STAR POINT MINE

ACT/007/006

PROBABLE HYDROLOGIC CONSEQUENCES OF MINING IN THE GENTRY AND CASTLE VALLEY RIDGE AREAS

UPDATE REPORT

MAY, 1992

CYPRUS PLATEAU MINING COMPANY

ENVIRONMENTAL RESOURCES

PROBABLE HYDROLOGIC CONSEQUENCES OF MINING IN THE GENTRY AND CASTLE VALLEY RIDGE AREAS

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May, 1992

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728. PROBABLE HYDROLOGIC CONSEQUENCES DETERMINATION.

This report and section of the permit has been prepared to answer questions and concerns related to the effects of mining in the Gentry and Castle Valley ridge areas on the hydrologic systems found within and adjacent to the Cyprus Plateau Mining Company (CPMC) permit area. The presentation of information requested within regulations R645-301-728.100 through R645-301-728.400 is found herein in a storybook format rather than broken up into subsections and headings by regulation number. It is felt that the reader will better understand hydrologic conditions and potential impacts more readily if the proposed format is followed rather than a broken section by section format.

The information provided herein has been separated into relevant topics for discussion. General topics of discussion presented will begin with an overview of pertinent studies, a review of Gentry and Castle Valley ridge characteristics, a description of exploration and testing completed by CPMC, a review of overall hydrogeologic conditions, a discussion of water quality characteristics of the area, a summary of the probable impacts to the hydrologic system by coal mining, and a discussion related to mitigation of potentially impacted waters.

PERTINENT STUDIES

A review of historic reports for the Gentry and Castle Valley ridge areas has been made through the years to identify to the degree possible existing information related to local hydrogeology. Reports which have been identified include those prepared for CPMC by in-house staff or by consultants, and one by the United States Geological Survey (U.S.G.S., 1988). Pertinent reports which have been prepared for CPMC have been included within historic permit applications. The report prepared by the USGS reviews and analyzes information for both the Wasatch Plateau and Book Cliffs coal fields. Information from these historic sources has been used throughout the preparation of this PHC to confirm the conclusions found as a result of the efforts by CPMC.

Downstream Users

One critical aspect of a PHC is the determination of downstream water right holders which might be affected should impacts be caused by mining operations. A review of water right holders was made and submitted as part of the 1991 permit application package. In addition to information provided therein, an additional search was made for the springs located south of the permit area which are owned by the Huntington-Cleveland Irrigation Company and operated by the Castle Valley Special Services District (CVSSD) including the Tie Fork Wells and Bear Canyon spring, and those owned and operated by the North Emery Water Users Association (NEWUA) including Birch spring. According to information provided by the water suppliers involved and the Utah Division of Water Rights database computer, there are three water sources used for culinary supply which may potentially by impacted by mining. These water sources include two wells located in Tie Fork Canyon and two springs identified as Birch and Bear Canyon springs.

Because of potential impact issues related to these springs, the water right evaluation included herein was made to determine the total amount of water which might be impacted should the source be completely lost. According to information provided by the State Division of Water Rights computer, all three water sources referenced are interconnected with a total water right of 352.25 cfs (see Table 728a).

The amount of water which has been available historically from the Tie Fork wells, Birch, and Bear Canyon springs is far below any single water right shown in Table 728a. The minimum right shown in the table is 45 cfs, whereas the average combined spring flow from the three sources just identified is only 0.74 cfs (only 1.6% of the 45 cfs right and 0.2% of the total combined flow right). Time flow plots for all three springs for the period of record since 1983 are included in Exhibit 728a. From the flow plots it is noted that the Tie Fork flows have been very stable over the period of record with one major anomaly which occurred in late 1988.

According to CPMC personnel the area experienced an earthquake during the fall of 1988 which appears to have temporarily increased flows in Tie Fork. The record shows that after three years the flows are returning to pre-earthquake conditions. Average flows including the higher flows subsequent to the earthquake are 0.2 cfs. If earthquake related flows are removed from the database, the average flow drops slightly to 0.19 cfs. The long term stability in flow rates for the Tie Fork wells indicates that the wells are fed by a large recharge area which is not influenced significantly by local precipitation activity. This is not the case for Birch and Bear Canyon springs.

Bear Canyon spring shows a relative doubling of flow rates during the summer period during the 1984, 1985 and 1986 runoff years, and a decline in water level since 1987 corresponding to local drought conditions or other mining impacts. Average flow for the period of record was calculated to be 0.38 cfs. Birch spring shows similar fluctuations in annual flow patterns with a corresponding decrease in flows over the relatively short period of record. Average Birch Spring flows are calculated to be 0.16 cfs. Because of the relative fluctuations noted at both these springs, it is believed that the recharge sources are much smaller than that projected for the Tie Fork source.

GENTRY AND CASTLE VALLEY RIDGE CHARACTERISTICS

Gentry and Castle Valley ridge coal tracts lie within the Wasatch Plateau which is located near the geographic center of Utah, approximately 5 miles west of Wattis, and about 16 miles southwest of Price, Utah. Topography of the plateau is very irregular and the eastern edge consists of a steep escarpment. Through geologic time canyons have been cut into this escarpment by erosion thereby forming steep cliffs along which the coal seams are often exposed. The relief of the area ranges from approximately 7,000 to over 10,000 feet above sea level. Coal seams are generally exposed at elevations between 7,000 and 8,000 feet.

Stratigraphy

The lowest stratigraphic unit of interest in this area is the Mancos Shale. The Mancos Shale is composed of, from bottom to top, the Tununk Shale Member, the Ferron Sandstone Member, the Blue Gate Member, the Emery Sandstone, and the Masuk Shale. The Masuk Shale is a sandy marine mudstone and siltstone which is approximately 1,000 feet thick locally. The Masuk Shale, as with other shale members of the Mancos Shale Group, acts as an aquiclude and does not carry appreciable quantities of water.

The Mesaverde Group consisting of the Star Point Sandstone, the Blackhawk Formation, The Castlegate Sandstone and the Price River Formation are found immediately above the Masuk Shale formation.

The Star Point Sandstone is the first cliff former in the area of interest and is on the order of 400 to 500 feet thick. The Star Point is composed of massive sandstone interbedded with thin layers of shale. Three separate identifiable sandstone units are evident within this larger sandstone layer. The lowermost sandstone unit found within the Star Point formation is the Panther member with the Storrs and Spring Canyon members lying within the intermediate and upper zones of the Star Point Sandstone.

The Blackhawk Formation lies above the Star Point Sandstone and is approximately 1,000 feet thick. All of the minable Wasatch Plateau coal seams are found within the lower 400 feet of this formation. The Blackhawk consists of alternating beds of sandstone, shale, and coal. The outcrop of the Blackhawk forms step-like cliffs which are typically not as steep as those formed by the Star Point. The Hiawatha coal seam is located at the bottom of the Blackhawk Formation and rests directly on the Spring Canyon Tongue of the Star Point Sandstone. The Third seam is located stratigraphically about 70 feet above the Hiawatha seam, with the Wattis seam lying approximately 30 feet above the Third seam. Within the lease area, the Wattis seam ranges in thickness from 6 to 9 feet. Generally speaking, fewer springs are found within the Blackhawk Formation than within the formations above it.

The Castlegate Sandstone (found above the Blackhawk formation) is generally considered to be a member of the Price River Formation. The Castlegate Sandstone forms the uppermost part of the escarpment in the Wasatch Plateau.

The Price River Formation which lies above the Castlegate Sandstone is composed primarily of sandstone interbedded with shale and conglomerate. The sandstone of this unit is not as massive as the Castlegate Sandstone member and is, therefore, less resistant. The Castlegate Sandstone and Price River Formation together form a unit which is on the order of 500 feet thick in the Gentry Ridge area. The sandstones of the Price River Formation and the Castlegate Sandstone are generally the sources of several good quality springs. The largest flow recorded for a Price River Formation spring in the Wasatch Plateau region is 25 gallons per minute.

The North Horn Formation, lying above the Price River Formation forms the slopes and rolling topography of the upper Wasatch Plateau and is found up to 600 feet thick in the area. It is composed of shale, sandstone, and limestone, which form alternating aquifers and impermeable beds.

The North Horn Formation grades into the Flagstaff Formation which forms the uppermost stratigraphic unit within the Plateau. The Flagstaff Formation, found to be approximately 200 feet thick in the Gentry Ridge area is composed primarily of limestone interbedded with sandstone and shale. Local springs originating in the Flagstaff Formation are generally of good quality.

Structure

The minable part of the Castle Valley and Gentry Ridge coal lease tracts are within the Gentry Ridge Horst which lies between the Bear Canyon Graben on the east, and the Pleasant Valley Graben on the west. These grabens are formed by north-south trending fault zones. The faults on the western edge of the Gentry Ridge Horst are believed to be displaced as much as 500 feet, while those on the eastern boundary of the horst displace a total of approximately 250 feet. Regional dips of the stratigraphic units within the lease area are approximately 3 degrees to the south southwest.

Consistency in Regional vs Local Ground Water Systems

Efforts to examine characteristics of the local ground water system have included the identification and review of previous efforts made by CPMC as well as by other local coal mines and governmental agencies. As a result of that review it has been noted that there appears to be an overall consistency in documented data. The general stratigraphy and geologic anomalies (including general aquifers and fault and fracture systems which drive hydrology) noted in the previous discussion were found to exist within all other references reviewed.

An example of this consistency was noted after discussions with DOGM personnel regarding the CO-OP mining operation and their recent drilling efforts. Findings at the time of this submittal indicated that there appears to be an upward gradient between the Storrs and Spring Canyon member of the Star Point sandstone and a downward gradient between the Storrs and Panther geologic groups. In addition it was noted that the Panther member is not fully saturated. This data would seem to indicate that the Spring Canyon sandstone to the south of the Plateau mine is a perched confined aquifer system.

Similar upward and downward gradients have been noted as a result of in-mine drilling operations within the Plateau mine in Gentry Ridge. To date four wells have been drilled in the northern end of Gentry Ridge, one of which is a nested well penetrating three separate zones within the Blackhawk and Spring Canyon Geologic formations. Recent data collected from this nested well indicates that there is a slight increase in pressure (approximately 1 to 2 feet in static water level) in the middle zone over the upper zone, resulting in an upward gradient. Water levels found within the lower zone however were approximately 10 feet lower than those observed in the middle zone indicating a downward gradient.

It is interesting to note the similarity in hydrogeologic conditions found within the general Wasatch Plateau coal fields. A single clearly identifiable aquifer does not appear to exist within the area. There is however a multitude of smaller aquifers which are now identified as being unconfined in the uppermost zones and either perched unconfined or perched confined in the middle and lower geologic units. The hydraulic gradients of these aquifers combine locally to produce what has been termed the local aquifer. In the Gentry Ridge area hydraulic gradients generally appear to be upward immediately below the coal seam with aquifers of lower head lying within deeper units. It is anticipated that the general gradient in the Castle Valley Ridge area will be downward since the regional water table lies beneath the coal seam. This general pattern is consistent with existing reports reviewed.

CPMC STUDIES AND TESTING

Cyprus Plateau Mining Company has completed numerous investigative studies in the attempt to determine local hydrogeology and the related impacts of mining. Within the immediate past these studies have included reviews of in-mine geology encountered, water sampling of mine inflows, sampling of downgradient spring water sources and the drilling of in-mine monitoring wells. A discussion of water quality is presented later within this section, however it is prudent that the discussion of recent well drilling operations be presented here.

Well Drilling

Four in-mine wells have been drilled within the last six months within the Gentry Ridge coal lease tract. All four of these wells were drilled from the Wattis coal seam and penetrate into the Lower Blackhawk and Spring Canyon formations. None of the wells have been drilled into the Storrs member of the Star Point Sandstone which lies between the Spring Canyon and Panther members. Wells drilled are numbered 92-01-WD through 92-04-WD as shown on Maps 728a and 728b. Well completion details are shown in Exhibit 728b. Well 92-02-WD, located in the northwest portion of the Gentry Ridge mine workings was drilled to 210.5 feet and was the first in-mine well drilled within the Gentry Ridge. This well penetrated the entire depth of the Spring Canyon sandstone below the Hiawatha coal seam. A 15 foot screened section is located within the lowermost portions of the Spring Canyon member.

Map 728a. Regional Hydrogeology
Map 728b. Gentry and Castle Valley Ridge Mine Inflows

The second well (92-01-WD), located just south of the west end of the graben crossing was drilled to a total depth of 191 feet and included the construction of three nested piezometers. Both uppermost piezometers terminated within the Blackhawk formation at depths of 71 and 114.5 feet. The lowermost piezometer terminated within the Spring Canyon sandstone at 191 feet with a 15 foot screened section. For further reference the piezometers are numbered 92-01-A-WD, 92-01-B-WD, and 92-01-C-WD for the shallow to deep piezometers respectively.

The third well (92-03-WD), located approximately two longwall panels (2,150 ft) south of well 92-01-WD was drilled to a total depth of 43 feet. This well was completed in the Blackhawk formation and cased with 10 feet of perforated casing at the bottom of the hole. The initial head measured upon well completion was 20 psi whereafter it has declined to less than 5 psi.

The fourth well installed (92-04-WD) located approximately midway between wells 92-01-WD and 92-02-WD was drilled to a total depth of 173.6 feet. During construction it was found that the bentonite seal placed around the well casing did not penetrate to its full intended depth. It was decided that to complete the well properly, the casing would have to be pulled and the hole reamed out. The reaming and casing of the well was completed in April of this year.

Information provided by these wells has already shed light on local ground water conditions and helped to identify and clarify permit and adjacent area ground water characteristics. Further discussion related to this data and the conclusions drawn is presented later.

HYDROGEOLOGY

Local hydrogeology as outlined herein will be discussed in terms of the locations and findings of seeps, springs and wells from which information has been obtained. Data thus obtained will be presented to show overall characteristics of ground water origin and movement.

Location of Seeps and Springs

The locations of seeps and springs which have been identified through surface investigations are shown on Map 728a. A review of the map will show the general orientation of these springs as they relate to faults and surficial geologic structure. It is important to note that the relationships between water source and geology shown on the map are a general guide only. No detailed attempts have been made to refine mapped surficial geology at the scale shown in relation to exact spring locations and noted field geology.

The majority of seeps and springs occur at either a geologic interface between bedding structures or at a fault. Seeps and springs found within the Wasatch Plateau are generally located on southern or western facing slopes downgradient of recharge areas. In the case of some springs near the southern end of the permit area it appears that the springs may be due to both faults and geologic interfaces.

Location of Wells

Currently active wells found within the permit area which are used for water level or quality monitoring include three east of the Bear Canyon Graben, one south of the Gentry Ridge permit area, and four in-mine wells located within the northern portions of the Gentry Ridge mine workings. These and other wells from which data have been collected over time are shown on Map 728a. The 1991 annual hydrologic report which has been prepared for the Division indicates that wells from which water level data have been obtained include wells 86-01-TD, 86-02-HD, 86-03-WD and 86-26-6. Two wells which were historically monitored no longer provide data. Of these, well 86-18-2 was lost to mining in August of 1989 and well 86-26-4 became plugged at the 9550 foot level.

The four in-mine wells identified earlier as 92-01-WD, 92-02-WD, 92-03-WD, and 92-04-WD are all located within the northern portions of the Gentry Ridge mine workings (See Maps 728a and 728b).

Mine Inflows

As with any mine located within the Wasatch Coal field, water will be encountered as mining progresses. These mine inflows will occur as roof drippers, inflow from sandstone geologic formations, leaks from small roof or rib fractures, and flow from major faults or fissures which are encountered during the advancement of mining. Small flows encountered to date within the mine have generally been associated with limited perched aquifer systems which drain as mining interrupts natural flow paths. Generally speaking, these small perched flows diminish over time to the point where flow ceases. Small flows encountered within the far northern and eastern ends of Gentry Ridge mining are believed to be following these same general characteristics. More will be said about Gentry Ridge mine inflows later.

Areas East of Gentry Ridge. The flow chart and data provided in the 1991 hydrologic summary reports that the average total discharge of water from the mine from perched channel sandstones during the 1985 through 1986 period was approximately 0.529 cfs (237 gpm). The average flow that occurred during the 1986 through 1987 period was 0.485 cfs (218 gpm). Average recorded flows for the years 1988, 1989, 1990 and 1991 were 0.158, 0.111, 0.083 and 0.053 cfs respectively (an annual decrease of between 25 and 40 percent per year). Mine water developed is used for in-mine and surface operations purposes and no mine discharge has occurred since July of 1987.

Much of the mine inflow is derived from water stored in the channel sandstones above and below the coal seams being mined. Inflow to the mine from a channel sandstone may be significant when first encountered, but as the mine advances, inflow from channel sandstones previously encountered drop off rapidly (often to zero) indicating that recharge to these perched systems in the Blackhawk Formation is limited. Limited recharge is a result of shale or mudstone layers in the Blackhawk and overlying formations which form barriers to the vertical movement of ground water.

As an indication of the volume of water potentially derived from storage in the channel sandstones of the Blackhawk Formation, the contributing area of aquifer was calculated that is required to produce an annual yield of 134 gpm. Assuming this flow rate and that the specific yield for the sandstone units is 0.1, the total volume of water released from storage is only 216 acre-feet. Further assuming that the sandstone unit is 10 feet thick, the required storage area to produce 216 acre-feet of water is only 216 acres. A 20 foot thick sandstone unit would require a contributing area of only 108 acres. The longwall area itself of the Wattis Coal Seam (See Map 722.100e of the mine permit application) covers some 130 acres. The total in-mine tributary area of monitoring sites includes approximately 1,400 acres.

Assuming that the above criteria and calculations are representative of true hydrogeologic conditions, and recognizing that recharge to the Blackhawk - Star Point aquifer system is limited, it is estimated that over 95 percent of traditional water made within the mine is derived from storage of the channel sandstones in the Blackhawk Formation, and actual total impact to surface receiving streams is probably less than five gpm.

Gentry and Castle Valley Ridges. Larger inflows which have been identified within the mine appear to be generally associated with the western boundary fault of the Gentry Ridge Horst. A review of mine inflow locations, the magnitude of the inflow, and the occurrence of local faulting shows that the major flows encountered within the mine are from these structurally weak areas. To date the great majority of flow has been obtained from mine workings which appear to be intercepting finger faults associated with the western boundary fault.

The first two large flows encountered by mining were located within the far western end of the 3rd West Mains where mining appears to have possibly intercepted floor fractures (See Map 728b). The flow located in the far north west end of the mains was originally recorded to be approximately 40 gpm with flow in the far south west end being approximately 20 gpm. Flows entering from these locations were jointly measured recently to be on the order of 40 gpm. Efforts are continuing within the mine at these and other inflow locations to obtain more accurate flow measurements through the use of portable flumes.

A third significant inflow was encountered within the south mains for the second longwall panel (3rd Right Mains) wherein a roof fracture, and potentially a finger fault was encountered. Flow from this general area was estimated recently to be about 100 gpm.

A flow estimated originally to be on the order of 40 gpm was encountered within the south mains of the third longwall panel. This flow now appears to be approximately 50 gpm and is believed to be associated with roof fractures. A smaller flow of about 7 to 10 gpm was found at the far south end of current 3rd Main South near the intersection of 5th Right. At the present time this flow is entering from the mine roof. Other inflows encountered within the mine which are not associated with fracturing or faulting appear to be relatively small, and of the same relative magnitude and occurrence which have been noted within other mine sections.

Some sections of the mine have been noted to have damp conditions. One of these areas is within the mains of 3rd South and in 1st, 2nd and 3rd Right Mains where CPMC personnel have indicated that the floor of the mine continues to be wet. The wet areas noted are small and appear to be indicative of conditions which would be expected in a submerged tight geologic structure. This submerged condition is consistent with what was expected based upon a review of both historic and current ground water level data.

Analysis of Ground Water. Ground water level data was reviewed for all wells currently monitored within and without the CPMC permit area. Data reviewed and used in the analysis of the local ground water included that from surface wells 86-18-2, 86-26-6, 86-35-2, 86-35-3, and from in-mine wells 86-01-TD, 86-02-HD, 86-03-WD, 92-01-WD, 92-02-WD, 92-03-WD and 92-04-WD. It is noted that some of the data available from the wells was taken from earlier measurements and used as an approximation where appropriate. A summary of data used in the analysis of the local water table is shown in Table 728b.

According to data provided, it appears that the overall water table has been relatively consistent over time with the exceptions of a few wells. Additional specifics related to water levels can be investigated in the annual hydrologic reports prepared for DOGM. Other analyses completed on ground water include several chemical tests which are described in detail in following sections.

Additional data collected as part of the ground water analysis includes well drilling data as taken from well drillers reports for exploration wells which were drilled in the Castle Valley Ridge area. Information provided by CPMC include that shown in Table 728c. Data presented in this table was taken during the drilling of each hole identified, and does not reflect an accurate ground water table representative of the area since water was added to the drill holes for logging. It is true however that the information is adequate to indicate whether or not the local water table is above or below the local coal seam at each well. This determination can be made for each well where, even after the addition of water, the recorded water level for wells found within the CVR permit area is below the coal seam. This data helps to substantiate the long standing conclusions made regarding the position of the coal seam with respect to the local water table in the Castle Valley Ridge area.

Only two wells shown in the table indicate that water levels were recorded above the Wattis coal seam. The first well (CVR-5A) shows a 40 foot head, however this could easily be due to water introduced into the hole for logging purposes and is not representative of other data shown in the vicinity. The second well (CVR-10) shows a substantial head of water over the coal seam, however the well was lost, and the replacement well (CVR-10C) located immediately adjacent to it shows the coal seam to be substantially higher than the local water table.

Ground Water Flow

Lateral Flow. Conclusions reached by way of review of available data include a general direction and characteristic of the local ground water table. As determined from the data, the general orientation of the ground water table is to the south southeast as shown on Map 728a. The same ground water patterns were found to exist on both sides of the eastern boundary faults associated with the Gentry Ridge Horst. The three wells located east of current mining operations 86-01-TD, 86-02-HD, and 86-03-WD form a triangular pattern capable of allowing a prediction of ground water flow direction. The overall ground water gradient in this area is calculated to be approximately 3%.

In-mine wells completed in 1992 within Gentry Ridge show a ground water flow gradient of 2% both within the northern as well as the southern portions of the ridge. Water level data from Tie Fork wells projected northward to well 86-26-6, and from there to well 92-03-WD show a remarkably consistent ground water gradient. This overall gradient has not changed significantly over the course of time from earlier projections, however the overall direction of movement has. Earlier estimates show the gradient to be to the south southwest whereas the gradient now appears to be to the south southeast. The addition of wells within Gentry ridge has helped to verify and correct earlier assumptions, and now indicates that the western boundary fault appears to be a "recharging" fault.

Ground water data provided from the well constructed within the eastern portions of the Bear Canyon Graben (during the time of construction of the Graben crossing) was utilized herein to help provide data between easterly and westerly data. It was felt at the time of construction that water within this well was at an elevation of approximately 8330 feet. Since the well was lost, and since no other data are available for the immediate vicinity, the same water level was used for estimation purposes. Using the estimate "as is", the water table shows a bend to the north as one moves westerly toward the Western Boundary Fault of the Bear Canyon Graben. The same ground water flow patterns would exist if this well were ignored in the analysis. This bending of contours indicates that the fault is a "discharging" fault. Any downward correction applied to the data at the graben well for the purposes of drought adjustment would increase the bend in the ground water contour to the north. Such a correction would strengthen the conclusion that the eastern boundary fault is a discharging fault.

By combining data and concepts which have been outlined above, one is lead to the conclusion that local ground water is moving southward, and is fault driven. Although some water moves through the geologic strata as porous media flow, it appears that the large portion of flow is fault or fracture driven. This conclusion is made due to the facts that 1) the theoretical permeabilities of the geologic structures present in the area are small and will not produce flows as identified in the field, and 2) the majority of seeps, spring and mine inflows are found to occur along fault and fracture planes. In addition, the orientation of the ground water contour lines at the boundary faults indicate that the Eastern Boundary Fault of the Pleasant Valley Graben is recharging the Gentry Ridge Horst, and the Western Boundary Fault of the Bear Canyon Graben is acting as a discharge fault.

Vertical Flow. Estimated vertical flow patterns were determined by utilizing water level data provided by nested well 92-01-WD. As stated earlier this well is a three nested piezometer which has been perforated within the lower reaches of the Blackhawk formation, and in the of the Spring Canyon member of the Star Point Sandstone. The most recent set of data from this well indicates that ground water movement is upward through members of the Blackhawk below the Wattis coal seam, and downward from the Blackhawk into the Spring Canyon sandstone.

The shallow, intermediate and deep piezometers had recorded water levels of 8322, 8324 and 8306 feet respectively during the most recent measurements. Head variation between the shallow and intermediate zones shows only a relatively slight upward gradient between the Wattis and Hiawatha coal seams, however a more pronounced difference of 18 feet (7.8 psi) was noted between the Lower Blackhawk (intermediate piezometer) and the Spring Canyon Sandstone (deep piezometer).

Preliminary information which was been made available to CPMC by DOGM related to exploration of ground water at the CO-OP mine has revealed that there are similar variations in head within the lower aquifer zones beneath coal bearing strata to the south. According to information received, testing at the CO-OP facility is showing an upward gradient between the Storrs and overlying Spring Canyon members of the Star Point Sandstone, and a downward gradient between the Storrs and underlying Panther members. In addition it is believed that the lowermost sandstone member (Panther) may not be fully saturated.

The presence of both upward and downward gradients within the various formations monitored both on CPMC permit areas as well as on CO-OP permit areas tends to strengthen the conclusion that the Gentry and Castle Valley Ridge coal lease tracts are riddled with numerous unconfined perched, confined, saturated, and unsaturated geologic structures. Pressure gradients lying immediately beneath the Wattis coal seam in northern Gentry Ridge indicate that flow is upward. Because of the upward dip of geologic structure to the north, this is not expected to be the case beneath Castle Valley Ridge.

Aquifer Testing. Aquifer testing (in the form of slug tests) was conducted on in-mine wells 92-01A-WD, 92-01B-WD, 92-01C-WD and 92-02-WD. Testing on wells 92-03-WD and 92-04-WD has not been competed to date. All four tests were completed by introducing a volume of water into the well and monitoring the resulting drawdown. Information related to these tests is included in Exhibit 728c and a summary of permeability for each aquifer tested is provided in Table 728d.

Data from the table shows that calculated permeabilities within the Blackhawk formation are two to nine orders of magnitude lower than those found within the Star Point Sandstone formation. Caution must be given however when using the above listed permeabilities because of the potential for distortion due to fault or fracture influences. It is suspected that some of the higher values shown may be influenced by faults or fractures.

Ground Water Source. Several attempts have been made to determine the source of waters throughout the Gentry Ridge area. The determination of source is important to be able to understand fully the potential impacts and ramifications of mining. As a result of reviewing and analyzing all data available, it is believed that the source of water for the mine permit area in both the Gentry and Castle Valley Ridge areas originates as infiltration from both local precipitation and from stream seepage. An apparent source of water for the local hydrologic system appears to be the Eastern Boundary Fault of the Pleasant Valley Graben which lies in a north-south orientation. This fault system has been identified to extend from the north through Nuck Woodward Canyon, through the western portions of the Gentry Ridge Horst, and south through Tie Fork Canyon.

Water flowing down Nuck Woodward Canyon is believed to be partially lost to this fault system whereafter it joins with deeper water moving within the fault. Water is then directed underground towards and through the permit area. It is believed that the faulting system is well established and extensive in nature because of the relative stability of flows which have been recorded within the Tie Fork springs. Such stability is not seen at the locations of other faults such as the Western Boundary Fault of the Bear Canyon Graben which may be in line with Birch and Bear Canyon springs. Although some water undoubtedly enters this western fault, the local capturing capacity is obviously limited due to a lack of recharge source. No consistent water supply is available for recharge to this western fault as there is for the eastern fault.

The overall local ground water system appears to be recharged from local precipitation, from surface water streams, and from regional fault flow. Since the geologic strata is oriented to the south, the majority of recharge will be from areas lying to the north. This overall pattern of flow is seen throughout the area and has been consistent over time.

WATER QUALITY

Water quality within the Gentry and Castle Valley Ridge permit areas has been found to be generally consistent through time both vertically and horizontally. As part of this effort, several additional water quality tests have been completed to substantiate concerns and requirements of the regulations related to the identification of water source. These testes completed have also been of aid in establishing seasonal variation of quality and quantity through a comparison of water data from adjacent areas. Water quality testing completed in addition to the water sampling program presented within the 1991 permit submittal includes testing for Deuterium, Waterborne Particulate, Tritium, and Carbon 14 dating. A summary of data applicable to these tests are included within Table 728e. A discussion of the data noted is presented in the following sections.

Water Quality vs Source

Attempts to identify the source of the various waters found within the permit area have been made by utilizing the water quality tests discussed herein. Each test is discussed separately so as to provide an independent analysis of each source. As a summary statement however, none of the data analyzed showed a clearly independent source of water for any of the tests completed.

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Deuterium. Deuterium tests were run on waters collected both within the mine as well as from surface spring sources. To understand the significance of the Deuterium test the following discussion is given as documented in "Study and Interpretation of the Chemical Characteristics of Natural Water" (USGS, 1970).

> "The hydrologic significance and utilization of radioactive nuclides has already been noted. Many of the elements occur in the form of mixtures of two or more isotopes, mostly stable rather than radioactive. The stable isotopes of an element behave essentially the same chemically, and usually the isotopic composition of an element is nearly constant no matter where it may be found. Some types of processes, however, tend to occur more rapidly or easily with lighter or heavier isotopes, and the isotopic composition of an element may, therefore, provide an indication of its past environment, owing to enrichment or impoverishment of light or heavy forms.
>
> The oxygen isotope O^{18} and the hydrogen isotope H^2 (deuterium) constitute about 0.2 percent and 0.016 percent, respectively, of normal oxygen and hydrogen,... These isotopes are of particular hydrologic significance because they are present in water and produce a significant proportion of molecules of H_2O that are heavier than normal water. In the process of evaporation, the heavier molecules tend to be enriched in residual water, and thus the lighter species are more abundant in water vapor, rain and snow, and most fresh water of the hydrologic cycle; the heavier forms are more abundant in the ocean.
>
> ...the usefulness of isotopic-abundance data in studies of water circulation has been amply demonstrated by continuing studies. The abundance of the hydrogen isotopic species has been considered a useful key to deciding whether a water from a thermal spring contains a significant fraction of water of magmatic or juvenile origin that has not been in the hydrologic cycle previously."

The values for deuterium shown in Table 728e for each water sample are very consistent and show that origins are similar. Data applicable to all special water quality tests run, including any figures or plots generated to show variations, are presented in Exhibit 728d.

Microbial Particulates. Microbial Particulate Analyses completed for the stations sampled shows only relatively minor changes in water quality. The data presented in the exhibit shows little variation between in-mine waters and waters originating from Tie Fork, however the tests do indicate more surface influence at Bear Canyon and Birch Springs. The presence of Ciliates and Crustaceans in Bear Canyon and Birch Springs, and the presence of Nematodes in Bear Canyon Spring indicate an influence by a surface source not characteristic of in-mine nor Tie Fork waters.

The methods of completion and collection of water at Birch and Bear Canyon springs may be allowing small amounts of surface water to mix with deeper flows thus introducing the low levels of microbes near the surface. The laboratory statement on all samples, "No particulates restricted to surface water were found in this sample" indicates that none of the particulates found in the samples were identified as of a type that is found "only" in surface waters. As a general conclusion, it appears that the majority of the water sampled seems to have been in the ground for a relatively long period of time.

Tritium. Tritium is a short lived radioactive isotope of hydrogen (^3H) which is formed in the atmosphere by the interaction of ^{14}N with cosmic-ray neutrons, by the explosion of nuclear devices, and by the operation of nuclear reactors and particle accelerators. Because tritium is rapidly incorporated into water molecules it has been found to be a relative indicator of the age of water. However, the amount of tritium measured is dependent upon a number of factors including: 1) the natural production rate in the atmosphere, 2) the decay of tritium by beta emission to stable $^{3}_{2}He$ with a half-life of 12.26 years, 3) the seasonal injection of tritium from the stratosphere into the troposphere, and 4) the presence of bomb, nuclear reactor, or particle accelerator tritium.

According to information available on the subject, it has been found that tritium has varied widely over the years from less than 25 T.U. (tritium units) prior to 1953 to more than 2,200 T.U. in 1984 following extensive atmospheric nuclear testing. As per information provided above, approximately 3.2 half lives have occurred since the 1953 atmospheric nuclear testing. If tritium concentrations of 25 T.U. were characteristic prior to that date, then water containing less than approximately 3 T.U. would generally be said to have entered the ground water aquifer prior to open air nuclear testing.

Reviewing conditions further reveals that water containing less than 3 T.U. can be said to 1) be water which entered the ground water system prior to nuclear testing of the 50's, or 2) be a mix of very old water and a small portion of newer water which has a relatively short ground water flow history. Similarly speaking, water containing more than 3 T.U. can be said to be either very "fresh", or be a mix of "older" and "newer" water.

Data shown in Table 728e seems to indicate that water found within Samples P92-02-WD, X3S7419R, X3R312R and Birch Spring seem to contain a large amount of old water. Tie Fork station 86-35-2 and Bear Canyon Springs appear to be influenced more by surface waters of a shorter ground water flow path.

Carbon Dating. A carbon dating water sample was collected from a roof inflow located within the 3rd West Mains. The results of this sample indicate that the water is approximately 8,670 (+/- 230) years old. Since this is the only sample analyzed for Carbon 14, no comparisons can be made as to the overall age of other waters sampled.

Anion-Cations. Recent water quality data collected from both regular sampling locations as well as from new in-mine and surface spring sources was reviewed and compared with historic data. The most recent water quality data was plotted in anion-cation form as shown on Map 728a. As seen from the map, very little variation in the overall balance of anions and cations is noted throughout the permit area. A distinct variation in the balance of anions and cations would indicate either the water was of a different source, or that the water was diluted with another source of varied quality.

A recent set of data collected at Tie Fork, Birch and Bear Canyon Springs seemed to indicate that there was a difference in source between the three springs and the water collected from in-mine and surface spring waters. The variation noted however did not match or correspond to historic data collected for the Tie Fork wells. Attempts were then made through resampling to determine whether the variation was due to sampling error, or whether the data was showing natural seasonal variations not known previously to exist. The result of the follow up tests confirmed that the data was in error and that there is no seasonal variation in magnesium as the data may have indicated (See Map 728a).

According to information now available it has been found that water chemistry within the Gentry and Castle Valley Ridge areas is very similar in nature. The similarity in waters indicates that the regional area is experiencing like responses to natural hydrogeologic conditions. None of the data found as a result of the above described analyses indicates that a different source or interaction is occurring to the hydrogeologic system underlying the Gentry and Castle Valley ridge lease tracts.

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According to information available on the subject, it has been found that tritium has varied widely over the years from less than 25 T.U. (tritium units) prior to 1953 to more than 2,200 T.U. in 1984 following extensive atmospheric nuclear testing. As per information provided above, approximately 3.2 half lives have occurred since the 1953 atmospheric nuclear testing. If tritium concentrations of 25 T.U. were characteristic prior to that date, then water containing less than approximately 3 T.U. would generally be said to have entered the ground water aquifer prior to open air nuclear testing.

Reviewing conditions further reveals that water containing less than 3 T.U. can be said to 1) be water which entered the ground water system prior to nuclear testing of the 50's, or 2) be a mix of very old water and a small portion of newer water which has a relatively short ground water flow history. Similarly speaking, water containing more than 3 T.U. can be said to be either very "fresh", or be a mix of "older" and "newer" water.

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Seasonal Variation

The seasonal water quality and quantity variations for the Gentry Ridge area have been identified and presented within the 1991 permit renewal application submitted by CPMC. Seasonal quality variations at sampled stations are shown on Map 722.100b of the permit. As can be seen on the map, little water quality variation has occurred at any of spring stations included within the sampling program. Similar seasonal characteristics are believed to be found in waters within the geologic formations found at depth within the mine. This conclusion is based upon the extreme similarity of water quality data at both in-mine and spring sampling stations. Similarities can be reviewed by comparing water quality data shown on Map 722.100b with that shown on Map 728a.

Comparison of Well and Spring Data

Because of the similarities discovered between in-mine wells, surface wells and spring waters, it is believed that the spring data currently available is representative of, and can be used as, an indicator of seasonal variation for deep waters without the additional disturbance and installation of new surface monitoring wells in either the Gentry or Castle Valley Ridge permit areas. Additional data related to seasonal variation which will continue to verify this condition will be obtained through the selective installation of new monitoring wells in the Nuck Woodward Canyon area to the west of Castle Valley Ridge, or from within the mine in the Wattis seam as mining progresses northward into Castle Valley Ridge. These new monitoring wells will be made from one or more of the exploratory wells which are currently planned for the area west of Castle Valley Ridge or from within the mine.

Ground Water Seasonal Baseline. Ground water baseline data is available as discussed within the 1991 permit renewal applications for the Gentry Ridge permit and adjacent area through 1) spring data collected from established sampling stations and 2) from wells drilled down from the surface. Additional ground water data is also now available from in-mine wells which have been drilled as shown on Maps 728a and 728b. Because of the nature of the local ground water system as discussed within the previous sections, spring data available within the Gentry and Castle Valley Ridge permit areas serves as the baseline required for the Castle Valley permit area.

PROBABLE MINING IMPACTS

Subsidence Effects

Subsidence has been noted to occur as a result of mining using both the room and pillar method and the longwall mining method. Subsidence resulting from room and pillar mining is generally inconsistent throughout the mining area and is sporadic in nature, while subsidence related to longwall mining is believed by CPMC to be controlled and predictable.

In room and pillar mining, one area of a mine might fail while an adjacent area continues to stand. Failed mine sections create a gobb area above the coal seam which under certain conditions does not traverse to the surface, such as when the gobb area is plugged by fallen debris or when there is sufficient overburden that the gobb does not extend to the surface. When subsidence does traverse to the surface it is generally manifested as cracking around a localized depression or sink hole.

During longwall mining, the roof area collapses behind the advancing longwall panel and creates a large gobb area over the entire panel width. This type of subsidence is generally considered "full" subsidence which creates a more uniform and controlled depression of the land surface. Surface effects are usually confined to a uniform drop in the surface amounting to some percentage of the total thickness of the coal seam which was extracted, and some cracking of the surface at tensile points such as near the boundaries of mining. Since CPMC uses longwall mining methods, this more uniform subsidence is projected for the permit areas.

According to J.F.T. Agapito and Associates, Inc. (Exhibit 525.120a shown in the permit application), three different zones are expected to develop above mined areas as a result of subsidence. Zone I includes the immediate roof which is highly stressed and free to collapse. Roof rocks within this zone collapse in small pieces until the void due to coal extractions is filled, creating a highly permeable zone. In Zone II, which lies above Zone I, the roof beams deform and fracture, but maintain their continuity because of lateral confinement. Fracturing of the roof beams is associated with lateral expansion which itself is limited by the sidewalls of the excavation. Such confinement tends to keep the fractures closed; however, this fracturing can increase the permeability of the strata in Zone II. Zone III lies above Zone II and extends from the top of Zone II to the ground surface. Movement within Zone III is generally projected to consist of gradual downward movement of the strata. Fractures are not usually expected to occur, except in tensile zones adjacent to the edge of excavation. Where they do occur, surface cracks will be shallow with depths less than 35 feet.

Perched Aquifers and Springs. As indicated in the report prepared by J.F.T. Agapito and Associates, the fissured zones (Zones I and II) where fracturing of the overlying strata occurs, are limited to less than 400 feet above the extracted coal seams. The perched aquifer system of the Price River - North Horn Formation lies approximately 1,100 feet above the uppermost Coal Seam (Wattis Seam), and is therefore located well within Zone III. Under these conditions, the primary impact of subsidence is expected to result from deformation of the strata geologic structure. No fracturing of the strata in Zone III is expected, except for minor surface cracking near the fringes of mined areas. Therefore, fracturing of the upper shale layers which support the perched aquifer system is not anticipated, nor is dewatering of the perched system through fractures associated with subsidence expected. It is anticipated that longwall mining the Gentry and Castle Valley Ridge areas will result in the unilateral subsidence or deformation of the entire ridge section and that the impact to local perched springs will be minimal.

The ridge section of the perched aquifer system along Gentry Ridge as well as the coal seam to be mined are bounded on the updip side by the western boundary fault of the Bear Canyon Graben and to the west by the mine plan boundary which lies a short distance east of the eastern boundary fault of the Pleasant Valley Graben. Once fully subsided, it is presumed that the entire stratigraphic section of the perched system will be deformed more or less uniformly maintaining the overall present dip of the strata. Differential settlement as mining progresses may have some temporary effects on the perched aquifer due to deformation of the strata until the entire area of recharge for the system has subsided. Subsidence over longwall panels has been documented by CPMC to occur rapidly after mining, approaching 85 to 90 percent of maximum within two years. It is expected that the majority of impacts which could potentially occur to local springs will be temporary in nature.

Fault related springs of the perched aquifer system of the Price River - North Horn Formation may experience greater impact from subsidence than other perched springs. Subsidence which intersects faults could result in a step wise movement of the fault thereby affecting the conduit system which feeds the fault related springs. If movement does not impair the seal at the shale aquitard interface of the fault (which is apparently sealed at most locations along the fault thereby creating a fault related spring in the perched system); the seal may re-establish itself at a new elevation causing the spring to issue at a different location. If the slippage along the fault plane were to damage the shale aquitard seal, seepage down the fault to a lower aquifer system would be established thereby diminishing or eliminating the flow from the spring. Impacts of this nature are determined through the water quality and quantity monitoring program.

Impacts to the springs issuing from the perched aquifer system in the Castlegate Sandstone, which lies some 700 to 800 feet above the Wattis Coal Seam are expected to be similar to those identified for the perched system of the Price River - North Horn Formations. The Castlegate Sandstone is located in subsidence Zone III where only deformation of the strata is generally predicted. Some shallow surface cracking (less than 35 feet) may occur however in tensile zones adjacent to the edges of mining excavation which could result in cracking of the sandstone formations. It is believed that shales and mudstones located beneath the sandstone units will act as aquitards and thereby aid in the prevention of a significant loss of water down the cracks to deeper aquifer systems. Water moving downward along a crack however may alter the location of some of the local springs. J.F.T. Agapito and Associates also concluded that the potential exists for shallow cracking at the surface for mining with less than 800 feet of cover. Therefore, this phenomenon should be restricted to the Castlegate Sandstone and underlying formations, and not result in major impacts to the perched system of the Price River - North Horn formations.

As part of the annual subsidence monitoring program a report has been prepared and submitted to the Division by the applicant entitled "Subsidence Monitoring Report - 1990 - Star Point Mine" which discusses the conditions since monitoring began. According to the report "There has been no identified impact to ground water in the Section 12 area. There is no surface water in the area." Within Section 18 near Miller Creek impacts however have been noted. According to the subsidence report:

> "Some stream water has been diverted into the mine near monitoring point GS-1 because of subsidence. The stream at this location is small, averaging 13 gallons per minute. Springs and base flow from the canyon bottom recharge the stream below this point. **Only a section of stream approximately 800 feet long has been affected. An important point to be learned from the study is whether mudstones and siltstones will expand and stop the downflow of stream water.**"

It was noted in the field during **July of 1991 by CPMC personnel** that some **healing** of the North Fork of the Right Fork (NFRF) of **Miller Creek is occurring**. The southwest tributary to the NFRF of Miller Creek (which enters the North Fork of Miller Creek in the northwest quarter of Section 18) lost its flow of water due to subsidence subsequent to mining beneath the section. During the July 1991 site visit, it was noted that water is again issuing from the tributary, indicating that the mudstones may be healing from the effects of subsidence. This preliminary information aids in confirming the hypothesis made earlier that because of their nature, local soils and rock would heal themselves over time. Additional information related to the natural healing of the stream will be gathered over the next few years as part of the subsidence study being conducted jointly with the USGS. Further discussion related to subsidence impacts was provided in the 1990 and 1991 hydrologic reports which have been submitted to the State. With regard to the North Fork of the Right Fork of Miller Creek the 1990 report states:

> "Subsidence caused the stream to be diverted into the mine between stream monitoring sites M-4 and M-6. A mitigation effort to return the flow to the surface was successful, but due to a State regulation, this process had to be halted. The USGS would like to let the water continue to seek its own path. They would like to find out if mudstones and siltstones present in the overburden will swell to fill the voids created by subsidence, thus stopping downward movement of stream water.

> Monitoring Station M-8, which is downstream from the subsidence zone, has shown an increase in TDS, conductivity, hardness, total alkalinity, calcium, magnesium, bicarbonate, chloride and sulfate since 1988. Longwall mining started in the Wattis coal seam north of the stream in August, 1988. Since then, mining has been conducted above the stream and south of the stream. A general upward trend in TDS has been occurring at monitoring locations ST-1 North Fork Miller Creek, and ST-2 South Fork Miller Creek (See Figure 24 of the subsidence report submitted annually to DOGM). This phenomenon is assumed to be due to the lower flows because of the drought. Most of the same constituents listed as increasing at monitoring point M-8 are also increasing at ST-1 and ST-2. The TDS levels in monitoring Stations 34-1, Wild Cattle hollow Creek and 34-2, Gentry Hollow Creek have exhibited this same upward trend since about 1984. Both of these streams have not been impacted by mining subsidence, so the upward trend appears to be due to lower flows associated with the drought. The very high TDS levels at M-8 and the large increases in the other constituents appear to be higher than the trends at the other stream sites being monitored."

As a further definition of the hydrologic impacts related to mining, flow hydrographs for all springs currently monitored as part of the permit have been prepared as presented on Figure 724.200d of the permit application. Of those presented, eight contain data for the period prior to 1986, nine were initiated between 1986 and 1988, and two were initiated since 1988. Springs containing data during at least two years prior to 1987 include 749, 751, 753, 978, S11-1, S14-9, S18-2, and 85-26-1. All of these springs show a marked increase in flow rate during the approximate period between 1986 and 1988. The increase is believed to be the result of large amounts of precipitation which occurred during the 1983 and 1984 period. Subsequent to that time, the regional area has experienced a drought resulting in marked flow decreases as shown in the figure.

Examination of the flow hydrographs for the above referenced springs, does not confirm that any impact has occurred to these springs from past mining activities, although monitored springs S18-2 and 500 have shown decreases recently. The cause of the declines in flow at these two springs is not fully known to date. It is possible that the decreases may be due to mining or drought. Continued monitoring will help to determine which as the current drought cycle ends.

Some springs with a sufficiently long period of record show significant increases in flow during the period of time when subsidence has been noted to occur. Spring 753 shows a marked increase in flow during the 1981 to 1987 period. This increase reflects the wetter climatic conditions experienced locally between 1982 and 1985.

Springs in Section 18 that may potentially be affected by subsidence include: 227, 228, 229, 238, 240, 493, 496, 497, 498, 499, 500, and S18-2. Flow hydrographs for those springs which are monitored are also found in Figure 724.200d of the permit. As can be seen, all the springs for which data is available are relatively small in nature. At the time of the 1986 inventory, Spring 228 had a flow of 9 GPM; Spring 229, 12 GPM; Spring 238, 4 GPM; Spring 500, 3 GPM; Spring 240, 2 GPM; and Spring S18-2, 9 GPM. All of the rest had flows less than 1 GPM each. Springs 229, S18-2, and 500 continue to be monitored for mining impacts. Recent changes noted in Spring 500 were discussed above. If subsidence causes hazardous conditions which make it unsafe to monitor any spring, CPMC will notify the Division immediately and discontinue monitoring.

Only five percent (10 springs) of the springs found within or adjacent to the permit area were found which issue from the Blackhawk Formation. None of the Blackhawk related springs are high yielding springs thereby indicating the generally poor aquifer and low recharge potential characteristics of the Blackhawk Formation. Of these ten springs, only two (in Seeley and Mud Water Canyon) are located in areas directly affected by subsidence. No springs were found issuing from the Blackhawk Formation in Section 18. The other eight springs are located outside of the mine plan area. Flow from the two springs described above could be diminished or totally eliminated as a result of subsidence, however, there are no ground water rights which have been found to be tied directly to these springs.

Water made within the mine is derived from perched aquifer systems consisting of channel sandstones intercepted along the roof and floors of the mine, and from faults and fractures which carry water from adjacent formations. The regional water table within Gentry Ridge and in the Bear Canyon Graben to the east has been identified to occur within the Star Point Sandstone Formation which lies beneath the coal seams being mined. **Within Castle Valley Ridge, the water table begins within the Star Point Sandstone and appears to drop away from the coal seam to the north where it may dip into the Mancos shale unit.** BASED ON DATA

Previous mining within the area has shown that inflow to the mine from a channel sandstone may be significant when first encountered, but as the mine advances inflows have been noted to drop off rapidly (often to zero) indicating that recharge to the localized perched system is limited. Limited recharge is a result of shale or mudstone layers in the Blackhawk and overlying formations which form barriers to the vertical movement of ground water. As indicated earlier, it is estimated that over 95 percent of water made within old mine sections is derived from storage of the channel sandstones in the Blackhawk Formation, and actual total impact to surface receiving streams is probably less than five gpm.

Some additional impact may be expected to ground water inflow to the North Fork of the Right Fork of Miller Creek from recent mining in the 3rd seam beneath Section 18. The impacts to Miller Creek will continue to occur through the reach of stream channel where fracturing of subsidence Zones I and II intercept the perched water in channel sandstones of the Blackhawk Formation.

The extent to which subsidence will continue to impact base flow of the North Fork of the Right Fork of Miller Creek as derived from flow from perched sandstone channels above the coal seams mined in the Blackhawk Formation is difficult to predict. As indicated by J.F.T. Agapito and Associates (1986), mudstones present within the Blackhawk and overlying formations are an average of nine feet thick, and are located at an average spacing of 40 feet. The existence of these impermeable units among the more permeable sandstone units is useful and essential for minimizing the ground water intercepted within the mine from dewatering the overlying perched systems within subsidence Zones I and II as well as preventing direct hydraulic connection between surface waters and underground workings, particularly at shallow overburden depths. In addition, it appears that the effects of subsidence may also diminish or disappear with time as the subsurface strata heals itself as discussed earlier.

The maximum potential impact to the base flow of the North Fork of the Right Fork of Miller Creek by intercepting ground water from the perched channel sandstones within the lower Blackhawk Formation can be made by assuming that all baseflow derived from the Blackhawk Formation (within the 400 feet immediately above the Wattis Coal Seam) is intercepted by the mine and lost from the North Fork of the Right Fork of Miller Creek. From a stream survey of the North Fork of the Right Fork of Miller Creek conducted on July 2, 1986, total ground water contribution to the streamflow of Miller Creek through the Blackhawk Formation was determined to be on the order of nine gpm. Of this nine gpm, approximately three gpm was derived from the upper Blackhawk Formation above subsidence Zones I and II and is therefore not anticipated to be intercepted by direct dewatering down into the mine. However, flow from this reach could be diminished due to deformation of the formation resulting from subsidence. Some of this nine gpm likewise occurs below the Third Seam, the lowest coal seam mined in Section 18.

Based upon this information, the maximum potential loss to the base flow of the North Fork of the Right Fork of Miller Creek is less than nine gpm. Since this survey was conducted in the early summer period when base flows are expected to be somewhat higher, the average annual impact to baseflow contributions from the Blackhawk Formation are expected to be on the order of five gpm or less. Variation in flows in the Right Fork of Miller Creek are found in Figure 724.200d of the 1991 permit. As noted in the figures shown in the 1991 annual hydrologic report prepared for DOGM, there is a continued decline in flow at Station M-8 over previous years data (0.031 cfs in 1990 to 0.004 cfs in 1991). Although the decline amounts to a 13 percent decline, the overall decrease in flow amounted to only 0.027 cfs. The percent of the decline which is attributable to the drought versus that which may be attributed to mining is uncertain at this point in time due to the continued severity of the regional drought. Additional time will be required, including a return to normal climatic conditions, before a reliable separation can be made between mining versus climatic impacts.

Aquifer characteristics in subsidence Zones I and II will continue to change due to fracturing of the formations in these zones above the coal extraction areas. One impact of fracturing will be increased secondary permeabilities of the lower Blackhawk Formation. Recharge to this lower zone is not anticipated to increase significantly since the fracturing associated with Zones I and II is anticipated to extend to a height of less than 400 feet above the coal seam. Since the next formation above the Blackhawk lies some 700 to 800 feet above the Wattis Coal Seam, the fracturing will be limited to the lower portion of the Blackhawk Formation which receives minimal recharge.

Regional Aquifer System. The regional aquifer system and water table has been identified to exist within the mine plan and adjacent areas in the Star Point Sandstone below the Blackhawk (coal bearing) Formation with the following exceptions. The first is within Gentry Ridge where the coal seam drops below the regional water table in a southward direction and the second is within Castle Valley Ridge where the coal seam and lower Star Point Sandstone is believed to rise above the regional water table. There has undoubtedly been some impact (although perhaps small) to the regional aquifer system due to mining as perched system in the channel sandstones of the Blackhawk Formation have been intercepted. The downward movement of recharge water is limited due to the presence of shales and mudstones as well as the presence of the Blackhawk Formation. The historic removal of waters discharging from the mine probably reflects less than a five gpm impact to surface streams which receive recharge from ground water systems of the mine plan area.

Mining beneath the regional water table of Gentry Ridge will require additional dewatering of the mine. It is anticipated that mine inflows will be greater than those experienced east of the Bear Canyon Graben. Dewatering of the mine will result in a temporary reduction of the piezometric surface of the regional aquifer. Subsequent to mining it is anticipated that the water table will tend to re-establish itself wherein natural flow paths will be restored to the degree possible. It is given that this restoration will not be complete because of local subsidence and inflowing waters which follow mine tunnels rather than their previous paths along faults, fractures or through the geologic medium. However, the general direction of ground water movement should be restored. Except where fracture systems are encountered, most of the initial mine inflow will be derived from dewatering ground water stored within the aquifer. Some of the water may also be derived from a decrease in natural discharge from the aquifer. Because of the relative tightness of the geologic strata encountered locally, the impacts on surface streamflows from dewatering the non-fracture related channel sandstones of the Blackhawk Formation are not expected to be much more significant than that projected for the system east of the Bear Canyon Graben.

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Regional Aquifer System. The regional aquifer system and water table has been identified to exist within the mine plan and adjacent areas in the Star Point Sandstone below the Blackhawk (coal bearing) Formation with the following exceptions. The first is within Gentry Ridge where the coal seam drops below the regional water table in a southward direction and the second is within Castle Valley Ridge where the coal seam and lower Star Point Sandstone is believed to rise above the regional water table. There has undoubtedly been some impact (although perhaps small) to the regional aquifer system due to mining as perched system in the channel sandstones of the Blackhawk Formation have been intercepted. The downward movement of recharge water is limited due to the presence of shales and mudstones as well as the presence of the Blackhawk Formation. The historic removal of waters discharging from the mine probably reflects less than a five gpm impact to surface streams which receive recharge from ground water systems of the mine plan area.

Mining beneath the regional water table of Gentry Ridge will require additional dewatering of the mine. It is anticipated that mine inflows will be greater than those experienced east of the Bear Canyon Graben. Dewatering of the mine will result in a temporary reduction of the piezometric surface of the regional aquifer. Subsequent to mining it is anticipated that the water table will tend to re-establish itself wherein natural flow paths will be restored to the degree possible. It is given that this restoration will not be complete because of local subsidence and inflowing waters which follow mine tunnels rather than their previous paths along faults, fractures or through the geologic medium. However, the general direction of ground water movement should be restored. Except where fracture systems are encountered, most of the initial mine inflow will be derived from dewatering ground water stored within the aquifer. Some of the water may also be derived from a decrease in natural discharge from the aquifer. Because of the relative tightness of the geologic strata encountered locally, the impacts on surface streamflows from dewatering the non-fracture related channel sandstones of the Blackhawk Formation are not expected to be much more significant than that projected for the system east of the Bear Canyon Graben.

It is believed that the more significant impact to the hydrologic system will occur as inflows are encountered at intercepted faults of the north-south extensional system. The discussion related to intercepted flows at some of these faults was presented earlier. The interception of significant quantities of ground water from faults within the mine beneath Gentry Ridge in the future may temporarily reduce recharge to springs and/or wells located within Tie Fork Canyon. This conclusion is reached partially based on the fact that the direction of ground water movement in the north south fault system south of "The Steeps", is to the south, thereby potentially providing recharge to Tie Fork and Huntington Creeks.

The CVSSD wells are located approximately 6,500 feet south of the present mine boundary in Gentry Ridge and issue from the Star Point Sandstone Formation. At this time some of the recharge to the wells is believed to be from 1) from local faults and 2) from the perched aquifer system of the Price River - North Horn Formation. As presently mapped (See Map 728a) the CVSSD wells align themselves relatively well with the eastern boundary fault of the Pleasant Valley Graben and the first finger fault east of the Pleasant Valley Graben. The eastern boundary fault of the Pleasant Valley Graben lies some 300 to 400 feet west of the present projected mining area and as such, the fault itself is not expected to be intercepted by the mine. The first finger fault east of the Pleasant Valley Graben fault has been encountered by mining in the far northwest corner of the Gentry Ridge mine workings at the west end of the 3rd West Mains, and at the west end of 1st, 2nd and 3rd Right Mains. The major fault of the Pleasant Valley Graben is west of the permit boundary. Drilling is periodically conducted at the west side of the mining zone as mining advances in an attempt to identify finger faults associated with the Pleasant Valley Graben, and to determine the presence of water that may be associated with the finger fault.

Because Birch and Bear Canyon springs lie approximately 6 miles south of the current permit boundary, and because other mines lie in their immediate vicinity, it is believed that mining in the Castle Valley and Gentry Ridge lease tracts will have little or no impact upon them. More will be said about this in the section discussing culinary water supply impacts.

The quantity of ground water inflow into the mine beneath Gentry Ridge and therefore, the magnitude of potential impact which mining will have is difficult to predict. However, it is believed that mine inflows will be slightly greater in non-faulted areas within the Gentry Ridge Horst than that experienced in the mine east of the Bear Canyon Graben. The potential for these increased flows arises from the fact that mining will dip below the regional ground water table. It is also believed that the more significant inflows will be encountered as finger faults are intercepted, particularly as the mine advances into the regional ground water table. To date, all significant flows encountered within Gentry Ridge have been within the western half of the mining activity and have been associated with either faults or fracture systems. At the Bear Canyon Fault, U. S. Fuel Company has encountered a sustained inflow at their 10th West Section and at other contacts with the fault in the King IV Mine. These larger sustained flows from the fault probably account for much of the mine water presently being discharged from the Mohrland Portal (800 to 900 gpm). Should significant water bearing fracture systems be encountered, higher flows on the order of those experienced by U. S. Fuel may be experienced.

Preliminary estimates have been made as to the total volume and sustained inflow which might be experienced as mining intercepts the projected local water table. The volume of water was determined by assuming that all water found above the mine coal seams as well as all water found within a 45 degree angle of draw away from the seams was intercepted by the mine. Using this methodology it was estimated that a total of 2,565 acre-feet of water could be dewatered from the area by mining.

The amount of water which might be discharged from beneath Gentry Ridge (at the time mining has progressed to the far southern end of the projected mining tunnels) was estimated using two separate methodologies. The first estimate was based upon uniform flow through a geologic medium and the second was based upon data collected to date from the mine. The estimate based on uniform flow was made by assuming that 1) all horizontal flow moving north to south within 500 feet of the mine workings was intercepted by the mine and 2) the depth of water intercepted by the mine is equal to the calculated water depth at the far southern end of the projected workings. Using this methodology, the estimated inflow is calculated to be in the range of 135 to 400 gpm. Calculations are presented in Exhibit 728.100e. It is believed that because local flows are controlled more by faulting and fracturing than porous media flow, that this estimate is low.

The second method of determining estimated mine inflow volumes is based upon mine water encountered to date. Preliminary estimates shown in Exhibit 728e show this estimate as being the combination of fault related flow as encountered to date, the addition of small flows which appear at small fissures and an estimate of porous media inflows. Using this method it is estimated that there may be as much as 1,000 to 1,100 gpm inflow into the mine during the mining of Gentry Ridge.

Because the mine workings within Castle Valley Ridge are located above any regional water table, mine inflows to the north of current mine workings are anticipated to be similar in nature to those found in mine workings east of the Bear Canyon Graben.

Impacts to Little Park Canyon. Concerns related to mining impacts on Little Park Canyon appear to be centered around those potentially created by the interruption of ground water movement created by dewatering effects of upgradient mining, the physical subsidence of the surface and subsurface strata, and resulting interruption of ground water flow toward the Canyon.

Interruption of Ground Water Movement. Mining within the Castle Valley Ridge area will result in the dewatering of localized perched aquifer systems as has occurred in other mined locations throughout the permit area. Existing mining being conducted west of the Bear Canyon Graben beneath Gentry Ridge has shown that the Wattis coal seam is above the local regional ground water table as predicted. Because the Castle Valley Ridge tract lies to the north of the area currently being mined, it too will be above the limited local ground water system. The interruption of ground water movement which could then impact Little Park Canyon will be limited to the small amount of water potentially developed by localized perched systems. As indicated elsewhere in this permit, these have been found to be of relatively minor extent.

The small amounts of water projected to be diverted by mining will flow to the south and west through mine tunnels where it will be available for recharge back into the ground water system. Although after mining the point of recharge may not be the exact location from which it was diverted, it is believed that the water will resume an overall natural flow path to the south through abandoned mine workings.

Subsidence Effects. Subsidence of varying magnitudes will occur in areas mined using the longwall method, however, mining proposed for the Castle Valley Ridge area has been designed to reduce these potentials based upon studies prepared by rock mechanic consultants. These efforts include the elimination of mining under Little Park Canyon in areas where there is less than 400 feet of cover, unless mining impacts can be prevented. It is anticipated that little if any impact will be noted to the hydrologic regime of Little Park Canyon resulting from subsidence because 1) the general direction of local ground water movement both before and after mining is anticipated to be to the south and 2) longwall mining will not occur immediately beneath the canyon. The mining

VERIFY THIS BASED ON WATER LEVELS

plan has been altered to avoid longwall mining beneath the canyon. As shown on the mine plan detail discussed within Section 100 of the permit application, the longwall panel south of Little Park Canyon intercepts only the uppermost reaches of the canyon and the airway and escape mains lie to the north an adequate distance to reduce the potential for subsidence damage.

Interbasin Transfer of Water

Ground water intercepted by the mine which is tributary to the San Rafael River Basin and discharged in Mud Water Canyon results in an interbasin transfer of water from the San Rafael River Basin to the Price River Basin. The possibility for this interbasin transfer of water increases as mining extends into Lease U-13097 beneath Gentry Ridge. This interbasin transfer would occur only if it were required to discharge more water than could be 1) pumped into abandoned mine workings without overflowing or 2) injected into local fault zones. More is said later about the possibilities of fault injection. Ground water of the Gentry Ridge area generally flows to the south-southeast and is tributary to the Tie Fork - Huntington Creek drainage basins which are tributary to the San Rafael River. Mud Water Canyon is tributary to the Price River.

Some interbasin transfer of water is possible through the Mud Water discharge at times that it is being operated. This transfer however is from one sub-basin within the Price River system (Miller Creek) to another sub-basin within that same river system (Corner Canyon via Mud Water Canyon)). No discharge has been recorded at the Mud Water discharge since July of 1987.

Mining which has occurred beneath Section 18 was originally believed to have the potential of intercepting ground water within the Blackhawk Formation. This ground water provides the base flow to the North Fork of the Right Fork of Miller Creek and could have potentially resulted in an additional transfer of five gpm or less to Mud Water canyon. If this were true, the total impact east of the Bear Canyon Graben due to exchanging water from one sub-basin to another in the Price River Basin by discharging water from Mud Water Canyon could have been as much as 10 gpm.

Surface water flow records indicate some points of interest related to this issue. The first is that no discharges have occurred at Mud Water Canyon since July of 1987, and hence no interbasin transfer of water. Water made within the mine has stayed within the mine thereby reducing impacts related to water transfers. A second point is that flow records appear to show an overall decline in flow since 1988. The cause of this decline, whether it be climatic or subsidence related is clouded by the fact that the area has also experienced a drought over the same time period. Verification of the cause will be made when the area returns to more normal precipitation patterns.

Although an estimate of ground water inflow which is likely to occur within the mine beneath Gentry Ridge is difficult to predict, it has been estimated that as much as 1,000 to 1,100 gpm could be diverted from current mining areas. The great majority of this inflow would be from faults and fractures encountered by mining. In areas not intercepting the north-south trending finger faults, inflow into the mine would be expected to be on the order of magnitude per area of the flow historically made from longwall areas within the mine beneath Hoag Ridge. More significant inflows into the mine may be anticipated as finger faults are intercepted as the mine is advanced to the south as the mine seam dips below the regional water table. It is also a possibility that flowrates on the order of those intercepted by U. S. Fuel Company at the Bear Canyon Fault could occur as these faults are intercepted. U. S. Fuel Company presently discharges 800 to 900 gpm at their Old Mohrland Portal. Measures to mitigate impacts from the potential for creating an inter-basin transfer of water are presented both herein and in the permit within Section 731.100.

Quality Variation as Mine Collapses

It was believed earlier that subsidence had little impact upon water quality once mining had been completed. This theory was based upon the concept that broken mine rock would be flushed of initial contaminants over a relatively short period of time and that water quality would quickly return to premined conditions. According to a report recently completed for the Castle Valley Ridge area (U.S.G.S., 1988) chemical changes to water quality have occurred at inactive mines. Information provided indicates that increases in such parameters as calcium, magnesium, sulfate and bicarbonate were reported. According to the study completed at the Mohrland mine located to the south and east of the Gentry Ridge lease area:

> "...increased sulfate concentrations and decreased pH are probably caused by oxidation of sulfide minerals. Some, but not all, of the increase in sulfate may be from dissolution of gypsum that is used in the mine for dust control.... Water quality changes occur soon after part of a mine is abandoned.
>
> The water from this part of the mine (speaking of a collapsed section) is more acidic, more mineralized, and contains a greater concentration of sulfate compared with water from the active part of the mine... and ...Geochemical changes resulting from roof collapse after abandonment may increase the solubility of strontium minerals present in the Blackhawk Formation."

The fracturing of rock formations above the coal seam apparently exposes new surfaces and creates a fresh contact face for the transfer of minerals. Water quality diagrams presented in the Castle Valley report show increases in calcium between an active and abandoned mine section on the order of 3.4 to 6.9 meq/l. Increases in magnesium, sulfate and bicarbonate were from 2.0 to 5.0, 0.4 to 4.7 and 5.0 to 7.3 meq/l respectively. Because of the proximity to the CPMC permit area, and because of the similarity in hydrogeology, it is anticipated that similar variations may occur within the permit area.

Impact to Culinary Water Supplies

Culinary water supplies potentially located within the flow path of ground waters which could even remotely be potentially impacted by CPMC operations include the Tie Fork Wells.Potential impacts to Birch and Bear Canyon Springs are believed to be negligible to nonexistent. A review of geological structure tends to indicate that the Tie Fork wells are located along the Eastern Boundary Fault of the Pleasant Valley Graben, while Birch and Bear Canyon springs are located in general orientation with the Western Boundary Fault of the Bear Canyon Graben.

It is believed that the general hydrologic flow paths feeding these water supplies (especially Tie Fork) is fault related and may be from the north through the CPMC permit area. Some of the water is believed to originate from Nuck Woodward Canyon, move southward through the Eastern Boundary Fault of the Pleasant Valley graben and enter the area of Tie Fork wells. It may also be possible for water to enter the fault in Nuck Woodward Canyon, move southward along the Eastern Boundary Fault of Pleasant Valley, south southeastward across Gentry Ridge toward the Western Boundary Fault of the Bear Canyon Graben, then southward towards Birch and Bear Canyon springs. The complexity and additional length of the later flow path greatly reduces the potential for impact on both Birch and Bear Canyon springs by mining.

The stability of flows within the Tie Fork water supply indicates that the recharge source consists of a large drainage area and that it is not readily influenced by surface sources. Little to no seasonal variation (except a temporary response to an earthquake which occurred in 1988) has been noted in the supply over the period of record. Birch and Bear Canyon springs on the other hand show marked changes through the period of record, are influenced by drought, show seasonal variation and are probably influenced by heavy localized precipitation events.

Tie Fork Wells. The potential mining impacts upon the Tie Fork wells may occur in terms of both quality and quantity, depending upon the time frame referenced. Because the local ground water table slopes to the south southeast, it is believed that mining may at least partially dewater the aquifer in the Gentry Ridge area which may potentially impact the Tie Fork wells. However, it must be remembered that Tie Fork wells have been very consistent over the years which generally indicates a deep source of recharge water. If the recharge source is deep, then the fault related water (which would be higher water within the fault system) which passes through the north-south extensional fault system near the western border of the Gentry Ridge lease tract may be an insignificant portion of the total well flow. This condition would be the most ideal for separation of mining impacts.

Long term impacts to Tie Fork wells are more likely to be related to quality since water will re-enter mine workings upon abandonment and follow the general dip of the mined coal seam to the south southwest. If sufficient voids exist within the fault system to carry the in-mine water, then the natural flow paths will be re-established and total recharge will be restored to the Tie Fork system. It is even possible that an additional amount of water may be recharged to the Tie Fork system if it is found that other in-mine waters are re-directed to the same point of recharge, and if the geologic formation will carry the increased flow volumes.

A deterioration of water quality is possible to the Tie Fork wells under this recharge scenario if 1) waters are indeed connected and 2) water is not filtered adequately through natural media before reaching the Tie Fork wells. This deterioration of water quality may be mitigated naturally if the source of Tie Fork water is deep and not heavily influenced by fault waters found within the Gentry Ridge faults encountered within the mine.

Birch and Bear Canyon Springs. The source of Birch and Bear Canyon springs has yet to be defined thoroughly. If the springs are in connection with the Western Boundary Fault of the Bear Canyon Graben however, the potential for water quality and quantity impacts due to mining would be much less (if any at all) than that for the Tie Fork wells.

Minimal to no impact is anticipated to be found at either of these springs because 1) the distance between projected mining and the springs is six miles, 2) a reduced water table in the vicinity of the mine will result in only a minimal overall decrease in hydraulic gradient and therefore in total flow to the springs in question, 3) the Western Boundary Fault of the Bear Canyon Graben is a discharging fault and therefore does not naturally receive large volumes of water through the rock structure which will be disturbed by mining, and ~~4) m~~inimal impacts which could potentially occur are masked by mining impacts which have likely occurred from other mine workings found immediately adjacent to the springs. There exists a much higher probability of mining impacts to these springs by local mine disturbance than from regional mine disturbance.

revisit later

Impact to Fish / Wildlife / Vegetation

To date no impacts have been noted to surface seeps or springs within or adjacent to the mine permit area which have impacted either fish, wildlife or vegetation. According to information presented and discussed above, it is believed that the majority of impact to the surrounding environment will potentially be a reduction in, not elimination of the water supplies currently identified as Tie Fork wells, Birch Spring, and Bear Canyon Spring. Under these presumed conditions it is felt that mining within Gentry and Castle Valley Ridges will have little overall change or impact upon local fish, wildlife and vegetation.

Mine Water Control

Water encountered during mining must be controlled so as not to inundate the mine workings. It is projected that upon collection, incoming water must be diverted and disposed of in one or more of the following methods. The first and easiest method of disposal is to pump encountered mine water into abandoned mine sections lying east of the Bear Canyon Graben. It is believed that water introduced within these abandoned workings will re-enter the north-south trending fault systems which lie along the eastern border of the Bear Canyon Graben. Although the exact destination of waters which enter the fault is unknown, the general direction is to the south as was the water which is encountered within Gentry Ridge.

If these eastern abandoned mine workings take less water than is removed from Gentry Ridge, then a second alternative is to discharge some or all of the water to the surface through the Mud Water Canyon discharge station. According to the current NPDES permit there is no limitation on the quantity of water which may be discharged from Mud Water Canyon. Should a substantial quantity however be discharged, there is the possibility that water rights within Huntington Canyon may require mitigation if impacts are noted.

A third option for the disposal of water encountered within Gentry Ridge includes the pumping, filtering and re-injecting of intercepted mine water into faults found within the central or eastern portions of the graben crossing tunnels. Reasons for targeting these faults for the disposal of encountered mine water include, 1) water thus injected will flow to the south under as natural a flow path and direction as possible during mining and 2) the faults are believed to be of sufficient secondary porosity to accept waters encountered within the mine. At this time it is believed that re-injection of encountered waters will be the last resort because of special problems including permitting which would be encountered through its implementation.

Once mining has been completed, flows will return to abandoned mine sections beneath Gentry Ridge where they will resume their approximate natural flow path as discussed earlier.

MONITORING PROGRAM

The water quality monitoring program for the permit area consists of both the currently adopted sampling program as well as the program outlined herein for Gentry and Castle Valley Ridges. The sampling program scheduled for implementation within Gentry and Castle Valley Ridges includes two existing wells located within Tie Fork Canyon, possibly one future well located west of Castle Valley Ridge and selected in-mine wells beneath Gentry and Castle Valley ridges.

Water Level

Current in-mine wells proposed to be monitored for water level include wells P92-01-WD, P92-02-WD, P92-03-WD, and P92-04-WD. Well P92-01-WD is located near the northeast end of the workings near the Graben tunnel crossing, well P92-02-WD is located near the northwest portions of the Gentry Ridge mine workings, well P92-03-WD is located near the east end of longwall panel three and well P92-04-WD is located midway between wells P92-01-WD and P92-02-WD. In-mine well P92-01-WD was completed as a triple nested well with shallow to deep piezometers being designated as P92-01A-WD, P92-01B-WD and P92-01C-WD respectively. Wells P92-02-WD, P92-03-WD, P92-04-WD were completed as single piezometers. Wells P92-01A-WD, P92-01B-WD and P92-03-WD were completed in the Blackhawk formation while the other wells were drilled into the Spring Canyon member of the Starpoint Sandstone. It is the plan to drill and add additional wells to the monitoring program as mining advances to the south beneath Gentry Ridge, and in the future to the north beneath Castle Valley Ridge (see Map 728b).

One or more selected well(s) located west of Castle Valley Ridge are also being evaluated for addition to the monitoring program outlined herein. These possible future monitoring well(s) will be selected from exploratory wells which are currently being permitted and should add valuable data related to ground water conditions west of the Eastern Boundary Fault of the Pleasant Valley Graben. The addition of new in-mine monitoring wells will be evaluated as data is collected and as future needs arise in both the Gentry and Castle Valley Ridge areas. At this time it is proposed to follow the monitoring schedule shown in Table 728f to obtain desired seasonal data. As indicated in the table it is proposed to collect well water levels quarterly unless impacts are visibly identified, whereafter they would be collected monthly until sufficient data shows existing trends, or for two years.

Water Quality

Water quality sampling may be conducted for at least one well located west of Castle Valley Ridge if installed, at wells P92-01C-WD, P92-02-WD and P92-03-WD within Gentry Ridge, at one to two wells (at a minimum) within Castle Valley Ridges as mining progresses northward, at the wells located within Tie Fork Canyon, and at all other currently defined surface and ground water stations shown in the 1991 permit application. In-mine wells located within Gentry and Castle Valley ridges wherein water quality samples are taken will be sampled annually as a step to confirm continued consistency between spring and in-mine quality data. Parameters to be used at these stations during the tests include as a minimum, field temperature, conductivity, pH and flow or level; and lab parameters including oil and grease, TDS and the operational water quality sampling list provided in the permit application.

Flow

Mine water flows within Gentry and Castle Valley ridges will be monitored by 1) recording flows intercepted as mining progresses (see Map 728b for an example of flow data) and 2) by recording total mine flow at a convenient discharge point. Because of the irregular nature of coal seam bedding planes it is often impossible to collect continued flow records from a particular source. In an effort to resolve this dilemma a record of total flow from these new mining areas will be kept at the point of discharge. At this time it is believed that the point of discharge will be at either the Mud Water Canyon discharge station, at a point where the water is diverted into abandoned mine workings east of the Rock Graben crossing, or at a point of fault injection. Other in-mine stations currently a part of the flow monitoring program will continue to be used unless the Division is notified and discontinuance is approved.

Water Right

Water rights which appear to be potentially impacted by mining in either the Gentry Ridge or Castle Valley Ridge areas include those associated with Birch Spring, Bear Canyon Spring, Tie Fork Wells and irrigation water. According to records on file with the State Engineers office, water rights for these water sources are held by the Huntington-Cleveland Irrigation Company (HCIC). As per information provided, the Castle Valley Special Services District (CVSSD) is entitled to and controls water from both the Tie Fork wells and from Bear Canyon Spring. Birch Spring is operated by the North Emery Water Users Association (NEWUA).

As indicated earlier, the water rights associated with these sources are combined with rights held by the HCIC and include both surface as well as ground sources. Combined water rights for all sources identified by the State Engineers office computer database total 352.25 cfs. This amount of right far exceeds the amount available at any or all of the potentially impacted sources of water. Average historic flows for these sources is discussed below.

Average Historic Flows

A review of historic data for all three ground water sources identified herein has shown that flows originating from either the Tie Fork Wells, Birch Spring or Bear Canyon Spring make up only a small fraction of the total water right held by HCIC. Available data for each of these sources has been prepared and was presented earlier in this section and as Exhibit 728a. From the figures it can be seen that average flows from each of the springs referenced above are 0.20, 0.16 and 0.38 cfs (90, 72 and 171 gpm) respectively. Total combined flows for these three sources are 0.74 cfs or 332 gpm. Mitigation of the water supply should be according to the flows recorded for each source and not tied to the water right since the water right has been combined for both surface and ground waters.

Mitigation Options

Efforts are currently underway to 1) minimize the amount of disturbance to the ground water system by following prudent in-mine practices, 2) determine what mitigation options are available should impacts be noted at any of the identified sources, and 3) meet with potentially impacted parties to discuss options and to determine acceptable mitigation alternatives.

Current mining activities undertaken to protect the ground water resource include the pumping of excess mine waters into abandoned mine sections. It is the intent of this effort to re-introduce mine waters into as natural a setting as possible thereby minimizing disturbance to the hydrologic balance. Steps being taken related to the determination of mitigation options as well as discussions with impacted or involved entities are outlined in Table 728g.

Each of the alternatives outlined above is being aggressively pursued with appropriate agencies or parties, including meetings with other local coal mines to identify the possibility of joining together to create a common mitigation solution. The Division will be kept abreast of appropriate mitigation activities undertaken with regards to mining in Gentry and Castle Valley Ridges.

REFERENCES

Cyprus Plateau Mining, 1991, Star Point Mines Permit No. ACT/007/006, Permit Application.

J.F.T. Agapito and Associates, 1986, Prediction of Subsidence Due to Two-Seam Longwall Mining in Section 18. Grand Junction, Colorado.

U.S.G.S., 1970, Study and Interpretation of the Chemical Characteristics of Natural Water - Second Edition, John D. Hem, Geological Survey Water-Supply Paper 1473.

U.S.G.S., 1988, Hydrology of Alkali Creek and Castle Valley Ridge Coal-Lease Tracts, Central Utah, and Potential Effects of Coal Mining, R.L. Seiler and R.L. Baskin, Water-Resources Investigations Report 87-4186.

U.S.G.S., 1991, Hydrology and Potential Effects of Mining in the Quitchupah and Pines Coal-Lease Tracts, Central Utah, R.A. Thiros and G.E. Cordy, Water-Resources Investigations Report 90-4084.

Tables

HANSEN ALLEN & LUCE INC

TABLE 728a. CVSSD Water Rights and Sources

SOURCE OF RIGHT	SOURCE DECLARED IN WATER RIGHT			
	WRNUM 93-219[1]	WRNUM 93-2220[4]	WRNUM 93-2221[2]	WRNUM 93-2222[3]
	150 cfs	45 cfs	77.25 cfs	80 cfs
SPRING AND WELL SOURCES				
Tie Fork Springs				
Bear Canyon Spring				
Little Bear Canyon Springs				
Birch Spring (Also known as Gate Spring)				
Rilda Springs				
Unnamed Spring				
SURFACE WATER SOURCES				
Huntington Creek - Cleveland Canal				
Huntington Creek - Harrison Ditch				
Huntington Creek - Huntington Canal				
Huntington Creek - Huntington Plant Diversion				
Huntington Creek - North Ditch				
Huntington Creek - Robins & Truman				
Huntington Creek - Rowley Ditch				
Huntington Creek - Seely & Collard				
Huntington Creek - Treatment Plant				
Huntington Creek - Tributaries				

1 Supplemental rights include 93-219, 222, 224, 226, 228, 239, 240, 243, 253, 254, 272, 303, 304, 309, 310.

2 Supplemental rights include 93-2191, 2194, 2197, 2200, 2203, 2206, 2209, 2212, 2215, 2218, 2221, 2224, 2227, 2230, 2233, 2236, 2239.

3 Supplemental rights include 93-2192, 2195, 2198, 2201, 2204, 2207, 2210, 2213, 2216, 2219, 2222, 2225, 2228, 2231, 2234, 2237, 2240.

4 Supplemental rights include 93-2190, 2193, 2196, 2199, 2202, 2205, 2208, 2211, 2214, 2217, 2220, 2223, 2226, 2229, 2232, 2235, 2238.

Table 728b. Data used in the Analysis of the Local Water Table

Well No.	Date	Water Level	Formation	Comment
86-18-2	8/86	8342.0	Lower Blackhawk Star Point Sandstone	1986 to 1989 Lost to mining in August 1989, most of 60 ft decline occurred in 1988.
	8/89	8280.0		
86-26-6	8/86	8185.0	Lower Blackhawk Star Point Sandstone	Data shows approx. 35 ft change since 1986, most during 1988.
	9/91	8150.0		
86-35-1,2,3	3/92	8027.0	Blackhawk	Water level taken at ground surface for Well 86-35-1.
86-01-TD	1/86	8350.0	Star Point Sandstone	Well has shown no change since 1986.
	1/92	8350.0		
86-02-HD	5/86	8413.0	Star Point Sandstone	Most of water level decline occurred in late 1987. Bottom of well is at elevation 8402.0.
	1/92	8402.5		
86-03-WD	8/86	8320.0	Lower Blackhawk	Data from replacement well to original well. Gradual decline since 1986.
	1/92	8303.5		
92-01-WD	3/92	8322.0	Lower Blackhawk	Shallow piezometer.
		8324.0	Lower Blackhawk	Intermediate piezometer.
		8306.0	Star Point Sandstone	Deep Piezometer completed in Spring Canyon Member.
92-02-WD	3/92	8343.0	Star Point Sandstone	Completed in Spring Canyon Member.
92-03-WD	3/92	8287.0	Lower Blackhawk	Level may not be fully stabilized.
92-04-WD	3/92	8232.0	Star Point Sandstone	Completed in Spring Canyon Member, level not fully stable.
Graben Crossing	Late 1980's	8330.0	Star Point Sandstone	Approximate only, well lost upon completion of Graben Tunnel.

Table 728c. Castle Valley Ridge Well Data

Well No.	Total Well Depth (ft)	Depth to Water (ft)	Depth to Top of Wattis Seam (ft)	Water Depth below Wattis Seam (ft)	Comment
CVR-1	1750	1611*	1578	33	Damp at 220 ft Lost Circ. at 610-620 ft Lost Circ. at 840-870 ft
CVR-2	1320	1246	1156	90	Lost Circ. at 380-400 ft Lost Circ. at 1210-1215 ft
CVR-3	1140	820	n/a	n/a	Lost Circ. at 500-535 ft Lost Circ. at 575-585 ft Lost Circ. at 805-825 ft Lost Circ. at 840-900 ft Lost Circ. at 910-940 ft Lost hole above coal seam
CVR-5	1185	925	n/a	n/a	Drilled Dry to 745 ft Lost Circ. at 1115-1185 ft Lost Hole, Caved at 975 ft
CVR-5A	1785	1513	1553	-40	Lost Circ. at 1710-1720 ft
CVR-6	1250	n/a	n/a	n/a	Lost Circ. at 1120-1180 ft Cored 1180-1250 ft Lost Hole, Caved at 1055 ft
CVR-7	1760	Dry	1550	>210	Lost Circ. at 220-235 ft Lost Circ. at 750-770 ft Lost Circ. at 1375 ft
CVR-8	1760	1723	1568	155	Lost Circ. at 200-215 ft
CVR-9	760	625	617	8	Retrieved Core, No Circulation
CVR-10	640	240	497	-257	Lost Hole
CVR-10C	645	Dry	500	>145	Replacement of CVR-10

* Measured with E-Log

Table 728d. Aquifer Slug Test Results

Well No.	Permeability (K)		Formation Tested
	ft/min	ft/day	
92-01A-WD	1.63×10^{-7}	2.35×10^{-4}	Blackhawk
92-01B-WD	3.81×10^{-10}	5.49×10^{-7}	Blackhawk
92-01C-WD	2.56×10^{-3}	3.7	Spring Canyon Sandstone
92-02-WD	3.07×10^{-4}	0.44	Spring Canyon Sandstone
CO-OP Well DH-1A	5.74×10^{-5}	8.27×10^{-2}	Spring Canyon Sandstone
CO-OP Well DH-1A	4.53×10^{-5}	6.52×10^{-2}	Storrs Sandstone
CO-OP Well DH-1A	5.10×10^{-2}	73.4	Panther Sandstone

Table 728e. Summary of Specialized Water Quality Data

d Deuterium		
Station	δ D / mil	δ^{18} O / mil
In-Mine X3W32F1	-132	-17.8
In-Mine X3W32F2	-131	-17.8 / -17.8*
In-Mine X3R31R1	-128	-18.0
In-Mine X3S31F4	-133 / -132*	-18.3
Well 86-35-3	-132	-17.7 / -17.7*
Well P92-01C-WD	-126	-18.0 / -18.1*
Well P92-02-WD	-128 / -129*	-18.0
Well P92-03-WD	-126	-18.2
Upper Tie Fork Spring	-127 / -129*	-17.7
Lower Tie Fork Spring	-128	-17.6
Big Bear Spring	-123	-17.3 / -17.4*

Waterborne Particulates				
Analysis	X3R31R1	Tie Fork Well	Big Bear Springs	Birch Springs
Filter Color	Off-White	White	White	White
Total Sediment (ml/100 gal)	0.3	0.02	0.04	0.04
Fine Amorphous Debris (1-5 µM dia)	Rare silica	Very rare silica,		
Large Amorphous Debris (5-100 µM dia)	Rare sand & organic detritus**	Very rare biofilm	Very rare sand & organic detritus	
Algae	0	0	0	0
Diatoms	0	0	0	0
Plant Debris	0	0	0	0
Giardia	0	0	0	0
Cryptosporidium	Sample not run			
Free-Living Nematodes (#/100 gal)	0	0	2	0
Pollen (#/100 gal)	0	0	0	0.8 (Pine)
Free-Living Amoeba	0	0	0	0

Free-Living Ciliates (#/100 gal)	0	0	5	26
Free-Living Flagellates	0	0	0	0
Crustaceans (immature Copepods) (#/100 gal)	0	0	2	1.5
Arthropods	0	0	0	0
Other (#/100 gal)	0	Very rare iron bacteria	2 (Rotifers)	0.8 (Rotifers)
Comments	No particulates restricted to surface water were found in these samples			

Tritium		
Location	**Sample Content Tritium Units (T.U.)**	**Error Margin**
P92-02-WD	0.15	+/- 0.09
X3S7419R	-0.04	+/- 0.09
X3S312R	0.31	+/- 0.09
86-35-2	9.32	+/- 0.31
Big Bear Spring	17.7	+/- 0.6
Birch Spring	0.98	+/- 0.09

Carbon Dating		
Location	**Sample**	**Age**
3rd West Roof	Barium salt	8,670 +/- 230 C-14 years (C-13 Corrected)

* Duplicate preparations and analyses were made.
** 5-150 µM diameter

TABLE 728f. Proposed In-mine Well Monitoring Schedule

Monitoring Year	Monitoring Frequency		Comment
	Water Level	Quality	
1st	Quarterly	Annually	For All Well Monitoring Stations
2nd and beyond	Monthly*	Quarterly*	If impact is questioned
	Quarterly	Annually	Otherwise

* Frequency would return to quarterly after a two year time period unless data showed that a quicker return to quarterly is reasonable.

TABLE 728g. Current Status of Potential Mitigation Study Efforts

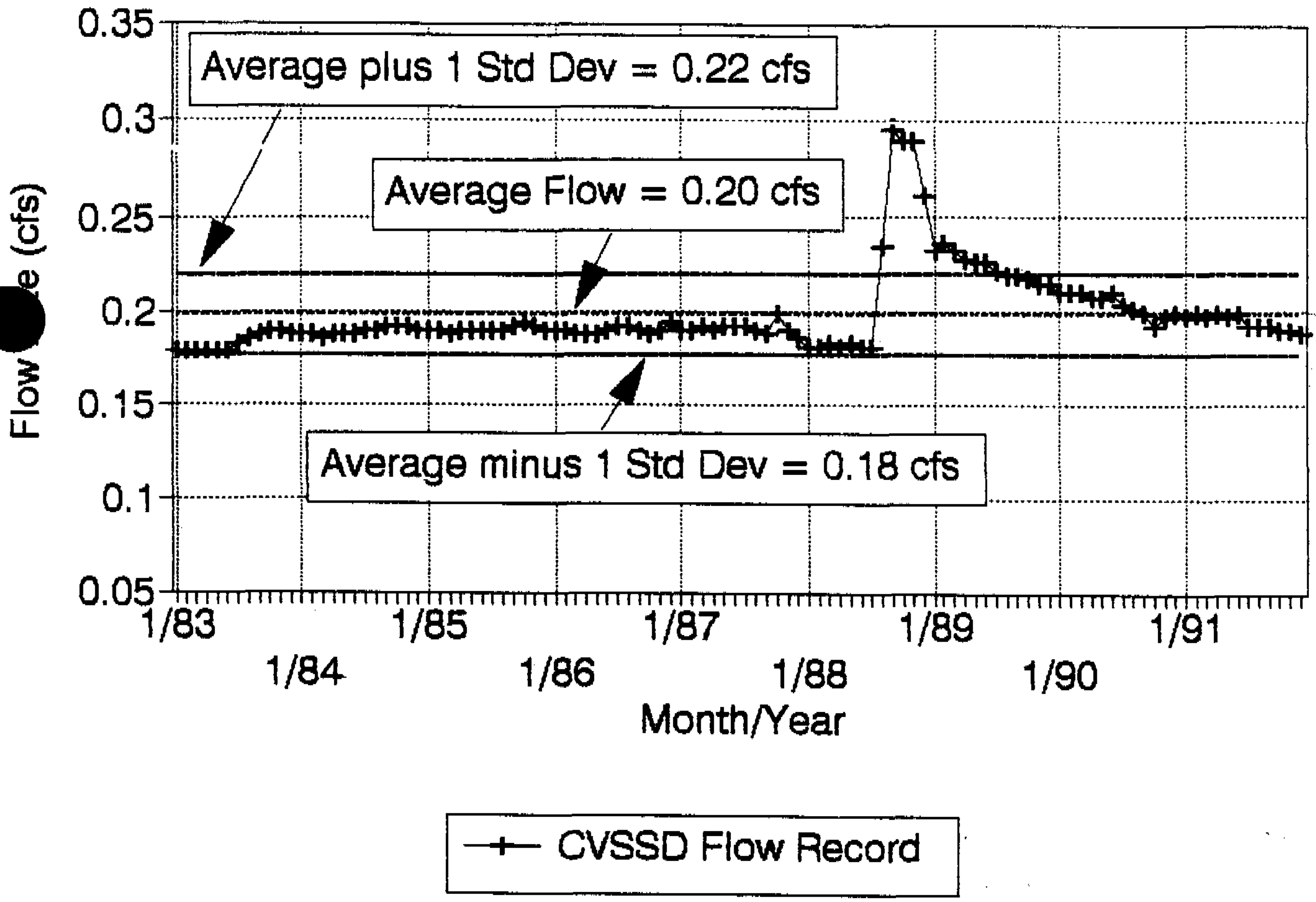
Potential Option	Action Being Taken	Date of Action
Maintain Prudent In-mine Practices	Pumping mine water into adjacent abandoned mine sections	Jan 1992
Re-inject mine waters into faults	Driller was contacted for scheduling to drill into the Graben fault zone wherein possible injection rates would be determined	April 1992
	Test Hole scheduled for drilling	May 1992
Replace Impacted Downgradient Waters	Update PHC	May 1992
	Met with NEWUA and CVSSD to discuss current operations and water supply requirments	March - April 1992
	As a progressive step, CPMC and PacifiCorp met to discuss overall hydrology and potential for impact to local water supplies, and potentials for joint mitigation should mining impacts occur	April - May 1992
	New study undertaken to scope out water supply and treatment alternatives (including costs) within Huntington Canyon	May - June 1992
	Meetings to be scheduled with DOGM to discuss and review current study efforts	June 1992
	Meetings scheduled with CPMC and PacifiCorp to review local hydrogeology and further clarify potential joint mitigation needs and options	Starting June 1992

Exhibit 728a

HANSEN ALLEN & LUCE INC

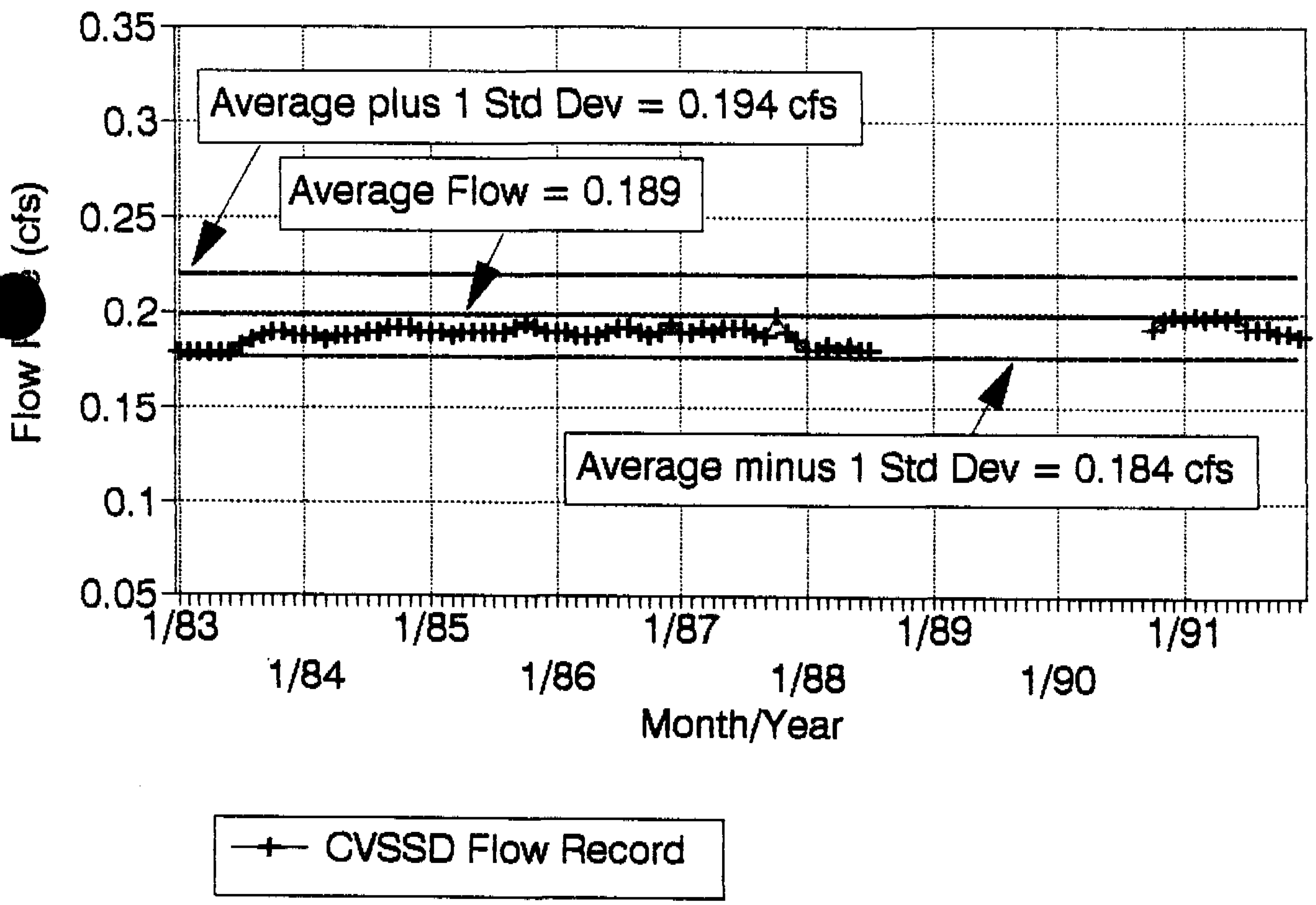
Tie Fork Flows

1983 - 1991

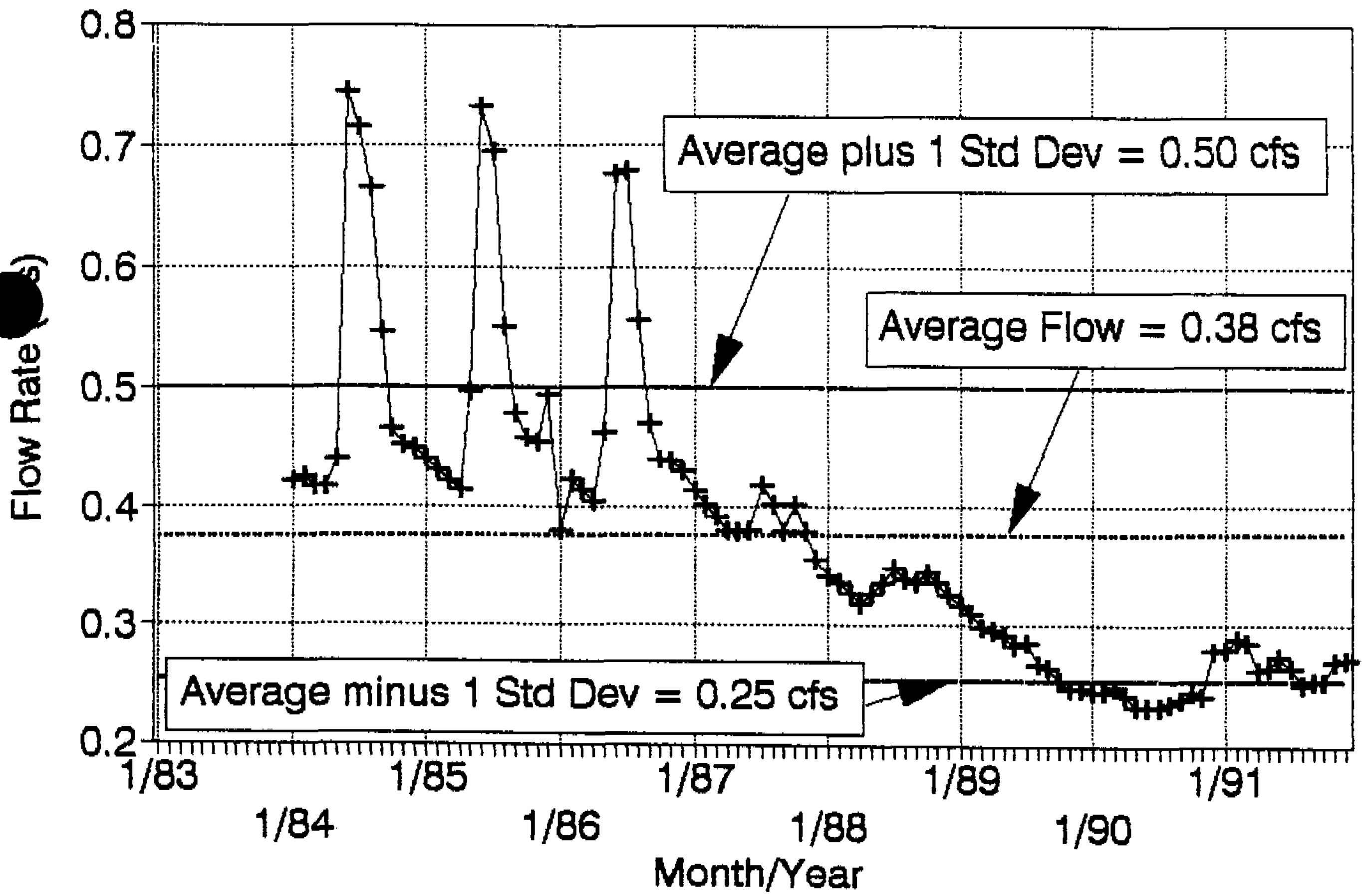


Tie Fork Flows

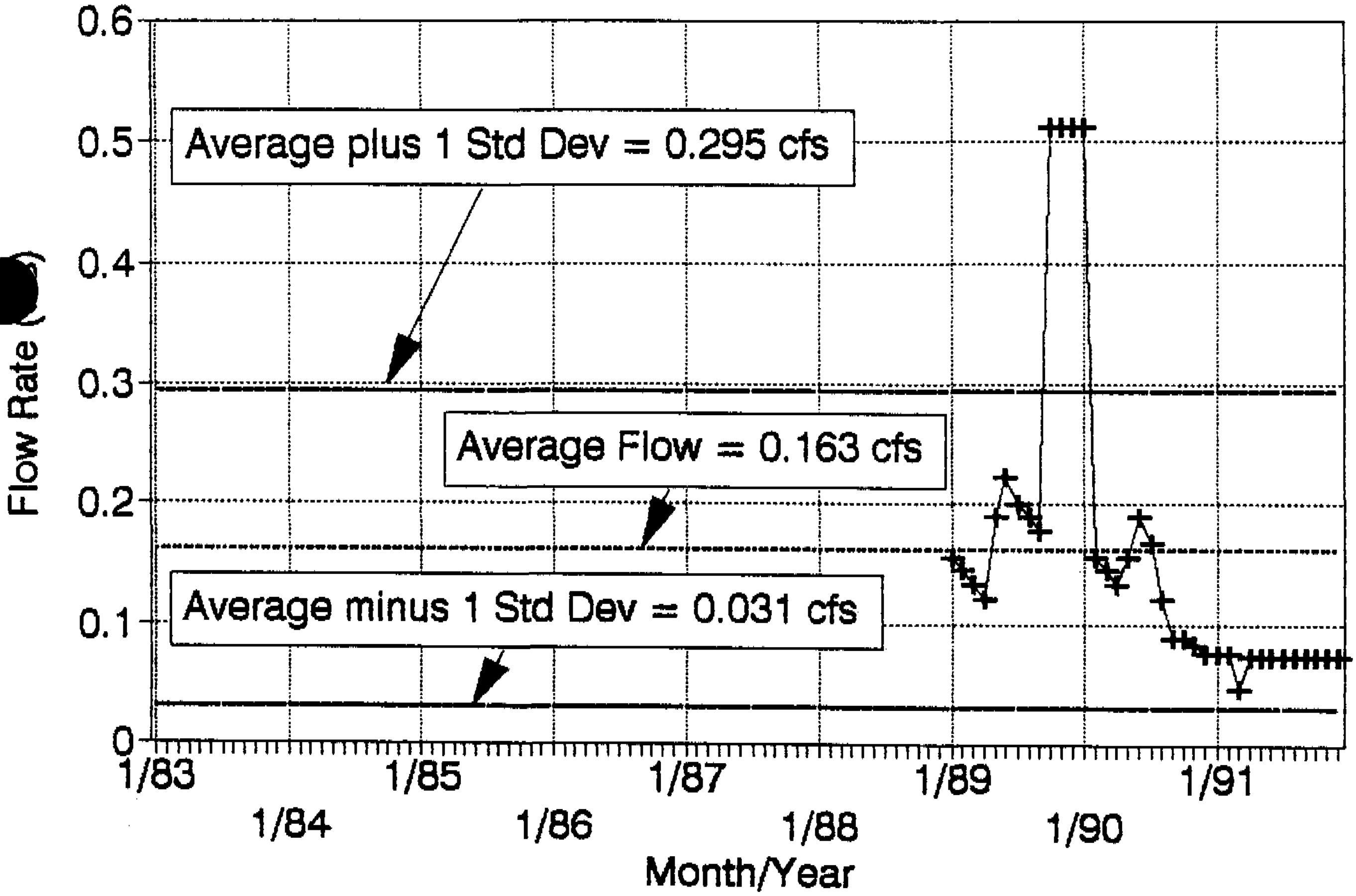
Earthquake Period Data Removed



Bear Canyon Spring
1984 - 1991



Birch Spring
1989 - 1991



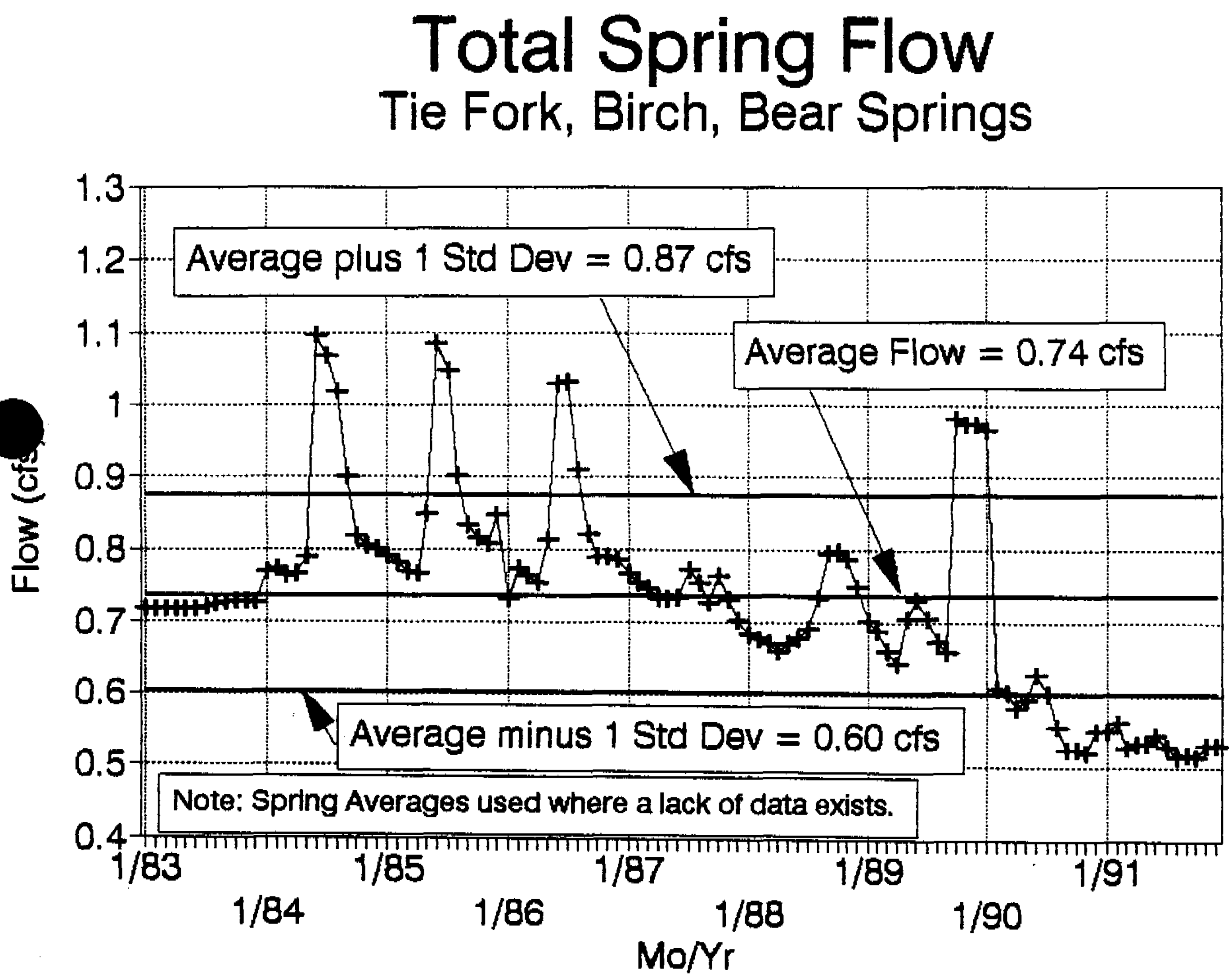
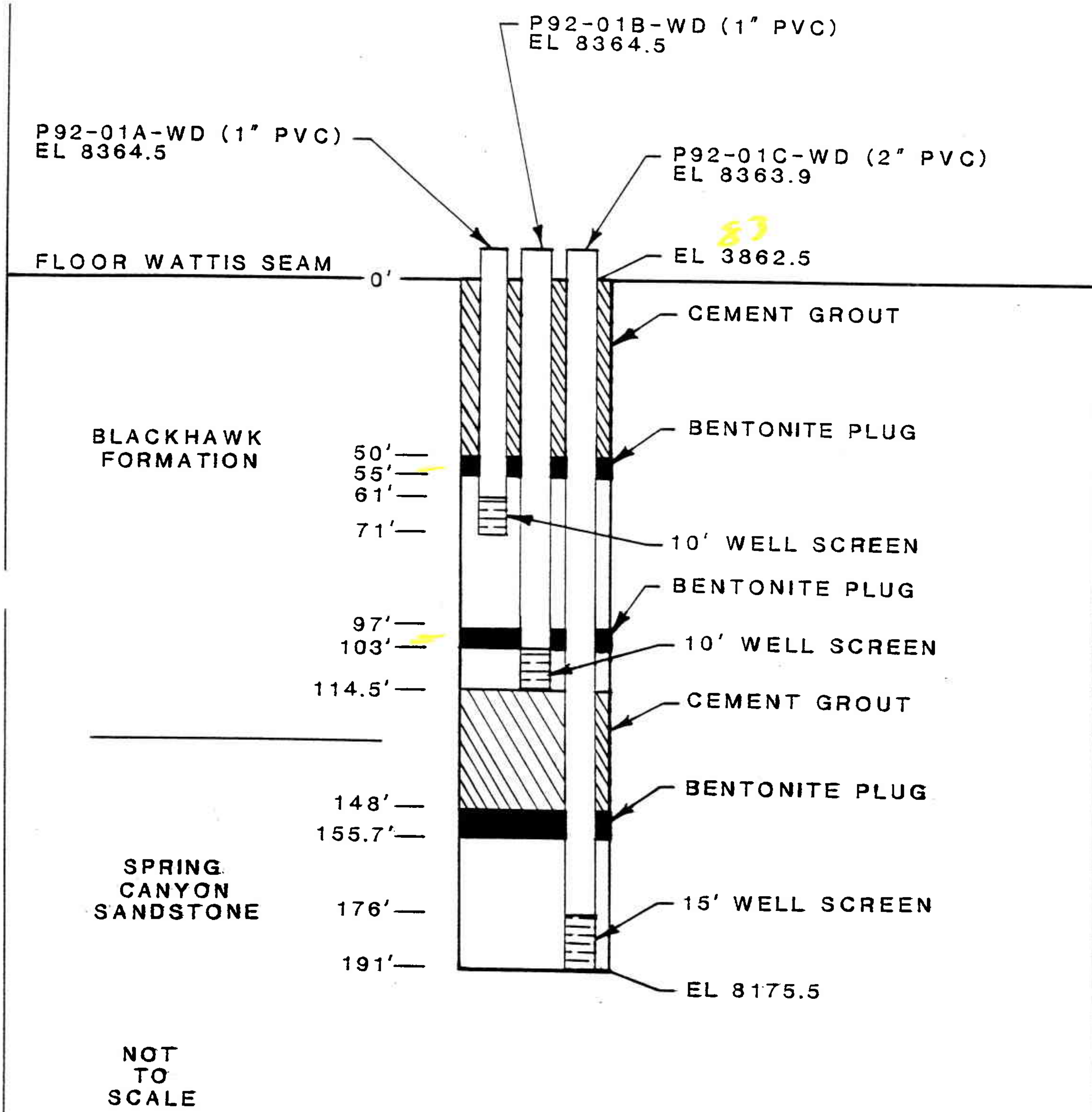

Total Spring Flow
Tie Fork, Birch, Bear Springs
Average plus 1 Std Dev = 0.87 cfs
Average Flow = 0.74 cfs
Average minus 1 Std Dev = 0.60 cfs
Note: Spring Averages used where a lack of data exists.
Flow (cfs)
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
1/83
1/84
1/85
1/86
1/87
1/88
1/89
1/90
1/91
Mo/Yr

Exhibit 728b

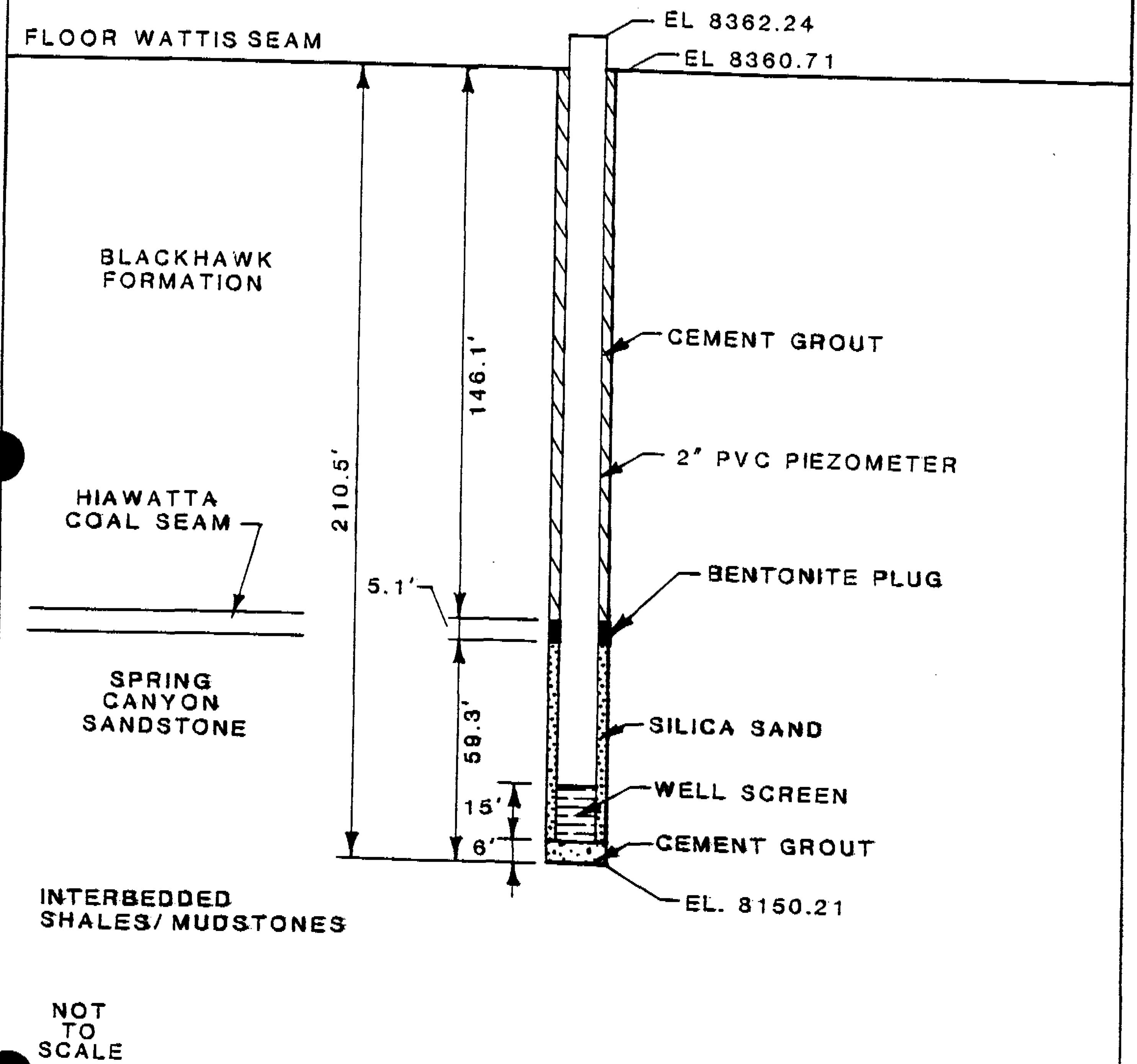
HANSEN ALLEN & LUCE INC



HANSEN ALLEN & LUCE inc

WELL P92-01-WD SCHEMATIC

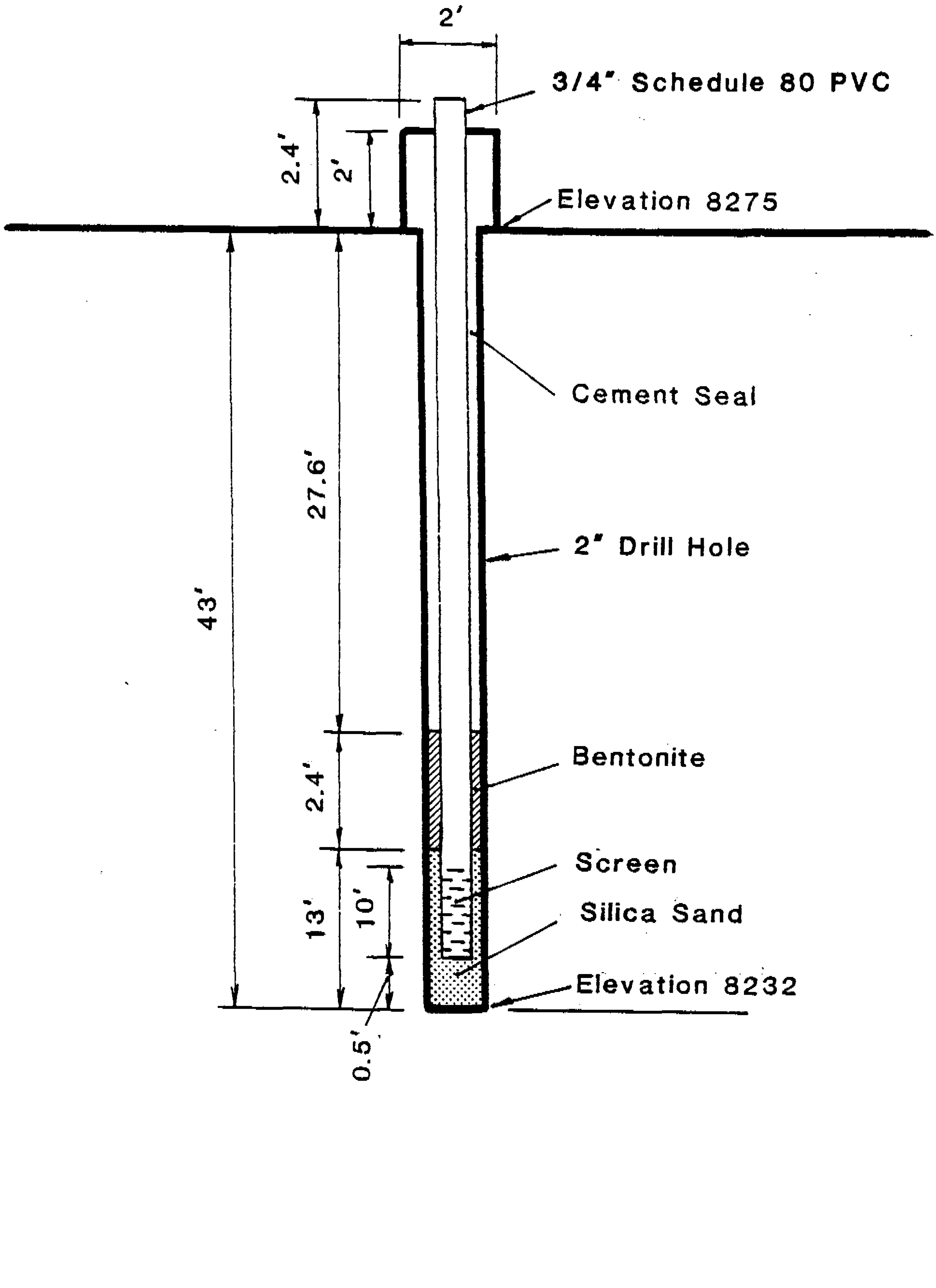
FIGURE



HANSEN ALLEN & LUCE inc

WELL P92-02-WD SCHEMATIC

FIGURE

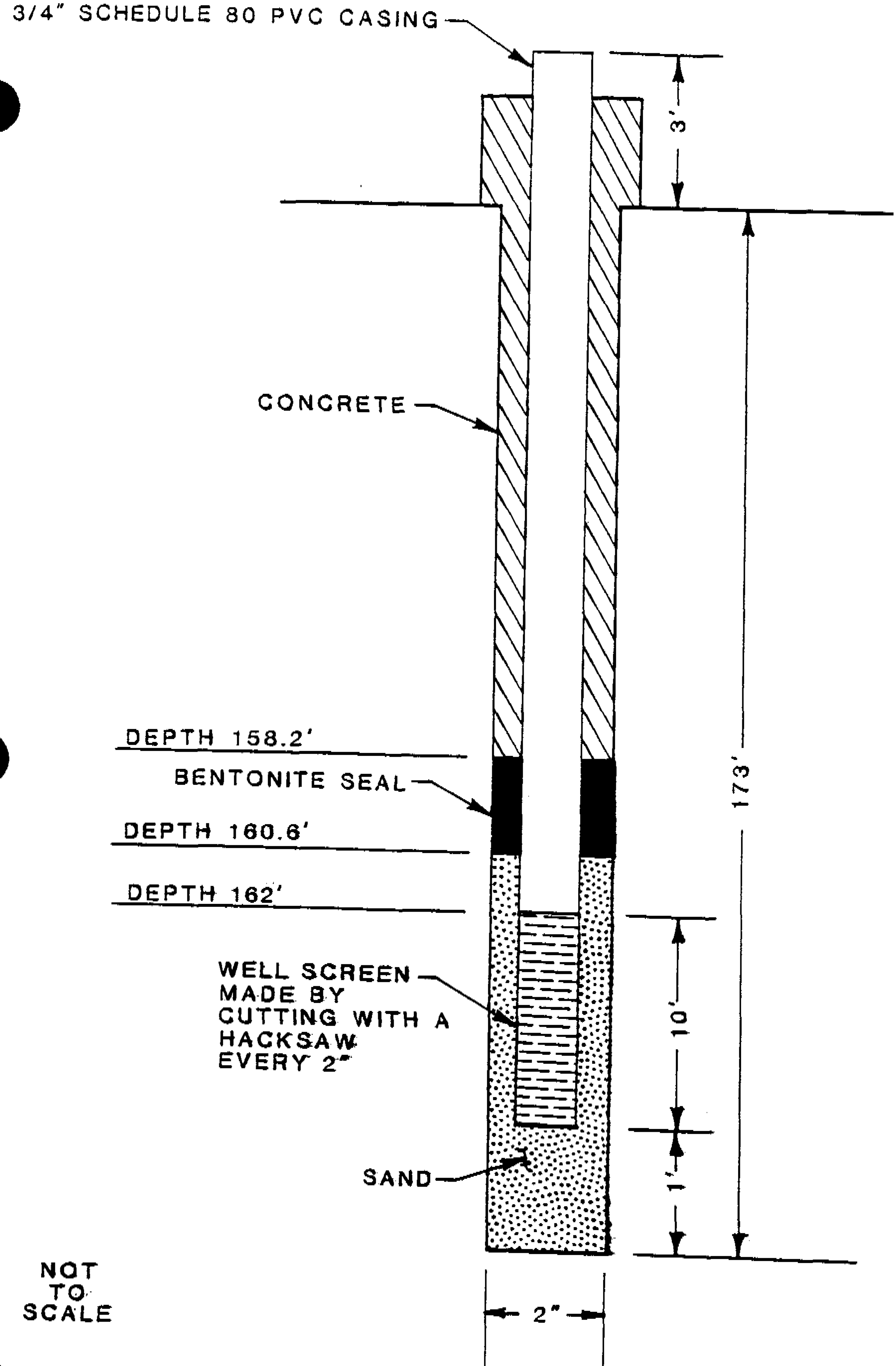


Not to Scale

HANSEN ALLEN & LUCE INC

WELL P92-03WD COMPLETION DETAIL SCHEMATIC

FIGURE



HANSEN ALLEN & LUCE inc

WELL P92-04-WD
COMPLETION DETAIL SCHEMATIC

FIGURE

Exhibit 728c

HANSEN ALLEN & LUCE inc

AQUIFER EVALUATIONS

WELL 92-01-WD (deep)

Limited data from deep hole 92-01C-WD

Approximate Characteristics

Initial Water depth = 165 ft
Well casing dia = 2" = 0.17 ft
Well hole dia = 5.65" = 0.46 ft

Spring Canyon Member ~ 60 ft thick

Saturated Thickness = 827.78 - [illegible] = 131.28 ft
Screen Length = 15'
Static Water Level = 31.28 ft

$K = 2.56 \times 10^{-3}$ ft/min (3.7 ft/day) SPRING CANYON SAND

WELL 92-02-WD

Hole Characteristics Match 92-01-WD
Saturated Thickness = 194.8 ft
Screen Length = 15 ft

$K = 3.07 \times 10^{-4}$ ft/min (0.44 ft/day) SPRING CANYON SAND

DATA RECEIVED FROM PETER NIELSEN (CPMC)

WELL 92-02A-WD (Shallow) Blackhawk

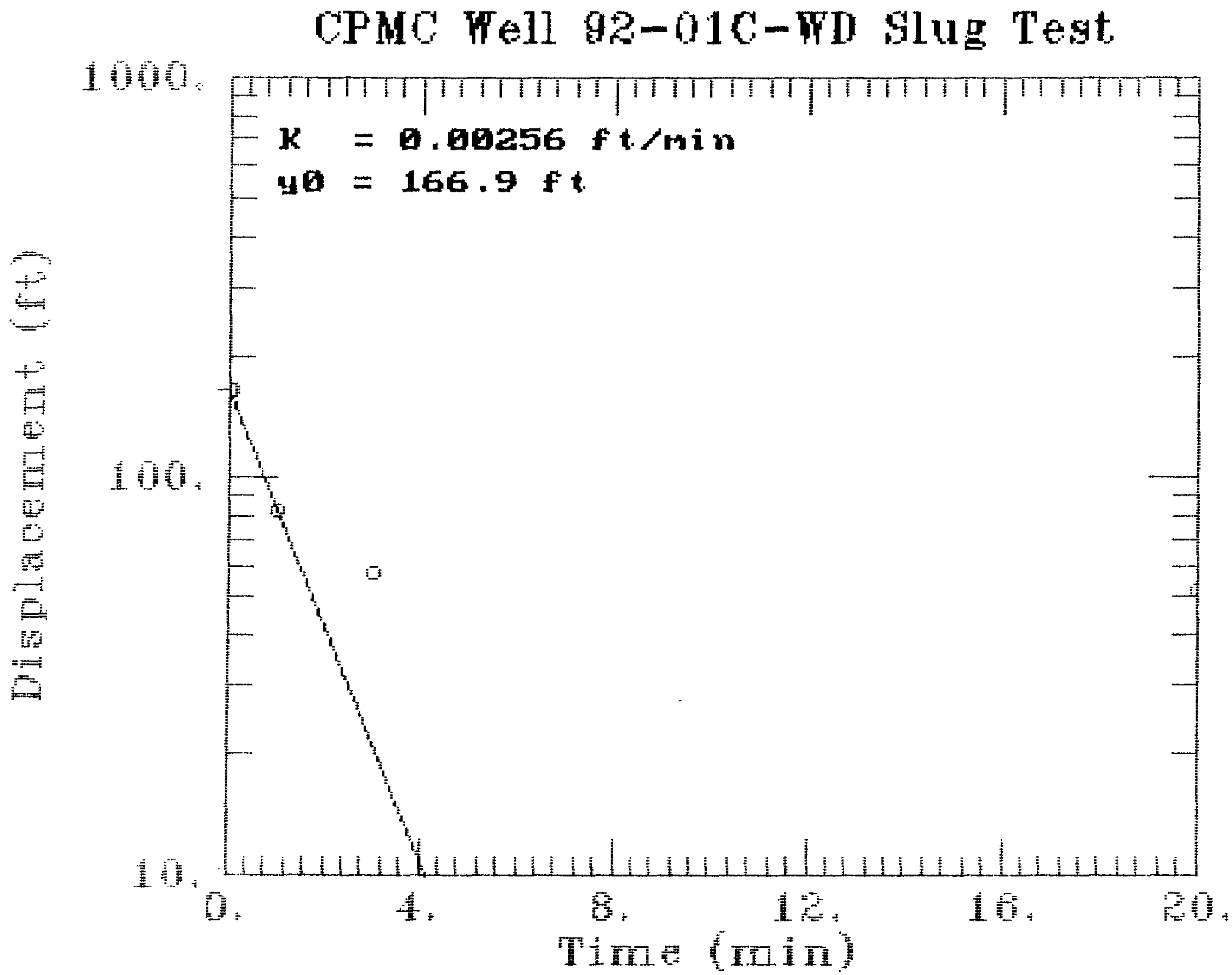
$T = 9.784 \times 10^{-6}$ ft²/m
b = 60 ft
$K = 1.63 \times 10^{-7}$ ft/min
$= 2.35 \times 10^{-4}$ ft/day

WELL 92-02B-WD (Middle) Blackhawk

$T = 4.346 \times 10^{-8}$ ft²/min
b = 114 ft
$K = 3.81 \times 10^{-10}$ ft/min
$= 5.49 \times 10^{-7}$ ft/day

[illegible] DATA (See [illegible] files)

Spring Canyon = 5.74×10^{-5} ft/min
Storrs = 4.53×10^{-5} ft/min
Panther = 5.10×10^{-2} ft/min



AQTESOLV

GERAGHTY & MILLER, INC.

Modeling Group

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A Q T E S O L V

A Program for

Automatic Estimation of Aquifer Coefficients

From Aquifer Test Data

By:

Glenn M. Duffield

and

James O. Rumbaugh, III

Geraghty & Miller Modeling Group

1895 Preston White Drive, Suite 301

Reston, VA 22091

(703) 476 - 0335

A Q T E S O L V is a user-friendly program designed to analyze data from aquifer tests automatically. Aquifer coefficients for a variety of aquifer test conditions can be estimated by A Q T E S O L V , including the following:

- o confined aquifers, unconfined aquifers, and leaky aquifers
- o pumping tests, injection tests, recovery tests, and slug tests

Features:

- o Interactive, menu-driven program design
- o Nonlinear least-squares estimation of aquifer coefficients
- o Statistical analysis of results
- o Complete graphical display of results

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A Q T E S O L V   R E S U L T S

Version 1.10

04/10/92 04:13:52

==

TEST DESCRIPTION

Data set........... 92_01_wd.dat
Data set title..... CPMC Well 92-01C-WD Slug Test

Knowns and Constants:
No. of data points.................. 4
Radius of well casing............... 0.17
Radius of well...................... 0.46
Aquifer saturated thickness......... 131.3
Well screen length.................. 15
Static height of water in well...... 131.3
Log(Re/Rw).......................... 3.884
A, B, C............................. 0.000, 0.000, 2.052

==

ANALYTICAL METHOD

Bouwer and Rice (unconfined aquifer slug test)

==

RESULTS FROM STATISTICAL CURVE MATCHING

STATISTICAL MATCH PARAMETER ESTIMATES

	Estimate		Std. Error
K =	2.5166E-004	+/-	3.1380E-004
y0 =	1.1603E+002	+/-	3.5039E+001

ANALYSIS OF MODEL RESIDUALS

residual = calculated - observed
weighted residual = residual * weight

Weighted Residual Statistics:
   Number of residuals.............. 4
   Number of estimated parameters.... 2
   Degrees of freedom............... 2
   Residual mean.................... 1.902
   Residual standard deviation....... 50.06
   Residual variance................ 2506

Model Residuals:

Time	Observed	Calculated	Residual	Weight
0.1	165	115.26	49.744	1
1	82.4	108.49	-26.086	1
3	57.4	94.83	-37.43	1
20	51.6	30.221	21.379	1

==

RESULTS FROM VISUAL CURVE MATCHING

VISUAL MATCH PARAMETER ESTIMATES

	Estimate
K =	2.5601E-003
y0 =	1.6692E+002

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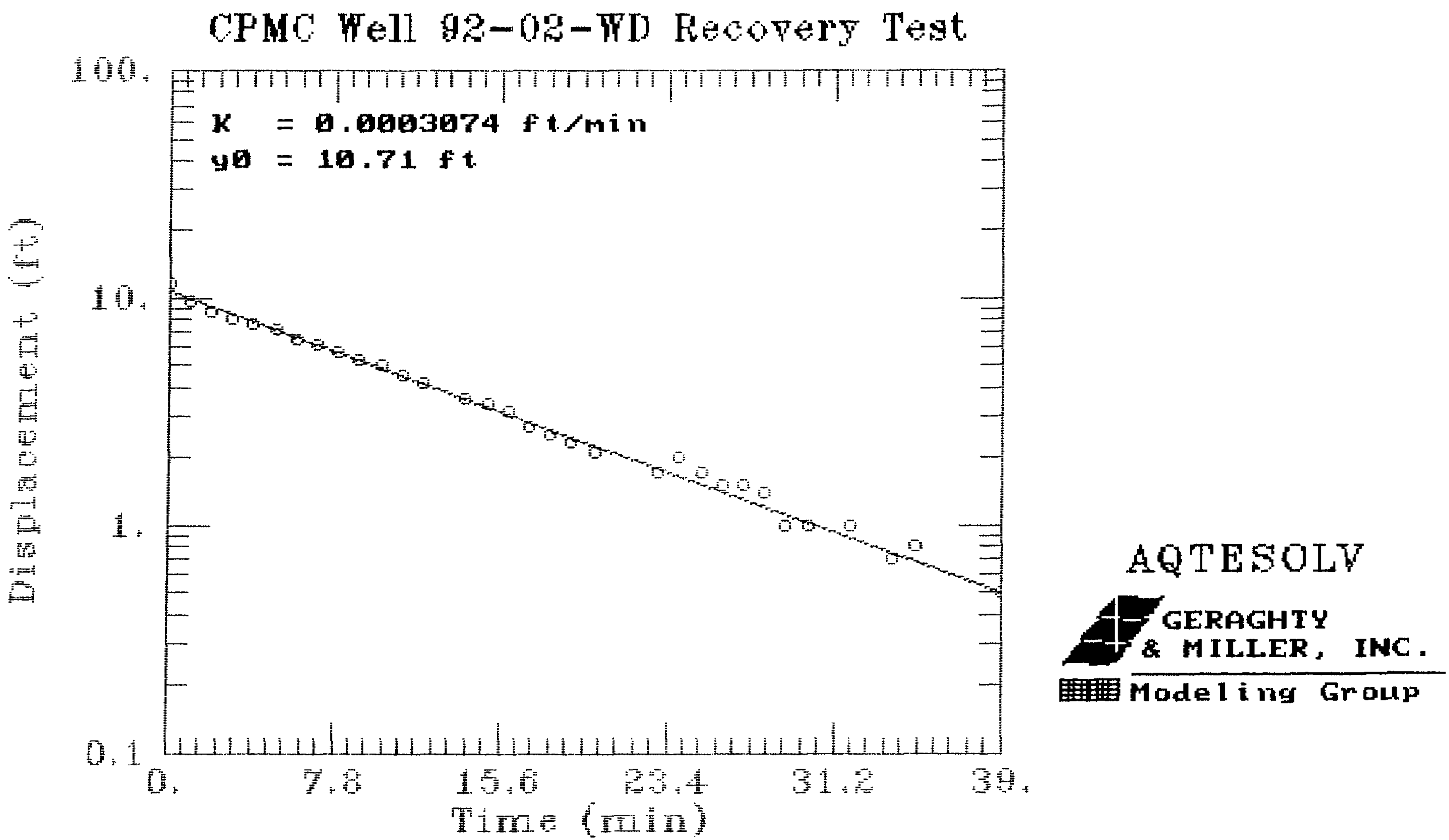
CPMC Well 92-02-WD Recovery Test
K = 0.0003074 ft/min
y0 = 10.71 ft
Displacement (ft)
100.
10.
1.
0.1
0.
7.8
15.6
23.4
31.2
39.
Time (min)
AQTESOLV
GERAGHTY & MILLER, INC.
Modeling Group

A Q T E S O L V

A Program for

Automatic Estimation of Aquifer Coefficients

From Aquifer Test Data

By:

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A Q T E S O L V is a user-friendly program designed to analyze data from aquifer tests automatically. Aquifer coefficients for a variety of aquifer test conditions can be estimated by A Q T E S O L V , including the following:

- o confined aquifers, unconfined aquifers, and leaky aquifers
- o pumping tests, injection tests, recovery tests, and slug tests

Features:

- o Interactive, menu-driven program design
- o Nonlinear least-squares estimation of aquifer coefficients
- o Statistical analysis of results
- o Complete graphical display of results

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A Q T E S O L V   R E S U L T S
Version 1.10

04/17/92 06:27:40

==

TEST DESCRIPTION

Data set........... 92_02_wd.dat
Data set title..... CPMC Well 92-02-WD Recovery Test

Knowns and Constants:
No. of data points.................. 32
Radius of well casing............... 0.17
Radius of well...................... 0.46
Aquifer saturated thickness......... 194.8
Well screen length.................. 15
Static height of water in well...... 194.8
Log(Re/Rw).......................... 4.085
A, B, C............................ 0.000, 0.000, 2.052

==

ANALYTICAL METHOD

Cooper, Bredehoeft, Papadopulos (confined aquifer slug test)

==

RESULTS FROM STATISTICAL CURVE MATCHING

STATISTICAL MATCH PARAMETER ESTIMATES

	Estimate		Std. Error
T =	8.1109E-003	+/-	1.2356E-003
S =	2.3461E-006	+/-	4.2969E-006

ANALYSIS OF MODEL RESIDUALS

residual = calculated - observed
weighted residual = residual * weight

Weighted Residual Statistics:
Number of residuals............... 32
Number of estimated parameters.... 2
Degrees of freedom................ 30
Residual mean..................... -0.04492
Residual standard deviation....... 0.255
Residual variance................. 0.06501

Model Residuals:

Time	Observed	Calculated	Residual	Weight
0.1	11.6	11.424	0.17648	1
1	9.66	10.326	-0.66588	1
2	8.75	9.3462	-0.59623	1
3	8.1	8.505	-0.40499	1
4	7.7	7.7666	-0.06662	1
5	7.2	7.1114	0.088639	1
6	6.5	6.5258	-0.025811	1
7	6.2	6	0.20002	1
8	5.7	5.526	0.174	1
9	5.3	5.0975	0.20253	1
10	5.1	4.7091	0.39093	1
11	4.6	4.3563	0.24373	1
12	4.2	4.0352	0.16478	1
14	3.6	3.4754	0.12461	1
15	3.4	3.2311	0.16887	1
16	3.2	3.0075	0.19247	1
17	2.7	2.8026	-0.10259	1
18	2.5	2.6145	-0.11454	1
19	2.3	2.4418	-0.1418	1
20	2.1	2.283	-0.18296	1
23	1.7	1.8778	-0.17777	1
24	2	1.7631	0.23693	1
25	1.7	1.6571	0.0429	1
26	1.5	1.5591	-0.059101	1
27	1.5	1.4684	0.031601	1
28	1.4	1.3844	0.015622	1
29	1	1.3065	-0.30648	1
30	1	1.2342	-0.23421	1
32	1	1.1047	-0.10471	1
34	0.7	0.99269	-0.29269	1
35	0.8	0.94239	-0.14239	1
39	0.5	0.77271	-0.27271	1

==

RESULTS FROM VISUAL CURVE MATCHING

VISUAL MATCH PARAMETER ESTIMATES

	Estimate
T =	8.1109E-003
S =	2.3461E-006

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Exhibit 728d

HANSEN ALLEN & LUCE inc

KRUEGER ENTERPRISES, INC.
GEOCHRON LABORATORIES DIVISION

24 BLACKSTONE STREET • CAMBRIDGE, MASSACHUSETTS 02139 • (617) 876-3691

STABLE ISOTOPE RATIO ANALYSES

REPORT OF ANALYTICAL WORK

Submitted by: Peter Nielsen
Cyprus Plateau Mining
P.O. Drawer PMC
Price, UT 84501

Date Received: 03/30/92
Date Reported: 03/31/92
Your Reference: Shipment

Our Lab. Number	Your Sample Number	Description	δD*	$\delta^{18}O$*
HOR-71269	X3W32F1	Water	-132	-17.8
HOR-71270	X3W32F2	Water	-131	-17.8 -17.8**
HOR-71271	X3R31R1	Water	-128	-18.0
HOR-71272	X3S31F4	Water	-133 -132**	-18.3
HOR-71273	86-35-3	Water	-132	-17.7 -17.7**
HOR-71274	Lower Tie Fork Spring	Water	-128	-17.6

** Duplicate preparations and analyses.

[Eg = D = 8 $\delta^{18}O$ + 10] (Craig, 1961 b)
or
[$\delta D = 8\delta^{18}O + 10$]

x range -50 – 10
y range -350 – 100

*Unless otherwise noted, analyses are reported in ‰ notation and are computed as follows:

$$\delta R_{sample}‰ = \left[\frac{R_{sample}}{R_{standard}} - 1 \right] \times 1000$$

Where:

D/H standard is SMOW
$^{18}O/^{16}O$ standard is SMOW

And:

$D/H_{standard}$ = 0.000316**
$^{18}O/^{16}O_{standard}$ = 0.0039948**

KRUEGER ENTERPRISES, INC.

GEOCHRON LABORATORIES DIVISION

24 BLACKSTONE STREET • CAMBRIDGE, MASSACHUSETTS 02139 • (617) 876-3691

STABLE ISOTOPE RATIO ANALYSES

REPORT OF ANALYTICAL WORK

Submitted by: Peter Nielsen
Cyprus Plateau Mining
~~P.O. Drawer PMC~~
Price, UT 84501

Date Received: 03/31/92
Date Reported: 04/06/92
Your Reference: Shipment

Our Lab. Number	Your Sample Number	Description	δD*	δ18O*
HOR-71278	P92-03-WD	Water	-126	-18.2
HOR-71279	P92-01C-WD	Water	-126	-18.0 -18.1**
HOR-71280	P92-02-WD	Water	-128 -129**	-18.0
HOR-71281	Big Bear Spring	Water	-123	-17.3 -17.4**
HOR-71282	Tie Fork Upper	Water	-127 -129**	-17.7

** Duplicate preparations and analyses.

*Unless otherwise noted, analyses are reported in ‰ notation and are computed as follows:

$$\delta R_{sample} ‰ = \left[\frac{R_{sample}}{R_{standard}} - 1 \right] \times 1000$$

Where:

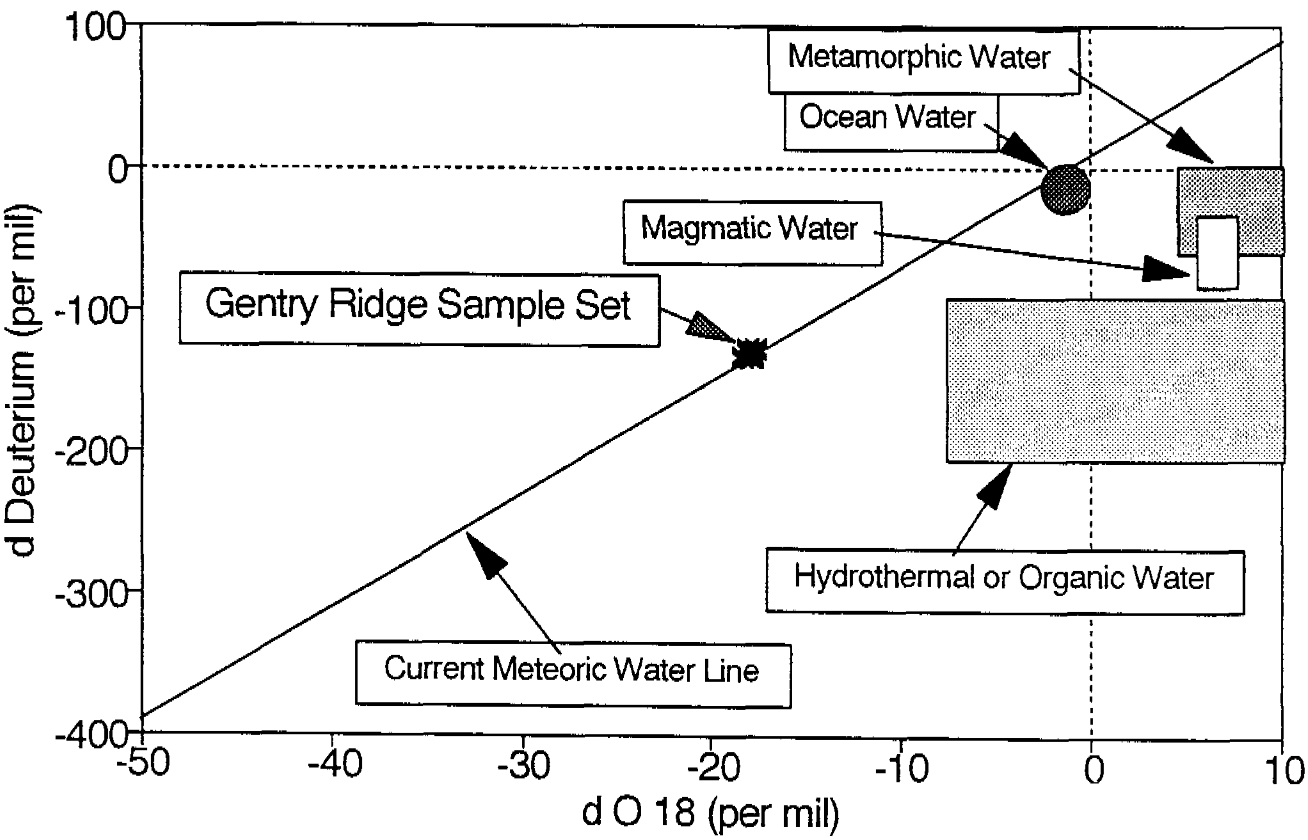
D/H standard is SMOW
$^{18}O/^{16}O$ standard is SMOW

And:

$D/H_{standard}$ = 0.000316**
$^{18}O/^{16}O$ = 0.0039948**

Deuterium/Oxygen 18 Analysis

Gentry Ridge Lease Area



ANALYSIS FOR WATERBORNE PARTICULATES

Invoice 920102

3/13/92

CH Diagnostic and Consulting Service, Inc.
2210 Empire Ave., Loveland, Colorado 80538
Carrie M. Hancock, President Telephone (303) 667-9789

Customer 920457
Cypress Plateau Mining Corp.
PO Drawer PMC
Price, Utah 84501

Laboratory Information
UPS; 3/12/92; 1010 Hrs.;
Polypropylene; Excellent;
Sample read by: Carrie Hancock

Sample Identification: Mine Ground Water, X3R31R1, unchlorinated; 8ºC

Date/Start 3/11/92; 0939 **Date/Stop** 3/11/92; 1145 **Sampler:** Ben Grimes

Gallons: 120 **Filter Color:** Off-white **Total Sediment:** 0.3 mL (0.3/100 gals)

Fine Amorphous Debris: Rare silica, 1-5 µM diameter

Large Amorphous Debris: Rare sand & organic detritus, 5-150 µM diameter

Algae: 0

Diatoms: 0

Plant Debris: 0

Giardia: 0

Cryptosporidium: Not done

Free-Living Nematodes: 0

Pollen: 0

Free-Living Amoeba: 0

Free-Living Ciliates: 0

Free-Living Flagellates: 0

Crustaceans: 0

Arthropods: 0

Other: 0

Comments: No particulates restricted to surface water were found in this sample.

ANALYSIS FOR WATERBORNE PARTICULATES

CH Diagnostic and Consulting Service, Inc.
2210 Empire Ave., Loveland, Colorado 80538
Carrie M. Hancock, President   Telephone (303) 667-9789

Invoice 920101

3/12/92

Customer 920457
Cypress Plateau Mining Corp.
PO Drawer PMC
Price, Utah 84501

Laboratory Information
UPS; 3/11/92; 1015 Hrs.;
Polypropylene; Excellent;
Sample read by: Carrie Hancock

Sample Identification: Tie Fork Well Water, Drilled Artesian Well *, unchlorinated

Date/Start 3/9/92; 0950   **Date/Stop** 3/9/92; 1130   **Sampler:** Ben Grimes

Gallons: 130   **Filter Color:** White   **Total Sediment:** 0.03 mL (0.02 mL/100 gals)

Fine Amorphous Debris: Very rare silica, 1-5 µM diameter
Large Amorphous Debris: Very rare biofilm, 5-100 µM diameter
Algae: 0
Diatoms: 0
Plant Debris: 0
Giardia: 0
Cryptosporidium: Not done
Free-Living Nematodes: 0
Pollen: 0
Free-Living Amoeba: 0
Free-Living Ciliates: 0
Free-Living Flagellates: 0
Crustaceans: 0
Arthropods: 0
Other: Very rare iron bacteria

Comments: *8.5ºC, pH 7.05. 150' from river/stream/lake
No particulates restricted to surface water were found in this sample.

ANALYSIS FOR WATERBORNE PARTICULATES

Invoice 920101

3/12/92

CH Diagnostic and Consulting Service, Inc.
2210 Empire Ave., Loveland, Colorado 80538
Carrie M. Hancock, President Telephone (303) 667-9789

Customer 920457
Cypress Plateau Mining Corp.
PO Drawer PMC
Price, Utah 84501

Laboratory Information
UPS; 3/11/92; 1015 Hrs.;
Polypropylene; Excellent;
Sample read by: Carrie Hancock

Sample Identification: Big Bear Springs, unchlorinated; 9.5ºC, pH 7.4,*

Date/Start 3/9/92; 1320 **Date/Stop** 3/9/92; 1420 **Sampler:** Ben Grimes

Gallons: 130 **Filter Color:** White **Total Sediment:** 0.05 mL (0.04 mL/100 gals)

Fine Amorphous Debris: Very rare silica, 1-5 µM diameter
Large Amorphous Debris: Very rare sand & organic detritus, 5-100 µM diameter
Algae: 0
Diatoms: 0
Plant Debris: 0
Giardia: 0
Cryptosporidium: Not done
Free-Living Nematodes: 2/100 gallons
Pollen: 0
Free-Living Amoeba: 0
Free-Living Ciliates: 5/100 gallons
Free-Living Flagellates: 0
Crustaceans: 2/100 gallons, immature Copepods
Arthropods: 0
Other: 2/100 gallons, Rotifers

Comments: *300' from river/stream/lake
No particulates restricted to surface water were found in this sample.

ANALYSIS FOR WATERBORNE PARTICULATES

CH Diagnostic and Consulting Service, Inc.

2210 Empire Ave., Loveland, Colorado 80538

Carrie M. Hancock, President Telephone (303) 667-9789

Invoice 920101

3/12/92

Customer 920457
Cypress Plateau Mining Corp.
PO Drawer PMC
Price, Utah 84501

Laboratory Information
UPS; 3/11/92; 1015 Hrs.;
Polypropylene; Excellent;
Sample read by: [signature]

Sample Identification: Birch Springs, unchlorinated; 11.5ºC, 400' from river/stream/lake

Date/Start 3/9/92; 1445 **Date/Stop** 3/9/92; 1530 **Sampler:** Ben Grimes

Gallons: 130 **Filter Color:** White **Total Sediment:** 0.05 mL (0.04 mL/100 gals)

Fine Amorphous Debris: Very rare silica, 1-5 µM diameter
Large Amorphous Debris: Very rare & organic detritus, 5-100 µM diameter
Algae: 0
Diatoms: 0
Plant Debris: 0
Giardia: 0
Cryptosporidium: Not done
Free-Living Nematodes: 0
Pollen: 0.8/100 gallons, Pine
Free-Living Amoeba: 0
Free-Living Ciliates: 26/100 gallons
Free-Living Flagellates: 0
Crustaceans: 1.5/100 gallons immature Copepod
Arthropods: 0
Other: 0.8/100 gallons, Rotifer

Comments: No particulates restricted to surface water were found in this sample.

KRUEGER ENTERPRISES, INC.
GEOCHRON LABORATORIES DIVISION
24 BLACKSTONE STREET • CAMBRIDGE, MASSACHUSETTS 02138 • (617) 876-3691

RADIOCARBON AGE DETERMINATION **REPORT OF ANALYTICAL WORK**

Our Sample No. GX-17709 Date Received: 02/20/92

Your Reference: submission form rec'd 02/20/92 Date Reported: 03/25/92

Submitted by: Mr. Jack Rogers
Cyprus Plateau
PO Box PMC
Price, UT 84501

Sample Name: 3rd West Roof.
Barium salt.

AGE = 8,670 +/- 230 C-14 years BP (C-13 corrected).
(34.0 +/- 1.0) % of the modern (1950) C-14 activity.

Description: Sample of barium salt.

Pretreatment: The barium salt precipitate was hydrolyzed, under vacuum, to recover carbon dioxide from the barium carbonates for the analysis. C-13 analysis was made on a small portion of the same evolved gas.

Comment:

$\delta^{13}C_{PDB}$ = - 9.3 ‰

Notes: This date is based upon the Libby half life (5570 years) for ^{14}C. The error stated is $\pm 1\sigma$ as judged by the analytical data alone. Our modern standard is 95% of the activity of N.B.S. Oxalic Acid. The age is referenced to the year A.D. 1950.

Here are some preliminary tritium results from Miami.

P92-02-WD 0.15 T.U. +/- 0.09

X3S7419R -0.04 T.U. +/- 0.09

3rd South, crosscut 7419 (5th entry near 5th right)

X3R312R 0.31 T.U. +/- 0.09

3rd Right, crosscut # 31 (near fault at 3rd right Face), roof

86-35-2 9.32 T.U. +/- 0.31

Big Bear Spring 17.7 T.U. +/- 0.6

Birch Spring 0.98 T.U. +/-0.09

I'm also sending a photocopy of the tritium imformation from a book that I have. It would appear that Big Bear, Birch and the lower flowing Tie Fork well have a surface connection with probably a few half-life times from recharge to discharge. I don't remember exactly what number we used for atmospheric tritium here in Utah, but it is similar to that given in the article (25 T.U.)

We are sending in samples from the other Tie Fork Well and from the lower Tie Fork spring along with a sample from the fault discharge at 3rd right and 3rd West.

The next step may be to use carbon 14 dating at some of the locations to see if we can get some dates from the water. It's this exciting!

Exhibit 728e

HANSEN ALLEN & LUCE INC

HANSEN ALLEN & LUCE INC

CLIENT: CPMC
PROJECT: 1991 Rewrite
FEATURE: Gentry Ridge Mine Water
PROJECT NO.: 002.08.100

SHEET 1 OF
COMPUTED: DEH
CHECKED:
DATE: 19 AUG 91

ESTIMATION OF MINE WATER BENEATH GENTRY RIDGE

Information from Glenn Miller Indicates the following general structure

MUDSTONE (80-90%)
SANDSTONE (10-20%) - Cemented } INTERBEDDED

WATTS SEAM

SILTSTONES (80-90%) - Cemented

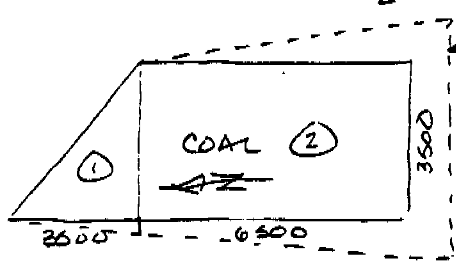
from "Groundwater" by Freeze & Cherry, 1979 Tables 2.2 + 2.4

Rock Medium	Porosity (n)	Permeability (gal/day/ft²)	Assumed Values η	Assumed Values K
Mudstone (Shale)	0-10	$10^{-2} \rightarrow 10^{-7}$	5	10^{-4}
Siltstone (Shale)	0-10	$10^{-2} \rightarrow 10^{-7}$	5	10^{-6}
Sandstone	5-30	$10^{1} \rightarrow 10^{-3}$	10	10^{-2}

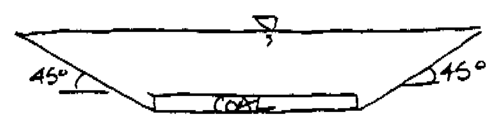
DETERMINE DEWATERING VOLUME DURING MINING.

Horizontal Area of Saturated Gentry Ridge Tunnels

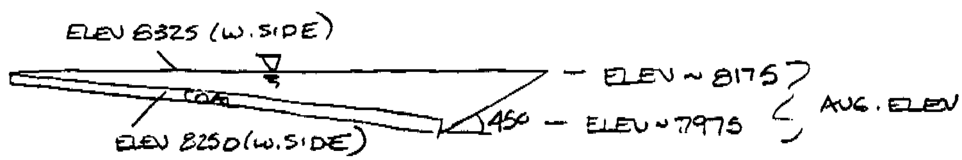
$$Area = 3500 * 6000 + \frac{1}{2} * 3500 * 1500 = 23,625,000\ ft^2 = 54\ ac$$



PLAN VIEW



END VIEW



SIDE VIEW

SATURATED THICKNESS @ NORTH END = 0'
@ x = 3,500 ft = 38' (AVG)
@ x = 10,000 ft = 200' (AVG)

AREAS/VOLUMES

AREA 1 (WATER LEVEL)

$A_{1a} = (3500)^2/2 + 38(3500)/2 = 6{,}191{,}500 \text{ ft}^2$

AREA 1 (COAL LEVEL) $A_{1b} = (3500)^2/2 = 6{,}125{,}000 \text{ ft}^2$

AVG. SAT DEPTH ABOVE COAL = (0+0+75)/3 = 25'
AVG COAL THICKNESS in GENTRY RIDGE = 8'
TOTAL SAT THICKNESS 33'

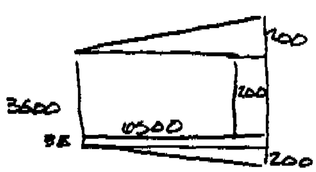
VOLUME 1 (DEWATERING)

$$V_1 = \left(\frac{6{,}191{,}500 + 6{,}125{,}000}{2}\right) * 33' * \underbrace{\left(.85(.05) + .15(.10)\right)}_{\text{AVG POROSITY} \sim 0.06} = 11{,}685{,}280 \text{ ft}^3$$

= 268 ACRE FEET

AREA 2 (COAL LEVEL) $A_{2a} = 6500 * 3500 = 22{,}750{,}000 \text{ ft}^2$

AREA 2 (WATER LEVEL)



$A_{2b} = 22{,}750{,}000 + 2\left(\frac{1}{2}(6700)200\right) + 3500(200) + 38(6700) = 25{,}044{,}600 \text{ ft}^2$

AVG AREA = $23{,}897{,}300 \text{ ft}^2$

AVG. SAT DEPTH ABOVE COAL = (75+0+200)/3 = 92 ft
COAL THICKNESS 8
TOTAL 100 ft

VOLUME 2 (DEWATERING)

$V_2 = 23{,}897{,}300 * 100 * \left(.85(.05) + .15(.10)\right) = 137{,}409{,}475 \text{ ft}^3$

= 3,154 ac-ft

TOTAL DEWATERED VOLUME = 3,422 AC-FT w/o Soil Capture

TOTAL EST. INFLOW THROUGH STRUCTURE (NO FAULT FLOWS)

Permeability of Material Below Coal = 10^1 gpd/ft²

Assume all water moving North to South is intercepted by the mine for a lateral width of 500 feet to both sides of mine workings.

$W = 3{,}500 + 2(500) = 4{,}500$ ft
$H = 208'$ (based on head at South end, including Coal)
$A = 4500 * 208 = 936{,}000$ ft²

Ground Water Gradient = $\frac{8400 - 8150}{12{,}000} * 100 = 2.08\%$

$$Q = KiA = 10^{+1} \frac{gal.}{day * ft^2} * 0.0208 * 936{,}000 ft^2 * \frac{d}{24hr} * \frac{hr}{60m}$$

$= 135.2$ gpm

Triple estimate for secondary permeability effects

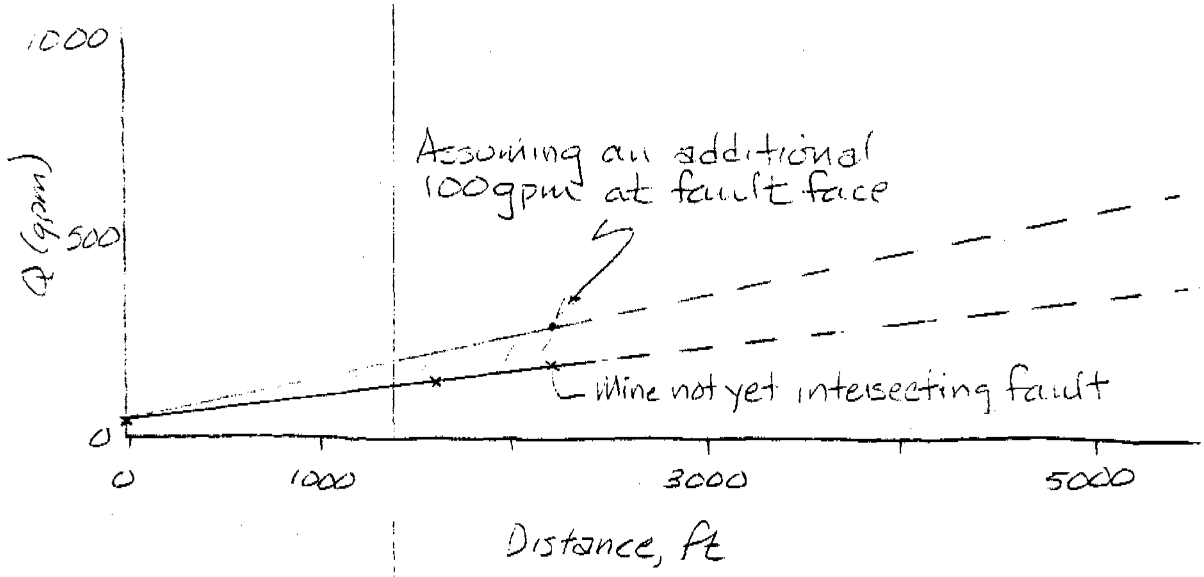
Range of Potential flows = <u>135 → 400 gpm</u>

ALTERNATE EVALUATION OF MINE INFLOWS

Evaluate flows based on distance Mined

DISTANCE (ft)	Flow (gpm)	Σ Q (gpm)
0	40	40
1600	100	140
2200	50	190

} APPROX FLOWS RECORDED 4/15/92



- AS HEAD INCREASES, THE POTENTIAL FOR INCREASED Q RISES.
- AT X=6500 ft, THERE IS A POTENTIAL FOR AS MUCH AS 800 gpm OR MORE FROM THE FAULT FACE.
- POTENTIAL DOES EXIST FOR A LARGE INFLOW ALONG A FAULT.

TOTAL MINE INFLOW:

MAJOR FAULT RELATED	800 gpm
MINOR FAULT/FRACTURE	100 gpm
POUROUS MEDIA INFLOW	150 gpm (ROUNDED FROM PREVIOUS ESTIMATE)
	1050 gpm

WATCH FAULT / FRACTURE [illegible] AS MINING ADVANCES TO SOUTH