Appendix 7-L
Gentry Mountain Chia

GENTRY MOUNTAIN
CUMULATIVE HYDROLOGIC IMPACT ASSESSMENT (CHIA)

For

STAR POINT MINE
C/007/0006

SUNNYSIDE COGERATION ASSOCIATES
C007/0042

HIAWATHA MINES COMPLEX
C/007/0011

DEER CREEK MINE WASTE ROCK STORAGE FACILITY
C/015/0018

TRAIL CANYON MINE
C/015/0021

BEAR CANYON MINE
C/015/0025

in

CARBON AND EMERY COUNTIES, UTAH

September 24, 2004

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I. INTRODUCTION

This CHIA (Cumulative Hydrologic Impact Assessment) predicts potential cumulative impacts to the hydrologic balance, associated with past, present and anticipated coal-mining operations within the Cumulative Impact Area (CIA). The CHIA determines whether material damage effects outside the individual permit boundaries will result from mining activities.

The CHIA document will:

1. Identify the Cumulative Impact Area. (**Part II**)

2 Describe the hydrologic system and its water resources. (**Part III**)

3. Predict hydrologic impacts. (**Part IV**)

4. Assess material damage. (**Part V**)

5. Make a statement of findings. (**Part VI**)

This CHIA has been prepared by the Utah Division of Oil, Gas, and Mining (UDOGM) and complies with Federal and Utah coal regulations 30 CFR 784.14(f) and R645-301-729, respectively. The last major CHIA update was a revision on June 21, 2001, for the Bear Canyon Mine-Wildhorse Ridge permit extension. A minor update to the CHIA was completed on September 4, 2003 to define the area and features controlled by SCA for the Star Point Refuse operation. The area was already included in the CHIA and no additional features or structures were added.

In addition to the references cited hydrologic and geological information was obtained from the Mining and Reclamation Plans (MRP) of the Bear Canyon Mine, Star Point Mine, Hiawatha Mine, Trail Canyon Mine and the Deer Creek Mine waste rock storage facility.

II. CUMULATIVE IMPACT AREA (CIA)

The Gentry Mountain Cumulative Impact Area (CIA) is located near Price, Utah, within the Transition Province between the Great Basin and Colorado Plateau. The CIA surrounds Gentry Mountain Ridge, which lies south of the town of Scofield in Carbon County and north of Huntington City in Emery County (Map 1). The area of interest can be found on the Hiawatha, Wattis, Candland Mountain, and Huntington U. S. Geological Survey (USGS) 7.5 minute quadrangles.

The CIA is shown in detail on Map 2. This CIA is the region where past, present, and anticipated or foreseeable future coal mining activities may interact to affect surface and groundwater. The CIA boundary incorporates mined areas and proposed mine lease areas at the Star Point, Hiawatha, Trail Canyon, and Bear Canyon Mines and at the Deer Creek and Sunnyside Cogeneration refuse piles. The CIA is defined based on the potential for the hydrologic resources to be impacted by mining activities. Both the surface and the impact areas are within the CIA outlined in Map 2.

Surface waters from the CIA flow from the eastern divide of the Wasatch Plateau to either the Price River or the San Rafael River. These rivers then discharge to the Green River before its confluence with the Colorado River.

Groundwater from the CIA includes all groundwater known to flow through or originate within the CIA boundary and includes all known aquifer discharge points that have the potential to be in hydrologic connection with the mines. Determination of the groundwater CIA boundary has been based on the major geologic features that control flow. Groundwaters issue from alluvial and colluvial aquifers, perched aquifers, channel sandstones and other water bearing lithologies, and fault and fracture systems within the CIA.

MINING HISTORY

MINING ACTIVITIES IN THE CIA.

Mining in the CIA predates the Surface Mining Coal Reclamation Act (SMCRA). The CIA Areas that have been mined within the permitted sites are also shown on Maps 2, 3 and 4.

Star Point Mine (Cyprus Plateau Mining Corporation - Permit C/007/006)

Operations began in 1916 when the Wattis brothers and Mr. Browning bought 160 acres from the United States and developed the property for coal production. The Lion Coal Company operated the Wattis No.1 and No. 2 Mines until the end of 1963. Mining was idled from 1964 through 1967. . In the fall of 1971, United Nuclear Corporation acquired the Star Point Mines. During that time they modernized the mine and expanded the Lions Deck facilities. They sold

the mine to Plateau Mining Corporation (PMC) on July 21,1980. PMC, a subsidiary of RAG American Coal Holding, Inc., changed their name to Cyprus Plateau Mining Corporation (CPMC) in 1999. The Star Point Mine developed six portal "units" within the permit area. A "unit" being an area containing several portals. Plateau Mining, Ltd. began mining the Hiawatha Coal Seam from the Star Point No. 1 and Star Point No. 2 Mines, which had not been mined by the Wattis or Lion Coal Companies. They mined in the Hiawatha Third and Wattis seams using room and pillar and longwall methods until the spring of 2000 when they began reclamation operations.

Table II-1. Star Point Mine Extracted Coal

Company	Time Period	Raw Coal Removed (tons)
Lion Coal Company	1917 - 1963	12,000,000
Plateau Mining Ltd.	1967 - 1971	750,000
United Nuclear Corporation	1971 - 1980	5,000,000
Cyprus Plateau Mining Corporation	1980 - 1990	12,000,000
	1991	no information
	1992	2,100,000
	1993	3,000,000
	1994	no information
	1995	no information
	1996	2,900,000 *
	1997	1,350,000 *
	1998	92,000 *
	1999	1,055,000 *
	2000	89,000 *

* Jahan Bani, 1997, 1998, 1999, 2000

Three additional portals were approved for Little Park Canyon, but were never built.

The Wattis, Third (Middle), and Hiawatha Seams were mined within the Star Point Mine permit area. Early development occurred on the east side of the Bear Canyon Fault (Map 3). Subsequent access to mining, west of the Bear Canyon Graben, was by a 3-main-entry rock tunnel constructed through the graben in 1989. Coal was removed through the Lion Deck Portal Area.

The Star Point No. 2 Mine's maximum annual coal recovery was approximately 3.5 million raw tons. Currently, CPMC has no leasehold interest, options, or pending bids on lands contiguous to the permit area.

The Star Point No. 1 and the South Wattis units have been sealed and reclaimed. A third portal unit at the Star Point No. 2 Mine, located on the Lion Deck, was sealed in January 2001 and reclaimed during 2002. The Corner Canyon fan area, the fourth unit, has three portal entries and the Mudwater Canyon fan unit, the fifth unit, has five portal entries, all of which were sealed and reclaimed in 2000- 2001. The two breakouts of the sixth unit, located in a side drainage

north and west of the Mudwater Canyon fan unit, were sealed and reclaimed in 1994.

Sunnyside Cogeneration Associates - Permit C007/0042

Sunnyside Cogeneration Associates (SCA) will mine the coal refuse pile remaining after the closure of the Star Point, CHIA Map 2. SCA acquired the coal refuse and associated subsoil cover material from Plateau Mining Corporation (PMC) [Cypress Plateau Mining Corporation's (CPMC) was reorganized and became Plateau Mining Corporation on June 30, 1999. All references to Cyprus Plateau Mining Corporation or CPMC in SCA's application infer Plateau Mining Corporation]. SCA plans to utilize the coal refuse material as a fuel source in its fluidized-bed combustion boiler at the power cogeneration plant at Sunnyside, Utah.

Construction of the refuse pile began in 1970 with wet processing of "run of mine" coal from the Wattis, Third and Hiawatha coal seams via the Star Point Mine operations. Refuse was continually added to the pile until mine closure in 1997. The quality of the refuse from the mine changed over time as processing improvements were made. The most deeply buried refuse has greater btu/lb and is more fine than the material above. Approximately 192,000 cu yds of waste from the Price River Coal AML project (Panther Mine) was transferred to this refuse pile in 1988 (personal communication with MaryAnn Wright, Louis Amodt and Chris Rohrer, May 15, 2003).

Subsoil salvaged from the expansion of the refuse pile in 1982 will be redistributed over the refuse pile at reclamation. The entire 235,000 cu yds of salvaged subsoil will be returned to the disturbed area. At final reclamation, 2.7 acres of the refuse pile will receive 4 feet of substitute topsoil cover and 59 acres of the former refuse pile will receive the remainder of the subsoil pile with a minimum coverage of twelve inches, for a total of up to 235,000 cu-yds of substitute topsoil removed from the subsoil stock pile.

Unusable refuse will be permanently placed in the former slurry ponds north of the refuse pile. The discarded refuse will be compacted in lifts of four feet into a 4h:1v slope. The refuse samples taken in 1987 had acid forming potential. The refuse was sampled again in 2001, but not for acid/toxic characteristics. SCA will monitor the refuse placed in the settling basins for acid and toxic characteristics just prior to final reclamation. Accordingly, any toxic waste or waste with the potential for acid-formation or with elevated Boron or Selenium can be covered with four feet of substitute topsoil from the subsoil pile.

Bear Canyon Mine (Coal Development Company - Permit C015025)

Mining associated with the Bear Canyon Mine began in 1938, prior to SMCRA. C. O. P. Coal Development Company acquired fee coal lands and federal coal leases U-2431 and U-24318 in the Bear Canyon area from Peabody Coal Company in 1980, and mining operations began in 1982. C.O.P. obtained federal coal leases U-020668 and U-38727 from Nevada Electric Investment Company in 1992. C.O.P. also holds federal coal leases U-46484, U-61048, and U-61049 to the north and east of the Bear Canyon Mine. All together, C.O.P. controls approximately 8,000 acres in and adjacent to Bear Canyon.

Co-Op Mining Company leased 3,336.18 acres from C.O.P. Company and developed the Bear Canyon Mine permit: federal leases U-38727, U-020668, and part of U-24316, plus approximately 1,600 acres of fee coal land. In 1997, Jahan Bani (Utah Geological Survey) estimated that Co-Op Mining Company controlled more than 30 million tons of coal reserves east and west of Bear Canyon, of which approximately 75 percent of the reserves are private or fee coal.

There are four coal seams at the Bear Canyon Mine; –from highest to lowest - the Tank, Upper Bear, Blind Canyon, and Hiawatha Seams. No mining has occurred in the Upper Bear Seam. Mining was conducted by room and pillar mining methods. Main access is through the Bear Canyon #1 Mine portal to the Blind Canyon Seam and the Bear Canyon #2 Portal to the Tank Seam. There is a Hiawatha portal, but a rock tunnel from the #1 Mine is the main access. Production began in the Hiawatha Seam in 1987: production was limited because the coal was scoured by channel-sand formations, but further mining is still considered a possibility. First mining from the Blind Canyon seam occurred during 1983 through 1996, and production began in the Tank Seam in 1994. In 2001, Co-Op was retreat mining the Blind Canyon and Tank Seams in federal lease U-024316 and fee coal lands. That work has been completed with the portals being backfilled and sealed, and the access road reclaimed.

As of September 2002, Mines #3 and #4 portals are being driven for the Wild Horse Ridge area to access the Tank and Blind Canyon Seams: six portals are anticipated. Initial access to the Tank Seam in the #4 Mine will be through a rock tunnel from the #3 Mine. The Tank Seam does not crop out in the Wild Horse Ridge area, and the portals for the #4 Mine will be constructed by breakout once a location with suitable conditions is identified.

Annual production from Co-Op prior to 1996 was 400,000 to 500,000 tons per year according to the 1996 State Coal Production Review, and the annual coal production for 1996 was 581,000 short tons (Jahan Bani, 1997). Annual production was 570,000 tons in 1997, 660,000 tons in 1998, and 881,000 tons in 1999 and over 1 million tons in 2000 (Jahan Bani, 1998, 1999, and 2000). Recoverable Reserves are estimated at 15,800,000 (Bear Canyon Mine Plan, Table 3.4-1).

Hiawatha Mine (U.S. Fuels Company - Permit C/007/011)

The Hiawatha permit area spans a total of 12,707 acres with 290 acres of disturbed area. U.S. Fuel ceased production in April 1993. Total production thru 1993 was greater than 50 million tons from more than 80 years of mining. The Hiawatha Mines Complex is now operated by the Hiawatha Coal Company, Inc.

Portals were constructed for the Hiawatha #1 Mine in 1903. Use of many mining related surface facilities continued post SMCRA within areas identified in Table II-2 (refer to Maps 3 and 6 for general locations). Several portals were associated with pre-SMCRA mining. From 1948 to 1975 the portals at the South Fork Mine yard supported the King No. 1 and King No. 3 Mines, which are interconnected underground. Three prospect portals were developed in the B

seam during that time. The three portals of the King No. 5 Mine and the four portals of the adjacent King No. 4 Mine were on the south side of the Middle Fork Mine Yard.

The King No. 6 Mine, located in South Fork Canyon, was developed following the enactment of SMCRA. In 1981, the old portals from the King No. 3 Mine were updated and the King No. 6 haulage portal was developed. One intake airway portal was developed in the North Fork Drainage in 1979. Production from the Hiawatha Complex for the period from 1990 – 1993, as reported to MSHA, are as follows: 584,000 tons (1990), 197,000 tons (1991), 108,000 tons (1992), and 13,500 tons (1993) of coal mined, respectively. The portals of the King No. 4 and King No. 5 Mines were backfilled in the first half of 1993. Plate 3c shows the areas U.S. Fuel Company mined during the last period of mine development. U.S. Fuel Company had future plans to mine both the A and B coal seams. They were mining in the B coal seam until 1992, then began a small amount of mining and exploration in the Hiawatha coal seam.

Table II-1A

Coal Seams at Mines on Gentry Mountain (possible correlation)					
Bear Canyon Mine		Hiawatha Mine Complex		Star Point Mine	
Tank	mined	Upper seam	unmined		
Upper Bear	unmined	B seam (Bear Canyon)	mined	Wattis	mined
Blind Canyon	mined	A seam (split from Hiawatha)	mined	Third	mined
Hiawatha	mined	Hiawatha	mined	Hiawatha	mined

Table II-2

Mine status at Hiawatha Mine Complex					
Mines	Seam	Location of Portal	Working status	Other openings	Reference source
King #1Mine (Blackhawk Mine)	Hiawatha	Canyon south of Hiawatha	Abandon 1975		Plate 5-2C
King #2 Mine (Mohrland Mine),	Hiawatha	Cedar Canyon	Abandon 1953		Exhibit V-1
King #3 Mine	Hiawatha	Middle Fork of Miller Canyon	abandon 1948		Plate 5-2C
King #4 Mine	B Seam/ Bear Canyon	Middle Fork of Miller	Inactive since 1993,	(Vent Portal in Right	Plate 5-2A

		Creek (north side)	considered for future mining	Fork of Miller Creek)	
King #5 Mine	B Seam/ Bear Canyon	Middle Fork of Miller Creek (south side)(	Inactive since 1993, considered for future mining	break out in left fork of Miller Creek, south side	Plate 5-2A
King #6 Mine	Hiawatha Seam, Bear Canyon/B Seam, Blind/A Seam	Left Fork of Miller Canyon	Inactive since 1993, considered for future mining		Plates 5-2A, B and C.
Hiawatha #1 Mine	Hiawatha Seam	Middle Fork of Miller Creek (south side),	abandon 1926		Plate 5-2
Hiawatha #2 Mine	Hiawatha Seam	Middle Fork of Miller Creek (north side)	abandon 1926	(vent portal in Right Fork of Miller Creek	Plate 5-2

Also see Exhibit IV-5

Trail Canyon Mine (Co-Op Mining Company)

The Trail Canyon Mine is a reclaimed underground mine located in Trail Canyon, a tributary to Huntington Creek (Map 3). This mine operated intermittently beginning in 1921, and was operated by Co-Op Mining Company through 1981. The permit area was approximately 270 acres with 10 acres of disturbed area. Reclamation activities began in June 1987. Most of the site grading and seeding was done in 1988 and 1989, but additional seeding was done as late as 1997. The Trail Canyon Mine obtained Phase I Bond release in July 18, 1994 and Phase II Bond release in January 31, 1996. Phase III Bond release was obtained in January 2001.

Deer Creek Waste Rock Storage Facility (PacifiCorp)

The Deer Creek Waste Rock Storage Facility encompasses 46.22 acres and is located approximately 2 miles northeast of the Deer Creek Mine (Map 6). The expected life of the

facility is 40 years. This site was predicted to receive 31,200 cubic yards of waste material annually. Utah Power and Light Company is the landowner of the Waste Rock Facility area.

III. HYDROLOGIC SYSTEM

The climate and geology, which affect the hydrologic characteristics, are described under specific headings and are followed by sections that discuss the groundwater and surface-water resources.

CLIMATE

Precipitation stations surrounding the CIA include the Bear Canyon Mine, East Mountain, Skyline Mine, and the town of Hiawatha. Climatic variations at these sites are influenced by elevation and aspect. The Bear Canyon Mine lies at an elevation of approximately 7,400 feet, while the town of Hiawatha lies at an elevation of 7,200 feet. The elevation across the CIA ranges from 6,300 feet in Huntington Creek to 9,850 feet on Gentry Mountain.

The climate of the CIA is semiarid, but precipitation increases with altitude. The average annual precipitation in the CIA may vary between 10 inches in the valley to over 30 inches on the ridges in the form of snow and rain. In the Wasatch Plateau, about 70 percent of the precipitation falls during October through April, mostly as snow. Summer thunderstorms and rain showers occur in the mountains and high valleys, but the towns and cities in the valleys may remain dry. Summer thunderstorms are generally localized, high-intensity, short-duration events. The 100-yr 24-hour precipitation event, with a probability of occurrence in any year of 0.01, would vary from 2.8 to 3.4 inches for May through October within the CIA (Miller, 1973).

To illustrate the variation in recorded precipitation, selected data from the Bear Canyon and Trail Canyon Mine rain gages are presented in Table III-1. The difference in the maximum annual and minimum annual precipitation is considerable for the Bear Canyon and Trail Canyon drainages, which are slightly over a mile apart. The Nation Resource Conservation Service (NRCS) has two precipitation stations at higher elevations west of the Bear Canyon Mine: from 1961 to 1990 (NRCS, 1994), average annual precipitation was 29 inches at the Mammoth-Cottonwood station (elevation 8,800 feet) and 33 inches at Red Pine Ridge (elevation 9,200 feet).

Table III-1. Recorded Precipitation Data

Mine	Monthly Precipitation (inches)		Annual Precipitation (inches)		
	Max	Min	Max	Min	Avg
Bear Canyon (1993-1996) b	3.87(8/95)	0.07 (6/94)	14.37 (1995)	7.9 (1994)	10.0
Bear Canyon (1999–2002)	3.92 (10/00)	0 (mult. Mo. Each yr.)	13.04 (2000)	6.09 (2001)	8.55
Trail Canyon (1993-1996)	5.01 (8/95)	0.15 (6/93)	22.54 (1995)	11.23 (1993)	14.8

The evaporation and infiltration rates in the CIA vary according to vegetation, soil type, and time of year. The potential evaporation for Bear Canyon Mine is about 40 inches/year while transpiration is less than 18 inches/year. The relative humidity ranges from 45 percent in the summer to 85 percent in the winter. (Bear Canyon Mine Plan).

Weather conditions found in the CIA can be gauged by the Palmer Hydrologic Drought Index (PHDI). This index characterizes dry and moist climate periods for a region. It indicates the severity of a wet or dry spell, with negative values denoting a dry spell, and positive values denoting a wet spell. Because the CIA borders the southern portion of Region 5 and northern portions of Regions 4 and 7, the climate is influenced depending on the predominate storm direction and storm characteristics (See Map 1a). Figure 14 illustrates the climatic conditions experienced in those three (3) regions from 1983 to 2003.

Temperatures are seasonally variable and generally cooler at higher elevations. January mean temperatures vary from a mean minimum of 8 to 12°F to a mean maximum of 28 to 32°F. July temperatures vary from a mean minimum of 40 to 52°F to a mean maximum of 72 to 84 ^{o}F. The average annual temperature is 45°F (Jeppson and others, 1968).

GEOLOGY

GENERAL

Geology described in this section focuses on elements needed to understand the hydrogeology: stratigraphy, general lithology, structure, and geologic factors determining occurrence.

The principal geologic controls that affect the presence of groundwater in the Gentry Mountain area are: extensional or boundary faults and grabens, local faults and fissures, aquitards such as clay or the Mancos Shale, channel sandstones, and structural dip. Each are discussed below.

STRATIGRAPHY AND GENERAL LITHOLOGY

Lithology of the Wasatch Plateau consists of Upper Cretaceous and Tertiary strata. Transgressive and regressive phases deposited a number of broad delta and prodelta sheet sandstones along a north-south trending interior seaway. The major coal deposits in Utah were formed along seaway shorelines and are planar and continuous. Landward influences such as small channel splays and levee deposits have created splits in the coal. Tidal inlet deltas, lagoonal muds, and washover fans produce rolls or undulations in the coal formation, fluvial channel scour, and discontinuous lenticular geology.

In ascending order by age, the strata found in the CIA are the Masuk Shale Member of the Mancos Shale, the Star Point Sandstone, the coal bearing Blackhawk Formation, the Castlegate Sandstone, the Price River Formation, the North Horn Formation, the Flagstaff Formation and Quaternary Alluvium (Figure B, Map 5), and the combined Price River/North Horn Formation. Additional information for these formations can be found in the mining and reclamation plans and other geologic references. The Blackhawk Formation and Star Point Sandstone are described in more detail because of their importance to coal mining and hydrology in the CIA.

Blackhawk Formation and Star Point Sandstone

The Star Point Sandstone consists of several sheet sandstones that were deposited along the shores and deltas of a north-south trending interior seaway. In the vicinity of the CIA, the Star Point Sandstone is comprised of, in ascending order, the Panther, Storrs, and Spring Canyon Sandstone Members. These members inter-tongue with marine shale layers of the Mancos Shale. The sandstones are usually gradational and sorted, medium-grained and cross-bedded at the top and fine-grained to silty at their base. They thicken westward and in places, such as near the central part of Huntington Canyon where they are more than 600 feet thick (Spieker, 1931), they merge into one massive sandstone unit. Farther west they grade into the back-barrier, coastal plain, and deltaic deposits of the Blackhawk Formation.

The Blackhawk Formation overlies the Star Point Sandstone. This formation is roughly 900 to 1,400 feet thick. It is the primary coal-bearing formation in the Book Cliffs and Wasatch Plateau Coal Fields, with mineable coal seams in the lower 400 feet (Doelling, 1972).

The Aberdeen, Kenilworth, and Sunnyside are sandstone members of the lower Blackhawk Formation and are similar to the sandstone members of the Star Point Sandstone. They are interbedded with coals, shales, and siltstones in the Blackhawk Formation and inter-tongue with the Mancos Shale on the seaway side.

Sandstones in the lower Blackhawk are dominantly sheet deposits, but there are also lenticular channel sandstones that were deposited by fluvial systems. In the upper Blackhawk Formation, sheet sandstones are thinner and less common, but channel deposits are more abundant and are the dominant sandstone bodies. The fluvial channel sandstones are generally fine grained and well cemented. Localized zones of high clay content occur within the channel sandstones. These sinuous channel deposits may be interconnected, but in cross-section or outcrop they appear laterally discontinuous and hydrologically, they act as local, perched aquifers rather than as large saturated zones 1.

The Hiawatha Seam is the lowest mineable coal seam of the Blackhawk Formation. It lies just above, and in places directly on, the Spring Canyon Sandstone. The names and general thicknesses of the mined coal horizons at the various mines are shown below

1 The term "regional aquifer" is used in several Mining and Reclamation Plans of the Wasatch Coal Fields. The term likely originated from hydrologic studies conducted by the U.S. Geological Survey. Although some formations contain large areas of saturated groundwater, the term regional aquifer does not necessarily apply to the SMCRA definition of an aquifer, which is a geologic unit or formation that readily stores and transmits groundwater for a specific use. The term regional aquifer does not always apply to SMCRA and the coal mining areas in the Blackhawk Formation, since many of the groundwater sources are perched and discontinuous, and do not necessarily supply water for a specific use. The Division prefers the terms perched and saturated groundwater zones when dealing with groundwater sources in the Blackhawk Formation.

Star Point Mine (Star Point Mine Plan)

Tank 0 - 7 feet thick uneconomical for development.

Wattis	2 - 12 feet thick 20 to 90 feet above Third.
Third	3 - 13 feet thick 30 to 80 feet above Hiawatha.
Hiawatha	1 - 11 feet thick.

Hiawatha Mine (Mine Plan Information Sheet)

Upper Seam	< 6 feet thick; 300 feet above the B Seam.
B seam	4- 12 feet thick; 0 -70 feet above A seam.
A seam	0-12 feet thick; lies 0-60 feet above the Hiawatha.
Hiawatha	up to 24 feet thick.

Trail Canyon Mine (Limited information in MRP)

Upper Seam	No information
Hiawatha	Mined by Community Mine and other predecessors of Trail Canyon Mine in Trail Canyon - no information.

Bear Canyon Mine (Jahan Bani; and Mine Plan Information Sheet)

Tank	8 to 10 feet thick; 0 to 8 feet thick and has 0 to 1600 ft over burden.
Blind Canyon	12 to 20 feet thick; 30 to 80 feet above the Hiawatha, and 0 to 1800 ft over burden.
Hiawatha	5 to 9 feet thick and 0 to 1900 feet over burden.

Aquitards such as Clay or Mancos Shale

The presence of numerous springs in the headwaters of the CIA (Map 6) is a result of impermeable layers within the Blackhawk and overlying formations. Except where fractures are actually opened by tension, shales and siltstones in the formations hinder the vertical movement of groundwater. These aquitards contribute to the formation of perched aquifer systems and also limit vertical migration between the sandstone tongues of the Star Point Sandstone (Bear Canyon Mine Plan).

Channel Sandstones

Channel sandstones may be isolated and localized, or they may be interconnected. They are commonly enveloped in finer grained sediments in strata overlying the coal seams, but also are found in the roof of the coal seams or even within the coal seams, as at the Bear Canyon Mine. They are a common source of water in the mines. Typically, when water is entering a mine from the surrounding rock, drilling roof-bolt holes into overlying channel sandstones will increase the inflow. Such roof-bolt holes flow until the overlying sandstones are de-watered, usually only a short period of time.

A large channel sandstone in the Blind Canyon Seam has been the major source of water at the Bear Canyon Mine. This channel sandstone traverses east and west across the north end of the Blind Canyon Seam in the No. 1 Mine. Drips from the roof of the mine increased as mining approached this channel-sandstone unit. Initial flows from this channel sandstone were 120 gpm (Figure 6). Flow rose to over 400 gpm in 1992, then decreased to less than 100 gpm by the time the nearest monitoring point, SBC-9, was abandoned in 1999. Flow monitored at SBC-13 is believed to originate from the Blind Canyon channel sandstone and flow through gob to the monitoring point: flow at SBC-13 appears to be increasing (Fig. 13b). Further north, in the Hiawatha Mine, another channel sandstone traverses a portion of the mine which helps supply water to the Mohrland portal (Plates 5-2a, -2b and -2c, Hiawatha MRP).

STRUCTURE

Spieker's 1931 geologic report portrays the major faults, grabens and stratigraphy on Gentry Mountain. Five significant fault zones trend north and south within the CIA; 1) the Pleasant Valley Fault, 2) the Trail Canyon Fault (East Fault of the Pleasant Valley Graben), 3) the Dry Canyon Fault, 4) the Blind Canyon Fault, and 5) the Bear Canyon Fault (Map 5, 5A, 5B). Normal faults are almost exclusively north-south trending and are associated with Basin and Range grabens. The grabens influence the local and regional hydrology. Fault displacements range from several feet to approximately 800 feet along the north-south fault zones. Other features such as large amplitude folds do not occur on the Wasatch Plateau, but regional dip is modified locally by the tilt and rotation of individual fault blocks. More detail is presented for the Pleasant Valley and Bear Canyon Grabens, which are significant features, in the CIA; joints and non-normal faults are also then discussed in the CIA.

Pleasant Valley Graben

The Pleasant Valley Graben extends from Scofield Reservoir south to Huntington Canyon and displaces strata as much as 400 feet near the Star Point Mine. The Pleasant Valley Fault appears continuous from Scofield Reservoir to the Tie Fork drainage. The eastern boundary of the Pleasant Valley Graben lies near the western edge of the Star Point Mine, where at least seven small faults have been mapped as the east boundary fault complex. Within the Star Point Mine area, this zone was considered highly fractured (Star Point Mine Plan).

The seven small faults of the east boundary fault complex are en-echelon, to the west, near the southwest corner in the NE 1/4 of Section 15, T. 15 S., R. 7 E. (Star Point Mine Plan). These normal faults generally increase in throw east to west through a 1,000 to 1,200-foot-wide zone (the total width of this eastern fault complex was undetermined). The eastern most fault of the Pleasant Valley Graben along the Castle Valley Ridge is offset at least 45 feet and may increase in offset to the north. The offset of the remaining faults may exceed 70-100 feet, and the dip varies with depth from 65° W to 84° W, with an average of 80° W - 85° W (Star Point Mine Plan).

Bear Canyon Graben

The Bear Canyon Graben forms an irregularly inclined and irregularly bounded trough extending from south of Huntington Canyon, where it merges with the Pleasant Valley Graben, northward to First Water Canyon. This graben trends N 4° W, and ranges in width from 1,600 feet to 2,400 feet between major boundary faults (Star Point Mine Plan).

A great deal of information was collected on the Bear Canyon Graben when developing the Graben Tunnels in the Star Point Mine (Map 3a). These rock tunnels cross the Bear Canyon Graben and connect the Wattis Seam east of the Bear Canyon Fault to the Wattis Seam in the Gentry Ridge Horst. Displacements across the eastern and western most faults averaged 250 feet. Fault gouge zones on the Bear Canyon Graben side (east) of the boundary faults were about 10-20 feet wide and appeared impermeable. Parallel to each major boundary fault within the Gentry Ridge Horst there are two fault zones approximately 200 to 250 feet in width. These zones consist of numerous offsets ranging from less than 1 foot to over 30 feet. Midway between the two boundary faults is another minor fault zone approximately 200 feet in width. Four faults have been mapped in this zone with displacements ranging from 1 to 9 feet. Water seepage has been noted along the faults in this zone at 5- 10 gpm (Star Point Mine Plan).

Joints and Non-normal Faults

Two types of regional stresses occur in the CIA, resulting in several joint sets. One stress was compressional and the other was extensional (Star Point Mine Plan). Three orientations of joint sets resulted from each regional stress.

The joints formed during compressional stress are oriented N 58° E, N 58° W, and N 85° W. The N 58° E and N 58° W orientations are vertical, generally planar, and closed with a tendency to terminate over short distances or at lithologic boundaries. Carbonate and pyritic mineralization is

common along these joint faces. The N 85° W joints are parallel to the maximum compressive stress. These joints lie along the N 85° W trending faults near the en-echelon and N 80° W faults (Star Point Mine Plan).

The joints formed during extensional stress orient N 5° W, N 6° E, and N 14° E. The N 6° E joints are more prominent and open. Due to the open nature of this joint set, ground- and surface-water migration and concentration is common along fracture systems having this orientation (Star Point Mine Plan).

A system of joint and fracture sets oriented N 15° E to N 17° E and a second set of minor joints with orientations N 60° E are found in the southern end of the Bear Canyon Graben, near the Bear Canyon Mine (Transcripts of Informal Conference, February 28, 1997).

Two non- normal N 80° W trending faults were encountered in the Star Point No. 2 Mine. Both were filled with biotite-rich intrusive rock at several locations. Displacement along the faults are from 0 to 5 feet within the Star Point Mine.

Extensional or Boundary Faults and Grabens

Boundary faults and interior faults of grabens generally form hydrologic boundaries impeding movement of groundwater across the faults. A boundary fault is commonly associated with gouge (pulverized clay-like material formed by the grinding of rock as the fault develops) and a highly fractured breccia zone (angular fragments from the fault movement): the amount of gouge and breccia is generally proportional to the amount of movement of the fault. Gouge can impede flow across or along the fault zone and cement the breccia. Fault gouge along the Blind Canyon Fault within the Bear Canyon Mine, in the southeastern zone of the Bear Canyon Graben, was observed to be dry. (Transcripts of Informal Conference, February 28, 1997). Gouge and breccia zones were excavated in the Bear Canyon Graben at the Star Point Mine, where breccia zones occur on one, and often both sides of the gouge (Star Point Mine Plan).

Significant groundwater has been intercepted near the Star Point Mine at two locations along the eastern boundary fault of the Bear Canyon Graben. At one location, flows were approximately 150 gpm when mining initially intercepted the fault zone and penetrated 40 to 60 feet of gouge and fractured rock, but decreased to no discharge after time. At the Hiawatha Mine, a sustained inflow of 900 to 1,000 gpm occurred where the workings contacted the Bear Canyon Fault in the 10th West Section of the U.S. Fuels King IV Mine (Star Point Mine Plan). This flow was encountered in the 1970's and diminished significantly within a short timeand flowed approximately 100 gpm when the area was last accessible. Most faults from the extensional system encountered in the Star Point No. 2 Mine had accompanying inflows of groundwater where groundwater was trapped against a gouge zone and was conducted along the breccia zone of the fault (Star Point Mine Plan).

Water may be conveyed along a fault until, 1) water discharges as a spring, 2) water discharges to a lower perched aquifer system, or 3) water discharges to the regional system. The higher yielding springs appear to be associated with the north-south extensional fault or joint systems found in the area (Star Point Mine Plan). Most springs having flows in excess of 10 gpm lie

either: 1) directly along a fault, 2) in close proximity to a fault, or 3) appear to fall in line with the projection of an identified fault.

Local Faults and Fissures

Local faults and fissures also influence movement. Parallel to the major boundary faults - the Bear Canyon Fault and the Trail Mountain Fault (East Fault of the Pleasant Valley Graben) - and extending inward are two fault zones approximately 200 to 250 feet in width (Map 3). Spring flows in these zones appear to respond quickly to snowmelt and recharge conditions, indicating the vertical permeability from fractures in the region is relatively significant (Star Point Mine Plan). Water seepage of from 1 - 20 gpm was observed to travel along these fractures depending on the gouge or breaking character of the fault (Star Point Mine Plan).

It has been hypothesized that at least part of the recharge for Big Bear Spring is conveyed from Big Bear Creek by way of local fractures. This is supported by water age-dating analysis, which indicates a portion of the water discharging from Big Bear Spring has a modern component.

Fault zones associated with boundary and interior faults may conduct ground water parallel to the faults. The Star Point Mine Plan (pages 700-6 and 700-7) states the following:

1. " The secondary permeability resulting from open fractures created along faults and joints provides the primary conduit system for movement within the Wasatch Plateau" .

2. " The extension joints and faults that strike in a north-south direction are generally open, and as such increase the secondary permeability. .... The open nature of these joints and faults and the attendant secondary permeability may be primarily limited to the sandstone units within these formations".

3. " Secondary permeability within the grabens is expected to be greater than secondary permeability outside of the grabens. Joint densities within the Bear Canyon Graben are approximately 50 percent greater than joint densities on either side of the graben".

Dip of the Strata

Strata in the eastern Wasatch Plateau have a regional dip of 1 to 3 degrees, generally to the south. Dip angles increase near faults to about 20 degrees (Bear Canyon Mine Plan). The dip of the strata is a major factor governing local and regional flow directions.

In the Gentry Ridge Horst between the Bear Canyon and Pleasant Valley Grabens, the coal seams in the Star Point Mine dip approximately 3 degrees to the south-southwest, and the dip and general direction of movement is to the southwest in the perched aquifer system of the Price River - North Horn Formations north of Tie Fork Canyon. A component of recharge within the Gentry Ridge Horst is from the north and discharges to Tie Fork Canyon. South of Tie Fork, the dip in the Bear Canyon Graben is southeast and flow moves toward the Bear Canyon Fault.

East of the Bear Canyon Fault, dip within the previously mined areas and direction of movement are to the east and southeast. Localized variations within the coal seams may determine the ultimate direction of water flow following mining. Structural contour maps supplied in the Hiawatha Mine plan (plates 6-6, 6-9, 6-12) indicate the dip within the Hiawatha Mine workings is southwest (toward the fault in the western half of the workings and south in approximately the eastern half of the workings).

The August 1988 Earthquake

According to CPMC personnel and the University of Utah Seismology Department (Nava and others, 1990), the area experienced several earthquakes during the fall of 1988. Information including dates and earthquake magnitude for the four largest earthquakes identified during this period (centered approximately 15 miles east of Ferron, Utah and 29 miles southeast of the Tie Fork wells) as provided by the University of Utah include:

Date	Time	Magnitude
August 14, 1988	1:07 p.m.	3.8
August 14, 1988	2:03 p.m.	5.3
August 15, 1988	8:50 a.m.	3.0
August 18, 1988	6:57 p.m.	4.4

A flow increase recorded at Upper Tie Fork Spring in August 1988 correlates with the August 14, 1988 earthquake. This is discussed further in several sections of this CHIA.

HYDROLOGIC RESOURCES

Surface- and groundwater resources within the CIA are described. Water rights associated with some of the more important resources are presented, along with descriptions of their hydrology and geology.

GROUNDWATER

Rights

Groundwater within and adjacent to the CIA is used for wildlife, stock watering, domestic, industrial, and municipal purposes. Water rights are assigned through association with a source such as a well or a spring, and then they are presented for the associated mines.

Water Rights Associated with Wells

The resources for well development are limited in the CIA. One well source, Water Right E1621, owned by Utah Power and Light, was identified within the Bear Canyon Mine Plan adjacent area. Adjacent to the Star Point Mine, three wells in the Tie Fork drainage were

developed as a result of drilling into a pressurized aquifer, which created artesian flow (85-35-1 was an exploratory hole deeded to Huntington City to supplement flow being developed by the city at flowing wells 86-35-2 and 86-35-3: flows from 86-35-2 and 86-35-3 are usually combined and reported as 86-35-2-3). The three Tie Fork wells are referred to as Upper Tie Fork Spring and are discussed below.

Rights associated with Springs

Stock watering is the predominant water-right use associated with springs on Gentry Ridge; these spring sources are also used by wildlife. Many springs in the Gentry and Hoag Ridge area have water rights filed on by the U.S. Forest Service.

Of the 88 groundwater rights listed in Table 724.100e of the Star Point Mine Plan, 87 are for springs, one for an in-mine well. Only eight have uses listed as "domestic" or "other". Of these eight water rights, CPMC (or Getty Oil Co.) owns five: 91-59 and 91-57 are associated with springs in Sagebrush Canyon, 92-9295 is a spring on Gentry Ridge, 91-61 is for spring S17-2, and in-mine well right 91-3555 is used to supply water for the Star Point Mine office. As for the three other "domestic" or "other" water rights, 91-103 and 91-104 are held by U. S. Fuel Company in the headwaters of the Middle and Left Fork of Miller Creek, and 93-219 is held by Huntington-Cleveland Irrigation for Tie Fork Springs (wells 85-35-1 and 86-35-2-3 - Maps 3 and 5). This right was segregated from surface-water right 93-3709 on Huntington Creek by change application number a7941. The water right allocates 150 cfs of water use to a 62-acre feet/year maximum.

Appendix 7-C of the Bear Canyon Mine Plan identified 35 water rights associated with 15 springs: 12 are for stockwatering, 17 are for domestic and municipal uses, and the remainder are for irrigation or other uses. There are also 4 in-mine water rights listed in Appendix 7-C, with various uses including mining, domestic, and irrigation. Discussions on the potential for impact to these sources are presented in the following sections of this CHIA.

Birch and Big Bear Springs have a number of associated water rights. These rights are summarized and presented in Table III-2. One water right associated with Birch Spring, owned by Nevada Electric Corporation, has a designated stockwatering use for 30 head of cattle at the spring source. This use is incompatible with the domestic use; however, the area around the spring is fenced and has not been grazed for many years. Big Bear Spring, also called Bear Canyon Spring, is referenced as Big Bear Spring in this document because it is the name associated with this water right.

Table III-2: Selected Water Rights Information [1]

Source	Water Right Number	Quantity	Priority	Owner
Birch Spring	93-304	150 cfs	1875	Huntington-Cleveland Irrigation Co.

	93-2198	80 cfs	1875	Huntington-Cleveland Irrigation Co.
	93-2197	77.25 cfs	1884	Huntington-Cleveland Irrigation Co.
	93-2196	45 cfs	1879	Huntington-Cleveland Irrigation Co.
	E2504 93 3703	0.00 cfs (see the following paragraph)	1887	Castle Valley Special Service District
	93-143	0.011 cfs	1875	Nevada Electric
Big Bear Spring	93-2201	80 cfs	1888	Huntington-Cleveland Irrigation Co.
	93-2200	77.25 cfs	1884	Huntington-Cleveland Irrigation Co.
	93-2199	45.0 cfs	1879	Huntington-Cleveland Irrigation Co.
	93-253	150 cfs	1875	Huntington-Cleveland Irrigation Co.
Tie Fork Springs (Wells)	93-219	150 cfs 162 AF	1875	Huntington-Cleveland Irrigation Co.
	93-2220	45 cfs	1879	Huntington-Cleveland Irrigation Co.
	93-2221	77.25 cfs	1884	Huntington-Cleveland Irrigation Co.
	93-2222	80 cfs	1888	Huntington-Cleveland Irrigation Co.

1 - Information was obtained through the State of Utah Water Rights Internet site. Because they make no claims to accuracy for the information at their site, the information needs additional confirmation.

The Tie Fork, Birch, and Big Bear Springs are within the North Emery Water Users Association (NEWUA) service area and are controlled by the Huntington Cleveland Irrigation Company for domestic and municipal uses. The domestic use is for 650 families. These uses are granted under the H.H. Christensen Decree. Water right E2504 is an exchanged right, from right 93-3703, that gives the Castle Valley Special Service District (CVSSD) the right to deliver water to the cities of Huntington (500 AF), Cleveland (114 AF) and Elmo (67 AF). The total quantity of water right use granted to the Huntington-Cleveland Irrigation Company is 392.5 cfs from the various spring and surface-water resources in Huntington Canyon.

Rights Associated with the Mines and Mine Water

Star Point Mine

Water right 91-3555 is held by CPMC for an in-mine well. When in operation, water was pumped to the surface to provide a domestic water supply for the office facilities.

Hiawatha Coal Mine

The main water resources associated with the Hiawatha Mine are the mine-water discharge points. Co-Op has rights to some springs in the area south of Hiawatha, and the ANR Co. Inc., holds water right 91-174 (application a4656) that allocates a diversion of 3.3 cfs from the Left Fork of Miller Creek for domestic and mining uses.

Table III-3: Hiawatha Mine Water Rights

Source	Right Number	Quantity	Priority	Owner/Use
King #1 Tunnel	91-251 a29532	0.942 cfs	1875	ANR Co. Inc. /Industrial &Municipal
	91-316 a6963	0.058 cfs	1989	ANR Co. Inc. /Industrial &Municipal
Mohrland Mine Seeps and Drains	93-1089	0.446 cfs	1884	United States Fuel Corporation/ Irrigation

Bear Canyon and Trail Canyon Mine

Water right application a15965 is controlled by the Co-Op Mining Company for diversion from a spring and mine portal. The quantity of use is for 150 cfs, or a total of 62 AF. Diversions are located in Sections 22 and Sections 24 of T. 16S, R. 7E. One diversion is associated with the Trail Canyon Mine and the other is associated with the Bear Canyon Mine Portal.

One water right and one water right application are listed with the Kingston family, who are tied with the corporate structure of the Co-Op Mine. Water right 93-1067 allocates 0.25 cfs for irrigation and mining. This right has a 1985 priority date. Water right application a13694 grants water to be diverted from the Bear Canyon Tunnel at a rate of 0.25 cfs, and is used to fill the two 10,000 gallon tanks near the mine. This right has multiple uses: irrigation, domestic, mine shower facilities, and other uses. It has a 1985 priority date.

General Groundwater Quantity

Recharge

Recharge is controlled by climatologic factors and the physical factors that allow the transport of water. Water must be available in excess of soil, plant uptake and evaporation losses in order to contribute to groundwater recharge. Moist climatic periods allow the rate of groundwater transport to reach its potential. Snowmelt at higher elevations provides the majority of the recharge to groundwater in this region. Streams and reservoirs may also contribute to recharge, but the extent of this recharge is unknown. Figure A illustrates the climate conditions experienced over the last 25 years based on the Palmer Hydrologic Drought Index.

Recharge in the Wasatch Plateau and Book Cliffs Coal Fields has been estimated to be three

to eight percent (Danielson and Sylla, 1983) and nine percent (Waddell and others, 1986) of the average annual precipitation. Snowmelt provides most of the groundwater recharge. It is estimated that four percent of the total annual precipitation recharges the local systems in the Star Point Mine permit area. This was determined by making the assumption that long - term recharge equals long-term discharge. Calculations can be found in the Star Point Mine plan .

Recharge to the perched aquifer system of the Price River and North Horn Formations is primarily from snowmelt along the flatter areas of Gentry and Hoag Ridge, and from snowpack that accumulates in surface watersheds (Map 6). Plate 7-2 of the Hiawatha Coal Company (HCC) MRP graphically illustrates the distribution of springs in the area and how the North Horn Formation provides the most consistent groundwater baseflow of the geologic formations in the area. These areas provide greater opportunity for water infiltration from melting snow. The normal annual precipitation for the higher elevations is 16 to 30 inches, of which 10 to 25 inches normally falls during October through April (Jeppson and others, 1968). Snowpack at these higher elevations commonly accumulate to depths of ten feet or more. The majority of fault-related springs, which issue from the perched aquifer system of the Price River and North Horn Formations, appear to provide limited recharge to the saturated zones of the Star Point Sandstone. Lower in the stratigraphic column, recharge is limited by shale or mudstone aquitards. Recharge to lower systems can occur along open fault planes, at contacts with water-bearing formations, or from surface-water seepage down the fault plane.

Once recharge enters the ground, the rate and direction of flow is governed mainly by gravity and geology. Lateral flow dominates in the gently dipping Tertiary and Cretaceous strata of the Wasatch Plateau, where layers of low-permeability rock that impede downward movement are common. Both lateral and vertical flow may be channeled through open faults and fractures or fractured breccia zones, but plastic or swelling clays that can seal faults and fractures are abundant. Typically groundwater recharged at higher elevations in the Wasatch Plateau flows both laterally and downward until it intercepts the surface and is discharged as a spring or seep, enters a stream as baseflow, is transpired by vegetation, or simply evaporates. Groundwater tends to flow more readily through shallower systems because the hydraulic conductivities are generally larger than those of deeper systems, but some of the groundwater will flow along deeper, slower flow-paths.

The hydraulic flow path of groundwater along joints, fractures, and faults is extremely complex, and the volume or rate of recharge down a fault is difficult to quantify (Star Point 1996 Permit Renewal). Springs in the region that are associated with faults have a quick recharge response. This response time suggests the fault zones receive a greater localized recharge rate than the region.

Aquifers

The two major aquifers within the CIA are the Star Point Sandstone and the combined North Horn and Price River Formations. These aquifers are modified by north-south normal faults systems that can act as boundaries or conduits, and sometimes act simultaneously as barriers to flow across the fracture but as conduits for flow parallel to the fracture. North-south trending normal faults structurally control local hydrologic regimens. Dip of the strata also controls flow direction; west of

the Bear Canyon Graben, strata dip to the south-southwest, and east of the Bear Canyon Graben, dip is south-southeast.

Work done for a previous CHIA (Gentry Mountain CIA, March 1994 revision) included an estimate that over 325 seeps and springs occur within the CIA, with a total potential discharge in excess of 1,500 gpm: 189 springs discharging from the North Horn and Price River Formations (1,200 gpm), 37 springs discharging from the Castlegate Formation (80 gpm), 53 springs discharging from the Black Hawk Formation and Star Point Sandstone (200 gpm), and 8 springs discharging from the Mancos Shale (40 gpm).

The North Horn - Price River Formations

In the CIA area, the most significant perched aquifer systems occur near the ridge top in the Price River and North Horn Formations. The majority of high elevation springs are located near Gentry Mountain Ridge above the Star Point Mine.

Two hundred and four springs were inventoried for the Star Point Mine permit and adjacent area in 1986 and 1991. More than 75 percent of the springs issue from the Price River and North Horn Formations. An additional 25 springs were found that issue from the Castlegate Sandstone. These formations represent 88 percent of all springs CPMC inventoried. Several springs that issue from the southern and western region along Gentry Ridge issue at shale-sandstone interfaces and are believed to be non-fault related. Aquifer storage and discharge characteristics from the Price River and North Horn Formation perched aquifer systems drop off significantly from early summer to late fall (Star Point Mine Plan).

Springs were found at various elevations along faults within the upper Price River and North Horn. In borehole 84-23-1, wet strata were identified at depths of 130 feet to 190 feet (elevations of 9,698 and 9,638 ft above msl, respectively), and the 190-foot depth correlates with a sandstone-shale interface and numerous springs. Monitoring well 86-26-4 located a water table along Gentry Ridge in a perched system at an approximate elevation of 9,550 feet (Star Point Mine Plan).

The general direction of movement is to the southwest in the perched aquifer systems of the Price River and North Horn Formations within the Gentry Ridge Horst, between Bear Canyon and Pleasant Valley Grabens. Few springs issue from this formation below McCadden Hollow (Map 6). Only a few low volume springs occur to the north of the Bear Canyon permit area and three springs were found within the permit area (Bear Canyon Mine Plan).

In the Hiawatha Coal Company mine plan, Table 7-2, Exhibits 7-2 and 7-7 illustrate the majority of the upper aquifer springs area located in the North Horn Formation (52 percent), which is located in areas of extensive cover.

The Star Point-Blackhawk Aquifers

The Star Point Sandstone consists of, from stratigraphically highest to lowest, the Spring Canyon, Storrs, and Panther Sandstone Members. The Spring Canyon member is composed of

fluvial shales, siltstones and channel sandstones. Channel sandstones are inter-woven throughout the formation and may appear somewhat discontinuous, but are associated with a large, ancient stream system. These channel sandstones may be linearly extensive except where they are dissected by faults. In the Hiawatha Mines Complex the culmination of mine inflows has produced a continuous discharge from the Mohrland portal of approximately 400 gpm since at least 1983. Based on Hiawatha Coal Company information, it appears that all the major inflows encountered to date, have been encountered in the 'B seam', stratigraphically the highest coal seam to be mined. According to Mayo, 2001, the discharge from the Mohrland portal has been age-dated at approximately 9,000 years old.

Clay is abundant throughout the Blackhawk Formation, producing localized perched aquifers. The Blackhawk Formation overlies the Star Point Sandstone and, based on local characteristics, the Blackhawk and the Star Point may be in hydrologic connection.

According to the Star Point Mine Plan, the saturated zone system occurs within the Blackhawk Formation in the Gentry Ridge Horst, between the Bear Canyon and Pleasant Valley Grabens. The dip of the Blackhawk strata is to the southwest and the coal in the Blackhawk Formation extends beneath where the stream in Tie Fork Canyon becomes perennial. The saturated zone extends up into the Blackhawk Formation within the southern portions of the Star Point Mine in the Gentry Ridge area (Star Point Mine Plan). According to the Star Point Mine Plan, mining conducted in 1991 verified that water was present both within and above the Star Point Sandstone. Farther down gradient, in the Bear Canyon Mine, the Star Point Sandstone tongues have separate potentiometric surfaces, and that they are separate from that of the Blackhawk Formation (Bear Canyon Mine Plan).

Information from the mines in the CIA suggests water movement is lateral within the tongues and vertical movement through the tongues is minimal, therefore recharge to the Star Point must occur primarily from vertical fractures and outcrop locations. In places, the recharge rate may be slow, or where highly fractured, as at Tie Fork Springs, recharge rates may be rapid. Secondary permeability resulting from open fractures created along faults and joints was identified as the primary conduit system for movement within the Star Point Mine.

Information from the Hiawatha Mine Plan indicated that the degree of interconnection between the Bear Canyon Fault and the Star Point Sandstone below the mine workings is unknown. Water that was encountered within the mine predominantly originated while mining in the B and A seams. The mining of the Hiawatha seam, which is the lowest coal seam and lies above the Spring Canyon member of the Star Point Formation has been relatively dry, producing minimal water. Also, the majority of the mining conducted in the Hiawatha seam has been down-dip of the mining conducted in the B and A seams indicating the coal in the area of the Hiawatha Mine area is not saturated. (See figure 7-23 from Hiawatha MRP.

Springs issue from the Blackhawk Formation and the Star Point Sandstone. Of the ten springs found issuing from the Blackhawk Formation in the Star Point Mine spring survey, five were found in Little Park Canyon on the west side of the permit area, three were found along or near the East Fault of the Pleasant Valley Graben in Wild Cattle Hollow near its junction with

Gentry Hollow, one was found in Mud Water Canyon, and one was found in Seeley Canyon (some of these springs are shown on Map 6). One spring flow rate was 11 gpm, while all other Blackhawk spring flow rates were 3 gpm or less (Star Point Mine Plan). The majority of springs in the Bear Canyon Mine area discharge from the Star Point Sandstone or colluvium adjacent to the sandstone. Two of the largest producing springs, Birch and Big Bear Springs, are associated with fault and joint systems and issue from the Panther Tongue.

Some water flows through the Blackhawk and issues from the Mancos Shale. The Star Point Mine identified seven springs that issue from the Mancos Shale. The two largest yielding springs, springs 102 and 103 in Seeley Canyon, issue from faults. Although a fault has not been identified that would extend through the location of the other five Mancos Shale related springs, it is likely that these springs are also fault or fracture related (Star Point Mine Plan).

According to Price and Arnow (1974), the upper Blackhawk Formation Cretaceous sediments have a low hydraulic conductivity and specific yields of 0.2 to 0.7 percent. Two pump tests from wells drilled into the Blackhawk Formation in Eccles Canyon, north of the CIA, produced transmisivities of 21 and 16.3 gallons per day per foot. The Blackhawk aquifers are generally laterally discontinuous perched aquifers and fluvial channel sandstones. The primary permeability within the Star Point Sandstone and overlying formations is quite low. Average linear flow velocities in the Star Point Sandstone had transmissivities from 1 to over 50 ft^2 /day (Bear Canyon Mine Plan, PHC).

General Groundwater Quality

The quality of the upper Cretaceous sediments in the Wasatch Plateau is characterized by total dissolved solids (TDS) concentrations less than 1,000 milligrams per liter (mg/L). The TDS measured in springs, wells, and mines issuing from or completed in the formations are reported for the Wasatch Plateau and Book Cliffs areas by Waddell and others (1981) as:

C	Price River Formation	122-792 mg/L
C	Castlegate Formation	315-806 mg/L
C	Blackhawk Formation	63-796 mg/L
C	Star Point Sandstone	355-391 mg/L

The local characteristics are summarized below for each formation. The Mancos shale is also included because some springs were found issuing at the top of the formation.

A groundwater quality analysis that is becoming increasingly important is the use of isotopic analysis or age dating. The importance is based on trying to identify a unique identifier for water in trying to establish its origin or mean residence time. The primary isotopic methods used are tritium analysis and radiocarbon analysis. Of ten (10) springs discharging from the Flagstaff Limestone, North Horn Formation, Price River Formation, and the Blackhawk Formation the tritium contents in the springs ranged from 12 to 32 units. Indicating that modern water recharge water supports these springs because the water is held in formation for only a short period of time. This is also supported by radiocarbon (^{14}C) analysis that provides

information regarding the number of years since the groundwater became isolated from soil zone gases and near-surface waters (Table 4 of Appendix 7-21 of the Hiawatha MRP outlines the study in detail).

Price River-North Horn Formations

This formation is entirely above all mine workings. Water quality from this formation is adequately described through spring water quality analyses because the formation has a quick response time to seasonal precipitation, and water is locally recharged and discharged at nearby springs. The Price River and North Horn Formations are similar, having the primary chemical constituents of calcium and bicarbonate. At certain locations, particularly along Gentry Ridge where the Flagstaff Formation also is present, magnesium becomes a more dominant cation than at the other locations (probably due to the solution of dolomite). The concentration of TDS is generally less than 300 mg/L. The mean concentration of TDS for springs, monitored by CPMC from 1979 to 1990, from the Price River and North Horn perched system varied from a low mean concentration of 124 mg/L to a high of 298 mg/L. In general, TDS concentrations are higher in the fall than in the early summer due to localized snowmelt and short residence time (Star Point Mine Plan).

Blackhawk Formation

Groundwater from the Blackhawk Formation is a mixed type with no single dominant cation or anion. Springs from the Blackhawk Formation tend to be a calcium bicarbonate type, but waters from the Blackhawk can contain significant concentrations of magnesium and sulfate. Water quality can be better where springs issue from fractures and are recharged locally. TDS concentrations tend to vary inversely with flow. pH is generally somewhat alkaline. Within the mines, some waters from the Blackhawk may be old and may have higher concentrations of TDS, magnesium, and sulfate.

Star Point Sandstone

Groundwater from the Star Point Sandstone is a mixed type with no single dominant cation or anion. Water quality can be better where springs issue from fractures and are recharged locally.

Mancos Shale

Sulfate concentrations may increase because of contact with shales having a high sulfide concentration.

SURFACE WATER

Surface waters from within the CHIA flow to both the Price River and San Rafael River Basins. These basins discharge to the Green River, which joins the Colorado River (Map 1).

The Price River Basin is located primarily within Carbon and Emery Counties and has an area of approximately 1,800 square miles. The Price River originates in the Wasatch Plateau, at the outlet of Scofield Reservoir. The river flows east-northeast from Scofield Reservoir and then turns and flows to the south-southeast. The Price River drainage basin is bounded by the Book Cliffs to the north- northeast and the Wasatch Plateau to the northwest, with the divide that extends from Gentry Ridge to Cedar Mountain forming the southern boundary within the Wasatch Plateau. Flow from the CIA enters the Price River south of Wellington, Utah (Map 1).

The San Rafael River Basin is located primarily in Emery County and lies south of the Price River Basin. This drainage basin covers approximately 2,300 square miles. The San Rafael River Basin drains sections of the Wasatch Plateau and the San Rafael Swell north of San Rafael Nob. Three major tributaries - Huntington, Cottonwood and Ferron Creeks - converge to form the San Rafael River. Huntington Creek is the primary surface-water resource in the San Rafael River Basin, draining the southeast portion of the CIA. The San Rafael River flows into the Green River (Map 1).

Surface-water Rights

Local water development in the region is primarily focused in the Huntington drainage. Water reservoirs were constructed in the Huntington Creek headwaters adjacent to the CIA, and the southwest regions of the CIA drain to Huntington Creek. The primary water users are North Emery Water Users Association (NEWUA) and the Huntington Cleveland Irrigation Company, which hold rights for domestic and municipal uses. The Castle Valley Special Service District (CVSSD) delivers water to the cities of Huntington (500 AF), Cleveland (114 AF) and Elmo (67 AF). The total quantity of use granted to the Huntington-Cleveland Irrigation Company is 392.5 cfs from the various spring and surface-water resources in Huntington Canyon. Other water rights associated with springs of the CIA may contribute to down stream surface-water rights.

Surface-water Quantity and Quality

Watersheds in the CIA

The CIA is contained within two major river basins, the San Rafael River Basin and the Price River Basin. Sub-basins, surface-water monitoring sites, and UPDES water monitoring sites are shown on Map 6. The sub-basins in the Price River Basin are Sand Wash (1), Miller Creek (2), Serviceberry Creek (3), Mud Water Canyon (4), and Corner Canyon (5). The sub-basins in the San Rafael River Basin are Nuck Woodward (6 and 7), Tie Fork Drainage (11, 9 and 10), Trail Creek Drainage (13), and Bear Creek Drainage (15), Fish Creek Drainage (16), and Cedar Creek Drainage (18), Miscellaneous Huntington Creek Tributaries (8, 12, and 17).

Price River Basin

Sand Wash Drainage (1) and Miller Creek Drainage (2)

Miller Creek (11,892 acres) and Sand Wash (6,082 acres) drain the southwest portion of

areas associated with the Hiawatha and Star Point Mines. Miller Creek has an average gradient of 15 percent and Sand Wash has an average gradient of 17 percent. Flow in the North Fork of the Right Fork of Miller Creek is intermittent to perennial.

Approximately 350 disturbed acres from the Hiawatha Mine lie within the upper reaches of Sand Wash and the Right and Left Forks of Miller Creek. Miller Creek was permanently diverted along a reach adjacent to the coal processing waste pile. Hiawatha and Star Point Mines mined under Miller Creek. Cypress Plateau mined under the North Fork of the Right Fork of Miller Creek.

Of the 36 springs identified within the North Fork of the Right Fork of Miller Creek, 21 springs issue from the Price River - North Horn Formation, 14 springs issue from the Castlegate Sandstone, and one spring issues from the Star Point Sandstone. Total flow from these springs during a spring inventory conducted for the Star Point Mine was 99 gpm (0.22 cfs). This represented 86 percent of the 0.26 cfs flow from the North Fork of the Right Fork of Miller Creek.

Serviceberry Creek Drainage (3)

Serviceberry Creek drains 6,321 acres within the CIA and has a 21 percent gradient, on average. Serviceberry Creek is ephemeral and is tributary to Miller Creek, east of the CIA. The Star Point Mine disturbed area (approximately 330 acres) lies primarily within the Serviceberry Creek drainage, and mining has occurred under the upper reaches of this watershed.

Mud Water - Los Angles Canyons Drainage (4) and Corner Canyon Drainage (5)

Mud Water and Los Angeles Canyons (3,040 acres) have a 19 percent gradient on average. The Corner Canyon drainage (6,951 acres) includes Seely and First Water Canyons. Mud Water and Corner Canyon drainages converge to form Gordon Creek. The Gentry Mountain CHIA prepared in 1989 stated that Mud Water, Seeley, and the South Fork of Corner Canyon were perennial in their lower reaches due to high-elevation spring flows and mine-water discharge. Mining occurred in the headwaters and ridges separating these drainages.

San Rafael River Basin - Huntington Drainage

Flow in Huntington Creek is controlled by three reservoirs upstream of and outside of the CIA: Electric Lake and Huntington and Cleveland Reservoirs. Typically, a rapid increase in streamflow results from snowmelt between April and June. Climatic influences and water releases from the reservoirs control year-to-year variations.

The USGS monitored Huntington Creek at station 09318000 almost daily from 05/03/1909 to 10/04/1979 (U. S. Geological Survey, NWIS): except that data for water-year 1918 are missing, there are only small gaps in the record. Mean daily discharge over this period averaged 106 cfs, with a maximum of 1,310 cfs (06/06/1952) and a minimum of 1.2 cfs

(12/17/1977). Extreme flows were 2,500 cfs on 8/2/30, and 0.87 cfs, which occurred twice - both during November - on 11/26/76 and 11/28/78 (Price and Plantz, 1987). On 04/25/1979, the USGS began monitoring Huntington Creek at 09317997, approximately 2 miles upstream of 09318000 and upstream of the Deer Creek confluence, and monitoring at this site continued until 09/30/1989 (U. S. Geological Survey NWIS): during this ten-year period mean daily discharge averaged 89 cfs, with a maximum and a minimum of 847 cfs and 8.1 cfs, respectively. It is important to note that according to the Palmer Hydrologic Drought Index (Figure A), 1981 through 1986 was a particularly wet period and flows from the Upper Huntington drainage are influenced by discharges from Electric Lake reservoir.

PacifiCorp measures the flow in lower Huntington Creek at two locations near the Deer Creek Mine, one just upstream and one just downstream of the Deer Creek confluence: HC001 is near USGS 09317997. The PacifiCorp data show that from 01/28/1991 to 9/5/2000, flow in Huntington Creek averaged 90 cfs, with a maximum of 490 cfs on 06/30/1995 and a minimum of 0 cfs (no flow) on 12/01/1993.

Nuck Woodward (6) and (7)

Nuck Woodward Canyon drains approximately 6,738 acres and is directly tributary to Huntington Creek. This drainage abuts the northwestern mined region of the Star Point Mine. The East Fault of the Pleasant Valley Graben appears to be a water source for the local hydrologic system of the Pleasant Valley Graben, which extends southwards from Nuck Woodward Canyon to the western portions of the Gentry Ridge Horst and to Tie Fork Canyon (Map 3).

Surface water in Nuck Woodward Canyon is thought to be connected to the groundwater in the Star Point Mine. The Star Point Mine Plan submitted in 1996 states, "Water flowing down Nuck Woodward Canyon is believed to be partially lost to this [Eastern Boundary] fault system where after it joins with deeper water moving within the fault. Water is then directed underground towards and through the permit area." Extensive local faulting through the streambed and local recharge comes from the direction of Nuck Woodward Canyon (Star Point Mine Plan, p. 700-68). "It may also be possible for water to enter the fault in Nuck Woodward Canyon, move southward along the East Fault of the Pleasant Valley Graben, south-southeastward across Gentry Ridge toward the Western Boundary Fault of the Bear Canyon Graben, then southward towards Birch and Big Bear Springs. The complexity and additional length of the water flow path greatly reduces the potential for impact on both Birch and Big Bear Springs by mining" (p. 700-83).

A stream survey completed for the Star Point Mine in 1992 identified losing stream sections in Nuck Woodward canyon. The stream survey included the entire reach of Nuck Woodward canyon adjacent to the Star Point Mine. Measurements taken during the survey did not include inflow that may have originated from the side drainages except for 10 gpm noted at "First Canyon". Information found in Table 728 in the Star Point Mine Plan indicates a majority of the stream appears to be losing water. Significant reach decreases were as much as 33

gpm.(Star Point Mine Plan, p. 700-68).

Tie Fork Drainage (11, 9, 10)

Wild Cattle Hollow (2,759 acres) and Gentry Hollow (3,830 acres) join Lower Tie Fork Canyon (1,199 acres) to form the Tie Fork Drainage. The average gradient for Gentry and Wild Cattle Hollow is 13 percent and the Lower Tie Fork Canyon gradient is 44 percent.

Wild Cattle Hollow was mined under within the Star Point Mine permit area, and Gentry Hollow was mined under within the Hiawatha Mine and the Star Point Mine permit areas. The Star Point Mine longwall panels abut Wild Cattle Hollow's main channel. Both Gentry Hollow and Wild Cattle Hollow are designated perennial creeks on the USGS Hiawatha quadrangle map.

Springs were monitored within the Star Point Mine area and adjacent area in June/July of 1986 and were monitored again in August 1991. All 51 springs found within the Gentry Hollow surface-water drainage basin issue from the North Horn Formation. Total discharge from these springs in 1990 was 418 gpm (0.93 cfs). If it is assumed that there are no stream losses between the springs and the junction of Gentry and Wild Cattle Hollows, total spring flow would represent 71 percent of the1.3 cfs total streamflow (Star Point Mine Plan).

From the 60 springs found within the surface-water drainage basin of Wild Cattle Hollow, 57 of the springs issue from the Price River - North Horn Formations. The three remaining minor springs issue from the Blackhawk Formation near the junction of Wild Cattle and Gentry Hollows. Total discharge from these 60 springs was 393 gpm (0.88 cfs), which represents 86 percent of the 1.02 cfs total streamflow measured in Wild Cattle Hollow (Star Point Mine Plan).

Discharge rates for Tie Fork Canyon are available for USGS station 09317920 from 10/20/1977 to 10/07/1981 (U. S. Geological Survey NWIS): data are missing for 02/28/1978 to 09/21/1978, 12/03/1979 to 04/29/1980, and 11/30/1980 to 05/01/1981. Measured mean daily discharge averaged 2.43 cfs. It ranged from 0 cfs (15 days between November 1977 and February 1978) to 29 cfs (five days in late May and early June 1980).

Huntington Creek Tributaries (8, 12, and 17)

Miscellaneous tributaries to Huntington Creek that originate within the CIA include: Pole Canyon, McElprang Canyon, Vicks Canyon, Grange Hole, Biddlecome Hollow (8), Blind or Dry Canyon - which includes Birch Spring (14), and two miscellaneous side drainages (12) and (17). The 46.22 permitted acres associated with the Deer Creek Waste Rock site lie within Watershed Area 17 (Map 6). The average gradients of the tributaries range from 40 to 70 percent.

Trail Creek Drainage (13) and Bear Creek Drainage (15).

Trail Canyon drainage encompasses approximately 2,954 acres, including McCadden Hollow. Bear Canyon drainage includes approximately 2,029 acres. The average gradient of

Trail and Bear Canyons is 20 to 25 percent.

Bear Creek lies below Gentry Ridge in steep, narrow canyons. It carries large sediment loads: Total Suspended Sediment (TSS) of 28, 092 mg/L was measured during a major storm event. Sediment sources are the exposed bedrock along the boundary of the Gentry Ridge escarpments and the springs that issue along the Bear Canyon Fault where erosive lithologic units are exposed. Trail Creek (9) is characterized by a steep gradient, narrow canyons, and good water quality.

Approximately 10 surface acres have been disturbed in both the Bear Canyon and Trail Canyon drainages. Trail Canyon includes a residential area of about 14 acres that is not associated with the Trail Canyon Mine. The disturbed area associated with the Trail Canyon Mine is reclaimed and was released from the reclamation bond in January 2001.

Fish Creek Drainage (16) and Cedar Creek Drainage (18).

Fish Creek drainage encompasses approximately 5,288 acres, and the average gradient is 19 percent. Fish Creek is identified as a perennial stream in the Bear Canyon Mine PHC, but monitoring has been very sparse. These drainages have gone dry during periods of prolonged drought. From 1991 to 1994 flow ranged from 0 gpm to 65 gpm in the Left Fork; during 1996 and 1997 low flow was 15 gpm in both the Left and Right Forks.

Cedar Creek drainage covers approximately 17,023 acres. The average gradient is 13 percent. The Hiawatha Mine area lies within portions of the Right and Left Fork of Cedar Creek. The Mohrland Mine surface facilities and disturbed area (approximately 25 acres) are adjacent to Cedar Creek. Mine water discharges continuously from the Mohrland Portal. The Right Fork is ephemeral and the Left Fork exhibits perennial characteristics in certain reaches due to mine-water discharge.

General Surface-water Quality

The State Division of Water Quality has classified waters in the Price River and its tributaries, below the Price City Water Treatment Plant intake, as Class 2B, 3C and 4. Waters in the San Rafael-Huntington Creek drainage are classified as 1C, 2B, 3A, and 4. Classes 1C, 2B, 3A, 3C, and 4 designate domestic, secondary contact recreation, cold water aquatics, warm water aquatics, and agricultural uses, respectively (UDWQ, 1994).

Suspended sediment load is site specific. The suspended sediment concentrations varied in surface-water samples collected by the USGS (Danielsen and others, 1981) in Huntington and Cottonwood Canyons: data for three sites are included in Table III-5 below. The sample from Bear Canyon shows a high sediment concentration while Tie Fork is low relative to the other two sites presented: Danielsen and others attributed the high concentration in Bear Canyon to continuous erosion and sloughing of fine-grained sediments caused by the springs that emerge from the Blackhawk Formation in the headwaters. Suspended sediment concentrations generally increase as flows increase.

Table III-5: SUSPENDED SEDIMENT LOADS (Danielsen and others, 1981, p. 17)

Stream	**Date**	**Concentration** (mg/L)	**Load** (tons/day)
Huntington Creek (09318000)	8-13-78	104	27
	11-17-78	72	2.5
	6-13-79	114	66
	8-7-79	44	15
Tie Fork Canyon (09317920)	8-13-78	12	0.03
	11-17-78	57	0.12
	6-13-79	38	0.68
	8-6-79	66	0.17
Bear Creek	10-25-78	8,860	1.9
	6-14-79	2,140	4.0

IV. PROBABLE HYDROLOGIC IMPACTS

In this section potential impacts to groundwater and surface water associated with mining are identified. Specific groundwater and surface-water resources within the CIA are identified and data are reviewed to determine potential impacts to the hydrologic balance. Probable impacts to the hydrologic balance are then determined.

RESOURCE HYDROLOGIC IMPACT ASSESSMENT

Quantity and quality may be affected by mining activities. Because of the semi-arid environment in Carbon and Emery Counties, potential changes in groundwater quantity seem to have been the recent focus of concern from the public. Changes in quality are discussed in conjunction with spring and surface-water uses **(SURFACE-WATER RESOURCE HYDROLOGIC IMPACT ASSESSMENT**) because use in the region is primarily tied to the associated surface discharge points.

Mining may alter the flow direction, water storage, and transmissivity. Altered the flow characteristics result from intercepting adjacent water sources, from water transfer across basins, and from changes in permeability and transmissivity in rock units above, below, and within the mined rock units. Transmissivity changes may affect quantity, recharge, and transport characteristics.

Changes in permeability and transmissivity may result from mining subsidence that increases permeability through rock deformation in the overlaying formations. Mining may depressurize groundwater in a rock unit below the mined rock and lower the potentiometric surface. Mining the coal resource creates a void that can increase transmissivity and water storage in the mined region. Water detention time may be increased or decreased depending on the storage volume and rate of water transmission. Changes in residence time may affect seasonal flow patterns.

Mining and mining related subsidence may intercept water from a surface-water source, perched aquifers, regional[1] aquifers, or fracture zones. Groundwater may continue along its original flow path after interception or it may be redirected. Potential effects include a loss or gain in water quantity at a storage location, an increase or decrease in flow at an existing discharge point, and a newly created discharge location.

Groundwater is removed as moisture in the mined coal and evaporated by mine ventilation.

Quality changes may include changes in pH, TDS, nutrients, metals, salts, organic and inorganic constituents. Mining may alter the quality when it causes different types or sources of water to mix. Surface water may be intercepted by subsidence and mix with groundwater. Springs and aquifers above the mine may be intercepted and mix waters with different qualities. Depending on the quality of the waters involved and the quantity or ratio of mixing,

improvement or degradation of the water being monitored may occur.

Mining activities can also change the chemistry of the system directly. Mining activities may affect the quality when mined surfaces are exposed to weathering and oxidation, which liberate acid and toxic materials, minerals, or salts that can be transported with groundwater. Mine rock dust generally increases TDS and may change the chemical signatures. Spills, human waste, hydrocarbons, longwall fluids, and other chemicals used in operations may be discharged to the groundwater.

GROUNDWATER INTERCEPTION AND WELL INFORMATION

Information about groundwater in the CIA is reviewed for each of the underground mines interception, and groundwater well data are reviewed. Mine-water discharge analyses are discussed in the **SURFACE-WATER RESOURCE HYDROLOGIC IMPACT ASSESSMENT** in this CHIA.

Star Point Mine Groundwater Interception

Mining at the Star Point mine occurred in two regions and affected a third. These regions are defined generally and some interaction between them apparently occurs. The first groundwater region is located on the east side of the Bear Canyon Fault, the second is located on the west side of the Bear Canyon Graben within Gentry Ridge, and the third region is along the East Fault of the Pleasant Valley Graben (Map 3). The following section discusses water intercepted during mining operations for the three regions: 1) water intercepted east of the Bear Canyon Fault, 2) water intercepted along the Bear Canyon Fault, and 3) water intercepted west of the Bear Canyon Graben.

In general, mine-water discharge has not occurred from the Star Point Mine largely because the mine has pumped and diverted the water into old workings, and the mine has also consumed some of the water intercepted. The primary diversion of groundwater occurred from June 1992 to December 1997 when water was pumped from the Gentry Ridge area, across the Bear Canyon Graben, and into the older Third Seam workings east of the Bear Canyon Fault. Volume increased rapidly from 1992 until it exceeded 1,300 gpm, from December 1994 to February 1995, then even more rapidly declined to less than 100 gpm by January 1997. Water was also pumped to Mother Goose sump in the Third Seam from the Wattis and Hiawatha Seams. During this pumping, decreased flows were observed at Upper Tie Fork Spring. Big Bear Spring and other Huntington water sources also may have been affected (Figure 1).

An average of nearly 1,000 gpm was being pumped from the Gentry Ridge area of the Star Point Mine, and average discharge from Hiawatha's UPDES 001 rose to 900 gpm, with peak discharge of 1,600 gpm in August and September 1993. When flow resumed at UPDES 002 in August 1995, the combined discharge approached 1,650 gpm, but dropped quickly and by the time pumping at Star Point ceased in 1997 the average combined UPDES discharge was less than it had been before pumping started, Figure 1a. From the chart in Figure 1 it can be seen that the correlation between the Star Point Mine pumping and increased discharges at Hiawatha's UPDES Sites 001 and 002 looks strong; however, pumping at Star Point Mine does not account

for the high UPDES discharges that occurred in April and May 1991 and April 1992, just before pumping began. There may be another, unidentified factor for high discharges at the Hiawatha Mine in addition to Star Point Mine pumping (Figure 1).

Star Point Mine: East Side

Most water intercepted east of the Bear Canyon Fault is pumped to sumps within the mined areas. Sumps located within the mine are shown on Map 3(Star Point MRP). The major sump areas are entitled Mother, Father, Baby, Twin, and New Goose sumps. Mother Goose sump is located in the Main West area of the Third (middle) coal seam. Father, Twin and New Goose sumps are located in the Wattis Seam workings. Baby Goose sump is located near the Mudwater discharge within the Third Seam. Flow meters that are monitored at Mother Goose sump measure water pumped to other areas of the mine (Star Point Mine Plan, p. 700-24).

Water discharged at the Mud Water Fan (UPDES UT0023736-001) has been monitored since February 1985: there has been no discharge from UPDES 001 since July 1987 (Star Point Mine Plan, p. 700-31).

Some water was used to supply culinary needs for the Lion Deck bathhouse and office. Water used from within the mine for culinary purposes has been monitored since February 1985. Losses from fan ventilation evaporation have not been estimated.

In-mine groundwater was monitored at 16 locations from April 1985 to March 1986. The Star Point mine plan states,"the total instantaneous flow from the 16 in-mine measuring points is an indication of the majority of flow made within the mine, but does not necessarily reflect the total flow made within the mine" The average annual flow from the 16 in-mine measuring points was approximately 150 gpm from April 1985 to March 1986. Over that 12-month period, the discharge from the mine to Mud Water Canyon (Star Point UPDES 001) was 66,611,600 gallons, an average of 129 gpm. The average annual discharge from the mine to the surface facilities for coal washing and surface dust control was only 0.5 gpm (267,432 gallons). The average annual discharge for culinary use was approximately 4.4 gpm (2,289,000 gallons). Therefore, the total annual discharge from the mine to the surface was 134 gpm, excluding the undetermined flow that exits the mine as water vapor in the air." (Star Point Mine Plan, p. 700-25).

The larger flows east of the Bear Canyon Fault occurred in longwall panels No 12 and No.3 (Map 3, Star Point Mine MRP). The Star Point mine plan states on page 700-25, "...the flow from the long wall area No. 12 has diminished over time since its peak in September of 1985 when long wall panel No. 3 was started. In March of 1986, the flow jumped to 120 gpm: the increase in seepage was from increased pumping of recycled water from the sump areas for dust suppression in the long wall panel area". The proximity of this panel to the subsided area of the North Fork of the Right Fork of Miller Creek and a fracture zone probably influenced inflow in this region (Map 3).

When the Star Point Mine Plan was updated in 1996 for permit renewal, 1WN6 and 9L12 were the only sites being used for in-mine monitoring. These two stations were last

monitored in October 1997, and the last mine portal was sealed in January 2001. There are no mine discharges from the main Star Point Mine portals or any of the fan portals in Corner Canyon and Mud Water Canyon. All portals have been sealed and backfilled.

Star Point Mine: Graben Crossing

A rock tunnel crossing was developed through the Bear Canyon Graben in 1989 to allow access to coal under Gentry and Castle Valley Ridges. The rock tunnel crossing extends from the Wattis Coal Seam east of the Bear Canyon Graben (elevation 8,492 feet) to the Wattis Coal Seam west of the graben (elevation 8,450 feet): the Wattis Seam is the only seam mined under Gentry Ridge. The rock tunnel is in the upper Blackhawk Formation, 200 to 325 feet above the Wattis Coal Seam. The saturated zone system was confirmed to lie 160 feet below the graben tunnel with information from a drill hole that was drilled down from within the graben crossing.

Water encountered east of the graben is above the saturated zone system in perched, primarily fracture related systems in the upper Blackhawk Formation. Water flowed into the mine at the eastern boundary fault, the Bear Canyon Fault, when the 2 nd Left and 2 nd West Mains intercepted the fault. Initial inflow at 2nd Left was 6 gpm from roof strata on the face offset (approximate elevation 8,780 feet). Within three weeks, liquified gouge at the faces of entries #2 and #3 flowed approximately 10 to 15 feet into the entries. Drilling from within the #1 entry penetrated 40 to 60 feet of gouge and fractured rock before tapping into a significant conduit (the drill hole penetrated 400 feet into the graben). Inflow from the drill holes peaked at about 150 gpm before dropping to 50 gpm after 2 weeks, to less than 10 gpm after 10 weeks, and subsequently to zero. In the 2 nd West Mains (approximate elevation 8,490 feet), Cypress experienced an initial inflow rate of about 20 gpm from the roof strata. This flow reduced to less than 10 gpm after 4 weeks. Very little water was found at the actual face. Inflow to the mine at the entry to the graben tunnel at 2nd West Mains dropped rapidly during drilling from 20 gpm to 10 gpm over a four-week period. Since that time, the flow has dropped to zero, indicating the dewatering of a perched aquifer system (Star Point Mine Plan, pp. 700-11 and 700-12).

Star Point Mine: West Side

Cypress recognized the water table under Gentry Mountain would be intercepted during mining so they entered into a mitigation agreement with NEWUA. This agreement is discussed further under the section in this CHIA entitled **Material Damage.**

Water was encountered along the eastern Bear Canyon Graben boundary fault and in the 3rd south mains: 13 to 50 gpm were reported near the eastern Bear Canyon Fault Zone. Water also seeped from the fourth right and fifth right mains through the floor. As mining continued down dip the larger flow rates (50 to 250 gpm) were recorded at the west side of the mined area near the headwaters of Wild Cattle Hollow.

Water from the Gentry Ridge area was pumped from June 1992 to December 1997 across the Bear Canyon Graben into the Third Seam workings east of the Bear Canyon Fault. Volume increased rapidly from 1992 until it exceeded 1,300 gpm from December 1994 to February 1995, then even more rapidly declined to less than 100 gpm by January 1997. Water was also pumped

to Mother Goose sump in the Third Seam from the Wattis and Hiawatha Seams.

UPDES discharges from the Star Point Mine over this period were sporadic and usually low volume. However, discharges from the Mohrland Portal at the Hiawatha Mine mimicked the pumping rate of the Gentry Ridge – Goose Graben pump (Figure 1), so it is a reasonable conclusion that some of the mine-water discharged from the Hiawatha Mine originated as water pumped across the Bear Canyon Graben in the Star Point Mine. Figure 2 shows the flow rates at Hiawatha's UPDES 001 and 002, Big Bear Spring and Star Point's Goose Graben pumping. The flows at Big Bear Spring had already started to diminish, 1989, before pumping began of Goose Graben, 1992.

The total interbasin transfer of water pumped from Gentry Ridge to Area 8 was estimated by the Division. Instantaneous flow rates from the Gentry Ridge monitoring station were reported for June 1992 through December 1997. Water quantities reported to the Division were instantaneous readings only: no totalizing flow rates were reported. The techniques and assumptions used to estimate the total flow pumped are presented in the following paragraphs.

Flow rates from the Tie Fork Well and flow rates monitored at the Gentry Ridge (GENTRID) in-mine monitoring site were used to estimate the quantity of interbasin transfer. Flow losses estimated for the Tie Fork Well were smaller than the flow volume estimated to be pumped across the Bear Canyon Graben, suggesting waters from other sources were intercepted by dewatering activities in the Gentry Ridge area.

Losses at Upper Tie Fork Spring were estimated from data received on December 18, 1997 from Darrel Leamaster, Manager for CVSSD. The following assumptions were made to obtain the estimated flow loss:

1) Missing data from November 1993 through April 1994 were estimated by interpolation between the October 1993 and May 1994 flow rates;
2) The average monthly flow prior to dewatering was assumed to be equal to 85 gpm (the rate observed on October 1991 prior to a recorded decrease in flow at the spring);
3) The dewatering period was assumed to extend into April 1996 simply because the Tie Fork wells regained the 85 gpm flow rate after this date. Flow rates recorded from November 1991 through April 1996 were subtracted from 85 gpm then added together to estimate the total loss of flow at Upper Tie Fork Spring.

Using the method described above it was estimated that the total flow volume decreased by 139.5 acre-feet (AF) during the period of mining under Gentry Ridge. The estimated maximum annual loss was 58.7 AF in 1995. The maximum loss to flow at Upper Tie Fork Spring occurred in May and June of 1995 and was 46 gpm (0.1cfs). A percentage of the loss can be attributed to climate, but adjustments for climate were not assessed.

A monthly flow volume was determined and then totaled for the period when water was pumped from Gentry Ridge across the Bear Canyon Graben into Area 8, east of the graben. The following assumptions were made to estimate the flow volume pumped from Gentry Ridge:

1) Where there was one record per month, that value was applied to the entire month;
2) Where there was more than one record per month, the first recorded flow volume was

applied from the first day of the month up to the date of that measurement, the volume of the second measurement was applied from the date of that measurement through the end of the month, and the average of the two measured flows was applied to each day between;

3) Where monthly flow values were missing, flows from the preceding and following months were averaged;

4) The pumping rate was assumed to be continuous, 24 hours per day.

Using this method the total water transported across the graben was estimated to be 4,584 AF.

The Star Point Mine Graben Goose information provided to CVSSD was obtained on April 17, 1998. The data are available for June 1992 through December 1997: however, data for a period from February 1993 through July 1993 are unavailable because the meter was not functioning. The maximum reported instantaneous flow rate from both data sets is 1,600 gpm on January 26, 1994. The maximum monthly discharge volume, 143 AF to 146 AF, occurred in March through May 1995 based on the average monthly rate in the CVSSD data. The maximum annual discharge was estimated to be 1,627 AF in 1995. The total water pumped across the graben based on the CVSSD data is 4,645 AF and does not include an estimate for the missing data period.

From these analyses the approximate 4,600 AF pumped from the Graben Goose is large compared to the 139.5 AF loss estimated for Upper Tie Fork Spring. This indicates a potential draw down zone where water sources from adjacent areas were intercepted during dewatering activities under the Gentry Ridge area. The relationship of other water sources needs be studied further to make a determination of any influences not reported. It is unknown if the water sources in the Pleasant Valley Graben are associated or supply flows to Bear Canyon Graben, the likely source for Big Bear Spring.

Star Point Mine Well Information

Star Point Mine wells are identified below in Table-IV-1 to aid in understanding the monitored formations. Graphs showing well water elevations are presented in Figures 3, 4 and 5. The well data are grouped within each region: East of the Bear Canyon Fault (figure 3); Gentry Ridge, West of the Bear Canyon Fault (figure 4); and flows from Tie Fork Spring and related data, west of the Pleasant Valley Fault (figure 5). Well locations are found on Map 5 - Gentry Mtn. Geology.

Table IV-1: Star Point In-Mine Monitoring Wells
East of the Bear Canyon Fault

Well Number	Depth and Formation Monitored	Relative Location	General Observations
P86-01-TD	145 feet - Spring Canyon Sandstone -27 ft below the Hiawatha Seam.	East of the Bear Canyon Fault near the Mother Goose Graben.	Increase of 45 ft of head since 1993. Abandoned 1998.
P86-02-HD Btm - 8402 ft	71 feet - Spring Canyon Sandstone - screened below the Hiawatha (screen interval 50 ft)	East of the Bear Canyon Fault on west side of Hoag Ridge.	Water level has always been at or below the lowest well perforations - 8463 to 8413 feet. Abandoned 1998.
P86-03-WD	194 feet - Black Hawk screened below the floor of the Third Seam (screen interval 43.5 feet)	East of the Bear Canyon Fault on the west side of Hoag Ridge south of 86-02-HD and mining section 8 sumps.	Water level shows a small decline of 20 feet 8,320 to 8,300 feet with a few temporary drops that could be due to climate, localized de-watering and mine-water routing, depressurizing from mining, subsidence, or measuring error (Drops occur in Nov. 86, July 87, Mar 91, July 93). Abandoned 1997.

East of the Bear Canyon Fault - Figure 3

Well P86-01-TD, 86-02-HD, and P86-03-WD were in-mine wells. They were abandoned in late 1997 to mid 1998, because the area of the mine where they were located was sealed. P86-01-TD, developed in the Spring Canyon Sandstone and located on the East Side of the Bear Canyon Fault and Graben, increased in head during early 1994 when pumping rates from the "Gentry Ridge" in-mine monitoring site reached its peak discharge. This well is located south of the sumps located near the North Fork of Miller Creek. Well 86-02-HD was also developed in the Spring Canyon Sandstone. Water level was at or below the lowest screened elevation since it was developed. Well P86-03-WD, in the Blackhawk Formation below the Third Seam, has shown a decreasing trend since it was first developed in 1986 and probably represents dewatering from mining in the Hiawatha Seam.

Gentry Ridge: West of the Bear Canyon Fault

Well 86-26-6 (Figures 4 and 5), developed in the Star Point Sandstone Spring Canyon Tongue, responded in a pattern similar to Tie Fork wells 86-35-2-3 (Figure 5). Well 86-26-6 dropped a total of 34.7 feet during June through August 1995 and had recovered to 74 feet above the initial water elevation as of September 1997. Water levels have been measured by gas pressure, and measurements after September 1997 - and probably the August 1997 measurement also - are not valid because the gas line has been partially blocked.

Table IV-2: Star Point Mine Monitoring Wells West of the Bear Canyon Fault

Well Number (Period of Record) Collar Elevation Bottom of Well	**Formation Monitored**	**Relative Location**	**General Observations**
86-26-6 (6/94-7/97) C.E. - Btm -	Spring Canyon Tongue, Star Point Sandstone.	In the ridge between Wild Cattle Hollow and Gentry Mountain.	Water level pattern decreased 34.6 feet in the fall of 1995 and increased to 74 feet above the first recorded elevation as of July 1997.
P-92-01-A-WD* (1/92-10/97) C.E. - 8364.5* Btm - 8291.5 ft	Blackhawk- screened 61 feet below floor of Wattis Seam (screened interval - 8301.5 - 8291.5)	In the Bear Canyon Graben, near the Bear Canyon Fault.	Water level decreased about 32 ft from above screened interval to near the well bottom on 10/27/94 and 06/15/96.
P-92-01-B-WD* (1/92-10/97) C.E. - 8364.5* Btm - 8248 ft	Blackhawk- screened 104.5 feet below floor of Wattis Seam (screen interval 8258 - 8248)	Nested with P-92-01-A and C	Water level decreased about 50 ft in April 1995. With two anomalous drops on 10/93 and 10/94 that may be related to pressure change from mining, mine dewatering, sumping activities.
P-92-01C-WD* (1/92-10/97) C.E. - 8364.5* Btm - 8171.5 ft	Spring Canyon Sandstone- screened 45.7 feet below the Hiawatha (screen interval 8186.5 - 8171.5)	Nested with P-92-01-A and B.	Water level decreased a maximum of 108 ft 4/95.
P-92-02-WD (1/92-10/97) C.E. - 8362.24 Btm - 8156.2 ft	Spring Canyon Sandstone- screened 54.5 feet below the Hiawatha (screen interval 8171.2 - 8156.2)	In the Bear Canyon Graben/near the Nuck Woodward stream NW of well 92-01-WD.	Water level dropped a maximum of 126 ft 08/95.
P-92-03-WD (3/92-2/96) C.E. - Btm -	Blackhawk- screened 32.5 feet below floor of Wattis Seam (screen interval 10.5 ft)	In the Bear Canyon Graben/near the Bear Canyon Fault south of well 92-01-WD.	Water level was a flowing well (above well collar). The potentiometric surface was 8,408 feet (3/92). The water level dropped 155 ft; as of 02/96: the last measurement.
P-92-04-WD (3/92-10/97) C.E. - 8363.0 Btm - 8193	Spring Canyon Sandstone- screened 27 feet below the Hiawatha (screen interval 8204 - 8189)	In Center of Bear Canyon Graben. N of 92-01-WD and E of 92-02-WD.	Dropped a total of 54 feet by 3/95.
85-35-1 (7/88-9/97) C.E. - Btm -	Spring Canyon Sandstone	Tie Fork Well east of well(s) 85-35-2-3. East of Eastern Pleasant Valley Fault Boundary.	Flowing well, part of Upper Tie Fork Spring.
86-35-2-3; 86-35-2 and 86-35-3 (1/86-9/97) C.E. - Btm -	Spring Canyon Sandstone	Tie Fork artesian wells 200 ft apart. West of Pleasant Valley Fault	Flowing wells, part of Upper Tie Fork Spring. Reduced head since mining in Gentry ridge in 1992.
P93-01-WD (10/93-present) C.E. - Btm -	Spring Canyon Sandstone	This well has a screen interval of 1 ft.	The water level, originally at the top of the well perforation, decreased 1 ft and is dry since 2/94.
P-92-10-1 C.E. - Btm -	One point of data.	Completed near Nuck Woodward Stream	The initial elevation indicates a recharge mound.

*P92-01A-WD, P92-01B-WD and P92-01C-WD are nested wells.

Well 85-35-1 (Figure 5) is a flowing well and is also considered a part of the Upper Tie Fork Spring system. Flow from 85-35-1 jumped to 386 gpm on June 22, 1995, during the period that Upper Tie Fork was at its lowest level because of mining at the Star Point Mine. Temporary in-mine sumping operations appear to have produced this spike in the flow at 85-35-1, and water-quality changes discussed in the following sections of this document also indicate mining has effected this well.

Wells developed in the Spring Canyon Tongue and located farther north and near the center of Gentry Ridge have not recovered to pre-mining elevations. By August 1995, wells P92-01C-WD, P92-02-WD, and P92-04-WD had fallen, respectively, 107 ft., 81.7 ft., and 117.7 ft below their initial potentiometric elevations. By December 1997, when they were last monitored, they had recovered part of the loss (Figure 4).

P92-03-WD, P92-01A-WD, and P92-01B-WD, wells completed in the Blackhawk Formation, also decreased in head during mining (Figure 4). The most notable decrease was at well P92-03-WD, which began as a flowing well when it was developed in March 1992. The water level dropped 70 feet during mine dewatering, and only a very slight recovery of 0.4 ft was observed from February to May 1996, when monitoring ended. The decrease in head at P92-03-WD may be a function of its position south (down gradient) of P92-01B-WD and P92-01A-WD. Some of the water from this location may now be redirected and contribute to the increased flows at Upper Tie Fork.

P92-01A WD dropped 32 ft and P92-01B-WD dropped 73 ft during mining of the Gentry Ridge area. At the time monitoring stopped in December 1997, water elevation at P92-01A WD had recovered to 30 ft below the initial elevation and at P92-01B-WD had recovered to 34 feet below the initial elevation (Figure 4). The variation in response between these wells can be attributed to two factors: 1) The well screen elevation relative to the mine dewatering activities (i.e., above or below the de-watered coal seam), and 2) The permeability within and below the well, which may limit rates of water loss from the formations.

Upper Tie Fork has been discharging above the pre-earthquake flow rate since late 1996, indicating both the earthquake and the mining activities probably affected the flow. Intercepted connate water (old water trapped in the formation when formed) and changes in the recharge area, porosity, and transmissivity are some mining related factors increasing flow at the Upper Tie Fork Spring. The wells that lie farther north and to the center of the graben may never recover to their initial elevation except during extremely wet climatic periods because there is increased storage capacity (porosity) in the mined region.

Bear Canyon Mine Interception

Flows have primarily entered the Bear Canyon Mine through fractures and channel sandstones. Some water was observed from roof bolts and from the mine floor. Flows from faults and fractures were stated to produce the largest volume of water flowing into the mine during the early mining periods. Flows from roof bolts in the ceiling typically flow moderately for one or two months and then eventually de-water (Attachment to Appendix 7-J, Bear Canyon Mine Plan). Water intercepted during mining has primarily occurred in the Blind Canyon Seam

and not in the Tank Seam.

Blind Canyon Seam

The majority of groundwater intercepted in the Bear Canyon Mine has come from the Blind Canyon Seam channel sandstone, which was deposited in a channel eroded into the coal deposits. Many similar sandstones channels encountered in coal mines are discontinuous, but this sand channel spans the mined area and appears to extend from the Blind Canyon Fault to the Bear Canyon Fault.

In August 1989 mining operations in the North Mains of the Bear Canyon Mine, in the Blind Canyon Seam, approached the margins of the channel sandstone in the mine roof. By November 1989 large roof drips began to flow into the mine in this area. Initial flows measured in February 1990 at SBC-9 were 120 gpm, and flows reached a maximum of 175 gpm in 1993 - 1994 (Figure 6).

In February 1992 monitoring began at SBC-10 in the 1st East entries: flow started at 250 gpm, and combined flow measured at SBC-9 and SBC-10 jumped to 382 gpm. Mining in the North Mains reached the main body of the sandstone in April 27, 1993, and SBC-9 was moved closer to the channel sandstone. Flows rapidly declined at SBC-10, dropping to approximately 25 gpm by 1994; however, from 1993 to 1995 combined flows were relatively stable at 150 to 200 gpm. SBC-10 became inaccessible in 1995. Flow at SBC-9 declined gradually from 1995 to 1999 and was 55 gpm when the area was sealed in November 1999. In 1997 water that is believed to be from the SBC-10 area began discharging from the gob at SBC-13: SBC-13 averages 30 gpm, and flow appears to be increasing (Figure 6).

Water users have postulated that water discharging from the channel sandstone was previously recharging Birch Spring; the details associated with Birch Spring flows are discussed in the RESOURCE HYDROLOGIC IMPACT ASSESSMENT section.

When mining began in the Blind Canyon Seam, the first inflows were identified as coming from the floor in the Second East Entry (Map 4) and it was thought that this water originated from the Spring Canyon Tongue. Initial hydrologic evaluations from the Bear Canyon Mine Plan Appendix 7-N (April 16, 1993) described the mine as intercepting the potentiometric surface of the Spring Canyon Tongue in the north ends of the North Main and Second East entries. It is now believed that this water originated from the Blind Canyon channel sandstone.

Before inflow from the Blind Canyon channel sandstone was encountered, water draining from faults and fractures produced the largest volumes flowing into the mine. The fault crossing in the East Bleeders (E ½ SE ¼ Section 14) was considered the principal water source feeding the portal sump (Bear Canyon Mine Plan, PHC). Inflow was approximately the same as the inflow that eventually came from the Blind Canyon channel sandstone. "Inflow to the East Bleeders continued until the summer of 1989, when water was encountered as the North Main entries were advanced northward. According to Wendell Owen, inflow to the East Bleeders gradually diminished and flow into the North Mains was approximately 110 gpm" (Bear Canyon

Mine Plan, PHC).

Initial mining in the Wild Horse Ridge area will be in the Tank Seam, but plans are to construct a rock tunnel down to the Blind Canyon Seam and construct portals from inside when it has been determined where conditions are suitable. This seam has proven to be very wet in the northern end of the adjacent Bear Canyon workings, which are separated from the Wild Horse Ridge workings by the Bear Canyon Fault. Mining projection maps show the workings will remain approximately 1,000 feet east of this fault: Bear Canyon has been eroded along this fault and the Blind Canyon Seam crops out between the planned mine and the fault, and there are also large sections of burned coal along the outcrop. If water is present in the Bear Canyon Fault, mining the Blind Canyon Seam under Wild Horse Ridge should not cause interference with its flow.

On March 22, 2000 a Division Order required the Applicant to modify the permit application by including " a minimum of one in-mine drill hole located in the northern portion of the Wild Horse Ridge Addition." That requirement was complied with by addition of monitoring well DH-5, located at the northern boundary of the mine addition. The drill hole will be tested using the same methodology that was used in the previous in-mine wells, as described in Appendix 7-N of the Bear Canyon Mine Plan.

Tank Seam

The Co-Op Mining Company has drilled eight exploratory drill holes up into the Tank Seam from the Blind Canyon Seam (page 2-13, Appendix 7 - J, PAP). All were dry except one that flowed at 0.5 gpm. Stratigraphically, the Tank Seam is 250 feet above the Blind Canyon Seam and approximately 8 to 10 gpm of water has been pumped from the Blind Canyon Seam workings into the Tank Seam for mining operations.

Initial mining in the Wild Horse Ridge area will be in the Tank Seam. This seam has proven to be basically dry in the adjacent Bear Canyon workings, which are separated from the Wild Horse Ridge workings by the Bear Canyon Fault. Mining projection maps show the workings will remain approximately 1,000 feet east of this fault: Bear Canyon has been eroded along this fault and the Tank Seam crops out between the planned mine and the fault, and there are also large sections of burned coal along the outcrop. If water is present in the Bear Canyon Fault, mining the Tank Seam under Wild Horse Ridge should not cause interference with its flow.

Bear Canyon Mine Well Information

Wells monitored at the Bear Canyon Mine include: DH-1A, DH-2, DH-3, DH-4, SDH-1, SDH-2, and SDH-3. These wells are shown on Maps 4 and 5. DH-1A, DH-2, and DH-3 were drilled into the Star Point Sandstone and developed in the Spring Canyon Tongue of the Star Point Sandstone. DH-1A was drilled on August 6, 1991 and DH-2 was drilled in September 1991. DH-3 was drilled in early 1992. DH-3 became inaccessible and was abandoned in November 1993. Replacement well DH-4 was drilled in January 1994. Wells SDH-1, SDH-2 and SDH-3 were drilled in 1994. Drill holes MW-117 and MW-116 lie east of the Bear Canyon Fault in areas where future mining is expected to occur; each has one water level measurement

obtained in September 1996. No additional wells have been drilled for the Wild Horse Ridge addition, but there is a commitment to drill at least one additional in-mine well, from the entries into the Tank Seam, to monitor the Spring Canyon Tongue.

Hydraulic conductivities from the lower tongues of the Star Point Sandstone were obtained from slug injection tests when the wells were drilled. Information from these tests indicated a loss of drilling fluid in the Panther Tongue, below 410 feet, suggesting well DH-1 may have intercepted a fracture. DH-2 had a quick displacement of water and a hydraulic conductivity equal to 0.054 ft/min in the Storrs Sandstone. Water dating conducted on a sample from DH-2 shows a younger water (600 - 1,500 years mean residence time) than the Blind Canyon channel sandstone (1,400-2,100 years mean residence time).

Following recovery from the slug tests, the first notable change at DH-1A and DH-2 occurred in 1995: a ten-foot increase in head was recorded on July 13, 1995 at DH-2 (Figure 7), and water levels recorded at DH-1A, the well closest to DH-2, showed approximately a three-foot increase. These were short-lived increases and levels dropped back down within the year. It is possible that these were measurement errors, or are the result of in-mine sumping operations; however, flow jumped to 386 gpm at Star Point well 85-35-1 in June 1995 (Figure 5), and water-quality changes were noted at both DH-1A and 85-35-1 at the time of these increases. Water-quality data were not obtained at DH-2 during this period. The similarities in water-quality and flow, or water-level changes at DH-1A and 85-35-1 during June and July 1995, suggest a fracture-flow connection between the Star Point and Bear Canyon Mines. No increased flow from the Blind Canyon channel sandstone was recorded during this period.

The second notable change at DH-2 is a water level drop of approximately three feet in 1996, followed by a further 12-foot drop during 1997 and 1998 (Figure 7). During 1999, the last year monitored, elevations yo-yoed over a 12-foot range. This erratic behavior in DH-2 may indicate direct connection through fractures with the surface, or with areas being actively impacted by mining. Except for the high in 1995 that was discussed previously, DH-1A showed a steady increase from mid-1992 through 1997.

Wells SDH-1 and SDH-2 lie within the same geologic region, north of the mine, between the Bear Canyon and Blind Canyon faults. The water elevation was 7,964 feet at SDH-2 in August 1995 when the well was developed. The observed water elevation at SDH-2 was 7,975.8 feet on September 02, 1997, an increase in elevation of 11.8 feet since the initial well development. The change in water elevation at SDH-2 may be the result of either climatic variation, mine pumping operations conducted at Star Point Mine, or both.

Measurements indicate the Spring Canyon Sandstone potentiometric surface at SDH-2 is roughly 50 feet above the Tank Seam (approximate elevation of 7,925 feet). SDH-2 is 7,700 feet north of the northernmost Bear Canyon Mine workings in the Blind Canyon and Tank Seams. The potentiometric surface in the Spring Canyon Tongue at in-mine well DH-4, located near the northernmost extent of mining in the Blind Canyon Seam, is approximately 300 feet below the Tank Seam. It is reasonable to assume that if there is any future mining to the north in the Tank Seam within the permit area, it will not intercept Star Point aquifer waters unless water is transported up-gradient by fracture flow. Perched aquifers above the coal may be intercepted

and dewatered.

The potentiometric surface is higher at SDH-2 than it is to the south at SDH-1 and DH-4. This may indicate groundwater is diverted somewhere south of SDH-2, possibly discharging to Bear Canyon Creek, the McCadden Hollow - Trail Canyon drainage, or the Bear Canyon Fault Zone. Another possibility is that, although the data can be interpreted as indicating a single potentiometric surface, the wells may be measuring potentiometric surfaces from isolated systems.

Well SDH-3 is separated from Bear Canyon by the Blind Canyon Fault and an unnamed fault. Information from SDH-3 is more pertinent to the adjacent Trail Canyon Mine. Little information on the hydrology of this area is available.

Hiawatha Mine Interception

The Hiawatha Mine had an extensive mining history prior to the enactment of SMCRA, therefore, a lot of information on mining from this period is unknown. Available information from references in the Star Point and Hiawatha Mine Plans are included.

The Middle Fork Mine complex includes parts of the old Hiawatha No. 1 and No. 2 Mines that were closed in 1928. The No. 2 Mine was used as a water storage reservoir that was constructed by sealing off the mine entries with reinforced concrete bulkheads. According to the mine plan, the bulkheads in the No. 2 Mine have been opened and the reservoir drained but the date it was drained is not presented. This reservoir contained about 60 million gallons (184 acre-feet) on average (Hiawatha Mine Plan).

The Mohrland Mine portal has been sealed, but mine water still discharges into Cedar Creek through a bypass system. This water was previously piped to the town of Hiawatha. The Division's records indicate that U.S. Fuel Company (now Hiawatha Coal Company) has been discharging mine water from Mohrland Portal from February 1979 to present. The mine discharge enters a diversion box containing a weir and a valve controlled supply pipe. The valve operates the amount of water that is diverted into a steel pipe that transmits it to the town of Hiawatha in Miller Creek (UPDES 002). The current practice to obtain the UPDES discharge rates for 001 and 002 is to measure the overflow of the weir, which goes to Cedar Creek, (001), shut the valve to the pipe flowing to Hiawatha, then take a second measurement of the weir flow. The difference is the flow to Hiawatha, (002). The flow represents all inflow from the three mined coal seams.

The water supply for the town of Hiawatha has been piped from the Mohrland Portal to water-storage tanks near the town. Hiawatha UPDES 001 monitors water discharged directly at the Hiawatha Mohrland Mine Portal. UPDES 002, in the past, measured overflow from the water tanks, so except for what is consumed from the water system, the combined flow from UPDES 001 and UPDES 002 represents the total discharge from the Mohrland portal. Prior to the pumping at the Star Point Mine, the average combined discharge from UPDES 001 and UPDES 002 was 350 - 400 gpm, but during the Star Point pumping, this average discharge rose to almost 650 gpm.

Between November 1992 and July 1995, there was no flow measured at UPDES 002, because the water supply system was shutdown. Water that would have normally gone to the water

tanks was discharging through UPDES 001 to Cedar Creek.

The Bear Canyon Graben eastern boundary fault was intercepted by U. S. Fuel Company in the 10th West Section in the King IV Mine. As indicated on page VII-3 of section 7.1 of the Hiawatha Mine Plan (September 1986), "large water flows have been encountered in the past, mainly due to contact with the Bear Canyon Fault, which is a major water bearing structure. Old mine workings have contacted the fault at several points and this probably accounts for most of the mine water presently being discharged from the Mohrland portal". Plate 7-22 of the MRP illustrates the points of mine water inflow.

Information in the Star Point Mine Plan indicates that the 10th West inflow encounter, by U. S. Fuel with the Bear Creek Graben, is located at an elevation of 8,180 feet, approximately 6,600 feet south of the Star Point Mine graben crossing. According to a memorandum prepared by John Mercier of CPMC, dated May 23, 1983 (Star Point Mine Plan, page 700-12):

> Mining in the 2nd Left encounter (in the Star Point Mine) initially experienced little water inflow (at 6 gpm) from roof strata on the face offset. Within three weeks, liquefied gouge in the faces of entries #2 and #3 flowed approximately 10 to 15 feet into the entries. Underground drilling in the #1 entry penetrated 40 to 60 feet of gouge and fractured rock before tapping into a significant conduit. Inflow peaked at about 150 gpm from drill holes before dropping to less than 10 gpm after 10 weeks (the flow dropped to 50 gpm in two weeks). Inflow from the drill hole that penetrated the fault at the 2nd Left encounter has since dropped to zero.
>
> A second encounter with the east side of the graben (in the 2nd West Mains) experienced an initial inflow rate of about 20 gpm from the roof strata. This flow was reduced to less than 10 gpm after 4 weeks of exposure. Very little water has been found at the actual face offset.

The Star Point Mine Plan states on page 700-12, that the King IV Mine lies below the regional water table. The groundwater encountered in the 10th West came primarily from the floor through an area the size of a bushel basket. The fault was not penetrated; therefore, water encountered within the mine is bounded on the west by the fault system gouge zone and presumably receives recharge from areas east of the fault. No dates were presented to identify when water was intercepted.

The Hiawatha Mine presently is not mining. However, Hiawatha Coal Company, Inc. became the operator in 1998 and it is expected that mining will resume under Hiawathat Coal Company's direction in the near future.

Hiawatha Mine Groundwater Well Information

No well information is available for the Hiawatha Mine. Drill hole logs were preserved

which illustrate the underground stratigraphic relationship along a north-south cross-section of Gentry Mountain. Plate 7-23 shows the potentiometric surface in the southern part of Gentry Mountain provided by wells in the Bear Canyon Mine. It is anticipated that when the Hiawatha Mine is reopened, more groundwater information will be obtained.

Trail Canyon Mine Groundwater Interception

Water discharging from abandoned portals at monitoring sites PS-1 and CS-1 originates from old mine workings in the Hiawatha Seam. Information from these sites is the only information on undergroundwater from the Trail Canyon Mine area. There is no information available on water intercepted during mining.

CS-1 discharges groundwater from the Community Mine (inactive in 1921) developed in the Hiawatha Seam, but the water originates from the Star Point aquifer along the Pleasant Valley Fault. Water in this mine was developed for culinary use by Trail Canyon residents in the 1960's and is in compliance with the drinking water standards (Trail Canyon Mine Bond Release Application Addendum, December 28, 1995). CS-1 is located on the west side of Trail Canyon, beyond the west edge of the Trail Canyon Permit Area Boundary. According to information in the Trail Canyon Mine Plan, the Trail Canyon Mine is hydrologically separated from CS-1 by the Trail Canyon Fault.

PS-1 is located on the east side of Trail Canyon in the Hiawatha Seam and was associated with the “Freed” Mines (operated from mid-1920's to 1936). Since 1970 water has been pumped from the Community Mine (CS-1) to the Freed portal. The Freed Mine is used as a culinary water storage reservoir. The portals to the Freed Mine were sealed in 1991 by the Division's Abandoned Mined Land Program, but use as a reservoir was maintained. When culinary water is not being pumped into the reservoir from CS-1, no flow occurs from PS-1. This suggests little or no inflow occurs into PS-1, and indicates the piezometric surface of the Star Point/Blackhawk is below PS-1 and below the Trail Canyon Mine (Trail Canyon Mine Bond Release Application Addendum, December 28, 1995).

The Trail Canyon Mine was developed from 1938 through the 1980's on the east side of Trail Canyon in the Blind Canyon Seam. The mine workings were relatively dry. Water would have to fill the Trail Canyon Mine workings to the north, 100 feet above the mine portals, to filter through to PS-1. No discharge has been observed from the closed portals associated with the Trail Canyon Blind Canyon Seam indicating the workings are not flooded to that point (Trail Canyon Mine Bond Release Application Addendum, December 28, 1995).

Trail Canyon Mine Groundwater Well Information

No well information is available for the Trail Canyon Mine.

POTENTIAL HYDROLOGIC IMPACTS TO SPRINGS

Spring resources with a water-quality or water-quantity change noted over the mining period are presented in the mining and reclamation plans and the data are discussed in the following

sections. The potential for noted hydrologic changes at these water resources are reviewed in relation to mining activities. Spring resources are categorically discussed on the basis of use; domestic, or wildlife and agricultural.

Spring SBC-14 (WILD HORSE RIDGE-6) is in a small sheltered area in the bottom of the drainage, adjacent to the proposed road to the Wild Horse Ridge portals. Despite steady flow (0.5 to 15 gpm measured from 1993 to 1997), there are no water rights issued on the water flowing from this spring. However, special care is to be taken during blasting and construction in this area to preserve not only this water source, but also the pristine characteristics that make the area around this spring unique.

Spring Sources With Domestic Uses

Tie Fork, Birch and Big Bear Springs are the major water resources identified as having associated domestic uses within the CIA. The changes in flow characteristics for these springs are presented and the impacts identified in Figures 8, 9, 10, 14a, 14b, 15, 16a and 16b. The graphs for each spring are presented in Appendix A. The graphs identify flow and chemistry values over time. For information on associated water rights see the discussion under HYDROLOGIC RESOURCES, Rights.

Tie Fork Spring

Development History

In 1981 and 1982, CVSSD built a new water line to Tie Fork Canyon and developed Upper Tie Fork Spring (Map 6). In December 1982, Upper Tie Fork Spring was placed on the CVSSD system. Average flow was 85 gpm.

Artesian conditions were encountered in exploratory drill hole 85-35-1, drilled near the junction of Wild Cattle Hollow and Gentry Hollow in Tie Fork Canyon. The driller noted that fractures were intercepted at a depth of 357 feet. Information available indicates that these fractures are located within the Spring Canyon Member of the Star Point Sandstone (Star Point Mine Plan). Drill Hole 85-35-1 was deeded to Huntington City in 1988.

Huntington City developed flowing wells 86-35-2 and 86-35-3 in the vicinity of several small springs where the East Fault of the Pleasant Valley Graben crosses Tie Fork Canyon. Wells 86-35-2 and 86-35-3 were drilled into either: 1) the breccia zone of the East Fault of the Pleasant Valley Graben, or 2) in an open sandstone fracture zone. The depths to which these two wells were drilled are unknown.

These three wells appear to have simply captured the flow from the previously developed Upper Tie Fork Spring and these three wells are now called Upper Tie Fork Spring. Wells 86-35-2 and 86-35-3 are the major sources of the flow and are usually combined and reported as 86-35-2-3. In October 1993, Upper Tie Fork Spring was removed from the town drinking water system under an agreement with CPMC, because a potential for mining impacts was identified at the Star Point Mine. The Lower Tie Fork Spring was put into the system as water replacement.

The Lower Tie Fork Spring is developed west of the eastern Pleasant Valley Boundary Fault.

Water Quantity

A flow increase was recorded at the Upper Tie Fork Spring in August 1988. This increase correlates with a 5.3 magnitude earthquake on August 14, 1988. After the earthquake, Upper Tie Fork Spring flow reached 133 gpm, then slowly dropped to 86 gpm in August and September 1991 (Figures 1, 5, and 8). Flows observed prior to the earthquake averaged 84 gpm.

Mining beneath Gentry Ridge appears to have caused a direct and rapid decrease in flow to Upper Tie Fork Spring. This is related to the pumping of water across the Bear Canyon Fault from June 1992 through December 1997 (Star Point Mine Plan). However, some of the decrease may be attributed to the drought occurring from February 1987 through August 1991 (See the PHDI data in Figure 8.) Flow declined to a minimum of 33 gpm in 1995, but recovered as pumping rates dropped and returned to pre-pumping levels by mid-1996, at which time there was still a small volume of water being pumped (Figures 1 and 8).

Mining activities and the earthquake have affected the flow rate at the Upper Tie Fork Spring. Flows have since rebounded to levels exceeding pre-earthquake and pre-pumping rates. Monthly flow reached a maximum of 142 gpm in October 1998, but has stabilized at approximately 125 gpm (Figure 8). The source of this additional flow is unknown, but it may be related to the reduction in flow at Big Bear Spring and the drop in water level in wells P92-03-WD, P92-01A-WD, and P92-01B-WD in the Gentry Ridge horst. The quick response time at the Upper Tie Fork Spring indicate a fault - fracture type flow system is present (Star Point Mine Plan).

Additional discussion related to water quantity at Upper Tie Fork Spring is found in the section on INTERCEPTION AND WELL INFORMATION for the Star Point Mine.

Low flow - or baseflow - at Lower Tie Fork Spring did decline from 1994 to 1995. Low flow at Lower Tie Fork in 1995 lagged three months behind the lowest flow recorded at Upper Tie Fork Spring (Figure 8). Although pre-pumping data are lacking, it appears that baseflows at Lower Tie Fork Spring were lower after mining ceased, than they were during the active mining period. The annual low flow has not rebounded to the degree that it has at the Upper Tie Fork Spring. Lower Tie Fork Spring, developed in December 1993, does not have the same flow characteristics as the Upper Tie Fork Spring.

Water Quality

Water quality at the Upper Tie Fork Spring was affected by pumping at the Bear Canyon graben. The pH dropped as pumping started, reaching lows of 6 in January and June 1993. As pumping increased through 1994, pH values returned to pre-pumping values, although some elevated values were recorded. When pumping decreased in 1997, pH levels rose to over 8. After pumping stopped, the pH returned to pre-pumping values (Figure 9).

When pumping started and as pH levels dropped, sulfate concentrations increased, reaching a high of 66 mg/L in September 1992. By January 1996, when pumping rates had dropped and pH

values had risen, sulfate concentrations fell to near the pre-mining levels. However, since pumping stopped, the sulfate concentrations appear to be in an upward trend (Figure 9).

Bicarbonate generally remained in the range of pre-pumping values during pumping, even though higher than usual concentrations were measured in September 1994 (320 mg/L) and June 1997 (327 mg/L). However, since pumping stopped, bicarbonate concentrations have been consistently high, over 350 mg/L (Figure 10). TDS fell slightly during the pumping period, but recovered when pumping ceased. Bicarbonate now contributes a larger portion of the TDS value than it did before pumping (Figure 10).

Baseline water-quality data for the Tie Fork Wells show sulfate concentrations are lower than characteristic Blackhawk Formation concentrations. Recharge for the Tie Fork wells appears to originate within the Price River - North Horn perched system, which lies above the Blackhawk Formation (Star Point Mine Plan). Increases in sulfate concentrations, and possibly other chemical constituents, similar to the Blackhawk Formation, may result from mining. These chemical changes may be the result from the mixing of Blackhawk Formation groundwater with North Horn groundwater.

Changes between dry and wet climatic cycles may effect oxidation and reduction within the hydrologic systems and create water chemistry changes similar to those observed. Variations in TDS, sulfate, bicarbonate, and pH may occur during future climatic cycles, independent of any mining activity.

Birch Spring

Development History

Birch Spring was originally developed in the 1970's by the Northern Emery Water Users Association (NEWUA). The spring boxes were updated in 1977, and the lines to the spring boxes were re-developed in 1980 (Informal Conferences - permit renewal, cause No. C/015/025). Additional redevelopment work was done in the fall of 1984 because flow rates from the collection system where not as large as expected. Redevelopment in 1984 included some blasting and backhoe work conducted to increase flow rates followed by collection system burial under impervious material. The water was re-connected for use after the 1984 development work. The collection system was developed again in 1986 (Figures 11a and 11b). Explosives used to redevelop Birch Spring in 1984 and1986 may have opened fracture flow paths for water to by-pass the spring collection system (letter from the Co-Op Mining Company, April 13, 1998).

The area over the spring collection system is well vegetated, which can reduce spring discharge through plant uptake and water transpiration. In 1998 the overflow pipe at the collection box was cleared of roots that were blocking flow. Roots may also have been clogging the collection lines, and silt may have accumulated in the lines as well.

In September 1998, NEWUA opened spring boxes #1 and #2. Pete Hess from UDOGM accompanied Jack Stoynoff from NEWUA. Mr. Hess noted that water was running over the top

of collection box #1 when it was uncovered and that when opened, it was full of gravel and sediment. It was estimated that approximately 15 gpm flowed from source #1 after cleaning the box. Box #2 was also opened and cleaned, and several of the pipes in the collection system were cleaned or replaced. Since this work in 1998, flow at Birch Spring has recovered to over 25 gpm (Figure 11b).

Hydrogeology

Birch Spring issues from the Star Point Sandstone west of the Bear Canyon Mine, however the source of recharge to the spring is unknown. The spring flows at a relatively steady rate, showing little or no seasonal variation even though numerous joints and fractures are found in the outcrops surrounding the spring.

Birch Spring issues from a fault, and it has been hypothesized that this fault is splay from the Blind Canyon Fault; however, field investigations have not identified such a connection to the Blind Canyon Fault, or any other major fault. Fractures in this area are parallel, with consistent vertical and north-south orientation. No transverse, interconnecting fractures have been observed in the vicinity of the Trail and Bear Canyon Mines, indicating that lateral hydraulic interconnectivity between faults and fractures is poor or nonexistent. The Trail Canyon Mine lies directly in line with the northward projection of the Birch Spring fault. The mine-workings map makes no note of this fault, but the text of the MRP mentions several minor faults encountered within the mine. There is no mention in the Trail Canyon Mine Plan of significant or continuous flows into the mine workings from any source.

An issue presented by the NEWUA was whether water intercepted in the Bear Canyon Mine at the sand channel, monitored at sites SBC-9 and SBC-10, decreased recharge to Birch Spring. Water movement across major faults, such as the Blind Canyon Fault, does not seem likely based on the information presented to date. However, there is a possibility that secondary faults could transport water from the saturated sand channel exposed in the Bear Canyon Mine across the Blind Canyon fault to Birch Spring (Map 4).

In the southern region of the Bear Canyon Mine, joint and fracture sets are oriented N 15° E to N 17° E and a second set of minor joints are oriented N 60° E (informal conferences - Chris Hansen, Earth Fax Engineering). Mining in the Tank Seam has exposed a fault near the Blind Canyon fault, north of the Blind Canyon Fan Portal, that strikes N 17° E, is offset 1.5 feet, and is down-dropped to the west, it was also observed in the Blind Canyon Seam (letter from the Co-Op Mining Company, April 13, 1998). According to Co-Op, the fault appears to terminate near the southern end of the Third West Bleeders, it did not intersect the Blind Canyon channel sandstone, and it appeared closed. A projected fault lies northwest of the Blind Canyon channel sandstone ("low coal area").

To the north, within the Star Point Mine permit area, faults and joint sets that formed perpendicular to regional extensional stresses are oriented N 5° W, N 6° E, and N 14° E. These joint sets are open. Ground and surface-water migration is common along these fracture systems (Star Point Mine Plan), but there is no clear flow-path to Birch Spring. The Dry Canyon Fault could provide a flow path from the "shattered zone" adjacent to Tie Fork Canyon to Birch Spring (Map 5).

Information was collected during a field visit by Charles Reynolds, Environmental Engineer for Co-Op, and Jim Smith, UDOGM Reclamation Geologist, on October 15, 1998. The field visit form and summary memo from Co-Op dated December 22, 1998 are presented in Appendix C. In summary, the documents stated the following:

- The fractures do not completely converge, and they parallel the Blind Canyon Fault within the mapped area.
- Most of the area is jointed. Joints appear to be gradually converging up slope and may actually converge northward, upward or both.

If the fracture zones or joint sets are open as a result of extensional stress, they may be more likely to carry flow. Detailed mapping of faults and joints would be needed to fully understand the relationship, if any, of these fractures to the hydrogeology of Birch Spring.

Water Quantity

Birch Spring is located in Huntington Canyon, about one mile south of the Trail Canyon Mine. Flow measurements done prior to installation of a flow meter in January 1992 are very sporadic and many are of questionable reliability. A handful of more reliable flow measurements during this period ranged from 9 to 100 gpm (Figures 11a and 11b). From 1992 through 2000, flows averaged 22 gpm; however, there was a slight downward trend over this period. Because mining activities ceased at Trail Canyon Mine in 1982, there is little probability this downward trend is related to activities at Trail Canyon Mine.

Flow data indicate two significant concerns: 1) decreased flow was observed from 1991 to 1998, and 2) peak flows such as those recorded in December 1988, June 1989, October 1989 through January 1990, and June 1990, have not been seen since. The water source for the peak flows may be separate from the normal Birch Spring flow.

The Star Point MRP provided information on flow at Birch Spring from January 1985 through December 1990. It is not available from other sources. These flow data have been used by both UDOGM and Co-Op in several documents and other matters relating to Birch Spring. The spring flow information was obtained by Ben Grimes, who was employed by Star Point Mine. At the time he was also President of the NEWUA. Spring data was collected by Jimmy Staker, an employee of NEWUA, who kept the records of his flow measurements at his home. Mr. Staker died several years ago and his original records cannot be found. Comparing the Birch Spring data between January 1985 and November 1988, with the data from Tie Fork Spring for the same time period. It is evident that it is the same data set. CVSSD's Tie Fork records are continuous and can be confirmed back to December 1982. The reported flows are more consistent with historic flows at Tie Fork and less consistent with what little other Birch Spring flow data for the same period. The Star Point data from January 1985 to November 1988 are not considered valid for Birch Spring. The Star Point data from December 1988 to August 1990 are questionable, because there is no way to confirm them.

NEWUA began measuring Birch Spring flows monthly between January and December 1991, using a bucket and stopwatch. An in-line flow meter was used and checked monthly with a bucket and stopwatch, after January 1992. Prior to 1991, Co-Op measured only the overflow of the collection system. Co-Op's early measurements do not include the flow within the collection system. Since 1991, Co-Op has at times reported NEWUA's measurements and at other times has made independent measurements. Star Point began independent quarterly monitoring in October 1992. Since 1991, the independent measurements of Star Point and Co-Op closely match NEWUA's data.

Peak flow discharges, attributed to Staker's measurements, as reported by the Star Point Mine, reached 117 gpm during December 1988, 100 gpm in June 1989, 230 gpm in October 1989 through January 1990 and 85 gpm in June 1990. Both Co-Op and NEWUA data confirm high flow during the October 1989 through January 1990 period; 129 gpm (of overflow) in October 1989 from Co-Op, and 100 gpm in January 1990 from NEWUA. Bill Malencik of UDOGM (memo dated November 1, 1989) measured 150 gpm on October 25, 1989, which did not include the flow in the adjacent ditch that was reported to flow 80 gpm on November 3, 1989. Based on Staker's data, each of these four peak flows at Birch Spring were followed by what appear to be periods of baseflow recession (Figure 11).

Following this series of peak events, flows declined rapidly and were measured at 40 gpm in September 1990. Flows held fairly steady at around 33 gpm through 1991, but then began decreasing slowly in January 1992, reaching a low of 14.5 gpm in May 1997. From May 1997 until the spring was redeveloped by NEWUA in September and October 1998, flow increased slowly, reaching a maximum of 21 gpm in October 1997. Since the 1998 redevelopment, flow has been as high as 27 gpm (Star point data, March 2000), but flows as low as 15 gpm (Star Point and Bear Canyon data, May and June 1999) have been recorded during the same period. Data since March 2000 indicate flow is consistently above 25 gpm.

Peak Flow Events

Three hypotheses explaining the 1988 to 1990 peak flows have been presented : 1) water may have been released from the bulkheads at Trail Canyon, 2) water intercepted within the Bear Canyon Mine was pumped from the Blind Canyon Fan Portal into Dry Canyon and reached Birch Spring through subsidence above the Trail Canyon Mine workings (Map 4), and 3) the water originated from the sump in the south workings at the Bear Canyon Mine.

First Hypothesis

The first hypothesis is that the 1988 to 1990 peak flows at Birch Spring originated from water stored behind bulkheads in the Trail Canyon Mine. Flow data for Birch Spring that are presented by CPMC for August, September, October, and November 1988 are considered invalid - as discussed above - but the high flow rates measured in December 1988 and later appear to be followed by periods of recession (Figure 11). These data also indicate a possible correlation with the August 14, 1988 earthquake. Hypothetically, water behind bulkheads in the Trail Canyon Mine was released during the earthquake and traveled along fault and joint systems to Birch Spring. However, it seems unlikely the three subsequent peak flows, which occurred some

time after the earthquake, would be related to the earthquake.

A large sediment load was observed in Birch Spring collection system during the peak flows. A possible source of sediment in water originating at the Trail Canyon Mine would be a connection between the groundwater and the surface. The only documented connection is a subsidence area observed on October 28, 1996 (Map 4). The surface subsidence effects in this area were on both sides of Dry Canyon and over a 100-foot-long section that dropped 6 to 8 feet along the ephemeral channel. This subsided area occurs over a mapped fault, the Dry Canyon Fault (west of the Blind Canyon Fault), that passes near Birch Spring. The subsidence was first identified on a map presented by Co-Op for the Trail Canyon Mine and dated March 22, 1983.

Second Hypothesis

The second hypothesis, presented by Mr. Galen Atwood for NEWUA during the 1996 Bear Canyon Mine informal conferences, contended that water intercepted in the Bear Canyon Mine was pumped from the mine through the Blind Canyon Fan Portal into Dry Canyon. This would have been in the late summer of 1989, when the 230 gpm flows were measured at Birch Spring. No factual evidence was presented for this hypotheses, although oil-and-grease, sediment, and dissolved solids levels and fecal coliform bacteria counts increased in the Birch Spring water during these high flows of late 1989 to early 1990. Again, the Trail Canyon Mine subsidence might have allowed connection along the Dry Canyon Fault to Birch Spring.

Third Hypothesis

The third hypothesis suggests water sumped into the old workings at the Bear Canyon Mine resulted in the peak flows at Birch Spring. Pumping of water into the old south workings apparently began sometime after mid-1989 when water from the Blind Canyon channel sandstone began flowing into the North Mains, and ended in April 1991 when discharge to Bear Creek began under a UPDES permit. During this period, water was observed flowing over the road below Birch Spring.

Potential flow paths from this sump to Birch Spring could have resulted from subsidence features occurring adjacent to the mine sump area, at the southern end of the permit area (Map 4). This subsidence feature is located in the small drainage tributary to Birch Spring. Co-Op mined beyond the permit area boundary in an area beneath the drainage in 1985. During mining a subsidence hole, with an average six-foot depth, developed in the drainage channel and a large fracture formed approximately 100 feet west of the subsidence hole. Ventilation stoppings and a barricade were installed in the mine, but no seal was installed (memo to file from Peter Hess, March 27, 1995). Approximately 150 feet southeast and up-slope from the larger hole, a smaller diameter hole, approximately 30 feet deep, subsided. It is unknown when this subsidence hole formed. The holes and fractures were observed during a UDOGM inspection in the fall of 1994 and are described in Appendix 3-N of the Bear Canyon Mine Plan. (NOV N94-46-4-1B was issued December 12, 1994, the subsidence damage in the drainage was mitigated, and the NOV was terminated in 1997.)

The subsidence holes and fractures might have facilitated a flow path between the sump

and Birch Spring that would not require any substantial head increase in the old-workings sump. Water was not suspected to have exited from the subsidence features at the ground elevation, because the old workings are separated from the active mine by bulkheads. These bulkheads are unable to contain pressures from a water reservoir with a large hydraulic head. Water would have seeped from behind the bulkheads if approximately a 20 ft head required for discharge at the surface developed. According to Co-Op there was no seepage from the bulkheads. However, the subsidence features might have provided a subsurface path for water and a source for sediment from the old workings to Birch Spring.

The adjacent Big Bear Spring also exhibited excess water during the Birch Spring peak flows. In October 1990 water was observed exiting the cliff face south of the Bear Canyon Mine. In December 1990 through January 1991 icicles were noticed on the cliffs above Big Bear Springs by UDOGM personnel and by Mr. Bryce Montgomery, hydrogeologist for CVSSD. It is believed that this discharge resulted from the water pumped into the abandoned workings at the south end of the Bear Canyon Mine. Sulfate, TDS, and oil and grease also increased in the Big Bear Spring water during this period.

According to the Informal Hearing, Cause NO. C/015/025, UDOGM, under Findings of Fact: Relative Findings:

> #6 "There is evidence that pumping may have influenced quantity of flow from outcroppings at or near Big Bear or Birch Spring in the recent past."
>
> #7: "Pumping into the abandoned workings at the south end of the mine, directly north of the existing Bear Canyon Mine may have influenced the quantity of water seeping from outcrops above Big Bear and Birch Spring."

Water flowed from the cliffs at approximately the same elevation and the same stratigraphic section as the coal seam and the coal mine. Horizontal flow through the Blackhawk Formation is much easier than vertical flow because of multiple layers of low-permeability clay, siltstone, and sandstone. As in other scenarios, it is most likely that faults or fractures provide a path from the mine workings to Birch Spring, which flows from a stratigraphic unit below the mine sump.

Long-term Declines in Flow

Flow rates from 9.3 gpm to 23 gpm were recorded at Birch Spring by the USGS (Danielson and others, 1981) during a drought period in 1978 and 1979 (Figure 11).

It is unclear whether the peak flows in 1988 to 1990 influenced long-term discharge from the spring. The lack of congruity and consistency in flow data makes such a determination difficult.

Based on NEWUA records, flow at Birch Spring declined from 33 gpm in February 1990 to about 19 gpm in 1997, with a 16 gpm low flow recorded May 1997. This decline in flow could have resulted from the drought that began in 1987 and continued through early 1993. Flows continued to decline to a low of 14 gpm recorded on June 1, 1999. Flows appear to be recovering from this low.

The last recorded spring discharge rate provided from NEWUA was 26 gpm on May 1, 2001, and data since March 2000 indicate flow is consistently above 25 gpm.

Birch Spring was originally developed in the 1970's. The spring boxes were updated in 1977, and the lines to the spring boxes were re-developed in 1980. Because flow rates from the collection system were not as large as expected, additional redevelopment work was done in the fall of 1984 and again in 1986. Co-Op has suggested that the explosives used to redevelop Birch Spring in 1984 and 1986 may have opened fracture flow paths for water to by-pass the spring collection system (Co-Op letter, April 13, 1998).

Charles Reynolds noted in 1977 that water was issuing from the area between Huntington Creek and Birch Spring in a seep area that may have existed for two or three years, estimating from the vegetative growth in the area surrounding the seep. Co-Op felt this seep was the result of the collection system's reduced capacity and reduced ability to carry the available water.

The area over the spring collection system is well vegetated, which can reduce spring discharge through plant uptake and water transpiration. In 1998, the overflow pipe at the collection box was cleared of roots that were blocking flow. Silt may have accumulated in the lines as well.

In September 1998, NEWUA opened spring boxes #1 and #2. Pete Hess from UDOGM accompanied Jack Stoynoff from the NEWUA. Mr. Hess noted that water was running over the top of collection box #1 when it was uncovered, and that when opened it was full of gravel and sediment. It was estimated that approximately 15 gpm flowed from source #1 after cleaning the box.

Information presented to date does not support the assertion that the decrease in flow from 1990 to 1998 was the result of mining operations. Information is not adequate to identify the cause of the decline in flow at Birch Spring. There are spring development and maintenance history aspects that may effect water quantity, but these are not clearly documented or understood. Many unanswered questions about the resource at Birch Spring remain. With time, additional data and analyses from the mine operators and the water users may provide the needed clarification.

Water Quality

Baseline water quality samples were collected by Trail Canyon Mine from 1991 to 1993. Bear Canyon Mine collected baseline data at Birch Spring in 1986, and has continued to monitor Birch Spring under the Bear Canyon Mine permit (C/015/0025). Specific conductance and TDS both show large differences between minimum and maximum values. However, such anomalies may be characteristic of high and low flows associated with natural climatic and erosional processes, especially if the spring is influenced by surface hydrologic events. The main water quality issues at Birch Spring have been the temporary increases in coliform bacteria, dissolved solids, oil-and-grease, and sediment during the 1989 - 1990 high flow periods. There have been no significant overall changes in water chemistry at this spring during this monitoring period; therefore, it does not appear there have been any permanent or long-term adverse effects

from mining. Monitoring of this spring will continue in conjunction with the Bear Canyon Mine permit (C/015/025).

Data in the UDOGM database, summarized in Table IV-3, show SBC-9 and SBC-10 have lower sulfate, bicarbonate, and chloride mean concentrations than Birch Spring, although high and low values sometimes do not show as clear a distinction. Mean solute concentrations tabulated in Table 3 of the Bear Canyon PHC (Appendix 7-J, Bear Canyon Mine Plan) are basically in agreement with Table IV-3.

Stiff diagrams are shown on Figure 15 of the Bear Canyon PHC. Stiff diagrams for SBC-9, SBC-10, Birch and Big Bear Springs, and springs in Trail Canyon are similar in appearance.

TABLE IV-3: SBC-9, SBC-10 and Birch Spring

Station	**Bicarbonate** (mg/L)			**Chloride** (mg/L)			**Sulfate** (mg/L)		
	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min
Birch Spring	371	439	102	9.7	25	3	117	298	38
SBC-9	354	440	270	6.18	27	0	44	206	20
SBC-10	321	412	152	7.9	20	0	52.1	100	5

Data from Bear Canyon Mine

Water quality varied some over time at SBC-10 and SBC-9, most notably the jumps in chloride concentrations in 1992 and 1998 (Figures 12 and 13a). TDS and sulfate also had some variation in concentration. Values for sulfate in late 1990 and early 1991 at SBC-9 were greater than two standard deviations above average. The variability of these data may indicate a variability in the sand channel water, influences from other water sources, or mining. Water sampled at SBC-9 has been taken from a sump that was relocated at least once during mining, and some samples may have been taken directly from the channel sandstone. Samples from SBC-13, which are believed to be flowing through gob from the SBC-10 area, show water quality improving over time (Figure 13b), perhaps indicating that soluble minerals are being flushed from the gob.

The movement of water from the Blind Canyon channel sandstone through fractures to Birch Spring may change in chemistry over time. Continued monitoring might determine if observed Birch Spring water chemistry could be derived from the water at the Blind Canyon channel sandstone.

Water Dating

Results are summarized in Table IV-4. Sample locations are on Map 4. Samples obtained on May 15, 1996 were collected during a joint sampling effort between the water users, represented by Peter Nielsen of SECOR, and Co-Op. Data from Mayo and Associates are in Table 4 of the Bear Canyon Mine PHC (Bear Canyon Mine Plan, Appendix 7-J). Analysis results for one sample from Birch Spring were obtained from the Star Point Mine Plan. The date was not provided, but the sample was collected prior to 1991, because the analytical results were

first presented in 1991.

Table IV-4: Water Age Dating

Source	Date	Sample Source	Parameter		
			TU	Carbon 14 Dating (Years Mean Residence Time)	δ34S
Birch Spring	5/15/96	Co-Op	0.35		+3.8
	Not known	Star Point Mine	0.93		
	Not known	Earth Fax (Bear Canyon Mine Plan Appendix 7-J 4/30/93)	1.12		
	5/26/98	Mayo and Associates - Co-Op	0.49	1,700	+3.0
Source #1	10/29/98		0.33	3,600	+5.1
Source #2			0.37	2,500	+5.0
Overflow			0.47	1,100	-7.8
SBC-9	11/13/96	Mayo and Associates - Co-Op	0.50	1,400	
	1/6/99		3.62	2,200	+3.5
	5/15/96	SECOR	0.40		+11.4
3rd West Bleeder	11/13/96	Mayo and Associates - Co-Op		500	
	5/15/96	SECOR	2.22		+10.8
3rd West South	11/13/96	Mayo and Associates - Co-Op		5,400	
	5/15/96	SECOR	0.0		-0.6
Big Bear Spring	5/15/96	Co-Op	14.2		5.4
	pre-1991	Star Point Mine	17.7		
	11/13/96	Mayo and Associates - Co-Op	15.8		
	5/26/98		14	Mixed	+6.0
	10/29/98		17	Mixed	+5.1
Hiawatha - Mohrland Portal	6/10/98 and 10/12/98	Mayo and Associates - Co-Op	5.52 5.41	Mixed/9,000 Mixed/9,000	22

Except for one slightly elevated value of 3.62 TU from June 1, 1999 for SBC-9, there is no indication that modern water is present in Birch Spring, or in the sand channel at SBC-9. Computed mean residence times were determined for the data presented by Mayo and Associates using the Pearson, Mooks, and Fontes models. The ages from oldest to youngest are; 3rd West South, Birch Spring, SBC-9, and 3rd West Bleeder (Map 4).

Although Big Bear Spring has chemical characteristics similar to Birch Spring, dating indicates “mixed” waters with high TU identifying a modern or “young” component in the water recharging Big Bear Spring (Table IV-4). Chemical characteristics of the Trail Canyon springs are similar to Birch and Big Bear Springs; however, sampling to determine the mean residence time was not conducted on any Trail Canyon springs.

Conclusions made from the water dating analyses are; 1) the age of the water at SBC-9 (1,400 to 2,200 years mean residence time) and Birch Spring (1,100 to 3,600 years mean residence time) are similar, but all data considered together might favor Birch Spring as being slightly older, 2) no modern water was found at Birch Spring or SBC-9 water source, and 3) water from the 3rd West Bleeders is younger in age (500 years mean residence time) than Birch Spring.

Water flowing from Mohrland Portal is the oldest encountered in the Mayo and Associates samples, but TU values indicate a mixture with modern waters.

$\delta^{34}S$ represents the isotopic sulfur ratio and is used to identify sulfate sources in groundwater. The Third West Bleeders and SBC- 9 have similar $\delta^{34}S$ levels, while the third west south and Birch Spring are lower. These $\delta^{34}S$ levels become important if geochemical modeling is conducted.

Big Bear Spring

Development History

The Big Bear Spring was developed as a water source by Huntington City around 1920. At that time a four-inch transmission line was used to convey the water, but the line capacity was not large enough to transport all water available during peak flows. In 1977 Huntington City upgraded the spring boxes and collection systems and installed a meter. This meter was used to collect spring flow data and was operating when Terry Danielson (Danielson and others, 1981) collected samples for the USGS in April through December 1978.

In 1981 the CVSSD replaced the 4" line with a 6" line and a new meter, which is adequate to transport all the spring flow. Following the new meter installation, flows are measured on the 15th and last day of each month by the CVSSD. The collection system was again modified in early 2001 to capture additional flow, but the results have not yet been determined. The telemetric system, connected to the spring collection system in 1995, currently records hourly flow rates. The spring was redeveloped in 2000 in an attempt to capture flow that was bypassing the collection system.

Hydrogeology

Big Bear Spring issues from fractures in the Spring Canyon Tongue of the Star Point Sandstone. Recharge is believed to originate from an area north of the spring (Bear Canyon Mine Plan). No one has identified whether the recharge zone is from the east, west, or both sides of the Bear Canyon Fault. An older version (prior to February 1997) of the Bear Canyon Mine Plan stated "..the Bear Springs flow is derived from interception and channeling of water bearing zones from areas extending well to the north (up-gradient) of the site. This includes water- bearing portions of the Star Point Blackhawk contact cut by the fault". Another hypothesis suggested that recharge came from Bear Creek and local faults and fractures. Although recharge to the spring from the creek is not confirmed, baseflow to Bear Creek comes from the Bear Canyon Fault. The fractures and faults of the Bear Canyon Graben and the shattered zone south of Tie Fork Canyon align with Big Bear Spring (Map 5); although these areas are several miles from Big Bear Spring, they have good potential as the sources for some of the recharge to Big Bear Spring.

Water Quantity

The changes in flow rates at Big Bear Spring over time are presented in Appendix A- Figure 14a. Figure 14a also includes the Palmer Hydrologic Drought Index (PHDI) for Region 5 and flows for Little Bear Spring and Upper and Lower Tie Fork Springs. The PHDI is a drought index used to assess long-term moisture supply. It indicates the severity of a wet or dry spell, with negative values denoting a dry spell and positive values denoting a wet spell. The Little Bear Spring and Upper Tie Fork Spring are presented to show relationships with other water right sources held by the Huntington Cleveland Irrigation Company.

The most notable change in the flow characteristics at Big Bear Spring are losses in seasonal peak flows beginning in 1987 and 1988 and continuing still. A combination of the drought and mining likely contribute to the decreased peak flows observed at Big Bear Spring. However, an exact connection or timing of mining effects have not been determined to date. Figures 14a and 14b show the period of drought and recorded periods where water was intercepted within the Bear Canyon and Star Point Mines. The following sections describe these occurrences.

The Drought

The drought, based on data presented for the PHDI in Region 5 began in 1987 and lasted until around May 1993. Seasonal peak flows decreased at Little Bear and Big Bear Springs along with the drought index (Figure 15). The mean annual flow (obtained from the monthly means) did increase slightly for Big Bear Spring from 1990 to 1996, but the magnitude of the increase in flow has not matched the increase in the PHDI. The slow response may result from mining influences or possibly a hysteresis effect following the drought (water recharges voids within the formation rather than discharging). The 1996 increase also corresponds to the period when pumping within the Star Point Mine across Gentry Ridge ceased.

Mine Water

Star Point Mine-water Interception

East of Gentry Ridge

Intercepted groundwater averaged 150 gpm from April 1985 through 1986 at the Star Point Mine. Flows originated from longwall panels #3 and #12 (Map 3). Longwall panel #3 was initiated in August 1982 and ended in March 1986. This panel was centrally located in the series of longwall panels just east of the Bear Canyon Graben and on the west edge of the mining block. Intercepted flow peaked within longwall area #3 in September 1985. Development of longwall panel #12 in the Wattis Seam was conducted in 1989 and the longwall was pulled in 1990. Little information on flow at the #12 longwall panel was found in the Star Point Mine Plan. According to the mine maps, panel #12 is located near the subsidence that occurred under the North Fork of the Right Fork of Miller Creek and is not suspected to be related to changes at Big Bear Spring.

Water intercepted in the Star Point Mine in 1986 through 1987 averaged 218 gpm. During

this period longwall panels #4 and #5 were mined in the Wattis seam. A surface subsidence fracture occurred above panel #4 that may have contributed inflow from the surface and formations above the coal. However, these panels are adjacent to the Bear Canyon Fault and mining could have intercepted flows that discharged to Big Bear Spring. A decreased peak flow was noted at the spring in 1987.

Bear Canyon Graben Crossing.

Fault related groundwater was encountered when the Bear Canyon Graben eastern boundary fault was intercepted by the mine at two locations: 1) the Eastern Boundary Fault 2nd Left (8,780 ft) and 2) the 2nd West Mains (8,490 ft). This information was obtained from a memorandum from John Mercier of CPMC (dated May 23, 1983 - see Star Point Mine Plan, page 700-12). A drill hole from the 2nd Left Main into the graben initially produced 150 gpm inflow but flow eventually decreased to zero. The precise date of this drilling was not presented in the mine plan.

The encounter on the east side of the graben in the 2nd West Mains produced an initial inflow rate of about 20 gpm from the roof. This flow reduced to less than 10 gpm after 4 weeks of exposure. Very little water was found at the actual face.

The rock tunnel crossing was developed in 1989. The water encountered in the graben crossing was believed to originate from perched systems associated with fractures (Star Point Mine Plan).

Other initial high flows water that later diminished were intercepted, but dates and locations were not identified in the Star Point Mine Plan. There has been concern that some of these high initial inflows drained fracture systems that provided recharge to springs associated with the fractures. Potentially these inflows have redirected flows previously discharging at the Big Bear Spring.

Gentry Ridge.

Throughout the mining process, flow entered from the mine roof. Water also seeped through the floor in the 4th Right and 5th Right longwall panels, which were mined in 1992 and 1993. Inflows that were not associated with fracturing or faulting were relatively small. Some sections of the Gentry Ridge workings were noted to have damp conditions: 3rd South and 1st, 2nd and 3rd Right Mains had small wet areas on the floor. CPMC personnel speculated that this was indicative of conditions that would be expected in a aquitard located beneath the water table, and felt that these wet conditions were consistent with forecasts made prior to entry into the Gentry Ridge area.

Smaller inflows were found in the 3rd South Mains, near the Western Boundary Fault of the Bear Canyon graben. Flow rates up to 50 gpm were reported 1992-1993, the size of these flows generally increasing as mining progressed to the south.

Larger inflows within the Star Point Mine have been where mine workings intercepted

segments of the western boundary fault of the Gentry Ridge Horst, which is also the eastern boundary fault of the Pleasant Valley Graben and may be continuous with the Trail Canyon Fault to the south (Map 3). Two large flows from floor fractures were encountered at the far western end of the 3rd West Mains. Combined flow was 100 gpm in January 1992, dropping to 40 gpm by April 1992, and was dry by May 1998 Star Point Mine Plan, page 700-63 and Sheet 728b). A roof fracture in the south mains for the second longwall panel (3rd Right Mains) flowed an estimated 100 gpm in April 1992, but this was dry by October 1993. Approximately 50 gpm was measured flowing from the roof in the south mains of the third longwall panel (4th Right Mains) in May 1992, but this also was dry by October 1993. As mining progressed downdip, to the south, in 1993, flows of as much as 200 to 250 gpm were reported from the vicinity of the western boundary fault during development near the headwaters of Wild Cattle Hollow, but there are no additional data for these locations. Inflows were pumped from the mined section until late 1995 when longwall mining ceased. Subsequent to that time, mine waters inflows have begun to re-establish the local potentiometric surface in the Pleasant Valley graben. No measurements or levels are known.

Bear Canyon Mine Water Inflows.

Previous mining at this site dated back to 1938, but there had been a hiatus of approximately 30 years before Co-Op began mining at the Bear Canyon Mine in 1982, in the Blind Canyon Seam. Flow has been measured sporadically at SBC-7, a sump just inside the portals, in the old workings. Flow at SBC-7 was 18 gpm in March 1988 and generally remained at 16 to 19 gpm through November 1989. When monitored in February, May, and August 1990, water had ceased flowing at SBC-7, and after flows were measured in November 1990 and February 1991, this site was considered dry and monitoring was discontinued. The first significant flow of water into the new workings of the Bear Canyon Mine was from the roof near the sump in the East Bleeders. Flow was first measured from the sump at SBC-8 in March 1988, varying between 18 to 22 gpm until February 1989. The water originated from faults and fractures and produced the largest volumes flowing into the mine during the early mining periods. The combined flow of SBC-7 and SBC-8 was 30 to 40 gpm up to November 1989, after which flow into the mine at these two locations became inconsistent and then ceased (Figure 6).

Other significant inflows, recorded at SBC-10 and SBC-9 (Figure 6), originated from the Blind Canyon channel sandstone. In August 1989 mining operations in the North Mains of the Bear Canyon Mine, in the Blind Canyon Seam, approached the margins of the channel sandstone in the mine roof. By November 1989 large roof drips began to flow into the mine in this area. Initial flows measured in February 1990 at SBC-9 were 120 gpm, and flows reached a maximum of 175 gpm in 1993 - 1994 (Figure 6). The increasing inflow in the North Mains corresponded with the onset of inconsistent and diminishing flows at SBC-7 and SBC-8.

In February 1992 monitoring began at SBC-10 in the 1st East entries: flow started at 250 gpm, and combined flow measured at SBC-9 and SBC-10 jumped to 382 gpm. Mining in the North Mains reached the main body of the sandstone in April 27, 1993, and SBC-9 was moved closer to the channel sandstone. Flows rapidly declined at SBC-10, dropping to approximately 25 gpm by 1994; however, from 1993 to 1995 combined flows were relatively stable at 150 to 200 gpm. SBC-10 became inaccessible in 1995. Flow at SBC-9 declined gradually from 1995 to 1999 and was 55 gpm when the area was sealed in November 1999. In 1997 water that is believed to be from the

SBC-10 area began discharging from the gob at SBC-13: SBC-13 averages 30 gpm, and flow appears to be increasing (Figure 6).

Potentially, flow at SBC-10 could be from a separate source because it decreased to a lower flow rate while SBC-9 remained at approximately the same flow rate. The water from SBC-10 may have originated from fractures unrelated to the channel sandstone.

Mining under Wild Horse Ridge is not expected to impact Big Bear (or Birch) Spring. Reasons for this conclusion are given in the PHC (Appendix 7-J, page 130-132):

1.) Faults with as much offset as the Bear Canyon Fault, 200 to 250 feet, are typically filled with low permeability gouge, which prevents movement of water both across and along the fault plane. Fault gouge is visible in the Bear Canyon Fault where it is exposed near the head of Bear Canyon;

2.) Fractures adjacent to such large faults typically transmit water parallel to the fault plane, but the fractures on the east (Wild Horse Ridge) side of the fault will not have good hydraulic communication with the fractures on the west side because of the fault gouge;

3.) Recharge most likely occurs in areas where the Panther Tongue crops out, rather than vertically through overlying strata;

4.) Dip is to the southeast, and flow will be strongly influenced to move in the direction of dip, rather than to the southwest towards Big Bear Spring;

5.) The gouge in faults will further inhibit lateral movement towards the west and Big Bear Spring;

6.) Water quality in three springs east of the Bear Canyon Fault is significantly different than water in Big Bear Spring, again indicating no or poor hydraulic communication between the Wild Horse Ridge area east of the fault and Big Bear Spring.

Hiawatha Mine WaterInflows

The dates when water was intercepted near the Bear Canyon Fault are not given in the Bear Canyon Mine Plan. However, the mean residence time of water flowing from the vicinity of the fault in the Hiawatha Mine is older than that for waters from the either the Bear Canyon Mine or Big Bear Spring (Table IV-4), indicating water intercepted near the Bear Canyon Fault in the Hiawatha Mine has not been flowing to either the mine or the spring.

Big Bear Spring Compared To Other Springs

Annual average flow from Big Bear Spring declined steeply from1986 through 1990, then remained fairly constant until the 1995 low (Figure 15). Bear Canyon flows increased in 1996 but did not approach the pre-drought flow rates, and have declined since. CVSSD worked on the collection system at Big Bear Spring from January to March 2001 in an attempt to recover additional flow.

Big Bear, Little Bear, Upper Tie Fork, and Lower Tie Fork Springs had a historic low flow during 1995, but Birch Springs did not (Figures 14a and 11). Little Bear Springs showed a quick increase in flow following this low and recovered to pre-drought output. Upper Tie Fork also recovered to pre-drought conditions, but more slowly, possibly affected by continued pumping at the Star Point Mine (Figure 5). Flow at Big Bear Spring also increased after the 1995 low but remained below pre-drought levels. Lower Tie Fork reached the low three months after Upper Tie Fork, and does not appear to have recovered significantly ((Figure 8).

Although Big Bear and Upper Tie Fork Springs had low flows recorded between April and June 1995, in May 1995 Lower Tie Fork had its highest recorded flow and the water level in well 85-35-1 spiked (Figure 5). All these extreme events occurred during dewatering of Gentry Ridge by the Star Point Mine. Lower Tie Fork Spring reached a low in October 1995, five months after the May peak. The 1995 lows at Little Bear and Upper Tie Fork can be simply explained by regional climatic influences, and at Big Bear by climate and maybe pumping at Star Point Mine, if a connection between the Pleasant Valley graben and Bear Canyon graben can be identified. Climate and pumping do not explain the peaks observed at Lower Tie Fork Spring and well 85-35-1. Lower Tie Fork Spring appears to respond independently from the other springs and it probably has a separate recharge zone.

The Star Point Mine may have intercepted groundwater that previously reached Big Bear Spring, and some of that water may now be redirected to the Tie Fork Well. The Bear Canyon Mine may have also affected recharge by intercepting some of the waters that moved through local fractures and provided the pre-drought peak seasonal flows (Figure 14a).

Of these springs that have been discussed, Little Bear Spring is farthest from mining at the Star Point and Bear Canyon Mines, yet it was the first of these springs to reach minimum flow in 1995. It is significant that Little Bear Spring flow was at a minimum during this 1995 period (Figure 14a and Table IV-5) because Little Bear Spring is considered to be in a separate hydrologic system from the Gentry Mountain springs: it is located on the opposite side of Huntington Canyon and elevated well above the canyon floor. One hypothesis for recharge of Little Bear Spring was that

recharge came from Huntington Creek through a fracture system; however, recent geophysical and dye-tracer work done by CVSSD is more supportive of a hypothesis that recharge is through fractures from Mill Fork Canyon, which is on the same side of Huntington Creek as Little Bear.

Table IV-5: Historic Lows and Highs for Selected Springs

Source	Historic Low Flow		Historic High Flow	
	Flow (gpm)	Month/Year	Flow (gpm)	Month/Year
Big Bear Spring	76	5/1995	378	6/1983
Upper Tie Fork	39	5/1995-	142	10/199
Lower Tie Fork	41	10/1995	147	5/1995
Little Bear Spring	198	4/1995	484	1/1998
Birch Spring -	2.5	11/1994	100	1/1990
Birch Spring - other extreme flows - see Figure 11.	15.8 (at SBC-5 just prior to redevelopment of the spring in September.)	8/1998	230 (Jimmy Staker via Ben Grimes: reliability of data unknown)	10/1990-1/1991

Water Quality

The change in hydraulic conductivity in mined strata may change the residence time for water traveling through the system. Data from the Big Bear Spring show a slight increase in TDS with time (Figure 16a), but this is probably related more to decrease in flow than to changes in residence time caused by mining (Figure 16b). TDS was generally lower during the high flow period before 1988 (Table IV-6 - Note: TDS was not determined during the highest flows during this period). TDS was higher than average during 1990 - 1991 and 1995 - 1996. The 1990 - 1991 increase in TDS corresponds to when Star Point Mine began mining under Gentry Ridge, and also roughly corresponds to when Bear Canyon Mine began discharging water intercepted in the mine in 1987 and then increased discharge beginning in 1991. The 1995 increase corresponds to the period when flows at several springs were at their lowest due to drought and when pumping from the Gentry Ridge Horst across the Bear Canyon Graben reached its maximum average monthly flow (Figure 2). The high value in 1999 is an unexplained single-point anomaly, perhaps caused by lab or field error. No definitive conclusions can be drawn about the relationship between mining operations at the Star Point and Bear Canyon Mines and changes in TDS at Big Bear Spring, although some short-term increases do appear related to mining activities.

Table IV-6: Big Bear Spring TDS

Station	Average - 1980 to 1988	Average - 1989 to 2000	Historic Average 1980 - 2000
TDS	289	360	350

Data from Bear Canyon Mine and CVSSD.

The data presented by Bear Canyon and Star Point Mines show that Big Bear Spring water differs in oxygen and hydrogen isotopic-ratios in relation to the Meteoric Water Line (Figure 17). Big Bear Spring data plot below the Meteoric Water Line for the sample presented by Co-Op in 1995 and the data plot above the water line for the sample obtained by Star Point prior to 1991.

Water with an isotopic composition that plots below the meteoric water line is considered to be isotopically enriched, and that above is isotopically depleted. Isotopic enrichment or depletion may result from the climate at the time of precipitation, geochemical changes that have occurred in the subsurface, or both. The variation between the two Big Bear Spring samples may simply reflect seasonal changes. The data are insufficient to make a definitive interpretation.

Spring Sources with Wildlife and Agricultural Uses

Miller Creek Springs

Springs 229, 232, 238, 492, 494, 500, 530, 753, 978, and S18-2 (Map 6) were monitored in association with USGS Water-Resources Investigations Report 95-4025 (Slaughter and others, 1995). These springs may have been affected by subsidence caused by longwall mining in the Star Point Mine (Map 3). Discharge from spring 500 diminished, following mining in the Wattis seam but prior to mining the Third Seam. Discharge from spring S18-2 diminished substantially about the same time and then became dry after June 1991. Spring 229 diminished in mid-summer, which is not unusual, but the spring did not regain measurable discharge after June 1989. Slaughter drew no definitive conclusion on the effect of mining subsidence on spring discharge.

Water quality in four springs did vary between pre-mining and post-mining data with slight increases in sulfate and slight decreases in bicarbonate recorded at springs 530, 238, 492, and 978 in 1992. No substantial variation in water quality was determined between the pre-mining and post-mining periods by the USGS study (Slaughter and others, 1995).

New springs may have developed below Gentry Ridge along the coal outcrops southeast and down dip from the mine sumps and well P86-01-TD (Figure 3). Water was pumped across the Bear Canyon Graben from the west into Area 8 and the Mother Goose sump in the Third Seam (Map 3). In a field visit to the Hiawatha Mine in 1997, UDOGM personnel noted that a considerable amount of water was flowing from seeps above and along the coal outcrops in the South Fork of Right Fork of Miller Creek. If these seeps and springs resulted from the pumping operations at the Star Point Mine they would have been expected to diminish after pumping operations ceased. No seeps or spring surveys were conducted in this region during or following pumping operations, and there has been no follow-up visit by the Division.

Gentry Ridge Springs

On August 16, 1997, Lee Mc Elprang, a private citizen concerned for the springs and water rights in the area, accompanied David Darby of UDOGM; Liane Mattson, Jeff DeFreest, and Charles Yankowitz of the USFS; and John Pappas of the Star Point Mine to observed springs in the Gentry Mountain region near Wild Cattle Hollow (Map 6). There is a concern that springs 424, 450, 452,

753, 971, 458, and 486 had been affected by mining subsidence. During this site visit the springs were flowing; however, it was raining the day of the visit so flow rates could not be measured accurately. It should be noted that some factors had changed by the time these springs were visited: 1) the drought period lasting through 1995 had ended, and 2) mine de-watering had ceased. Spring 971 east of the Bear Canyon Fault lies over longwall panels 4 and 5 where subsidence occurred (Map 3). This spring have been monitored on an irregular basis beginning in 1989. The only flow recorded was in May 1990; however, water-quality data were obtained on May 30, 1990 and July 15, 1991. This spring is roughly 1,200 feet above the Wattis Seam and was mined under in June 1987. From July 1987 through July 1988 longwall panels were mined in the Third Seam. This spring could have been directly affected by mining in the Wattis and Third Seams, but because there are no flow data prior to 1989, the impact of mining on the flow of this spring cannot be determined.

SURFACE-WATER RESOURCE HYDROLOGIC IMPACT ASSESSMENT

Under this section, potential surface-water impacts are described first, then mine-water discharge information is discussed and finally data from drainages are reviewed for impacts associated with mining. This review focuses on the drainages with mine-water discharge or other identified potentials for impact.

POTENTIAL IMPACTS TO SURFACE-WATER QUALITY AND QUANTITY

Water Quality - General

Increases in TDS and sulfate are the most commonly observed changes in surface-water quality that result from mining in the CIA. These chemical changes are not often significant, because there is a large variability in TDS in the natural system and the water quality degrades downstream naturally. Mining may alter surface-water quality when surface water is re-routed and mine-water flows are discharged to the surface.

Re-routing surface water may change localized water quality by increasing the runoff retention time from a mine-site and decreasing sediment loading. The changes in peak flows and sediment load may increase or decrease stream competence and downstream channel aggregation or degradation.

Mining operations may change water quality due to contamination from acid- or toxic-forming materials, hydrocarbon and chemical contamination, other materials associated with mining such as rock-dust and road salting, increased sediment yield from disturbed areas, flooding and streamflow alteration.

Surface-water quantity changes include mine-water discharge, losses to stream flow through interception from subsidence, and diversion of surface water. Re-directing surface water may change localized flow characteristics, increase the detention time for runoff from a mine site, or may locally decrease or increase peak flows rates and flow velocities. Disturbed areas may increase the runoff volume and decrease infiltration, and sedimentation ponds may locally increase infiltration or evaporation rates. Mine-water discharges may be at constant or varied

rates and be of sufficient volume to change the flow regimen. Subsidence holes or fractures that propagate to the surface may reduce or relocate stream flow or ephemeral flow. Subsidence induced landslides or rock fall may interrupt stream flow.

Streams within the CIA receive maximum flow rates in May through July in response to snowmelt runoff (Price and Plantz, 1987). Flows decrease significantly during the autumn and winter months. Summer thunderstorms may cause localized short-duration, high-intensity runoff.

Water Use

The Price and San Rafael River Basins are primarily used for stock watering, farming, coal mining, electric power generation, and industrial purposes. Within the Castle Valley, agriculture and power production utilize nearly all of the in-flowing water (Mundorff, 1972). Flows in the gaged streams may occasionally approach zero. Storage reservoirs are common at higher elevations west and north of the CIA.

Minewater Discharge to Surface Waters

The mine water discharged from the Bear Canyon and Hiawatha Mines as reported by the Utah Pollutant Discharge Elimination System (UPDES) Permit, Discharge Monitoring Reports (DMR) are summarized in Table IV-7. The Deer Creek Waste Rock Site and the Trail Canyon Mine do not have mine-water discharge. All monitored sites do not provide data from a totalizing flow meter, therefore total flow volumes discharged from some mines are unknown.

Table IV-7: Minewater Discharge: Reported by UPDES Discharge Monitoring Report

Mine (period of record)	Maximum Monthly Flow		Maximum of the Monthly Average Flows		Average Flow	#Months with Zero Flow recorded
	GPD	Date	GPM	Date	GPM	GPM
Star Point UPDES-011 (10/1990-12/1997)	216,000	Nov. 1996	150	Nov. 1996	77	74 (from two sample records)
Hiawatha UPDES-001 Mohrland Portal (1/1979- 1/1997)	N.A.		^1,584	Aug. 1993 Sept. 1993	379.6	23
Hiawatha UPDES-002 Miller Creek (1/1983-3/1997)	N.A.		^1221	May 1991	159.6	22
Hiawatha UPDES-012 North Fork Vent (6/1983 - 7/1994)	N.A.		^14	May 1984	2.6	17
Bear Canyon UPDES-003 (4/1991- 3/1997)	504,000	Jan. 1992	318	Feb. 1992	148	0

N.A. means not available. ^ No averages available maximum and minimum determined from recorded point discharge.
*Averages, Minimum and Maximum were determined for months where there was a discharge. Months without discharge were not included.
Missing data are as follows:
Hiawatha -001Some months have no data record from the 1980's through the beginning of 1990.
Hiawatha -002Some monthly information is missing through the years in the period of record. Larger blocks of data are missing from 1986 through 1988 and in 1993 and 1994.
Hiawatha -010Some monthly information is missing through the years in the period of record.
Bear Canyon Some months have no data record from the 1980's through the beginning of 1990. An earlier discharge is reported in 1985 at 0.2 GPM.

THE SAN RAFAEL RIVER BASIN

Huntington Drainage

Nuck Woodward Creek and Little Park Canyon

Data from two monitoring sites were collected by Cypress Plateau on Nuck Woodward Creek above and below Little Park Canyon (Map 6). A brief data review showed no obvious changes to the water quantity or quality through the monitored period. There are no discharges from mine sites to this drainage.

Mining in the Castle Valley Ridge area was designed to protect the channel in Little Park Canyon by leaving a block of coal beneath the channel. This channel has been dry for at least 6 months each year during 1992 and 1993 making it an intermittent channel. No subsidence was recorded for this area.

Bear Creek

Water Quantity

Stream flow in Bear Creek varies greatly depending on precipitation and runoff factors. Table IV-8 below summarizes Bear Creek flows and mine-water discharge. The average daily discharge at the Bear Canyon Mine is determined by dividing the total monthly flow from the in-line flow meter by the number of days in each month. Discharge rates can vary due to the rate of mining, in-mine sumping, and mining consumption.

Figure 18 shows the difference between flows recorded in Bear Creek at BC-1 above the Bear Canyon Mine and BC-2 below the mine. It also shows the discharge from UTG04006-004, the Bear Canyon Mine-water discharge point. Before significant discharge from the mine began, flows above and below the mine were similar. The larger flow downstream at BC-2 from 1991 through 1999 can be attributed to the Bear Canyon Mine discharge.

TABLE: IV-8: Bear Creek and Mine-water Discharge

Station	Pre-mine water Discharge Average (gpm) (8/80 -8/91)	Post-mine water Discharge Average (gpm) (8/91 - 2nd Q/97)	Historic Average (gpm) (8/80 - 2nd Q/97)
Upper Bear Creek BC-1	51.3	80.4	62.0
Lower Bear Creek BC-2	52.5	209	117

Mine-water Discharge UTG04006-004	Maximum (gpm)	Historic Average (gpm)
UPDES Discharge Point (4/1991 -3/1997)	782	141

Mining in the Tank Seam has been dry and requires that water be pumped from the Blind Canyon Seam, reducing the discharge to Bear Creek. A waterline was installed from the Blind Canyon Seam up through a borehole to the Tank Seam. Mining has artificially increased flows to the creek through mine-water discharge. Therefore, mining consumption is not expected to decrease natural streamflow rates.

Water Quality

Sediment

Total Suspended Solids (TSS) levels in Bear Creak above the Bear Canyon Mine are typically higher than below the mine (Table IV-9). Mine water is discharged into Bear Creek between the upper and lower sites. The mine discharge water contains considerably less TSS than the stream water and dilution is a factor in decreases noted at the lower sampling location (BC-2). Additionally, the stream gradient decreases down canyon reducing stream velocity and allowing suspended sediments to be deposited.

TSS at BC-1 (upstream) and BC-2 (downstream) average 3845.7 and 3187.4 mg/L. During precipitation events large amounts of sediment are transported in Bear Creek, thus large data ranges are observed for TSS. The maximum TSS for the BC-1 and BC-2 are 37,940 and 28,092 mg/L, respectively.

The TSS levels from the mine water DMR (UTG04006-004) are lower than stream background levels. Water in the mine is contained in sumps until settling allows discharge water to be in compliance with the mine's UPDES permit.

TABLE IV-9: Bear Creek Total Dissolved and Suspended Solids

	Total Dissolved Solids (mg/L)		Total Suspended Solids (mg/L)	
Station	Historic Average	Historic Maximum	Historic Average	Historic Maximum
Upper Bear Creek	498	3,200	2,789	23,098

BC-1				
Lower Bear Creek BC-2	459	3310	2,527	22,270
Mine-water Discharge UTG04006-004	333	998	8.3	46

Data from UDOGM database.

From a total of 110 TSS mine-water discharge samples, 65 samples were below the detection limit and 45 above the detection limit. Average TSS was 8.3 mg/L. The maximum mine-water discharge value recorded as 46 mg/L, which is much lower than the levels recorded for Bear Creek.

The minewater discharge, containing little sediment, can increase the waters ability to transport sediment (competence). The increase in competence may increase degradation (down cutting) below the discharge point until equilibrium is reached: however, the potential for increased sediment transport is naturally decreased because the gradient decreases downstream from the mine-water discharge. This in turn can create a shallow stream channel that will need to adjust to the sediment loading.

According to Susan White, Reclamation Biologist with the UDOGM, Bear Creek does not support fish and is not considered a cold water fishery. It may support some cold water species of macro-invertebrates. Huntington Creek is a local cold water fishery and has a Class 3A state water-quality designation. Recreational use (Class 2) of Bear Creek is primarily from the neighboring Trail Canyon City residents. The increased mine flow would not negatively impact the recreation at this site.

Total Dissolved Solids

The Class 4 water-quality standard for TDS is 1,200 mg/L. The maximum TDS level in the Bear Canyon Mine water is 782 mg/L with an average concentration of 363 mg/L, which is less than TDS concentrations upstream. Mine-water TDS may decrease the natural water TDS at the downstream Bear Creek site.

Additional Quality Standards

Acid forming discharges are uncommon in the region and acid forming materials are not known to be extensive in Utah coal mines. Should the presence of pyrite in the mine area cause a decreased pH locally the mixing with higher pH waters in the system would result in localized affects in the permit area and is not likely occur off the permit area due to downstream buffering.

THE PRICE RIVER BASIN

Sand Wash Drainage

Potential discharges within the Sand Wash Drainage would come from two UPDES discharge points located at the south west end of the Hiawatha Mine (UT0023094-006A, and -

007A). No discharge has been recorded for these sites.

Mudwater Canyon

Mudwater Canyon received mine discharge from the Star Point Mine, UT0023736-001 several years ago. This drainage is in an ephemeral system and impacts appear to be minimal. Data from monitoring the UPDES parameters are summarized in the Star Point Mine Plan. Their table lists the recommended EPA standards for wildlife as taken from the EPA. The results from their table show the following:

- pH, Iron, and Manganese are well below EPA standards;
- Oil & Grease and Total Suspended Solids levels are low; and
- TDS levels have increased significantly in 1996, but the level discharged is still no higher than the receiving stream.

Fish Creek

Some portions of the Fish Creek drainage along Wild Horse Ridge may be subsided. Otherwise, there should be no impacts from mining in this drainage. Monitoring station FC-1, near the mouth of Left Fork of Fish Creek, was added to the Bear Canyon Mine plan to monitor water quality and quantity in the creek.

Miller Creek Drainage

The direction of surface water movement is from Star Point Ridge, east of the Bear Canyon Graben, is down-dip to the south-southeast, toward Miller Creek. Baseflow to Miller Creek from the Star Point Sandstone was estimated to be on the order of 62 gpm, based on a stream survey conducted on the North Fork of the Right Fork of Miller Creek. Baseflow from the saturated zone at the time represented approximately 50 percent of the total streamflow within the creek (Star Point Mine Plan, page 700-10).

Significant baseflow occurs to North Fork of the Right Fork of Miller Creek where the stream crosses the Star Point Sandstone. Between the headwaters region and stream monitoring station ST-1, sulfate concentrations increase significantly.

TDS concentrations at ST-1(same as M-15 - see Map 6 for locations of monitoring stations) ranged from 240 mg/L to 1,472 mg/L over 10 years between August 1980 to September 1990 (Star Point Mine Plan). Specific conductance at M-14 was measured at 592 micro-mhos per centimeter and doubled to 1,190 micro-mhos per centimeter at ST-1(M-15), indicating a significant inflow of poorer quality water.

Subsidence Impacts

Longwall mining in the Wattis Seam began August 2, 1988 and ended April 26, 1990. The Third Seam was mined in December 1990 through November 3, 1991. The overburden thickness above the Wattis coal seam is about 300 to 500 feet. As a result of subsidence, three surface fractures - 8 inches, 4 feet and 7 feet wide - had occurred by August 1992. The following changes to

the hydrology of the Right Fork of Miller Creek resulted from the longwall mining. (Slaughter and others, 1995):

- Intercepted surface flows occurred at two locations. Surface water was diverted into fractures;
- Debris slide/rockfall deposition associated with subsidence occurred in the North Fork of the Right Fork of Miller Creek;
- Intercepted water was discharged at a new location where the existing channel traversed the Star Point Sandstone below the coal seam (surface-water monitoring station M-8); and
- Water-quality changes downstream of the mining included increased TDS from 300 mg/L to 1,500 mg/L and changed from predominate ions of magnesium, calcium and bicarbonate to predominate ions of magnesium and sulfate.

Intercepted Flows

The two interceptions of surface flow occurred in the North Fork of the Right Fork of Miller Creek in Section 18, T. 15 S., R. 18 E. and in a side canyon to the North Fork of the Right Fork in Section 12 (Star Point Mine, 1996 Annual Report, Subsidence Monitoring Report). The 1996 Star Point Mine PHC quantified the loss to stream flow as "...the maximum potential loss to the base flow of the North Fork of the Right Fork of Miller Creek is less than nine gpm".

The subsidence features in the North Fork Right Fork of Miller Creek located in Section 18 are associated with fractures. The stream water was diverted into the mine near subsidence monitoring point GS-1 in 1989. The subsidence affected a section of the stream approximately 800 feet long. (Star Point Mine, 1996 Annual Report, Subsidence Monitoring Report). The stream was diverted into the fractures at surface-water monitoring point M-6 in January or February 1989. At this location overburden is about 300 feet above the Wattis Coal Seam.

The side canyon to the North Fork of the Right Fork of Miller Creek, in the northwest quarter of Section 12, T. 15 S., R. 18 E., was diverted into the ground due to mining subsidence sometime between January 27 and April 27, 1989. It was again diverted at an upstream location in June 1990. Both surface-water interceptions occurred at sandstone-siltstone contacts. Overburden above the Wattis Seam is about 500 ft, at monitoring site M-3 (Slaughter and others, 1995) and subsidence was associated with known faults. Subsidence varied from hairline fractures to 6 inches and vertical displacement across the cracks varied from none to 2 feet. Width varied from hairline to about 2 feet. The cracks were fenced in the summer of 1991.

Beginning in July 1990, flow was observed in the section of the stream where flow had been previously intercepted. Flows have been observed during years with increased snow precipitation. These flows may suggest the fractures are healing. The Star Point Mine committed to collect additional data to determine if the fractures are healing. (Star Point Mine, 1996 Annual Report, Subsidence Monitoring Report), but the outcome of further investigations is not known at this time

Debris Slide/Rockfall Deposition

In October or November 1988, a rock slide moved soil, rock, and vegetation into the North Fork of the Right Fork of Miller Creek. The debris slide, about 150 feet wide, originated in the Blackhawk Formation and Castlegate Sandstone. The movement of water through this debris could

account for some of the changes in the chemical composition of the water that are discussed below.

Subsidence and Surface-water Quantity Changes

Streamflow appears to have increased through the stream reach traversing the Blackhawk Formation. Direct seepage to the stream from groundwater is about 21 gpm; however, of the 15 gpm increase between measuring points M-6 and M-8, a substantial inflow is presumed to be derived from the Star Point Sandstone and a channel sandstone at the base of the Blackhawk Formation where the Hiawatha Coal Seam has been locally displaced. According to the Star Point Mine 1996 Annual Subsidence Monitoring Report, the increase in flow due to seepage from the system was anticipated from the Spring Canyon Member of the Star Point Sandstone. The water table identified within the Spring Canyon Member flows to the southeast toward Miller Creek. The remaining 12 gpm increase measured between M-2 and M-8 is believed to be derived from the saturated zone system of the Star Point Sandstone.

According to the Star Point Mine 1996 Annual Subsidence Monitoring Report, the loss in streamflow between measuring points M-9 and M-14 is believed to be due to flow from the stream into alluvial deposits that are present in the channel below station M-9. North Fork of the Right Fork of Miller Creek experiences a substantial gain in stream flow through the Storrs and Panther members of the Star Point Sandstone, based on a 49 gpm gain in flow between measuring points M-14 and M-15.

Subsidence and Surface-water Quality Changes

The most downstream point of impact to North Fork of the Right Fork of Miller Creek is at monitoring Site M-8. Selected water-quality parameters at this point were used to summarize the resulting change in water-quality characteristics to Miller Creek from mining subsidence. Water samples collected indicate the concentration of dissolved constituents increased from 310 to 799 mg/L between September and December 1988 and the type of water changed from magnesium calcium bicarbonate to magnesium sulfate. Dissolved solids increased to a maximum of 1,602 mg/L in July 1990 (Slaughter and others, 1995).

Mine-water Discharge Surface-water Quality Changes

The Hiawatha Mine surface facilities are located primarily within the Miller Creek Drainage. Numerous UPDES Discharge points are associated with the mine (UPDES Permit No. UT0023094). The following UPDES sites have no recorded discharge over the period of record:

-003	Upper Coal Storage Yard Pond
-004	Pond #4, North of Slurry Pond #1 (reclaimed-no longer exists)
-005	Pond #5, East of Slurry Pond #1.
-006	Pond #6, East of Slurry Pond #4.
-007	Pond #7 South East of Slurry Pond #5.
-008	Middle Fork Mine Yard.
-009	South Fork Mine Yard.
-011	Truck Loading Pond.

-013 Number 6 Mine-water tank overflow.

All these sites have a period of record from July 1994 through May 1991 except for site -013, which has a period of record from May 1991 through July 1994.

The information presented in Table IV-10 summarizes data for the three sites with recorded discharge to the Miller Creek Drainage. These sites include: The Hiawatha North Fork Ventilation Fan (UPDES UT0023094-010), a discharge valve on the Mohrland Pipe Line that is monitored when drained (UPDES-012), and the Miller Creek Mine-water Discharge (UPDES-002).

Mine-water discharges from UPDES No. UT0023094-002 through a pipe south of the Hiawatha Preparation Plant area, enters an underground culvert beneath the preparation plant, exits the culvert to the north of Refuse Pile #4, and finally drains to a tributary to Miller Creek. Iron coatings are observed at both the mine pipe and culvert discharge locations. To check for acid production, Bob Davidson and Susan White of UDOGM conducted sampling during a site visit on July 8, 1977. Although the mine water is acidified within the mine increasing the ferrous iron (Fe +2) concentration in solution, the contact with CO_2 and $CaCO_3$ raises the pH and results in Fe $(OH)_3$ deposition and pH within the 6.5 -9 limits.

Table IV-10: Mine-water Discharges Reported by UPDES Discharge Monitoring Report

Hiawatha Mine-UPDES Permit No. UT0023094	North Fork Ventilation Fan UPDES-010			Hiawatha Complex Discharge UPDES-012			Hiawatha Miller Creek Mine-water Discharge UPDES-002		
	ax	in	vg.	ax	in	Avg.	ax	in	Avg.
Flow (gpm)	74		7.6	4		5.09	51		21.77
Field Specific Conductance umhos/cm	73	99	11	52	68	602.4	199	77	943
Field pH	.11	.82	.A.	.4	.5	N.A.	.6	.5	N.A.
TSS(mg/L)	4		.43	3	.D.	5.68	2	.D.	2.07
TDS(mg/L)	18	41	18	40	13	3 43.3	010	33	702
T-Iron (mg/L)	.96	.D.	.53	44	.D.	0.07	.0	.D.	0.13

Oil and Grease	.D.	.D.	.D.	.33	.D.	0 .35	.6	.D.	1 .46

Serviceberry Creek

A major portion of the mine facilities surround Sage Brush Canyon, a tributary to Serviceberry Creek. Both Sage Brush Creek and Serviceberry Creek function as ephemeral drainages (Map 6), the channels are usually dry except during rainstorms or when snow melts. The main stem of Serviceberry Creek has no water monitoring locations; however, water monitoring site 10-1 is located in Sage Brush Canyon. The site once had an average flow of 3.5 gpm and a maximum flow of 35.9 gpm. The source for these flows was the overflow from the make-up water storage tank. The make-up water supplied the coal treatment plant and received water from mine discharge. When the tank overflowed it discharged into Sage Brush Creek under UPDES permit UTG-0040025-011, the mine labeled it monitoring site 011. Longwall operations ceased production in November 1996, all of Star Point's entries are closed (sealed) and backfilled. The Star Point Mine no longer discharges water as of January 2000. Three sedimentation ponds (Ponds 005, 006 and 009) and several small settling contain the runoff from the coal refuse pile. Ponds 005 and 009 and all the catch basins will be destroyed as coal refuse is removed from the piled. Pond 006 will be reclaimed to meet approximate original contour. Removal of the refuse by SCA will only benefit the area by reducing the volume of refuse and ensuring that it will never be exposed. All runoff will be controlled by alternate sediment control measures until vegetation is established and effluent standards to receiving streams are met.

The substitute soil stockpile is located in a Serviceberry Creek. All of the stockpiled material will be removed and the site regraded to AOC. The drainage on the site will be restored to transmit flows. As with the refuse pile alternate sediment control measures will be implemented to control sediment loading to receiving streams.

The area permitted by SCA lies within the Gentry CIA. No other potential impacts will take place than have already been identified in the CIA boundary, established before SCA acquired the refuse pile and subsoil stockpile.

Tie Fork Canyon

Water-quality changes in Tie Fork Canyon may occur from changes in the water quality of Upper Tie Fork Spring. No surface-water quality monitoring sites are currently monitored in lower Tie Fork Drainage. Sites 34-1 and 34-2 are located near the Gentry Hollow and Wild Cattle Hollow confluence (Map 6). When the discharge from Upper Tie Fork is not diverted into CVSSD's collection system, it may change stream water quality because of its significant flow rate. Tie Fork Spring water characteristics are discussed in the section on Tie Fork Spring.

V. MATERIAL DAMAGE CRITERIA

Material damage is not defined in either the Utah or Federal regulations. Criteria that are used to determine material damage to hydrologic resources in coal mining programs administered by other states or by the Federal office of Surface Mining (OSM) include:

C! Actual or potential violation of water-quality criteria established by federal, state or local jurisdictions;

C - Changes to the hydrologic balance that would significantly affect actual or potential uses as designated by the regulatory authority;

C - Reduction, loss, impairment, or preclusion of the utility of the resource to an existing or potential water user;

C - Short term (completion of reclamation and bond release) impairment of actual water uses that cannot be mitigated; and

C - Significant actual or potential degradation of quantity or quality of surface water or important aquifers.

MATERIAL DAMAGE CRITERIA - RELEVANT STANDARDS AGAINST WHICH PREDICTED IMPACTS CAN BE COMPARED

The following criteria, alone or in-combination with other criteria, may be used to determine Material Damage and will be based on factors related to the use of a resource:

C Utah Department of Health Classification; waters in and adjacent to the CIA are classified as 1C -protected for domestic use with prior treatment, 3A- protected for cold water species of game fish and cold water aquatic life, and 4 - protected for agricultural uses;

C Water-quality Standards for waters of the State of Utah set by the Utah Department of Environmental Quality and the state Division of Water Quality (UDWQ, 1994);

C Primary (PDW) and secondary (SDW) drinking water standards set by the Division of Drinking Water in Rules for Public Drinking Water Systems, R309 (Utah Administrative Code);

C Water-quality standards, 40CFR Ch.1 Subpart 434.55, applies to underground mine-water drainage at Post-Mining Areas after best practicable control technology currently available is applied;

- Changes in water quality and quantity that cause irreparable damage so as to impair a use. These would be commensurate with identified land uses within and adjacent to the mine;

- Category 1 Waters within boundaries of a USDA National Forest, with specific exceptions, are designated by the Utah Division of Water Quality as High Quality Waters and are subject to the state's anti-degradation policy to maintain water at the existing high quality and prohibit new point source discharges of wastewater, treated or otherwise (UDWQ, 1994, R317-2-3.2 and R317-2-12.1,);

- The Utah Department of Environmental Quality, Division of Water Quality authorized discharge into surface waters under the Utah Pollutant Discharge Elimination System (UPDES); and

- Flow diminution demonstrated to be caused by mining activities that reduce the use for a water right appropriated by the state.

Applicable UPDES standards are listed in Table V-I. Additional limits apply to each site and are reviewed and presented in greater detail if the limit is exceeded. Toxic pollutant discharge limitations apply, based on the occurrence, concentration levels, and discharging or placing wastes that produce an undesirable effect.

DAMAGE TO RESOURCES

Hydrologic Impacts to the Upper Tie Fork Spring were mitigated by Cypress through an agreement with the CVSSD and Huntington-Cleveland Irrigation Company.

Available information does not definitively identify a cause for the decline in flow at Birch Spring. There are spring development and maintenance aspects that may have effected water quantity, but all of these, especially earlier ones, are not documented or clearly understood. The source of the groundwater and its flow path to Birch Spring are not clearly known, and other questions about changes in the quality and quantity of the resource at Birch Spring remain answered. Collection of additional data and information from the mine operators and the water users may, over time, to answer some of these questions.

Utah Administrative Rule R645-301-731.350 requires that determinations of probable hydrologic consequences include findings on underground coal mining and reclamation activities to determine if state appropriated water resources have been impacted. Any State-appropriated water resources contamination, diminished or interruption from coal mining activities have to be mitigated, replaced or the right holder compensated for the value of the loss. This rule is effective for state appropriated waters that exist within the permit or adjacent areas at the time the permit application was submitted or after October 24, 1992.

Hiawatha Coal Company supplied additional information and studies conducted to update their MRP as defined by DOGM in the permit renewal process. One factor reviewed was

to identify the potential impacts from mining within the Hiawatha Mine Complex permit area to Big Bear Spring.

The Big Bear Spring flow hydrograph reflects a high seasonal peak flow from 1980 to 1987 (Figure 14b). Those same years appeared to have above normal drought conditions (positive PHDI units). Drought conditions from 1987 to 1993 could have contributed to the decrease in the peak flow hydrograph. However, when the recovery rate of Big Bear Spring is compared with other springs, the peak flows recovered after 1993 in Little Bear Spring and in Lower Tie Fork, but not in Big Bear Spring (Figure 14a). This comparison may indicate that mining, or some other factor may have influenced the flow to Big Bear Spring.

Big Bear Spring is located in Bear Canyon and within the Bear Canyon graben (Map 4). All mining conducted in the Hiawatha Complex mines took place on the east side of the Bear Canyon graben (Maps 3a, 3b and 3c). It has been identified in this CHIA that mining has come in contact with the Bear Canyon fault on a few occasions and inflows to the mine were produced. Plate 7-22 of Hiawatha's MRP shows one inflow in the 10th North (in the 1970's) that was very large. It produced approximately 1000 gallons per minute (gpm) when first contacted, then reduced to 100 gpm over time.

Older mine working maps were reviewed to establish any potential influence that mining at the Hiawatha Complex may have had on the groundwater flows, both within the mine and to state appropriated water resources. The older, superceded, mining sequence maps, Exhibit III-7a (October 1980), and 7b (June 29, 1983), from Chapter III and mine projection map Exhibit III-6b (1988 Annual Report), shows that the western side of the Bear Canyon fault was mined in the B Seam prior to 1980 (CHIA Map 3b). There was also extensive mining on the east side of the Bear Canyon fault in the Hiawatha Seam, along the south- western side of the permit area (CHIA, Map 3c). There is no mining along the Bear Canyon fault in the A Seam.

Most inflows to the mine were reported to occur in the B Seam. Since the mine closed in 1993, inflow locations and quantity are not completely known. Total mine discharge is measured at the Mohrland portal site. The Division's records indicate that US Fuel was discharging mine water from Mohrland Portal from February 1979 to present. Hiawatha Coal Company has committed to age date and characterize mine water inflows when the mine re-opens.

From the information presented on geology and groundwater it is likely that the Bear Canyon fault stores some water and acts as a barrier to groundwater moving east. Hiawatha Coal Company recently supplied stratigraphic contour maps, Plates 6-6, 6-9 and 6-12 in Hiawatha's MRP, which show that any drainage intercepted and directed into the mine would travel in a south westerly direction. This is the reason for the Mohrland discharge. Total flow from the Morhland portal represents the total flow of groundwater into the mine. Some water is known to be coming from the 10th West section of the King IV Mine. Other flows are known to be coming from the older King 2 Mine, since it was used as a sump area at one time. Plate 7-1 of the Hiawatha MRP identifies four areas in the mine where water inflows. It was discussed earlier that mining in the Pleasant Valley graben likely increased flows to the Hiawatha Mine as groundwater was stored in the Star Point

Mine up dip of the Hiawatha Mine. During the years Star Point was pumping water to their underground reservoir east of the Bear Canyon fault, the discharge at Mohrland increased.

It appears from all information submitted by Hiawatha Coal Company that all mining that could intercept groundwater along the Bear Canyon fault was completed prior to 1983. The information provided does not point to any specific cause for decreased flows to Big Bear Spring as far as mining within the Hiawatha Mine Complex is concerned. Based on the time difference between mining of the Hiawatha Mine and identified drawdown of flow to Big Bear spring.

Springs impacted by the subsidence occurring east of the North Fork of the Right Fork of Miller Creek were not specifically tied to a water right; therefore, no material damage was identified in association with these springs. Water was intercepted by the mine and is believed to re-issue down stream where new flow was documented.

Table V-1: Mine-water Discharges Reported by UPDES Discharge Monitoring Report

Limitations	Trail Canyon Mine-Bear Canyon Mine UPDES Permit UTG0040000 expires 4/30/2003			Star Point Mine UPDES Permit UT-0023736 expires 12/31/91			Hiawatha Mine UPDES Permit UT0023094 - Not located within the MRP. To be incorporated later.			PacifiCorp Deer Creek Coal Mine UPDES Permit UT0023604 expires 11/30/97		
Field pH (range)	6.5-9.0			6.5-9.0			6.5-9.0			6.5-9.0		
Discharge	30-Day	7-Day	Daily Max	30-Day	7-Day	Daily Max	30-Day	7-Day	Daily Max	30-Day	7-Day	Daily Max
Flow (gpm)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
TSS (mg/L)	25	35	70	25	35	70				25	35	70
TDS	NA	NA	2,000 (lb/day)	NA	NA	2,000 (lb/day) *1,300				NA	NA	2,000 (lb/day)
T-Iron (mg/L)	NA	NA	1.0	NA	NA	*2.0 (a)				NA	NA	1.0 (b)
Oil and Grease (mg/L)	NA	NA	10	NA	NA	10				NA	NA	10

a. Total Iron exceeding 2.0(mg/L) requires review of actions necessary to achieve compliance. No daily maximum will exceed 7 mg/L.
b. Total Iron standard may be approved if water-quality standard is not violated.
c. TDS limit applies to a total for all discharge points associated with this UPDES permit.
* Applies to site 001.

DAMAGE TO SURFACE-WATER RESOURCES

Miller Creek Drainage

Water Right number 92-174 located on the Right Fork of Miller Creek is owned by U. S. Fuel Company and is reserved for industrial purposes (3.3 cfs). U.S. Fuel Company made an agreement with CPMC to allow impacts due to mining. Prior to mining the flows were around 6 gpm (Star Point Mine 1996 Annual Report, Subsidence Monitoring Report). Although surface-water quality and quantity changes occurred, because of mining in the North Fork of Miller Creek, no determination was made by the Division of Water Resources or the State Department of Environmental Quality showing that changes to the hydrologic balance would significantly affect actual or potential uses. These waters were outside of the USDA National Forest Boundary and therefore were not subject to the anti-degradation policy that applies within the USDA National Forest Boundary. Although TDS and sulfate levels have increased there was no identified impairment of the designated use, thus no material damage has occurred.

SUBSIDENCE EFFECTS

Noticeable cracks have occurred in the Blackhawk Formation where pillars have been pulled in both the Star Point and Bear Canyon Mines, in areas with a shallow overburden, and on narrow promontories and ridges with steep side slopes. As mitigation, some of these features were fenced to the satisfaction of the Forest Service. No material damage claim was identified in association with this subsidence from the landowner (USDA Forest Service).

VI. STATEMENT OF FINDINGS

It has previously been determined by the Board of Oil, Gas and Mining and upheld by the Supreme Court of the State of Utah, December 31, 1996, that current scientific evidence does not indicate a hydrologic connection between the Bear Canyon Mine, Blind Canyon seam, and Big Bear Spring and Birch Spring.

Big Bear Spring has an observed reduction in peak flow following many years of coal mining in the CIA (Figure 14b). There are several possibilities that Big Bear Spring could have been impacted, the flow data set for the spring indicates that peak annual flows are being diminished by some activity, however no one specific activity or reason can be identified at this time. An evaluation of the impacts caused by drought is inconclusive. Data indicates that the drought seasons may have had some impact on the spring, as well.

Since the closure of the Hiawatha Mine, access has been lost to many of the underground workings, where mine water inflow and underground flow paths could be measured and identified. It is hoped that renewed underground access will provide useful information to age date the inflow sources and establish a link to recharge areas.

There is no direct evidence to connect the decreased flow in Big Bear Spring or Birch Spring with mine water interception or subsidence at the Hiawatha Complex. There is no evidence that appropriated water rights for this area that were issued after October 24, 1992, have been impacted.

Numerous hydrologic changes have occurred over the extensive period of mining in the Gentry Mountain CIA. This is reflected by the changes observed in mine discharge rate and as noted in flow hydrographs of some springs. Most of these changes appear to have taken place in the past, many years prior to SMCRA. Water rights were issued on mine discharges in the 1870s and 1880s. Since then, the mines have changed ownership and recorded hydrologic information has been lost. Some mining related influences have been influenced. These influences have been mitigated through agreements, between the mine companies, water rights holders, and landowners. Mining in the CIA has been conducted in accordance with applicable rules and without known material damage.

The Division will continue to collect and assess monitoring data, survey reports and other information to identify any mining related changes and impacts to the hydrologic regime of the CIA.

No probability of material damage from anticipated coal mining operations has been found.

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APPENDIX A.

WATER RESOURCE HYDROLOGIC IMPACT ASSESSMENT FIGURES

Figure 1: **Hiawatha Mine Discharge: Upper Tie Fork and Graben Goose**
Figure 1a: **Hiawatha Mine Discharge at Mohrland**
Figure 2: **Hiawatha Mine Discharge: Graben Goose & Bear Canyon Springs**
Figure 3: **Star Point Wells: East of Bear Canyon Fault**
Figure 4: **Star Point Wells: Gentry Ridge**
Figure 5: **Tie Fork Wells: And related Monitoring Sites**
Figure 6: **Bear Canyon Mine: In-Mine Flows Sand Channel**
Figure 7: **Bear Canyon In-Mine Drill Holes**
Figure 8: **Tie Fork Springs and the Palmer Hydrologic Drought Index**
Figure 9: **Sulfate and pH: Tie Fork Well 85-36-2-3**
Figure 10: **Bicarbonate and TDS: Tie Fork Well 85-36-2-3**
Figure 11a: **Birch Spring Flow: Combined Data Sources**
Figure 11b: **Birch Spring Flow: Combined Data Sources**
Figure 12: **Chemistry at SBC-9: Sand Channel**
Figure 13a: **Chemistry at SBC-10: Sand Channel**
Figure 13b: **Chemistry at SBC-13: Sand Channel**
Figure 14: **PHDI in Vicinity of Gentry CHIA**
Figure 14a: **Selected Spring Flow: And the Drought Index Region 5**
Figure 14b: **Bear Canyon Spring the PHDI and Mine-Water Interception**
Figure 15: **Big Bear Spring (Bear Canyon Spring): Annual Flows-Moving Average**
Figure 16a: **Bear Canyon Mine: Big Bear Spring Total Dissolved Solids (TDS) vs Time**
Figure 16b: **Bear Canyon Mine: Big Bear Spring Total Dissolved Solids (TDS) vs Flow**
Figure 17: **Meteoric Water Line: Deuterium and Oxygen 18**
Figure 18: **Bear Canyon Mine & Bear Creek Flows: Flow vs Time**

APPENDIX A

APPENDIX B.

CUMULATIVE HYDROLOGIC IMPACT ASSESSMENT MAPS

Map 1: **Gentry Mountain CHIA Location Map**
Map 1a: **Utah Coal Permit Areas and Palmer Hydrologic Index Climate Divisions**
Map 2: **Cumulative Impact Area (CIA)**
Map 3: **Star Point and Hiawatha Mining & Subsidence Areas**
Map 4: **Bear Canyon & Trail canyon Mining & Subsidence Areas**
Map 5: **Gentry Mountain Geology**
Map 6: **Gentry Mountain CHIA surface Hydrology**

APPENDIX B

APPENDIX C.

UTAH DOGM FIELD REPORT and SUMMARY MEMO from CHARLES REYNOLDS REGARDING OCTOBER 15, 1998 INVESTIGATION of BIRCH SPRINGS and RELATED FAULTS and FRACTURES

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State of Utah
DEPARTMENT OF NATURAL RESOURCES
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DQ 7H

DIVISION OF OIL GAS & MINING
FIELD VISIT FORM
TECHNICAL

Date : 15 October, 1998

Time: 9:00 a.m. to 3:00 p.m.

Mines: CO-OP Bear Canyon Mine.

File Number: ACT/015/025

DOGM Staff: Jim SMITH

Other Attendees: Charles REYNOLDS, CO-OP

Purposes:

1. To examine the 3-dimensional orientation, continuity, and interconnectivity of joints (fractures) associated with Birch Spring.

2. To examine the relationship of the Blind Canyon fault to Birch Spring and associated joints.

3. To examine possible relationships between Birch Spring and the geology and geography of the terrain immediately surrounding the spring.

Observations:

1. Birch Spring is not a single source but several sources flowing from fractures and a fault, mainly on the west side of the box canyon containing the springs.

2. The Blind Canyon fault is evident on aerial photos and on the ground: the fault in the box canyon is not the Blind Canyon fault.

3. Joints and faults appear to strike consistently N-S $\pm$ 5°, but there are a few joints that strike approximately N 20°W.

4. Joints and faults appear to be basically vertical and planar, but on large vertical exposures the joints are often seen to be gently curved or even sinuous.

5. Observed faults are characterized by zones, several feet wide, of large, blocky rubble or breccia. Fracturing in the zone is dominantly vertical to near vertical, for example the fault at the west side at the head of the box canyon containing Birch Spring.

west side at the head of the box canyon containing Birch Spring.

6. Faults and large joints can be followed vertically from the Storrs Sandstone, up through the overlying shales, and into the Spring Canyon Sandstone; however, .

7. Some large adjacent joints, such as those exposed above sources #1 and #2 at Birch Spring, are connected by sets of steeply dipping fractures, similar to the fault zones only not vertically extensive.

8. Large joints can be followed or projected for hundreds of feet along strike.

9. Joints appear to be gradually converging upslope (north) and may actually converge northward or upwards or both.

10. Most of the area is jointed, the distance between joints ranging from 2 or 3 feet to 35 feet; one section between the Blind Canyon fault and Birch Spring is not visibly jointed across an exposure approximately 50 feet wide.

11. Vegetation is growing on the three reclaimed breakout/subsidence areas in Section 28, but the easternmost has continued to settle or subside.

Conclusions:

1. Birch Spring does not issue from the Blind Canyon fault, but the several water sources that constitute Birch Spring issue from large joints and a fault zone.

2. Joints and faults have good continuity vertically and along strike, which is roughly N-S. Ground-water flow from north to south would be facilitated along these fractures.

3. There are thick unfractured sections, and lateral interconnectivity between joints and faults is not as well developed. East-west flow would be impeded relative to north-south flow.

4. Although the terrain is steep, the extensive jointing could allow local recharge from precipitation and snowmelt.

5. Additional reclamation work is needed at the subsidence area in Section 28.

Recommendations:

No further action at this time. Charles REYNOLDS is preparing a response to the complaint from NEWUA, as outlined in Tech-005, that will include his interpretation of the geology and geography of the area around Birch Spring. Further action will depend on the acceptability of CO-OP=s response and on the time and effort UDOGM can allocate to the problem. Further actions could include detailed geologic interpretation from low-altitude aerial photos and 3-dimensional mapping and modeling using EarthVision.

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DIV. OIL, GAS & MINING

December 22, 1998

Coal Program
Utah Division of Oil, Gas & Mining
1594 West North Temple, Suite 1210
P.O. Box 145801
Salt Lake City, Utah 84114-5801

ACT/015/025 #2
Pam, Ken, Sharon

To Whom It May Concern,

Re: Birch Spring Action Plan, Tech Directive 005, Bear Canyon Mine, ACT/015/025, Emery County, Utah

This letter is to summarize the progress of the work which has been accomplished on Steps 3 and 4 of the Action Plan which was approved by the Division per letter dated August 7, 1998.

Step 3 consisted of conducting additional on-the-ground investigations of faults, fractures, and joints in the area of Birch Spring. On October 15, 1998, afield survey was conducted involving myself and Jim Smith, Division representative.

The survey included identifying the faults and fractures associated with and adjacent to Birch Spring. The survey began at Birch Spring. Birch Spring No. 1 and 2 sources flow from the South joint of a double fracture. A significant fracture was also identified 20 feet West of the Birch Spring fracture. A fault was observed East of Birch Spring having at least three points of offset totaling approximately 15 feet. These three geologic structures were then tracked simultaneously to the North.

During the survey, additional faults and fractures were identified East of these three structures. Two additional fractures and one additional small fault was observed East of Birch Spring and West of the Blind Canyon Fault. The total distance across this area was approximately 600 feet, with each structure being separated by what appeared to be competent blocks of formation with no significant fracturing, some as wide as 50'.

The two fractures and the fault surrounding Birch Spring were mapped Northward to the Ridge between the Birch Spring drainage and Blind Canyon (approximately 1,000 ft). The lack of outcrop prevented following the fractures beyond this point.

In mapping these fractures northward, the mapping simultaneously progressed up through the tongues of the Starpoint Sandstone. The following observations were made:

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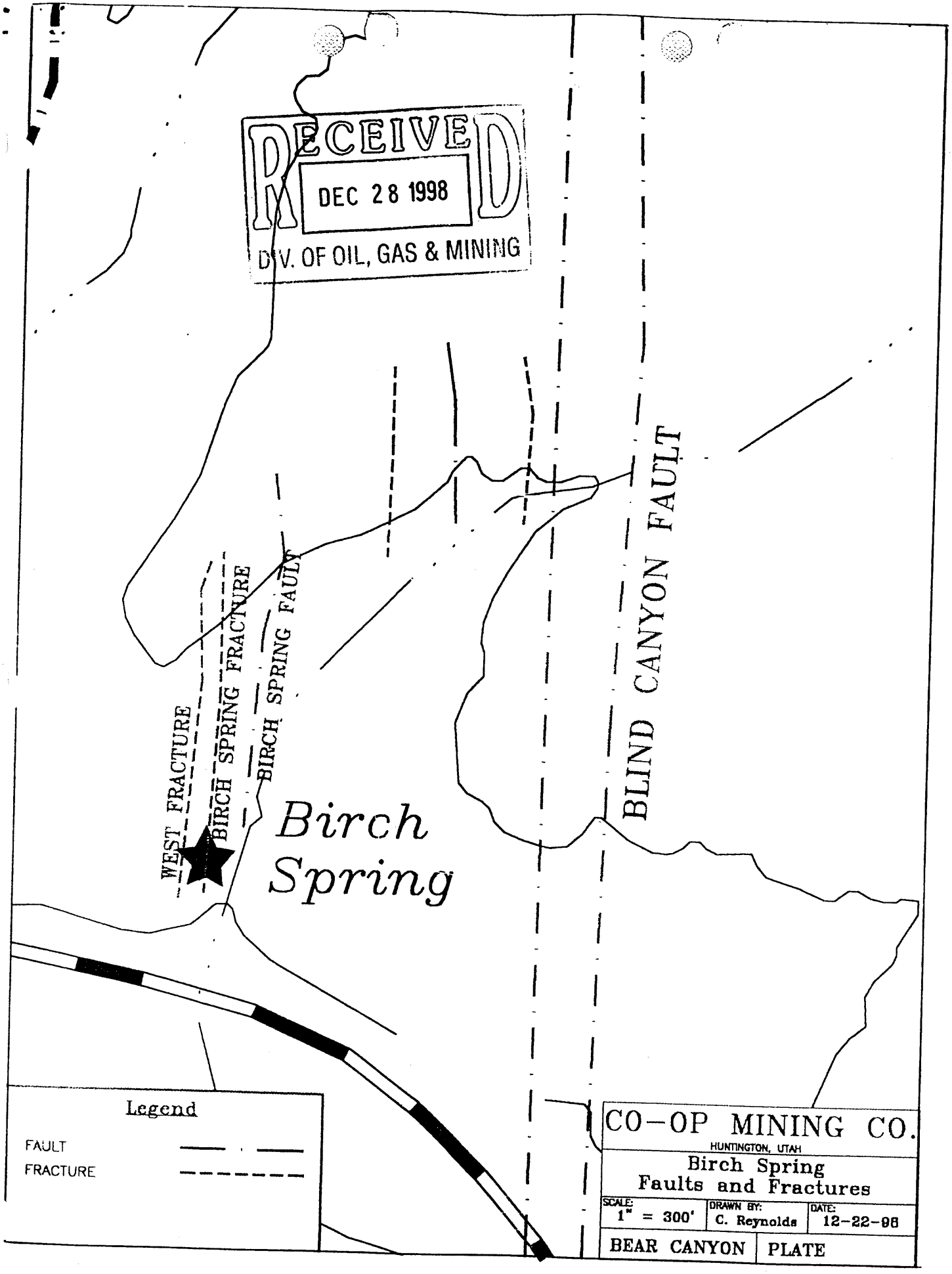
DIV. OF OIL, GAS & MINING



Starpoint Pumping - Hiawatha Discharge

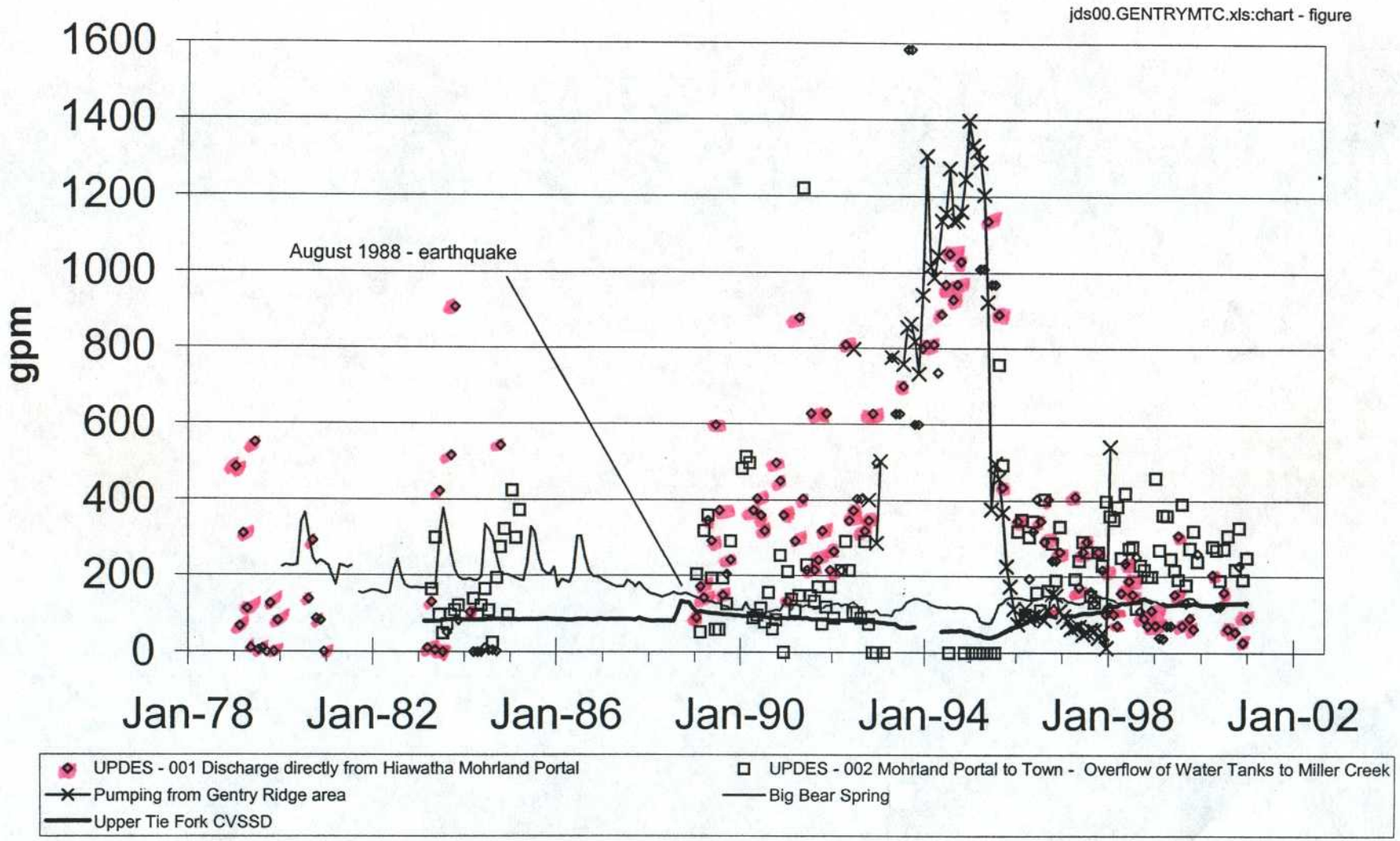


Figure 1

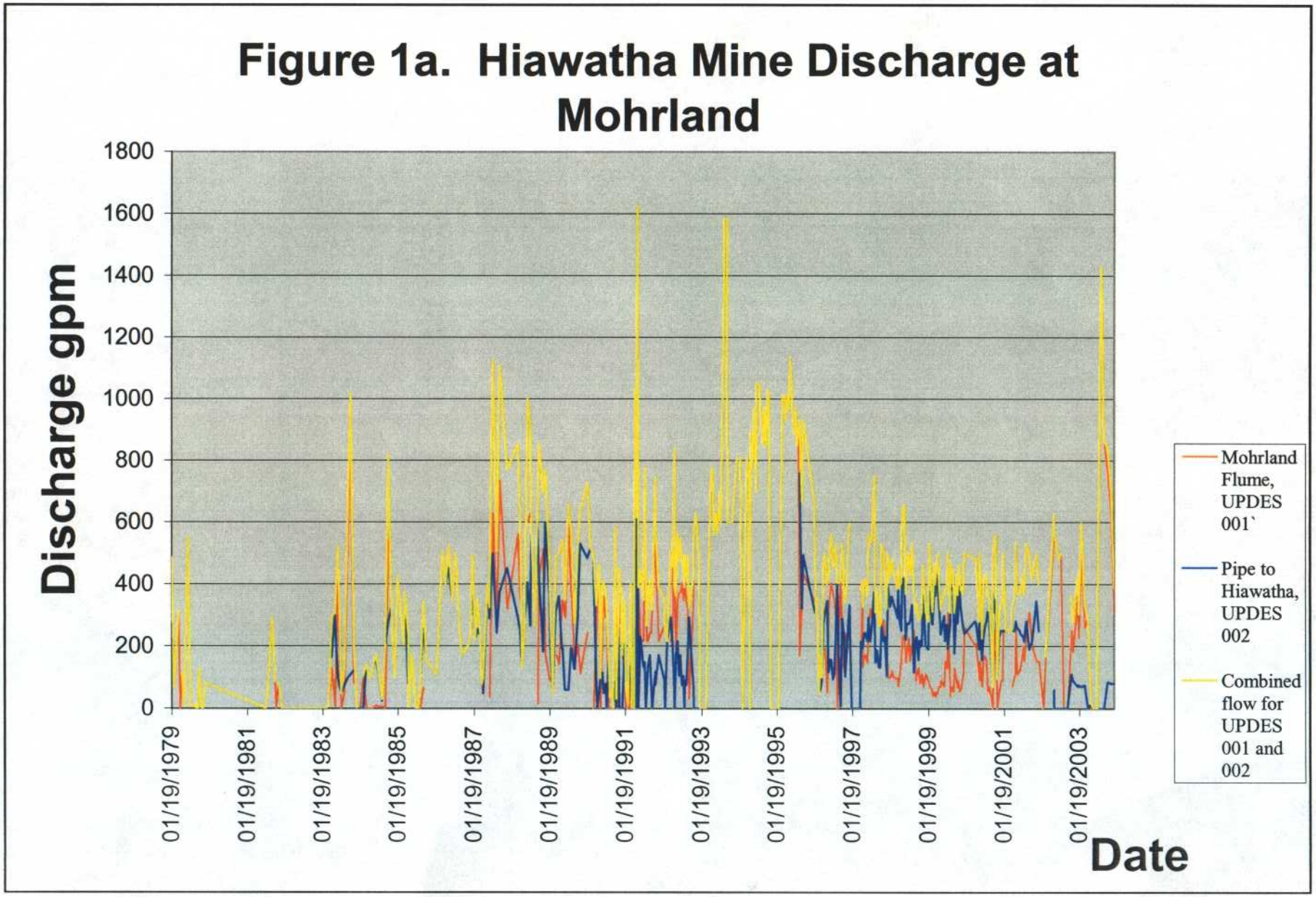
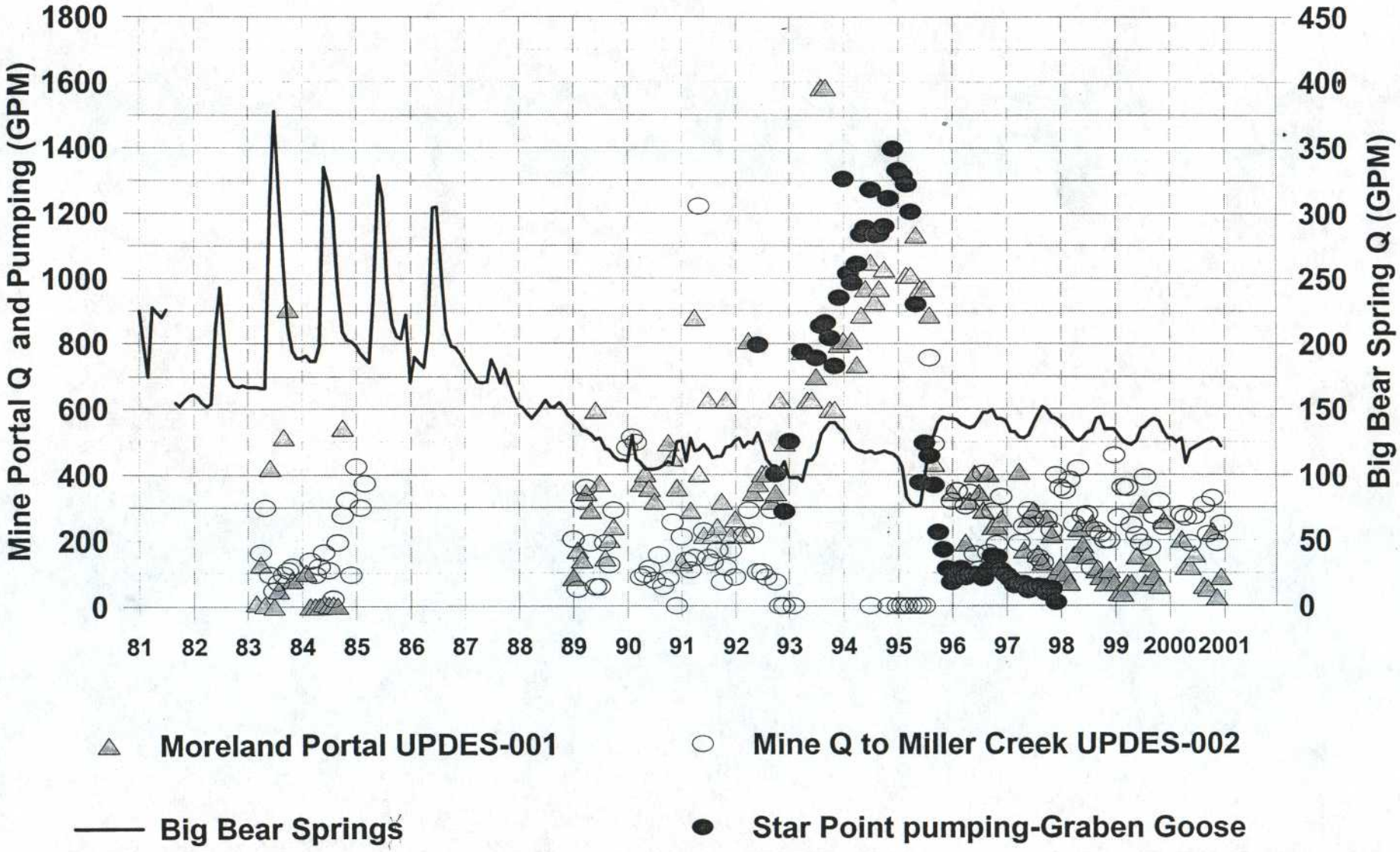


Figure 1a. Hiawatha Mine Discharge at Mohrland
Discharge gpm
1800
1600
1400
1200
1000
800
600
400
200
0
01/19/1979
01/19/1981
01/19/1983
01/19/1985
01/19/1987
01/19/1989
01/19/1991
01/19/1993
01/19/1995
01/19/1997
01/19/1999
01/19/2001
01/19/2003
Date
Mohrland Flume, UPDES 001`
Pipe to Hiawatha, UPDES 002
Combined flow for UPDES 001 and 002

Figure 2

Hiawatha Mine Discharge

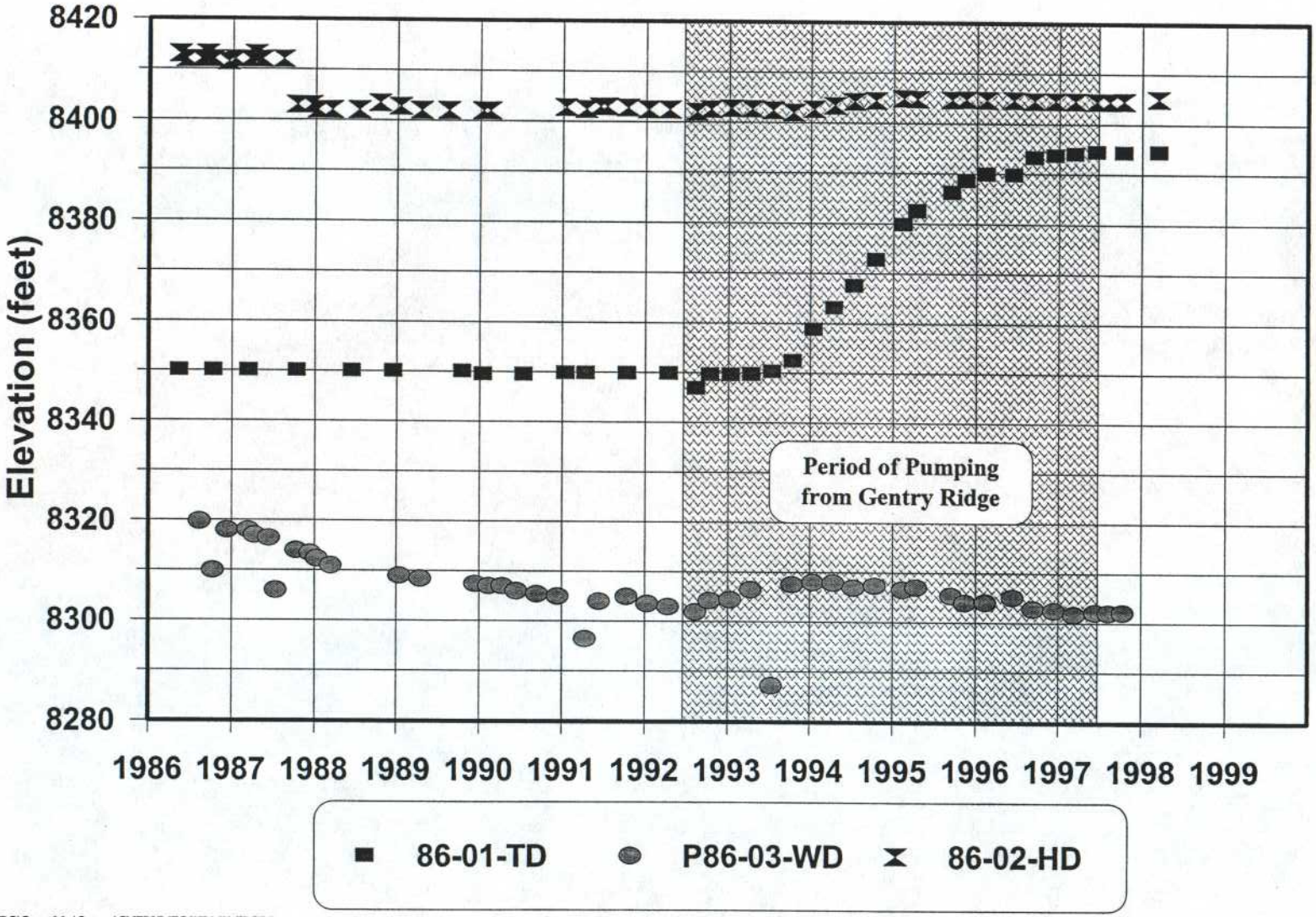
Graben Goose and Bear Canyon Springs



O:CHIA\GENTRYMT\GENTRYMT\QUATTRO:bbearhiaQ
2MAY2001

Star Point Wells

East of The Bear Canyon Fault



H:\QUATTRO\GentryMtn\Quattro\GNTRYMTC.WB2:WellBCF E

Figure 3

Star Point Wells: Gentry Ridge

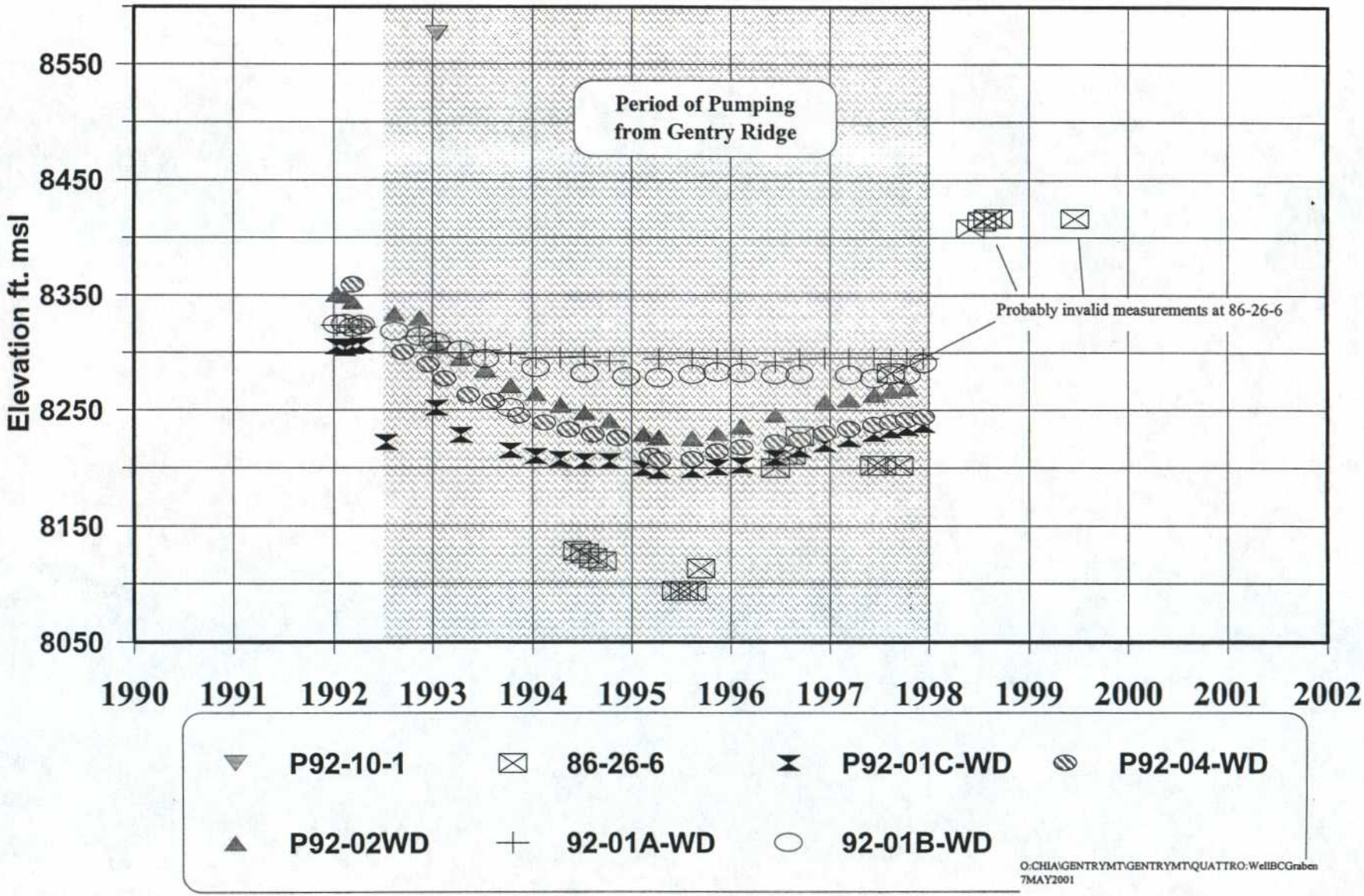
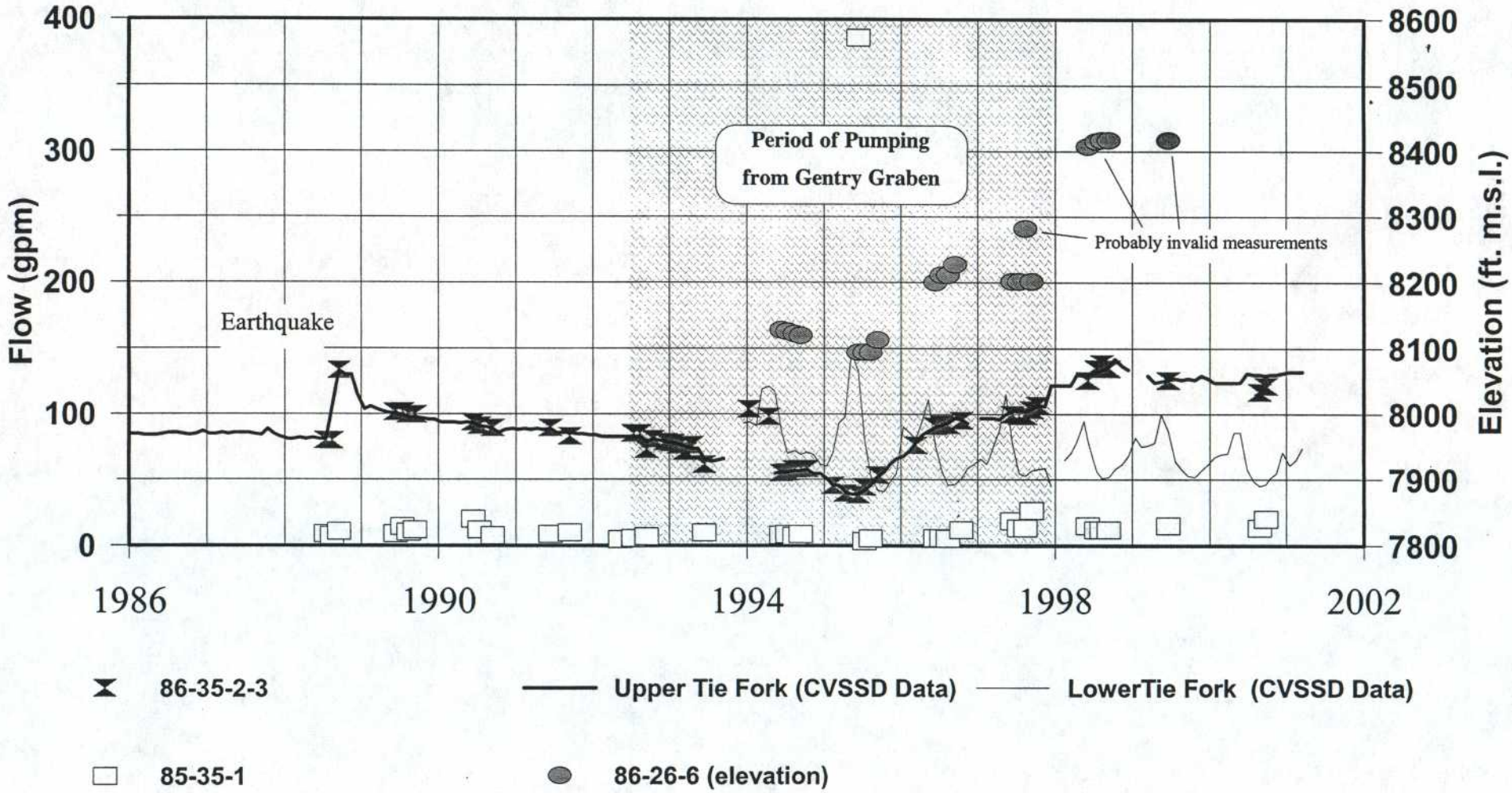


Figure 4

Figure 5

Tie Fork Wells
and Related Monitoring Sites



O:CHIA\GENTRYMT\GENTRYMT\QUATTRO:WB2:TieFork
2MAY2001

Bear Canyon Mine

In-Mine Flows

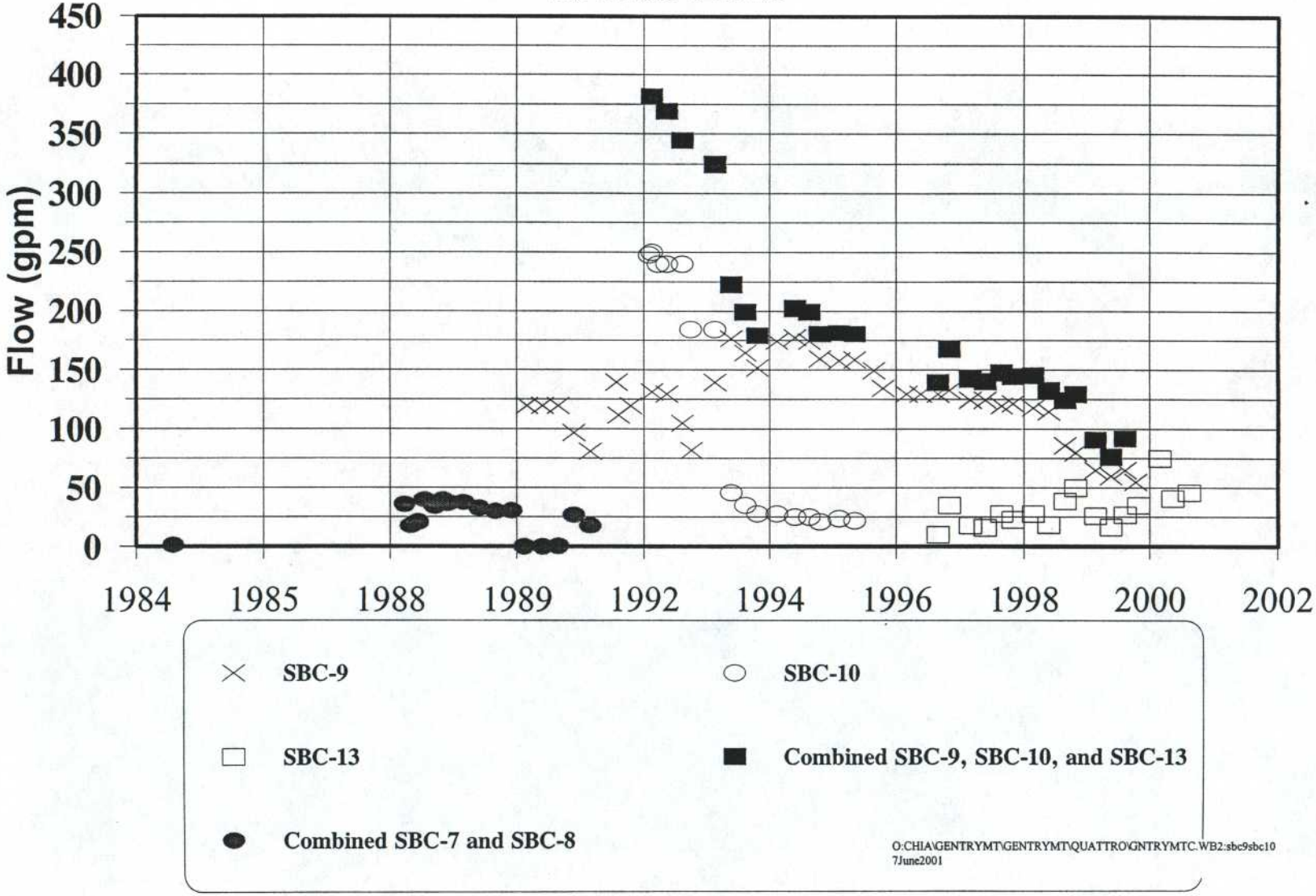
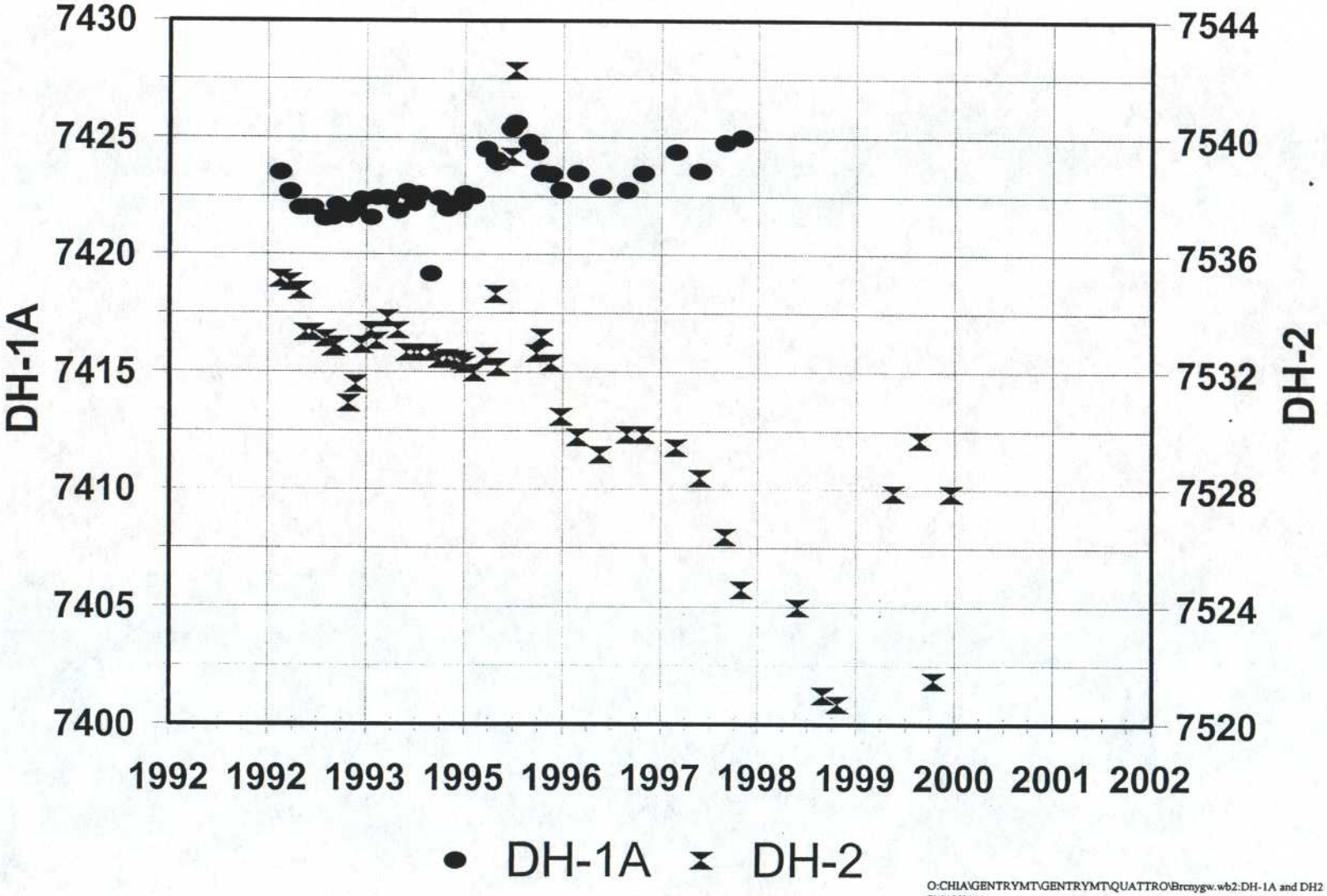


Figure 6

Bear Canyon In-Mine Drill Holes

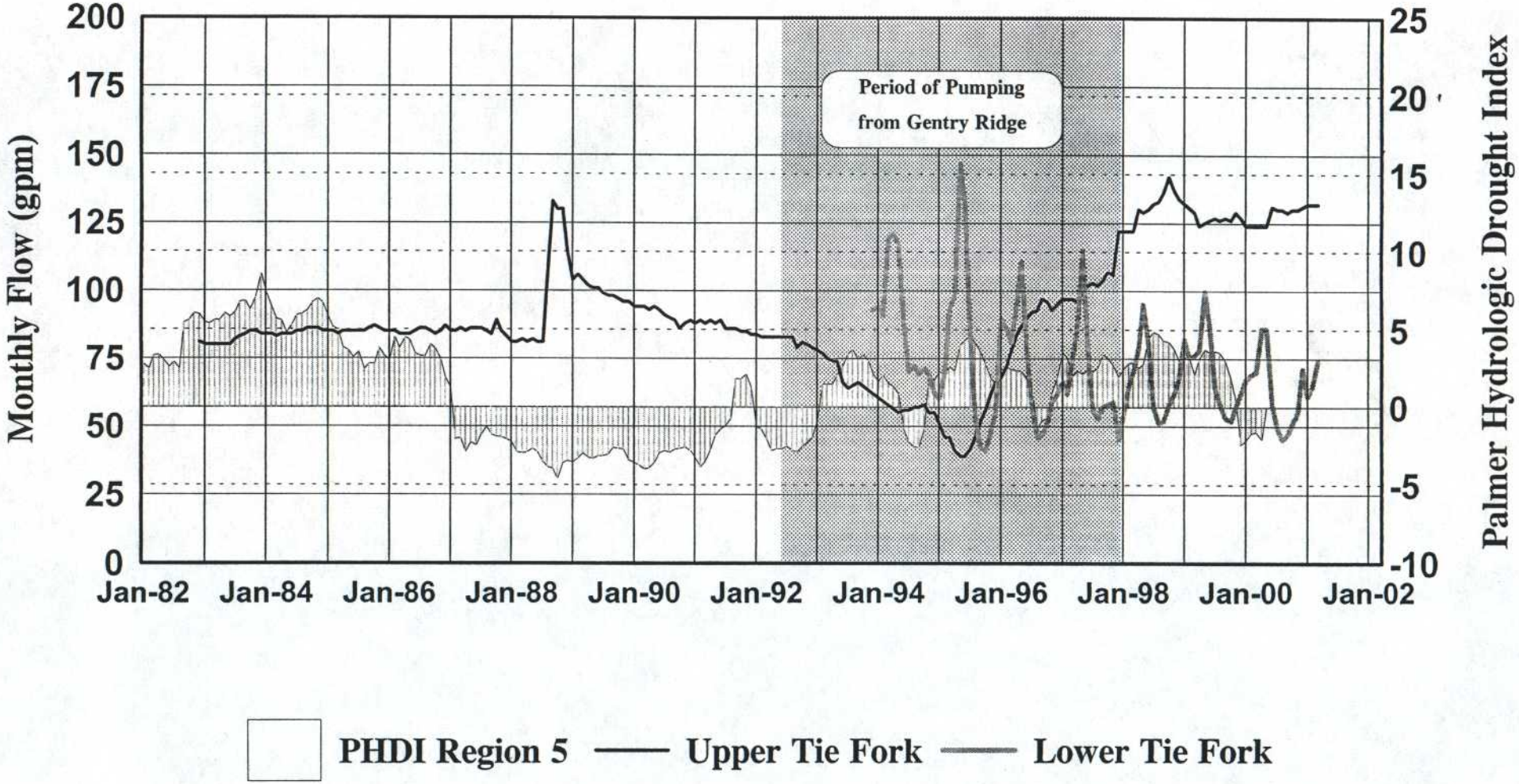
Star Point Sandstone



O:CHIA\GENTRYMT\GENTRYMT\QUATTRO\Brcnygw.wb2:DH-1A and DH2
7MAY2001

Figure 7

Tie Fork Springs and
the Palmer Hydrologic Drought Index

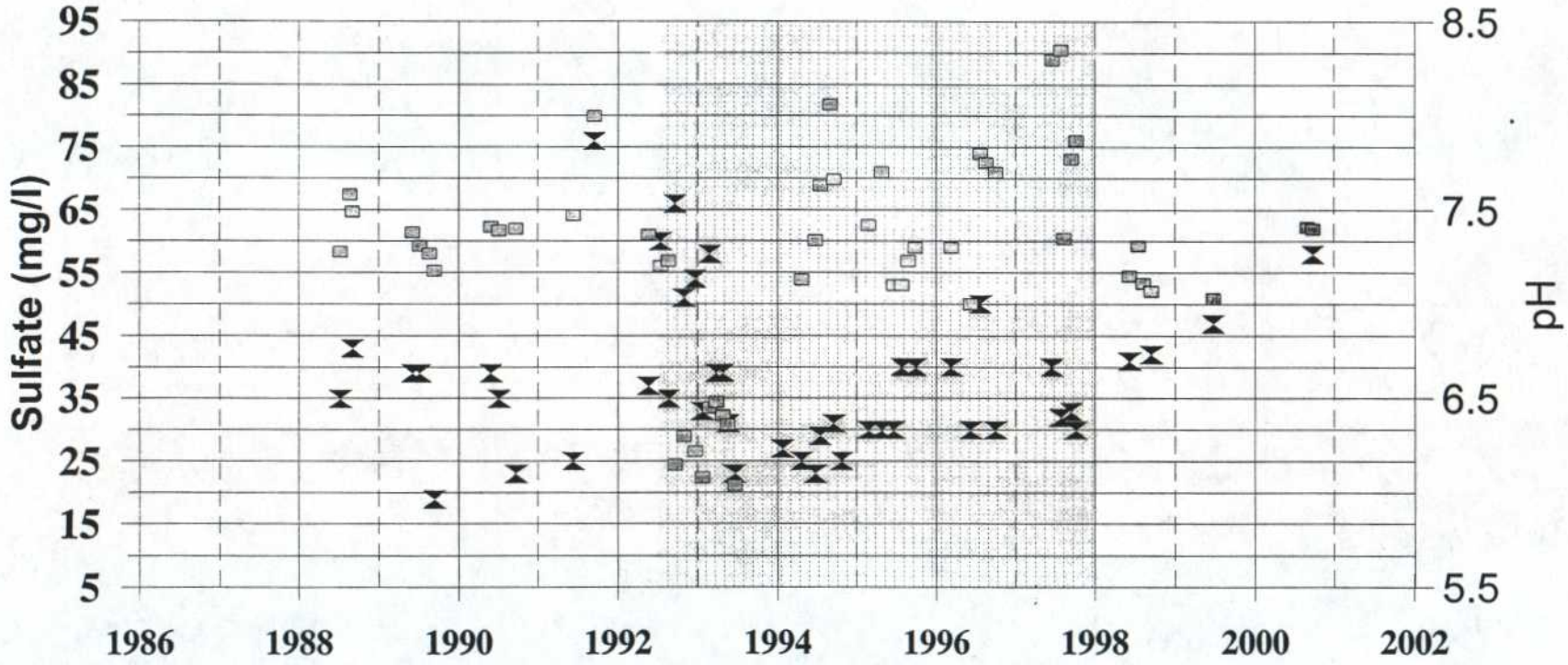


O:CHIA\GENTRYMT\GENTRYMT\QUATTRO\GNTRYMTC.WB2::tief Region5
9MAY2001

Figure 8

Sulfate and pH

Upper Tie Fork Well 86-35-2-3



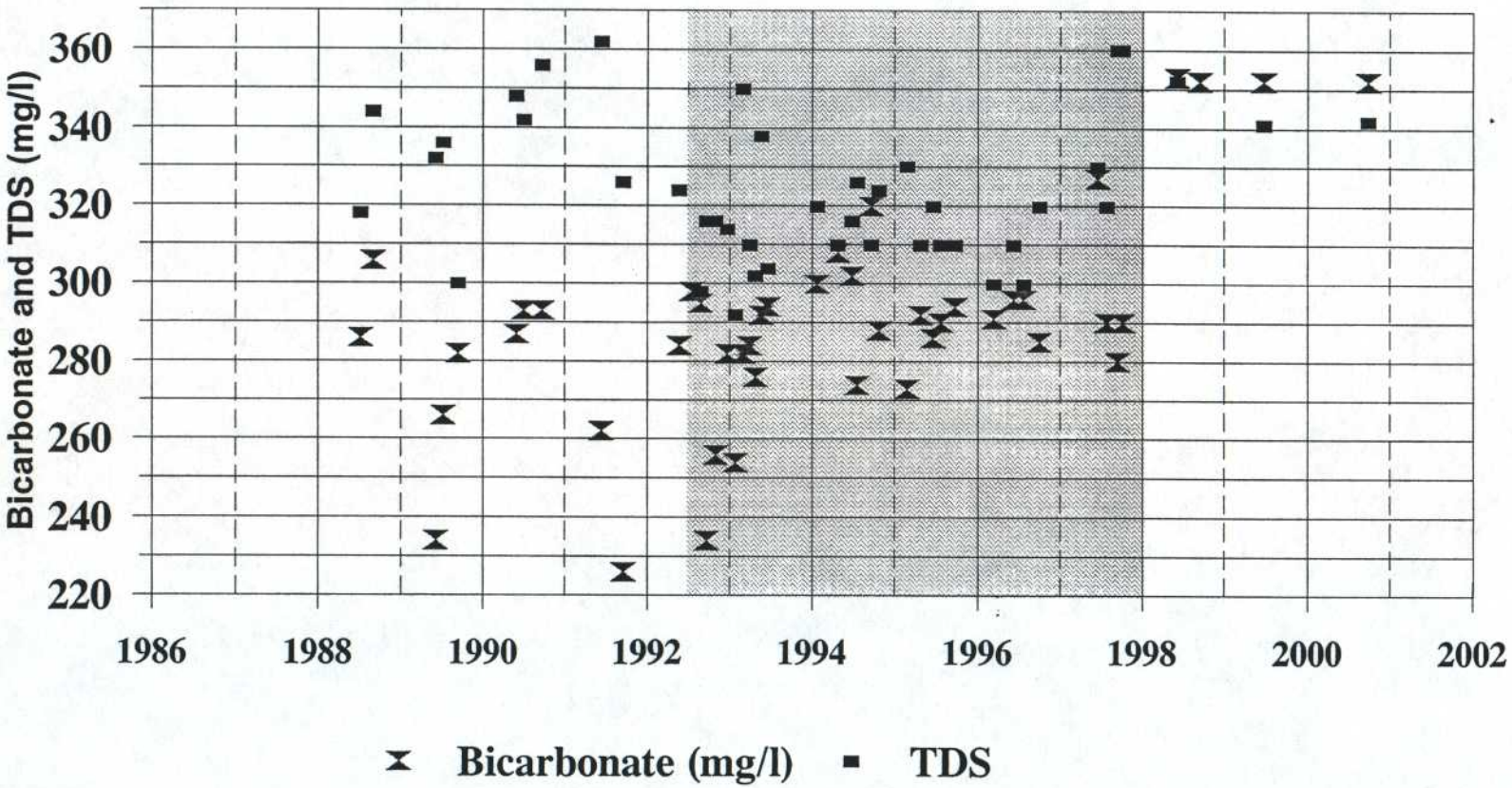
Sulfate (mg/l) Field-pH

O:CHIA\GENTRYMT\GENTRYMT\QUATTRO\STRPTWE2.WB2:Tie Forkphsul
9MAY2001

Figure 9

Bicarbonate and TDS

Upper Tie Fork Well 86-35-2-3



10O:CHIA\GENTRYMT\GENTRYMT\QUATTRO\STRPTWE2.WB2:Tie Forkbictds
10MAY2001

Figure 10

Birch Spring Flow
Combined Data Sources

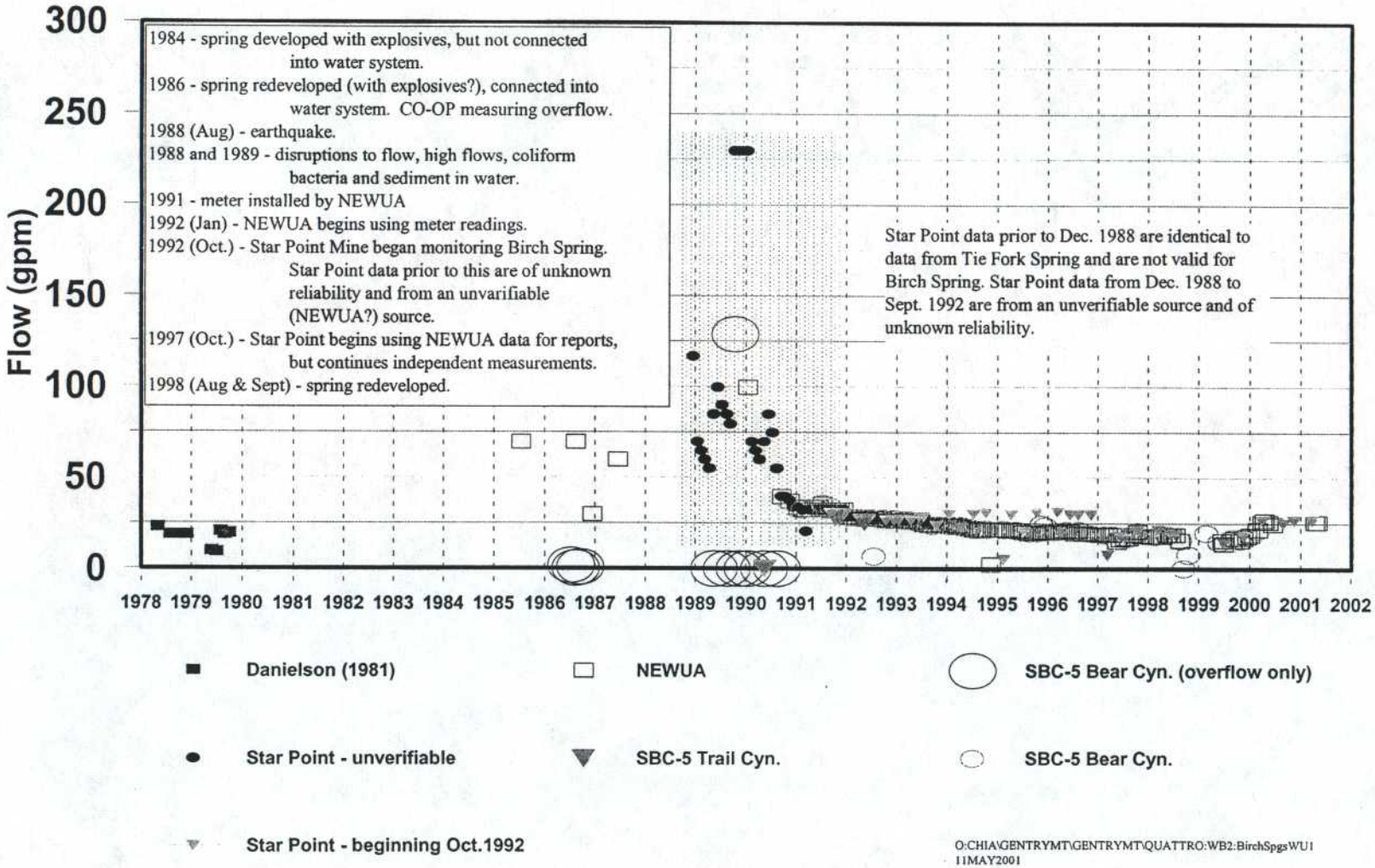
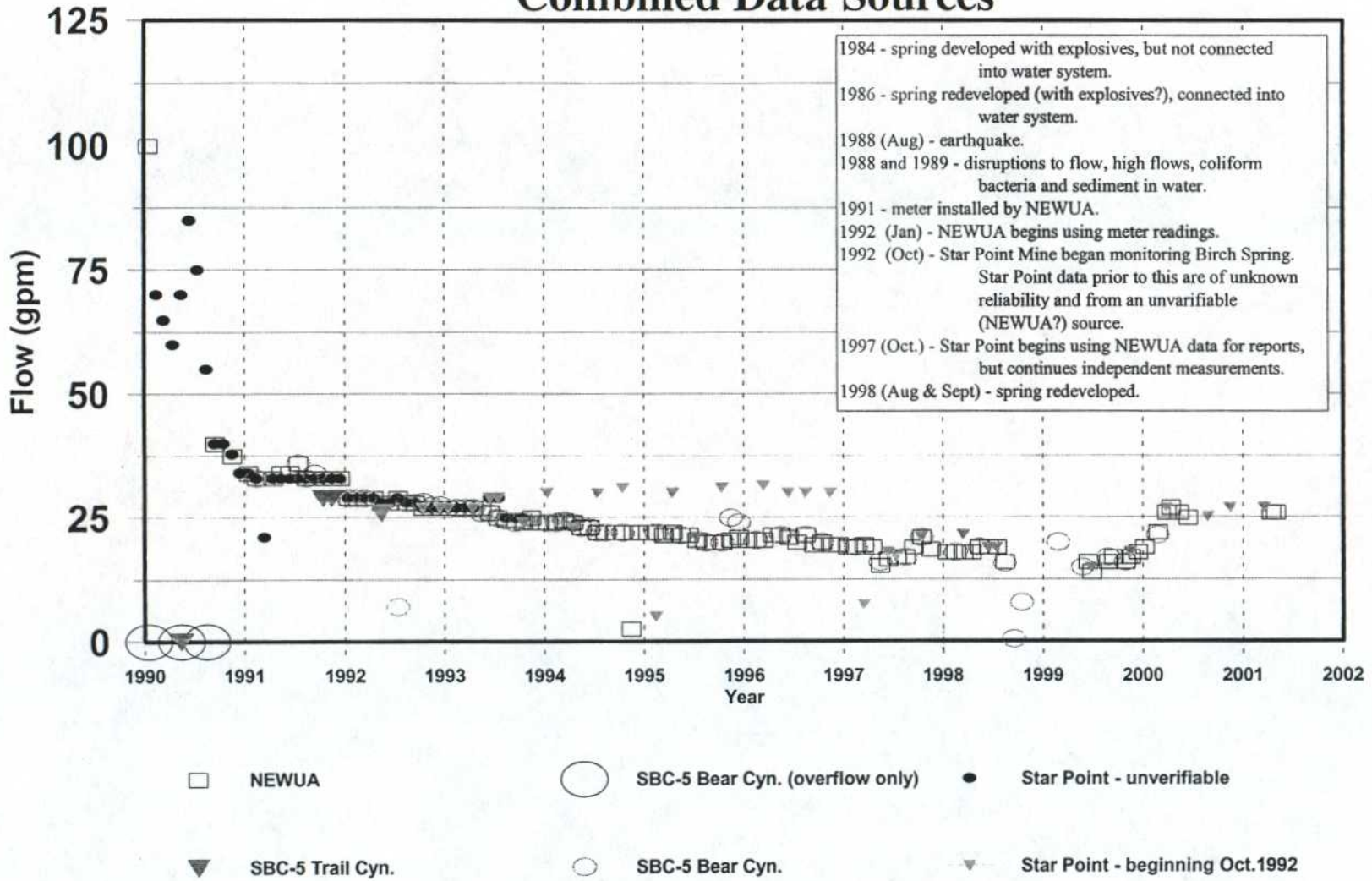


Figure 11a

Birch Spring Flow

Combined Data Sources



O:CHIA\GENTRYMT\GENTRYMT\QUATTRO:WB2:BirchSpgsMay01
11MAY2001

Figure 11b

Chemistry of SBC-9

Sand Channel

O:CHIA\GENTRYMT\GENTRYMT\QUATTRO\GNTRYMTC\sbc9A.wb3:SBC9chem
11June2001

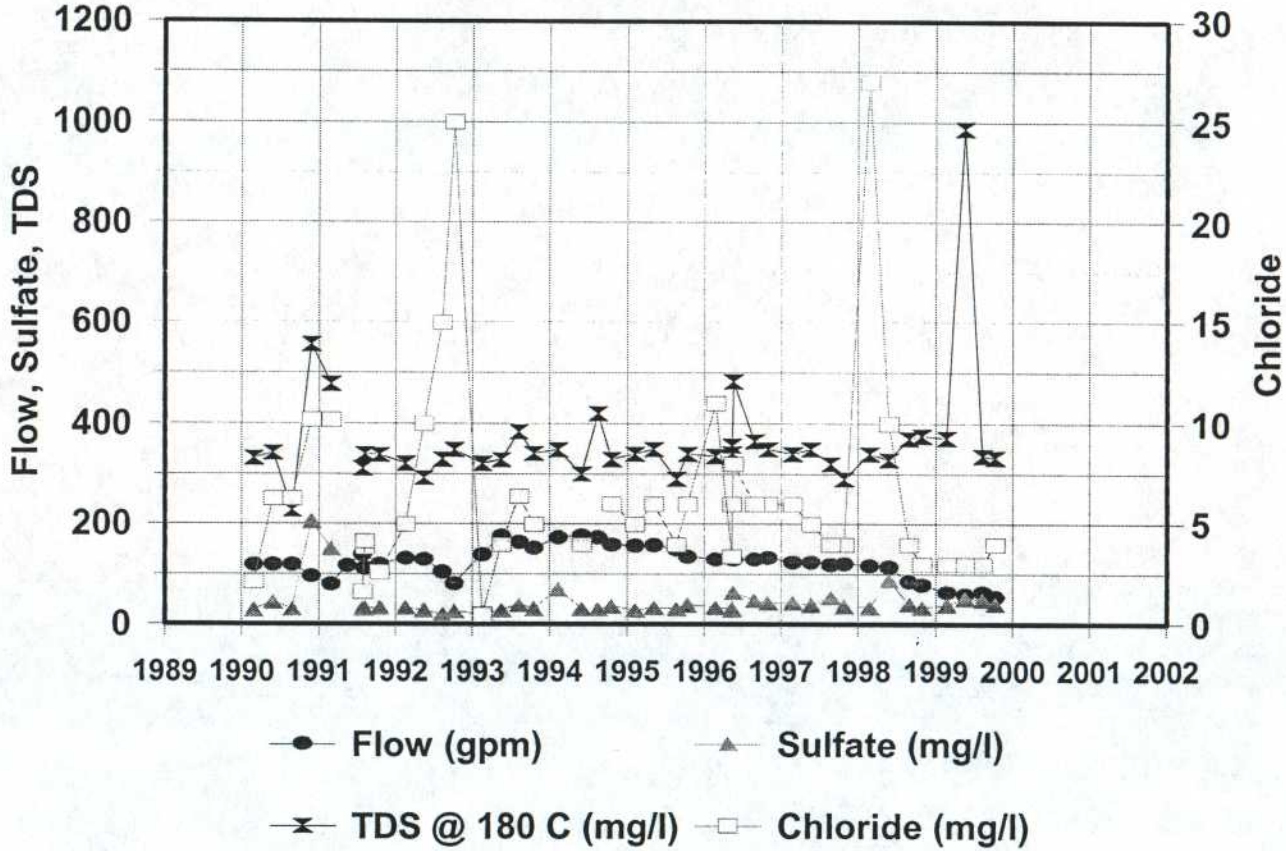


Figure 12

Chemistry of SBC-10

Sand Channel

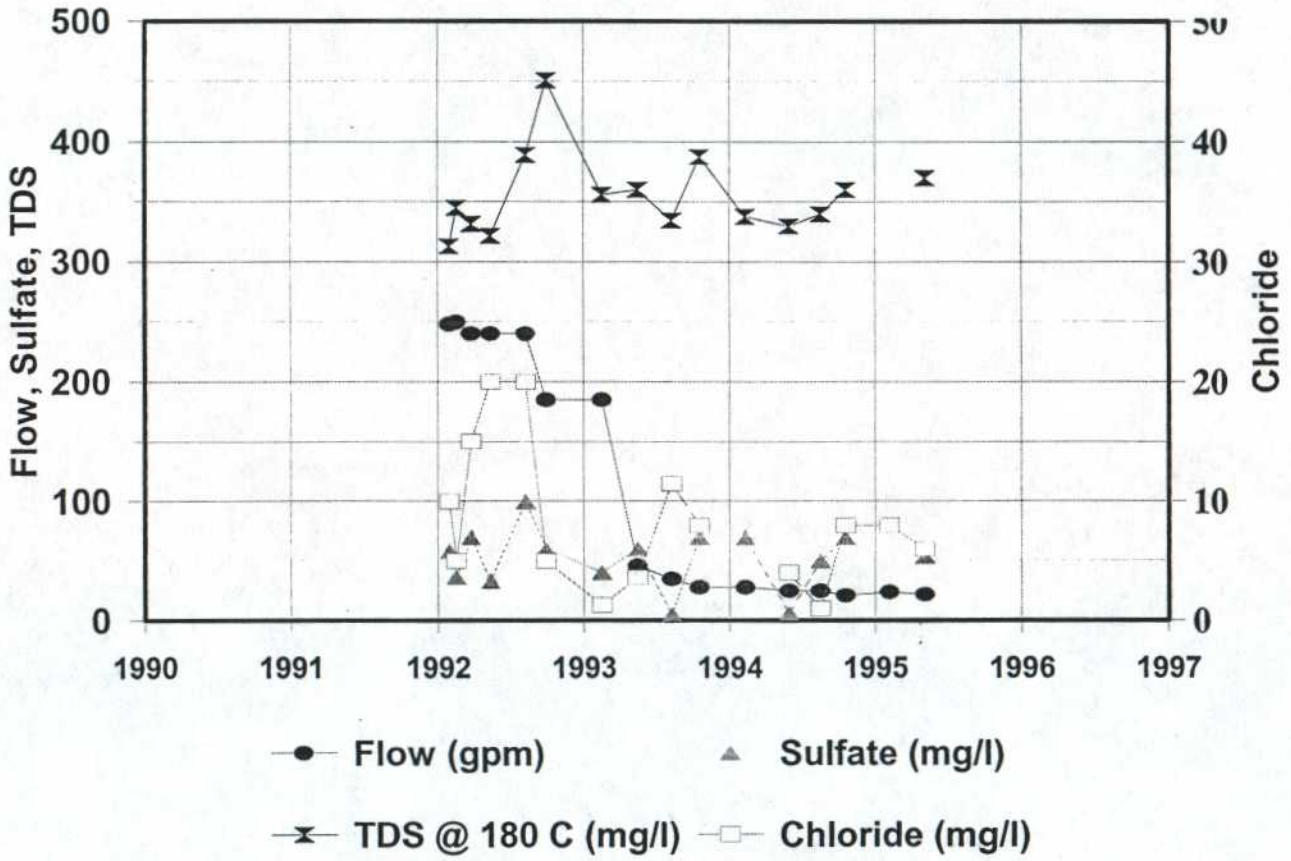


Figure 13a

Chemistry of SBC-13

Sand Channel

O:CHIA\GENTRYMT\GENTRYMT\QUATTRO\GNTRYMTC\abc9A.wb3:SBC13chem
11June2001

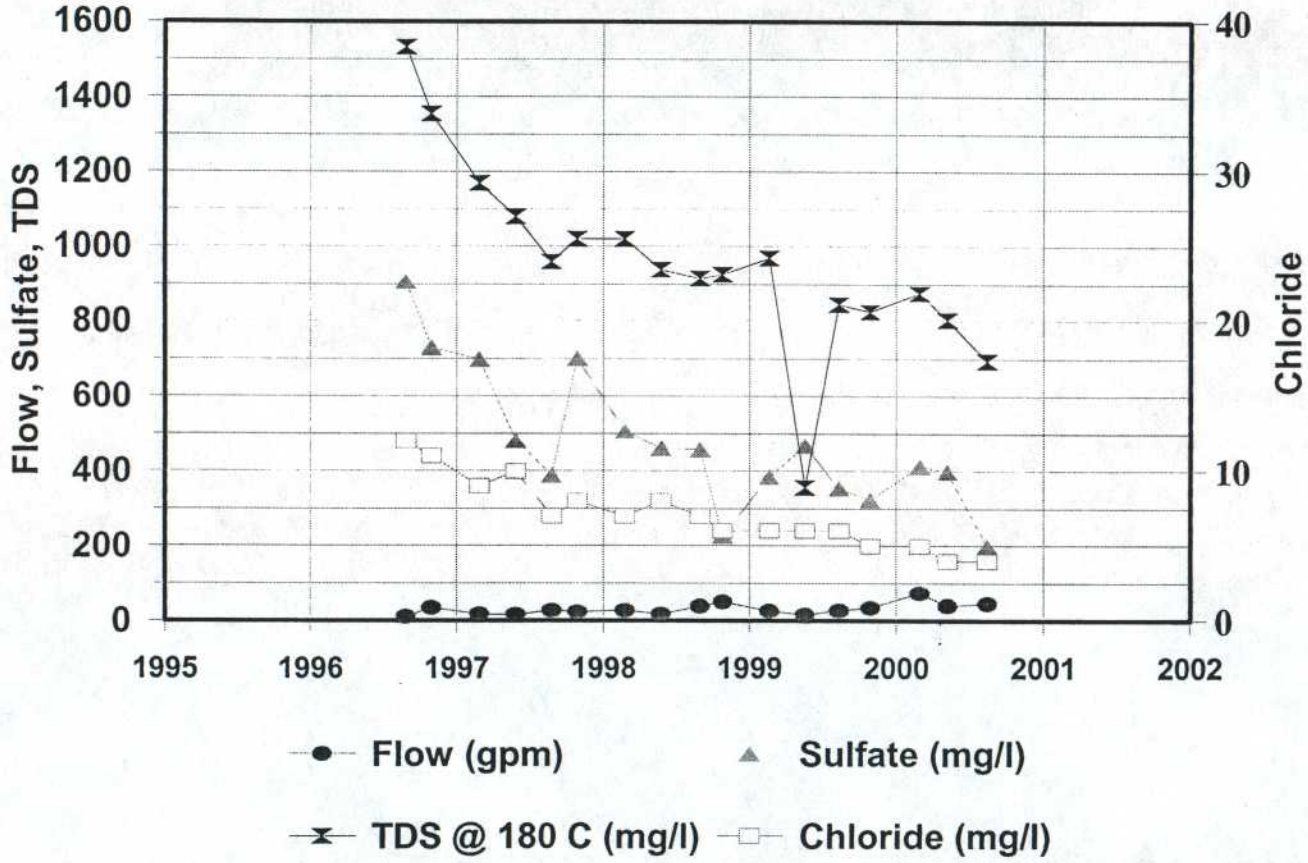


Figure 13b

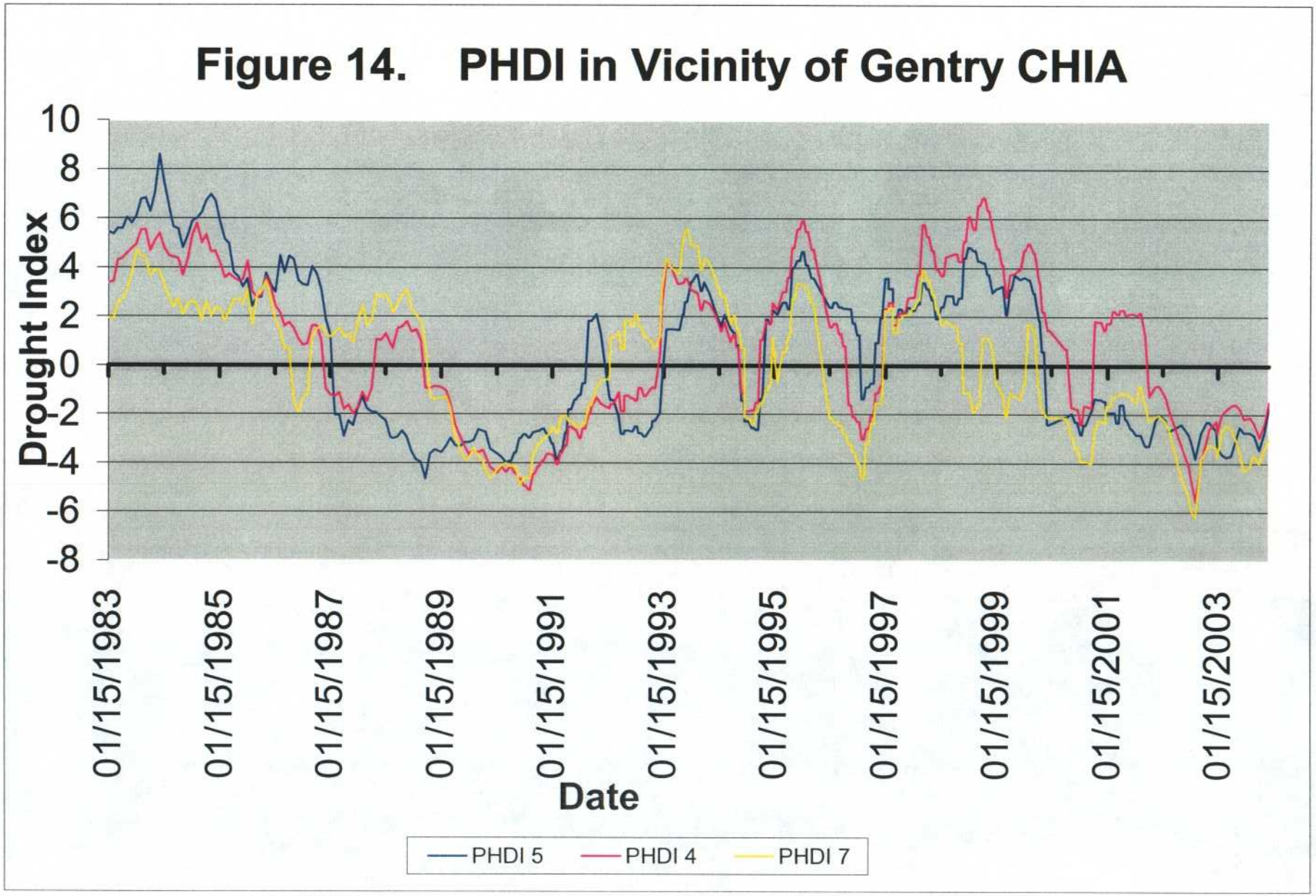
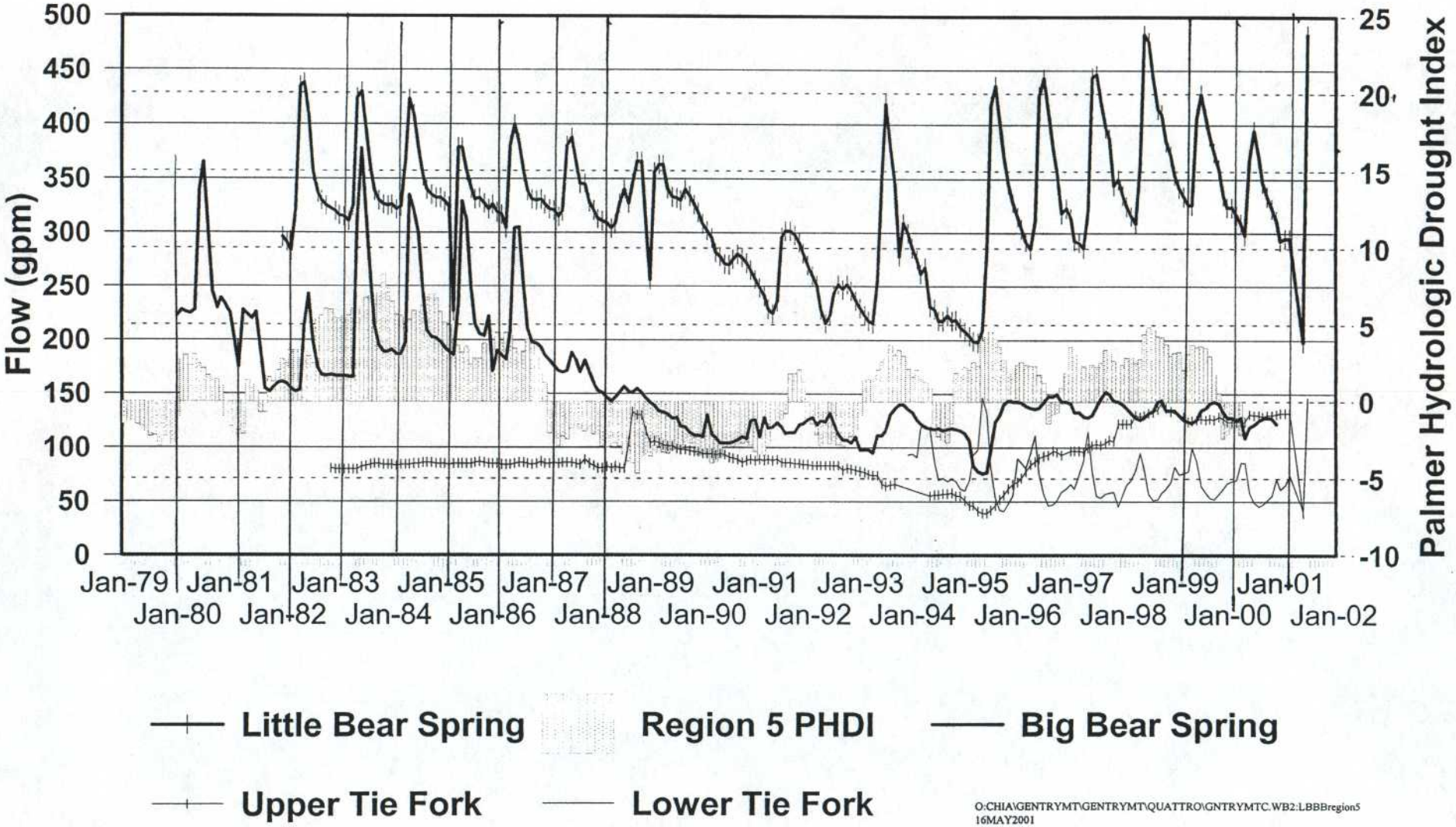


Figure 14. PHDI in Vicinity of Gentry CHIA
Drought Index
10
8
6
4
2
0
-2
-4
-6
-8
01/15/1983
01/15/1985
01/15/1987
01/15/1989
01/15/1991
01/15/1993
01/15/1995
01/15/1997
01/15/1999
01/15/2001
01/15/2003
Date
PHDI 5
PHDI 4
PHDI 7

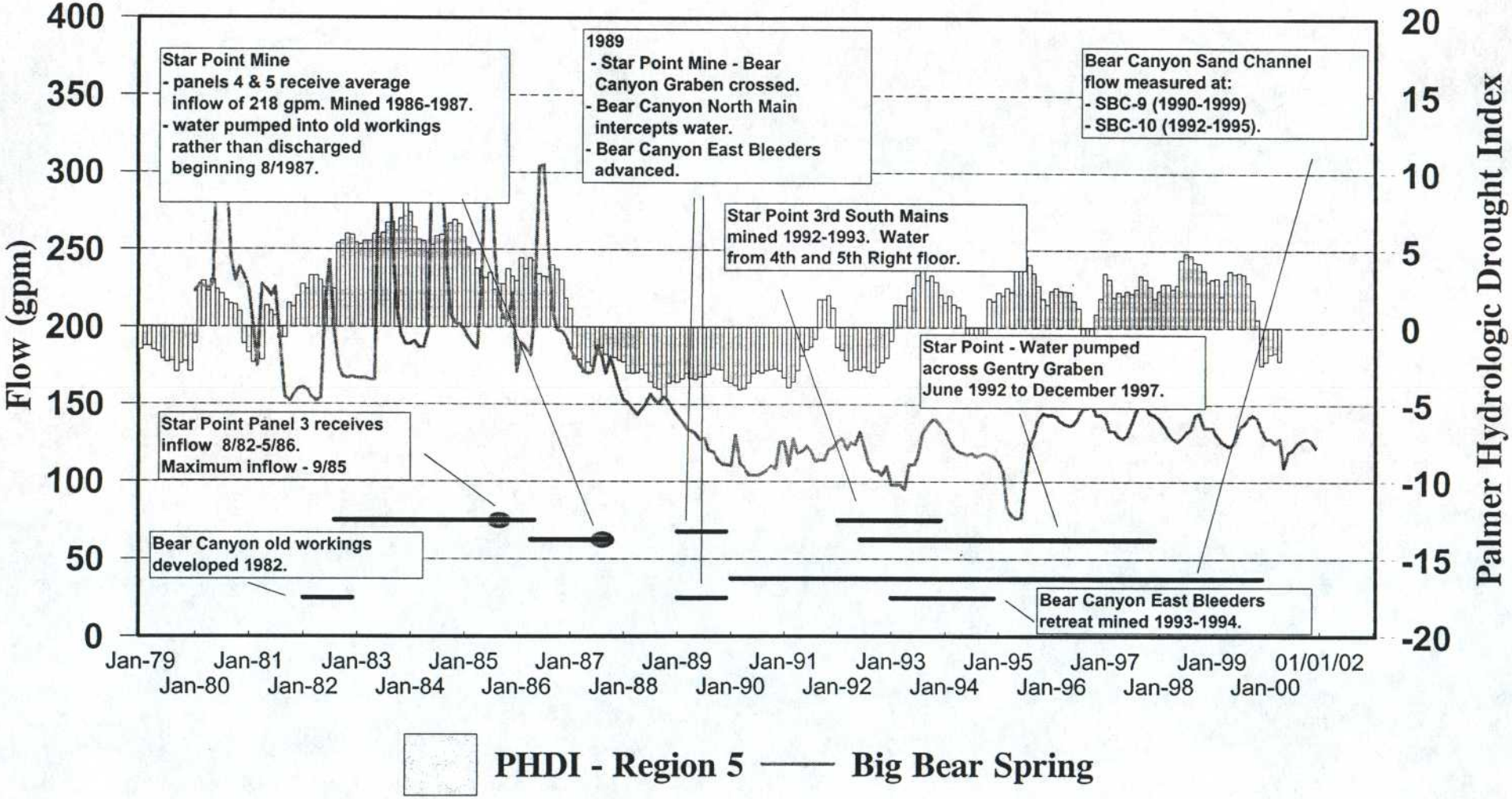
Flow of Selected Springs and Region 5 PHDI



O:CHIA\GENTRYMT\GENTRYMT\QUATTRO\GNTRYMTC.WB2:LBBBregion5
16MAY2001

Figure 14a

Big Bear Spring, the PHDI, and Mine Water Interception



O:CHIA\GENTRYMT\GENTRYMT\QUATTRO\GNTRYMTC.WB2:bigbmining
16MAY2001

Figure 14b

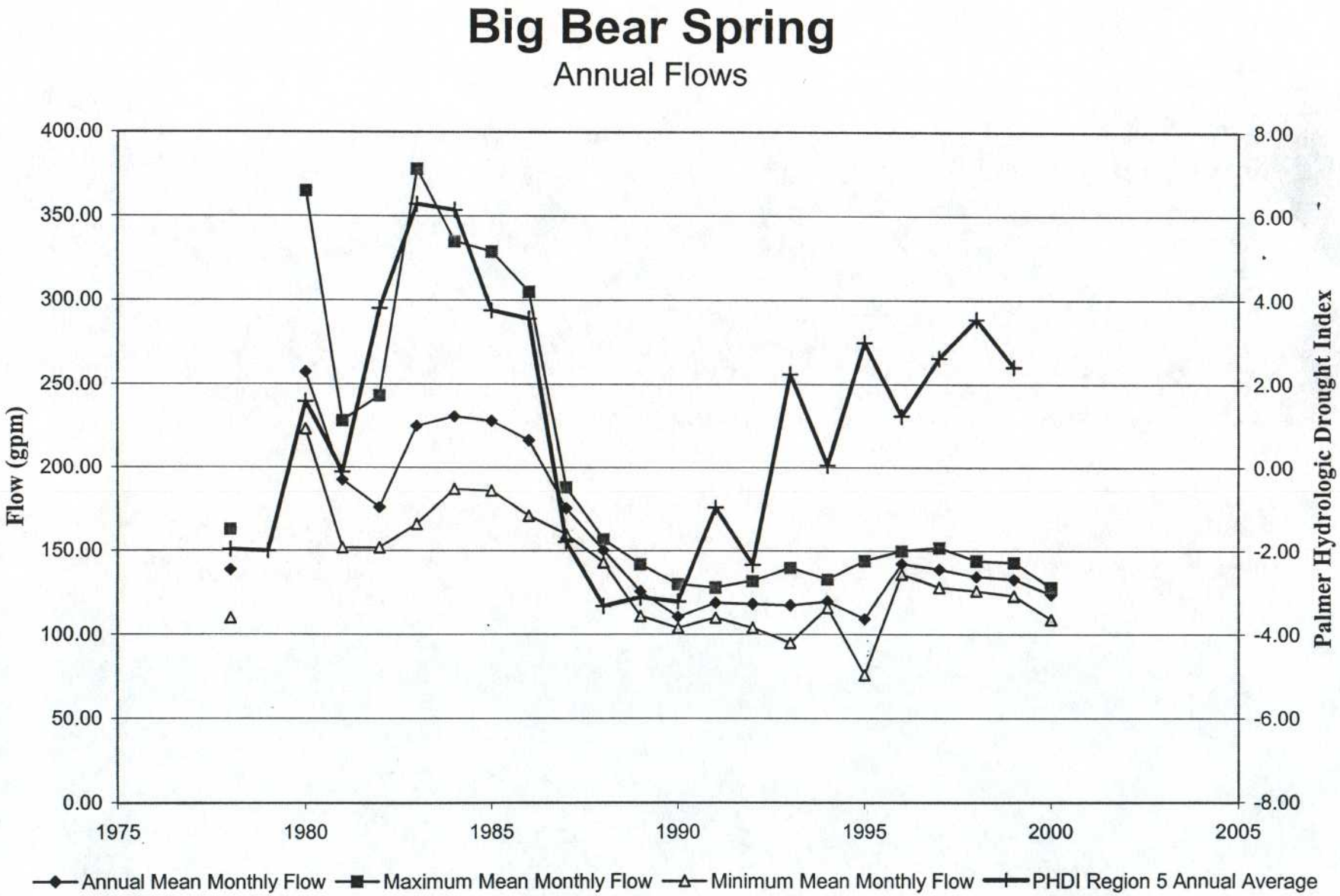
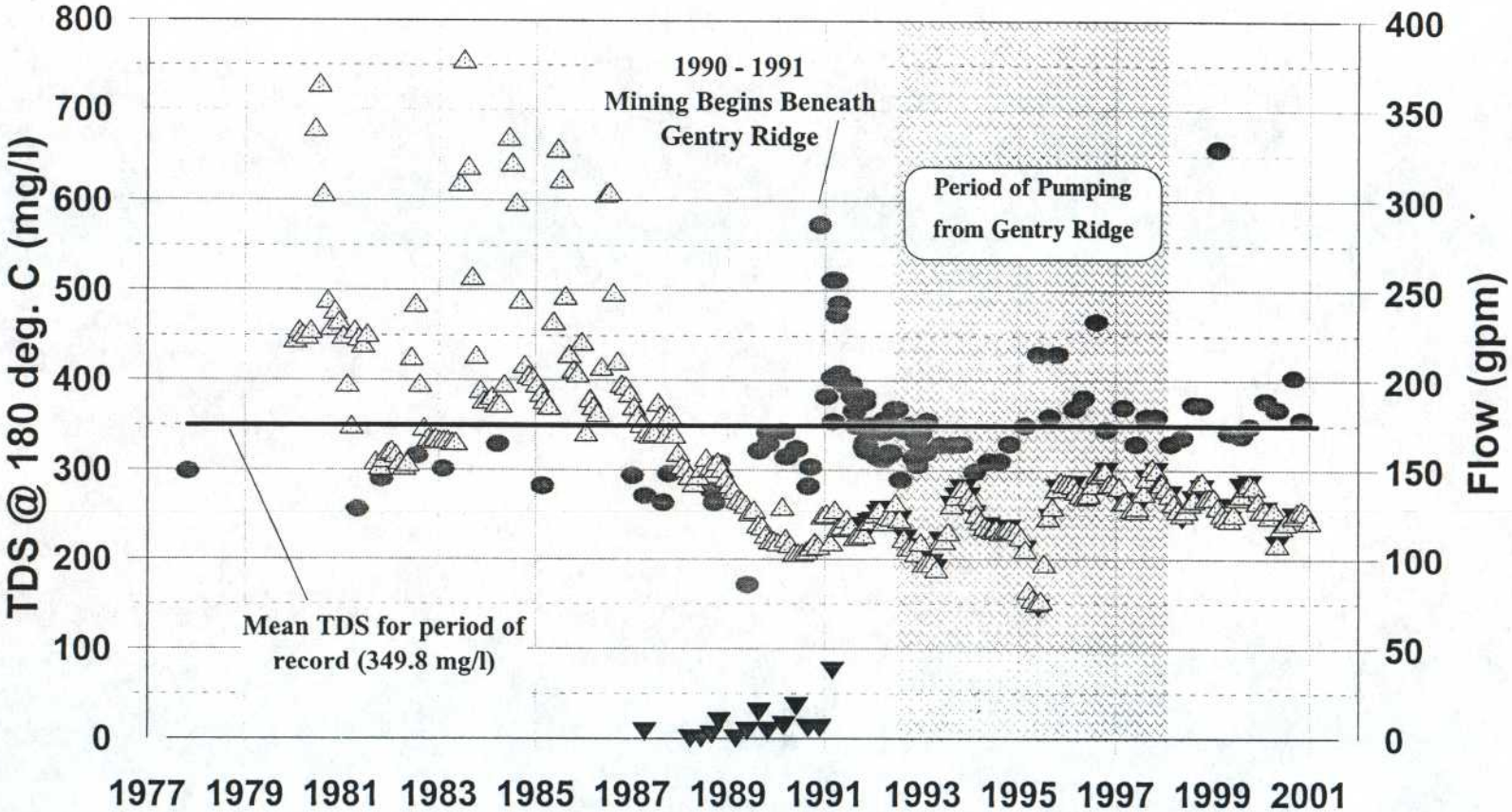

Big Bear Spring
Annual Flows
Flow (gpm)
Palmer Hydrologic Drought Index
400.00
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
8.00
6.00
4.00
2.00
0.00
-2.00
-4.00
-6.00
-8.00
1975
1980
1985
1990
1995
2000
2005
Annual Mean Monthly Flow
Maximum Mean Monthly Flow
Minimum Mean Monthly Flow
PHDI Region 5 Annual Average

Figure 15

Bear Canyon Mine: Big Bear Spring

Total Dissolved Solids (TDS) vs Time



● TDS

▼ Bear Canyon Mine Discharge

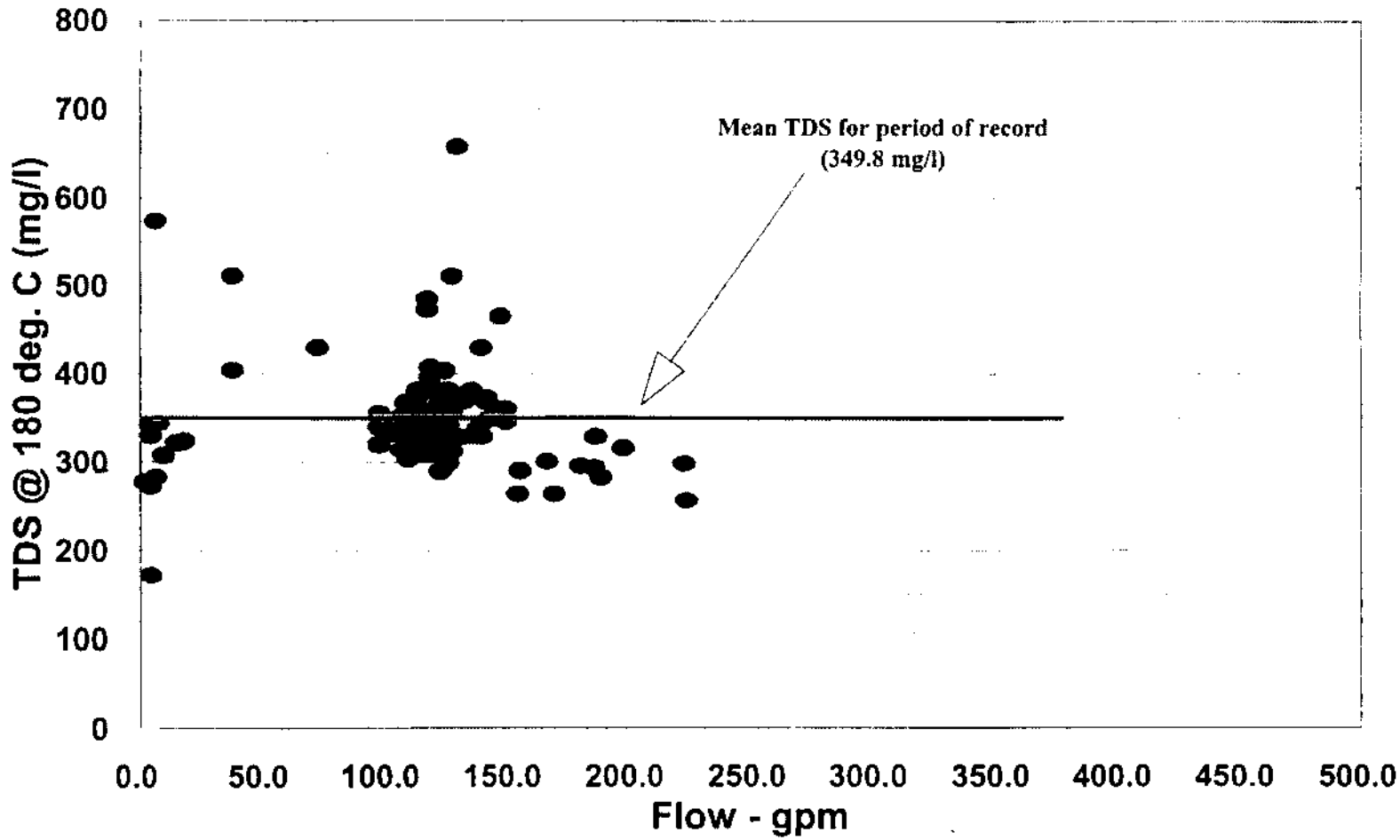
△ Big Bear Spg Avg. Monthly Flow

O:CHIA\GENTRYMT\GENTRYMT\QUATTRO\GNTRYMTC.WB2:bbTDSvsTIME
29MAY2001

Figure 16a

Bear Canyon Mine: Big Bear Spring

Total Dissolved Solids (TDS) vs Flow



O:CHIA\GENTRYMT\GENTRYMT\QUATTRO\GNTRYMTC WB2 bbTDSvsFLOW
29MAY2001

Figure 16b

Meteoric Water Line
Deuterium and Oxygen 18

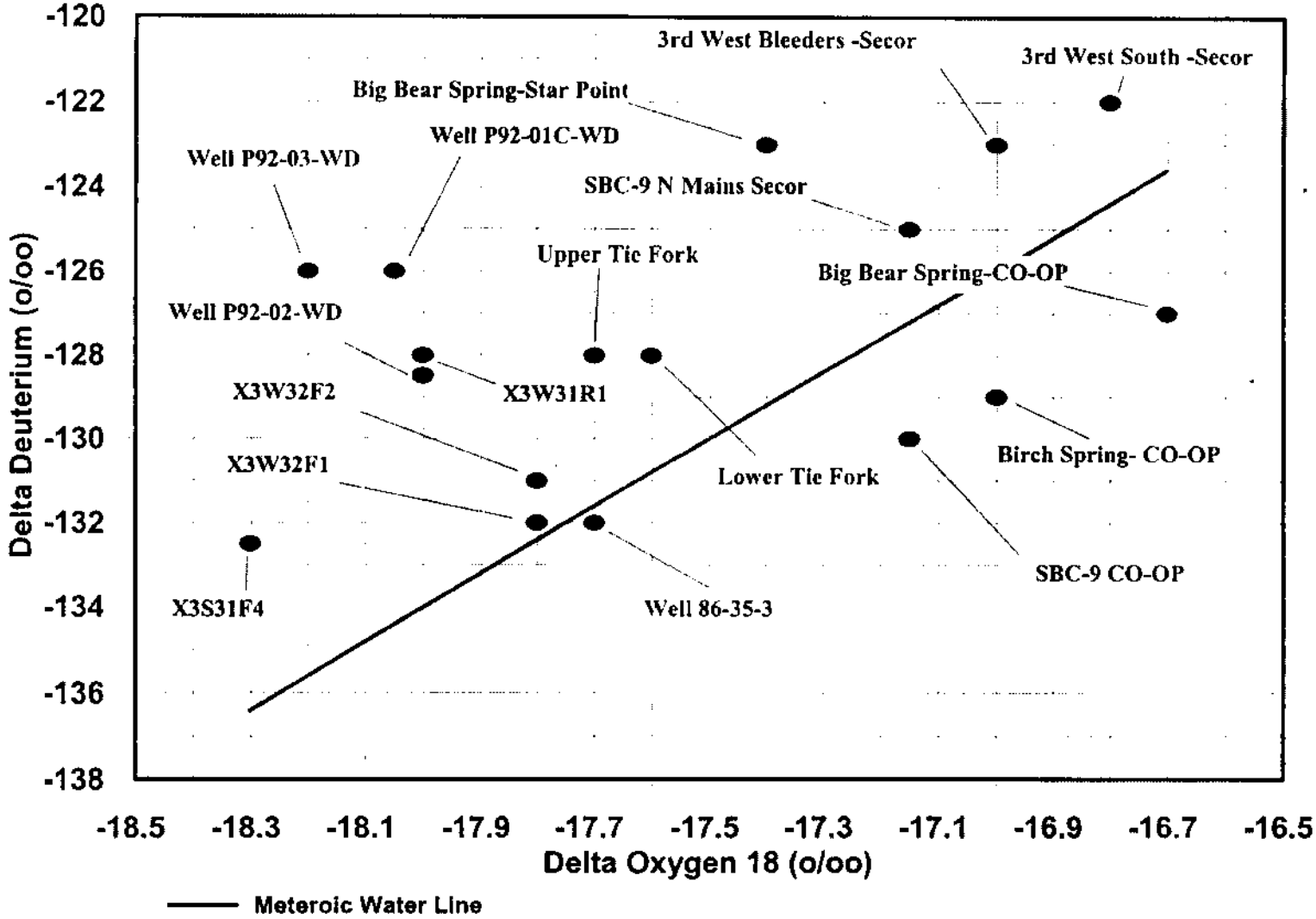
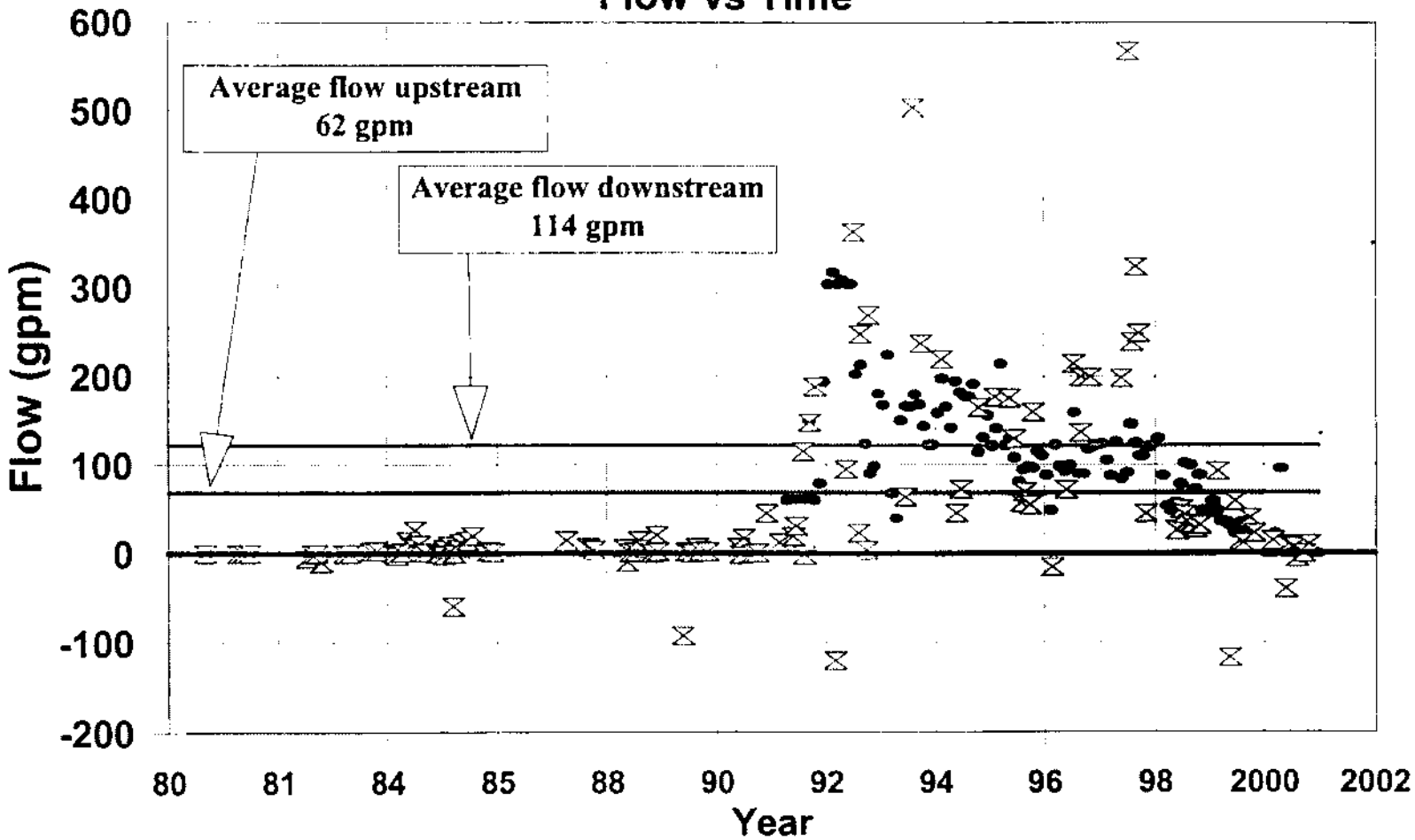


Figure 17

Bear Canyon Mine & Bear Creek Flows

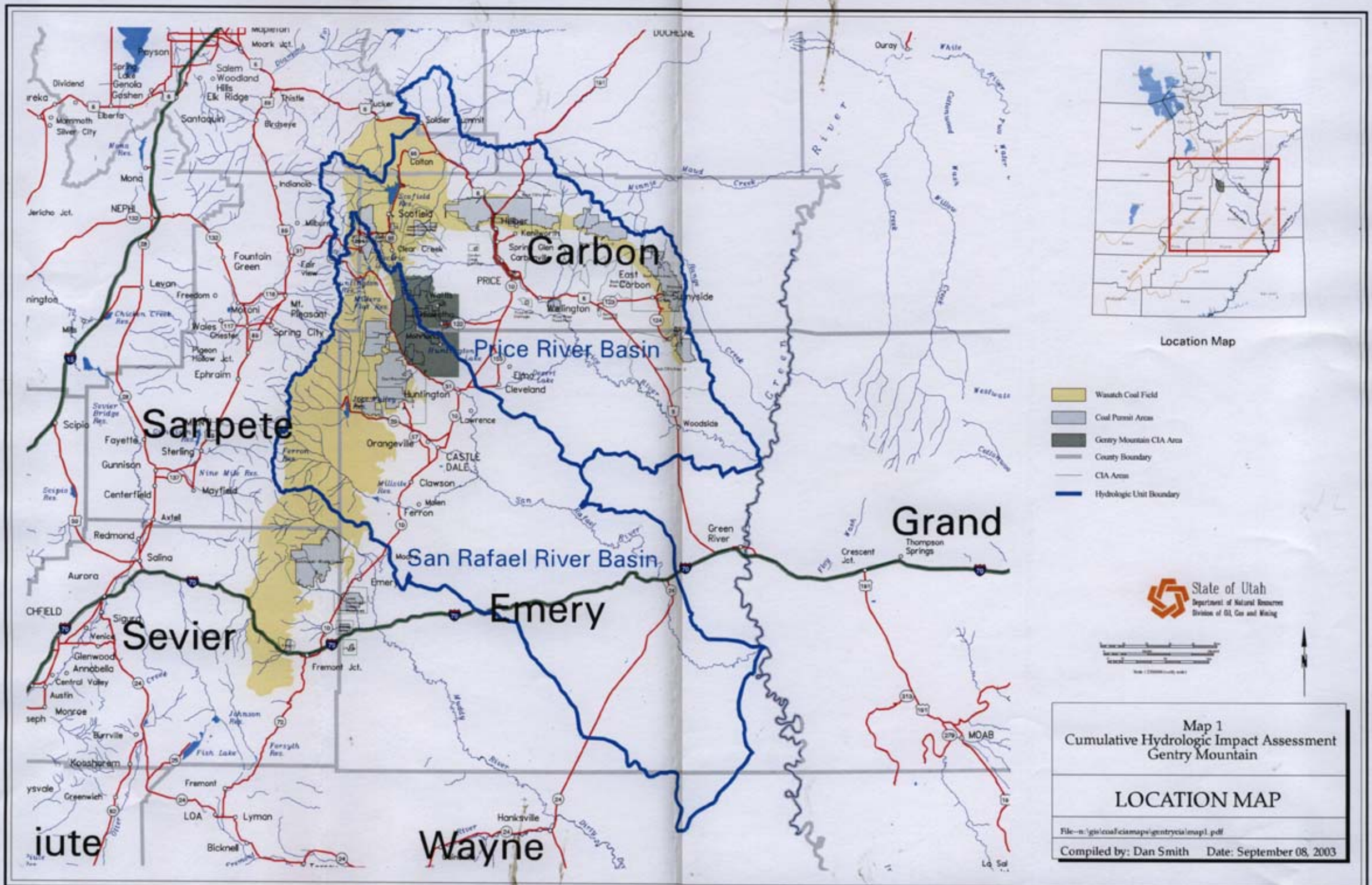
Flow vs Time



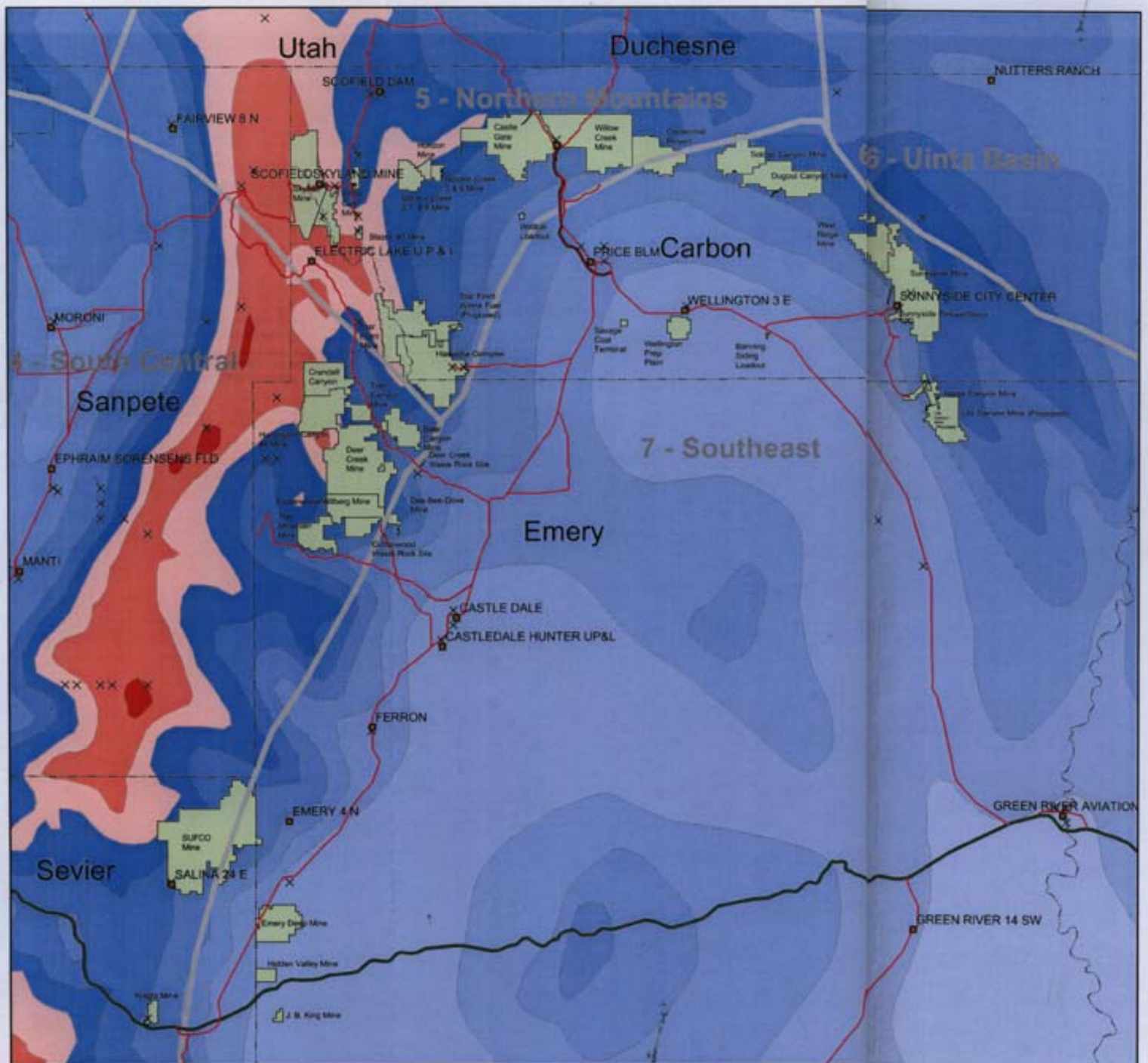
• Mine Water Q: Monthly Average ⧖ BC-2 minus BC-1

O:\CHIA\GENTRY\MT\GENTRY\MT\QUATTRO\Bryntsurface WB2 Figure18
1/JUNE2001

Figure 18


Carbon
Price River Basin
Sanpete
San Rafael River Basin
Emery
Grand
Sevier
Wayne
Location Map
Wasatch Coal Field
Coal Permit Areas
Gentry Mountain CIA Area
County Boundary
CIA Areas
Hydrologic Unit Boundary
State of Utah
Department of Natural Resources
Division of Oil, Gas and Mining
Map 1
Cumulative Hydrologic Impact Assessment
Gentry Mountain
LOCATION MAP
File--n:\gis\coal\ciamaps\gentrycia\map1.pdf
Compiled by: Dan Smith
Date: September 08, 2003

Map 1a
Utah Coal Permit Areas and Palmer Hydrologic Index Climate Divisions



0 4.5 9 18 27
Miles

N

Legend

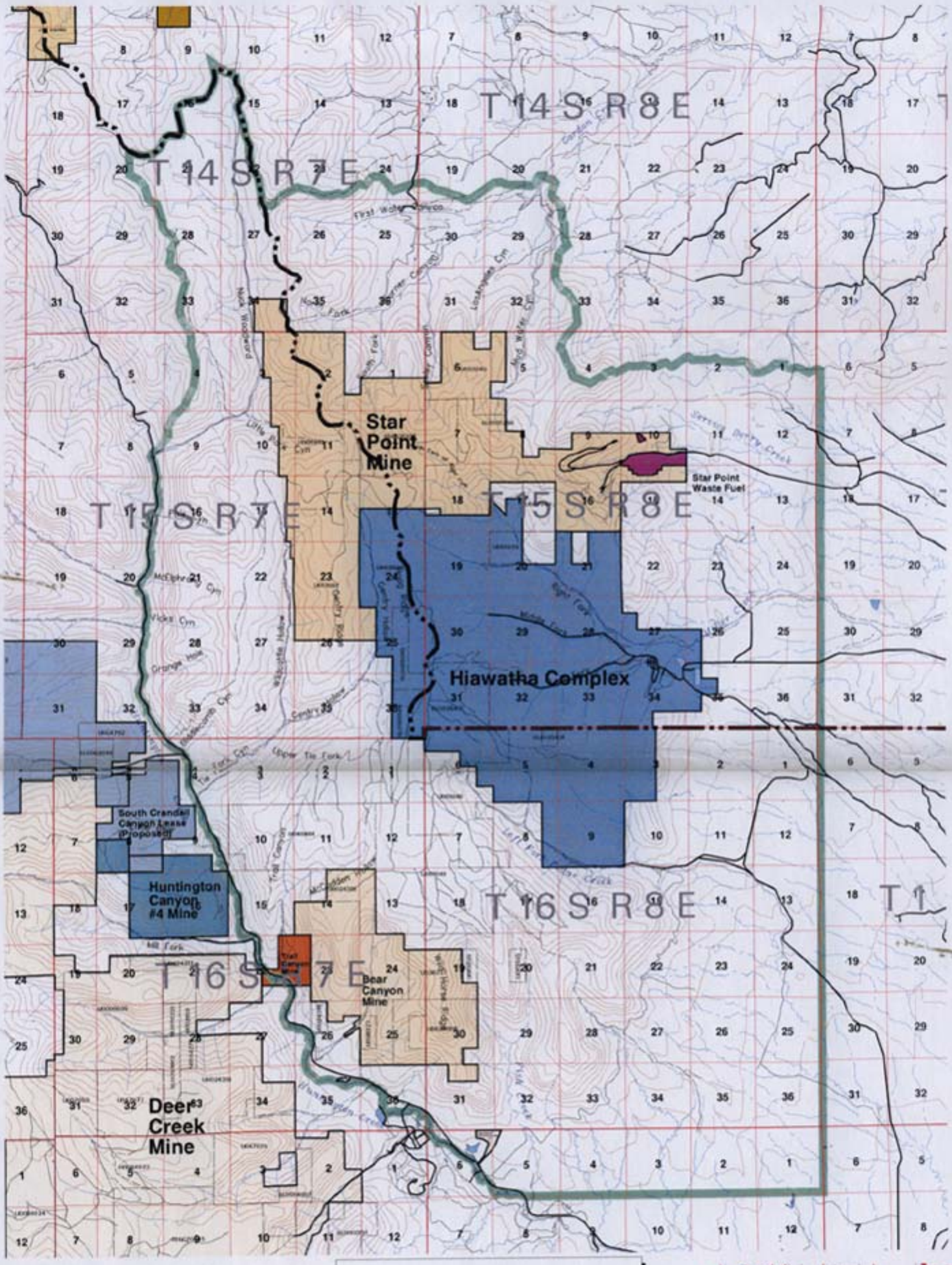
- Current Cooperative Weather Stations
- All Cooperative Weather Stations
- Interstate
- Divided Highway
- Principal Highway
- Improved Highway
- Zones
- County Boundaries
- Coal Permit Areas

Avg Normal Precip.

- <6 inches
- 6-8 inches
- 8 - 10 inches
- 10 -12 inches
- 12 -16 inches
- 16 - 20 inches
- 20 -25 inches
- 25 -30 inches
- 30 -40 inches
- 40 - 50 inches
- 50 -60 inches
- >60 inches

The Cooperative Weather Station data and Zones data was downloaded from the National Climatic Data Center web site.
The current Cooperative Weather Stations are stations that have current data.
Coal Permit Area data produced by Division of Oil, Gas and Mining.
All other data obtained from Utah Automated Geographic Reference Center.

Map Produced July 2001 by Daniel Smith



CIA Area
Intermittent Stream
Perennial Stream
Lease Boundary
Contours 200ft Interval
Main Road
Graded Dirt Road
Dirt Road
County Boundary
Permit Boundary

State of Utah
Department of Natural Resources
Division of Oil, Gas and Mining

N

Map 2
Cumulative Hydrologic Impact Assessment
Gentry Mountain

CUMULATIVE IMPACT AREA (CIA)

File--n:\gis\coal\ciamaps\gentrycia\map2.pdf

Compiled by: Dan Smith Date: July 06, 2004

Location Map

Subsidence or break out areas
Selected Long Wall Mining Panels
Mined Mains
Permit Area
Wattis Seam Sump Drainage Area
Third Seam Sump Drainage Area
Streams
Major Faults
Infered Major Faults
Minor Faults
Infered Minor Faults
Subsidence Fractures
Bottom of Coal Seam Contour
Springs
Wells
Surface Water Monit. Site
UPDES Monit. Site

Map 3a
Cumulative Hydrologic Impact Assessment
Gentry Mountain

Hiawatha Mine - A Seam
Mining and Subsidence Areas

File--n:\gis\coal\ciamaps\gentrycia\map3a.pdf

Compiled by: Dan Smith Date: June 29, 2004

State of Utah
Department of Natural Resources
Division of Oil, Gas and Mining

N

Scale 1:40000 (verify scale)

Location Map

Subsidence or break out areas
Selected Long Wall Mining Panels
Mined Mains
Permit Area
Wattis Seam Sump Drainage Area
Third Seam Sump Drainage Area
Streams
Major Faults
Infered Major Faults
Minor Faults
Infered Minor Faults
Subsidence Fractures
Bottom of Coal Seam Contour
Springs
Wells
Surface Water Monit. Site
UPDES Monit. Site

Map 3b
Cumulative Hydrologic Impact Assessment
Gentry Mountain

Hiawatha Mine - B Seam
Mining and Subsidence Areas

File--n:\gis\coal\ciamaps\gentrycia\map3b.pdf

Compiled by: Dan Smith Date: June 29, 2004

State of Utah
Department of Natural Resources
Division of Oil, Gas and Mining

N

Scale 1:40000 (verify scale)

Location Map

Subsidence or break out areas
Selected Long Wall Mining Panels
Mined Mains
Permit Area
Wattis Seam Sump Drainage Area
Third Seam Sump Drainage Area
Streams
Major Faults
Infered Major Faults
Minor Faults
Infered Minor Faults
Subsidence Fractures
Botton of Coal Seam Contour
Springs
Wells
Surface Water Monit. Site
UPDES Monit. Site

State of Utah
Department of Natural Resources
Division of Oil, Gas and Mining

N

Map 3c
Cumulative Hydrologic Impact Assessment
Gentry Mountain

Hiawatha Mine - Hiawatha Seam
Mining and Subsidence Areas

File--n:\gis\coal\ciamaps\gentrycia\map3c.pdf

Compiled by: Dan Smith Date: June 29, 2004

Scale 1:40000 (verify scale)

Location Map

U046484

U061049

U0024316

U038727

U0020668

Trail Canyon Fault

Dry Canyon Fault

Pleasant Valley Fault

Blind Canyon Fault

Bear Canyon Fault

Trail Canyon Mine

Bear Canyon Mine

Trail Canyon Fan Portal

Intake & Belt Portal

Intake Portal

Fan Portal

Tank Seam Portals

Portal Entrys

Belt Portal

Intake Portal

Portal Entry

Bear Canyon Seam Portal

SDH-2

SDH-3

SMH-2

SMH-1

SBC-12

UT-1

4-8W

TS-1

CS-1

DH-1A

DH-2

RCW4

SBC-5

SBC-6

SBC-4

BC-2

UTG040006-002

UTG040006-003

UTG040006-006

HCC01

HCC02

HCC03

MHC 01

DCWR7

10 11 12 7 15 14 13 18 22 23 24 19 27 26 25 30 34 35 36 31

Subsidence or break out areas

Mined Areas

Permit Area

Blind Canyon Seam

Hiawatha Seam

Tank Seam

Trail Canyon

Streams

Major Faults

Infered Major Faults

Minor Faults

Infered Minor Faults

Floor Seeps

Springs

Wells

Surface Water Monit. Site

UPDES Monit. Site

State of Utah
Department of Natural Resources
Division of Oil, Gas and Mining

N

Map 4
Cumulative Hydrologic Impact Assessment
Gentry Mountain

Trail Canyon & Bear Canyon
Mining and Subsidence Areas

File--n:\gis\coal\ciamaps\gentrycia\map4.pdf

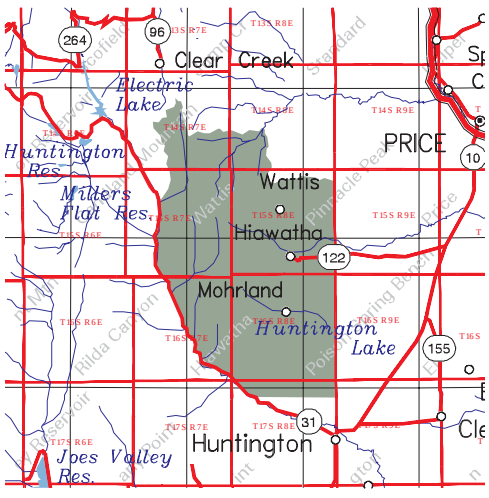
Compiled by: Dan Smith Date: September 08, 2003

0 1/4 1/2 1 mi

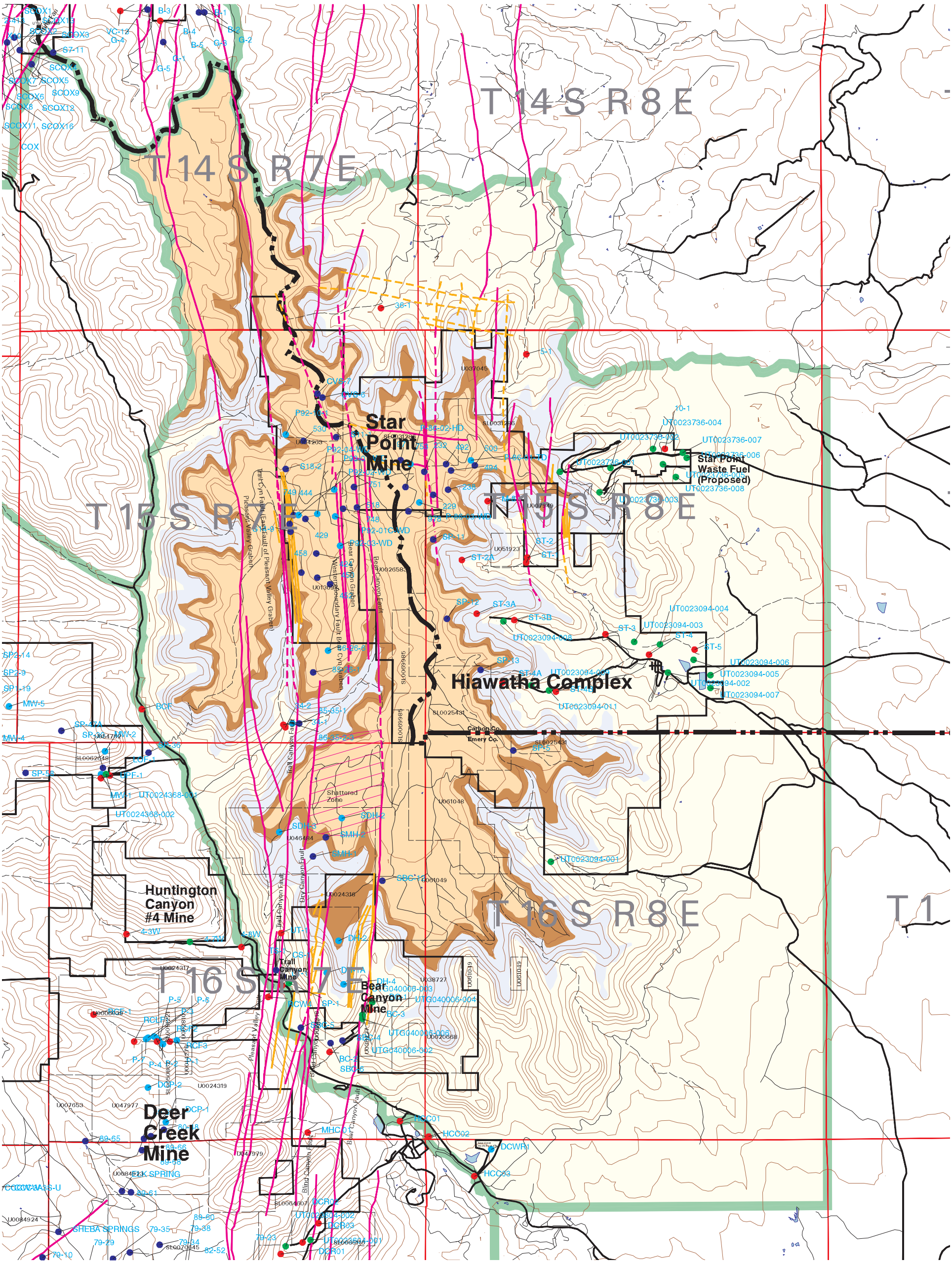
0 1000 2000 5000 ft

0 1/4 1/2 1 k

Scale 1:25000 (verify scale)



Location Map



Price River and North Horn Frm
Castlegate Formation
Blackhawk Formation
Area Below Coal Resource
CIA Area
Permit Boundary
Lease Boundary
County Boundary
Contours 200ft Interval

Main Road
Graded Dirt Road
Dirt Road
Springs
Wells
Surface Water Monit. Site
UPDES Monit. Site

Map 5
Cumulative Hydrologic Impact Assessment
Gentry Mountain Mine

GENRTY MOUNTAIN GEOLOGY

File--n:\gis\coal\ciamaps\gentrycia\map5.pdf

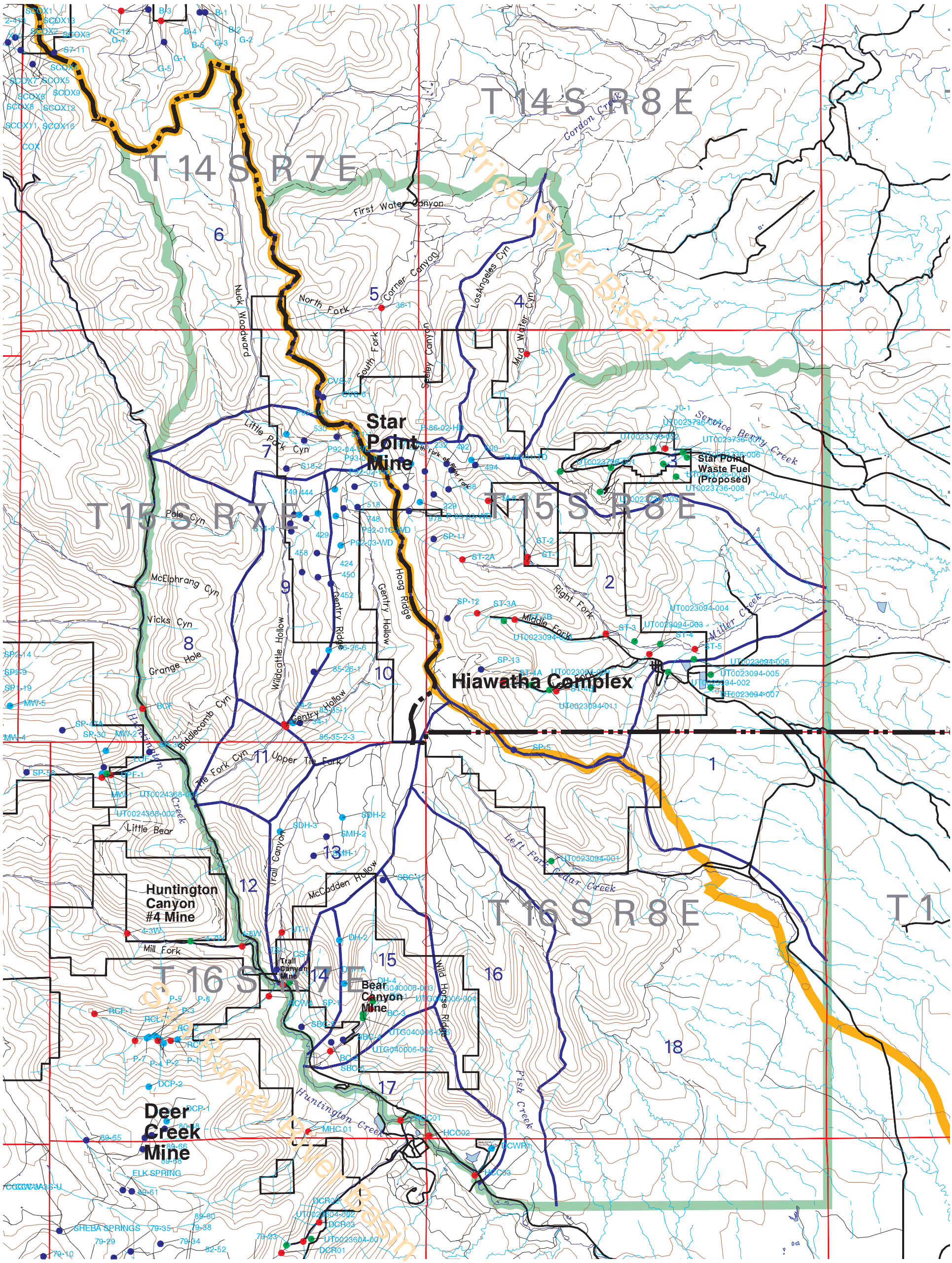
Compiled by: Dan Smith Date: September 08, 2003

State of Utah
Department of Natural Resources
Division of Oil, Gas and Mining

N

Scale 1:90000 (verify scale)

Location Map



CIA Area
Intermittent Stream
Perennial Stream
Contours 200ft Interval
Main Road
Graded Dirt Road
Dirt Road
Major River Basin
Springs
Wells
Surface Water Monit. Site
UPDES Monit. Site

Hydrologic Units
1 Sand Wash
2 Miller Creek
3 Serviceberry Creek
4 Mud Water Canyon
5 Corner Canyon
6 Nuck Woodward Creek North
7 Nuck Woodward Creek South
8 Huntington Creek Sub-basin
9 Wild Cattle Hollow
10 Gentry Hollow
11 Tie Fork Canyon
12 Huntington Creek Sub-basin
13 Trail Canyon
14 Birch Springs
15 Bear Canyon
16 Fish Creek
17 Huntington Creek Sub-basin
18 Cedar Creek

State of Utah
Department of Natural Resources
Division of Oil, Gas and Mining

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Map 6
Cumulative Hydrologic Impact Assessment
Gentry Mountain Mine

SURFACE HYDROLOGY

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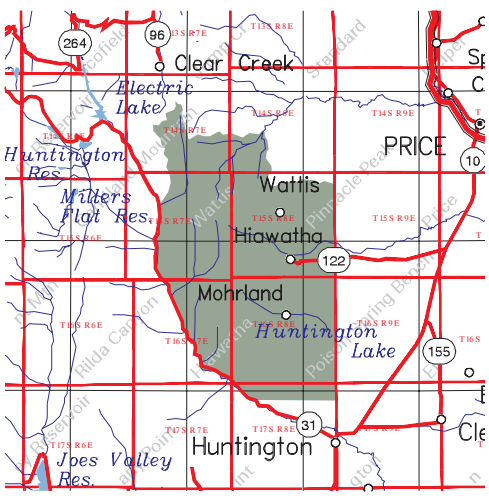
Compiled by: Dan Smith Date: September 08, 2003

Scale 1:90000 (verify scale)



Location Map