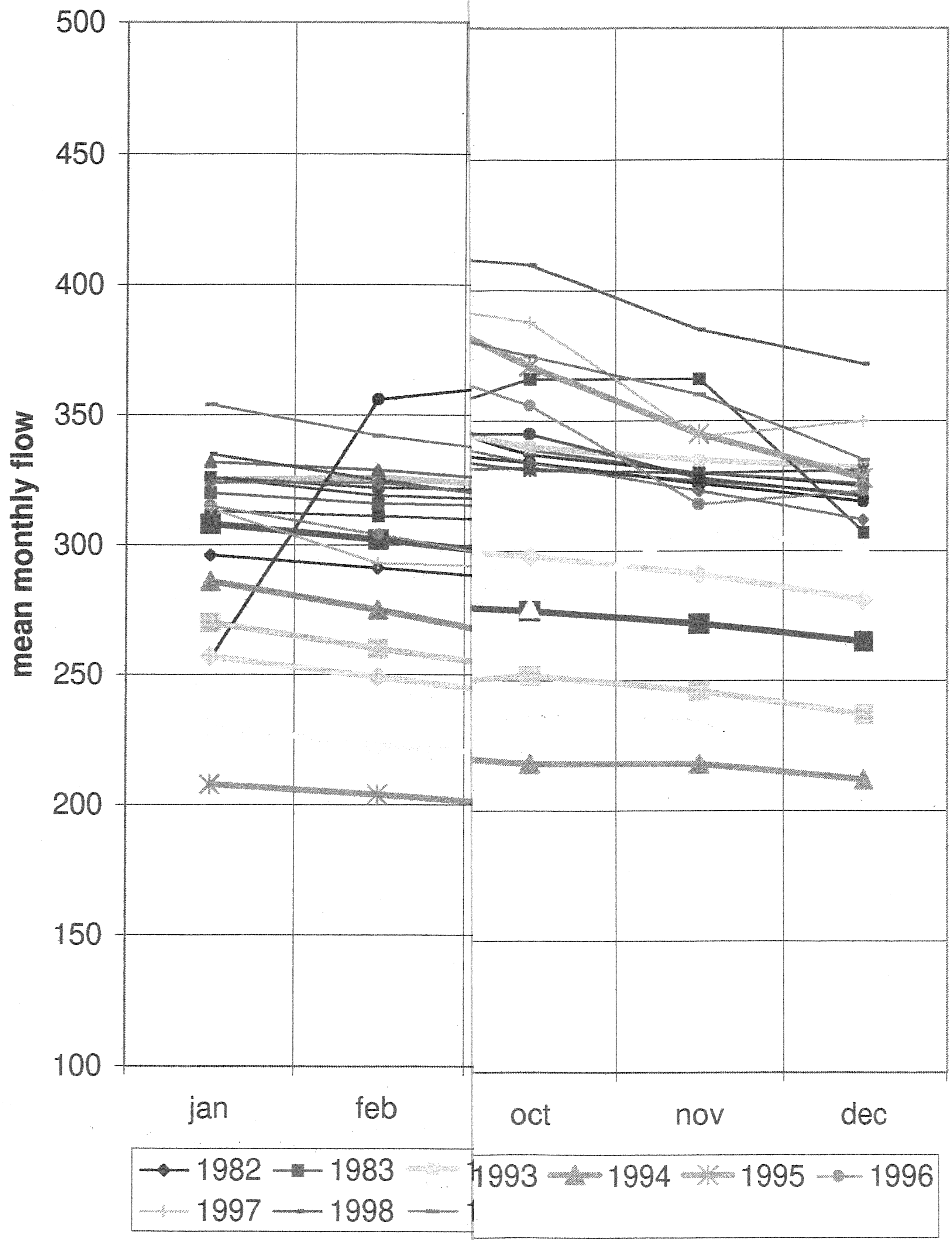
Two cross sectional areas were examined. The first was at the end of an access road to Mill Fork Canyon. The second was about one mile further up into Mill Fork Canyon.

The thickness of the saturated sediments was estimated to range from 0 to 30 feet in the lower study area. In the upper area the thickness of the saturated sediments was determined to range from 0 to 50 feet.

The cross sectional area of the saturated sediments was about 2,000 square feet at the lower resistivity profile and 3,300 square feet at the upper resistivity profile.

The survey also revealed that groundwater in the surveyed profiles flows from the canyon slopes to the canyon creek. Depth to groundwater in the surveyed area ranged from 0-30 feet.

The data indicates that there is an approximately 1,300-square-foot difference in area of saturated sediments between the two surveyed profiles.



500
450
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mean monthly flow
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Mayo and Associates, Mill Fork stream gauging locations.cdr 14 Jan 99

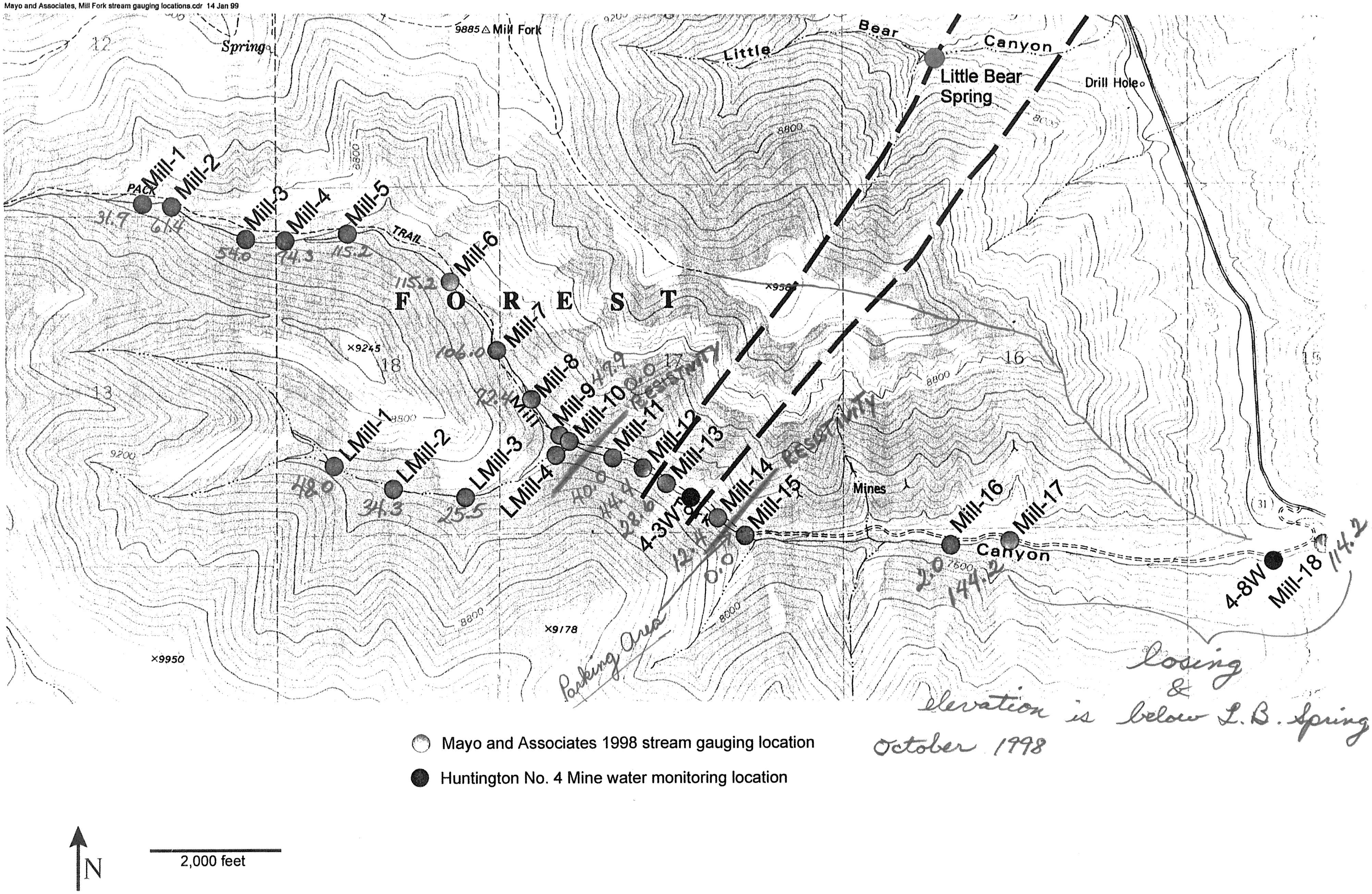


Figure 7 Stream gauging and monitoring stations on Mill Fork Creek.

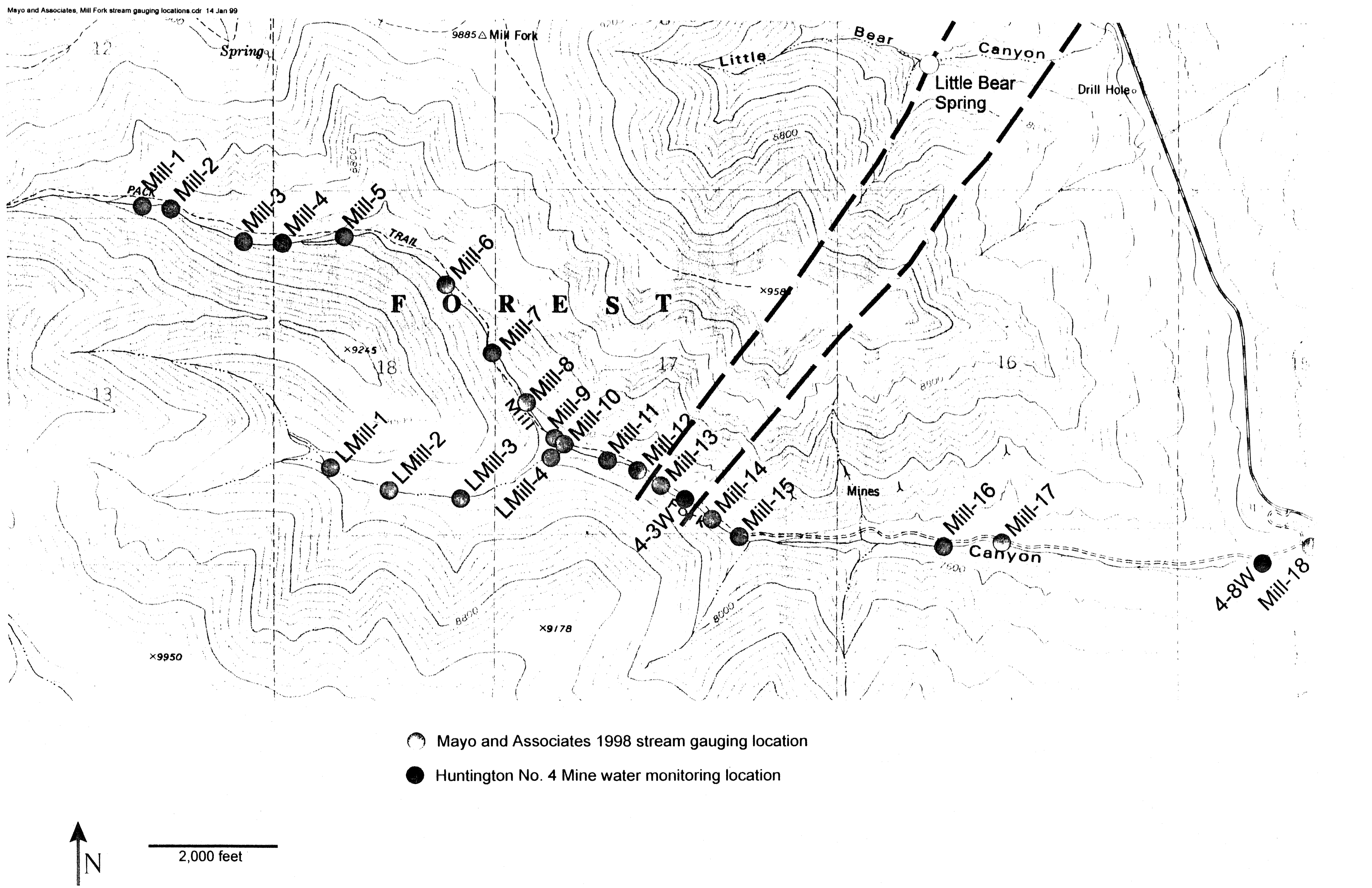


Figure 7 Stream gauging and monitoring stations on Mill Fork Creek.

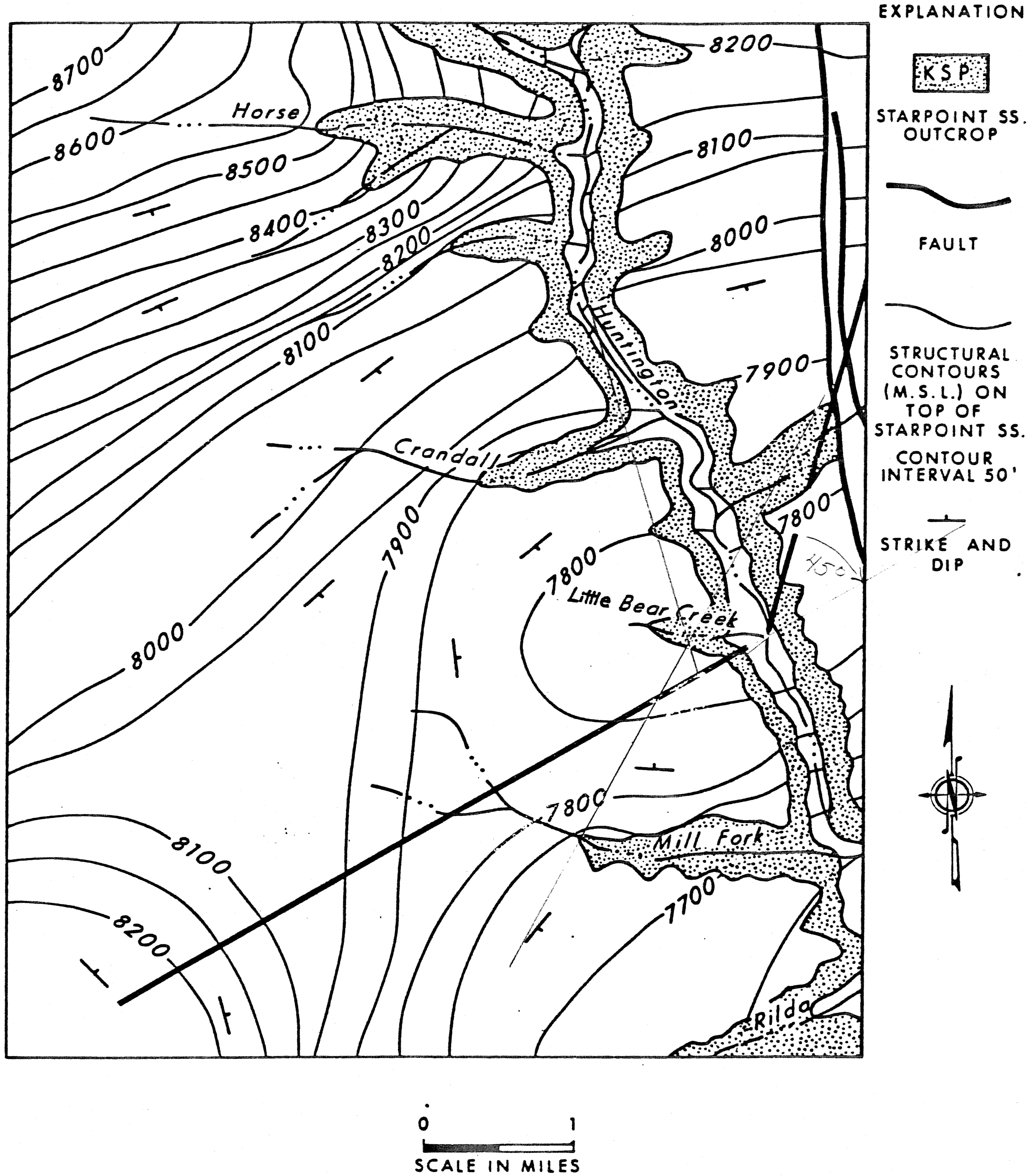
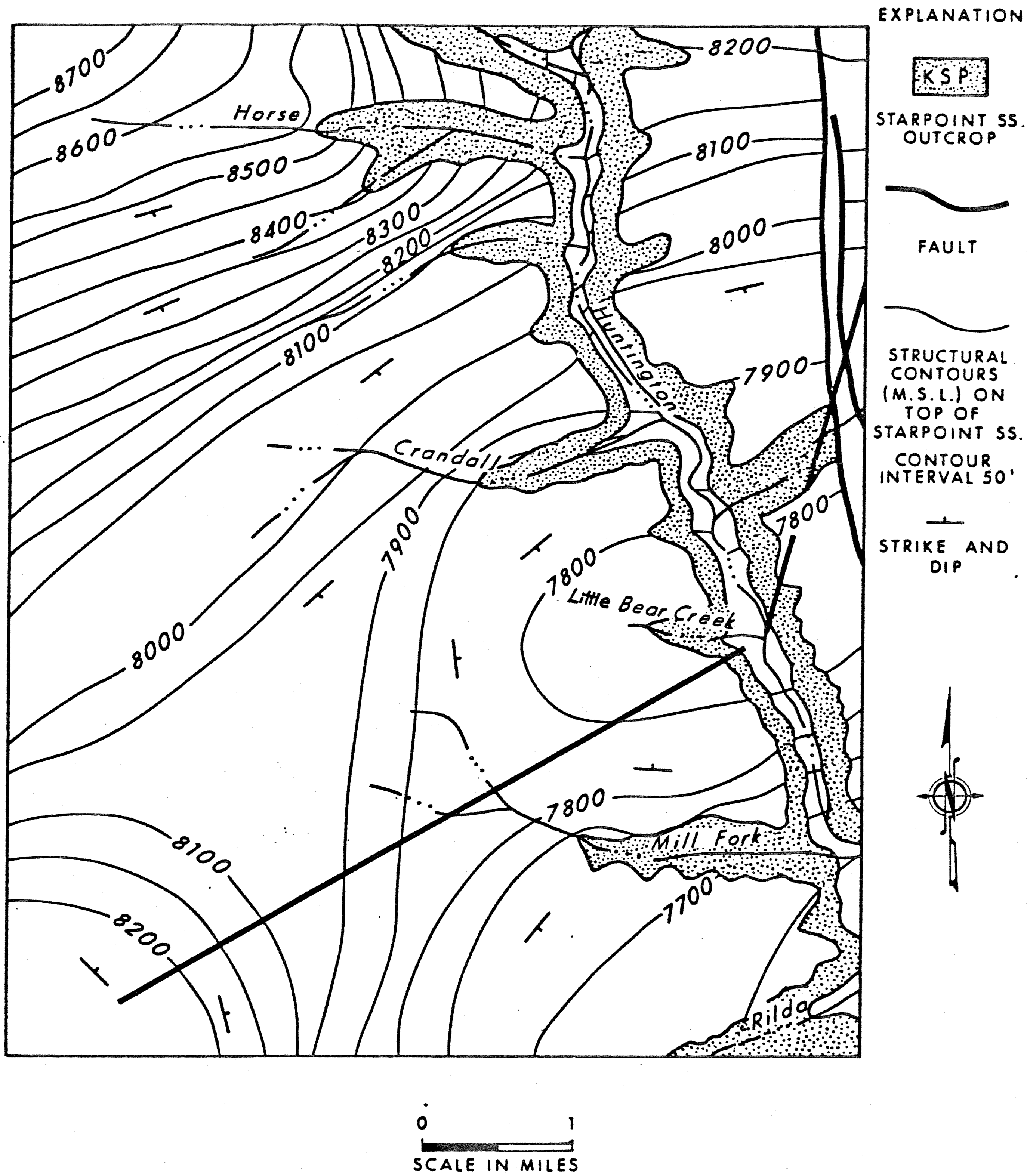


Figure. 7.2 Structural contours (M.S.L.) on top of Starpoint Sandstone (Edmund Spreker, U.S.G.S.)

D.H.R. 8/82



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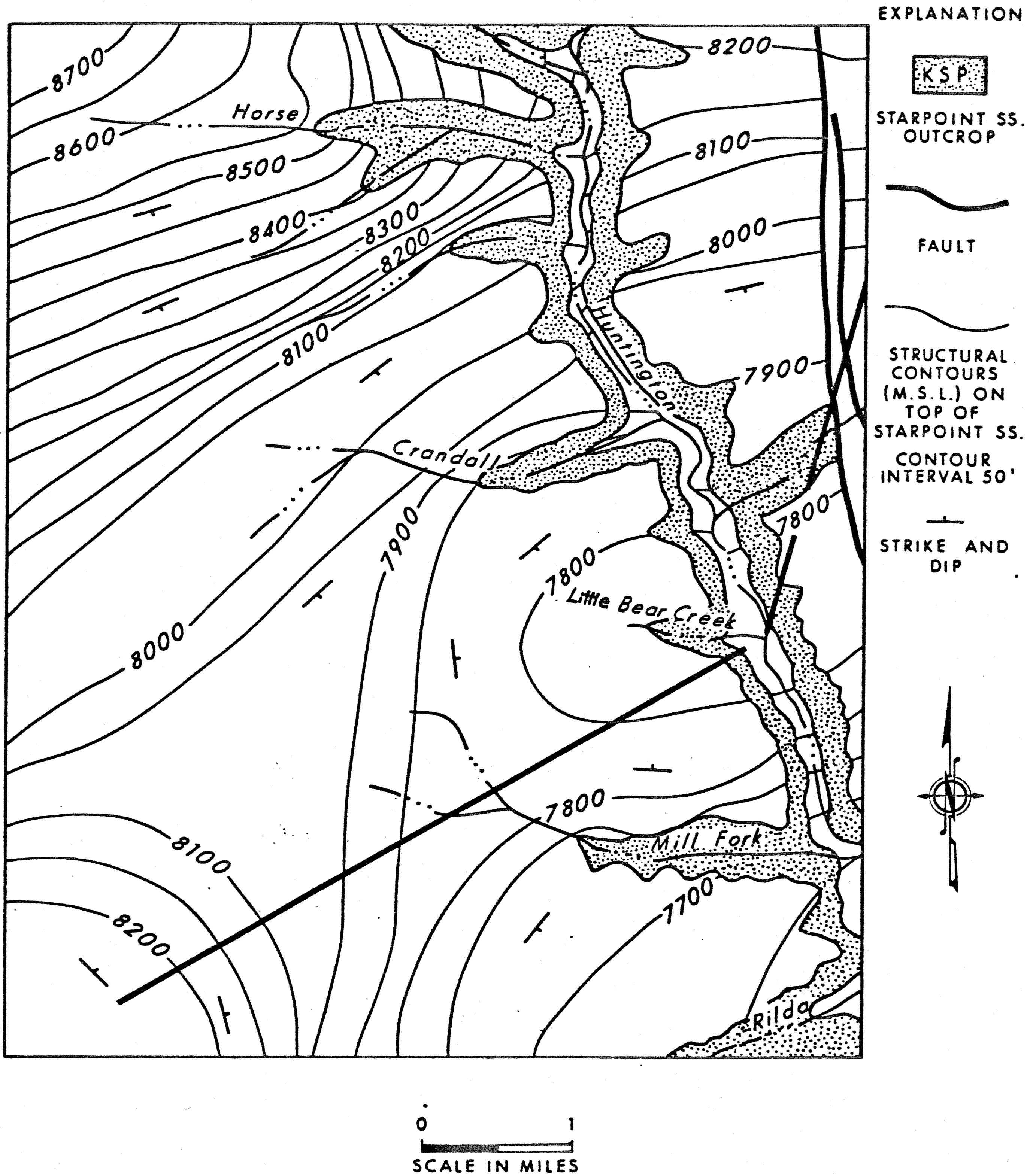

Figure. 7.2 Structural contours (M.S.L.) on top of Starpoint Sandstone (Edmund Spreker, U.S.G.S.)

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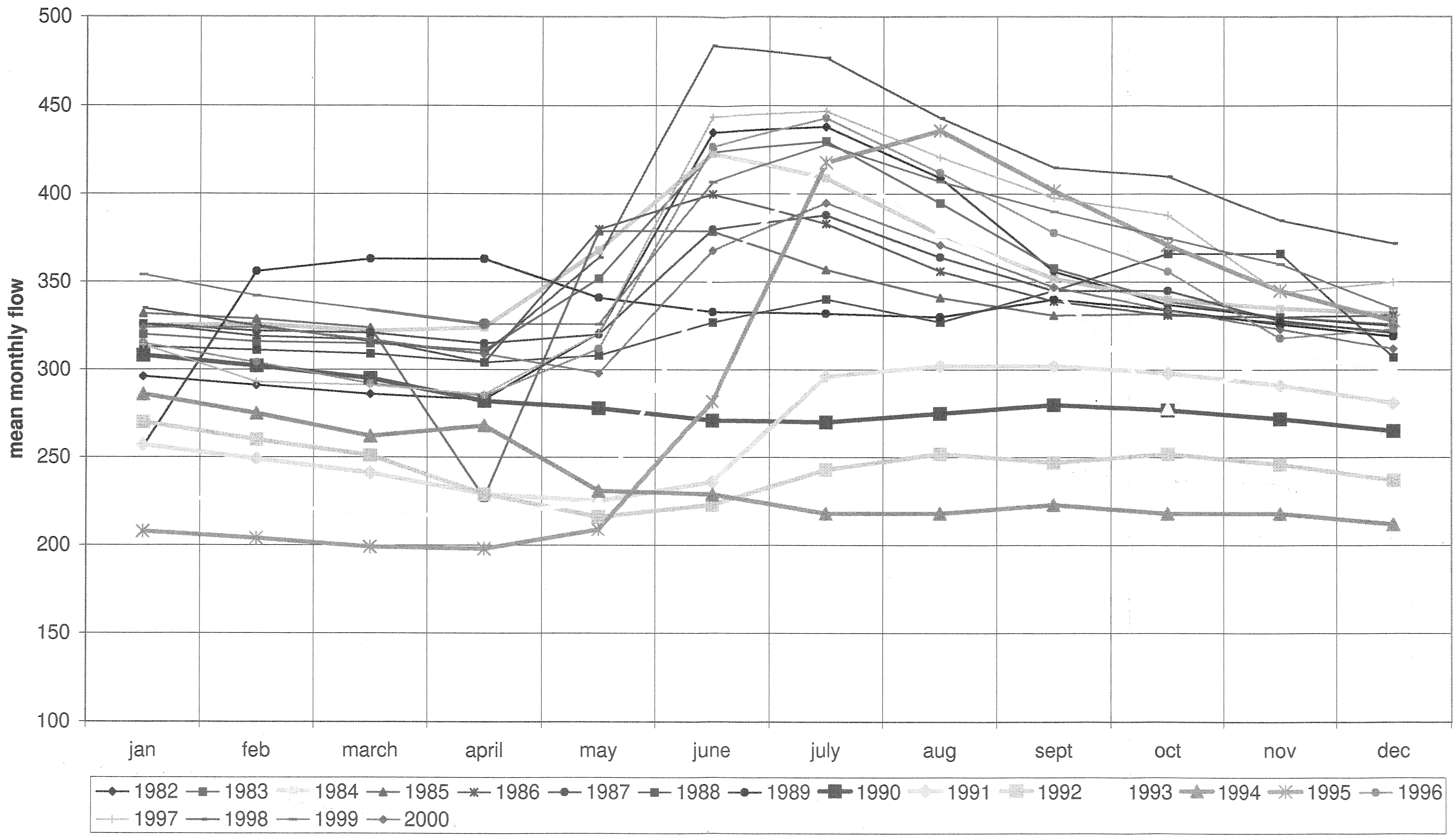
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Mayo and Associates, Mill Fork stream gauging locations.cdr 14 Jan 99

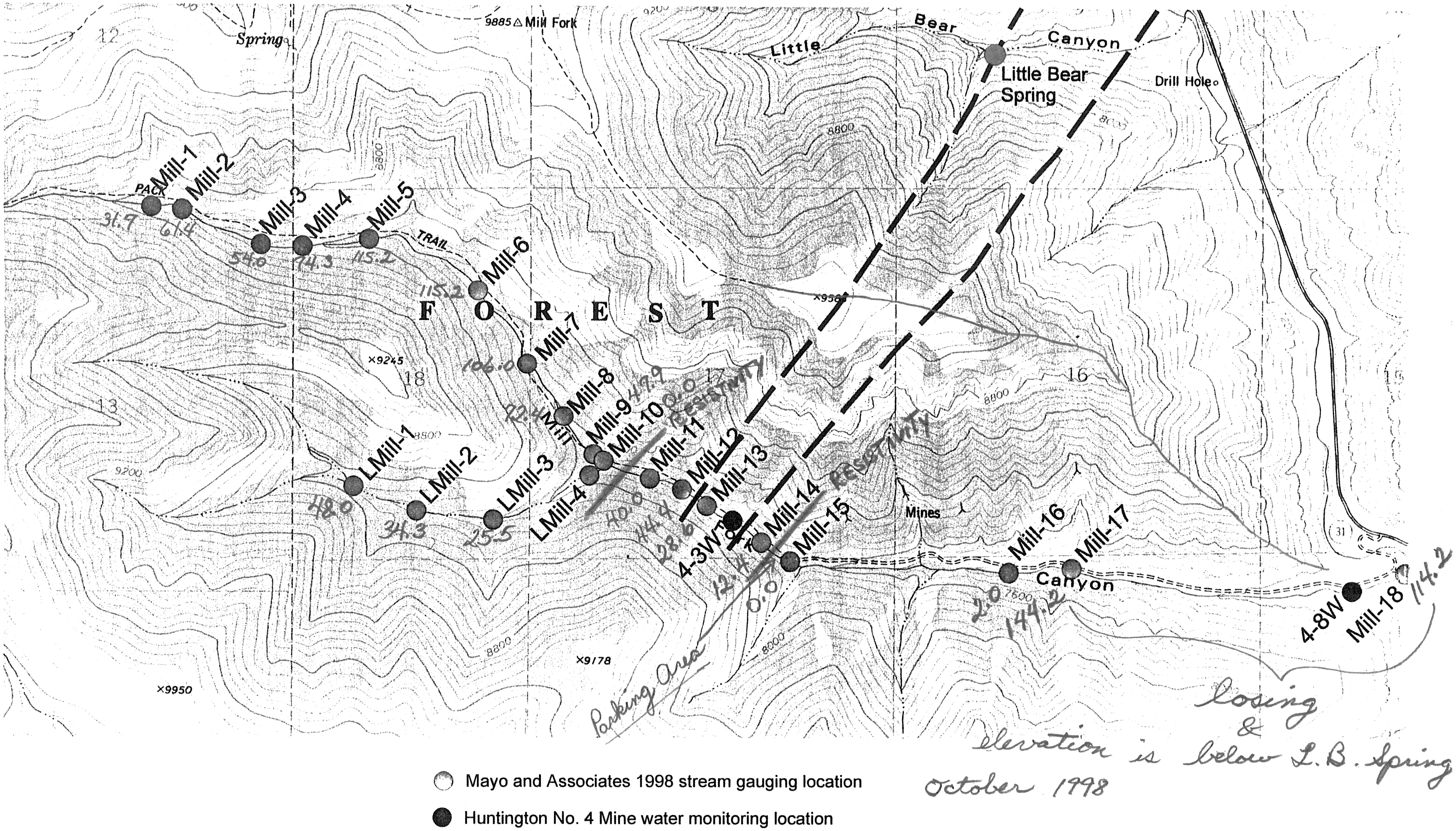


Figure 7 Stream gauging and monitoring stations on Mill Fork Creek.

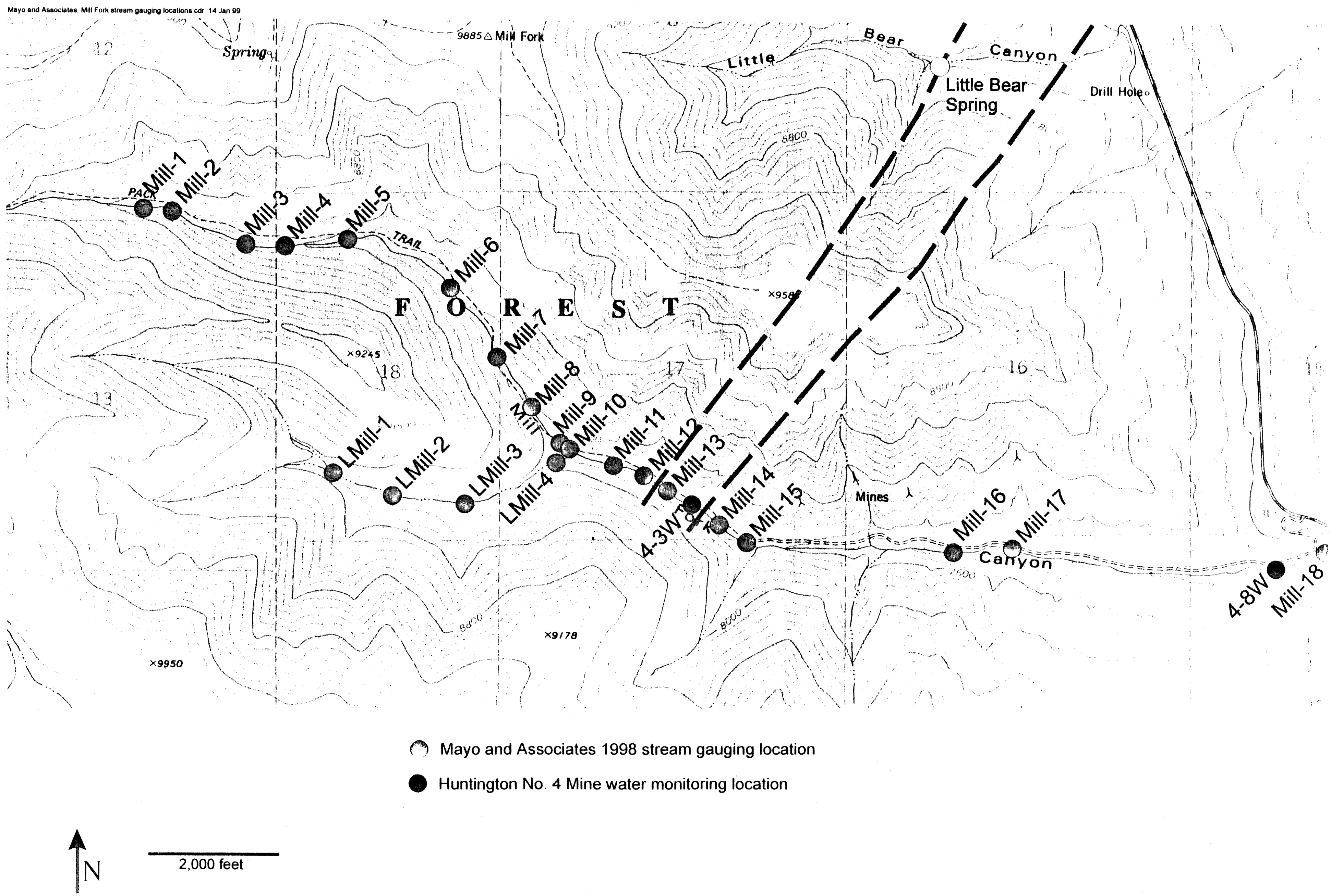


Figure 7 Stream gauging and monitoring stations on Mill Fork Creek.

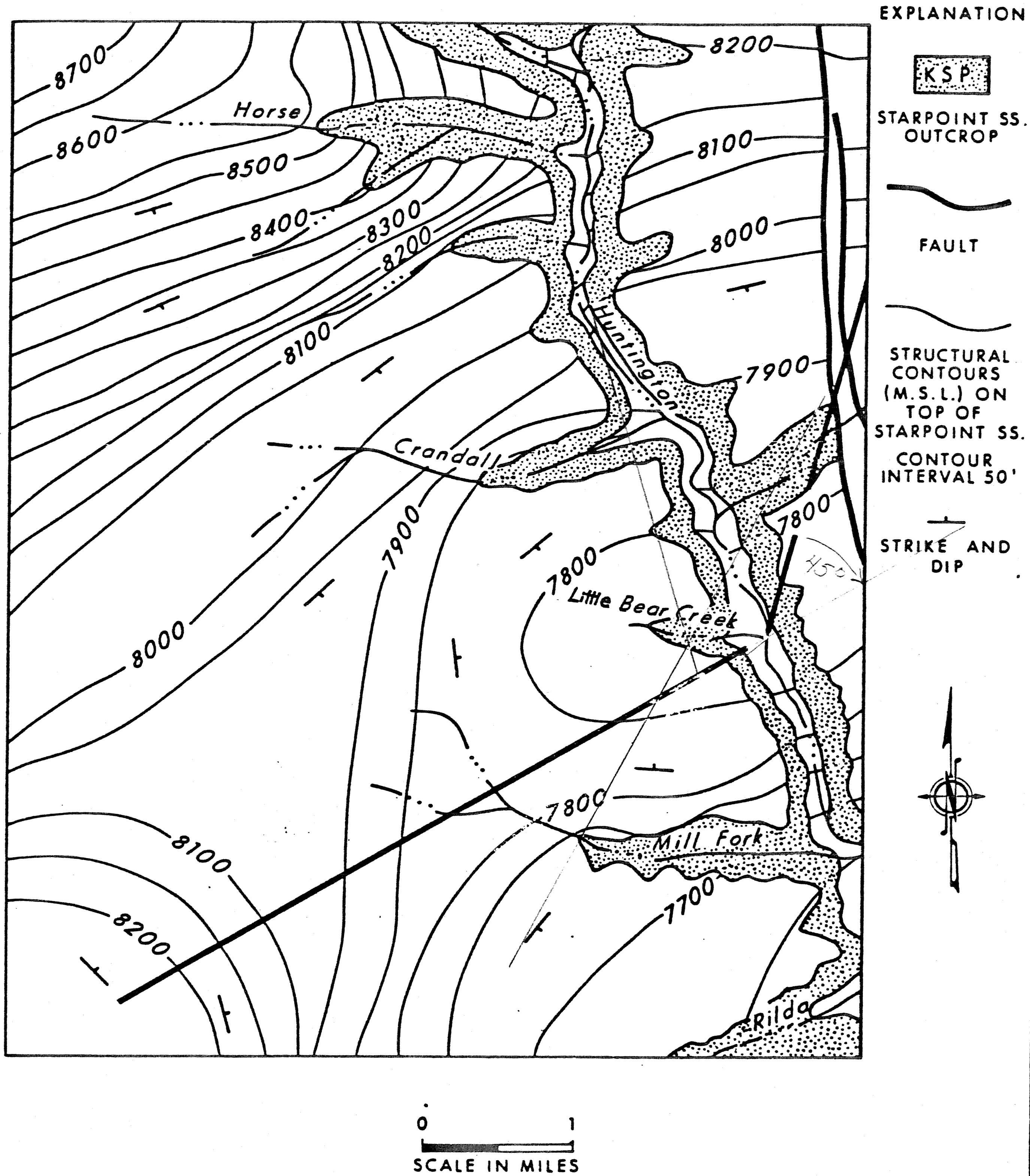
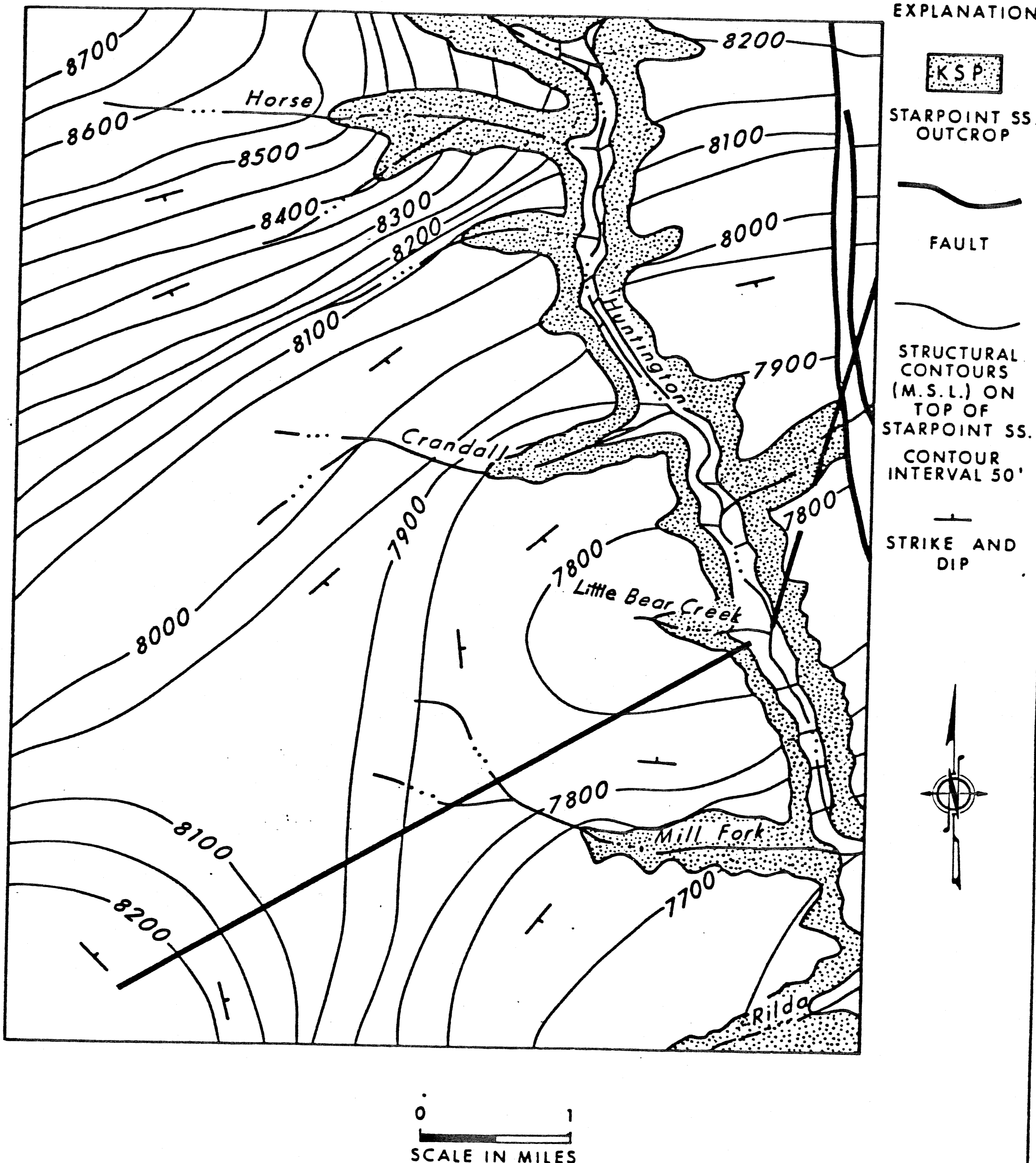


Figure. 7.2 Structural contours (M.S.L.) on top of Starpoint Sandstone (Edmund Spreker, U.S.G.S.)

D.H.R. 8/82



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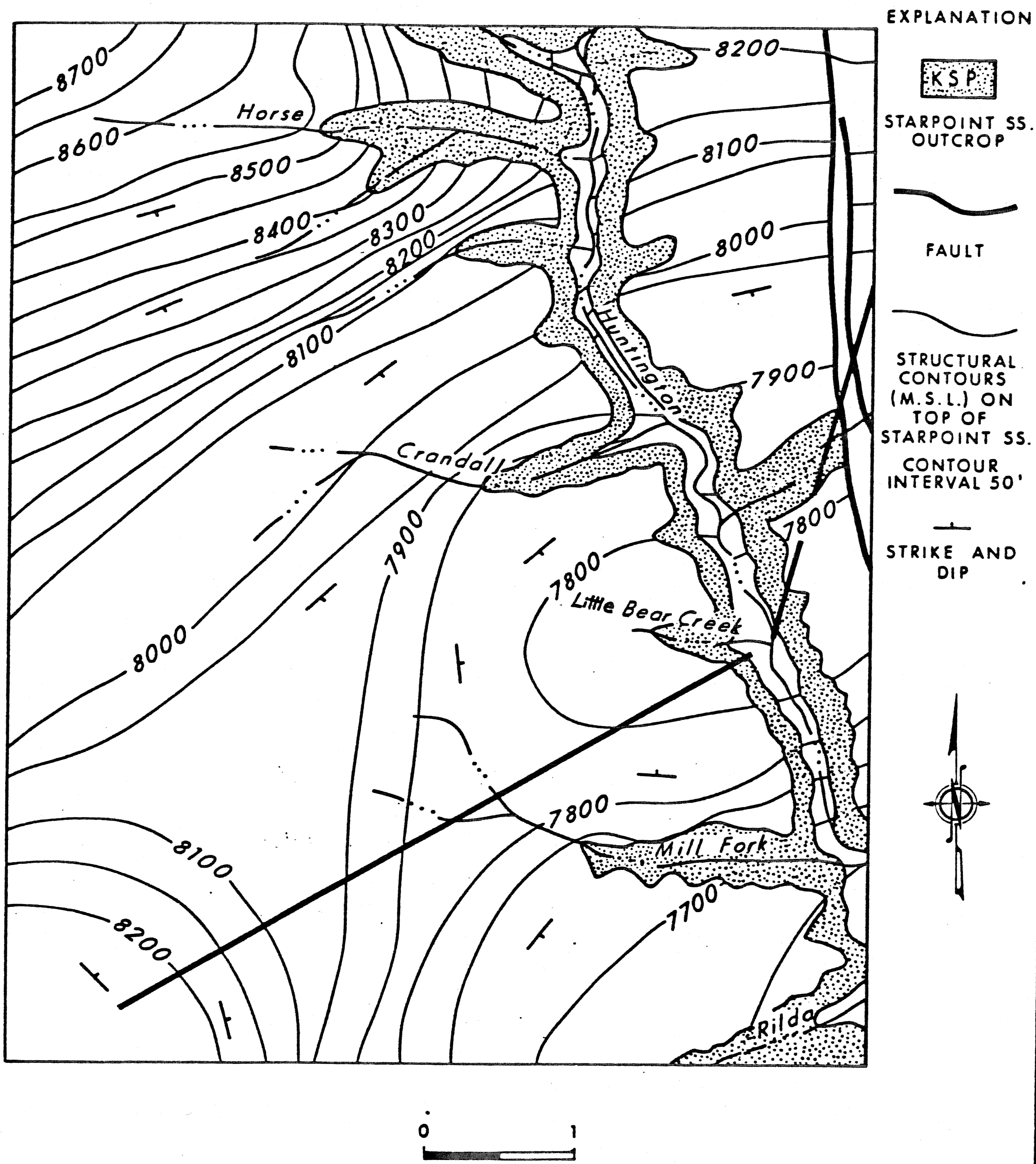


Figure. 7.2 Structural contours (M.S.L.) on top of Starpoint Sandstone (Edmund Spreker, U.S.G.S.)

D.H.R. 8/82

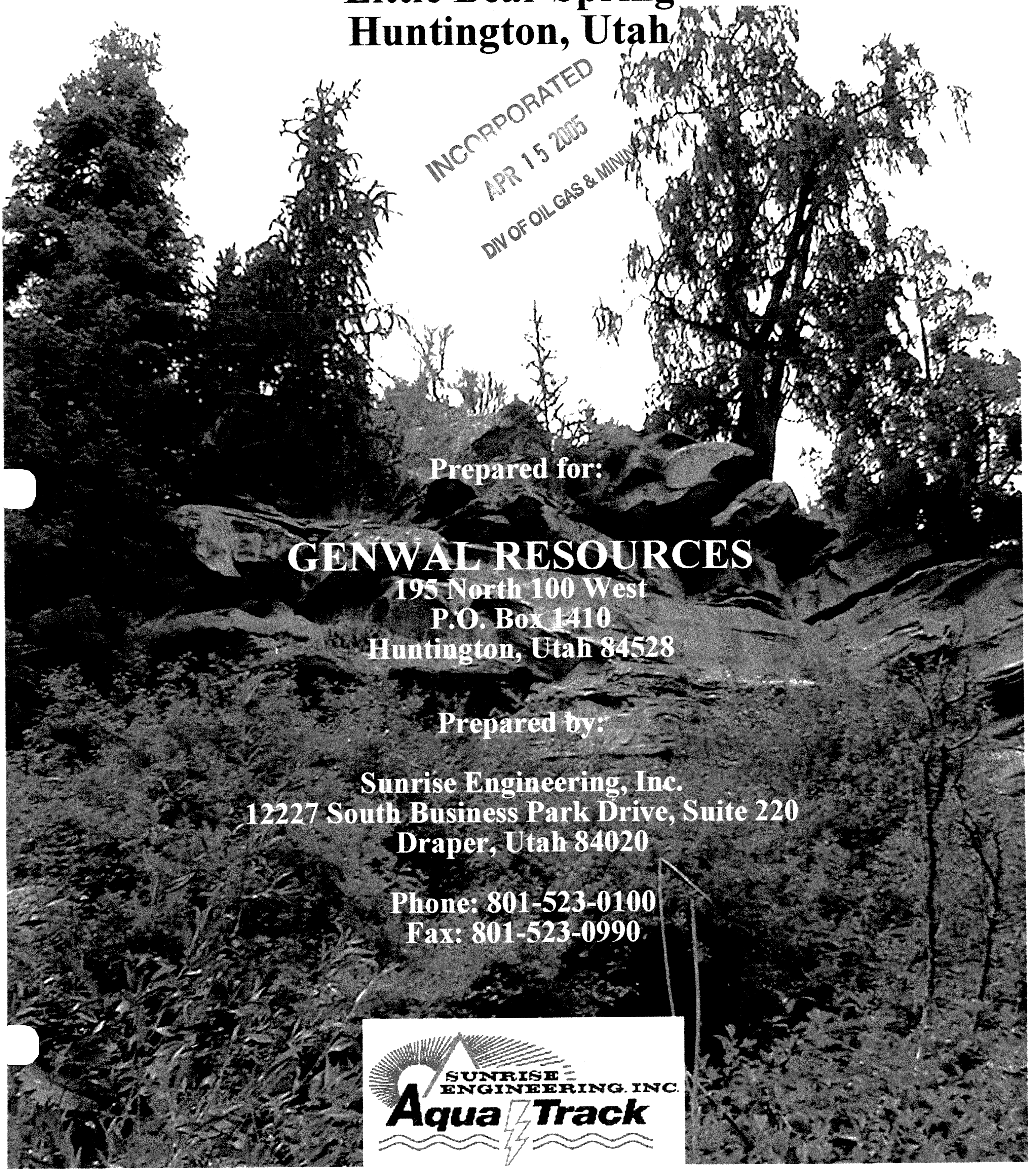
APPENDIX 7-62

LITTLE BEAR SPRING STUDY (2ND EXPANDED STUDY, 1999)

AQUA TRACK

AQUATRACK SURVEY

Little Bear Spring
Huntington, Utah



Prepared for:

GENWAL RESOURCES
195 North 100 West
P.O. Box 1410
Huntington, Utah 84528

Prepared by:

Sunrise Engineering, Inc.
12227 South Business Park Drive, Suite 220
Draper, Utah 84020

Phone: 801-523-0100
Fax: 801-523-0990

SUNRISE ENGINEERING, INC.
Aqua Track

SUNRISE ENGINEERING INC.
12227 South Business Park Drive • Suite 220
Draper, Utah 84020
Tel (801) 523-0100 • Fax (801) 523-0990

MESA, AZ
BOISE, ID
AFTON, WY
FILLMORE, UT
WASHINGTON, UT
SALT LAKE CITY, UT
PRESCOTT VALLEY, AZ

November 1, 2001

Mr. Dave Shaver
GENWAL Resources
195 North 100 West
P.O. Box 1410
Huntington, Utah 84528

Re: AquaTrack Survey
Little Bear Canyon
Sunrise Project No. 00560

Dear Mr. Shaver:

Sunrise Engineering, Inc. (Sunrise) has completed an AquaTrack survey at the above referenced site. The survey was conducted in general accordance with our proposal dated March 6, 2001.

Our services consist of professional opinions and recommendations made in accordance with generally accepted hydrogeological principles and practices at the time of execution. This warranty is in lieu of all other warranties either expressed or implied. The information in this report relates only to the subject site and should not be extrapolated or construed to apply to any other areas.

We appreciate this opportunity to be of service to you. If you have any questions regarding this report, please feel free to contact us at (801) 523-0100 or (435) 743-6151.

Sincerely,
SUNRISE ENGINEERING, INC.

Prepared by:

Dao Yang, P.E.
Project Engineer

Reviewed by:

Val Kofoed, P.E.
Principal Engineer

Jerry Montgomery, Ph.D.
Chief Geophysicist

EXECUTIVE SUMMARY

Sunrise Engineering, Inc. (Sunrise) has completed an AquaTrack survey for GENWAL Resources in Little Bear Canyon where Little Bear Spring, a culinary water source for the Castle Valley Special Service District, is located. The spring yields approximately 300 gallons per minute (gpm) of culinary water. The purpose of this survey was to investigate the north slope of Little Bear Canyon and determine if any preferential groundwater pathway exists and connects Little Bear Canyon and Crandall Canyon approximately 1.5 mile north of Little Bear Spring. Near Crandall Canyon, coalmining operations are active. If a preferential groundwater pathway exists which conveys water from Crandall Canyon to Little Bear Canyon, the quality of water from Little Bear Spring may become degraded.

Previous investigation data was also reviewed and incorporated into this report.

The tool used in this survey was AquaTrack, a geophysical technology that uses electrical current injected into the subsurface to track, map and monitor groundwater. As the current flows through groundwater, it follows the path of the least resistance. In most cases, the path of the least resistance is the water bearing strata. The groundwater acts as a subsurface conductor. AquaTrack employs electrons as tracers to follow the subsurface continuous conductor. As the current flows through the groundwater, the current creates a magnetic field characteristic of the injected audio-frequency current. This magnetic field can then be detected and surveyed from the ground surface using a special magnetic receiver.

Mapping the magnetic field is to delineate where the electrical current is flowing, and identifying the location of the electrical current is to map where groundwater is located. The end results provide a map showing the most probable groundwater flow pattern(s) for the area of investigation.

The findings of this survey and previous surveys is summarized below:

- A preferential groundwater pathway along a fault line was identified to connect Mill Fork Canyon and Little Bear Canyon. Little Bear Spring is located on this pathway.
- The saturated sediments in Mill Fork Canyon are capable of supporting continuous recharge to Little Bear Spring.
- Mill Fork Creek loses approximately 300 gpm of surface water. The lost water likely recharges Little Bear Spring.

- The primary groundwater source of Little Bear Spring is from the preferential groundwater pathway leading to Mill Fork Canyon where small sinkholes were identified to be within the fault zone.
- The fault that is believed to connect Mill Fork Canyon and Little Bear Canyon was inferred to extend to the northern slope of Little Bear Canyon. It appears that the fault intercepts all groundwater from the area up-gradient (northwest) of the fault and conducts the water to the canyon creek. This inference is also supported by the fact that the area down-gradient (southeast) of the fault is not a groundwater-bearing zone. The survey data also indicates that the water north of Little Bear Spring is minimal and probably incidental.
- Groundwater as a result of natural recharge resulting from precipitation moves from the northern slope of Little Bear Canyon towards the canyon creek. The amount of water is not significant.

This survey does not cover the area across the northeast topographic divide, Sunrise cannot infer that no preferential groundwater pathway runs across the divide that may potentially introduce groundwater to Little Bear Canyon from Crandall Canyon where mining operations are active. However, the data from this survey indicates a very low probability of any water from Crandall Canyon Creek to Little Bear Canyon.

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AQUATRACK SURVEY

Little Bear Canyon
Huntington, Utah
November 1, 2001

1.0 INTRODUCTION

Sunrise Engineering, Inc. (Sunrise) has completed an AquaTrack survey for GENWAL Resources in Little Bear Canyon where Little Bear Spring, a culinary water source for the Castle Valley Special Service District, is located. The purpose of this survey was to investigate the north slope of Little Bear canyon and to determine if any preferential groundwater pathway exists which connects Little Bear Canyon and Crandall Canyon approximately 1.5 mile north of Little Bear Spring. Near Crandall Canyon, coalmining operations are active. If a preferential groundwater pathway exists which conveys water from Crandall Canyon to Little Bear Canyon, the quality of water from Little Bear Spring may become degraded.

1.1 Background

Little Bear Spring, located in Little Bear Canyon approximately 12 miles northwest of Huntington, Utah, is a culinary water source utilized by the Castle Valley Special Service District to supply water to the towns of Huntington, Cleveland and Elmo. Historical data indicates that the spring can continuously yield more than 200 gallons per minute (gpm) of water with a maximum of about 500 gpm. Because of the proximity of Little Bear Spring to the existing and proposed coal mining area to the north of the spring, considerable attention has been given to the hydrogeologic conditions surrounding the spring. Delineating the spring recharge or contribution zone can help assess any potential adverse impacts of the mining operations on the spring. Hydrogeologic studies previously conducted in the area (e.g., Mayo and Associates, 1999; Water Technology and Research, 1999; Sunrise, 2001) have indicated that the spring recharge is primarily from Mill Fork Canyon. However, the area north of Little Bear Spring may also contribute water to the spring.

1.2 Previous Studies

Mayo and Associates (1999) conducted a groundwater and surface water study at Little Bear Spring and in the surrounding area and concluded that the recharge to Little Bear

Spring is most likely from the surface water and alluvial groundwater from Mill Fork Canyon, a creek located approximately 1.5 miles south of Little Bear Spring.

Water Technology and Research (1998, 1999) conducted AquaTrack surveys surrounding the Little Bear Spring area. Based on the data collected from these two surveys, Water Technology and Research (1999) concluded that Little Bear Spring is fed by a fault that cuts the axis of a syncline and receives recharge probably from Mill Fork Canyon.

Water Technology and Research (1999) further concluded that the primary source is from Mill Fork Canyon. Groundwater was found to follow a fault line in the mountain range south of Little Bear Spring. This fault extends beyond the mountain ridge between Little Bear Canyon and Mill Fork Canyon and connects small sinks in the bottom of Mill Fork Creek. The secondary source could potentially be from the area north of Little Bear Canyon.

Sunrise (2001) conducted a resistivity survey in Mill Fork Canyon. The purpose of that survey was to estimate the volume of alluvium saturated with groundwater upstream and downstream of the fault identified in the previous AquaTrack surveys to divert water from the Mill Fork Canyon drainage to Little Bear Spring. Two profiles, one up-gradient of the fault and the other down-gradient of the fault, were surveyed. The thickness of the saturated sediments was estimated to range from 0 to 30 feet in the down-gradient profile and from 0 to 50 feet in the up-gradient profile. The cross-sectional area of saturated sediments was estimated from the survey data to be about 2,000 square feet at the downstream profile and 3,300 square feet at the upstream profile. Depth to groundwater in the surveyed area ranged from 0 to 30 feet below grade. This survey indicated that the saturated sediments in Mill Fork Canyon are capable of supporting continuous recharge to Little Bear Spring.

Mayo and Associates (2001) used the comprehensive basin approach to study the potential for Little Bear Spring recharge in Mill Fork Canyon. Mayo and Associates estimated that Mill Fork Creek loses approximately 300 gpm of surface water. The lost water likely recharges to Little Bear Spring.

1.3 Project Objective

Because the previous studies clearly indicated that Mill Fork Creek is the primary source of Little Bear Spring, and the area north of Little Bear Creek is at best a secondary recharge zone. The extent of this zone has not been demarcated. The objective of this survey was to determine if the existing and proposed mining area north of Little Bear Creek would impact the secondary recharge zone.

1.4 Scope of Work

To accomplish the above stated project objective, Sunrise proposed to investigate an approximately one-square-mile area north of Little Bear Creek.

Data collected from the field reconnaissance was analyzed and presented in this report. The data collected by Water Technology and Research (1998 and 1999) was also incorporated into this report.

2.0 METHODS OF INVESTIGATION

2.1 General Description

The tool used in this investigation is AquaTrack. AquaTrack is a geophysical technology that uses electrical current injected into the subsurface to track, map and monitor groundwater. Understanding the location and extent of groundwater can be a complex matter. However, when there is a need to know where groundwater is located, the right tool results in the greatest insight. AquaTrack is that tool.

The greatest benefit of this patented technology is its ability to reduce the cost of subsurface investigations and remediation. AquaTrack provides the ability to direct electricity into specific aquifers, thereby tying the results of the survey to existing sources of groundwater.

Traditional electromagnetic and electrical survey equipment does not have the range or capability that AquaTrack can provide. These types of geophysical technology are limited to less than 100 feet. The AquaTrack technology has the horizontal range between 1,000 and 5,000± feet depending on subsurface conditions. Thus, AquaTrack technology can provide better and more accurate information about the location and flow pattern of groundwater under the ground surface. Using the AquaTrack technology requires an in-depth knowledge of geophysical, geological and hydrogeological principles, methods and practices for correct interpretation of the survey data.

The method of mapping and monitoring groundwater and subsurface aqueous systems used in AquaTrack is protected by Patent 5,825,188, and other patents pending.

2.2 Theory and Scientific Principles

The AquaTrack technology uses a low-voltage, low-amperage and audio-frequency electrical current. Electrodes are placed strategically in wells, springs or surface water bodies and emit an audio-frequency electrical current into the groundwater being investigated. The distance between electrodes can vary from tens to thousands of feet, depending upon the access to groundwater and the aquifer characteristics and the area to be investigated.

One of the basic principles utilized in this technology is Ohm's Law. As the current flows through groundwater, according to Ohm's Law, it follows the path of the least resistance. In most cases, the path of the least resistance is the water bearing strata. The few exceptions are ore bodies, buried metal pipes and wires. The groundwater acts as a subsurface conductor. AquaTrack employs electrons as tracers to follow the subsurface continuous conductor. As the current flows through the groundwater, the current creates a magnetic field characteristic of the audio-frequency current. This magnetic field runs perpendicular to the electrical current and can be described by Bio-Savart Law. This magnetic field can then be detected and surveyed from the ground surface using a special magnetic receiver.

Mapping the magnetic field is to map where the electrical current is flowing, and mapping the electrical current is to map where groundwater is located. The end results provide a map showing the most probable groundwater flow pattern(s) for the area of investigation.

2.3 Magnetic Field Measurement

A magnetic receiver, which consists of a magnetic sensor, filters and amplifiers, measures the magnetic field, filters out unwanted frequencies, amplifies the signal and converts the information into an electrical current that can be measured and recorded. Because the magnetic field is a three-dimensional vector, like the speed of an airplane flying in the air, quantification of the magnetic strength at a specific point can be accomplished by measuring its magnitude and direction, or magnitudes of different components in three normal directions like X, Y and Z. In application of the AquaTrack technology, the magnetic receiver has been designed to measure the magnetic field in a horizontal plane (X-Y plane) and the vertical direction (Z-direction). In the horizontal plane, the receiver can detect the maximum and minimum magnetic values in two normal directions on the plane. For each survey station, the maximum and minimum magnetic values on the horizontal plane, the vertical magnetic value, location relative to the designated survey origin, and survey time are recorded. These recorded data are called raw or field data.

Surveys are normally conducted on a grid system or parallel survey lines. The survey design is dependent on the size of aquifer being investigated, the complexity of the system being mapped and area accessibility. It is possible to miss important features, or anomalies, by gridding or spacing stations too sparsely. Site-specific survey design can be typically established from a hydrogeological assessment of the area and the type of investigation being performed. Normally a survey starts with a course grid and tightening of the grid occurs in areas where additional information is required.

Magnetic field surveys are subject to variation throughout the day due to a variety of natural and manmade electromagnetic interference. Repeated base station readings throughout the survey are made and used to track and correct possible variations resulting from outside interference.

2.4 Data Normalization

The field data contains magnetic interference generated from the environment such as the AquaTrack antenna wire, power source, transmitter, receiver, phone lines, power cables or even special local geology setting (such ore bodies or iron rich volcanic rock) and interference from nature (earth and sun). Because the readings cannot all be taken at the same time, temporal interference and variations exist in the raw data. Therefore, data normalization needs to be performed on all the readings to remove any significant interference before the final presentation of analyzed data. Data normalization consists of removing drift caused by fluctuations in the ambient field, adjusting for current drift of the transmitter and correcting for the antenna wire using Biot-Savart Law.

2.5 Data Interpretation

AquaTrack survey data is interpreted in much the same way as traditional magnetic surveys. The normalized data shows relative highs and lows when it is plotted. These are referred to as anomalies that represent areas of different physical conditions. A high magnetic reading represents a high conductivity, while a low magnetic reading represents a low conductivity. These highs and lows are traceable from profiles to the adjacent profiles. The results of tracing highs on the profiles can then be transferred to a contour map.

The changes in conductivity represent an increase or decrease in the presence of groundwater. At this point in the development of the AquaTrack technology, it is not possible to determine the quantity or quality of water present. The AquaTrack technology simply identifies the highest probability of where groundwater is present in the area of investigation.

Survey results can be mapped using a computer program that utilizes vector mathematics helping identify the location of groundwater reservoirs, aquifers and/or flow patterns of the study area.

3.0 DESCRIPTION OF STUDY AREA

3.1 Project Location

The study area is depicted on **Figure 1**, consisting of a portion of U.S. Geologic Survey (USGS) 7.5-Minute Topographic Quadrangle Map for Rilda Canyon, Utah (USGS, 1978). Little Bear Spring is the focus of the project and is located in the northeastern quarter of the southwestern quarter of Section 9, Township 16 South, Range 7 East, Salt Lake Base and Meridian. The spring is located approximately 12 miles northwest of Huntington, Utah. The spring is located in Little Bear Canyon on the east slope of the central Wasatch Plateau.

3.2 Topography and Drainage

The topography in the study area is depicted on **Figure 1**. Little Bear Spring is located at an elevation of approximately 7,520 feet above mean sea level and on the south side of the Little Bear Canyon floor. The canyon floor slopes towards the east and the mountain slopes on both sides of the canyon dip towards the canyon creek. It is unlikely that the area with lower elevation would recharge to the spring. Thus, the 7,520-foot topographic contour line was assumed to be the lower drainage boundary of the spring. The up-gradient drainage boundaries coincide with the local mountain ridges, as shown in **Figure 1**. The total surface drainage area of Little Bear Canyon that is available to the spring is estimated to be approximately 1.2 square miles. This catchment area is small compared to the spring yield of 300 gpm (Mayo and Associates, 2001).

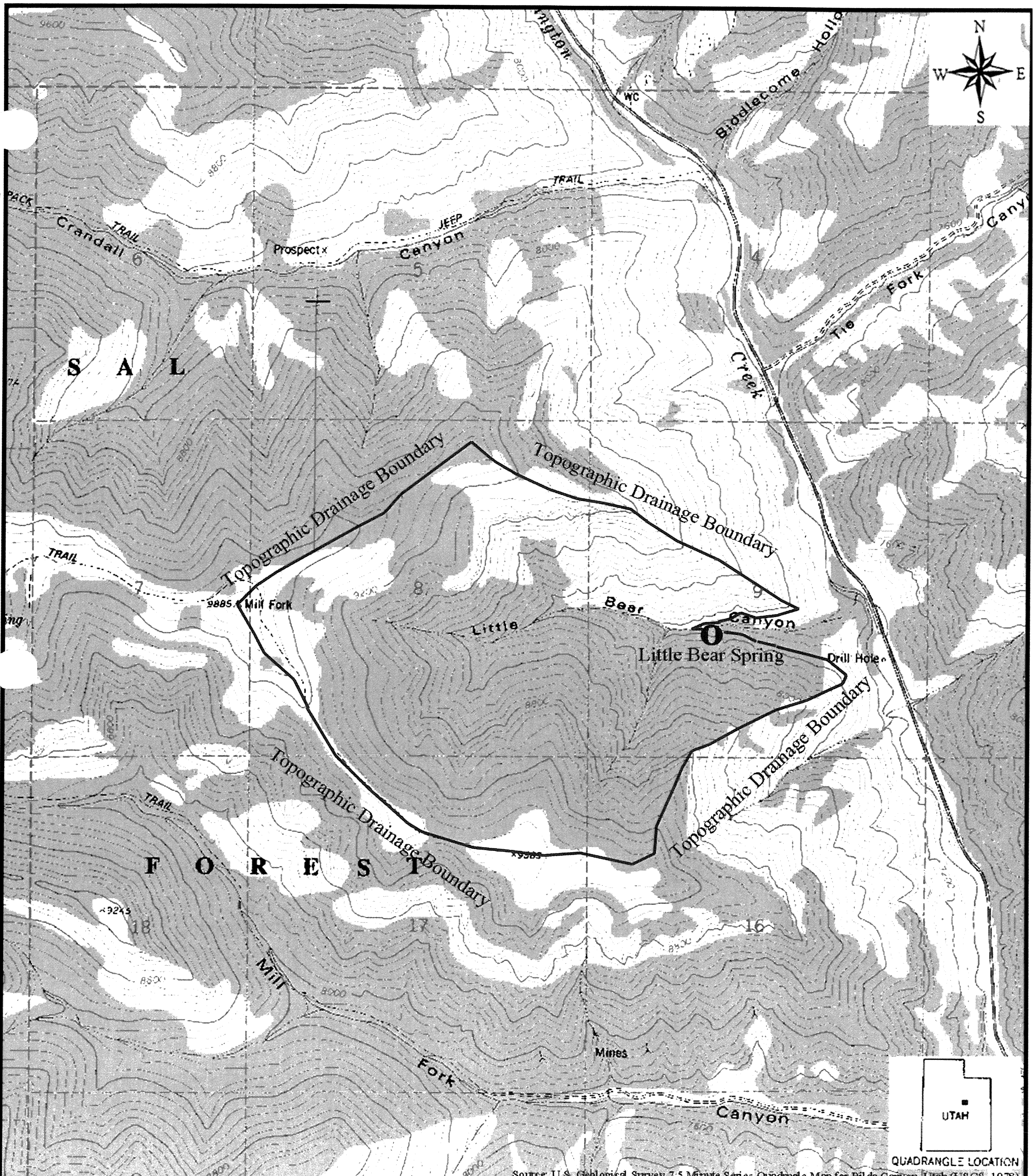


FIGURE 1. SITE VICINITY MAP
AquaTrack Survey - Little Bear Canyon
Huntington, Utah

Sunrise Project No.: 00560	Scale = 1" : 2000' Drawn by: Dao Yang	Date: September 7, 2001	Sunrise Engineering, Inc. Aqua Track

3.3 General Geology and Hydrogeology

The Wasatch Plateau is a flat-topped mass about 80 miles long and 25 miles wide, and it appears as a huge upland that trends about North 20 degrees East, separating Sanpete Valley on the west from Castle Valley on the east. The top of the plateau is at an altitude of about 10,000 feet. The west flank of the plateau is a continuous westward-facing downwarp - the Wasatch monocline - that extends for almost the full length of the plateau. Westward-flowing consequent streams on the monocline have locally cut through the mantle of tilted beds to form deep, serpentine canyons that extend far back toward the crest of the plateau. In striking contrast to the west flank, the east flank is cliffy. The study area is located on the east flank of the Wasatch Plateau. The cliff-forming formations are pockmarked with small cave-like structures, indicating the formations were not well cemented or the cement was calcite that was leached away leaving these voids or holes in the cliff-forming rocks (Water Technology and Research, 1999). These holes and voids probably are the structures that form the small sinkholes in Mill Fork Creek.

Figure 2 shows the surficial geology of the project area and **Figure 3** is a geologic cross-section showing the generalized geologic stratification in the Little Bear Spring area. The location of this approximately west-east oriented cross-section is shown in **Figure 2.**

Little Bear Canyon is located approximately along the axis of a low angle syncline, as shown in **Figure 2.**

Figure 2 indicates that seven bedrock formations crop out in the project area. These formations are: Flagstaff Limestone (Tf) and North Horn Formation (Tknh) of Tertiary and Mesozoic sedimentary rocks; Price River Formation (Kpr), Castlegate Sandstone (Kc), Blackhawk Formation (Kbh), Star Point Sandstone (Ksp) and Mancos Shale (Km) of Mesozoic Sedimentary rocks.

According to Montgomery (1993), there is a regional aquifer consisting of the coal-bearing Blackhawk Formation and the underlying Star Point Sandstone. The Star Point Sandstone is underlain by the basically impervious Mancos Shale that inter-fingers with the overlying sandstone units. Within the mountain masses, groundwater is accumulated in storage within the pervious rock units, their bedding planes, and within all fractures, joints and permeable fault planes. Some water is perched or held up by non-pervious or low-permeability rock beds, such as shale or siltstone. Most of water is stored in the regional aquifer. Towards and within the bottom of the overall groundwater system, all

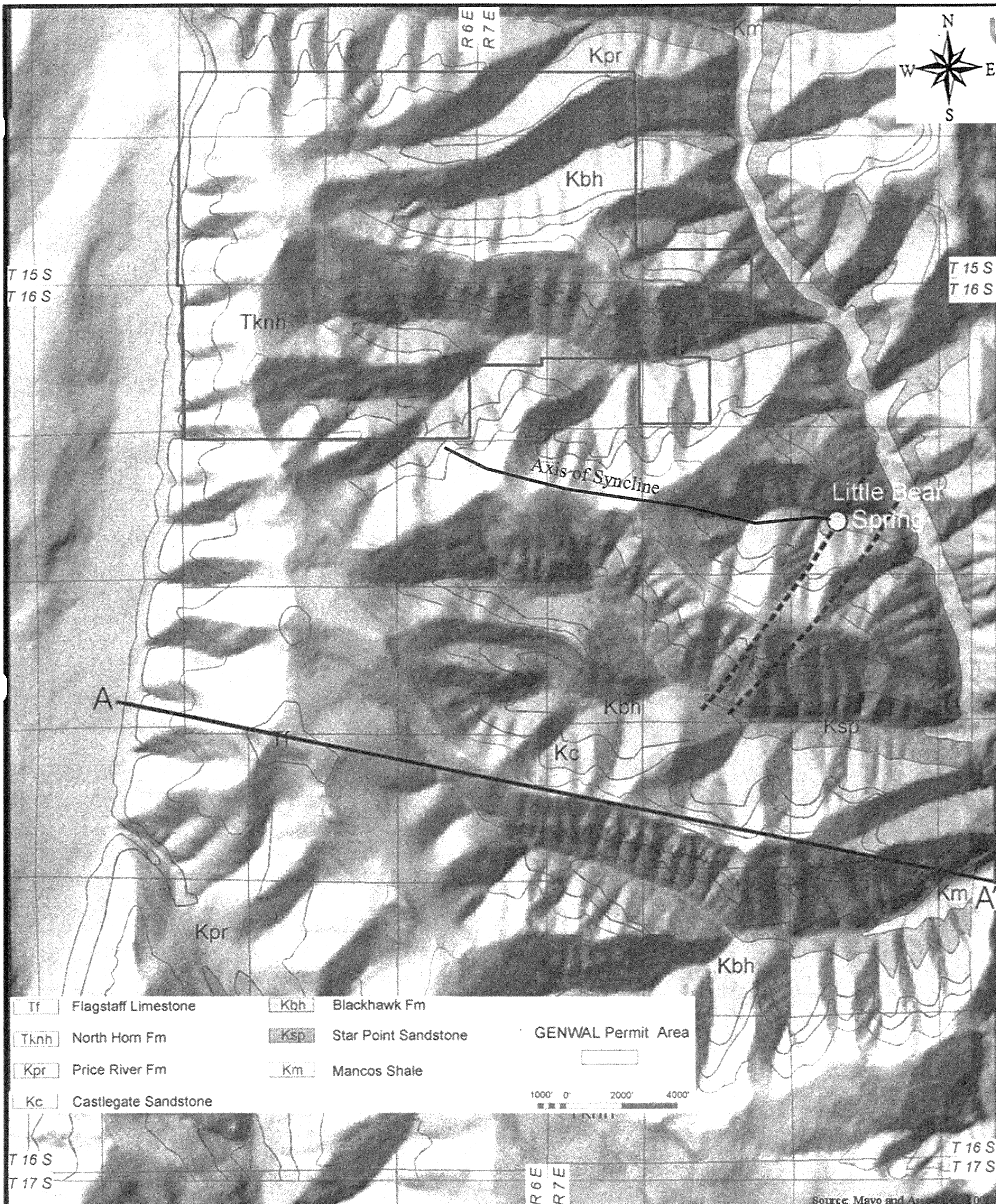
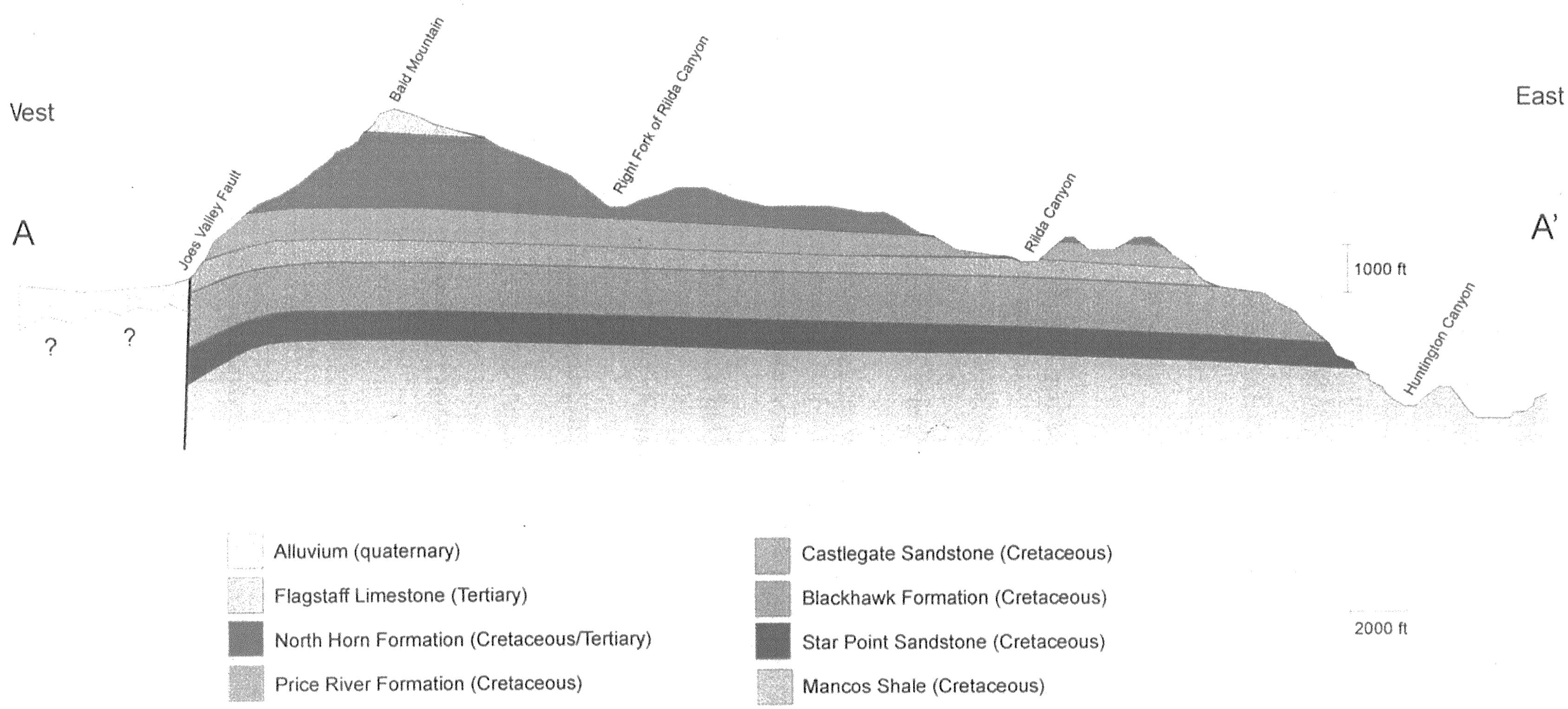


FIGURE 2. GEOLOGIC MAP
AquaTrack Survey - Little Bear Canyon
Huntington, Utah

Sunrise Project No.: 00560	Scale = 1" : 4800' Drawn by: Dao Yang	Date: October 4, 2001	Sunrise Engineering, Inc. Aqua Track



Source: Mayo and Associates (2001)

FIGURE 3. GENERALIZED CROSS-SECTION A-A'

AquaTrack Survey - Little Bear Canyon
Huntington, Utah

Sunrise Project No.: 00560	Scale = AS SHOWN Drawn by: Dao Yang	Date: October 4, 2001	SUNRISE ENGINEERING, INC. AquaTrack

interconnected, pervious rock units and fracture openings are filled and saturated with groundwater. Those low-permeability rock units may be saturated or partly saturated (where interconnection is poor) with groundwater but do not yield much water, if any, to penetrating drill holes or coal-mine excavations, whereas adjacent or nearby rock units may yield appreciable water quantities beneath the overall groundwater surface. Near the edges of deeply incised canyons, those parts of the rock units above the groundwater surface have and continue to be drained naturally through all available permeability, mostly readily through open faults, joints and bedding planes.

The recharge to this groundwater system is from snowmelt and rainfall. The higher mountainous areas receive more precipitation and thus provide greater groundwater recharge. The extensive, high Wasatch Plateau above all of the stream drainage, springs and coal mines of the Huntington Canyon and adjacent coal mining and water producing areas cover hundreds of square miles and receive an average annual precipitation of 16-40 inches, with the greatest part of it resulting in stream runoff. Because of the higher storage capacity of the regional aquifer within the lower part of the groundwater system, its yield to springs, coal-mine interceptions and base flow to streams is consistent and less susceptible to seasonal precipitation and drought fluctuations, compared to local perched aquifers.

Because of the abundance of joints, fractures and faults present within the groundwater system, the permeability varies appreciably within various rock units and at different structural positions. Almost all springs in the area discharge from either joints or faults, and depending upon their length, width, degree of sediment or gouge filling, their interconnection and relation to adjacent rock units and nearby large faults, and their position within the aquifer system, will determine the amount of spring yield. The near-vertical faults generally trend northerly with some local exceptions, and the near-vertical joints trend widely from northwest to northeast.

Little Bear Spring discharges from the regional aquifer, the basal formation of which is the Star Point Sandstone. Farther back into the mountains from the facing slope where the spring discharges, the overlying formation to the Star Point Sandstone also is a part of the regional aquifer. This is the Blackhawk Formation from which all of the various beds of the area are mined, which is approximately 800 feet thick and is composed of interbedded sandstone, shale, siltstone, mudstone and coal.

Coal mining in the area is taking place within the higher slopes and has not penetrated far enough back into the mountain to intersect the groundwater surface of the regional aquifer system, very little, if any, water has been intercepted and produced in the mines. This is the present condition of the GENWAL Coal Mine located in the upper part of Crandall Canyon, as shown in **Figure 2**.

The Star Point Sandstone Formation has a total thickness of 350-450 feet and consists of interbedded sandstone and shale with gradations of both into three distinct sandstone and shale members. The upper unit is the cliff-forming Spring Canyon Member, 50-100 feet thick; the middle unit is the semi-cliff-forming Storrs Member, 45-100 feet thick; and the basal unit is the cliff-forming Panther Member, 50-80 feet thick. Since the Panther Sandstone Member is underlain by the main body of the Mancos Shale, composed of impervious bentonitic clay and silt, it is the bottom of the groundwater system of the region. Any groundwater not exiting naturally at some higher position as springs and seeps, or intercepted by coal mining operations, will eventually exit from the aquifer system, except for that water retained in crevices of the rock material against the force of gravity. Thus, commencing at the land surface where precipitation infiltrates into the subsurface, on-down through the various soil and rock units and fracture-fault systems, groundwater recharge to the regional aquifer is an accumulation of it all, less that which spills naturally as seeps and springs, and is intercepted by coal mining operations. These overlying geologic formations of the area successively upward above the Blackhawk Formation are as follows: Castlegate Sandstone, approximately 250 feet thick; Price River Formation of interbedded sandstone and shale approximately 700 feet thick; North Horn Formation of shale, mudstone and interbedded sandstone approximately 800 feet thick; the Flagstaff Limestone 0-400 feet thick; and the alluvium of variable thickness.

4.0 FIELD RECONNAISSANCE/DATA COLLECTION

The fieldwork was conducted during July 16-25, 2001. Survey was conducted along four curving lines. The orientation of the lines was determined based on the topographic contour outline as displayed in **Figure 1**.

4.1 Equipment and Setup

The equipment used during the field survey consisted of a transmitter, a receiver, two electrodes, wires, a global positioning system (GPS) and other tools used for distance measurements.

4.1.1 Transmitter

The transmitter consists of a Honda 500-watt generator, an ELGAR (Model 501SL) power supply and an impedance matching circuit.

The generator provides power. The ELGAR power supply receives 60-hertz power from the generator and provides a 400-hertz 130-volt sinusoidal signal. The accuracy of the frequency is within one part in 10,000.

The ELGAR power supply feeds power to an impedance matching circuit. This circuit is designed to provide the best impedance match between the ground and the audio frequency (400-hertz) power supply. The voltage in the impedance matching circuit is adjustable from 0 to 400 volts with the maximum current output of 2 amperes. The optimal power and impedance match is 200 watts. The impedance matching circuit is connected to two electrodes used to energize the subsurface. Current is measured as part of the impedance matching circuit.

4.1.2 Receiver

The receiver consists of a magnetic sensor tuned to 400 hertz, and a receiver electronics package.

The magnetic sensor has a Q factor of 15 with an overall sensitivity of roughly 10^{-12} Tesla. The sensor itself tunes and resonates at 11,000 hertz. Sympathetic capacitive effects begin to appear in the sensor's response at 800 hertz. Thus, at 400 hertz, there is an adequate inductive response from the magnetic sensor without capacitive interference.

The receiver electronics package contains 60-, 360- and 420-hertz notch filters, several amplifiers, 400-hertz band-pass filters and other components, and filters and amplifies electrical signal from the sensor. Amplification can be set at 1, 10, 100 and 1,000 times. The electronics package has a Q factor of 200 and an electronics noise level of 1 millivolt at an output of 1,000 times. The total sensitivity of the whole package is about 10^{-15} Tesla.

The sensor output is amplified as a voltage and the electronically amplified signal output is read directly from the instrument.

4.1.3 Electrode Setup and Return Circuit

An electrode consists of a ¼-inch diameter 2-foot long stainless steel rod. A group of four steel electrodes were placed into the collection box of Little Bear Spring. Two other groups each consisting of three steel electrodes, used as return circuits, were driven into the ground and located 1,883 feet west and 2,302 feet east of the collection box of Little Bear Spring, respectively, as shown in **Figures 4a and 4b**. The Xs in **Figures 4a and 4b** represent the electrode locations used in the survey. The electrodes were connected to the impedance matching circuit using an antenna consisting of a single insulated 18 gauge copper wire, represented by a yellow line in **Figures 4a and 4b.** Because of the cliffy terrain, it took 3 days to install the antenna and electrodes.

4.1.4 GPS

A GPS (Trimble Pathfinder) unit was used to determine the spatial location/coordinates (X, Y and Z) of each survey station. The location information is important for data analysis. It is very efficient and effective in the field using a GPS unit to determine the coordinates of each survey station.

4.2 Survey Stations and Lines

Survey stations are represented with red +s and shown in **Figures 4a and 4b.** A total of 115 stations were surveyed for this project.

A survey line consists of a number of survey stations used for data collection along a line with a certain horizontal distance or interval. For this project, the horizontal distance between stations ranged from 100 feet to 150 feet along a survey line. Four lines (Lines 1 through 4) were surveyed and are shown in **Figures 4a and 4b.** 1998 and 1999 survey stations are also shown in **Figures 4a and 4b.**

4.3 Raw Data Gathering

Because of the remote, steep and cliffy terrain, it took 150 man-hours to collect the raw data.

4.3.1 General Description

After a 400-hertz frequency electric current was injected into the subsurface through the electrodes, a magnetic field was generated about the ground where electricity flowed in the subsurface. The magnetic receiver was used to measure the magnetic strength at survey stations from the ground surface. The receiver was moved around from one survey station to another on the ground surface. The data from the receiver and transmitter were entered directly into a portable computer. Manual records were also made in the field for backup purposes. On-site communication was conducted through portable two-way radios.

All the field data records were re-organized and are attached in **Appendix A.**

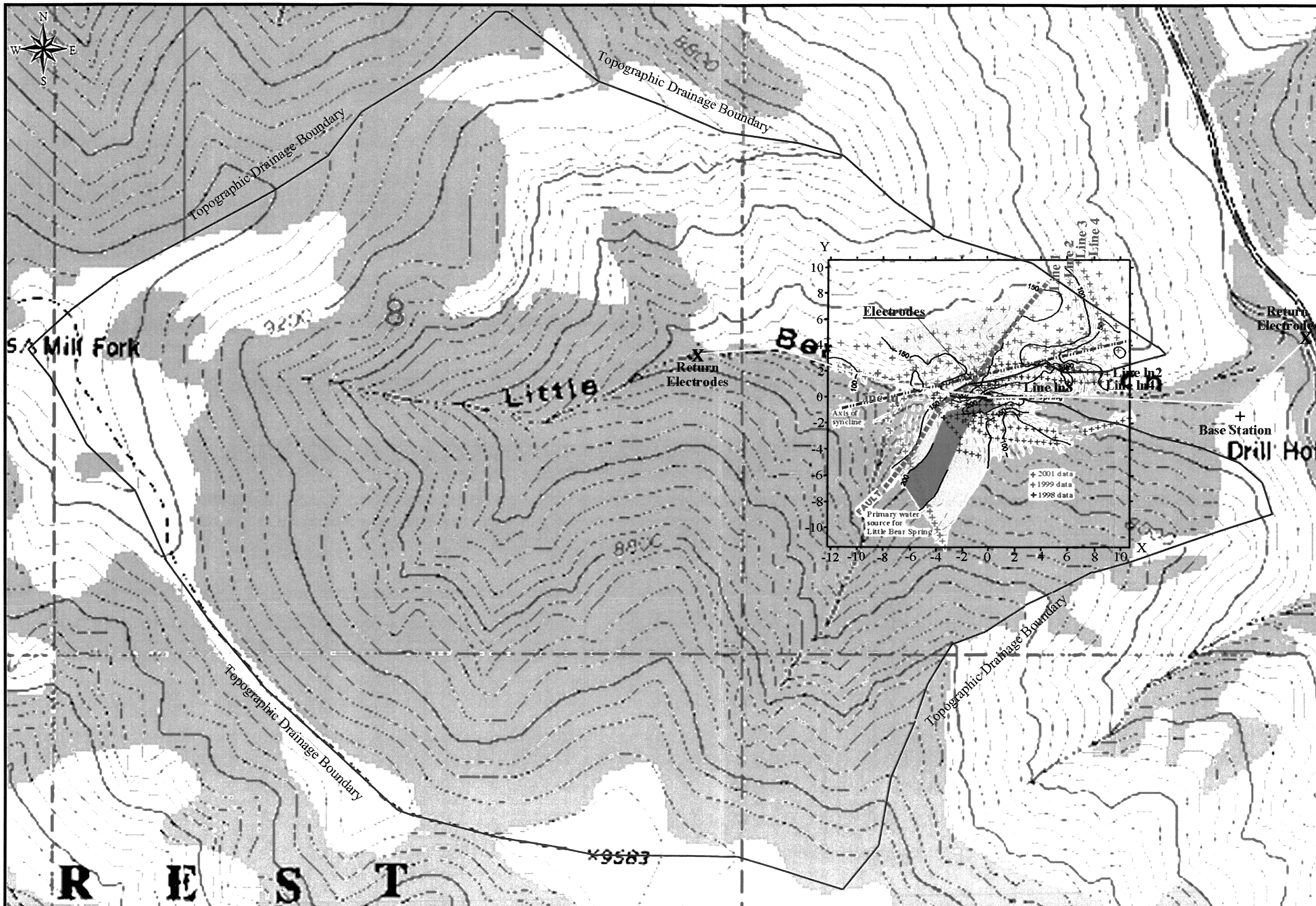


FIGURE 4a. TWO-DIMENSIONAL PRESENTATION WITH ANTENNA LAYOUT, SURVEY STATIONS AND SURVEY LINES

AquaTrack Survey - Little Bear Canyon
Huntington, Utah

Date:
October 29, 2001

Scale = 1" : 700'
Drawn by: Dr. Montgomery

Sunrise Project No.:
00560

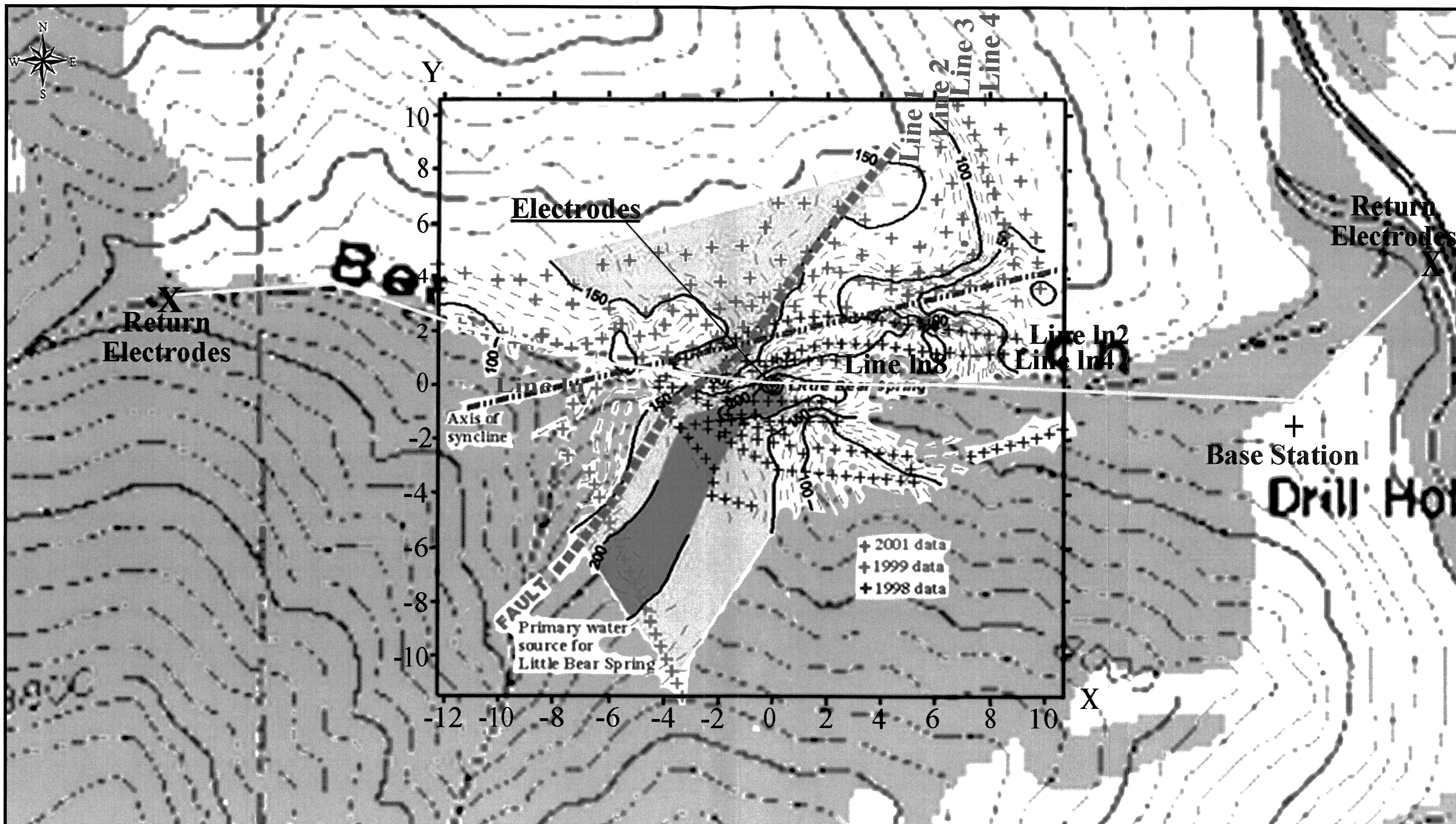


FIGURE 4b. ENLARGED TWO-DIMENSIONAL PRESENTATION WITH ANTENNA LAYOUT, SURVEY STATIONS AND SURVEY LINES

AquaTrack Survey - Little Bear Canyon
Huntington, Utah

Sunrise Project No.: 00560	Scale = 1" : 350' Drawn by: Dr. Montgomery	Date: October 31, 2001	Sunrise Engineering, Inc. AquaTrack

4.3.2 Spatial Positioning Survey

For each survey station, the Trimble Pathfinder GPS unit was used to determine the spatial coordinates (X-easting, Y-northing, and Z-elevation). The horizontal coordinate system (X-Y) is presented in **Figures 4a and 4b**.

4.3.3 Base Station Survey

To record the temporal variations in magnetic field, Sunrise used a base station. The field personnel surveyed the base station at least twice a day during the field reconnaissance. This information is called drift data and used for data normalization. The location of the base station is shown in **Figures 4a and 4b.**

4.3.4 Antenna Survey

The antenna wire location was also surveyed. The antenna wire itself also generates a magnetic field when it was energized. This magnetic field could cause significant interference with the magnetic field emanating from the energized groundwater. Other physical conditions were also investigated to identify any potential sources of interference. During the survey, no other apparent sources of potential interference were noted.

5.0 DATA NORMALIZATION AND INTERPRETATION

The field data consists of the horizontal magnetic field data, the vertical magnetic field data, and survey station locations. Interference was removed from the field data to provide representative information that reflects the actual impact of the electricity injected into the subsurface.

5.1 Data Normalization

For this project, the effects of the antenna wire were removed from the raw data. The temporal variation (drift), measured by repeating base station readings, was also removed from the field data. As stated in Section 2.3, because the magnetic field is a three-dimensional vector, like the speed of an airplane flying in the air, the magnetic receiver used in the AquaTrack survey has been designed to measure the magnetic field in a horizontal plane (X-Y plane) and the vertical direction (Z-direction). In the horizontal plane, the receiver can detect the maximum and minimum magnetic values in two normal directions on the plane (not exactly the X- or Y-directions). The maximum horizontal magnetic component is the most important in the data analysis. Therefore, the data normalization is primarily conducted on the maximum horizontal magnetic component. Once the need arises to normalize other components, the normalization procedure is the same.

5.1.1 Correction of Interference from Antenna Wire

Biot-Savart Law was used to remove the impact from the antenna wire. According to Biot-Savart Law, the magnetic strength vector (magnitude and direction) from the antenna wire can be calculated for any survey station based on the coordinates (X-easting, Y-northing and Z-elevation), and the current and layout of the antenna wire. The reading at each survey station is corrected by vectorially deducting the magnetic strength from the antenna wire.

5.1.2 Correction of Drift Impact

Impact from the drift was adjusted based on the relative values of the repeated readings (**Appendix A**). For example, if the all-time average value of the maximum horizontal magnetic strength at a base station was 200 mV and a repeating reading was 220 mV on a day, all the readings obtained during the day would be corrected by multiplying by 110% (220/200 = 110%).

5.2 Data Interpretation

To facilitate the data analysis, the normalized data were plotted as contour maps or profiles. Generally, a relatively large value of maximum horizontal magnetic strength (measured in mV) in a profile indicates that a higher water content exists beneath the survey station.

5.2.1 Profiles

A profile is a mathematical presentation of the survey data obtained from each station along a survey line. The number along the bottom of a profile are in hundreds of feet (e.g., the distance between –5 and 5 would be 1,000 feet) and signal strength on the left side of the profile is in millivolt (mV).

Figure 5 shows the profiles of normalized data for lines 1 through 4. Four more profiles were also plotted in **Figure 5** for lines lu, Ln2, Ln4 and Ln8 displaying partial data collected north of the spring in 1998 and 1999. The data collected south of the spring in 1998 and 1999 are not plotted in the profiles. All the profiles run from west to east (left to right) and were created for an observer to look north. The horizontal axis represents

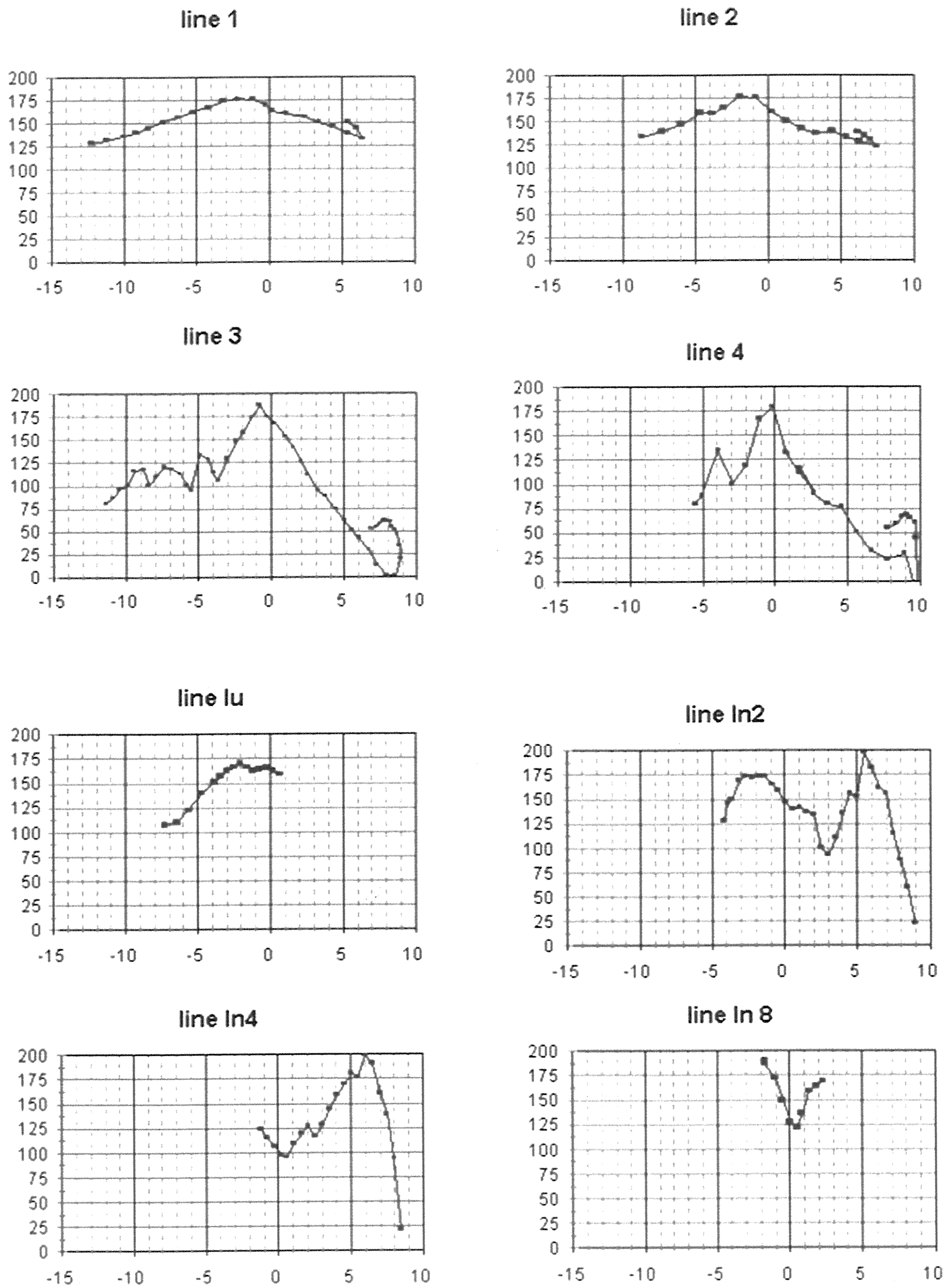


FIGURE 5. PROFILES

AquaTrack Survey - Little Bear Canyon
Huntington, Utah

Sunrise Project No.: 00560	Scale = NOT TO SCALE Drawn by: Dr. Montgomery	Date: October 26, 2001	SUNRISE ENGINEERING, INC. Aqua Track

the coordinates of easting, or X. A detailed explanation of five profiles (lines 1 through 4 and lu) is given to demonstrate how the profiles are interpreted.

Profile Line 1: Line 1 is a curved survey line running between the 8,800- and 7,840-foot contour lines and was survey in 2001. Profile Line 1 indicates that a weak flattop with a value of 175 mV occurs between X = -300 and –100 feet, indicating weak groundwater movement exists in the vicinity and the center of the flow is at X = -200 feet. The profile also shows flat slopes on both sides of the flattop, indicating there is no distinct groundwater channel. This profile generally indicates general presence of groundwater in the area and there is not much groundwater.

Profile Line 2: Line 2 is a curved survey line running between the 7,920- and 7,840-foot contour lines and was surveyed in 2001. Profile Line 2 indicates that a weak flattop with a value of 175 mV occurs between X = -200 and -100 feet, indicating weak groundwater movement exists in the vicinity and the center of the flow is at X = -150 feet. The profile also shows flat slope on both sides of the flattop, indicating there is no distinct groundwater channel. This profile generally indicates general presence of groundwater in the area and there is not much groundwater.

Profile Line 3: Line 3 is a curved survey line running between the 7,920- and 7,760-foot contour lines and was survey in 2001. Profile Line 3 indicates that a peak with a value of 190 mV occurs at X = -100 feet, indicating a groundwater channel is present in the vicinity and the center of the channel is at X = -100 feet. It appears that this channel is associated with the fault and it probably follows the fault to the northeast.

Profile Line 4: Line 4 is a curved survey line running between the 7,920- and 7,760-foot contour lines and was surveyed in 2001. Profile Line 4 indicates that a weak peak with a value of approximately 170 mV occurs at X = 0, indicating a weak groundwater channel exists in the vicinity and the center of the channel is at X = 0. Again, it appears that this channel is associated with the fault, running to the northeast.

Profile Line lu: Line lu is the northern part of the 1999 curved survey line. Line lu basically runs along the 7,600-foot contour line. Profile Line lu indicates that a weak flattop occurs between X = -200 feet and 0, indicating a weak groundwater channel exists in the vicinity and it is centered at X = -100 feet.

A detailed explanation of other profiles is not given here to avoid tediousness. The findings from each of the profiles are summarized **Table 1**.

Table 1. Findings from Profiles

Survey Line #	Number of Stations	Description of Findings
1	21	Weak groundwater movement is centered at X = -200 feet. The groundwater is probably surface fed.
2	20	Weak groundwater movement is centered at X = -150 feet.
3	50	Groundwater moving into a weak channel that is centered at X = 0.
4	24	A weak groundwater channel is centered at X = 0.
lu	16	A 200-foot wide weak groundwater channel is centered at X = -100 feet.
Ln2	28	A 200-foot weak groundwater channel is centered at X = -200 feet and a groundwater channel is centered at X = 50 feet.
Ln4	20	A groundwater channel is centered at X = 600 feet.
Ln8	9	Line Ln8 was too close to the electrodes. The reading is not accurate which is a limitation of the AquaTrack technology.

5.2.2 Two-Dimensional Presentation

Figures 4a and 4b show the contours (in mV) of the normalized maximum horizontal magnetic strength and groundwater channels in the area. Areas with high maximum horizontal magnetic strength are considered as groundwater channels beneath the ground surface. A vertex-type curvature is an indication of the orientation for a water channel. On the other hand, a valley-type curvature indicates a dry zone. **Figures 4a and 4b** also incorporate the results for the area south of the spring, which were interpreted by Water Technology and Research (1998, 1999). In **Figures 4a and 4b**, the dark blue shading represents a preferential groundwater pathway and the light blue shading denotes an area with less groundwater present while the area without any shading in the surveyed zone indicates that this area has little groundwater or insignificant groundwater present.

Figure 4a also shows the surface drainage of the spring. As described in Section 1.2, Water Technology and Research (1998, 1999) concluded that Little Bear Spring is located near the axis of a syncline, denoted by a dashed dark red line. Water Technology and Research (1999) further concluded that the primary source is from Mill Fork Canyon. Groundwater was found to follow a fault line, represented by a dashed pink line, in the mountain range south of Little Bear Spring. This fault extends beyond the mountain ridge (topographic divide) between Little Bear Canyon and Mill Fork Canyon and connects sinks in Mill Fork Canyon. The dark blue shading south of Little Bear Spring in **Figures 4a and 4b** represent a preferential groundwater pathway along the fault line.

The fault line is also shown in **Figure 2**. The light blue shading on both sides of the dark blue shading south of the spring indicates that groundwater also moves towards the spring outside the fault zone based on the 1998 and 1999 survey results.

Water Technology and Research (1999) also concludes that the secondary water source of Little Bear Spring is potentially from the area north of the spring. The triangular-shaped light blue shading north of the spring, as shown in **Figures 4a and 4b**, was derived from the data gathered during this survey. This shading indicates that there is not any preferential groundwater pathway in the surveyed area. However, groundwater generally moves along the mountain slope towards the axis of the syncline. The groundwater movement indicated by the light blue shading can be explained as the result of natural recharge resulting from precipitation. The survey data indicates the northeastern survey area is not a groundwater-bearing zone where no shading was derived from the survey data. Based on the survey data, Sunrise inferred that the fault identified to connect Little Bear Canyon and Mill Fork Canyon extends to the north of Little Bear Spring. On the northern slope of Little Bear Canyon, it appears that the fault intercepts all groundwater from the area up-gradient (northwest) of the fault and conducts the water to the canyon creek. This inference is supported by the fact that the area down-gradient (southeast) of the fault is not a groundwater-bearing zone. However, this does not appear to contribute significant amount of water to Little Bear Spring.

5.0 CONCLUSIONS AND RECOMMENDATIONS

Sunrise has completed an AquaTrack Survey for GENWAL Resources in an area north of Little Bear Canyon.

The findings of this survey and previous surveys is summarized below:

- A preferential groundwater pathway along a fault line was identified to connect Mill Fork Canyon and Little Bear Canyon. Little Bear Spring is located on this pathway.
- The saturated sediments in Mill Fork Canyon are capable of supporting continuous recharge to Little Bear Spring.
- Mill Fork Creek loses approximately 300 gpm of surface water. The lost water likely recharges Little Bear Spring.
- The primary groundwater source of Little Bear Spring is from the preferential groundwater pathway leading to Mill Fork Canyon where small sinkholes were identified to be within the fault zone.

- The fault that is believed to connect Mill Fork Canyon and Little Bear Canyon was inferred to extend to the northern slope of Little Bear Canyon. It appears that the fault intercepts all groundwater from the area up-gradient (northwest) of the fault and conducts the water to the canyon creek. This inference is also supported by the fact that the area down-gradient (southeast) of the fault is not a groundwater-bearing zone. The survey data also indicates that the water north of Little Bear Spring is minimal and probably incidental.
- Groundwater as a result of natural recharge resulting from precipitation moves from the northern slope of Little Bear Canyon towards the canyon creek. The amount of water is not significant.

This survey does not cover the area across the northeast topographic divide, Sunrise cannot infer that no preferential groundwater pathway runs across the divide that may potentially introduce groundwater to Little Bear Canyon from Crandall Canyon where mining operations are active. However, the data from this survey indicates a very low probability of any water from Crandall Canyon Creek to Little Bear Canyon.

6.0 GENERAL COMMENTS

This report was prepared for the exclusive use of Little Bear Spring for specific application to this project and has been prepared in accordance with currently generally accepted principles and practices in the field of geophysics. No warranties, expressed or implied, are intended or made. As additional information becomes available the interpretations and recommendations expressed in this report will be subject to revision.

7.0 REFERENCES

Mayo and Associates, LC. 2001. Investigation of the Potential for Little Bear Spring Recharge in Mill Fork Canyon, Emery County, Utah.

Montgomery, Bryce. 1993. Hydrogeologic Study for "Wellhead Protection Program," Drinking Water Source Protection Regulations R309-113, of Castle Valley Special Service District Water Sources.

Sunrise Engineering, Inc. 2001. Resistivity Survey – Mill Fork Canyon near Huntington, Utah.

U.S. Geologic Survey. 1978. USGS 7.5-Minute Series Topographic Quadrangle Map for Rilda Canyon, Utah.

Water Technology and Research. 1998. AquaTrack Survey – Little Bear Spring Study, Huntington Canyon, Utah.

Water Technology and Research. 1999. AquaTrack Survey – Little Bear Spring Study, Huntington Canyon, Utah.

Appendix A

Field Data Records

ID	EASTING	NORTHING	ELEVATION	+N/-S	+E/-W	MIN	DIR	MAX	VERT	REPORT	TIME	DATE
1				base	-	193.8	0.0	626.0	2540.0	950 time	10:59:54am	07/18/01
2				2	a	20.5	0.0	1469.0	2592.0		11:05:29am	07/18/01
3	1598343.894	14324912.718	7793.197	1	1	5.3	0.0	65.0	12.3		12:18:48pm	07/18/01
4	1598444.516	14324880.521	7800.482	1	2	7.9	0.0	76.2	15.1		12:31:11pm	07/18/01
5	1598564.290	14324856.787	7803.588	1	3	9.8	0.0	91.6	20.8		12:35:34pm	07/18/01
6	1598646.254	14324855.943	7808.098	1	4	12.2	0.0	104.6	28.5		12:40:26pm	07/18/01
7	1598742.015	14324873.233	7803.200	1	5	13.8	0.0	123.0	39.2		12:45:19pm	07/18/01
8	1598839.442	14324838.964	7819.519	1	6	15.5	0.0	144.6	52.6		12:50:43pm	07/18/01
9	1598946.451	14324913.045	7809.086	1	7	18.8	0.0	163.0	82.5		12:56:23pm	07/18/01
10	1599045.967	14324930.765	7809.158	1	8	23.7	0.0	182.3	108.6		01:02:35pm	07/18/01
11	1599148.224	14324960.345	7808.813	1	9	29.8	0.0	200.0	148.2		01:07:29pm	07/18/01
12	1599248.125	14324950.212	7807.379	1	10	33.6	0.0	225.0	196.0		01:19:58pm	07/18/01
13	1599344.868	14324978.383	7800.270	1	11	40.8	0.0	232.1	259.0		01:26:55pm	07/18/01
14	1599454.989	14324986.453	7804.948	1	12	44.2	0.0	230.6	322.0		01:33:17pm	07/18/01
15	1599539.169	14325052.533	7802.643	1	13	50.1	0.0	209.0	345.0		01:39:59pm	07/18/01
16	1599587.306	14325142.442	7814.878	1	14	54.8	0.0	187.3	333.1	30 feet from run off spring	02:06:25pm	07/18/01
17	1599683.398	14325141.289	7801.581	1	15	63.6	0.0	175.9	377.0		02:36:51pm	07/18/01
18	1599806.599	14325131.563	7798.341	1	16	69.6	0.0	162.3	438.0		02:43:44pm	07/18/01
19	1599905.589	14325082.170	7783.354	1	17	73.2	0.0	142.3	511.0		02:47:28pm	07/18/01
20	1600005.213	14325013.554	7785.366	1	18	67.8	0.0	125.0	576.0		02:51:09pm	07/18/01
21	1600107.239	14324983.261	7785.759	1	19	59.2	0.0	99.8	601.0		02:56:54pm	07/18/01
22	1600205.353	14325037.454	7787.038	1	20	53.0	0.0	80.6	584.0		03:05:35pm	07/18/01
23	1600169.357	14325157.807	7794.130	1	21	47.9	0.0	119.9	485.0	min paralell w wire max parll w river	03:11:59pm	07/18/01
24	1600104.481	14325260.721	7807.262	1	22	37.0	0.0	141.3	393.3		03:18:24pm	07/18/01
25	1600183.286	14325349.320	7739.950	2	1	20.8	0.0	186.6	377.0		03:26:00pm	07/18/01
26	1600226.498	14325217.614	7739.530	2	2	22.8	0.0	165.8	503.0		03:36:14pm	07/18/01
27				2	3	38.0	0.0	145.0	601.0		03:47:43pm	07/18/01
28	1600306.991	14324953.562	7720.932	2	4	42.5	0.0	104.7	760.0		03:56:15pm	07/18/01
29	1600191.720	14324895.746	7696.999	2	5	71.0	0.0	132.5	864.0		04:02:32pm	07/18/01
30	1600106.102	14324888.688	7696.918	2	6	61.0	0.0	157.8	863.0		04:09:05pm	07/18/01
31	1600007.422	14324892.716	7694.885	2	7	70.2	0.0	190.8	836.0		04:13:28pm	07/18/01
32	1599896.331	14324951.696	7694.266	2	8	96.4	0.0	178.1	772.0		04:30:01pm	07/18/01
33	1599793.365	14324994.780	7700.467	2	9	91.8	0.0	207.8	680.0		04:41:16pm	07/18/01
34				2	10	78.8	0.0	247.2	578.0	in canyon below L1 14	04:47:58pm	07/18/01
35	1599595.752	14324931.856	7712.637	2	11	70.6	0.0	300.5	614.0		04:57:21pm	07/18/01
36	1599484.284	14324865.871	7699.016	2	12	60.3	0.0	383.0	567.0		05:06:10pm	07/18/01
37				2	13	53.8	0.0	386.0	386.0		05:16:23pm	07/18/01
38	1599266.665	14324838.611	7721.719	2	14	40.5	0.0	328.0	365.0		05:23:32pm	07/18/01
39				2	15	35.8	0.0	292.6	190.6		05:32:11pm	07/18/01
40	1599105.061	14324735.102	7705.235	2	16	26.0		298.0	128.9		05:48:53pm	07/18/01
41	1598970.615	14324750.943	7704.280	2	17	20.6	0.0	230.6	79.2		05:57:57pm	07/18/01
42				2	18	15.3	0.0	192.8	46.0		06:05:03pm	07/18/01
43				2	19	13.0	0.0	160.7	31.6		06:21:23pm	07/18/01
44	1601504.670	14324550.880	7247.030	BASE	-	279.0	0.0	1093.0	2599.0		07:13:33pm	07/18/01
45	1601508.571	14324547.525	7235.801	base	-	176.0	0.0	717.0	2568.0		09:06:12am	07/20/01
46	1598784.649	14324703.383	7703.713	2	19	26.6	0.0	539.0	1277.0	repeat	10:04:13am	07/20/01
47	1598704.288	14324707.157	7695.954	2	20	21.3	0.0	620.0	1344.0		10:11:48am	07/20/01
48	1598588.712	14324695.928	7694.515	2	21	19.0	0.0	945.0	1501.0		10:17:48am	07/20/01
49	1598495.962	14324729.763	7690.350	2	22	13.4	0.0	860.0	1590.0		10:22:58am	07/20/01
50	1598422.102	14324747.383	7699.918	2	23	9.0	0.0	1013.0	1586.0		10:28:36am	07/20/01
51	1598425.698	14324692.529	7661.735	3	1	3.3	0.0	1653.0	2123.0	100 feet east of 2a	10:35:56am	07/20/01
52				3	1.5	10.2	0.0	1415.0	2200.0		10:46:47am	07/20/01

53	1598524.661	14324654.040	7667.969	3	2	6.0	0.0	1470.0	1960.0	10:52:56am	07/20/01
54	1598581.909	14324659.095	7671.113	3	2.5	11.5	0.0	1243.0	1860.0	10:55:52am	07/20/01
55	1598627.341	14324624.527	7654.457	3	3	7.9	0.0	1540.0	2076.0	11:00:50am	07/20/01
56	1598692.201	14324616.474	7653.919	3	3.5	15.0	0.0	1266.0	1850.0	11:05:48am	07/20/01
57	1598728.736	14324652.786	7653.713	3	4	7.5	0.0	840.0	1825.0	11:11:23am	07/20/01
58	1598725.526	14324645.964	7649.256	3	4	5.6	0.0	793.0	1708.0	11:42:01am	07/20/01
59	1598779.447	14324617.240	7646.204	3	4.5	14.0	0.0	869.0	1740.0	11:45:18am	07/20/01
60	1598833.056	14324602.770	7646.464	3	5	16.8	0.0	938.0	1672.0	11:50:25am	07/20/01
61	1598890.080	14324619.214	7645.641	3	5.5	23.7	0.0	812.0	1513.0	11:55:42am	07/20/01
62	1598944.439	14324638.621	7650.317	3	6	25.3	0.0	704.0	1308.0	11:58:37am	07/20/01
63	1598991.429	14324673.907	7655.455	3	6.5	26.3	0.0	543.0	1175.0	12:01:49pm	07/20/01
64	1599017.171	14324693.136	7649.476	3	7	31.5	0.0	478.0	1166.0	12:05:11pm	07/20/01
65	1599081.891	14324648.246	7627.294	3	7.5	24.3	0.0	761.0	1293.0	12:09:58pm	07/20/01
66	1599137.265	14324655.699	7631.642	3	8	18.0	0.0	680.0	1104.0	12:13:06pm	07/20/01
67	1599172.621	14324690.340	7625.398	3	8.5	22.9	0.0	563.0	1043.0	12:19:45pm	07/20/01
68	1599202.595	14324744.198	7632.036	3	9	30.0	0.0	489.0	858.0	12:25:15pm	07/20/01
69	1599266.073	14324725.755	7624.152	3	10	20.6	0.0	603.0	817.0	12:28:49pm	07/20/01
70	1599326.792	14324691.484	7621.010	3	10	16.2	0.0	671.0	687.0	12:38:31pm	07/20/01
71	1599373.252	14324751.125	7632.605	3	10.5	17.3	0.0	688.0	366.0	12:46:17pm	07/20/01
72	1599433.139	14324778.033	7619.532	3	11	8.6	0.0	728.0	162.3	12:52:35pm	07/20/01
73	1599491.695	14324762.661	7619.189	3	11.5	3.2	0.0	749.0	3.6	12:59:07pm	07/20/01
74	1599534.387	14324793.446	7619.311	3	12	2.8	0.0	670.0	116.6	01:03:09pm	07/20/01
75	1599591.843	14324820.831	7617.615	3	12.5	8.9	0.0	615.0	242.0	01:07:00pm	07/20/01
76	1599665.771	14324842.646	7614.971	3	13	16.5	0.0	530.0	349.0	01:19:02pm	07/20/01
77				3	13.5	24.8	0.0	472.0	350.0	01:25:31pm	07/20/01
78	1599769.379	14324903.515	7621.410	3	14	32.5	0.0	414.0	396.0	01:35:54pm	07/20/01
79	1599817.052	14324886.840	7620.836	3	14.5	37.0	0.0	360.0	473.0	01:39:20pm	07/20/01
80	1599884.270	14324859.837	7626.366	3	15	43.0	0.0	301.0	558.0	01:44:31pm	07/20/01
81	1599936.973	14324846.445	7628.599	3	15.5	41.9		280.0	576.0	01:51:26pm	07/20/01
82	1600004.572	14324825.708	7633.410	3	16	40.8	0.0	238.0	605.0	01:57:24pm	07/20/01
83	1600065.751	14324804.325	7632.346	3	16.5	49.6	0.0	206.0	643.0	02:03:46pm	07/20/01
84				3	17	42.0	0.0	181.0	638.0	02:11:57pm	07/20/01
85	1600168.425	14324824.623	7638.945	3	17.5	48.9	0.0	162.8	634.0	02:19:22pm	07/20/01
86	1600236.304	14324821.073	7624.486	3	18	53.3	0.0	135.3	668.0	02:29:14pm	07/20/01
87	1600295.250	14324839.224	7627.413	3	18.5	55.0	0.0	106.0	637.0	02:34:21pm	07/20/01
88	1600358.301	14324838.901	7617.967	3	19	56.4	0.0	89.0	663.0	02:37:53pm	07/20/01
89	1600417.017	14324864.678	7623.880	3	20	44.3	0.0	91.3	653.0	02:45:53pm	07/20/01
90	1600453.982	14324919.866	7622.138	3	20.5	25.2	0.0	124.3	600.0	02:54:29pm	07/20/01
91	1600448.579	14324976.475	7622.356	3	21	22.2	0.0	148.0	533.0	02:58:41pm	07/20/01
92	1600430.441	14325024.560	7621.534	3	21.5	20.8	0.0	167.6	469.0	03:02:09pm	07/20/01
93	1600418.032	14325069.063	7630.727	3	22	18.8	0.0	178.0	421.0	03:07:06pm	07/20/01
94	1600393.089	14325113.311	7631.987	3	22.5	20.0	0.0	182.6	372.0	03:10:30pm	07/20/01
95	1600382.519	14325180.356	7631.339	3	23	16.4	0.0	194.5	330.0	03:16:00pm	07/20/01
96	1600359.730	14325225.194	7634.115	3	23.5	16.5	0.0	196.0	305.0	03:19:07pm	07/20/01
97	1600340.238	14325274.621	7635.494	3	24	15.3	0.0	198.0	275.0	03:21:54pm	07/20/01
98	1600332.679	14325338.590	7634.988	3	24.5	13.8	0.0	195.0	245.0	03:28:12pm	07/20/01
99	1600308.614	14325394.814	7638.238	3	25	14.8	0.0	191.8	213.7	03:31:22pm	07/20/01
100	1600287.135	14325440.420	7641.900	3	25.5	13.3	0.0	185.0	194.0	03:34:29pm	07/20/01
101	1600247.882	14325502.821	7638.317	3	26	12.6	0.0	182.0	169.0	03:37:58pm	07/20/01
102	1600347.782	14325524.478	7578.944	4	1	10.7	0.0	192.8	180.0	03:48:51pm	07/20/01
103	1600402.307	14325416.642	7573.563	4	2	9.6	0.0	206.0	226.0	03:53:35pm	07/20/01
104	1600443.690	14325307.098	7561.595	4	3	9.6	0.0	225.0	290.0	03:57:11pm	07/20/01
105	1600477.437	14325226.513	7554.798	4	4	7.2	0.0	230.0	342.3	03:58:57pm	07/20/01

106	1600497.518	14325104.861	7560.563	4	5	7.1	0.0	220.8	458.0		04:01:55pm	07/20/01
107	1600535.704	14325017.045	7560.497	4	6	4.9	0.0	206.8	548.0		04:06:19pm	07/20/01
108	1600542.427	14324925.167	7556.731	4	7	3.9	0.0	165.4	658.0		04:08:36pm	07/20/01
109	1600553.834	14324829.807	7552.621	4	8	7.6	0.0	16.8	785.0		04:11:40pm	07/20/01
110	1600464.180	14324782.941	7520.865	4	9	22.5	0.0	120.0	900.0		04:35:29pm	07/20/01
111	1600342.518	14324756.986	7515.636	4	10	63.0	0.0	94.5	964.0		04:40:36pm	07/20/01
112	1600237.390	14324743.630	7520.449	4	11	69.0	0.0	111.2	998.0		04:45:22pm	07/20/01
113	1600133.037	14324719.789	7516.573	4	12	53.5	0.0	176.9	1082.0		04:48:27pm	07/20/01
114	1600031.415	14324697.070	7528.255	4	13	36.2	0.0	284.6	1113.0		04:51:36pm	07/20/01
115	1599934.200	14324715.910	7527.012	4	14	45.7	0.0	308.0	1110.0		04:55:54pm	07/20/01
116	1599838.326	14324757.336	7523.300	4	15	61.8	0.0	376.0	994.0		05:02:17pm	07/20/01
117				4	16	53.7	0.0	587.0	1003.0		05:10:40pm	07/20/01
118				BASE	-	181.0	0.0	716.0	2560.0		05:57:02pm	07/20/01
119	1601504.080	14324542.500	7240.716	base	-	171.8		704.0	2577.0		09:40:31am	07/21/01
120				4	15	60.6	0.0	390.0	997.0		10:24:50am	07/21/01
121				4	16	59.8	0.0	553.0	1008.0		10:36:29am	07/21/01
122				4	17	31.6	0.0	774.0	1140.0	30 feet east ofold line 2 n 6	10:39:53am	07/21/01
123				4	18	20.2	0.0	1364.0	691.0		10:52:00am	07/21/01
124				4	19	11.9	0.0	1478.0	396.0		10:55:25am	07/21/01
125				4	20	22.8	0.0	1046.0	1557.0		11:02:38am	07/21/01
126				4	21	33.7	0.0	893.0	2052.0		11:12:53am	07/21/01
127	1599179.497	14324569.372	7507.998	4	22	32.8	0.0	2575.0	2644.0	at old station - LU +5	11:16:22am	07/21/01
128	1599066.394	14324567.190	7515.179	4	23	44.0	0.0	1648.0	2650.0	20 feet north west of old station line U +6.00	11:25:29am	07/21/01
129	1599019.168	14324523.829	7501.026	4	24	20.0	0.0	2596.0	2775.0	followed cliff to canyon floor. this station approx 35 feet from wire	11:39:03am	07/21/01
130	1598789.599	14324705.447	7706.910	2	19	22.8	0.0	478.0	1193.0	r	12:27:43pm	07/21/01
131	1598881.310	14324702.004	7713.329	2	18	27.3	0.0	442.0	1039.0	r	12:31:35pm	07/21/01
132	1598978.301	14324753.464	7699.128	2	17	34.9	0.0	338.0	924.0	r	12:39:36pm	07/21/01
133	1599107.442	14324732.786	7698.254	2	16	25.8	0.0	416.0	780.0	r	12:43:24pm	07/21/01
134				2	15	30.6	0.0	366.0	603.0	r	12:48:07pm	07/21/01
135	1599267.482	14324845.462	7717.601	2	14	20.3	0.0	440.0	387.0	r	12:52:08pm	07/21/01
136	1599371.307	14324870.284	7695.705	2	13	14.8	0.0	478.0	215.2	r	12:57:42pm	07/21/01
137	1599479.570	14324868.882	7698.233	2	12	4.8		491.0	46.5	r	01:00:21pm	07/21/01
138	1599593.109	14324935.926	7709.355	2	11	3.1	0.0	410.0	104.8	r	01:08:43pm	07/21/01
139	1599656.827	14325025.287	7714.856	2	10	9.2	0.0	348.3	135.4	r	01:19:35pm	07/21/01
140	1599789.880	14324996.999	7696.523	2	9	23.2	0.0	319.0	244.0	r	01:23:10pm	07/21/01
141	1599894.716	14324960.567	7695.882	2	8	30.0	0.0	266.8	323.3	r	01:27:29pm	07/21/01
142	1600007.257	14324896.470	7696.441	2	7	36.5	0.0	211.0	395.0	r	01:31:27pm	07/21/01
143	1600102.626	14324894.084	7694.630	2	6	40.0	0.0	177.7	459.0	r	01:35:08pm	07/21/01
144	1600189.731	14324900.529	7692.483	2	5	43.8	0.0	147.0	469.0	r	01:40:24pm	07/21/01
145	1600310.881	14324956.986	7717.888	2	4	36.6	0.0	110.9	406.0	r-ridge line	01:47:33pm	07/21/01
146				2	3	24.6	0.0	146.2	320.2	r	01:56:25pm	07/21/01
147	1600228.807	14325216.576	7735.990	2	2	20.1	0.0	163.2	250.0	r	01:59:06pm	07/21/01
148	1600184.359	14325344.543	7742.306	2	1	14.8	0.0	165.6	193.3	r	02:05:10pm	07/21/01
149	1601506.843	14324547.914	7238.891	base	-	168.0	0.0	670.0	2550.0		03:12:41pm	07/21/01
150	1601693.650	14325038.377	7153.566	ant-river-x	-	0.0	0.0	0.0	0.0	antenna crosses river at steel cable	10:26:52am	07/25/01
151	1602081.518	14323631.515	7104.792	riv	wst	0.0	0.0	0.0	0.0	west side river at crossing	11:11:39am	07/25/01
153	1601504.043	14324540.509	7239.595	base	-	0.0	0.0	0.0	0.0	base station	11:21:10am	07/25/01
154	1600864.278	14324365.068	7304.108	antenna	inter	0.0	0.0	0.0	0.0	antenna intsects with road	11:26:50am	07/25/01
156	1599688.194	14324517.573	7390.376	hill	-	0.0	0.0	0.0	0.0	lower stop start exit --- line 4	11:36:41am	07/25/01
157	1599567.290	14324506.206	7412.173	new	box	0.0	0.0	0.0	0.0	new spring collection box	11:40:16am	07/25/01
158	1599490.631	14324483.968	7416.588	old	box	0.0	0.0	0.0	0.0	old spring collection box and electrode 2	11:41:51am	07/25/01
159	1598881.760	14324445.450	7479.211	horse	tie	0.0	0.0	0.0	0.0	tied horses	11:51:22am	07/25/01
160	1598848.886	14324433.505	7511.675	stop	start	0.0	0.0	0.0	0.0	middle stop start exit--- line 2	11:53:10am	07/25/01

161	1598724.072	14324486.299	7522.140	canyon	south	0.0	0.0	0.0	0.0 mouth east canyon	11:56:56am	07/25/01
162	1598350.850	14324621.205	7566.344	line	start	0.0	0.0	0.0	0.0 start-end line 1 2 3	12:05:37pm	07/25/01
163	1598273.545	14324660.930	7529.452	wire	broke	0.0	0.0	0.0	0.0	12:11:45pm	07/25/01
164	1597894.097	14324736.281	7666.637	canyon	north	0.0	0.0	0.0	0.0	12:49:43pm	07/25/01
165				top	elec	0.0	0.0	0.0	0.0 200-+- feet north -above electrode	01:44:20pm	07/25/01
166	1597614.125	14324868.880	7810.477	top	elec	0.0	0.0	0.0	0.0 150-+- feet north -above electrode	01:57:41pm	07/25/01
167	1597631.779	14324802.243	7762.404	upper	electrode	0.0	0.0	0.0	0.0 70 feet north -- above	02:08:59pm	07/25/01

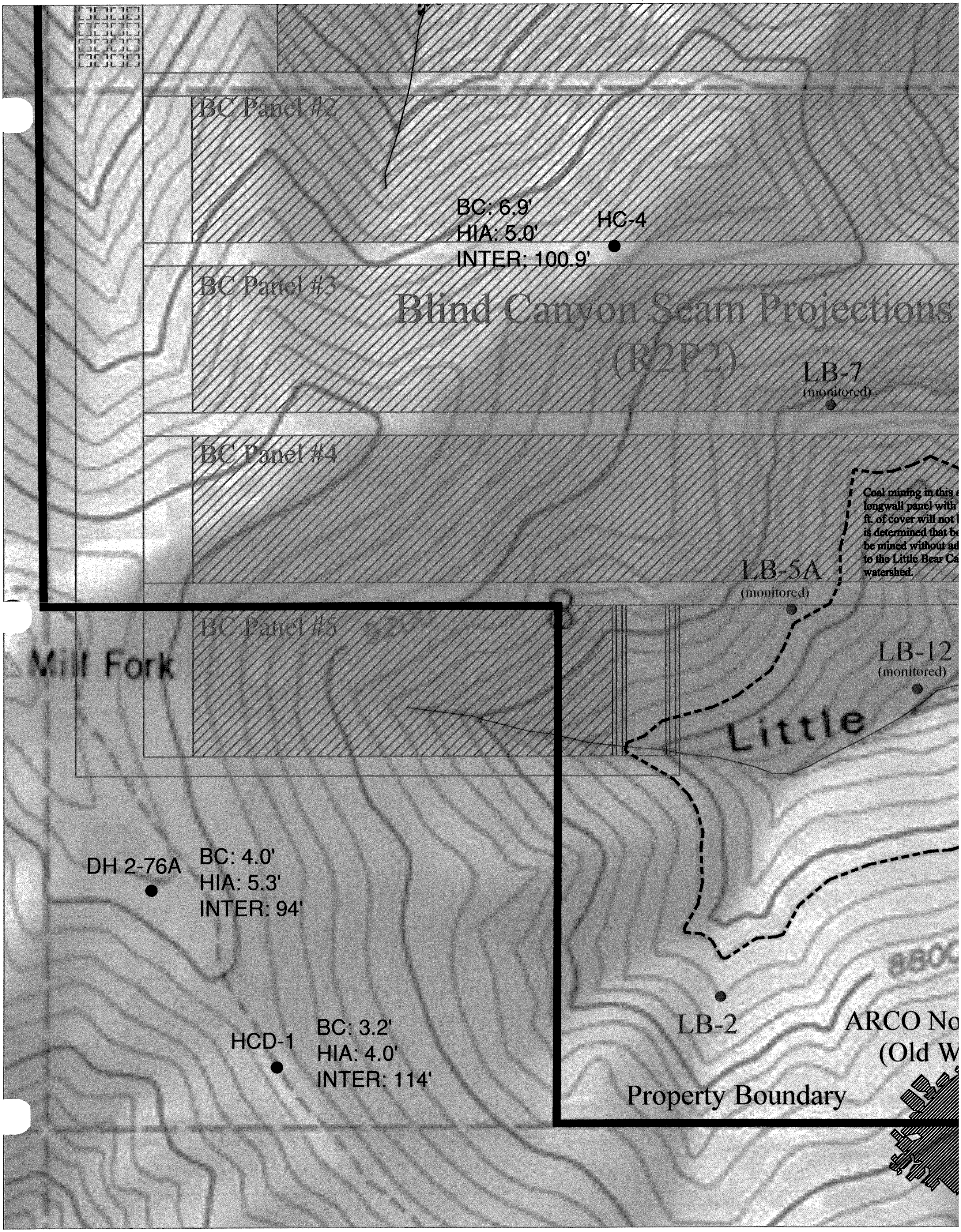
APPENDIX 7-63

HYDROLOGY/ GEOLOGY MAP
OF
LITTLE BEAR WATERSHED

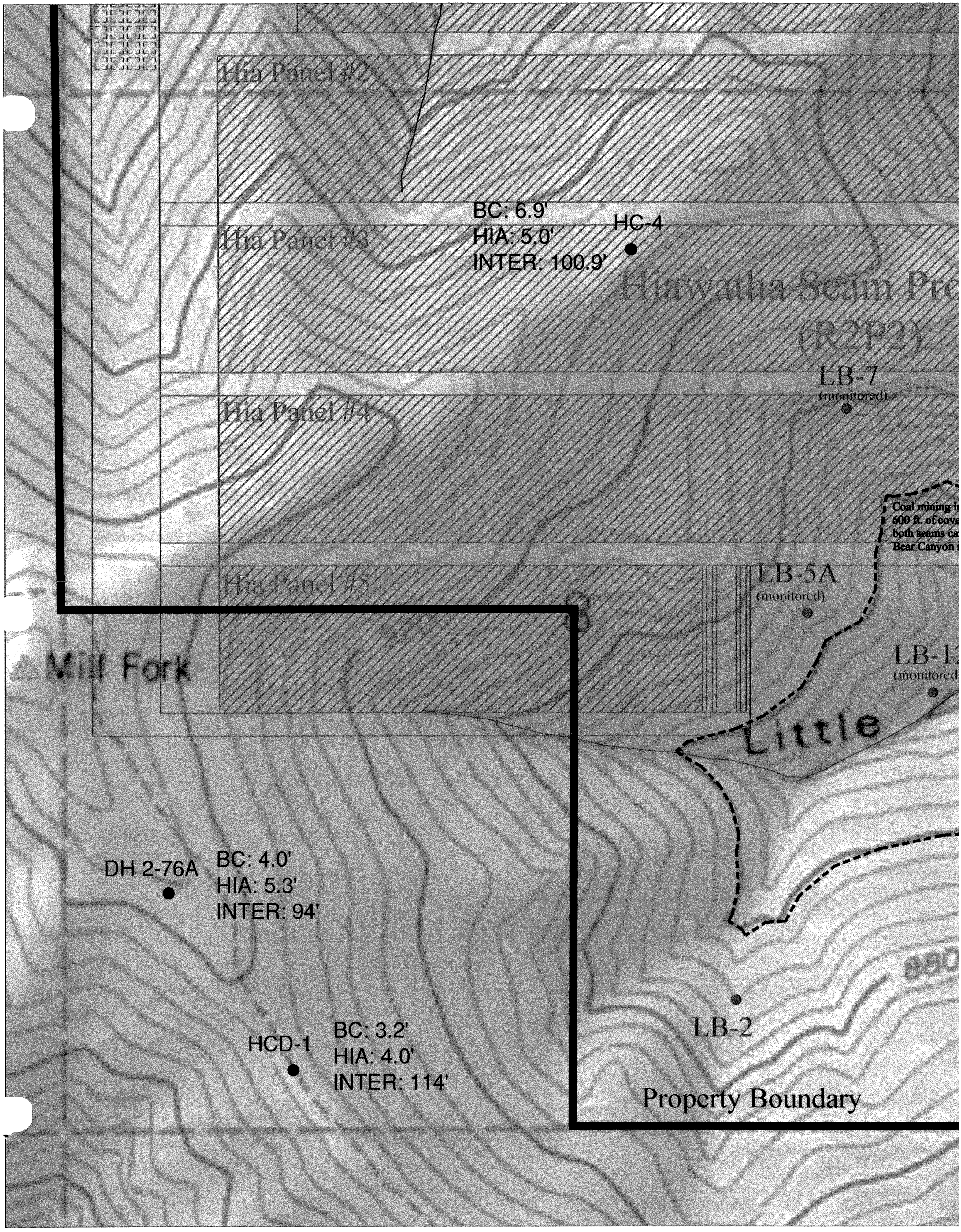
Springs and seeps identified in the southern portion of the South Crandall lease area near or below the 600-foot cover line, 14 July 2004

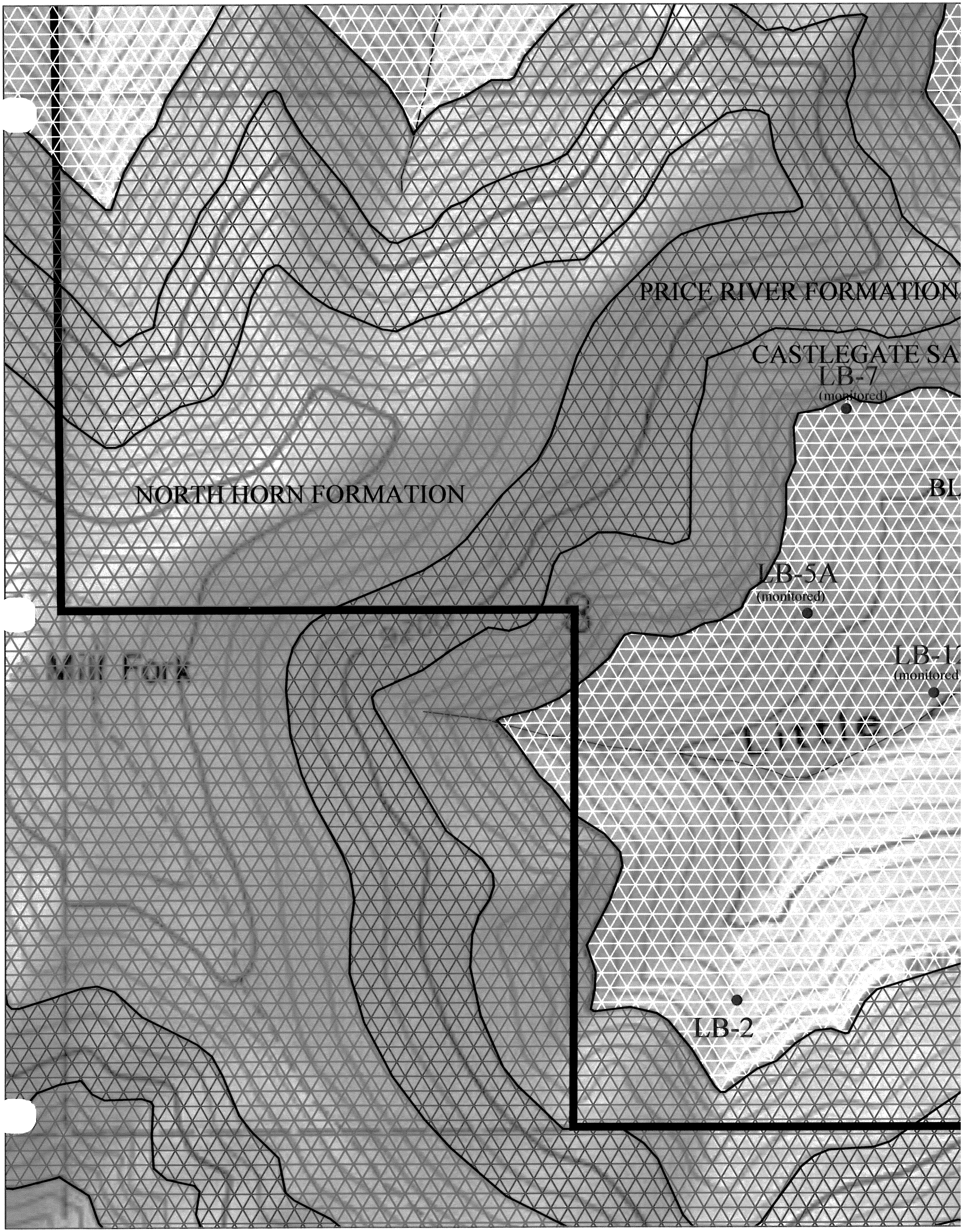
Petersen Hydrologic, Survey July 2004.xls 27 Aug 04

	UTM coordinates NAD 27, Zone 12 S		Date	Flow (gpm)	T (°C)	pH S.U.	Cond (µS)	Comments
LB-2	486397	4365567	15-Jun-04	13.3	7.4	8.39	451	Spring flow originates from Blackhawk Formation above this location (monitored at bedrock-high below main spring area)
LB-12	486712	4365961	14-Jul-04	damp ground	---	---	---	Damp ground only, not enough flow to measure field parameters
LB-5A	486510	4366085	14-Jul-04	1.8	8.4	7.80	706	Discharges from base of Blackhawk Formation sandstone channel (not in potentially subsided area)
LB-7	486573	4366403	14-Jul-04	1.1	8.5	7.99	501	Seepage from base of Castlegate Sandstone/muddy landslide deposits in channel bottom
LB-7A	486969	4366426	14-Jul-04	seep/drip	---	---	---	Seepage from base of Castlegate Sandstone cliff, not enough flow to measure field parameters
LB-7B	487003	4366446	14-Jul-04	seep/drip	---	---	---	Seepage from base of Castlegate Sandstone cliff, not enough flow to measure field parameters
LB-7C	486998	4366398	14-Jul-04	0.21	11.4	8.44	424	Discharges from colluvial sediments near the Blackhawk Formation, Castlegate Sandstone contact



BC Panel #2
BC: 6.9'
HIA: 5.0'
INTER: 100.9'
HC-4
BC Panel #3
Blind Canyon Seam Projections
(R2P2)
LB-7
(monitored)
BC Panel #4
Coal mining in this a
longwall panel with
ft. of cover will not b
is determined that be
be mined without ad
to the Little Bear Ca
watershed.
LB-5A
(monitored)
BC Panel #5
Mill Fork
LB-12
(monitored)
Little
DH 2-76A
BC: 4.0'
HIA: 5.3'
INTER: 94'
LB-2
ARCO No
(Old W
HCD-1
BC: 3.2'
HIA: 4.0'
INTER: 114'
Property Boundary


Hia Panel #2
Hia Panel #3
BC: 6.9'
HIA: 5.0'
INTER: 100.9'
HC-4
Hiawatha Seam
(R2P2)
LB-7
(monitored)
Hia Panel #4
Hia Panel #5
LB-5A
(monitored)
(monitored)
Mill Fork
Little
DH 2-76A
BC: 4.0'
HIA: 5.3'
INTER: 94'
LB-2
HCD-1
BC: 3.2'
HIA: 4.0'
INTER: 114'
Property Boundary


PRICE RIVER FORMATION
CASTLEGATE SA
LB-7
(monitored)
NORTH HORN FORMATION
BL
LB-5A
(monitored)
Mill Fork
LB-12
(monitored)
Little
LB-2