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ENERGY WEST MINING COMPANY
A SUBSIDIARY OF PACIFICORP

P.O. Box 310
15 North Main Street
Huntington, Utah 84528

October 29, 2013

Hand Delivered

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OCT 29 2013
DIV. OF OIL, GAS & MINING

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

Subj: Amendment to Volume 9, Appendix A to Reduce the Hydrologic Monitoring Program for Sites Within and Outside Mine Permit Boundaries, PacifiCorp, Wilberg/Cottonwood Mine C/015/0019, Deer Creek Mine C/015/0018, and Trail Mountain Mine C/015/0009, Task ID #4381, Emery County, Utah.

PacifiCorp, by and through its wholly-owned subsidiary, Energy West Mining Company "Energy West" as mine operator, hereby submits an amendment to amend Volume 9, Hydrologic Volume, Appendix A, to reduce the water monitoring responsibilities as outlined in the hydrologic monitoring program.

PacifiCorp has conducted extensive research into interrelationships between the surface and groundwater hydrologic systems and the potential impacts associated with underground mining East and Trail Mountains. Analysis has included; seep and spring surveys, drainage surveys, baseline data collection, in-house and consultant hydrologic studies and government and non-government research projects. Included with this submittal, Energy West discusses the geology and ground water hydrology within the permit areas of its mines.

Two research projects, or investigations, are included in the appendices. In Appendix A, the United States Bureau of Mines Informational Circular No. 1994 summarizes the results of a hydrologic research study to evaluate the hydrologic and overburden failure data to assess the response of local ground water to underground mining in both single and multiple-seam conditions.

In Appendix B are the results and discussion by Mayo and Associates of the investigation of surface and ground water systems in the PacifiCorp lease areas. Neither paper presented found any substantial relationship between the underground mining (and the intercepted ground waters) operations and changes in the surface and ground water quantity or quality. The papers suggest that geology and seasonal climatic variability controls the fluctuating high and low discharge rates of surface and ground water systems on East and Trail Mountains.

In Appendix C is a signed copy of the Memorandum of Understanding between the BLM, USFS, and DOGM. The objectives of the MOU is to establish the roles to be played and procedures to be followed by its signatory agencies when responding to relinquishment of a Federal coal lease (i) to insure the protection of public lands and resources in a manner that will not impair the

public interest and (ii) to allow the agencies to function in a more timely and effective manner so that the rights of both the lessee and the public are protected.

Among the procedures is the evaluation of any potential impacts to the surface and ground water systems. The MOU allows coordination and concurrence between the agencies to make decisions on whether or not the hydrology within the federal coal lease has been impacted. None of the agencies noted impacts to the hydrology of any of the federal coal lease areas applied for relinquishment and signed their concurrence to the action.

Energy West is reducing the extent of the mine's hydrologic monitoring by eliminating sites that are either 1) outside of its current mine permit boundaries, 2) outside its current federal coal lease boundaries, 3) in areas that have been mined and are not planned for future underground mining operations, or 4) those areas that are considered to have no economic value because of either poor coal quality or problematic mining conditions and will not be mined. Those sites that are being removed are outlined in the attached summary sheet.

To justify removal from the monitoring program, Energy West has detailed pertinent information for each site to be removed. Much of the information was taken from the current Supplemental Volume 1 – "Lease Relinquishment; Phases I, II, and III," or "Partial Lease Relinquishment, Federal Coal Lease UTU-64375 January 9, 2009". A Justification Statement for removal is outlined by site or group of sites. General information of the Statement includes location description, lease association, subsidence monitoring results, water quality and quantity data, and a justification for removal. Water quality data is presented giving (in most cases) pre- and post-mining water quality, and historic water quality. A subsidence profile (copied from the Annual Subsidence Report) is also included to show the maximum subsidence that has occurred within the vicinity of the site, if applicable. And lastly, a map illustrates the physical location of each site on both East and Trail mountains.

In 2002, Energy West submitted and received approval (by DOGM) to include in its Mining and Reclamation Plan its "Volume 1 – Lease Relinquishment, Phase's I, II, and III." This volume is a collection of information which supports lease relinquishment and the issue of "substantial completeness" as it pertains to areas of mining-induced subsidence. Lease-specific information supplied to regulatory agencies (those agencies described in the MOU) contains the disposition of subsided areas with descriptions of hydrologic and vegetative impacts, if any. Subsidence monitoring contains several years of a collection of both aerial photogrammetric and conventional surveying information. From this information, the determination was made that mining-induced subsidence had reached its predicted value and was considered "substantially complete" with no significant or irreparable damage to the environment, inclusive of the hydrology, vegetation, wildlife and other land uses. The BLM (with signatory concurrence according to the MOU) accepted this information and approved all three phases of relinquishment in April and October of 1992, April 1997, and again in 2009.

Energy West included all the information associated with the phased relinquishment into the State mining and reclamation permit which was approved for addition in November 2002. The BLM (with signatory concurrence of the coordinating agencies) also approved the partial relinquishment of lease UTU-64375 and UTU-49332 within the Trail Mountain LMU in January 2009. A portion of this approved application, "Evaluation of Impacts to Ground and Surface Water Hydrology", is included in Appendix D. The map provided with this submittal shows all federal coal leases previously approved for relinquishment.

Also include with this submittal is the amended pages within Volume 9, Appendix A. Sites that are identified for removal are "~~struck out~~". The required C1/C2 forms are attached.

The information, studies, and data that has been presented in this amendment volume documents that groundwater resources have not been impacted by underground mining operations within the East and Trail Mountain mining areas. Therefore, Energy West is removing the listed sites (refer to amendment volume) from its hydrologic monitoring program. Beginning in 2014, the stated monitoring sites will no longer be sampled for quality or quantity of their discharge. If the Division does not agree with Energy West's findings, please provide compelling scientific evidence that suggests that our underground mining operations have impacted these sites.

If you have any questions concerning this action, please contact Dennis Oakley at 435-687-4825.

Sincerely,

Kenneth S. Fleck

Kenneth Fleck
Geology and Environmental Affairs Manager

Cc: file

The following responses to deficiencies are formatted as found in the technical analysis document. They are broken down into logical section headings similar to the R645 regulations. In each section, the regulation number along with the associated deficiency is follow by the permittee's italicized response.

R645-301-731.214: Spring 79-29 - The justification for eliminating this spring from the groundwater monitoring program is that there has been no change in pre-mining and post-mining water quality or quantity. This explanation is justified for removal of this spring from the monitoring plan. However, this argument was made in the first submittal and left out of the July 2013 submittal.

The said justification for spring 79-29 was inadvertently left out of the previous submittal. The justification is now included along with flow data, quality data, and subsidence data for this spring.

R645-301-731.214: Spring 82-52 - The justification for eliminating this spring from the groundwater monitoring program is that there has been no change in pre-mining and post-mining water quality or quantity. Several possible inaccurate statements are included in the justification form. Such as:

"Pre- and Post-water quality data is included for spring 82-52. Data show insignificant variances between pre- and post- quality results."

Based on DOGM review mining began in 1975 but monitoring was not begun until 1982 and this indicates that no premining data is available. The permittee must either better demonstrate premining data or adjusted these statements and reevaluate spring 82-52. The justification for removal will be reexamined after this further explanation or reevaluation.

The Division is correct in its statement that no pre-mining data is available for spring 82-52. Mining in the area near the spring began in 1975 prior to any hydrological monitoring. Monitoring had not begun until 1982 for spring 82-52. However, 82-52 is adjacent to mains development and never been directly undermined.

The justification document has been rewritten to better express the arguments for removal from the monitoring program. The justification relies on data sets for quantity and quality of the spring,

comparison of flow to the Palmer Drought Index, and the findings by the Bureau of Mines that there are no discernible affects from mining on springs that are located over barrier pillars or mains.

R645-301-731.214: Spring 89-60 - The justification for eliminating this spring from the groundwater monitoring program is that there has been no change in pre-mining and post-mining water quality or quantity. Several possible inaccurate statements are included in the justification form. Such as:

"Pre- and Post-water quality data is included for springs 79-38, 89-60, and Ted's Tub."

and

"Sites 79-38, 89-60, and Ted's Tub have been monitored by Energy West Mining Company since 1979."

Based on DOGM review mining began in 1988 but monitoring was not begun until 1989 and this indicates that no premining data is available. The permittee must either better demonstrate premining data or adjusted these statements and reevaluate spring 89-60. The justification for removal will be reexamined after this further explanation or reevaluation.

The inaccurate statements have been corrected. Refer to the justification document.

R645-301-731.214: Spring 80-47 - The justification for eliminating this spring from the groundwater monitoring program is that there has been no change in pre-mining and post-mining water quality or quantity. Several possible inaccurate statements are included in the justification form. Such as:

"Pre- and Post-water quality data is included for spring 80-47. Data show insignificant variances between pre- and post- quality results."

Based on DOGM review mining began in 1977 but monitoring was not begun until 1981 and this indicates that no premining data is available. The permittee must either better demonstrate premining data or adjusted these statements and reevaluate spring 80-47. The justification for removal will be reexamined after this further explanation or reevaluation.

The inaccurate statements have been corrected. Refer to the justification document.

Spring 79-40 - The justification for eliminating spring 79-40 from the groundwater monitoring program is there has been no change in pre-mining and post-mining water quality or quantity. The pre-mining water quantity data shows flow between 2 gpm to 15 gpm from 1983 to 1988. Since subsidence was completed in 1998 flows have ranged from 0 gpm to 2 gpm. Due to the periods of no from 2002 to 2004

and 2007 to 2010 the Division finds it necessary to continue monitoring of this location to better evaluate these dry periods flow.

Energy West disagrees with the Division's assessment of the spring. Pre-mining data does not show flows between 2 and 15 gpm. Pre-mining flows for spring 79-40 were 0.13 (1981) and 3.2 (1982). During the period that the spring was being undermined, flows of 15 gpm in 1983 down to 5.6 in 1985 were reported. However, if a comparison of the three graphed lines (East Mountain Springs, Spring: 79-40 vs. Precipitation, Peak flow (July) vs East Mountain Weather Station and Palmer Drought Index), it is evident that the precipitation and spring flow follows the trend of the Palmer hydrological drought index. The 1983 water year experienced unprecedented precipitation. Above average water years followed again in 1984, 1985, and 1986. During the next 6 years (1987 thru 1992), extreme drought conditions distressed the area and therefore, springs throughout the East Mountain area produced minimal flows or dried up completely.

In 1993 above normal conditions returned and reverted back to drought conditions the following year. This sinusoidal cycle lasted three years. In 1997 and 1998, the area again experienced wetter than normal conditions. In 2000, extreme drought resumed.

By comparing the PHDI to the spring flow of 79-40, Energy West believes that the seasonal climatic variability (mainly snow pack conditions) is the controlling factor to flow quantities discharging from springs. It is also believed that the active zone of the groundwater system (the zone of direct hydraulic communication with the surface) has experienced little opportunity to fully recharge to accommodate the higher flows that were experienced in 1983 thru 1986.

Through subsidence monitoring, Energy West reported that subsidence was virtually unchanged between 1995 and 2004 (last year of monitoring this area). The flow chart shows normal flow through this time period. Energy West, therefore, does not believe that underground mining or subsidence has had any impact on the discharge of 79-40 or other springs on East Mountain.

Two springs approximately 1300 feet to the west of 79-40 (spring 80-41 and 80-44) were two of the eight springs that were part of the Bureau of Mines study (IC 9405, Reponse of Springs to Longwall Coal Mining, at the Deer Creek and Cottonwood Mines, Wasatch Plateau, Ut) that looked at the "effects of mining and associated subsidence in varying geologic conditions". The Bureau recognized that "subsidence produces alterations in overburden characteristics which in turn produce associated changes in the hydrologic system... The study addressed the effects of overburden failure on hydrologic resources in proximity to a mined area".

The study hypothesized that springs are expected to show a greater response to underground mining where they are located over panels than those located over mains or barrier pillars since overburden

deformation occurs over longwall panels as the roof caves and fractures form in the overburden. The springs in this study did not show a dramatic decrease in flow as was expected.

The study concluded that the limited response observed for the springs was thought to be influenced by site-specific conditions that buffered the effects of mining. These conditions include the thick overburden present and the presence of formations in the overburden that contain hydrophilic clays and mudstones. These clays were described to act as aquatards retarding the migration of water, lessening the vertical extent of strata dewatering. Additionally, the presence of a massive sandstone layer (the Castlegate Sandstone) can cause bridging in the overburden, thereby limiting subsidence and the associated hydrologic response.

With the above stated meteorological facts coupled with the report by the Bureau of Mines, Energy West is confident that there have been no impacts to the springs on East and Trail Mountain due to underground coal mining operations.

R645-301-731.214: Spring 18-2-1 - The justification for eliminating this spring from the groundwater monitoring program is there has been no change in pre-mining and post-mining water quality or quantity. The pre-mining water quantity data shows flow between 0 gpm to 18.9 gpm from 1987 to 1998. Since subsidence was completed in 2002 flows have ranged from 0 gpm to 3.6 gpm. Due to the numerous periods of since 2002, the Division finds it necessary to continue monitoring of this location to better evaluate these dry periods flow.

At no time do the records show a flow of 18.9 gpm. Nor do monitoring records date back to 1987. Actual records between 1988 thru 1998 show flows from 0.03 gpm in 1992 to 11 gpm in 1988. The highest flow followed three consecutive years of wet to very wet water years. The lowest flows recorded (0 gpm) were found during three consecutive dry to extremely dry years.

"Subsidence monitoring showed a steady increase (as reported in the 2008 Annual Subsidence Report) in subsidence from 1997 through 2001". The panels below spring 18-2-1 were completely extracted during 1997 and 1998. During this same time period, spring flow monitoring recorded its second and third highest flows of 7.5 gpm in 1997 and 9.8 in 1998. The Palmer Hydrological Drought Index also reported above normal precipitation for those same years. This pattern suggests that spring flow is most likely regulated by climate rather than impacted by underground mining operations.

Subsidence at the spring was recorded at 1 to 2 feet in 2008 and was considered substantially complete. Lease relinquishment of lease UTU-64375 was retroactively approved on January 9, 2009 by the BLM. The USFS and DOGM concurred with the application which stated that there were no impacts to the

natural resources within the area of UTU-64375. Monitoring for subsidence in the area ceased as of 2010.

The lease relinquishment application included a narrative which discussed the ground and surface water hydrology of Trail Mountain. This narrative is included herein in Appendix D.

Energy West disagrees with the Division that it is necessary to continue monitoring of this location to better evaluate the dry period flows. Energy West is confident that the evidence presented is sufficient to show that there has been no impact to the spring due to underground mining operations.

R645-301-731.214: Spring 84-56 - The justification for eliminating spring 84-56 from the groundwater monitoring program is that there has been no change in pre-mining and post-mining water quality or quantity. No pre-mining water quality data is presented so this is unsupported. Further, the request does not sufficiently explain the measurement of no flow from 2002 until 2006 and again from 2007 until 2011. Prior to mining flows were present from 1.6 gpm to 6.2 gpm. Since 2011 flows up to 0.84 gpm have appeared. The Division finds it necessary to continue monitoring of this location to evaluate the return of this flow.

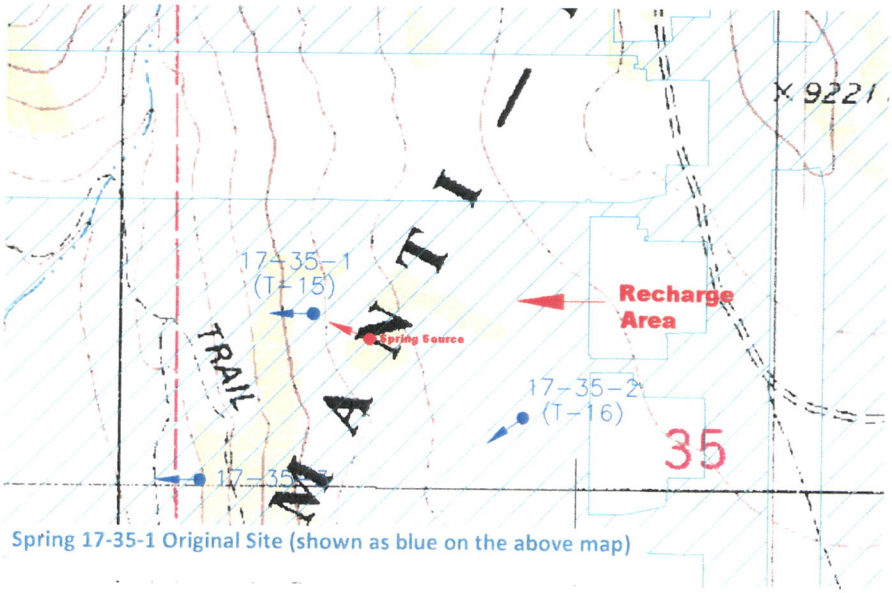
Discharge of spring 84-56 follows a similar trend as most shallow formed springs on East Mountain. As stated in the justification, spring 84-56 is located on an east-facing slope in very heavy vegetative cover and has been developed. However, the site has deteriorated due to cattle grazing and lack of maintenance.

Like other springs located in the North Horn Formation, spring 84-56 occurs in a permeable fluvial channel that intersects the land surface. The spring is underlined by impermeable mudstones that disconnect shallow formed springs from lower stratigraphic structures.

Prior to mining, discharges from the spring were already trending downward (1984 – 1987). The Palmer Hydrologic Drought Index was also trending downward during this same time period. The high flow of 6.2 gpm was reported during a peak of precipitation. Then, in 2002, the East Mountain weather station reported its lowest precipitation measurement. The PDHI reported extreme regional drought conditions from 2000 – 2004, and again in 2007. Energy West believes that there is sufficient evidence to show that spring flow from shallow formed springs is controlled by climatic conditions and not underground mining operations. The decreasing trend of spring 84-56 is similar to the trend of springs 79-26 and 79-32 both of which have not been undermine by underground coal mining operations.

R645-301-731.214 and 728.334: Spring 17-35-1 - The justification for eliminating spring 17-35-1 from the groundwater monitoring program is that there has been no change in pre-mining and post-mining water quality or quantity. Prior to mining flows varied from less than 0.5 gpm to more than 3 gpm from 1988 to 1999. However, following subsidence completion in 2002 every measurement has registered as no flow or at best ground saturation. In addition, the Permittee indicates that a grazing permittee unsuccessfully attempted to redevelop the spring in August 2000. The Division rejects the request to cease monitoring at spring 17-35-1. In addition, if no flow has been present since 2002 and a grazing permittee has attempted and failed at redevelopment then the Division requires the permittee update their MRP to address any probably hydrologic consequences at this location.

Spring 17-35-1 is a low output spring, emanating from the North Horn Formation in Section 35, Township 17 South with peak flows typically less than 1.0 gpm. Recharge is limited to the west facing gentle upslope. Snowpack accumulation is also limited due to the geographic limitation and prevailing winds. PacifiCorp initiated monitoring of 17-35-1 at the location shown in blue which corresponded to the location monitored by the previous operator. Spring development included a two foot corrugated metal standpipe with a one inch polyline supplying water to a metal trough protected with vertical timbers. The piping and trough system failed due to the lack of maintenance and impacts from grazing and wildlife. An attempt by the grazing permittee was made to reestablish flow by replacing a portion of the polyline and



Spring 17-35-1 Original Site (shown as blue on the above map)

placing a new unprotected trough along the original trough. Flow was established for a short time, however the piping system failed from the standpipe area and flow from the spring saturated the contour furrow adjacent to the trough. No point source could be established for monitoring purposes. PacifiCorp conducted an in-depth site investigation prior to lease relinquishment in 2009 and located the groundwater source of 17-35-1 slightly upslope approximately 250 feet from the original monitoring location, shown in red on the map above. PacifiCorp was unaware of this location during initial monitoring of 17-35-1. Site development included a two foot corrugated metal standpipe and polyline piping to the original site. After the failed attempt to reestablish flow at the original (lower) site, the grazing permittee installed a metal unprotected trough at the source, see adjacent photo. Again, lack of maintenance and impacts from cattle grazing and wildlife have made the spring collection system inoperable. Flow from the groundwater source has been uninterrupted with output consistent with the original site. PacifiCorp has discussed hydrogeology of this site with the subsurface and surface management agencies during the lease relinquishment process. Partial relinquishment of Federal Lease UTU-64375 was approved in 2009.

Personnel realignment in preparation for the closure of Trail Mountain caused confusion related to the monitoring of site 17-35-1. As a result, PacifiCorp personnel inadvertently continued to monitor the original site instead of the groundwater source.

R645-301-731.214: Because the Division's database does not contain all of the flow data presented in the permittee's justifications the permittee shall electronically submit a copy of all flow data provided in justification graph in Microsoft Excel or comma separated format.

The division has received from Energy West quality and quantity data in the annual report since the start of the monitoring program. Energy West has also submitted this data quarterly as required by the Utah Coal Regulations. The Division may need to review how the water data is managed and take appropriate actions to limit the loss of pertinent hydrologic data.

However, the flow data utilized from illustrating spring discharge over time and comparing to the East Mountain weather station and the Palmer Hydrologic Drought Index is readily available in an Excel spreadsheet format. Energy West will insure that the Division's hydrologist receives this information.

R645-301-731.214: Appendix A shall be updated as necessary in accordance with these findings. In addition, the permittee shall keep all locations within currently held leases and notate these as inactive and that monitoring will be resumed if mine workings are ever redeveloped.

Appendix A has been amended and included with this submittal. The Division should review and determine their findings on the application as submitted.

APPLICATION FOR COAL PERMIT PROCESSING

Permit Change ☒ New Permit ☐ Renewal ☐ Exploration ☐ Bond Release ☐ Transfer ☐

Permittee: PacifiCorp

Mine: Wilberg/Cottonwood, Deer Creek, Des Bee Dove, & Trail Mtn Mines **Permit Number:** C/015/0019, etc.

Title: Amendment to Volume 9, Appendix A to Reduce the Hydrologic Monitoring Program for Sites Within and Outside Mine Permit Boundaries, PacifiCorp, Wilberg/Cottonwood Mine C/015/0019, Deer Creek Mine C/015/0018, and Trail Mountain Mine C/015/0009, Task ID #4381, Emery County, Utah.

Description, Include reason for application and timing required to implement:

Instructions: If you answer yes to any of the first eight (gray) questions, this application may require Public Notice publication.

☐ Yes ☒ No 1. Change in the size of the Permit Area? Acres: _____ ☐ increase ☐ decrease.
☐ Yes ☒ No 2. Is the application submitted as a result of a Division Order? DO# _____
☐ Yes ☒ No 3. Does the application include operations outside a previously identified Cumulative Hydrologic Impact Area?
☐ Yes ☒ No 4. Does the application include operations in hydrologic basins other than as currently approved?
☐ Yes ☒ No 5. Does the application result from cancellation, reduction or increase of insurance or reclamation bond?
☐ Yes ☒ No 6. Does the application require or include public notice publication?
☐ Yes ☒ No 7. Does the application require or include ownership, control, right-of-entry, or compliance information?
☐ Yes ☒ No 8. Is proposed activity within 100 feet of a public road or cemetery or 300 feet of an occupied dwelling?
☐ Yes ☒ No 9. Is the application submitted as a result of a Violation? NOV # _____
☐ Yes ☒ No 10. Is the application submitted as a result of other laws or regulations or policies?
Explain: _____
☐ Yes ☒ No 11. Does the application affect the surface landowner or change the post mining land use?
☐ Yes ☒ No 12. Does the application require or include underground design or mine sequence and timing? (Modification of R2P2)
☐ Yes ☒ No 13. Does the application require or include collection and reporting of any baseline information?
☐ Yes ☒ No 14. Could the application have any effect on wildlife or vegetation outside the current disturbed area?
☐ Yes ☒ No 15. Does the application require or include soil removal, storage or placement?
☐ Yes ☒ No 16. Does the application require or include vegetation monitoring, removal or revegetation activities?
☐ Yes ☒ No 17. Does the application require or include construction, modification, or removal of surface facilities?
☒ Yes ☐ No 18. Does the application require or include water monitoring, sediment or drainage control measures?
☐ Yes ☒ No 19. Does the application require or include certified designs, maps or calculation?
☒ Yes ☐ No 20. Does the application require or include subsidence control or monitoring?
☒ Yes ☐ No 21. Have reclamation costs for bonding been provided?
☐ Yes ☒ No 22. Does the application involve a perennial stream, a stream buffer zone or discharges to a stream?
☐ Yes ☒ No 23. Does the application affect permits issued by other agencies or permits issued to other entities?

Please attach four (4) review copies of the application. If the mine is on or adjacent to Forest Service land please submit five (5) copies, thank you. (These numbers include a copy for the Price Field Office)

I hereby certify that I am a responsible official of the applicant and that the information contained in this application is true and correct to the best of my information and belief in all respects with the laws of Utah in reference to commitments, undertakings, and obligations, herein.

Kenneth Fleck — Print Name
Kenneth S. Fleck — Manager of Environmental Affairs — 10/28/2013
Sign Name, Position, Date

Subscribed and sworn to before me this 28th day of October, 2013

Brookelle Langi
Notary Public

My commission Expires: February 4, 2017

Attest: State of Utah } ss:
County of Emery }

NOTARY PUBLIC
BROOKELLE LANGI
Commission No. 663339
Commission Expires
FEBRUARY 4, 2017
STATE OF UTAH

For Office Use Only:	Assigned Tracking Number:	Received by Oil, Gas & Mining

Form DOGM- C1 (Revised March 12, 2002)

APPLICATION FOR COAL PERMIT PROCESSING
Detailed Schedule Of Changes to the Mining And Reclamation Plan

Permittee: PacifiCorp
Mine: Wilberg/Cottonwood, Deer Creek, Des Bee Dove, & Trail Mtn Mines **Permit Number:** C/019/0019, etc.
Title: Amendment to Volume 9, Appendix A to Reduce the Hydrologic Monitoring Program for Sites Within and Outside Mine Permit Boundaries, PacifiCorp, Wilberg/Cottonwood Mine C/015/0019, Deer Creek Mine C/015/0018, and Trail Mountain Mine C/015/0009, Task ID #4381, Emery County, Utah.

Provide a detailed listing of all changes to the Mining and Reclamation Plan, which is required as a result of this proposed permit application. Individually list all maps and drawings that are added, replaced, or removed from the plan. Include changes to the table of contents, section of the plan, or other information as needed to specifically locate, identify and revise the existing Mining and Reclamation Plan. Include page, section and drawing number as part of the description.

			DESCRIPTION OF MAP, TEXT, OR MATERIAL TO BE CHANGED
☐ Add	☒ Replace	☐ Remove	Volume 9, Appendix A, Replace entire appendix.
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Any other specific or special instruction required for insertion of this proposal into the Mining and Reclamation Plan.

Received by Oil, Gas & Mining

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DIV. OF OIL, GAS & MINING

OPB = Outside Permit Boundaries
CCC = Cottonwood Canyon Creek
DC = Deer Creek
MF = Mill Fork
RC = Rilda Creek
HU = Huntington Creek
MHC = Meetinghouse Creek
GW = Grimes Wash
ST = Straight Canyon
IC = Indian Creek

DOGM Database #	Monitoring Site	Mine	Location (Section)	Location (Twnshp/Rng)	Within Relinquished Area? (Y/N)	Lease #	Relinquishment Date	Date Mined (Blind Canyon)*	Date Mined (Hiawatha)*	Type	Stratigraphic Structure/Water Body Influence	Remarks
33	89-61	DC	5	T17S, R7E	N	U-084923		No Mining	No Mining	Spring	North Horn Form.	developed spring NEWUSSD - Mining to the east of spring
39	Elk Spring	DC	5	T17S, R7E	N	U-084923		No Mining	No Mining	Spring	North Horn Form.	developed spring NEWUSSD - Mining to the east of spring
9	79-10	DC	12	T17S, R6E	N	U-084924		No Mining	No Mining	Spring	North Horn Form.	Sheba being retained and located 1907' N and 1333' E of 79-10
10	79-15	DC	8	T17S, R7E	Y	U-02664	Apr-92	1975 (1st)		Spring	North Horn Form.	No legal right of entry into area
18	79-34	DC	8	T17S, R7E	Y	U-02664	Apr-92	1974 (1st)		Spring	North Horn Form.	No legal right of entry into area
19	79-35	DC	8	T17S, R7E	Y	U-02664	Apr-92	1990 (1st) 1990 (2nd)		Spring	Flagstaff Form.	No legal right of entry into area
16	79-29	DC	18	T17S, R7E	N	U-084923		1991 (1st) 1992 (2nd)		Spring	North Horn Form.	Located far southern end of DC on border of relinquished lease U-084923
20	79-38	DC/CTW	16	T17S, R7E	Y	U-040151	Apr-92	1988-1991	1992 (2nd)	Spring	North Horn Form.	No legal right of entry into area
32	89-60	DC/CTW	16	T17S, R7E	Y	SL-070645/U-02292	Apr-92	1988-1991 (2nd)	1992 (2nd)	Spring	Price River Form.	No legal right of entry into area
60	Ted's Tub	DC	17	T17S, R7E	Y	U-083066	Apr-97	1988 (2nd)	1992 (1st)	Spring	North Horn Form.	No legal right of entry into area
30	82-52	DC	15	T17S, R7E	N	SL-070645/U-02292		1975 (1st)	1982 (1st)	Spring	Price River Form.	Located far southern end of DC - 1st mining only - No future mining planned
14	79-26	CTW	17	T17S, R7E	N	U-083066		No Mine Workings	No Mine Workings	Spring	North Horn Form.	
17	79-32	CTW	19	T17S, R7E	N	U-083066		No Mine	No Mine	Spring	Form.	
12	79-23	DC	15	T17S, R7E	N	U-040151		1974-1975 (1st)	1981-1982 (1st)	Spring	North Horn Form.	Area mined out. No future mining proposed
13	79-24	DC	15	T17S, R7E	N	U-040151		1974-1975 (1st)	1981-1982 (1st)	Spring	Price River Form.	Area mined out. No future mining proposed
38	Burnt Tree	DC	16	T17S, R7E	Y	U-040151	Apr-97	1987 (2nd)	1992 (1st) 1993 (2nd)	Spring	North Horn Form.	No legal right of entry into area
11	79-2	DC/CTW	21	T17S, R7E	N	U-040151		1982-1986 (2nd)	1994 (1st) 1995 (2nd)	Spring	North Horn Form.	Area mined out. No future mining proposed
21	79-40	DC/CTW	21	T17S, R7E	N	U-040151		1982-1986 (2nd)	1994 (1st) 1995 (2nd)	Spring	Price River Form.	Area mined out. No future mining proposed
22	80-41	DC/CTW	21	T17S, R7E	N	U-040151		1982-1986 (2nd)	1994 (1st) 1995 (2nd)	Spring	Price River Form.	Area mined out. No future mining proposed
23	80-43	DC/CTW	20	T17S, R7E	N	U-040151		1982-1986 (2nd)	1994 (1st) 1995 (2nd)	Spring	North Horn Form.	Area mined out. No future mining proposed
24	80-44	DC/CTW	21	T17S, R7E	N	U-040151		1982-1986 (2nd)	1995 (1st) 1996 (2nd)	Spring	Price River Form.	Area mined out. No future mining proposed
20	79-28	DC/CTW	20	T17S, R7E	N	U-083066			1978 (1st) 1993 (1st)	Spring	North Horn Form.	Area mined out. No future mining proposed
25	80.46	DC/CTW	21	T17S, R7E	N	U-040151			1980 (1st) 1983 (2nd)	Spring	North Horn Form.	Area mined out. No future mining proposed
26	80-47	DC/CTW	21	T17S, R7E	N	U-040151			1977 (1st)	Spring	North Horn Form.	Area mined out. No future mining proposed
29	82-51	DBD	26	T17S, R7E	N	U-02664	Dec-06	1980 (1st)		Spring	Price River Form.	DBD Mine reclaimed
31	84-56	CTW	28	T17S, R7E	Y	U-47978	Apr-92			Spring	North Horn Form.	No legal right of entry into area
1	17-21-1 (T-8)	TM	21	T17S, R6E	OPB	ML-51191				Spring	North Horn Form.	Controlled by Fossil Rock Fuels
2	17-22-1 (T-9)	TM	22	T17S, R6E	OPB	ML-51191				Spring	North Horn Form.	Controlled by Fossil Rock Fuels
5	17-35-1 (T-15)	TM	35	T17S, R6E	Y	UTU-64375	Sep-10		1998 (1st)	Spring	North Horn Form.	No legal right of entry into area
6	17-35-2 (T-16)	TM	35	T17S, R6E	Y	UTU-64375	Sep-10			Spring	North Horn Form.	No legal right of entry into area - No flow data ever recorded
8	18-2-1 (T-6)	TM	2	T18S, R6E	Y	UTU-64375	Sep-10		1996 (1st) 1998 (2nd)	Spring	Upper Price River	No legal right of entry into area
7	18-1-1 (T-18)	TM	11	T18S, R6E	OPB	No Lease Assoc.				Spring	North Horn Form.	Oliphant Mine Discharge
89	T-19	TM	3	T18S, R6E	OPB	No Lease Assoc.				Surface		

REMOVED SITES

PACIFICORP
ENERGY WEST
HYDROLOGIC MONITORING PROGRAM
DEER CREEK, WILBERG/COTTONWOOD, DES-BEE-DOVE, and TRAIL MOUNTAIN MINES

I. MONITORING LOCATIONS

A. Surface Water Hydrology (for maps refer to Deer Creek, Wilberg/Cottonwood, Des-Bee-Dove Mine: Volume 9 Map HM-1, Deer Creek Volume 12 R645-301-700: Hydrologic Monitoring Map MFS1851D Mill Fork Lease for East Mountain locations listed below / Trail Mountain Mine: Volume 3 Plate 7-1 and Plate 7-2 for Trail Mountain locations listed below).

1. Cottonwood Creek Drainage System

a. ***Cottonwood Canyon Creek*** (refer to Deer Creek, Wilberg/Cottonwood, Des-Bee-Dove Mine: Volume 9 Map HM-1 or Trail Mountain Mine Permit Volume 3 Plate 7-1)

(1) SW-1 - Above Trail Mtn. Mine
(Approximately 5000 feet upstream from the inlet culvert for the disturbed area.) 2150 feet South, 2000 feet East of the Northwest corner of Section 24, Township 17 South, Range 6 East.

(2) SW-2 - Below Trail Mtn. Mine
(Approximately 200 feet downstream from the outlet culvert for the disturbed area.) 1300 feet South, 1750 feet West of the Northeast corner of Section 25, Township 17 South, Range 6 East.

(3) CCC01 - USGS Flume:
(Approximately 7800 feet downstream from the outlet culvert for the disturbed area.)1500 feet North, 200 feet East of the Southwest corner of Section 31, Township 17 South, Range 7 East.

(4) SW-3 - Below Trail Mtn. Mine
(Approximately 3800 feet above confluence with Straight Canyon) 2400 feet South, 2400 feet East of the Northeast corner of Section 6, Township 18 South, Range 6 East.

b. ~~***Unnamed Drainage off Straight Canyon*** (refer to Trail Mountain Mine Permit Volume 3 Plate 7-1)~~

~~(1) T-19~~
~~(Approximately 200 feet upstream from the from confluence with Straight Canyon) 2500 feet South, 1100 feet East of the Northeast corner of Section 3, Township 18 South, Range 6 East.~~

c. ***Grimes Wash*** (refer to Deer Creek, Wilberg/Cottonwood, Des-Bee-Dove Mine: Volume 9 Map HM-1)

(1) GWR01 - Right Fork:
(Approximately 1500 feet upstream of the inlet culvert for the disturbed area.) 550 feet North, 1500 feet West of the Southwest corner of Section 22, Township 17 South, Range 7 East.

(2) GWR02 - Left Fork:
(Approximately 50 feet upstream of the inlet culvert for the disturbed area.) 200 feet South, 2350 feet East of the Northwest corner of Section 27, Township 17 South, Range 7 East.

(3) GWR03 - Below the mine:
(Approximately 500 feet downstream of the outlet culvert below the disturbed area.) 1770 feet South, 1820 feet West of the Northeast corner of Section 27, Township 17 South, Range 7 East.

d. ***Indian Creek*** (refer to Deer Creek Volume 12 R645-301-700: Hydrologic Monitoring Map MFS1851D)

(1) ICA - Indian Creek Above
(Approximately 2500 feet northwest of the Mill Fork permit boundary) 400 feet North, 2350 feet West of the

Southwest corner of Section 3, Township 16 South, Range 6 East.

(2) ICF - Indian Creek Flume
(Approximately 2100 feet west of the Mill Fork permit boundary) 300 feet North, 3400 feet West of the Southwest corner of Section 10, Township 16 South, Range 6 East.

(3) ICD - Indian Creek Ditch
(Approximately 1600 feet west of the Mill Fork permit boundary, irrigation ditch for Upper Joes Valley) 240 feet North, 2850 feet West of the Southwest corner of Section 15, Township 16 South, Range 6 East.

(4) ICB - Indian Creek Below
(Approximately 3700 feet west of the Mill Fork permit boundary, junction of Indian Creek and FDR040) 70 feet North, 120 feet West of the Southwest corner of Section 16, Township 16 South, Range 6 East.

2. Huntington Creek Drainage System

a. ***Huntington Creek*** (refer to Deer Creek, Wilberg/Cottonwood, Des-Bee-Dove Mine: Volume 9 Map HM-1)

(1) HCC01 - Above Deer Creek Confluence:
1400 feet north, 2200 feet west of the southeast corner of Section 36, Township 16 South, Range 7 East.

(2) HCC02 - Below Deer Creek Confluence:
300 feet north, 300 feet west of the southwest corner of Section 31, Township 16 South, Range 8 East.

(3) HCC04 - @ Research Farm*
800 feet north, 200 feet east of the southwest corner of Section 5, Township 17 South, Range 8 East.
*Not listed on map due to scale.

b. ***Deer Creek*** (refer to Deer Creek, Wilberg/Cottonwood, Des-Bee-Dove Mine: Volume 9 Map HM-1)

(1) DCR01 - Above the mine:
(Approximately 600 feet upstream from the mine facility.) 200 feet North, 800 feet West of the Southeast corner of Section 10, Township 17 South, Range 7 East.

(2) DCR04 - Near C1/C2 Belt Intersection:
(Approximately 5,000 feet downstream from the mine facility.) 300 feet North, 2000 feet East of the Southeast corner of Section 2, Township 17 South, Range 7 East.

(3) DCR06 - @ Huntington Creek Confluence:
(Approximately 15,000 feet downstream from the facility) 1400 feet north, 1100 feet east of the southeast corner of Section 6, Township 16 South, Range 7 East.

c. ***Meetinghouse Canyon - South Fork*** (refer to Deer Creek, Wilberg/Cottonwood, Des-Bee-Dove Mine: Volume 9 Map HM-1)

(1) MHC01 - Meetinghouse Canyon South Fork
(Approximately 200 feet upstream from the north and south convergence.) 800 feet North, 1500 feet East of the Southwest corner of Section 35, Township 16 South, Range 7 East.

d. ***Rilda Canyon*** (refer to Deer Creek, Wilberg/Cottonwood, Des-Bee-Dove Mine: Volume 9 Map HM-1)

(1) RCF-1 - Rilda Canyon - Right Fork:
(Approximately 4000 feet upstream from the Right and Left fork convergence.) 400 feet South, 200 feet West of the Northeast corner of Section 30, Township 16 South, Range 7 East.

(2) RCLF1 - Rilda Canyon - Left Fork, below Rilda Canyon Portals: (Approximately 200 feet upstream from the Right and Left fork convergence.) 2400 feet North, 2100 feet West of the Southeast corner of Section 29, Township 16 South, Range 7 East.

(3) RCLF2 - Rilda Canyon - Left Fork, above Rilda Canyon Portals: (Approximately 1600 feet upstream from the Right and Left fork convergence.) 1600 feet North, 2300 feet West of the Southwest corner of Section 29, Township 16 South, Range 7 East.

(4) RCF2 - Rilda Canyon - Above NEWUSSD springs: 2500 feet South, 400 feet West of the Northeast corner of Section 29, Township 16 South, Range 7 East.

(5) RCF3 - Rilda Canyon - Below NEWUSSD springs: 2550 feet South, 1000 feet East of the Northeast corner of Section 28, Township 16 South, Range 7 East.

(6) RCW4 - Rilda Canyon: (Approximately 1000 feet upstream from the confluence with Huntington Creek.) 850 feet North, 1900 feet West of the Southeast corner of Section 26, Township 16 South, Range 7 East.

e. ***Mill Fork Canyon*** (refer to Deer Creek Volume 12 R645-301-700: Hydrologic Monitoring Map MFS1851D)

(1) MFA01 - Mill Fork Canyon - Above Old Mine: (Approximately 2000 feet above old mine portals @ end of USFS development road.) 100 feet North, 1500 feet West of the Southeast corner of Section 17, Township 16 South, Range 7 East.

(2) MFB02 - Mill Fork Canyon - Above Huntington Creek Confluence: (Approximately 200 feet above confluence with Huntington Creek @ culvert outfall.) 100 feet South, 1900 feet East of the Northwest corner of Section 22, Township 16 South, Range 7 East.

(3) MFU03 - Mill Fork Canyon - Above Mill Fork Fault Crossing: (Approximately 700 feet upstream of projected Mill Fork Fault crossing) 1150 feet North, 1700 feet East of the Southwest corner of Section 17, Township 16 South, Range 7 East.

3. **Reclamation Monitoring:** Following final reclamation, backfilling and grading monitoring will be conducted at points immediately above and below the reclaimed site.

B. Groundwater Hydrology

1. **East Mountain Springs** (refer to Deer Creek, Wilberg/Cottonwood, Des-Bee-Dove Mine Permit : Volume 9 maps HM-4 and HM-5)

~~Burnt Tree *~~	~~80-41~~
~~Elk Spring [1]*~~	~~80-43~~
Sheba Springs *	~~80-44*~~
~~Ted's Tub~~	~~80-46*~~
~~79-2~~	~~80-47~~
~~79-10 *~~	80-48
~~79-15~~	80-50
~~79-23 *~~	~~82-51~~
~~79-24~~	~~82-52*~~
~~79-26 *~~	~~84-56*~~
~~79-28 (Flag Lake)~~	~~89-60(Alpine Spring)~~
~~79-29 *~~	~~89-61~~ [1]
~~79-32~~	89-65
~~79-34~~	89-66
~~79-35 *~~	89-67
~~79-38~~	89-68
~~79-40~~	Rilda Canyon-(Meters 2&3) [2] [1]

~~* Recession Study Springs (Flow August & September)~~
[1] ~~Developed by NEWUSSD in 2009~~
[2] [1]-NEWUSSD controls Rilda Canyon meters. Monitoring will be conducted when meters are functioning.

2. **Trail Mountain Springs** (refer to Trail Mountain Mine Permit Volume 3 Plate 7-1)

~~T-6~~	T-14
~~T-8~~	~~T-15~~
~~T-9~~	~~T-16~~
T-10	~~T-18 (Oliphant Mine Discharge)~~

3. **East Mountain Springs - Mill Fork Area** (refer to Deer Creek Permit Volume 12 R645-301-700: Hydrologic Monitoring Map MFS1851D)

EM-216
JV-9
JV-34
MF-7
MF-10
MF-19B
MF-213
MF-219
MFR-10
EMPOND
Little Bear Spring
MFR-30
RR-5
RR-15
RR-23A
SP1-26
SP1-29
UJV-101
UJV-206
UJV-213
Grants Spring

4. **Piezometric Data**

a. Surface

(1) Rilda Canyon (refer to Deer Creek, Wilberg/Cottonwood, Des-Bee-Dove Mine: Volume 9 Map HM-1)

P1
P5
P6
P7
EM-47

(2) Cottonwood Canyon Creek

East Mountain (refer to Deer Creek, Wilberg/Cottonwood, Des-Bee-Dove Mine: Volume 9 Map HM-1)

EM-31
CCCW-1A
CCCW-1S
CCCW-2A
CCCW-3A
CCCW-3S U
CCCW-3S L

Trail Mountain (refer to Trail Mountain Mine Permit Volume 3 Plate 7-1)

TM-1B
TM-3

b. Underground: In-Mine

(1) Deer Creek Mine (Refer to Annual Hydrologic Reports for Locations : Map HM-2)

5. In-Mine Water Locations

a. Deer Creek Mine (Refer to Annual Hydrologic Reports for Locations : Map HM-2)

b. Wilberg/Cottonwood Mines (Refer to Annual Hydrologic Reports for Locations : Map HM-3) In temporary cessation, portals sealed.

c. Trail Mountain Mine (Refer to Annual Hydrologic Reports for Locations : PLATE 7-3) In temporary cessation, portals sealed.

6. Waste Rock Wells (refer to Deer Creek, Wilberg/Cottonwood, Des-Bee-Dove Mine: Volume 9, Map HM-1)

a. Deer Creek
b. Cottonwood

C. UPDES Monitoring Locations

a. ***Deer Creek Mine***
UPDES UT0023604
001- Sediment Pond
002- Mine Discharge

b. ***Wilberg/Cottonwood Mines***
UPDES UT0022896
001- Mine Discharge @ Cottonwood Canyon (TMA)
003- Sediment Pond @ Mine Facilities
005- Sediment Pond Discharge @ Waste Rock Site

d. ***Trail Mountain Mine***
UPDES UT0023728
001- Sediment Pond
002- Mine Discharge

II. MONITORING SCHEDULE (see enclosed monitoring schedules for operational, baseline, and reclamation monitoring)

A. Field Measurements

Field Measurements collected during quality sampling: Listed below are the sites which will be monitored by PacifiCorp - Energy West in accordance with the guidelines established by DOGM; i.e.

- Date and Time
- Flow
- pH
- Temperature
- Conductivity
- Dissolved oxygen (perennial streams only)

Surface Monitoring

Surface monitoring locations will be field monitored quarterly for all field parameters, except Indian Creek - monitoring to be conducted during baseflow only.

1. Cottonwood Canyon Creek

a. Cottonwood Canyon Creek

(1) SW-1
(2) SW-2
(3) CCC01 - USGS Flume
(4) SW-3

b. Grimes Wash

(1) GWR01
(2) GWR02
(3) GWR03

c. Indian Creek

(1) ICA
(2) ICF
(3) ICD
(4) ICB

~~d. Straight Canyon~~

~~(1) T-19 (Unnamed Side Drainage)~~

2. Huntington Canyon Drainage

a. Deer Creek

(1) DCR01
(2) DCR04
(3) DCR06

b. Huntington Creek

(1) HCC01
(2) HCC02
(3) HCC04

Flow in Huntington Creek is measured only at HCC01 by Utah Power, and will be reported in the Annual Hydrologic Report.

c. Meetinghouse Canyon - South Fork:

(1) MCH01

d. Rilda Canyon

(1) RCF1*
(2) RCLF 1
(3) RCLF 2
(4) RCF2
(5) RCF3
(6) RCW4

* Baseline flow will be measured adjacent to EM-163

e. Mill Fork Canyon

(1) MFA01
(2) MFB02
(3) MFU03

Groundwater Monitoring

1. East Mountain Springs (see monitoring location list I.B.1)

2. Trail Mountain Springs (see monitoring location list I.B.2)

3. East Mountain Springs - Mill Fork Area (see monitoring location list I.B.3)

   East/Trail Mountain Springs will be field monitored during the months of July and October. ~~In addition, the East Mountain Recession Study Springs (denoted by asterisks in the Monitoring Location section) and Trail Mountain Springs will be field monitored for flow only from July through October. T-18: Oliphant Mine Discharge will be collected and analyzed quarterly.~~ Rilda Canyon Springs - (NEWUSSD: Meters 2 & 3; when functioning) will be field monitored monthly depending upon access.

4. In-Mine

   a. Deer Creek
   b. Wilberg/Cottonwood
   c. Trail Mountain

   In-mine locations will be field monitored quarterly for all field parameters except pH, conductivity, and dissolved oxygen.

5. Piezometric Wells

   a. Surface

      Piezometric surface wells will be field monitored for level only on a monthly basis depending upon access.

      (1) Rilda Canyon (see Map HM-1 for locations)

      P1
      P5
      P6
      P7
      EM-47

(2) Cottonwood Canyon Creek (see Map HM-1 for locations)

EM-31
CCCW-1A
CCCW-1S
CCCW-2A
CCCW-3A
CCCW-3S U
CCCW-3S L
TM-1B
TM-3

6. Waste Rock Wells

a. Deer Creek
b. Cottonwood

UPDES Monitoring

1. Deer Creek
2. Wilberg/Cottonwood
3. Trail Mountain

UPDES sites will be monitored as specified in the individual permits.

Reclamation Monitoring

Surface Water Resources: (see enclosed summary of operational, baseline, and reclamation monitoring schedules)
Surface monitoring locations will be field monitored monthly for flow and all field parameters quarterly until bond release.

Ground Water Resources: (see enclosed summary of operational, baseline, and reclamation monitoring schedules)

Springs — East/Trail Mountain Springs will be field monitored during the months of July and October.

Rilda Canyon Springs (NEWUSSD: Meters 2 & 3; when functioning) will be field monitored monthly for flow depending upon access. East/Trail Mountain Springs (including Rilda

Springs ~~and T-18 [Oliphant Mine~~]) monitoring will be conducted until permit area reduction approval or unless otherwise approved by the Division.

Wells: Piezometric surface wells (Rilda Canyon and Cottonwood Canyon including TM-3 in Straight Canyon): will be field monitored for level only on a monthly basis depending upon access. Piezometric surface well monitoring will be conducted until permit area reduction approval or unless otherwise approved by the Division.

Waste Rock Wells and TM-1B: will be field monitored for level only on a quarterly basis. Monitoring will be conducted until sealing during final reclamation.

UPDES: Sites will be monitored as specified in the individual permits

B. Quality Sampling (Laboratory Measurements)

a. **Surface Water Hydrology:** Water samples will be collected and analyzed quarterly (one sample at low flow and high flow) during the first or second week of the quarter, except for Indian Creek - quality samples will be collected during baseflow only. Parameters analyzed are those listed in the DOGM Guidelines for Surface Water Quality (see Table 1-Surface Water Quality Parameter List). Quarterly sampling was initiated during March 1988 and will continue throughout the year; i.e., June, September, and December. Baseline analysis was performed in 2001 and will be repeated every five years there-after.

a. Cottonwood Creek Drainage

(1) Cottonwood Canyon Creek

(a) SW-1
(b) SW-2
(c) SW-3

(2) Grimes Wash

(a) GWR01
(b) GWR02

(c) GWR03

(3) Indian Creek

(a) ICA
(b) ICD
(c) ICB

~~(4) Straight Canyon~~

~~(a) T-19~~

b. Huntington Creek Drainage

(1) Deer Creek

(a) DCR01
(b) DCR04
(c) DCR06

(2) Huntington Creek

(a) HCC01
(b) HCC02
(c) HCC04

(3) Meetinghouse Canyon - South Fork:

(a) MCH01

(5) Rilda Canyon

(a) RCF1
(b) RCF3
(c) RCW4

(6) Mill Fork Canyon

(a) MFA01
(b) MFB02

(c) MFU03

Reclamation Monitoring - Surface Water Hydrology: Water samples will be collected and analyzed quarterly (one sample at low flow and high flow) during the first or second week of the quarter. Parameters analyzed are those listed in the DOGM Guidelines for Surface Water Quality (see Table 1-Surface Water Quality Parameter List). Sampling will be conducted on a quarterly basis until bond release. Baseline analysis will be performed on the 5th and 9th years following reclamation. In no case will baseline sampling time frame exceed 5 years converting from operational to reclamation monitoring.

2. Groundwater Hydrology

a. East/Trail Mountain Springs: Water samples will be collected and analyzed during the months of July and October. Rilda Canyon Springs (NEWUSSD: Meters 2 & 3; when functioning) ~~and T-18 (Oliphant Mine Discharge)~~ will be monitored for quarterly for quality. Parameters analyzed are those listed in the DOGM Guidelines for Groundwater Water Quality (see Table 2-Ground Water Quality Parameter List).

b. In-Mine: Two water samples will be collected and analyzed per mine quarterly. Parameters analyzed are those listed in the DOGM Guidelines for Groundwater Water Quality (see Table 2-Ground Water Quality Parameter List).

c. Wells: TM-1B will be sampled quarterly. Parameters analyzed are those listed in the DOGM Guidelines for Groundwater Water Quality (see Table 2-Ground Water Quality Parameter List).

d. Waste Rock Wells: One water sample will be collected and analyzed per location quarterly. Parameters analyzed are those listed in the DOGM Guidelines for Groundwater Water Quality (see Table 2-Ground Water Quality Parameter List)

Baseline analysis was performed in 2001 and will be repeated every five years thereafter.

Reclamation Monitoring - Groundwater Hydrology:

a. East/Trail Mountain Springs: Water samples will be collected and analyzed during the months of July and October. Rilda Canyon Springs

(NEWUSSD: Meters 2 & 3; when functioning) will be monitored quarterly for quality. Parameters analyzed are those listed in the DOGM Guidelines for Groundwater Water Quality (see Table 2-Ground Water Quality Parameter List). East/Trail Mountain Springs (including Rilda Springs ~~and T-18 [Oliphant Mine Discharge]~~) monitoring will be conducted until permit area reduction approval or unless otherwise approved by the Division.

b. In-Mine: Two water samples will be collected and analyzed per mine quarterly until the mine is sealed or the sites become inaccessible. Parameters analyzed are those listed in the DOGM Guidelines for Groundwater Water Quality (see Table 2-Ground Water Quality Parameter List).

c. Wells: Well TM-1B will be sealed during final reclamation. Quarterly sampling will continue until sealing. Parameters analyzed are those listed in the DOGM Guidelines for Groundwater Water Quality (see Table 2-Ground Water Quality Parameter List).

d. Waste Rock Wells: Waste rock wells will be sealed during final reclamation. One water sample will be collected and analyzed per location quarterly until well sealing. Parameters analyzed are those listed in the DOGM Guidelines for Groundwater Water Quality (see Table 2-Ground Water Quality Parameter List).

e. Post Reclamation Monitoring: PacifiCorp commits to conduct annual surveys to identify new discharge locations within and below sealed portals. If discharge occurs, one water sample will be collected and analyzed per location quarterly. Parameters analyzed are those listed in the DOGM Guidelines for Groundwater Water Quality (see Table 2-Ground Water Quality Parameter List). Baseline analysis will be performed on the 5th and 9th year.

3. UPDES Monitoring Sites

a. Deer Creek Mine
b. Wilberg/Cottonwood Mines
c. Trail Mountain Mine

UPDES sites will be monitored as specified in the individual permits.

III. ANNUAL REPORTS

All data collected regarding the hydrology of East/Trail Mountain will be summarized by the applicant in an annual Hydrologic Monitoring Report. Copies of the report will be submitted to the Utah State Division of Oil, Gas and Mining. In addition, any raw data collected will be submitted to the Utah State Division of Oil, Gas and Mining on a quarterly basis.

DISCUSSION OF THE GEOLOGY AND THE GROUNDWATER HYDROLOGY OF EAST AND TRAIL MOUNTAINS

Introduction

PacifiCorp has conducted extensive research into interrelationships between the surface and groundwater hydrologic systems and the potential impacts associated with underground mining. Analysis has included; seep and spring surveys, drainage surveys, baseline data collection, in-house and consultant hydrologic studies and government and non-government research projects. PacifiCorp initiated hydrologic monitoring related to mines of the East Mountain and Trail Mountain properties, including; Deer Creek, Des-Bee-Dove, and Wilberg/Cottonwood mines in 1977 and Trail Mountain mine in 1993. Monitoring of surface, intercepted, and discharged water conducted by PacifiCorp has been utilized to document quality and quantity characteristics of the hydrologic regime and was not conducted specifically to each coal lease (i.e. Federal/State/Fee).

Research by government and non-government agencies has been extended to evaluate the effects of subsidence due to underground mining operations to the surface and ground water systems. Subsidence of overburden in the Wasatch Plateau has often been cited for disrupting the local ground and surface water resources overlying underground coal mining operations. However, the data presented from these investigations have failed to find a relationship between the quality and quantity of spring discharge and mining operations. Research also includes age dating of groundwater and the presence of active and inactive groundwater systems.

This document presents a brief discussion of the investigations performed as well as their findings. The complete documents for the studies are attached herein (Appendix A: Response of Springs to Longwall Mining, Bureau of Mines, Appendix B: Surface and Groundwater Investigations, Mayo & Assoc.).

PacifiCorp proposes to eliminate spring monitoring on certain springs on both the East Mountain and Trail Mountain mining properties. The majority of the springs proposed for elimination are in areas which PacifiCorp has been approved for relinquishment of the federal coal lease and/or is outside its mining permit boundary. PacifiCorp has gathered quantity and quality data for each of the proposed springs. The flow data is compared to precipitation data as well as the Palmer Hydrologic Drought Index. The PDHI is based on moisture inflow (precipitation), outflow, and storage, and does not take into account the long-term trend.

Justification statements for the springs proposed for elimination have been prepared to; outline the status of the lease where the spring is located, give a brief description of the subsidence (if any), and summarizes the water quality and quantity data. There are 29 springs proposed for elimination. Locations of these springs are in areas where; 1) the area has been mined out and no further mining is planned, 2) the areas are no longer included as part of PacifiCorp's mining permit, or 3) subsidence has been determined substantially complete and the area has been relinquished. This information is included as part of the amendment package submitted to the Division of Oil, Gas, and Mining.

Research Conducted

The U.S. Bureau of Mines (USBM) completed an independent study (1994) of the mining impacts on the hydrology of East Mountain (Document entitled "Response of Springs to Longwall Coal Mining at Deer Creek and Cottonwood Mines, Wasatch Plateau, UT, Information Circular 9405, U.S. Bureau of Mines"). The data in this study was collected by PacifiCorp from springs determined to accurately represent hydrologic conditions on East Mountain. This determination was made by an ad hoc committee including representatives from DOGM and the U.S. Forest Service. This document is cited as support in the environmental assessment for Coal Lease Application UTU-67939, Winter Quarters Tract (July 1995).

The USBM used spring data available from the Deer Creek and Cottonwood mines (most of which are included in this discussion report in support of elimination of monitoring). The expected response of springs to undermining would be dramatic alterations in flow. The lack of observed flow responses, however, was attributed to geologically driven site-specific conditions that buffered the effects of mining. These conditions included the thickness of overburden between the mine level and the springs (1,320 – 1800 feet). Additionally, the presence of hydrophilic clays and mudstones in the overburden, which act as aquatards, retarding the migration of water, likely lessened the vertical extent of strata dewatering. The locations of the springs above the estimated elevations of fracturing and caving in the overburden due to subsidence also contributed to the limited effects. The study failed to find any springs in the study area that were impacted by mining. This report is included in Appendix A.

In 1997, PacifiCorp contracted Mayo & Associates to conduct a comprehensive study of surface water and groundwater systems of East Mountain & Trail Mountain. The hydrology and hydrogeology of the PacifiCorp central Utah coal leases were evaluated by analyzing: 1) solute and isotopic compositions of surface waters and groundwaters, 2) surface water and groundwater discharge data, 3) piezometric data, and 4) geologic information. The result of the East/Trail mountain study combine with research on surrounding coal properties (Mayo & Associates and Brigham Young University) was the development of a comprehensive understanding of the interrelationship between surface and groundwater systems of the Central Utah Coal Field. This report is also included herein in Appendix B. The following is a brief description of a groundwater model that was developed as part of this investigation:

Groundwater Model

The overall pattern of groundwater flow and surface water-groundwater interactions in the East and Trail Mountain areas can be described by a fairly simple conceptual model involving both active and inactive groundwater flow regimes. Active regime groundwater flow systems contain abundant tritium (^{3}H), have excellent hydraulic communication with the surface and thus are dependent on annual recharge events and are affected by short term climatic variability. Groundwater in these systems circulates shallowly and has short flow paths. The active regime includes alluvial groundwater, all of the Flagstaff Limestone, near-surface exposures of all other bedrock formations except, perhaps, the Mancos Shale. The near surface active regime extends about 500 to 1,000 feet into cliff faces and is controlled by fracturing, weathering, and the surface exposures of fluvial

channel sandstones. Further into the cliff faces the discontinuous character of the channel sands prevents active groundwater flow.

Inactive groundwater flow regimes contain old groundwater (i.e. 2,000 to 12,000 years), have very limited hydraulic communication with the surface and with other active groundwater flow systems, and are not influenced by either annual recharge events or short term climatic variability. Groundwater in these systems tends to occur in sandstone channels in the North Horn, Price River, and Blackhawk Formations which are not in direct hydraulic communication with the surface (i.e. greater than about 500 to 1,000 feet from cliff faces). These sandstone channels are vertically and horizontally isolated from each other and when encountered in mine workings are usually drained quickly. The blanket sands of the Star Point Sandstone are also largely in the inactive zone. For the most part, faults encountered in mine workings are part of the inactive regime.

Relinquishment

In years 1992, 1995, 1997, 2006, and 2009, PacifiCorp has submitted acreage relinquishment applications to the Bureau of Land Management (BLM) for various federal leases that are directly leased or sublease by PacifiCorp. Applications have sought to relinquish federal lease acreage which has either been (1) mined out, (2) considered sub-economic (unmineable) due to limited mining access because of inherent faulting and adverse geologic conditions, and/or (3) the remaining unmined areas are burned, and no recoverable reserves remain. Applications for relinquishment have been sought for acreage in both the East and Trail Mountain Logical Mining Units (LMU).

These applications have been reviewed by the BLM, with regulatory input from the Manti LaSal National Forest (USFS) and the Utah Division of Oil, Gas, and Mining (DOGM). PacifiCorp participated with a governmental agency task force which included representatives from BLM, USFS, and DOGM to develop a "Memorandum of Understanding for Processing of Requests to Relinquish Federal Coal Leases (10-MOU-97-001). This document establishes "Standards for Relinquishment Consideration" including the amount of accepted variation in annual subsidence data (refer to Appendix C). As stated in the MOU, the area will be considered stable, if the cumulative subsidence during the pre-relinquishment period (3 years) has been 1 foot or less under normal circumstances. PacifiCorp's experience on East and Trail Mountain has shown that the areas of minimum detectable subsidence, i.e. one foot or more, very rarely extend outside of the outline of the total mine workings, even in areas where more than one seam has been mined.

Field inspections and helicopter surveys conducted annually have not identified any visible evidence of subsidence within the relinquishment areas. In addition to the surveys, PacifiCorp hosted field reviews with regulatory agencies; including BLM, USFS, and DOGM. During the field reviews, PacifiCorp discussed both the East and Trail Mountain subsidence monitoring program and inspected the ground surface for evidence for subsidence. Based on the meetings and supporting data, subsidence was substantially complete, and the areas proposed for lease relinquishment were declared stable.

Hydrology

Since 1979 detailed data on the hydrology of the East Mountain and Trail Mountain areas have been collected, compiled, and analyzed by PacifiCorp and several government agencies. Information collected by PacifiCorp is the result of exploratory drilling, field investigations, geologic mapping, aerial photography, spring surveys, groundwater tests, monitoring of numerous wells and stream stations, climatological monitoring, and investigations by independent consultants. The data collection program is part of a complete Hydrologic Monitoring Program which has been approved by the State of Utah, Division of Oil, Gas and Mining (DOGM) and the Office of Surface Mining (OSM). All data collected have been and will continue to be submitted to OSM, DOGM, United States Forest Service (USFS), and the Bureau of Land Management (BLM) each year in the annual Hydrologic Monitoring reports submitted by PacifiCorp.

Hydrologic monitoring plan for the East Mountain and Trail Mountain mine properties is specified in Volume 9 Hydrologic Section: Appendix A in the approved Mining and Reclamation Plan (MRP).

As outlined by the BLM, the interested parties have agreed that under normal circumstances, the minimum time period for continued monitoring after cessation of mining activities will be three years. During this time period the operator/lessee will establish that the surface has substantially stabilized according to Appendix "A".

The following sections will describe and provide detail concerning the groundwater and surface water resources within and adjacent to the East Mountain and Trail Mountain mine properties.

Groundwater

Groundwater resources of the East and Trail Mountain mines are limited and are controlled by the terrain, slope aspect and geologic structures. Terrain of these properties range from flat to narrow ridge tops with gentle slopes in the upland part of the area to very steep side slope conditions along the areas borders. The topography and slope aspect limit the amount of recharge to these areas.

Strata in the East and Trail Mountain properties are gently down-folded in the area of the Straight Canyon Syncline which is present in the central portion of East Mountain and northeast of the northern boundary of Trail Mountain permit. The bearing of the Straight Canyon Syncline is approximately N30°E and the structure plunges to the southwest. Dips in the syncline range from two to six degrees with the north limb dipping the steepest.

In the area south of the Straight Canyon Syncline the coal seam dips gently in a northwest direction toward the syncline; however, to the northwest of the Straight Canyon Syncline the Hiawatha seam dips in a southeast direction at three to five degrees.

The strata within the East Mountain property have been offset by a series of north-south trending normal fault zones. Generally, the faults are nearly vertical and do not have significant amounts of fault

gouge or drag associated with them. One of the major faults present in the region, the Pleasant Valley Fault, has been intersected in both the Deer Creek and Wilberg mines.

The Pleasant Valley Fault consists of two parallel fractures about 150 feet apart. The fault's total displacement (where it was intersected in the Deer Creek Mine) to the north is 150 feet with its downthrown side on the east. The displacement diminishes to less than one foot where it was intersected in the Wilberg Mine near the south end of the East Mountain property.

Another north-south trending fault, the Deer Creek Fault, is present to the east of the Pleasant Valley Fault. It limits the eastward development of the Wilberg/Cottonwood and Deer Creek mines. The displacement of the Deer Creek Fault ranges from 100 to 170 feet with the east block being downthrown.

A northeast-southwest trending fault system, the Roans Canyon Graben, is present along the axis of the Straight Canyon Syncline. In the central portion of East Mountain the fault system contains up to six normal faults having displacements ranging from a few feet to over 150 feet. Coal deposits present to the north of the fault have been accessed through rock tunnels driven from the 3rd North section of the Deer Creek Mine.

The rock formations exposed in the East and Trail Mountain area range from Upper Cretaceous to Tertiary in age (see Figure HF-2, Volume 9, Hydrologic Volume). The formations, in ascending order, are the Masuk Shale member of the Mancos Shale, Star Point Sandstone, Blackhawk, Castlegate Sandstone Sandstone, Upper Price River, North Horn, and Flagstaff Limestone. The coal deposits are restricted to the lower portion of the Blackhawk Formation.

The Masuk Shale is the upper member of the Mancos Shale and consists of light to medium gray marine mudstones. Usually this formation weathers readily, forming slopes which are often covered by debris. It is generally devoid of water.

Overlying and intertonguing with the Masuk Shale is the Star Point Sandstone. In the East Mountain area the Star Point consists of three or more cliff-forming massive sandstones totaling about 400 feet in thickness. Generally, the sandstones are fine to medium-grained and moderately well-sorted. The upper contact of the Star Point Sandstone is usually quite abrupt and readily identifiable on the outcrop. Even though the Star Point Formation exists throughout the entire East and Trail Mountain properties, the low permeability and lack of recharge limit its usefulness as a water producing aquifer. Permeability are the limiting factors of recharge, i.e., very little outcrop exposure and limited vertical groundwater migration caused by the mudstone layers of the North Horn and Blackhawk formations. Locally, the Star Point Sandstone exhibits aquifer characteristics.

The Blackhawk Formation consists of alternating mudstones, siltstones, sandstones, and coal. Although coal is generally found throughout the Blackhawk Formation, the economic seams are restricted to the lower 150 feet of the formation. The sandstones contained within the Blackhawk Formation are fluvial and increase in number in the upper portions of the formation. Many of the tabular sandstone channels

form local perched water tables. The total thickness of the Blackhawk Formation in the mining areas is about 750 feet.

The Castlegate Sandstone, the lower member of the Price River Formation, generally caps the escarpment which surrounds the eastern limits of the East and Trail Mountain properties. The Castlegate Sandstone consists of about 250 feet of coarse-grained, light gray, fluvial sandstones; pebble conglomerates; and subordinate zones of mudstones.

The Upper Price River Formation, which overlies the Castlegate Sandstone, is about 350 feet thick and forms slopes which extend upward from the Castlegate Sandstone escarpment. Although some mudstones are present, fine-grained, poorly sorted sandstones dominate the Upper Price River Formation.

The North Horn Formation is about 850 to 900 feet thick in the regional area. Mudstones dominate the rock types present and are generally gray to light brown in color. Localized, lenticular sandstone channels are present throughout the formation. The sandstone beds are more common near the upper and lower contacts of the formation.

The Flagstaff Formation is the youngest formation and only exposed in East Mountain area. The formation consists of white to light gray lacustrine limestone. An erosional remnant of 100 to 150 feet of this formation remains, forming a cap on the highest plateaus.

Waters entering the groundwater system are mostly from snow melt. The amount of water which enters the groundwater system is highly variable from one site to another. The low surface relief on the tops of East and Trail mountains encourage the infiltration of melting snow. Conversely, the many areas with steep slopes have a much more limited infiltration opportunity. All of the geologic formations which surface in the area have relatively low permeability which further reduces the amount of water entering the groundwater system. Probably less than five percent of the annual precipitation recharges the groundwater supply (Price and Arnow, 1974; U. S. Geological Survey, 1979 – PacifiCorp has referenced this report in Volume 9 Hydrologic Volume and has transmitted a copy of this report to the Division for reference).

Geology controls the movement of groundwater. Because of the low permeability of the consolidated sedimentary rocks in the East Mountain and Trail Mountain areas, groundwater movement is primarily "through fractures, through openings between beds, and, in the case of the Flagstaff Limestone, through solution openings" (Danielson et.al., 1981, p. 25 - PacifiCorp has referenced this report in Volume 9 Hydrologic Volume and has transmitted a copy of this report to the Division for reference).

The majority of the groundwater which infiltrates the Flagstaff Limestone flows down vertical fractures which intersect sandstone channel systems in the North Horn Formation. The majority of the groundwater reaching this point intersects the surface in springs located in the North Horn Formation. Very little recharge intersects the Price River Formation and Castlegate Sandstone; consequently, they are not water saturated where intersected in the numerous drill holes penetrating those units. The

remaining water then flows downdip (to the southwest) from the northern reaches of East and Trail mountains until it intersects the trace of the northeast trending Roans Canyon Fault Graben. The system acts as an aquiclude because swelling bentonitic clays along the fault prohibit most of the water from penetrating across the fault. Most of the recharge south of the Roans Canyon Fault System comes from the snow melt directly above. The same mode of water migration occurs there as to the north; but, when the water intersects the sandstone channels, it migrates toward the canyons which surround and dissects the mining properties.

Data have been collected from numerous coal exploration drill holes, from within the mine workings, from surface drainages, and from the springs in the area. The data have identified two separate isolated aquifer systems on the East and Trail Mountain properties; the first is localized perched water tables in the North Horn Formation, and the second is a combination of localized perched water tables in the Blackhawk Formation and the Star Point Sandstone which exhibits some limited potential as a regional aquifer. Stratigraphy is the main controlling factor restricting groundwater movement and development of regional and perched aquifer systems within the area of the mining properties. The following is a description of the various formations and how they influence the groundwater systems. The description is in descending order, which parallels the general groundwater flow.

Stratigraphy Description in Detail

Flagstaff Limestone

This formation displays a strong joint pattern which permits good groundwater movement both vertically and horizontally through the formation.

North Horn Formation

This formation is comprised of a variety of rock types which range from highly calcareous sandstone to mudstone. Its permeability is variable.

Lenticular sandstone channels are oftentimes present in the upper and lower portions of the formation. Water which percolates down fractures from the overlying Flagstaff Limestone works its way into the sandstones, forming the perched water tables. The actual lateral extent, or correlation, between the perched water tables has not been identified; and it is not practical to do so because the tables are limited in extent and variable in stratigraphic location. Many springs have been identified where the sandstone channels intersect the land surface.

The lower two-thirds (upper Cretaceous in age) of the formation is generally highly bentonitic mudstone which is impermeable. It is likely that this material is acting as an aquiclude, preventing adequate recharge from reaching the Upper Price River Formation or Castlegate Sandstone below. The mudstones present swell when they come in contact with water. Therefore, vertical migration of water along fractures through this material is limited because the fractures are sealed by the swelling clays.

The depth of the aquifers in the North Horn Formation is variable due to the rugged topography. The localized perched water tables may either intersect the surface of the ground or be covered by as much as 1,000 feet of overburden. They are located at least 1,400 feet above the coal seam to be mined. Communication of water between the perched aquifers in the North Horn Formation and the water flowing into the mine is limited in quantity and occurs very slowly. The monitoring of the numerous springs located on Trail Mountain gives PacifiCorp the ability to assess any effects that mining might have on the North Horn Formation perched aquifers.

With the data available it is not possible to compile a piezometric map of the water-bearing strata in the North Horn Formation because the channels are discontinuous and not interconnected.

Upper Price River Formation

The Upper Price River Formation is comprised predominantly of sandstone but commonly contains mudstone beds between the point bar deposits. It is generally void of water because it lacks adequate recharge.

Castlegate Sandstone

The formation is thought to be fairly permeable but, where it has been intersected by drill holes, has never been found to be water-saturated. It is oftentimes dry or slightly damp in some zones. It is void of significant water because it lacks adequate recharge.

Blackhawk Formation

The Blackhawk Formation contains only perched or limited aquifers which exist within the strata overlying the coal seams and the upper portion of the Star Point Sandstone Formation. The perched aquifers exist as fluvial channels (ancient river systems) which overlie and scour into the underlying strata. These channel systems were part of a deltaic depositional setting active during and after the coal-forming peat accumulation. The largest influx of water encountered during the mining process occurs beneath the fluvial channels. The sandstone channels are mainly composed of a fine-to medium-grained sand with similar characteristics to the Star Point Sandstone Formation. The semi-permeable and porous nature of the channels allows an effective route for water transport. Other constituents of the Blackhawk Formation (i.e., mudstone, carbonaceous mudstone, coal seams, and interbedded mudstones/siltstone and sandstones) generally act as aquicludes which impede vertical groundwater flow to the lower stratigraphic units. In areas other than where faulting and fracturing have created secondary permeability, the migration of water from the perched aquifers-sandstone channel systems of the Blackhawk Formation to the Star Point Sandstone Formation is limited. Extensive mining in the Trail Mountain mine, which produces coal from the Hiawatha seam, is stratigraphically located on top of the upper member of the Star Point Formation Sandstone. Only minor quantities of groundwater have been produced from the Star Point Sandstone Formation. The

coal seams of the Blackhawk Formation are effective in impeding vertical groundwater movement. In many areas in the mine where roof coal was left in place because of abundant thickness or as an additional effort to support the immediate roof, production of groundwater occurred only when roof support was installed or when a roof failure occurred exposing the overlying sandstone channel systems. The table below lists the hydrologic characteristics of individual rock types reported by the USGS, Open File 84-067.

Lithology: Sh, shale; Slt, siltstone; Ss, sandstone; f, fine grained; m, medium grained. Hydraulic conductivity: I, impermeable to water even at a pressure of 5,000 psi.

Geologic Unit	Lithology	Depth below the land surface (ft)	Porosity (%)	Hydraulic Conductivity (feet per day)	
				Horizontal	Vertical
Blackhawk Formation	Ss, f	1,521	14	$1.5x10^{-2}$	$3.7x10^{-3}$
	Slt	1,545	3	$9.3x10^{-8}$	$1.2x10^{-7}$
	Sh	1,786	2	I	I
	Ss, f	1,792	14	$1.1x10^{-2}$	$3.9x10^{-3}$
	Sh	2,170	4	$1.1x10^{-8}$	
	Slt	2,265	2	$2.0x10^{-7}$	$2.2x10^{-6}$
Star Point Sandstone	Ss, m	2,466	17	$3.1x10^{-2}$	$1.1x10^{-2}$
	Ss, m	2,493	11	$1.5x10^{-2}$	$6.6x10^{-3}$

The majority of the water flowing into the mines comes from within the limited fluvial channel aquifers; however, water is also transmitted into the mine workings by way of faults, joints or fractures, and in-mine drill holes (see Figure HF - 4, Volume 9 Hydrologic Volume). The Des-Bee-Dove permit area is an exception. The Deer Creek Fault, which separates Deer Creek and Wilberg/Cottonwood mines from Des-Bee-Dove, forms an aquiclude to the water migration to the east. Since 1978 the water flowing into the mine workings has been measured. The measurement locations in the Deer Creek Mine are shown on Map HM-2, Volume 9 Hydrologic Volume, in the Wilberg/Cottonwood Mine on HM-3, Volume 9 Hydrologic Volume. Many locations within the mines have been monitored in the past, but a limited number of accessible long-term water monitoring locations now exists because most water-producing areas of the mines are dewatered and stop flowing shortly after initial mining in the area.

In several locations in the Deer Creek and Wilberg/Cottonwood mines, such as retreated longwall panels, water is being produced but cannot be measured because the workings are inaccessible. The water entering these areas flows into numerous low areas in the mine which

act as temporary sumps. The water is then pumped to the main sump located near the mine portal. Because the pumping system in the mine is ever changing (i.e., portable pumps being moved to various locations within the mine as the need arises), it is not possible to collect meaningful data from specific areas of the mine that can be compared with data collected from years or even months past.

The most accurate measurement of water flowing into the mine workings is achieved by measuring the total water leaving the mine, which is done and reported annually in the Hydrologic Monitoring Report. The total amount of water leaving the mine includes metered discharge water as well as estimated water which evaporates from the mine workings.

Based on current data, several observations have been made concerning the Blackhawk water-bearing strata. The sandstone, which is semi-permeable and porous, affords an effective route of water transport; while relatively impervious shale in the Blackhawk Formation prevents significant downward movement of the percolating water. Of the water-producing areas, those closest to the active mining face exhibit the greatest flows. As mining advances the area adjacent to the active face continues to be excessively wet, and previously mined wet areas experience a decrease in flow. It appears that the water source is being dewatered since mined out areas of the mine do not continue to produce water indefinitely. The water source must be either of limited extent, e.g., a perched aquifer, or have a limited recharge capacity.

Star Point Sandstone

The Star Point Sandstone Formation overlies and intertongues with the Masuk Shale. The formation is approximately 150 to 200 feet in thickness and consists of at least three upward coarsening sandstone units. Mudstone units of the Masuk Shale are present above the lower two sandstone members of the Star Point Sandstone Formation due to the intertonguing nature of the contact between the two units.

The Star Point Sandstone Formation, which immediately underlies the Hiawatha Coal Seam, exhibits some characteristics of an aquifer but experiences little recharge. Studies conducted by the USGS indicate that the Star Point Sandstone Formation is of low permeability, thus limiting its usefulness as a water-producing aquifer. Most of the water discharge from the Star Point Formation is where it has been intersected by the major canyons in the plateau or where faulting has caused secondary permeability. Drill holes completed in the Deer Creek and Wilberg/Cottonwood mines defined the piezometric gradient in the lower Blackhawk/Star Point Formation System and confirmed the groundwater flow to conform with the topographic relief and structural features, i.e., regional dip, Straight Canyon Syncline, and regional faulting (see Figure HF-5, Volume 9, Hydrologic Volume). This, plus the fact that the Star Point Formation is only slightly to moderately permeable, allows only limited flow of groundwater through the formation.

Water in most of the Blackhawk/Star Point aquifer is confined under pressure between shale and siltstone beds within the aquifer (USGS Lines, Open File Report 84-067). Water is released from storage from confined aquifers mainly by compression of the sandstones and less permeable, confining beds as pressure in the aquifer declines. The quantity of water that can be released from storage is dependent on the storage coefficient, which is about $1x10^{-6}$ per foot of thickness for most confined aquifers (Lohman, 1971, p. 8). Data collected by PacifiCorp on the Roans Canyon Fault System in 1988, 3rd North fault crossing, confirmed the USGS storage coefficient estimations, with values ranging from $1.6x10^{-4}$ to $7.0x10^{-6}$. Transmissivity values computed for pump tests conducted by the USGS on Trail Mountain on non-fully penetrating wells in the Blackhawk/Star Point aquifer ranged from 0.7 to 100 ft^2 /day with a majority of the two results ranging from 1 to 10 ft^2 /day. The computed transmissivity of 100 ft^2 /day was greater than the laboratory data (listed early in this section) and was believed to be due to secondary permeability in the form of fractures. Transmissivity results ranging from 0.7 to 10 ft^2/day are indicative of the low permeability rock in most of the cretaceous and tertiary strata within the Wasatch Plateau.

Groundwater Occurrence

Groundwater naturally discharges, in greatly varying quantities, from most formations exposed in East and Trail Mountains. Approximately 75% of the identified springs issue from the North Horn Formation, which comprises nearly the entire plateau surface of these areas. No springs have been identified which discharge from the Star Point Sandstone or the Mancos Shale.

Within the mines, groundwater issues from short-lived roof drips, the mine floors in some locations in the Trail Mountain, Deer Creek, Cottonwood, and Wilberg mines, and from the mine roof and mine floor after encountering some faults. Confined groundwater occurs in monitoring wells in the Star Point Sandstone that have been installed in the mines and elsewhere. Groundwater discharge is generally not associated with the Mancos Shale.

Springs and Seeps

The most frequent occurrences of springs are those located about 150 to 350 feet below the top of the North Horn Formation (see Figure HF-6, Volume 9, Hydrologic Volume). The drill hole data show a predominance of fluvial siltstone and sandstone at that stratigraphic interval. These sedimentary rocks represent many isolated fluvial systems which are water-bearing. The springs are formed where the fluvial channels intersect the land surface. Because the fluvial channels within this zone are generally not interconnected, the springs are not interrelated but share the same mode of occurrence.

Numerous springs located in the lower portion of the North Horn Formation occur when water flowing through fluvial sandstones which are underlain by a thin zone of impervious mudstone at the base of the North Horn Formation intersect the land surface. The surface drill hole data indicate that impervious mudstone units occur at the upper and lower portion of the North Horn Formation. Even though these individual mudstone layers are discontinuous, the occurrence of this type of strata exists throughout the

East Mountain Property. As part of Volume 9 - Hydrologic Support Information, logs of representative holes from the East Mountain exploration programs are included to document the occurrence of this type of strata (additional drill hole data are located at PacifiCorp's Salt Lake or Huntington offices). The springs related to this mode of occurrence are not generally interrelated because they are fed by waters flowing through isolated fluvial channel sandstones and siltstones.

Several springs are located along the Roans Canyon Fault Graben. Generally, the springs are located within the North Horn Formation along the fault zone. Few springs are located in the area below the base of the North Horn Formation below where the impervious mudstone is located, supporting the fact that water percolating down a fracture or fault is stopped from further downward travel when it reaches the impervious clay zone which forms a seal along the fracture. Many of the largest springs on East Mountain are located along this fault system. Because the fault system is located along the trough of the Straight Canyon Syncline, water from both the north and the south flows toward the fault where it is allowed to migrate to the land surface. The springs located along this fault zone are generally interrelated.

A few springs are located within both the Flagstaff and Price River formations; however, their occurrence is insignificant in comparison to springs located in the North Horn Formation.

Generally springs with discharges exceeding 50 gpm are associated with faulting where permeability has been increased by fracturing. The discharge of the springs varies directly with the amount of precipitation and also varies seasonally. Discharge is greatest during the snow melt period, normally from late April through the month of June. Following periods of groundwater recharge the discharge recedes fairly rapidly at first, then gradually, indicating a double porosity effect. At the end of the water year the remaining discharge is only twenty to thirty percent (20-30%) of the peak discharge. Annual variations and historical comparisons are depicted in the annual Hydrologic Monitoring reports.

Spring Discharge Characteristics

More than 100 spring hydrographs have been created from water monitoring data and analyzed. Approximately 75% of the springs discharge from the North Horn Formation. The remainder discharge from creek bottom alluvial systems, the Flagstaff Limestone, the Price River Formation, the Castlegate Sandstone, and the Blackhawk Formation. No springs have been identified which discharge from the Star Point Sandstone or Mancos Shale.

Groundwater hydrology of East Mountain is a dynamic and complex process. Simply comparing yearly precipitation values to discharge rates does not accurately reflect the complete hydrologic situation. PacifiCorp has been comparing spring discharge rates to yearly precipitation as a simple trend indicator since the inception of the spring monitoring program. However, thorough analysis of yearly spring discharge data must take in account a multitude of hydrologic and climatic factors including;

- slope aspect of the recharge area (south facing versus north facing slope),
- type of vegetative cover,

- timing, type, and areal distribution of precipitation (snow or rain),
- timing of data collection versus precipitation,
- geologic occurrence of the spring (whether joint/fracture/fault controlled, outcrop of near surface fluvial sandstone channel systems or down gradient drainage flow systems),
- change in head differential, migration of source or source measuring point
- alteration of the recharge area: example - timbering practices, fires
- change/disruption of the discharge area: examples – grazing, wildlife, attempts to replace or enhance the discharge location and piping structures.

PacifiCorp recognized this dynamic hydrogeologic system and designed the groundwater/spring monitoring program based on the following criteria:

- ❖ Stratigraphic position (geologic formations ranging from the Flagstaff Limestone to the coal bearing Blackhawk Formation, structural control aspects – faulting)
- ❖ Area of potential influence from subsidence (springs monitored within and outside the area of potential impact)
- ❖ Representative areal distribution of springs (takes into account the variable aspect of precipitation)
- ❖ Established water rights
- ❖ Measurable flow based on historical surveys
- ❖ Reliable measuring point(s)

In addition to the site selection process, PacifiCorp established the spring monitoring program sampling schedule (July – peak flow and October – base flow) to conform to normal early and late season access to the mountainous terrain allowing for a consistent yearly comparison. However, during periods of below normal precipitation, especially prolonged periods of drought, timing of data collection can skew or miss the peak flow volumes. This is particularly evident in the southern portions of the East Mountain and Trail Mountain. Each of the variables listed above is taken into account to assess potential interruptions to the groundwater systems by underground mining.

Over the last thirty years, Central Utah has experienced extreme climatic cycles, including an unprecedented record setting wet cycle in the late seventies and early eighties followed by several prolonged drought cycles. Development of PacifiCorp's spring monitoring program coincided with the record setting wet period elevating recharge and discharge rates to levels not achieved since this period. Monitoring data reveals that the unprecedented record setting wet cycle resulted in elevated flows for several years after even though the hydrologic cycle was returning to a normal pattern. However, instead of returning to a long term normal cyclic pattern, the intermountain west experienced several periods prolonged extreme drought. Episodic cycles of normal precipitation following these periods of extreme drought have ultimately affected the recharge and discharge of the near surface shallow spring systems. This is evident in reviewing similar declining discharge recession curves of springs that are outside the influence of mining. Surface runoff data

from drainages of East and Trial mountains confirms the trends of the groundwater system monitoring.

Summary

PacifiCorp proposes to eliminate spring monitoring on certain springs on both the East Mountain and Trail Mountain mining properties. Many of these springs have been monitored as early as 1977 for both quantity and quality of the spring's discharge. PacifiCorp instituted a Hydrologic Monitoring Program in 1979 which has been approved by the State of Utah, Division of Oil, Gas and Mining (DOGM) and the Office of Surface Mining (OSM). All data collected have been and will continue to be submitted to OSM, DOGM, United States Forest Service (USFS), and the Bureau of Land Management (BLM) each year in the annual Hydrologic Monitoring reports.

In-house research has been conducted on the collected data to analyze the interrelationships between the surface and groundwater hydrologic systems and the potential impacts associated with underground mining. Analysis has included; seep and spring surveys, drainage surveys, baseline data collection, and other hydrologic studies.

The Bureau of Mines conducted a study looking at mining induced subsidence and its potential disruption to the hydrologic systems of the Wasatch Plateau. The study hypothesized that springs are expected to show a greater response to underground mining where they are located over panels than those located over mains or barrier pillars since overburden deformation occurs over longwall panels as the roof caves and fractures form in the overburden. The springs in this study did not show a dramatic decrease in flow as was expected.

The study concluded that the limited response observed for the springs was thought to be influenced by site-specific conditions that buffered the effects of mining. These conditions include the thick overburden present and the presence of formations in the overburden that contain hydrophilic clays and mudstones. These clays were described to act as aquatards retarding the migration of water, lessening the vertical extent of strata dewatering.

This discussion also has included a presentation of the geology the East and Trail Mountain mining properties and its association to the surface and ground water systems. It has been shown that geology controls the movement of groundwater. Waters entering the groundwater system occur mostly from snow melt. The amount of water which enters the groundwater system, however, is highly variable because the terrain and slope aspect of the area is highly variable. On steeper and/or south facing slopes, water has less chance to infiltrate into the groundwater system.

Stratigraphy has been noted as the main controlling factor restricting groundwater movement. All of the geologic formations which surface in the area have a relatively low permeability which further reduces the amount of water entering the groundwater system. Data collected from holes drilled through the strata have identified two separate isolated aquifer systems on the East and Trail Mountain

properties; the first is localized perched water tables in the North Horn Formation, and the second is a combination of localized perched water tables in the Blackhawk Formation and the Star Point Sandstone which exhibits some limited potential as a regional aquifer. These systems have been identified as part of Mayo & Associates "Investigation of Surface-Water and Groundwater Systems in the PacifiCorp Lease Area, East and Trail Mountains", as active and inactive groundwater systems.

Active groundwater flow systems have excellent hydraulic communication with the surface and thus are dependent on annual recharge events and are affected by short term climatic variability. Inactive groundwater flow regimes contain old groundwater (i.e. 2,000 to 12,000 years), have very limited hydraulic communication with the surface and with other active groundwater flow systems, and are not influenced by either annual recharge events or short term climatic variability.

Finally, justification statements have been prepared by PacifiCorp to justify the elimination of certain spring monitoring responsibilities by the company. As quality and quantity parameters have been monitored, there has been no data collected that shows any diminution or impacts to the quality of the surface or groundwater systems associated to PacifiCorp's mining operations within the East and Trail Mountain mining properties.

Flow data for springs has been presented comparing July's peak flow to the collected precipitation data from PacifiCorp's East Mountain weather station as well as the Palmer Hydrologic Drought Index. The data shows a very prominent correlation and trends suggest that spring flow is most likely regulated by climate rather than being impacted by underground mining operations. There has been no evidence in the 33 years of monitoring by PacifiCorp and others that suggest underground mining operations have impacted any spring discharges within the East or Trail Mountain mining areas.

This discussion report concludes that for all the investigations, research, analysis of the data, and information collected of the geologic and hydrologic systems within the East and Trail Mountain mining properties, there has not been any relationship found between the quality and quantity of spring discharge and PacifiCorp's underground mining operations.

Location: Section 5, Township 17 South, Range 7 East, SLB&M. These sites are located within the Deer Creek Mine permit along the Roans Canyon Fault Graben. The two springs approximately 600 feet apart on the southern side of the graben.

Lease Association: This site is associated with federal coal lease U-084923. The lease (subleased by M. McKinnon) was assigned to Utah Power & Light Co. from the Peabody Coal Company in 1979.

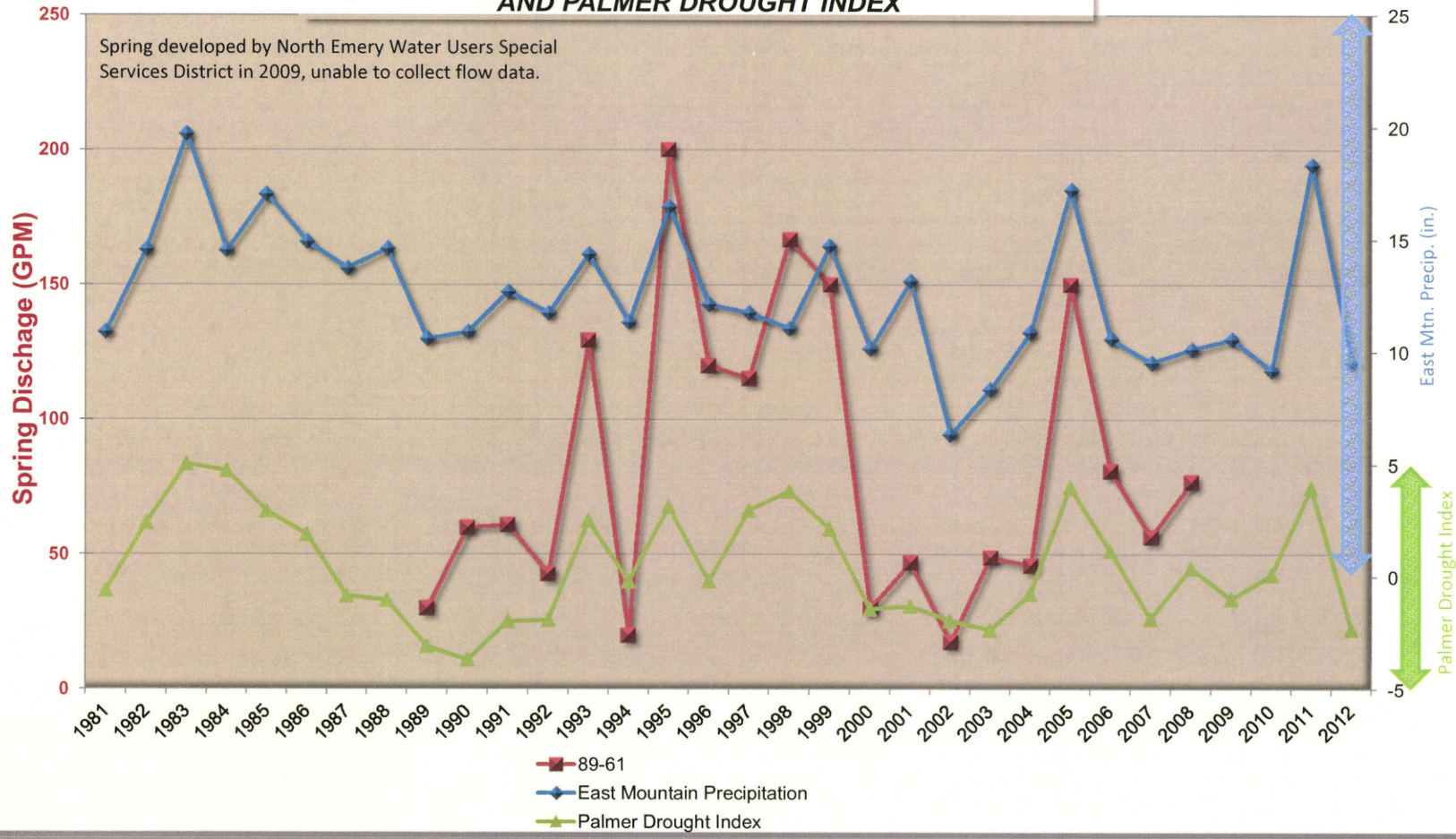
Subsidence: The springs lie above an unmined area directly west of the 1st and 2nd Left longwall panels. These panels were stopped short of complete panel extraction. Monitoring shows that the area has little to no subsidence. No other subsidence data is included of these sites.

Water Data: Historic and post-water quality data is included for spring 89-61 and Elk Spring. Data show insignificant variances between the historic quality and post-quality results. Historic flow data has been collected since 1984 and has continued through 2012. This information is found on the following page where July spring flow is plotted against precipitation data collected from the East Mountain weather station, as well as the Palmer Drought Index for regions 4, 5, and 6. The East Mountain weather station is located on the southern tip of East Mountain. Spring flow shows a positive correlation with precipitation. The mode of occurrence for this site is fault controlled. The stratigraphic location is within the North Horn Formation.

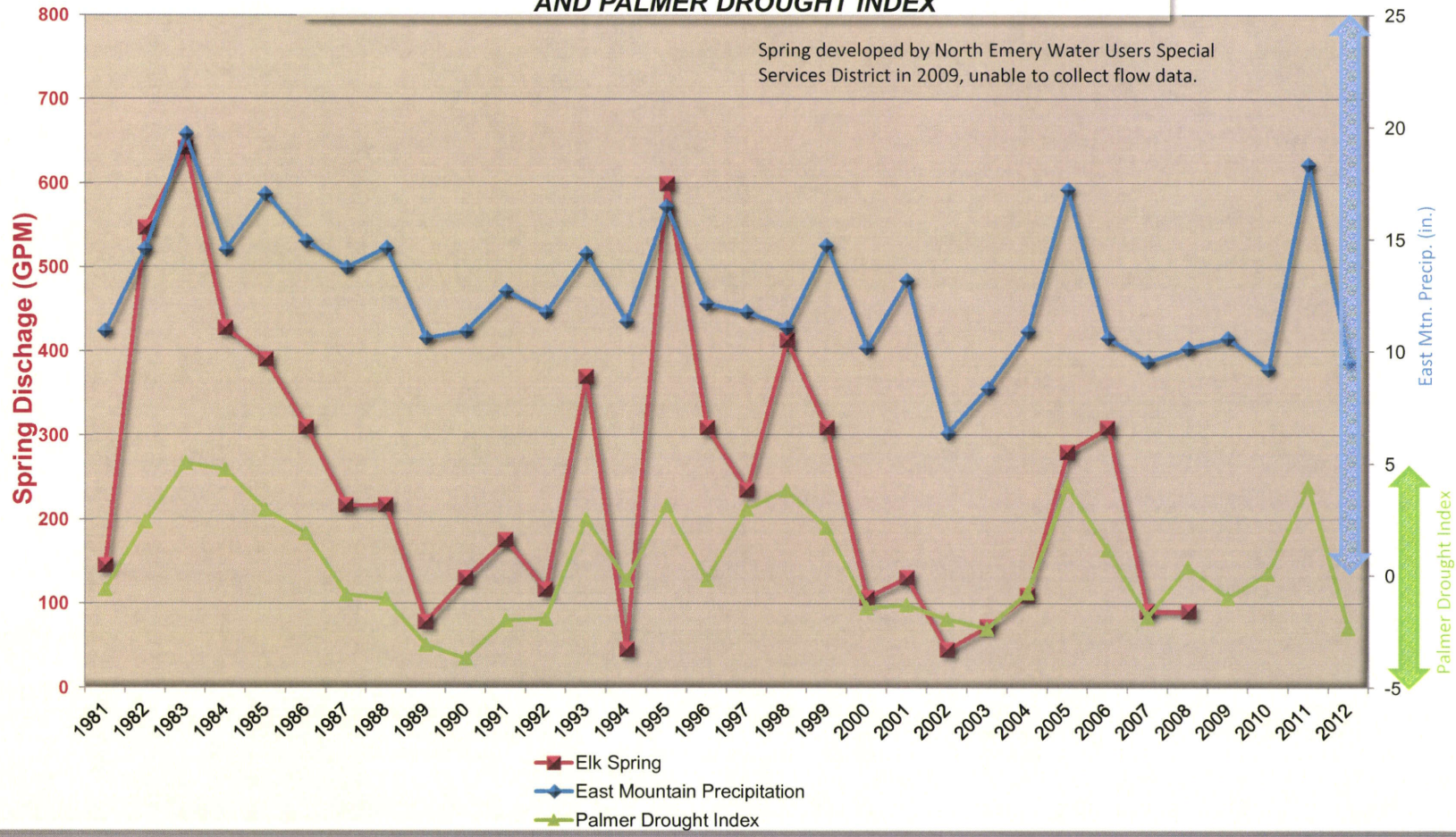
Justification for removal from monitoring: Sites 89-61 and Elk Spring were developed for culinary use starting in 2009 by North Emery Water Users Special Services District. The spring water is diverted into a collection line and directed down canyon through a 6" waterline and to the slow sand water treatment plant in Huntington Canyon. The springs give NEWUSSD additional source capacity to meet their yearly culinary demands. Although Energy West Mining Company has monitored these sites (89-61; 1989, Elk; 1979), the data since development of the springs is irrelevant to the mining operations. Prior to development, there have been no reported occurrences in which mining has impacted these sites. Historic quality and quantity data has not indicated such impacts to the site.

Since the springs have been developed for culinary use by NEWUSSD, Energy West Mining Company retains no legal right of entry to the site, nor control of the site. Therefore, this site will be removed from the Energy West Mining Company's hydrologic monitoring program.

EAST MOUNTAIN SPRINGS
SPRING: 89-61 vs. PRECIPITATION
PEAK FLOW (JULY) vs. EAST MOUNTAIN WEATHER STATION AND PALMER DROUGHT INDEX



EAST MOUNTAIN SPRINGS
SPRING: Elk Spring vs. PRECIPITATION
PEAK FLOW (JULY) vs. EAST MOUNTAIN WEATHER STATION AND PALMER DROUGHT INDEX



East Mountain Spring: 89-61
Water Quality Data: Operational
Mine Association: Deer Creek Mine
Date of Development: No Mining
Date of Second Mining: No Mining
Spring Developed for Culinary Use by NEWUSSD in 2009

Historical Data: 1989 - 2012

	MAXIMUM	MINIMUM	AVERAGE	# ANALYSIS
BICARBONATE	443	271	335.73	40
CALCIUM	110.1	59.6	71.518	41
CARBONATE	5	0	1.3846	13
CHLORIDE	15	2	4.6902	41
CONDUCTIVITY	624	390	545.46	41
DISSOLVED OXYGEN	10.1	4.6	7.3938	16
FLOW	200	0.45	50.985	40
HARDNESS	380	264	294.1	41
TOTAL IRON	0.2	0	0.1	8
DISSOLVED IRON	0.2	0	0.0794	17
MAGNESIUM	32.4	24.2	27.993	41
DISSOLVED MANGANESE	0	0	0	3
MANGANESE	0.2	0	0.0538	16
OIL AND GREASE				0
PH	8	6.6	7.4466	41
POTASSIUM	5.97	0.01	1.4112	23
SET SOLIDS				0
SODIUM	14.72	5.6	8.8712	41
SULFATE	27	1.5	15.28	41
SUSPENDED SOLIDS	13	1	5.0714	14
TEMPERATURE	45.6	3.4	14.584	37
TOTAL DISSOLVED SOLIDS	359	243	304.93	40

East Mountain Spring: Elk Spring
Water Quality Data: Operational
Mine Association: Deer Creek Mine
Date of Development: No Mining
Date of Second Mining: No Mining
Spring Developed for Culinary Use by NEWUSSD in 2009

Historical Data: 1979 - 2012

	MAXIMUM	MINIMUM	AVERAGE	# ANALYSIS
BICARBONATE	347	236	279.72	68
CALCIUM	112	35.5	62.25	78
CARBONATE	10	0	1.2973	37
CHLORIDE	20	1.6	4.3708	65
CONDUCTIVITY	545	262	449.94	79
DISSOLVED OXYGEN	11.1	4.9	8.0259	27
FLOW	599.3	0.1	122.06	79
HARDNESS	376	192	247.09	69
TOTAL IRON	0.2	0	0.0667	18
DISSOLVED IRON	0.5	0	0.089	41
MAGNESIUM	35.7	10	22.915	78
DISSOLVED MANGANESE	0.007	0	0.0006	11
MANGANESE	0.2	0	0.041	42
OIL AND GREASE	1.1	0.1	0.6	2
PH	8.55	6.8	7.8311	82
POTASSIUM	10	0.1	1.6366	44
SET SOLIDS				0
SODIUM	29	2.78	7.3865	65
SULFATE	196.9	0.7	15.817	66
SUSPENDED SOLIDS	30	0.2	4.1387	31
TEMPERATURE	45.5	3.3	18.348	73
TOTAL DISSOLVED SOLIDS	351	178	253.55	67

Left Fork Fault Zone

Left Fork Fault Zone

2nd West

2nd West

2nd West Tailgate

2nd West Headgate

ROAN'S CANYON FAULT GRABEN

Deer Creek Mine

3rd Left

2nd Left

1st Left

1st West

1st West Mains

3rd North

9th East

8th East

7th East

6th East

STRAIGHT CANYON SYNCLINE

ELK SPRING

89-61

N

AREA 26

CAD FILE NAME/DISK#: AREA26-2007.DWG

ENERGY WEST MINING COMPANY
A SUBSIDIARY OF PACIFICORP

2007 SUBSIDENCE – AREA 26
DEER CREEK MINE – 1ST WEST LW
2ND & 3RD LEFT LW, 2ND WEST LW

DRAWN BY: K.S.F., K.J.L.		FIGURE 17
SCALE: 1" =600'		DRAWING #:
DATE: February 12, 2008	SHEET 1 OF 1	REV. ___

Spring: 89-61

Note: Spring 89-61 was developed in 2009 as a culinary source for NEWUSSD. Water is piped from the spring to their slow sand plant in Huntington Canyon.

Elevation: 9,137 feet
Coordinate: N 39°22'13.8" W 111°09'34.8"
Aspect: North Facing
Associated Formation: North Horn

Spring: Elk Spring

Note: Elk Spring was developed in 2009 as a culinary source for NEWUSSD. Water is piped from the spring to their slow sand plant in Huntington Canyon.

Location: T 17S, R 7E, Section 5
Associated Formation: North Horn

Location: Section 12, Township 17 South, Range 7 East, SLB&M. The site is located within the Deer Creek Mine permit boundary and situated within the confines of the Roans Canyon Fault Graben.

Lease Association: This site has been associated with federal coal lease U-084924. The lease was acquired by Utah Power & Light in 1977 from Peabody Coal Company. Because the spring is located within the confines of the Roans Canyon Fault Graben no mining has not been conducted in the immediate vicinity of the spring.

Subsidance: No subsidence has occurred in the area of Spring 79-10.

Water Data: The spring was originally chosen as a monitoring site because of its location within the fault graben and down dip from mine workings. Its location allowed the permittee to monitor quantity and quality parameters as related to its mining in the general area. Historic water quality data is included for spring 79-10. Data show no abnormalities in the water quality parameter for this area of East Mountain. Historic flow data has been collected since 1979 and has continued through 2012. This information is found on the following page where July spring flow is plotted against precipitation data collected from the East Mountain weather station, as well as, the Palmer Drought Index for regions 4, 5, and 6. The East Mountain weather station is located on the southern tip of East Mountain. Spring flow shows a positive correlation with precipitation. The mode of occurrence as indicated above for this site is the Roans Canyon Fault Graben. The stratigraphic location is within the North Horn Formation.

Justification for removal from monitoring: Site 79-10 has been monitored by Energy West Mining Company since 1979. There have been no reported occurrences in which mining has impacted this site. Historic quality and quantity data has not indicated such impacts to the site.

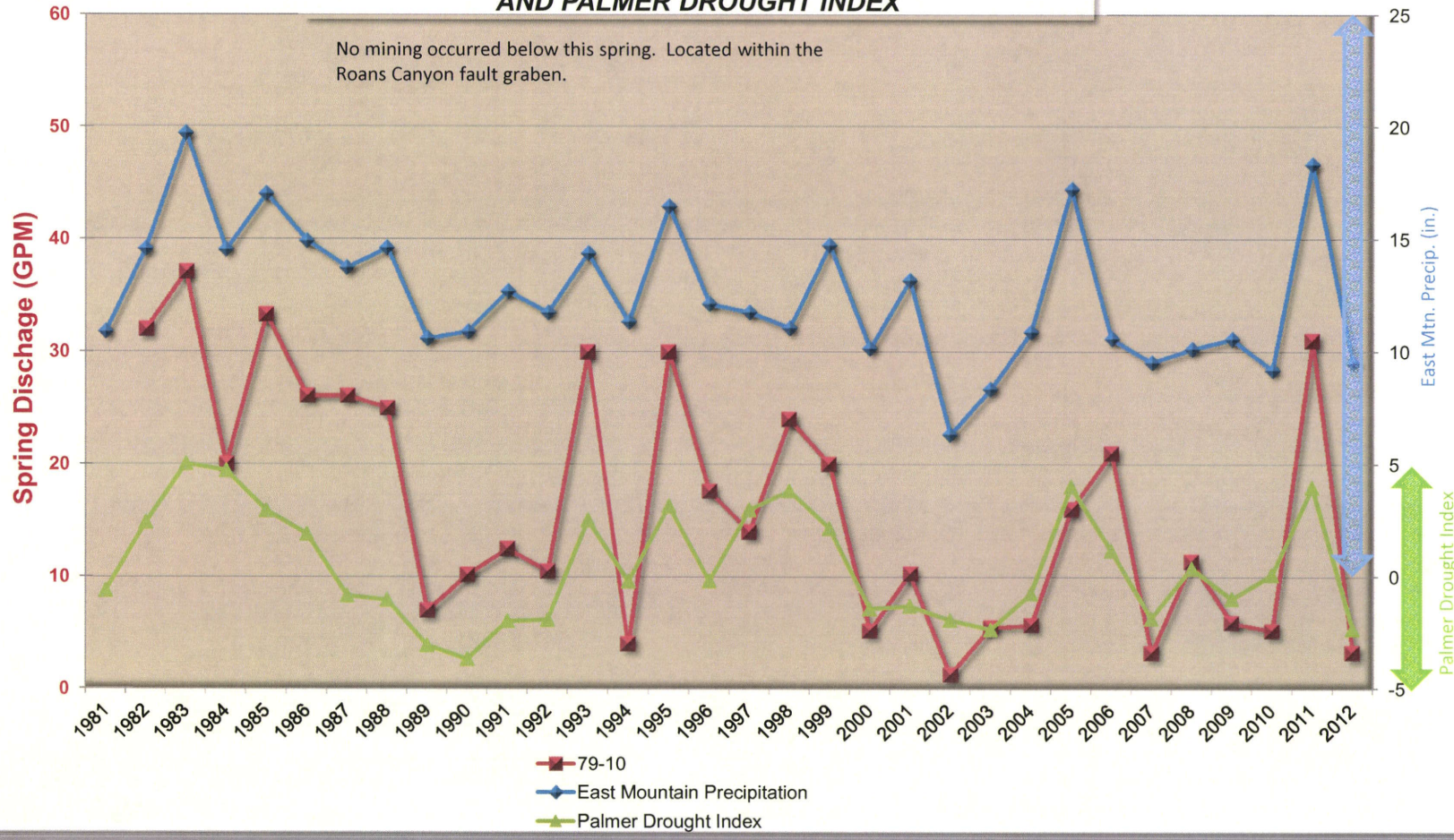
Although this site is within a current federal coal Lease and within the mine permit boundary, its location is in the southern extents of the permit boundary where no future mining is planned. Sheba Spring, located 1900 feet north and 1300 feet east of Spring 79-10, will be retained as part of the water monitoring program of the permittee.

With the facts presented, Energy West is removing this site from its hydrologic monitoring program and will no longer sample for quality or quantity of its discharge. If the Division does not agree with Energy West's findings, please provide compelling scientific evidence that suggests that our underground mining operations have impacted this site.

East Mountain Spring: 79-10
Water Quality Data: Operational
Mine Association: Deer Creek Mine
Date of Development: No Developmental Mining
Date of Second Mining: None

Historical Data: 1979 - 2012	MAXIMUM	MINIMUM	AVERAGE	# ANALYSIS
BICARBONATE	370	244	305	61
CALCIUM	112.9	41.5	71.915	71
CARBONATE	18	0	1.641	39
CHLORIDE	20	1	4.7759	58
CONDUCTIVITY	605	280	487.54	72
DISSOLVED OXYGEN	11.4	5.5	8.1962	26
FLOW	32	1.1	8.8458	74
HARDNESS	363	200	272.96	70
TOTAL IRON	1.1	0	0.3037	20
DISSOLVED IRON	0.33	0	0.0841	29
MAGNESIUM	25.4	12.6	22.418	71
DISSOLVED MANGANESE	0.042	0	0.0125	10
MANGANESE	0.2	0	0.0398	42
OIL AND GREASE	0.1	0.1	0.1	1
PH	8.35	7.05	7.7016	74
POTASSIUM	11.8	0.17	1.6134	37
SET SOLIDS				0
SODIUM	16.5	1.47	4.8231	58
SULFATE	144	3	10.986	59
SUSPENDED SOLIDS	22	0.5	4.8913	23
TEMPERATURE	47.1	3.3	22.79	67
TOTAL DISSOLVED SOLIDS	382	200	275.93	59

EAST MOUNTAIN SPRINGS
SPRING: 79-10 vs. PRECIPITATION
PEAK FLOW (JULY) vs. EAST MOUNTAIN WEATHER STATION AND PALMER DROUGHT INDEX



Spring: 79-10

Elevation: 9,419 feet
Coordinate: N 39°21'24.2“ W 111°11'04.0"
Aspect: Southeast
Associated Formation: North Horn

Location: Section 8, Township 17 South, Range 7 East, SLB&M. These sites are located outside the Deer Creek Mine permit boundary and outside of a current Federal Coal Lease.

Lease Association: Sites 79-15, 79-34, and 79-35 have been associated with federal coal lease SL-070645/U-02292. The lease was acquired by Utah Power & Light in 1977 from Peabody Coal Company. Room and pillar mining was started in 1975 in the Blind Canyon Seam below Spring 79-34. Longwall mining in the surrounding area includes the 2nd Left panels (completed in 1993) to the north, 1st thru 7th Right panels (completed in 1992) to the west and in the location of spring 79-35, and 17th Right panels (completed in1991) to the south. There has been no second mining below springs 79-15 and 79-34.

The permittee submitted an application for the relinquishment of 1,240 acres in April 1997. In March 2006, The BLM approved (with USFS and DOGM concurrence) relinquishment of this acreage. This approval was retroactive as of the date of the submittal. There are no remaining economical recoverable coal reserves in the relinquished area.

Subsidence: Refer to the Supplemental Volume 1, Lease Relinquishment, tab Phase III, tab Data Report Summary for additional subsidence information. Additional data from the 2004 Annual Subsidence Report is included herein.

Subsidence in the vicinity of spring 79-35 and west of the area of springs 79-15 and 79-34 reached a maximum of less than 1 foot. The subsided areas to the north and south were of lesser extent. Subsidence was determined complete in 1994. There is no subsidence in the vicinity of springs 79-15 and 79-34 and there has been no evidence to show any impacts to quality or quantity of the spring's discharge.

Water Data: Since the area underlying springs 79-15 and 79-34 was mined prior to spring monitoring, no pre-mining data is available. Historic data show no abnormalities in the water quality parameters for this area of East Mountain.

Pre- and Post- water quality data is included for spring 79-35. Data show insignificant variances between pre- and post- mining quality results Historic flow data has been collected for these springs since 1981 and has continued through 2012. This information is found on the following page where July spring flow is plotted against precipitation data collected from the East Mountain weather station, as well as the Palmer Drought Index for regions 4, 5, and 6. The East Mountain weather station is located on the southern tip of East Mountain. Spring flow shows a positive correlation with precipitation. The mode of occurrence for these springs are permeable fluvial channels that intersect the land surface within the stratigraphic location of the North Horn Formation.

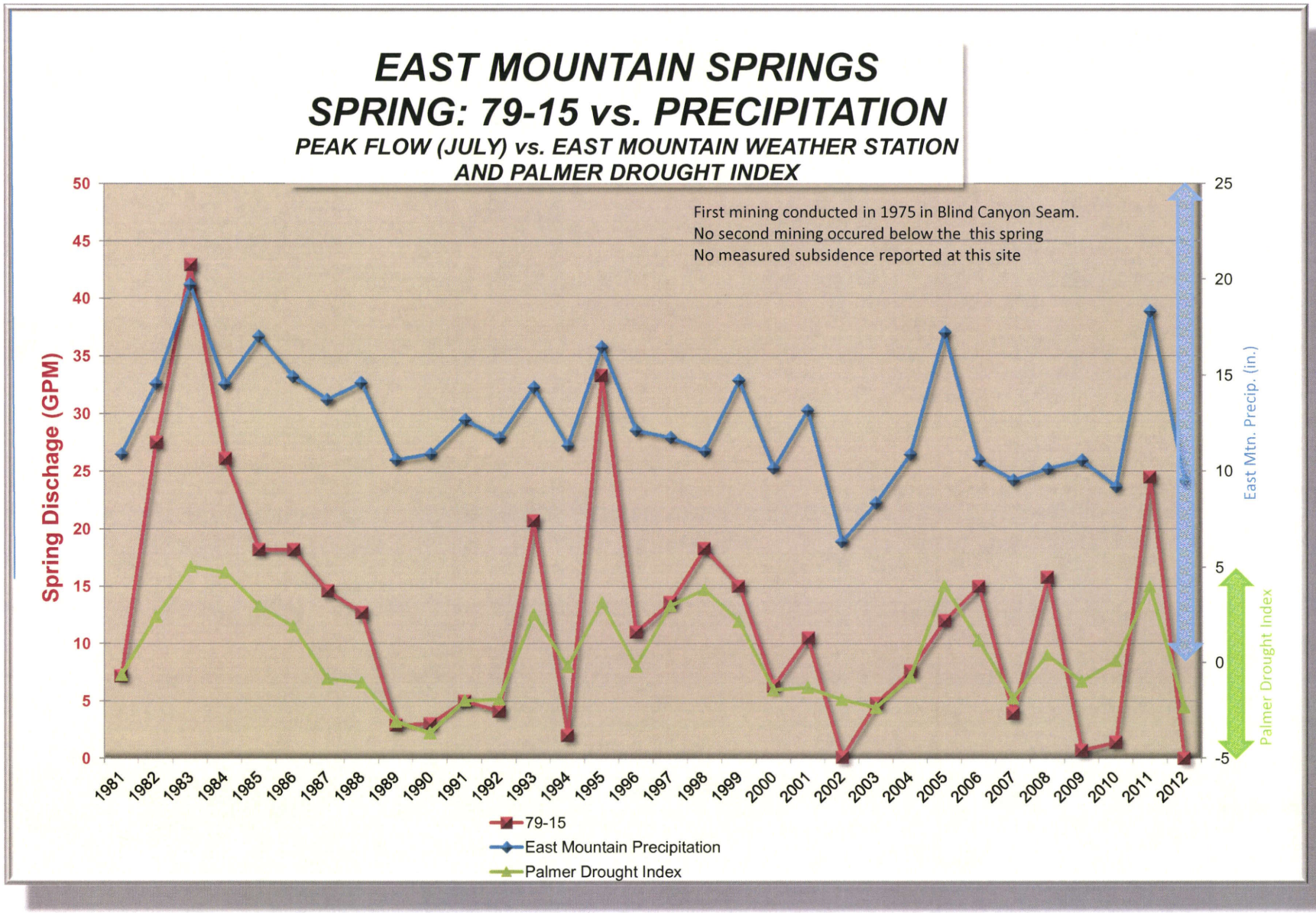
Justification for removal from monitoring: Springs 79-15, 79-34, and 79-35 have been monitored by Energy West Mining Company since 1979. All sites are located in the upper reaches of the Huntington drainage within the North Horn Formation. They occur from fluvial channels intersecting the land surface. Springs 79-15 and 79-35 are approximately the same elevation as Ted's Tub and show similar flow characteristics. 79-15 is within the drainage of Deer Creek Canyon where runoff from snowmelt is concentrated. Spring 79-35 is located below a ridge below where snow drifts form recharging the area above. Vegetative cover in the area of the springs is heavy which seems to delay runoff and produces good spring flows in July.

Spring 79-34 is located in the upper reaches of Whetstone Canyon and within the drainage where runoff from snowmelt is concentrated. The slope where the spring is located is north-facing and within heavy vegetative cover. Like 79-15 and 79-35, these heavily vegetated areas tend to delay runoff and produce good spring flows in July.

Subsidence within the area of the springs is minimal, averaging between one and two feet.

Since the federal coal lease has been relinquished (with DOGM concurrence) and the sites are no longer within the boundaries of a mine permit, Energy West Mining Company retains no legal right of entry to the site, nor control of the site. These sites show consistently variable flow over time. Energy West believes that the variability of flow has been influenced by climatic conditions and not underground mining operations. Although single seam mining has undermined these springs, there is no indication that there have been impacts from underground coal mining operations.

With the facts presented, Energy West is removing these sites from its hydrologic monitoring program and will no longer sample for quality or quantity of their discharge. If the Division does not agree with Energy West's findings, please provide compelling scientific evidence that suggests that our underground mining operations have impacted these sites.


EAST MOUNTAIN SPRINGS
SPRING: 79-15 vs. PRECIPITATION
PEAK FLOW (JULY) vs. EAST MOUNTAIN WEATHER STATION
AND PALMER DROUGHT INDEX
First mining conducted in 1975 in Blind Canyon Seam.
No second mining occured below the this spring
No measured subsidence reported at this site
Spring Dischage (GPM)
East Mtn. Precip. (in.)
Palmer Drought Index
50
45
40
35
30
25
20
15
10
5
0
25
20
15
10
5
0
-5
1981
1982
1983
1984
1985
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1988
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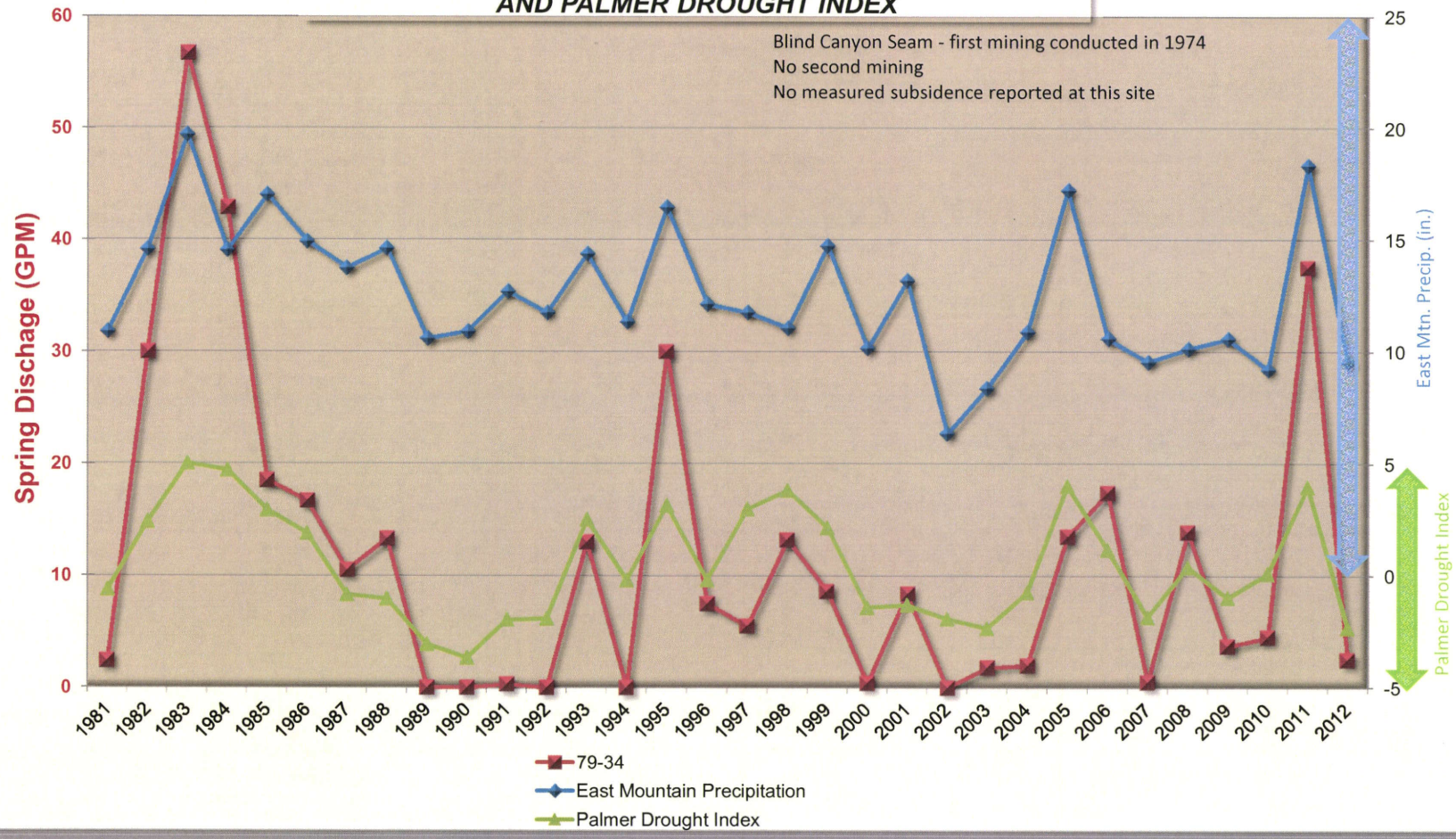
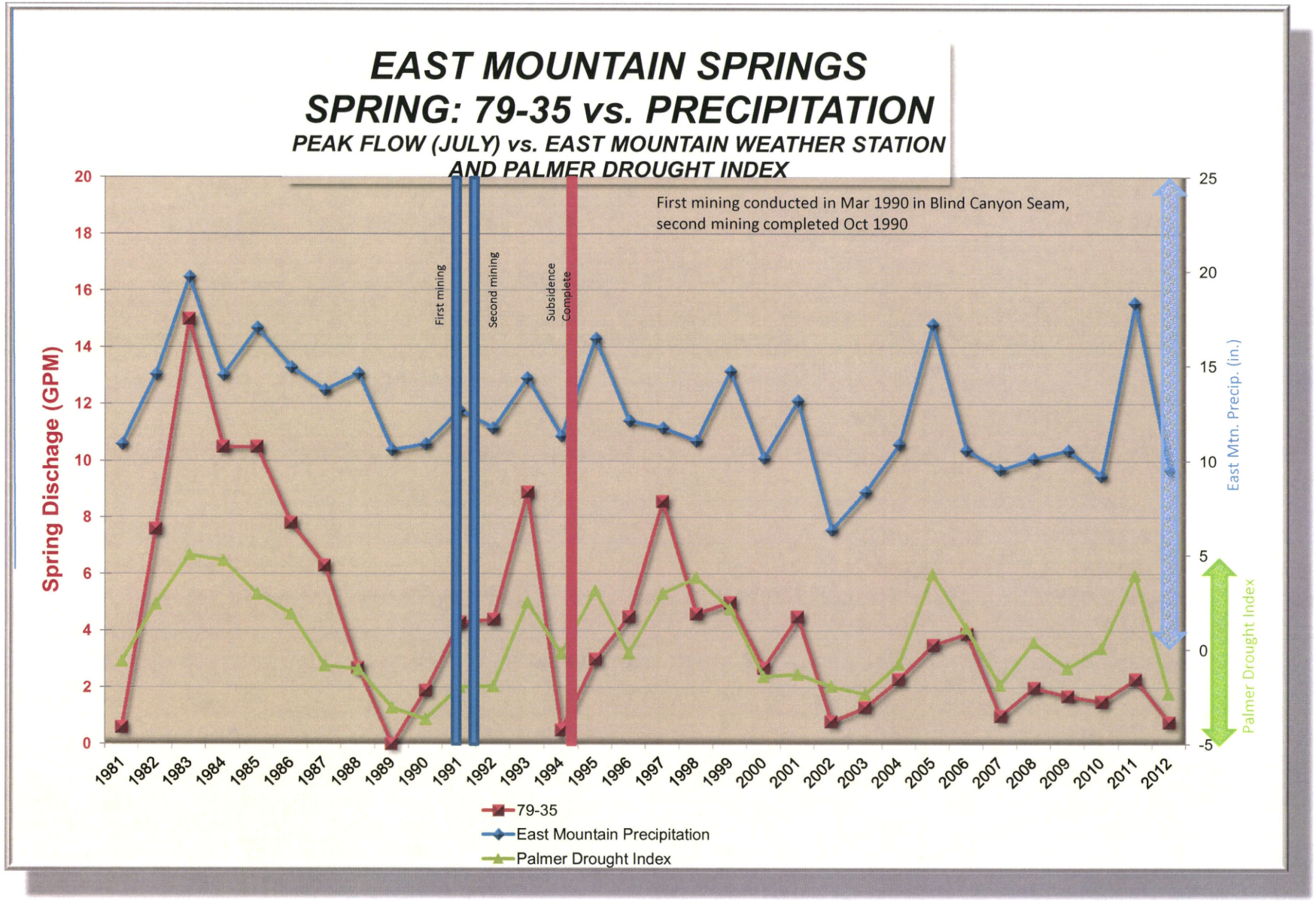
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
79-15
East Mountain Precipitation
Palmer Drought Index

EAST MOUNTAIN SPRINGS
SPRING: 79-34 vs. PRECIPITATION
PEAK FLOW (JULY) vs. EAST MOUNTAIN WEATHER STATION AND PALMER DROUGHT INDEX




EAST MOUNTAIN SPRINGS
SPRING: 79-35 vs. PRECIPITATION
PEAK FLOW (JULY) vs. EAST MOUNTAIN WEATHER STATION
AND PALMER DROUGHT INDEX
First mining conducted in Mar 1990 in Blind Canyon Seam,
second mining completed Oct 1990
First mining
Second mining
Subsidence Complete
Spring Dischage (GPM)
East Mtn. Precip. (in.)
Palmer Drought Index
79-35
East Mountain Precipitation
Palmer Drought Index

East Mountain Spring: 79-15
Water Quality Data: Operational
Mine Association: Deer Creek Mine
Date of Development: Blind Canyon Seam: 1975
Date of Second Mining: None

Historical Data: 1979 - 2011

	MAXIMUM	MINIMUM	AVERAGE	# ANALYSIS
BICARBONATE	432	252	320.88	58
CALCIUM	328	59.4	79.521	57
CARBONATE	8	0	1.6087	23
CHLORIDE	20	2	5.0321	56
CONDUCTIVITY	675	351	508.02	57
DISSOLVED OXYGEN	12.4	4.7	7.4824	17
FLOW	43	0.69	9.1943	58
HARDNESS	930	236	294.58	45
TOTAL IRON	2.4	0.076	0.4088	28
DISSOLVED IRON	0.36	0	0.0786	35
MAGNESIUM	41.12	16.3	24.141	57
DISSOLVED MANGANESE	0.026	0	0.0097	12
MANGANESE	0.2	0	0.0439	23
OIL AND GREASE	0.2	0.2	0.2	1
PH	8.77	7	7.6891	58
POTASSIUM	8	0.09	1.3286	40
SET SOLIDS				0
SODIUM	39	3.32	7.2279	57
SULFATE	591	1	29.272	57
SUSPENDED SOLIDS	399	0.5	21.977	31
TEMPERATURE	61.4	2.8	16.274	54
TOTAL DISSOLVED SOLIDS	430	214	289.45	58

East Mountain Spring: 79-34
Water Quality Data: Operational
Mine Association: Deer Creek Mine
Date of Development: Blind Canyon Seam: 1974
Date of Second Mining: None

Historical Data: 1979 - 2012

	MAXIMUM	MINIMUM	AVERAGE	# ANALYSIS
BICARBONATE	459	263	343.46	37
CALCIUM	144	37.9	77.315	36
CARBONATE	5	0	0.5714	14
CHLORIDE	10	2	6.2029	34
CONDUCTIVITY	763	420	595.81	36
DISSOLVED OXYGEN	12.3	4.5	7.62	5
FLOW	56.7	0.28	10.894	37
HARDNESS	363	216	308.14	29
TOTAL IRON	34.4	0	2.6168	25
DISSOLVED IRON	1.82	0	0.1278	25
MAGNESIUM	40.9	21.4	31.353	36
DISSOLVED MANGANESE	0.878	0	0.1026	18
MANGANESE	0.1	0	0.0164	17
OIL AND GREASE	0.7	0.7	0.7	1
PH	7.92	6.7	7.5627	37
POTASSIUM	7.5	0.5	1.4243	30
SET SOLIDS				0
SODIUM	20.3	5.44	10.538	36
SULFATE	251	2	28.765	37
SUSPENDED SOLIDS	61	0.5	18.462	13
TEMPERATURE	46.3	2.8	10.303	36
TOTAL DISSOLVED SOLIDS	472	264	339.27	37

East Mountain Spring: 79-35
Water Quality Data: Operational
Mine Association: Deer Creek Mine
Date of Development: Blind Canyon Seam: 1990
Date of Second Mining: Blind Canyon Seam: 1990

Historical Data: 1979 - 2012					Pre-Mining Data: 1979-1990				Post-Mining Data: 1992-201				
	MAXIMUM	MINIMUM	AVERAGE	# ANALYSIS	MAXIMUM	MINIMUM	AVERAGE	# ANALYSIS	MAXIMUM	MINIMUM	AVERAGE	# ANALYSIS	
BICARBONATE	355	236	290.22	59	355	272	308.67	12	336	236	285	45	BICARBONATE
CALCIUM	192	59.8	79.94	66	192	70	95.314	14	98.8	59.8	75.262	48	CALCIUM
CARBONATE	7	0	1.125	32	1	1	1	12	7	0	1.2353	17	CARBONATE
CHLORIDE	40	0.9	3.7786	56	10	2.5	4.2091	11	15	0.9	2.6814	43	CHLORIDE
CONDUCTIVITY	580	300	457.58	67	580	312	446.33	15	547	344	470.48	48	CONDUCTIVITY
DISSOLVED OXYGEN	11.2	4.7	8.2476	21	8.1	6.7	7.5667	3	11.2	4.7	8.5857	14	DISSOLVED OXYGEN
FLOW	20	0.3	2.9712	69	20	0.33	4.6939	18	8.9	0.3	2.3025	48	FLOW
HARDNESS	421	219	264.69	62	421	228	285	11	314	219	259.55	47	HARDNESS
TOTAL IRON	1.2	0	0.3178	28				0	1.2	0	0.3178	28	TOTAL IRON
DISSOLVED IRON	0.47	0	0.0877	31	0.47	0.02	0.1508	12	0.2	0	0.0512	17	DISSOLVED IRON
MAGNESIUM	21.7	10.9	16.271	66	17.4	12.3	14.2	14	21.7	10.9	16.942	48	MAGNESIUM
DISSOLVED MANGANESE	0.076	0	0.011	17				0	0.076	0	0.011	17	DISSOLVED MANGANESE
MANGANESE	0.2	0	0.0357	37	0.03	0.01	0.014	10	0.2	0	0.0479	23	MANGANESE
OIL AND GREASE	1.8	1.8	1.8	1	1.8	1.8	1.8	1				0	OIL AND GREASE
PH	8.52	6.94	7.822	70	8.3	6.95	7.675	18	8.52	6.94	7.9165	48	PH
POTASSIUM	5	0.1	0.8666	35	4	0.1	0.8236	11	5	0.15	0.7878	23	POTASSIUM
SET SOLIDS				0				0				0	SET SOLIDS
SODIUM	36	0.17	4.2638	56	36	2.61	8.4682	11	5	0.17	3.2174	43	SODIUM
SULFATE	206	0.3	14.946	56	206	2	53.142	12	10	0.3	4.4595	42	SULFATE
SUSPENDED SOLIDS	101	0.1	13.695	21	84.5	0.1	9.2167	12	101	1	24.857	7	SUSPENDED SOLIDS
TEMPERATURE	49.8	3.9	19.493	63	44	3.9	24.193	15	49.8	4.6	18.025	48	TEMPERATURE
TOTAL DISSOLVED SOLIDS	430	210	267.46	57	430	218	273.58	12	297	210	265.91	43	TOTAL DISSOLVED SOLIDS

Deer Creek 1st West

N 376,000

Deer Creek 1st West Mains

Deer Creek 1st Left

PROFILE

PROFILE

PROFILE

Deer Creek 2nd Left

Deer Creek 3rd North Mains

Deer Creek 3.5 South

Deer Creek Main East

N

N 374,000

Deer Creek 3rd Left

79-34

79-15

Deer Creek 4th South Mains

Deer Creek Main West

AREA 20

Deer Creek Mine

Deer Creek 17th Right

79-35

E 2,096,000

E 2,098,000

E 2,100,000

E 2,102,000

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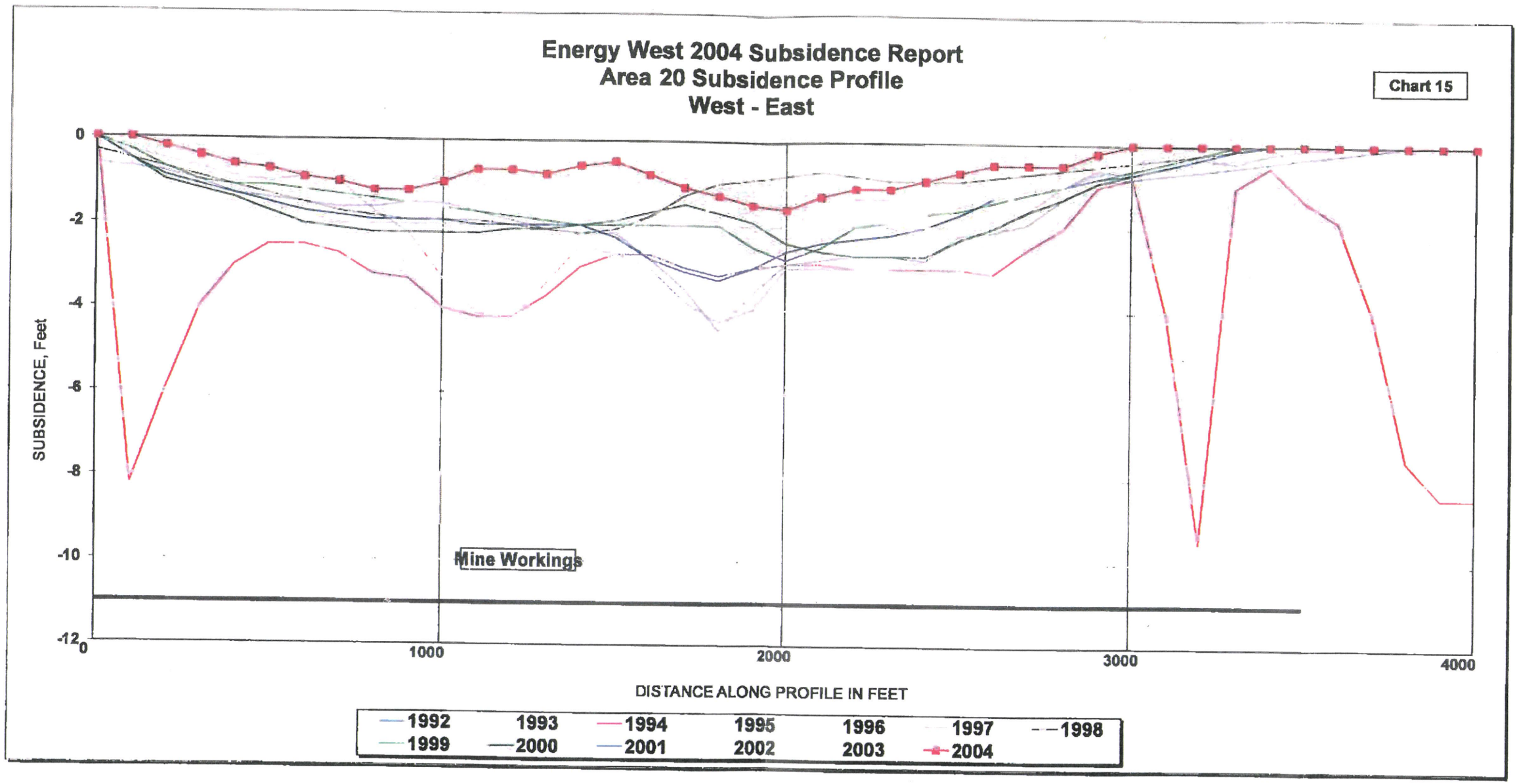
ENERGY WEST
MINING COMPANY
HUNTINGTON, UTAH 84528

2004SUBSIDENCE – AREA 20
DEER CREEK MINE
1st & 2nd Left Longwall Panels

DRAWN BY:	K.S.F., K.J.L.	FIGURE 11	
SCALE:	1" =500'	DRAWING #:	
DATE:	MARCH 09, 2005	SHEET 1 OF 1	REV.


Energy West 2004 Subsidence Report
Area 20 Subsidence Profile
West - East
Chart 15
SUBSIDENCE, Feet
0
-2
-4
-6
-8
-10
-12
0
1000
2000
3000
4000
Mine Workings
DISTANCE ALONG PROFILE IN FEET
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004

Spring: 79-15

Elevation: 9,266 feet
Coordinate: N 39°21‘25.9“ W 111°09‘38.2"
Aspect: Southeast
Associated Formation: North Horn

Spring: 79-34

Elevation: 9,173 feet
Coordinate: N 39°21‘31.5“ W 111°09‘09.6"
Aspect: Northeast
Associated Formation: North Horn

Spring: 79-35

Elevation: 9,656 feet
Coordinate: N 39°21’19.6“ W 111°09’56.2"
Aspect: Southeast
Associated Formation: Base of Flagstaff

Location: Section 18, Township 17 South, Range 7 East, SLB&M. This site is located within the Deer Creek Mine permit boundary and within the federal coal lease U-084923.

Lease Association: This site is associated with federal coal lease U-084923. The lease (subleased by M. McKinnon) was assigned to Utah Power & Light Co. from the Peabody Coal Company in 1979. The Blind Canyon seam has been mine in this lease. Panel development began the Blind Canyon Seam in 1991 from Deer Creek's 4th South Mains. Longwall mining occurred on the west side of the 4th South Mains where six panels were extracted. Mining in this area was completed in 1992.

Subsidance: Maximum subsidence in the area north and adjacent to Spring 79-29 has stabilized at approximately less than one foot. A comparison of the subsidence shown on the 1996 subsidence map to equivalent maps for years 1993, 1994, and 1995 shows subsidence was stable and complete for this area.

Additional data from the 2004 Annual Subsidence Report is included herein for the area north of Spring 79-29.

Water Data: Pre- and Post-mining water quality data which dates back to 1979 is included for spring 79-29. Data show insignificant variances between pre- and post-mining quality results. Historic flow data has been collected since 1981 and has continued through 2012. This information is found on the following page where July spring flow is plotted against precipitation of the East Mountain weather station, as well as the Palmer Drought Index for regions 4, 5, and 6. The East Mountain weather station is located on the southern tip of East Mountain. Spring flow shows a positive correlation with precipitation. The mode of occurrence for this site is permeable fluvial channel that intersect the land surface. The stratigraphic location is within the North Horn Formation.

Justification for removal from monitoring: Site 79-29 has been monitored by Energy West Mining Company since 1981. The spring is located on the West side of East Mountain in the top reaches of Roans Canyon. The spring has a western orientation and located in heavily vegetated cover. These areas tend to delay runoff and produce good spring flows in July.

Like other springs located in the North Horn Formation, spring 79-29 occurs in a permeable fluvial channel that intersects the land surface. The spring is underlined by impermeable mudstones that disconnect shallow formed springs from lower stratigraphic structures.

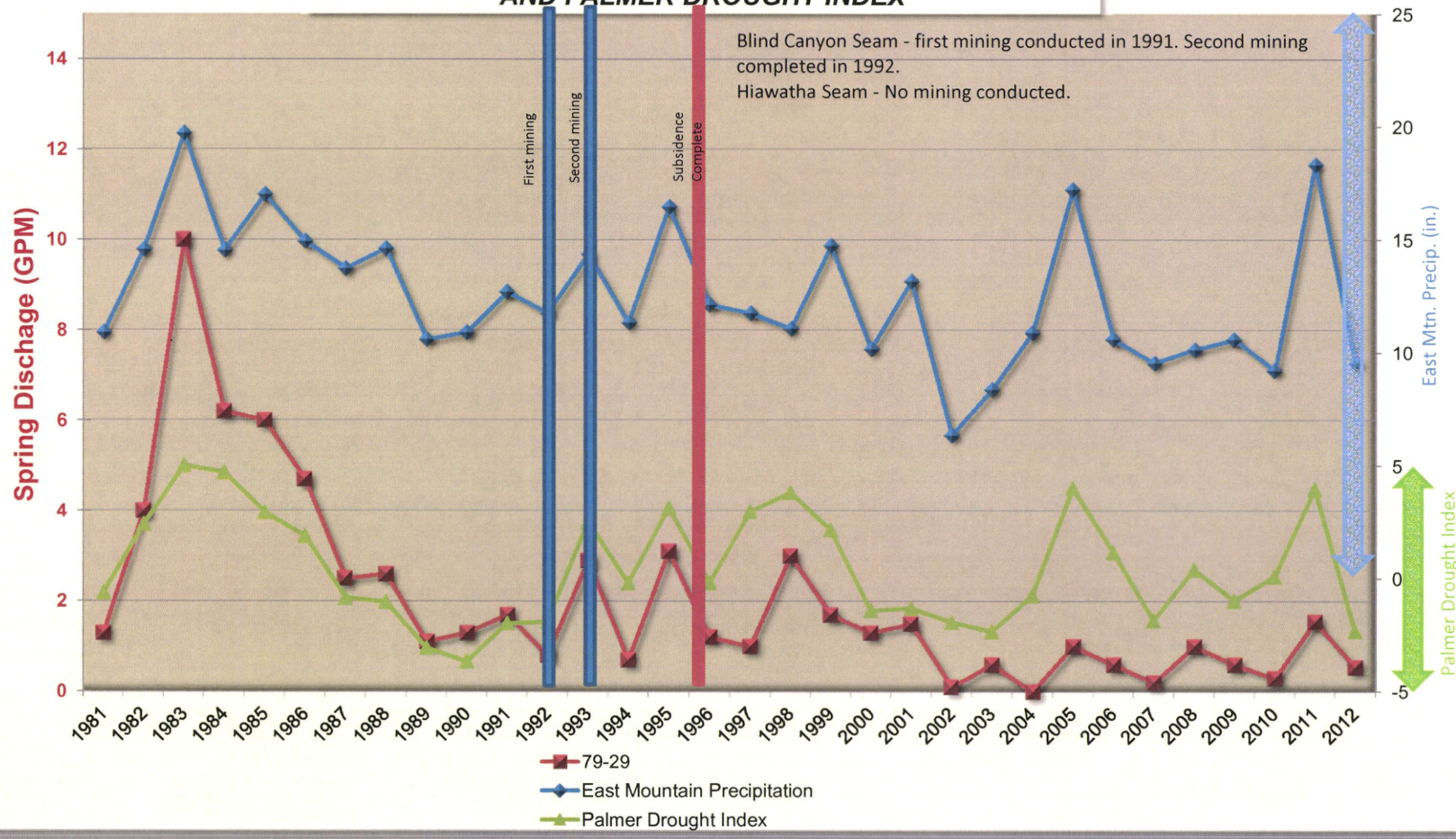
Spring flow is fairly consistent with the reported precipitation from the East Mountain weather station and the Palmer Hydrological Drought Index. This site is located with a current federal coal lease and within the Deer Creek mine permit boundary. There are no plans for any future mining in this area as this area has been completely mined out. Permanent seals have been

installed underground that completely isolates the area from the rest of the mine. Permanent seals eliminate the potential for any further mine development.

Although the sites show decreases to their flow over time, Energy West believes that the decreased flow has been influenced by climatic conditions and not underground mining operations. The trend of this spring mimics the trend of springs 79-26 and 79-32 both of which have not been undermine by underground coal mining operations.

With the facts presented, Energy West is removing this site from its hydrologic monitoring program and will no longer sample for quality or quantity of their discharge. If the Division does not agree with Energy West's findings, please provide compelling scientific evidence that suggests that our underground mining operations have impacted this site.

EAST MOUNTAIN SPRINGS
SPRING: 79-29 vs. PRECIPITATION
PEAK FLOW (JULY) vs. EAST MOUNTAIN WEATHER STATION AND PALMER DROUGHT INDEX



East Mountain Spring: 79-29
Water Quality Data: Operational
Mine Association: Deer Creek Mine
Date of Development: Blind Canyon Seam: 1991
Date of Second Mining: Blind Canyon Seam: 1992

Historical Data: 1979 - 2012					Pre-Mining Data: 1979-1990				Post-Mining Data: 1993-2012				
	MAXIMUM	MINIMUM	AVERAGE	# ANALYSIS	MAXIMUM	MINIMUM	AVERAGE	# ANALYSIS	MAXIMUM	MINIMUM	AVERAGE	# ANALYSIS	
BICARBONATE	405	247	312.49	53	405	281	328.57	14	345	247	303.06	33	BICARBONATE
CALCIUM	110	23.9	44.237	63	110	30.2	52.784	19	104	32.9	40.642	36	CALCIUM
CARBONATE	10	0	1.3077	39	1	1	1	18	10	0	1.6667	18	CARBONATE
CHLORIDE	40	11.2	18.404	50	25.2	11.2	18.092	13	22	13	16.935	31	CHLORIDE
CONDUCTIVITY	664	380	561.22	64	660	380	545.9	20	664	503	583.11	36	CONDUCTIVITY
DISSOLVED OXYGEN	11.7	5	6.9429	28	8.8	6	6.9286	7	11.7	5	7.0615	13	DISSOLVED OXYGEN
FLOW	7	0.25	1.6788	66	6	0.7	2.1848	23	7	0.25	1.5242	36	FLOW
HARDNESS	480	197	253.75	60	319	197	247.88	17	480	226	254.51	35	HARDNESS
TOTAL IRON	2.7	0	0.2888	17				0	2.7	0	0.2888	17	TOTAL IRON
DISSOLVED IRON	0.26	0	0.0855	33	0.26	0.02	0.1214	14	0.2	0	0.0656	16	DISSOLVED IRON
MAGNESIUM	54	19.5	35.436	63	39	19.5	32.553	19	54	29	36.819	36	MAGNESIUM
DISSOLVED MANGANESE	0.01	0	0.0029	9				0	0.01	0	0.0029	9	DISSOLVED MANGANESE
MANGANESE	36	0	0.8931	42	0.08	0.01	0.0156	16	36	0	1.771	21	MANGANESE
OIL AND GREASE	0.9	0.9	0.9	1	0.9	0.9	0.9	1				0	OIL AND GREASE
PH	8.3	6.95	7.7376	67	8.3	6.95	7.7961	23	8.29	7.38	7.7419	36	PH
POTASSIUM	9	0.3	2.0557	46	9	0.46	3.1692	12	5	0.8	1.6647	30	POTASSIUM
SET SOLIDS				0				0				0	SET SOLIDS
SODIUM	40.08	21.8	33.01	50	36.27	21.8	31.328	13	37.28	30	33.31	31	SODIUM
SULFATE	230	4.1	37.525	51	230	4.1	58.471	14	37	20	30.071	31	SULFATE
SUSPENDED SOLIDS	37	1	6.888	25	37	1	8.1571	14	28	3	8.5	6	SUSPENDED SOLIDS
TEMPERATURE	48.1	3	23.413	59	43	3	29.179	19	41.8	3.4	18.024	36	TEMPERATURE
TOTAL DISSOLVED SOLIDS	432	240	325.61	51	432	252	337.14	14	350	240	319.52	31	TOTAL DISSOLVED SOLIDS

N 376,000

N 374,000

N 372,000

E 2,092,000

E 2,094,000

E 2,096,000

PROFILE

PROFILE

PROFILE

PROFILE

PROFILE

ROANS CANYON FAULT GRABEN

Deer Creek 1st Right

Deer Creek 2nd Right

Deer Creek 3rd Right

Deer Creek 4th Right

Deer Creek 5th Right

Deer Creek 7th Right

Deer Creek 4th South

Deer Creek 4th South

Deer Creek Mine

79-35

7929

0

1

2

3

4

5

AREA 18

CAD FILE NAME/DISK#: J:\GEO\SUBSIDENCE\2004\Area18-2004.DWG

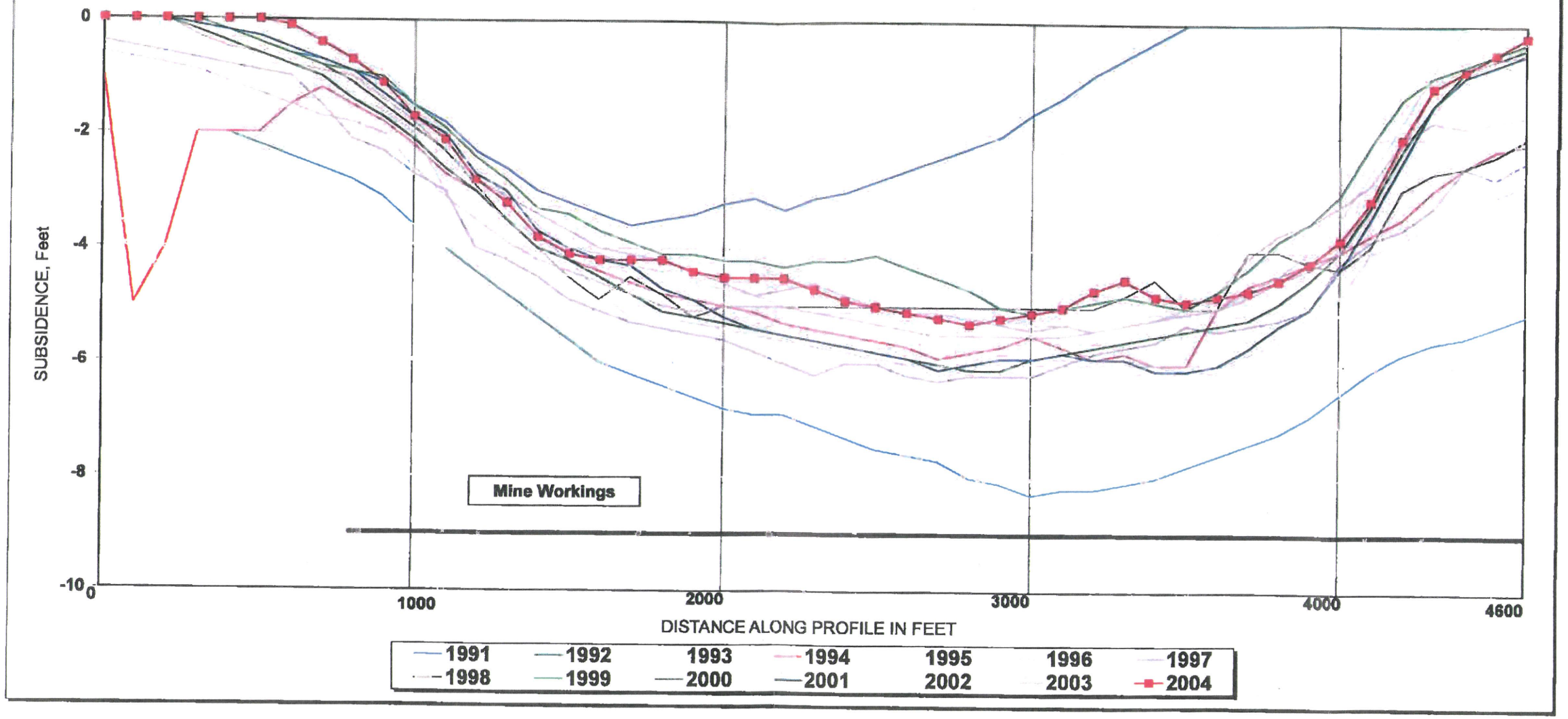
ENERGY WEST
MINING COMPANY
HUNTINGTON, UTAH 84528

2004 SUBSIDENCE – AREA 18
DEER CREEK MINE
2nd – 7th Right Longwall Panels

DRAWN BY:	K.S.F., K.J.L.	FIGURE 9	
SCALE:	1" =500'	DRAWING #:	
DATE:	MARCH 09, 2005	SHEET 1	REV. ___

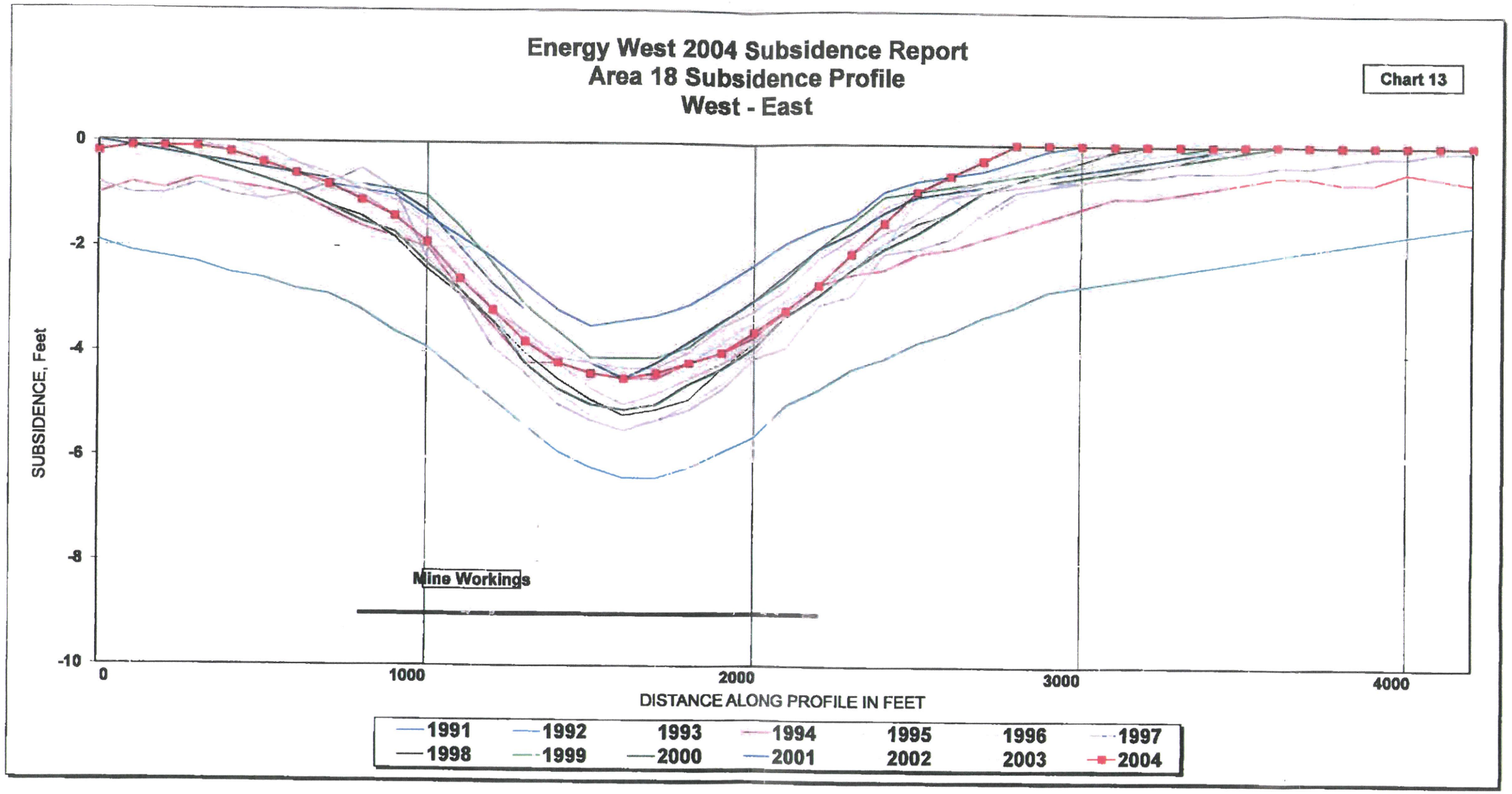
Energy West 2004 Subsidence Report
Area 18 Subsidence Profile
North - South

Chart 12



Energy West 2004 Subsidence Report
Area 18 Subsidence Profile
West - East

Chart 13



Spring: 79-29

Elevation: 9,365 feet
Coordinate: N 39°20’49.5“ W 111°10’27.6"
Aspect: West
Associated Formation: North Horn

Location: Section 16 and 17, Township 17 South, Range 7 East, SLB&M. Historically, these sites were located within the Deer Creek Mine permit boundary; however, since relinquishment of lease SL-070645/U-02292 and U-083066, (see below) the sites now lie outside any federal coal lease or mine permit boundary.

Lease Association: Springs 79-38 and 89-60 were associated with federal coal lease SL-070645/U-02292. Ted's Tub was associated with Federal Coal lease U-083066. The former was acquired in 1977 by Utah Power & Light from Peabody Coal Company. The latter, PacifiCorp was the sublessee to the Church of Jesus Christ of Latter Day Saints who was leaseholder of U-083066. Panel development off of the 3rd South Mains was started in 1988 in the Blind Canyon Seam for the 12th Right through 17th Right longwall panels. Extraction of these panels was completed in 1991.

For development in the Hiawatha Seam (Wilberg/Cottonwood Mine) near the vicinity of the springs, the 9th Left longwall panel was completed in 1992

The permittee submitted an application for the relinquishment of 1,240 acres (SL-070645/U-02292) and 60 acres (U-083066) in April 1997. In March 2006, the BLM approved (with USFS and DOGM concurrence) relinquishment of this acreage. This approval was retroactive as of the date of the submittal. There are no remaining economical recoverable coal reserves in the relinquished area.

Subsidence: Maximum subsidence in the mined area stated above reached approximately 13 feet. However, this was in the areas where double seam extraction took place (3rd thru 5th Right longwall panel (DC) and the 2nd thru 5th Left panel (WIL/CTW)); south of springs. The attached North/South Profile (2004 Annual Subsidence Report) shows only approximately 4 feet of subsidence occurred near 79-38, 89-60, and Ted's Tub. A comparison of the subsidence shown on the 1996 subsidence map to equivalent maps for years 1993, 1994, and 1995 shows subsidence was stable and complete for this area. Refer to Supplemental Volume 1, Lease Relinquishment, tab Phase III, tab Data Summary Report, pages 14 thru 17 and pages 24 thru 26.

Additional data from the 2004 Annual Subsidence Report is included herein.

Water Data: Pre- and Post-water quality data is included for springs 79-38, and Ted's Tub. Data show insignificant variances between pre- and post-quality results. Spring 89-60 was added to the water monitoring program in 1989 as a request from the Manti-LaSal National Forest. No pre-mining quality data exists for this spring.

Historic flow data has been collected since 1981 (springs 79-38, Ted's Tub) and 1989 (spring 89-60) and has continued through 2012. A graph shows the July spring flow plotted against precipitation of the East Mountain weather station, as well as the Palmer Drought Index for

regions 4, 5, and 6. The East Mountain weather station is located on the southern tip of East Mountain. Spring flow shows a positive correlation with precipitation. The mode of occurrence for Spring 79-38 is flow along permeable strata underlain by impermeable mudstone which intersect the land surface. The stratigraphic location for 79-38 is the base of the North Horn Formation. No mode of occurrence has been identified for Spring 89-60. This spring is stratigraphically located in the Price River Formation. Mode of occurrence for Ted's Tub is permeable fluvial channels that intersect land surface. The stratigraphic location for this spring is the North Horn Formation.

Justification for removal from monitoring: Sites 79-38, Ted's Tub and Site 89-60 are located in the upper reaches of a sub-drainage in Deer Creek Canyon. Springs 79-38 and Ted's Tub are located in the North Horn Formation. They occur from fluvial channels intersecting the land surface. Spring 89-60 is located in the Price River Formation. All three springs have an east to northeast orientation in heavy vegetative cover.

79-38:

This site has been monitored by Energy West Mining Company since 1979. It's location in the drainage with heavy vegetative cover and oriented on a northeast facing slope seems to produce very good flows in July. However, recent recession data (refer to Annual Reports) show that the spring loses 90 – 100 percent of its flow by October. A thorough analysis of this spring suggests that its flow or discharge is controlled by climatic episodes.

Spring flow is fairly consistent with the reported precipitation from the East Mountain weather station and the Palmer Hydrological Drought Index. This site is located within the relinquished federal coal lease and outside of the Deer Creek and Wilberg/Cottonwood mine permit boundaries. There are no plans for any future mining in this area as this area has been completely mined out. Permanent seals have been installed underground in the Deer Creek Mine to isolate the underground workings from the rest of the mine. The Wilberg/Cottonwood Mine has been permanently sealed at its portals. Permanent seals eliminate the potential for any further mine development.

89-60:

This site has been monitored by Energy West Mining Company since 1989 for quality for flow. It's location in the drainage with heavy vegetative cover and oriented on an east facing slope seems to produce very good flows in July. However, recession data (refer to Annual Reports) show that the spring loses 90 – 100 percent of its flow by October. A thorough analysis of this spring suggests that its flow or discharge is controlled by climatic episodes.

Spring flow is fairly consistent with the reported precipitation from the East Mountain weather station and the Palmer Hydrological Drought Index. This site is located within the relinquished federal coal lease and outside of the Deer Creek mine permit boundary. There are no plans for any future mining in this area as this area has been completely mined out. Permanent seals have been installed underground in the Deer Creek Mine to isolate the underground workings from the rest of the mine. Permanent seals eliminate the potential for any further mine development.

Ted's Tub:

This site has been monitored by Energy West Mining Company since 1979. It's location in the drainage with heavy vegetative cover and oriented on a northeast facing slope seems to produce very good flows in July. However, recent recession data (refer to Annual Reports) show that the spring loses 60 – 90 percent of its flow by October. A thorough analysis of this spring suggests that its flow or discharge is controlled by climatic episodes.

Spring flow is fairly consistent with the reported precipitation from the East Mountain weather station and the Palmer Hydrological Drought Index. This site is located within the relinquished federal coal lease and outside of the Deer Creek and Wilberg/Cottonwood mine permit boundaries. There are no plans for any future mining in this area as this area has been completely mined out. Permanent seals have been installed underground in the Deer Creek Mine to isolate the underground workings from the rest of the mine. The Wilberg/Cottonwood Mine has been permanently sealed at its portals. Permanent seals eliminate the potential for any further mine development.

These sites show consistently variable flow over time. Energy West believes that the variability of flow has been controlled by climatic conditions and not underground mining operations. Although single and double seam mining has undermined these springs, there is no indication that there have been impacts from underground coal mining operations.

With the facts presented, Energy West is removing these sites from its hydrologic monitoring program and will no longer sample for quality or quantity of their discharge. If the Division does not agree with Energy West's findings, please provide compelling scientific evidence that suggests that our underground mining operations have impacted these sites.

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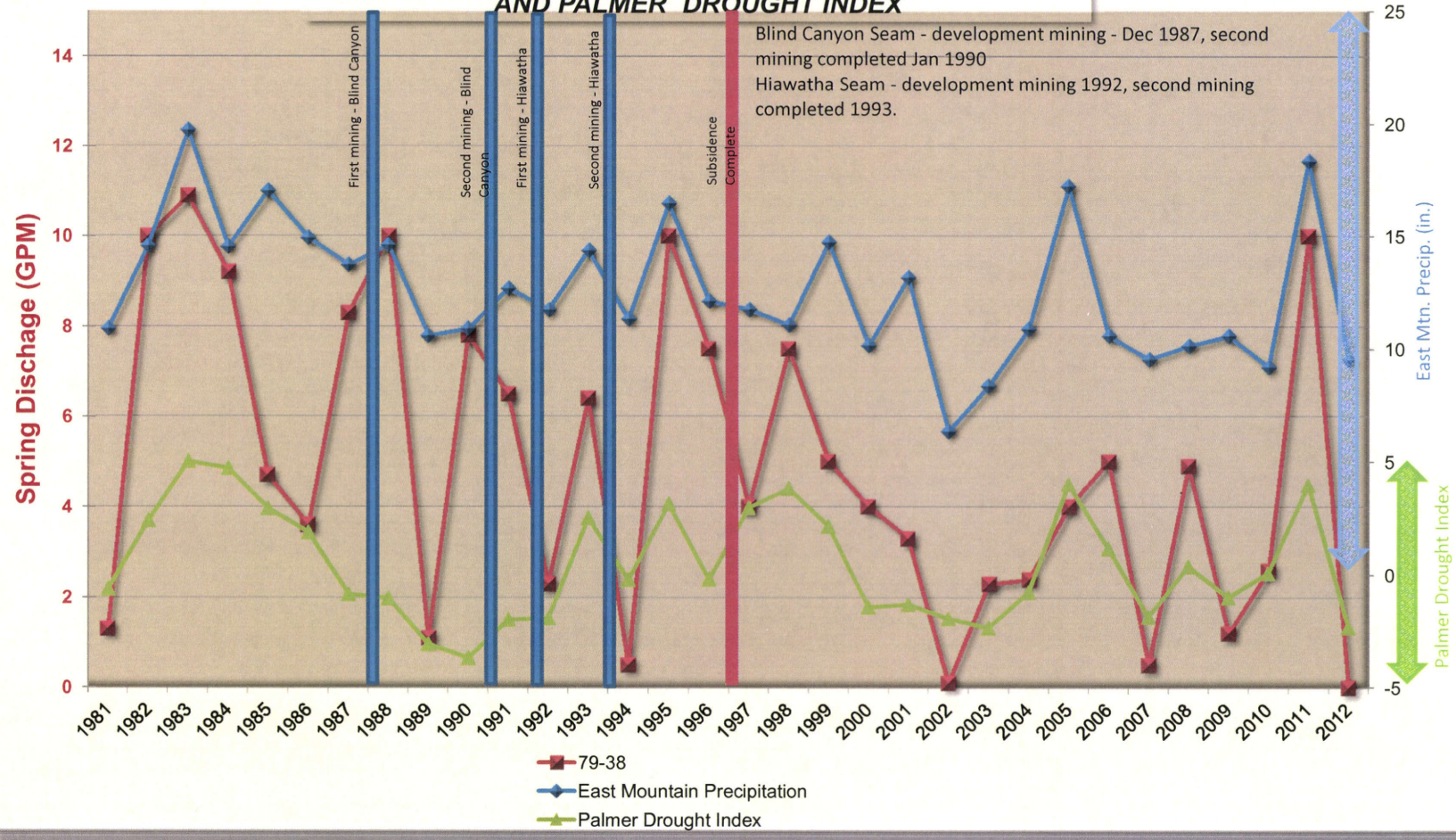
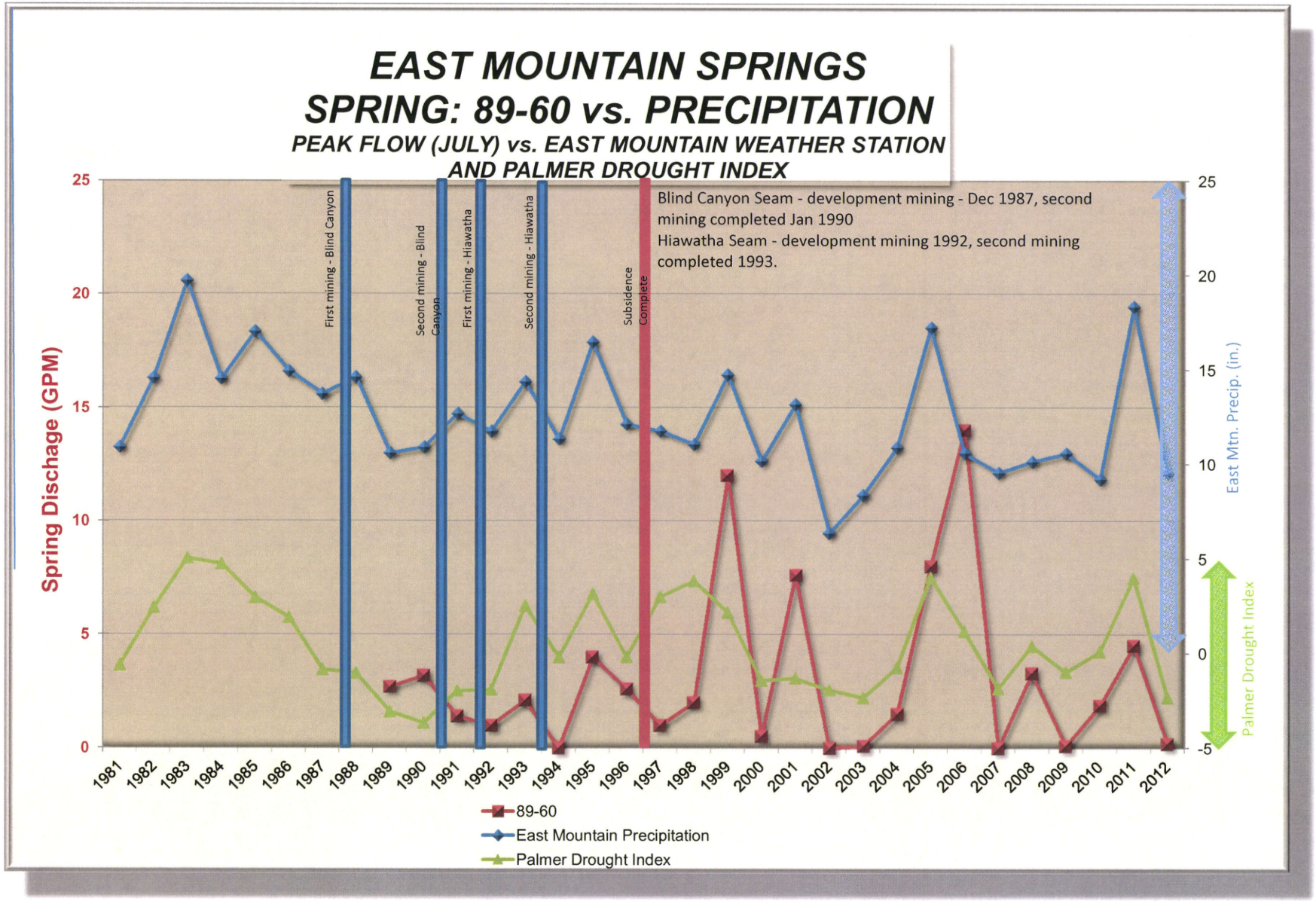
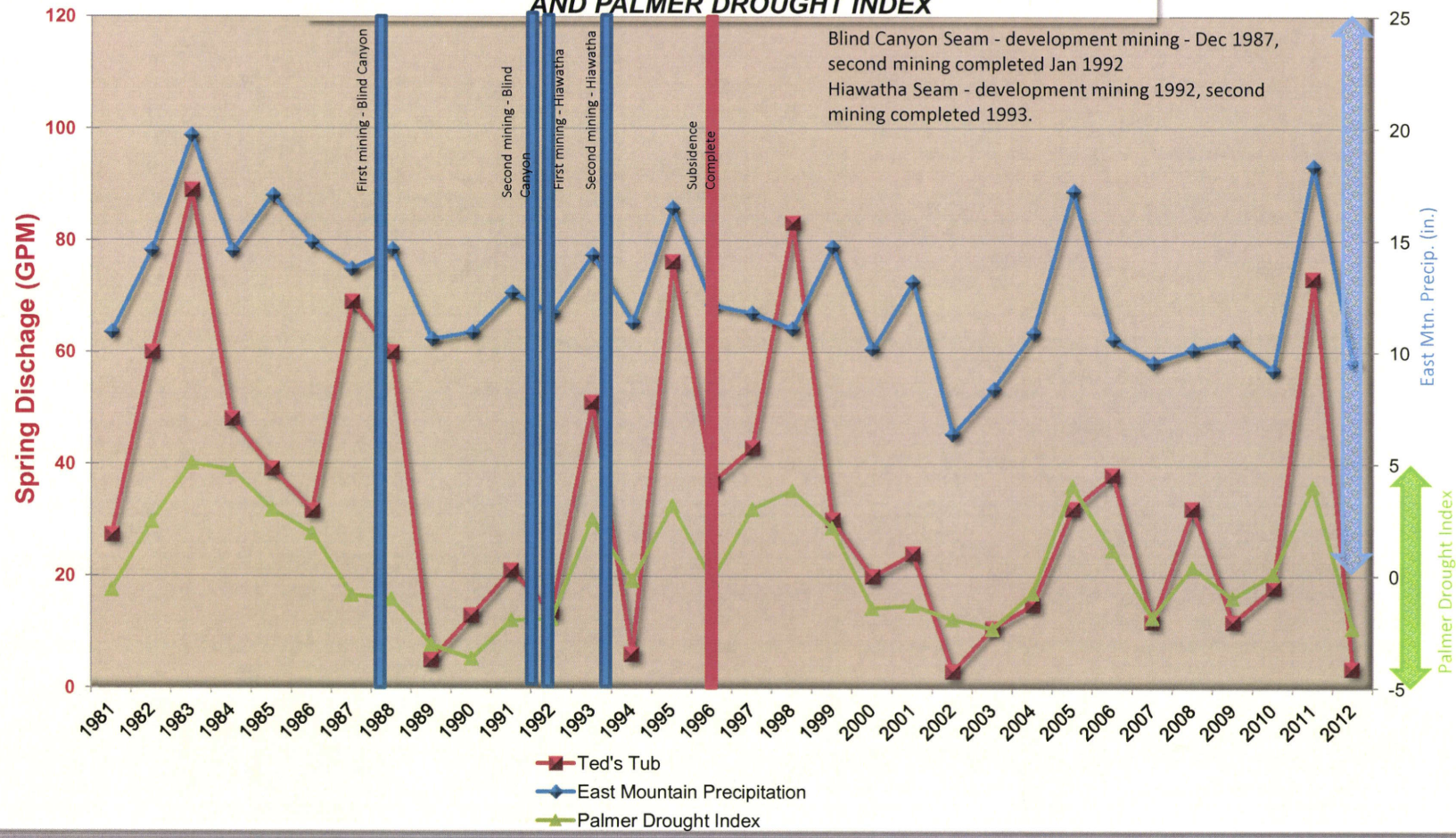
EAST MOUNTAIN SPRINGS
SPRING: 79-38 vs. PRECIPITATION
PEAK FLOW (JULY) vs. EAST MOUNTAIN WEATHER STATION AND PALMER DROUGHT INDEX




EAST MOUNTAIN SPRINGS
SPRING: 89-60 vs. PRECIPITATION
PEAK FLOW (JULY) vs. EAST MOUNTAIN WEATHER STATION
AND PALMER DROUGHT INDEX
Blind Canyon Seam - development mining - Dec 1987, second mining completed Jan 1990
Hiawatha Seam - development mining 1992, second mining completed 1993.
First mining - Blind Canyon
Second mining - Blind Canyon
First mining - Hiawatha
Second mining - Hiawatha
Subsidence Complete
Spring Dischage (GPM)
East Mtn. Precip. (in.)
Palmer Drought Index
89-60
East Mountain Precipitation
Palmer Drought Index

EAST MOUNTAIN SPRINGS
SPRING: Ted's Tub vs. PRECIPITATION
PEAK FLOW (JULY) vs. EAST MOUNTAIN WEATHER STATION AND PALMER DROUGHT INDEX



East Mountain Spring: 79-38
Water Quality Data: Operational
Mine Association: Deer Creek Mine
Date of Development: Blind Canyon Seam: 1989; Hiawatha Seam: 1992
Date of Second Mining: Blind Canyon Seam: 1990; Hiawtha Seam: 1993

Historical Data: 1979 - 2011					Pre-Mining Data: 1979-1988				Post-Mining Data: 1991-2012				
	MAXIMUM	MINIMUM	AVERAGE	# ANALYSIS	MAXIMUM	MINIMUM	AVERAGE	# ANALYSIS	MAXIMUM	MINIMUM	AVERAGE	# ANALYSIS	
BICARBONATE	478	313	387.9	51	478	314	391.45	11	446	313	383.25	36	BICARBONATE
CALCIUM	181	34	75.792	50	181	56	96.19	10	95.2	34	68.645	36	CALCIUM
CARBONATE	5	0	1.2222	18	1	1	1	4	5	0	1.4	10	CARBONATE
CHLORIDE	30	3.2	8.94	50	17	3.2	7.83	10	30	4	9.2694	36	CHLORIDE
CONDUCTIVITY	804	430	651.48	50	750	430	626.5	10	804	470	668.25	36	CONDUCTIVITY
DISSOLVED OXYGEN	10.4	4.1	7.0071	14				0	10.4	4.1	6.9667	12	DISSOLVED OXYGEN
FLOW	10.9	0.38	3.8694	51	10.9	1.3	6.3091	11	10	0.38	3.1872	36	FLOW
HARDNESS	351	230	278.5	44	313	265	286.5	4	315	230	272.14	36	HARDNESS
TOTAL IRON	7.64	0.09	1.5219	29				0	7.64	0.09	1.5219	29	TOTAL IRON
DISSOLVED IRON	0.83	0	0.2207	28	0.61	0.05	0.2182	11	0.32	0	0.1031	13	DISSOLVED IRON
MAGNESIUM	55.9	14.7	25.82	50	55.9	17.2	29.92	10	36	14.7	24.713	36	MAGNESIUM
DISSOLVED MANGANESE	0.343	0.002	0.0564	16				0	0.343	0.002	0.0564	16	DISSOLVED MANGANESE
MANGANESE	0.2	0.002	0.0467	24	0.02	0.01	0.015	2	0.2	0.002	0.0511	18	MANGANESE
OIL AND GREASE	2.5	2.5	2.5	1	2.5	2.5	2.5	1				0	OIL AND GREASE
PH	8.35	6.85	7.8153	51	8.1	6.85	7.5673	11	8.35	6.97	7.8872	36	PH
POTASSIUM	8.5	0.04	1.4744	35	8.5	0.7	2.4844	9	5	0.1	1.1793	22	POTASSIUM
SET SOLIDS				0				0				0	SET SOLIDS
SODIUM	73.63	3.1	42.98	50	30.4	10.5	22.5	10	73.63	40.8	49.816	36	SODIUM
SULFATE	283	2.9	37.116	51	283	2.9	60.809	11	50	20	29.417	36	SULFATE
SUSPENDED SOLIDS	358	2	41.443	23	358	2	57.473	11	75	5	29.25	8	SUSPENDED SOLIDS
TEMPERATURE	55.9	2.7	17.713	47	49	3.5	19.482	11	55.9	2.7	15.476	34	TEMPERATURE
TOTAL DISSOLVED SOLIDS	546	202	383.53	49	546	310	362.4	10	457	202	392.94	35	TOTAL DISSOLVED SOLIDS

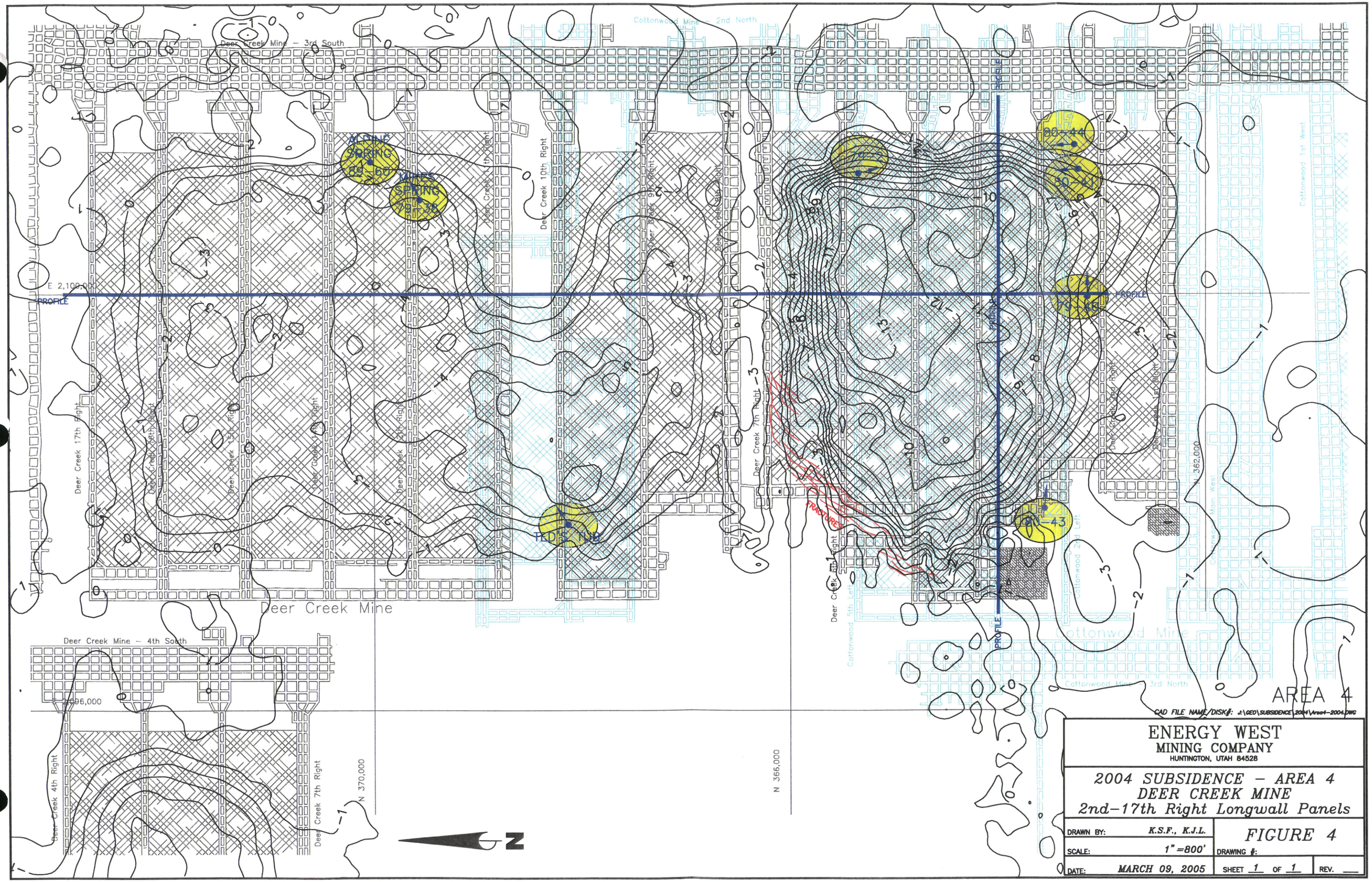
East Mountain Spring: 89-60
Water Quality Data: Operational
Mine Association: Deer Creek Mine
Date of Development: Blind Canyon Seam: 1989; Hiawatha Seam: 1992
Date of Second Mining: Blind Canyon Seam: 1990; Hiawatha Seam: 1993

Historical Data: 1989 - 2012

	MAXIMUM	MINIMUM	AVERAGE	# ANALYSIS
BICARBONATE	498	336	404.93	27
CALCIUM	118.3	64.54	81.26	27
CARBONATE	10	0	1.3	10
CHLORIDE	10	4	6.2889	27
CONDUCTIVITY	789	480	696	27
DISSOLVED OXYGEN	9	4.1	6.6714	7
FLOW	24.5	0.14	3.9259	27
HARDNESS	417	263	313.93	27
TOTAL IRON	7.14	0.06	1.0832	19
DISSOLVED IRON	0.1	0	0.035	12
MAGNESIUM	34	0.01	25.717	27
DISSOLVED MANGANESE	0.552	0.003	0.0857	10
MANGANESE	0.1	0	0.021	13
OIL AND GREASE				0
PH	8.46	7.06	8.0326	27
POTASSIUM	1.35	0.3	0.9106	18
SET SOLIDS				0
SODIUM	63.14	30.4	42.111	27
SULFATE	80	2	34.83	27
SUSPENDED SOLIDS	65	6	32.333	6
TEMPERATURE	54.5	3.1	14.748	25
TOTAL DISSOLVED SOLIDS	480	347	418.15	27

East Mountain Spring: Ted's Tub
Water Quality Data: Operational
Mine Association: Deer Creek Mine
Date of Development: Blind Canyon Seam: 1988, Hiawatha Seam: 1992
Date of Second Mining: Blind Canyon Seam: 1992, Hiawatha Seam 1993

Historical Data: 1979 - 2012					Pre-Mining Data: 1979-1987				Post-Mining Data: 1994-2012				
	MAXIMUM	MINIMUM	AVERAGE	# ANALYSIS	MAXIMUM	MINIMUM	AVERAGE	# ANALYSIS	MAXIMUM	MINIMUM	AVERAGE	# ANALYSIS	
BICARBONATE	375	254	313.67	63	375	283	322.69	16	370	254	305.63	38	BICARBONATE
CALCIUM	143	58	74.406	61	143	64	91.286	14	72.4	58	67.006	38	CALCIUM
CARBONATE	15	0	1.3636	22	1	1	1	2	15	0	1.5714	14	CARBONATE
CHLORIDE	20	1.7	4.3098	61	5.6	2.4	3.9286	14	6	1.7	3.2421	38	CHLORIDE
CONDUCTIVITY	611	315	513.97	61	600	315	494.93	14	611	453	534.74	38	CONDUCTIVITY
DISSOLVED OXYGEN	9.1	4.4	7.5385	13				0	8.5	4.4	6.9	6	DISSOLVED OXYGEN
FLOW	89	1.1	22.034	62	89	2.2	31.288	16	83.2	1.1	17.495	38	FLOW
HARDNESS	389	222	261.31	49	265	247	256	2	274	222	256.45	38	HARDNESS
TOTAL IRON	4.66	0.06	0.7666	32				0	4.66	0.06	0.7848	31	TOTAL IRON
DISSOLVED IRON	0.58	0	0.1014	37	0.41	0.04	0.126	15	0.2	0	0.0429	14	DISSOLVED IRON
MAGNESIUM	26.2	7	20.4	61	22	7	1685	14	24	18.41	21.668	38	MAGNESIUM
DISSOLVED MANGANESE	0.393	0.004	0.0575	19				0	0.393	0.004	0.0575	19	DISSOLVED MANGANESE
MANGANESE	0.2	0.002	0.0367	32				0	0.2	0.002	0.0375	23	MANGANESE
OIL AND GREASE	2.9	1.5	2.2	2	2.9	1.5	2.2	2				0	OIL AND GREASE
PH	8.52	6.95	7.7071	63	8.1	6.95	7.6119	16	8.52	7.3	7.7647	38	PH
POTASSIUM	13.15	0.2	1.5686	45	8	0.2	1.27	14	5	0.35	1.2145	26	POTASSIUM
SET SOLIDS				0				0				0	SET SOLIDS
SODIUM	25.93	4.54	12.394	61	14.5	5	7.0186	14	25.93	7	15.156	38	SODIUM
SULFATE	140	1	19.344	63	140	1	36.15	16	22	6	12.429	38	SULFATE
SUSPENDED SOLIDS	169	0.5	14.087	30	66	0.5	8.975	16	169	4	39	5	SUSPENDED SOLIDS
TEMPERATURE	59	2.8	13.666	60	47	2.8	8.8188	16	54.7	3.1	10.213	38	TEMPERATURE
TOTAL DISSOLVED SOLIDS	359	239	293.13	63	359	239	286.19	16	350	240	296.32	38	TOTAL DISSOLVED SOLIDS



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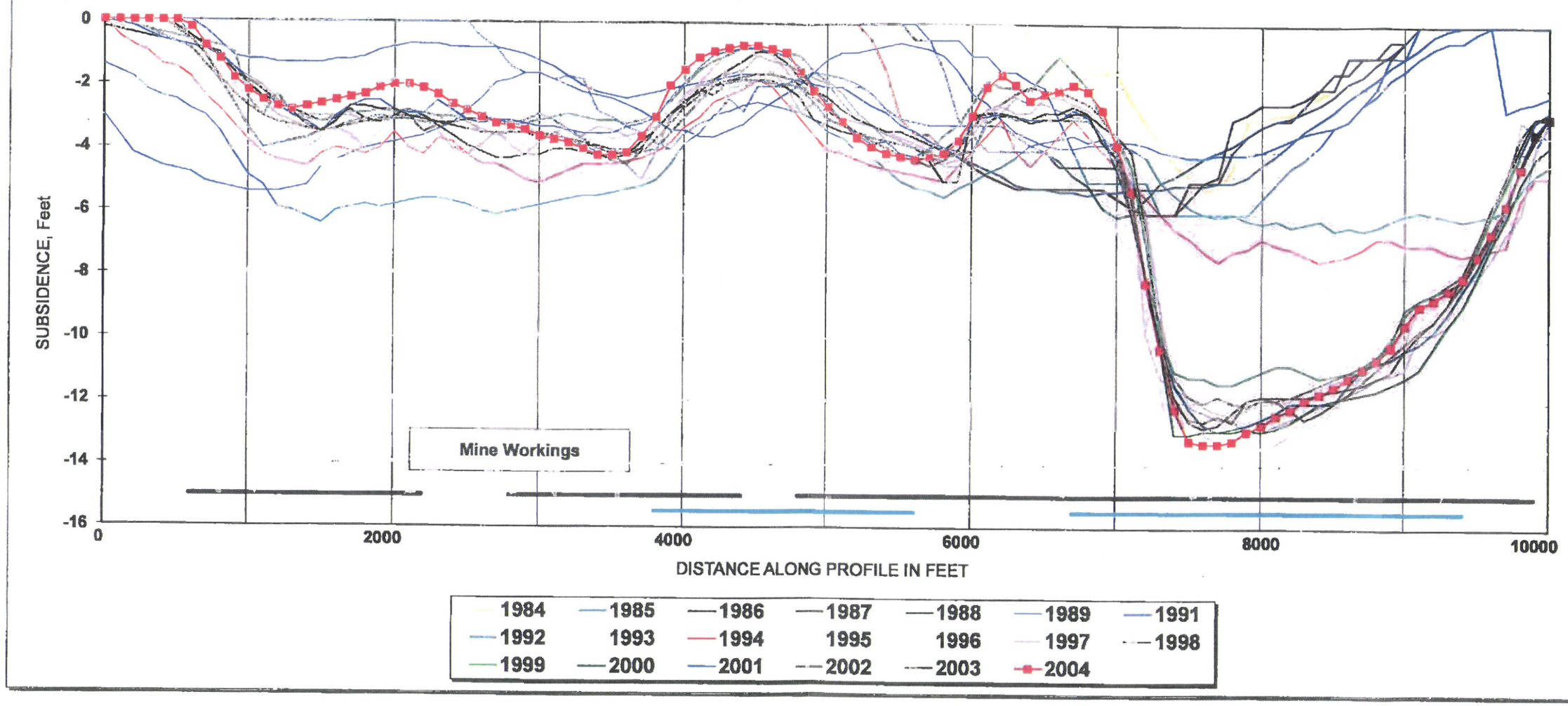
ENERGY WEST
MINING COMPANY
HUNTINGTON, UTAH 84528

2004 SUBSIDENCE – AREA 4
DEER CREEK MINE
2nd–17th Right Longwall Panels

DRAWN BY:	*K.S.F., K.J.L.*	*FIGURE 4*
SCALE:	*1"=800'*	DRAWING #:
DATE:	*MARCH 09, 2005*	SHEET 1 OF 1 — REV. ___

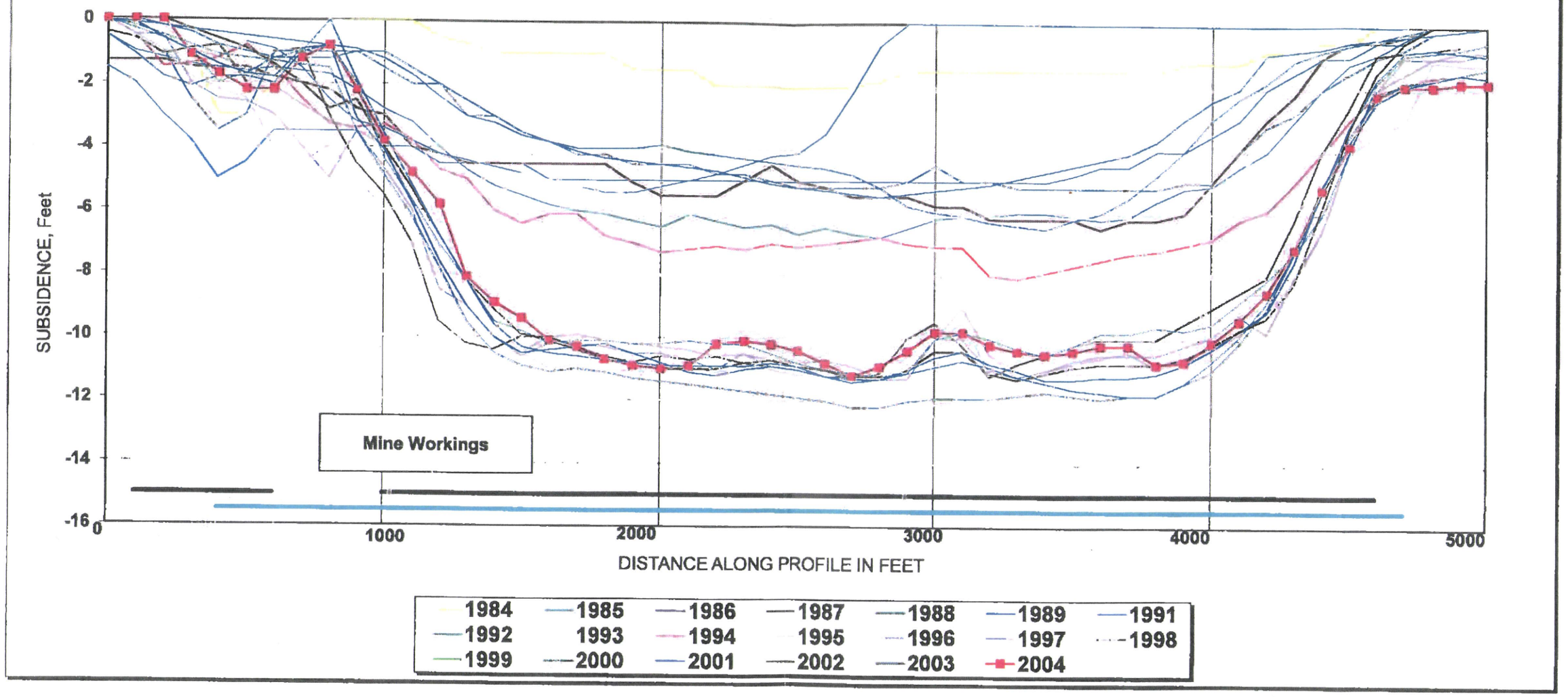
Energy West 2004 Subsidence Report
Area 4 Subsidence Profile
North - South

Chart 2



Energy West 2004 Subsidence Report
Area 4 Subsidence Profile
West - East

Chart 3



Spring: 79-38

Elevation: 9,185 feet
Coordinate: N 39°20’48.0“ W 111°08’53.0"
Aspect: East
Associated Formation: Base of North Horn

Spring: 89-60

Elevation: 9,069 feet
Coordinate: N 39°20'50.6" W 111°08'47.2"
Aspect: East
Associated Formation: Top of Price River
Note: This is actually 89-60 and not as noted on placard.

Spring: Ted's Tub

Elevation: 9,345 feet
Coordinate: N 39°20'34.0“ W 111°09'29.8"
Aspect: North Northeast
Associated Formation: North Horn

Location: Section 15, Township 17 South, Range 7 East, SLB&M. This site is located within the Deer Creek Mine permit boundary and within the federal coal lease SL-070645/U-02292. The site was originally located within the Wilberg/Cottonwood and Deer Creek mine permit boundary. The Wilberg/Cottonwood mine permit boundary was reduced which excluded the area of spring 82-52 from its permit boundary. DOGM approved this permit boundary reduction in 2002.

Lease Association: This site is associated with Federal Coal lease SL-070645/U-02292. The lease was acquired by Utah Power & Light in 1977 from Peabody Coal Company. Both the Hiawatha and Blind Canyon seams have been mined in this lease. For mining areas near the spring, room and pillar mining began in the Blind Canyon Seam in 1975 from Deer Creek's 2nd South Mains.

Subsidence: Spring 82-52 lies west of the 2nd South Mains of the Deer Creek Mine. The mining in this area was completed well before subsidence monitoring was initiated. It is most likely that some subsidence has occurred, but the total amount cannot be quantified. However, no subsidence has occurred since photogrammetric monitoring began in 1980. Refer to Supplemental Volume 1, Lease Relinquishment, tab Phase III, tab Data Summary Report, pages 14 thru 17 for lease specific information, and assessment of the environmental impacts.

Additional data from the 2004 Annual Subsidence Report is included herein.

Water Data: Post-mining water quality data is included for spring 82-52 for years 1982 thru 2012. No pre-mining data is available. Data did not show a significant difference in quality as compared to springs that haven't been undermined.

Historic flow data has been collected since 1982 and has continued through 2012. This information shows the July spring flow plotted against precipitation of the East Mountain weather station, as well as, the Palmer Drought Index for regions 4, 5, and 6. The East Mountain weather station is located on the southern tip of East Mountain. Spring flow shows a positive correlation with precipitation. The mode of occurrence for this spring has not been identified. The stratigraphic location is within the Price River Formation.

The U.S. Bureau of Mines completed an independent study (1994) of the mining impacts on the hydrology of East Mountain (Response of Springs to Longwall Coal Mining at the Deer Creek and Cottonwood Mines, Wasatch Plateau, Ut., Information Circular 94005, U.S. Bureau of Mines). This report is included as Appendix A in this submittal. The data in this study was collected by PacifiCorp from springs determined to represent hydrologic conditions on East Mountain. Spring 82-52 was included as part of this study.

Justification for removal from monitoring: Site 82-52 has been monitored by Energy West Mining Company since 1982. The spring is located on a north-facing slope in Deer Creek Canyon. The spring has been developed; however, the site has deteriorated rapidly (fence/collection/pond) due to cattle grazing and lack of maintenance.

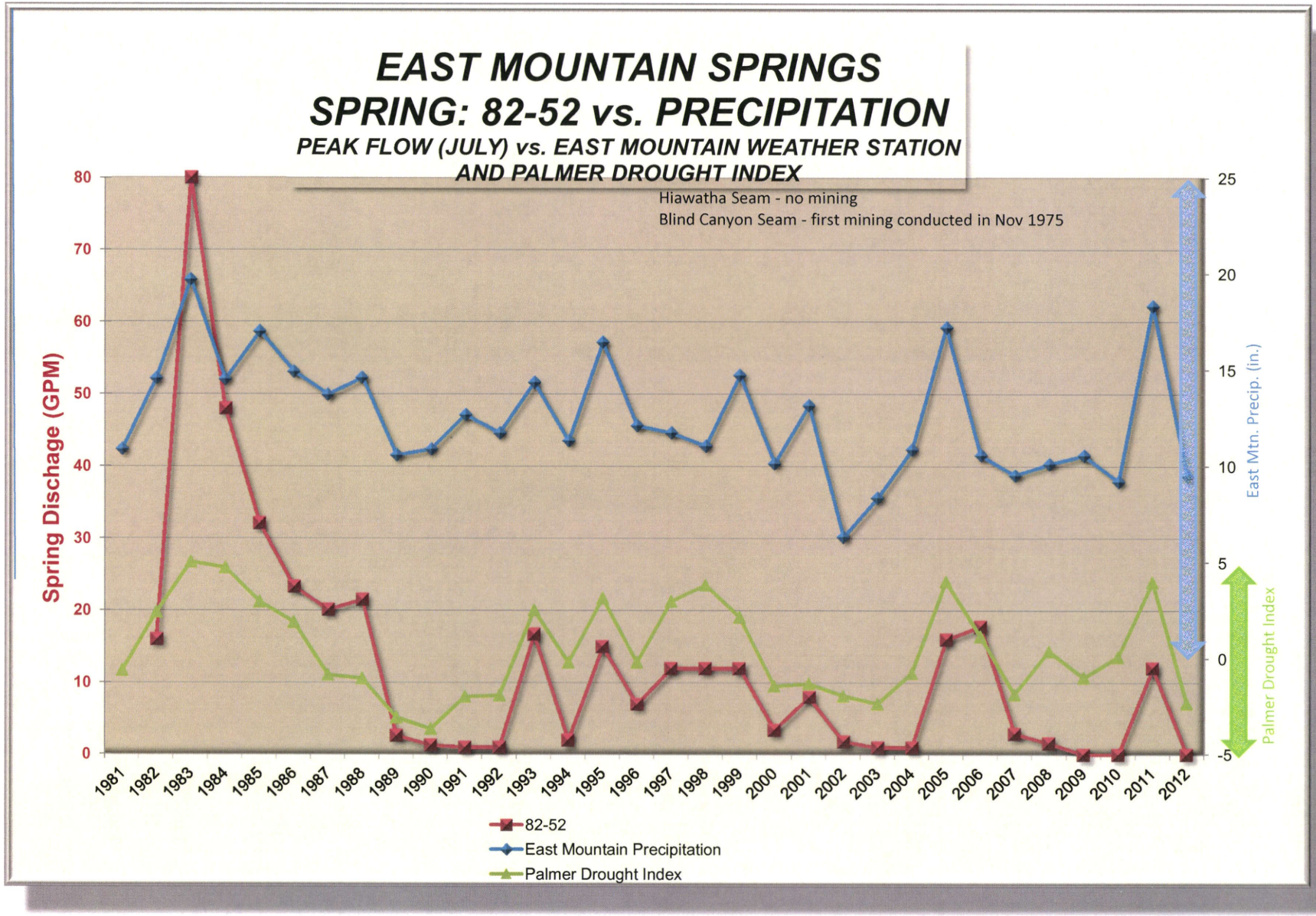
Vegetative cover is heavy in the area of the spring which may account for the good recorded July flow data. However, during the drought periods from 1987 to 1992 and again from 2000 thru 2004 flow monitoring showed near zero or zero discharge. Spring flow continued once climatic wet conditions returned.

Although the stratigraphic location of this spring is in the Price River Formation, it is near the contact of the North Horn Formation in which impermeable clays and mudstones dominate the rock types that limit percolation of ground waters to lower stratigraphic structures or underground mining areas.

Spring flow is consistent with the reported precipitation from the East Mountain weather station and the Palmer Hydrological Drought Index. This site is located within a current federal coal lease and within the Deer Creek mine permit boundary. There are no plans for any future mining in this area as this area has been completely mined out. Permanent seals have been installed underground. Permanent seals eliminate the potential for any further mine development.

Although the site shows a decrease to its flow over time, Energy West believes that the decreased flow has been influenced by climatic conditions and not underground mining operations. The trend of this spring mimics the trend of springs 79-26 and 79-32 both of which have not been undermine by underground coal mining operations.

With the facts presented, Energy West requests that the above noted site be removed from the hydrologic monitoring program.


EAST MOUNTAIN SPRINGS
SPRING: 82-52 vs. PRECIPITATION
PEAK FLOW (JULY) vs. EAST MOUNTAIN WEATHER STATION
AND PALMER DROUGHT INDEX
Hiawatha Seam - no mining
Blind Canyon Seam - first mining conducted in Nov 1975
Spring Dischage (GPM)
East Mtn. Precip. (in.)
Palmer Drought Index
82-52
East Mountain Precipitation
Palmer Drought Index

East Mountain Spring: 82-52
Water Quality Data: Operational
Mine Association: Deer Creek Mine
Date of Development: Blind Canyon Seam: 1975
Date of Second Mining:

Historical Data: 1982 - 2011

	MAXIMUM	MINIMUM	AVERAGE	# ANALYSIS
BICARBONATE	523	334	409.85	61
CALCIUM	160	38.4	74.401	72
CARBONATE	9	0	1.6061	33
CHLORIDE	35	2	10.067	58
CONDUCTIVITY	826	401	682.67	72
DISSOLVED OXYGEN	10.8	4.2	7.7407	27
FLOW	80	0.24	8.5126	73
HARDNESS	436	192	330.9	63
TOTAL IRON	0.74	0	0.1796	19
DISSOLVED IRON	0.33	0	0.0872	33
MAGNESIUM	42.15	8	35.933	72
DISSOLVED MANGANESE	0.02	0	0.0066	8
MANGANESE	0.2	0	0.0412	40
OIL AND GREASE				0
PH	8.66	6.8	7.6631	74
POTASSIUM	8	0.09	1.4779	44
SET SOLIDS				0
SODIUM	37.63	12	29.16	59
SULFATE	211	5	44.288	59
SUSPENDED SOLIDS	96	0.5	8.4516	31
TEMPERATURE	51	2.2	21.019	64
TOTAL DISSOLVED SOLIDS	488	262	400.42	59

E 2,102,000

E 2,104,000

E 2,106,000

Cottonwood 2nd North

Deer Creek 3rd South

Deer Creek D North

Cottonwood 2 1/2 North

Deer Creek C North

Cottonwood 12th Right

Deer Creek B North

Deer Creek A North

Deer Creek A South

Cottonwood 10th Right

Cottonwood 1 1/2 North

Deer Creek 2nd South

Deer Creek Mine

FRACTURES

BURNT TREE SPRING

82-52

79-23

FAULT

FAULT

-5 -4 -3 -2 -1 0 1 2

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AREA 11

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ENERGY WEST
MINING COMPANY
HUNTINGTON, UTAH 84528

2004 SUBSIDENCE – AREA 11
Deer Creek Mine C & D North Panels
Cottonwood 11th Right Panel

DRAWN BY:	K.S.F., K.J.L.	*FIGURE 7*	
SCALE:	1" =500'	DRAWING #:	
DATE:	MARCH 09, 2005	SHEET 1 OF 1	REV.

Spring: 82-52
(A.K.A. Sheepherders Spring)

Elevation: 9,061 feet
Coordinate: N 39°20'46.6“ W 111°07‘47.0"
Aspect: North
Associated Formation: Price River

Location: Spring 79-26 is located in Section 17, Township 17 South, Range 7 East, SLB&M. Spring 79-32 is located in Section 19, Township 17 South, Range 7 East, SLB&M. These sites are located within the Wilberg/Cottonwood Mine permit boundary and within the federal coal lease U-083066.

Lease Association: The springs are associated with federal coal lease U-083066. PacifiCorp is the sublessee to the Church of Jesus Christ of Latter Day Saints who is the leaseholder of U-083066.

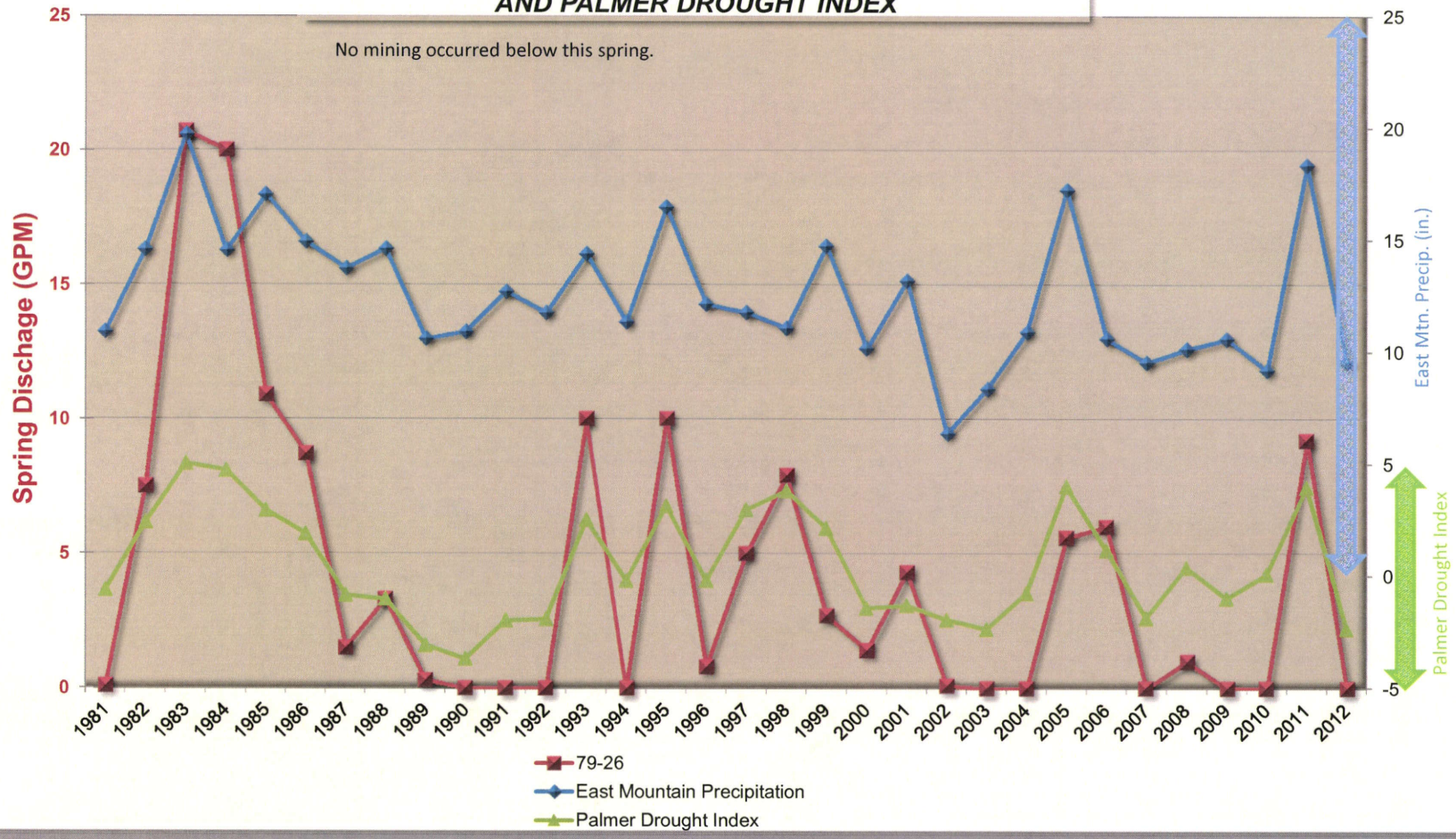
Subsidence: No coal mining activities have occurred in the underground areas below the springs.

Water Data: Water quality data is included for springs 79-26 and 79-32. Data show no abnormalities in the water quality parameter for this area of East Mountain. Historic flow data has been collected since 1981 and has continued through 2012. This information is found on the following page where July spring flow is plotted against precipitation data collected from the East Mountain weather station, as well as, the Palmer Drought Index for regions 4, 5, and 6. The East Mountain weather station is located on the southern tip of East Mountain. Spring flow shows a positive correlation with precipitation. The stratigraphic location for Spring 79-26 is within the North Horn Formation. The Stratigraphic location for Spring 79-32 is the base of the Flagstaff Formation.

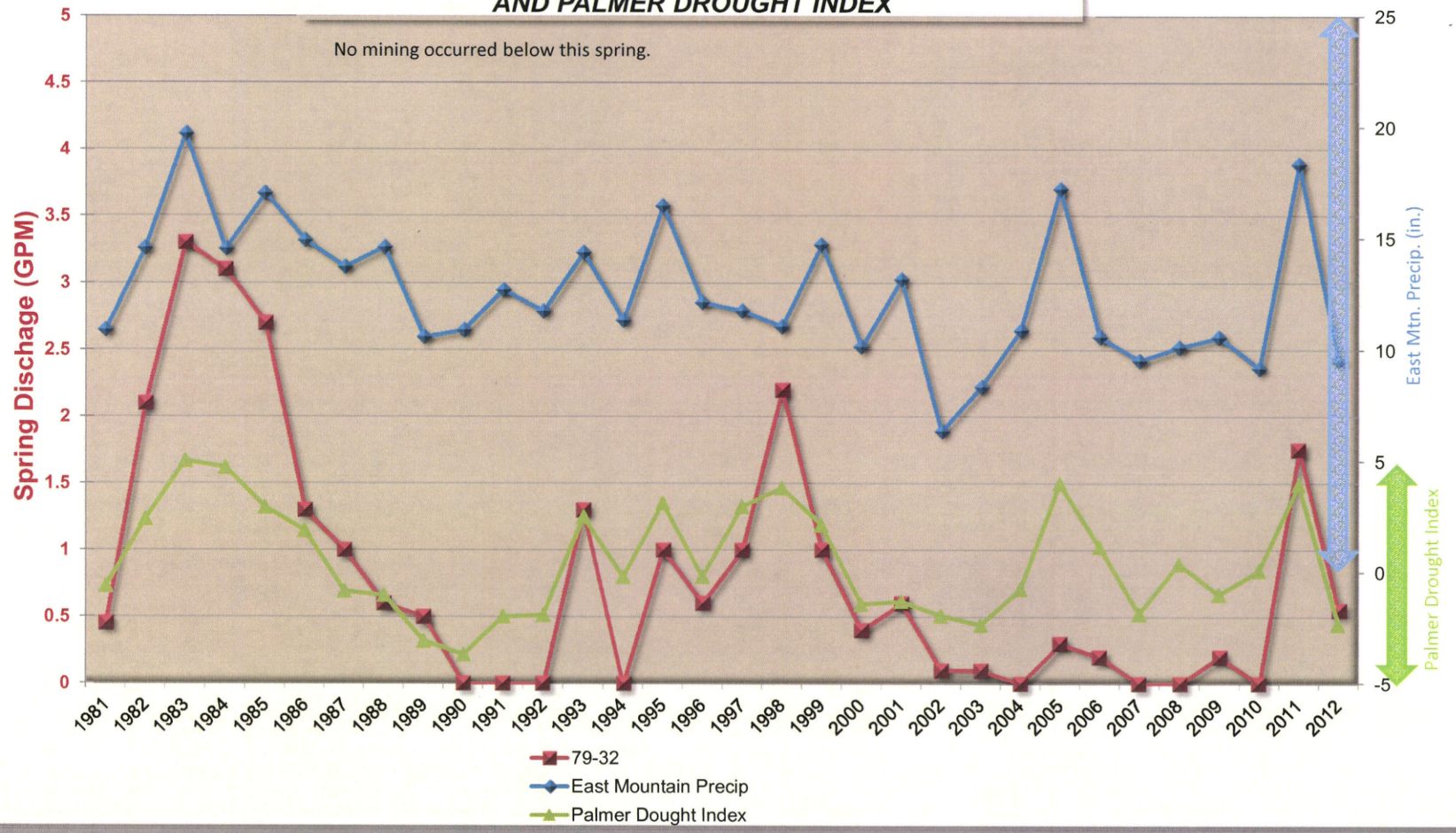
Justification for removal from monitoring: Sites 79-26 and 79-32 have been monitored by Energy West Mining Company since 1979. These springs are located on the west side of the East Mountain within heavy vegetative cover. These springs are approximately ½ mile from any underground workings; therefore, no undermining of these springs has occurred.

Although these sites are within a current federal coal lease and within the Wilberg/Cottonwood Mine permit boundary, its location is not in an area where future mining is planned. With the facts presented, Energy West is removing these sites from its hydrologic monitoring program and will no longer sample for quality or quantity of their discharge. If the Division does not agree with Energy West's findings, please provide compelling scientific evidence that suggests that our underground mining operations have impacted these sites.

EAST MOUNTAIN SPRINGS
SPRING: 79-26 vs. PRECIPITATION
PEAK FLOW (JULY) vs. EAST MOUNTAIN WEATHER STATION AND PALMER DROUGHT INDEX



EAST MOUNTAIN SPRINGS
SPRING: 79-32 vs. PRECIPITATION
PEAK FLOW (JULY) vs. EAST MOUNTAIN WEATHER STATION AND PALMER DROUGHT INDEX



East Mountain Spring: 79-26
Water Quality Data: Operational
Mine Association: Wilberg/Cottonwood
Date of Development: No Developmental Mining
Date of Second Mining: None

Historical Data: 1979 - 2012

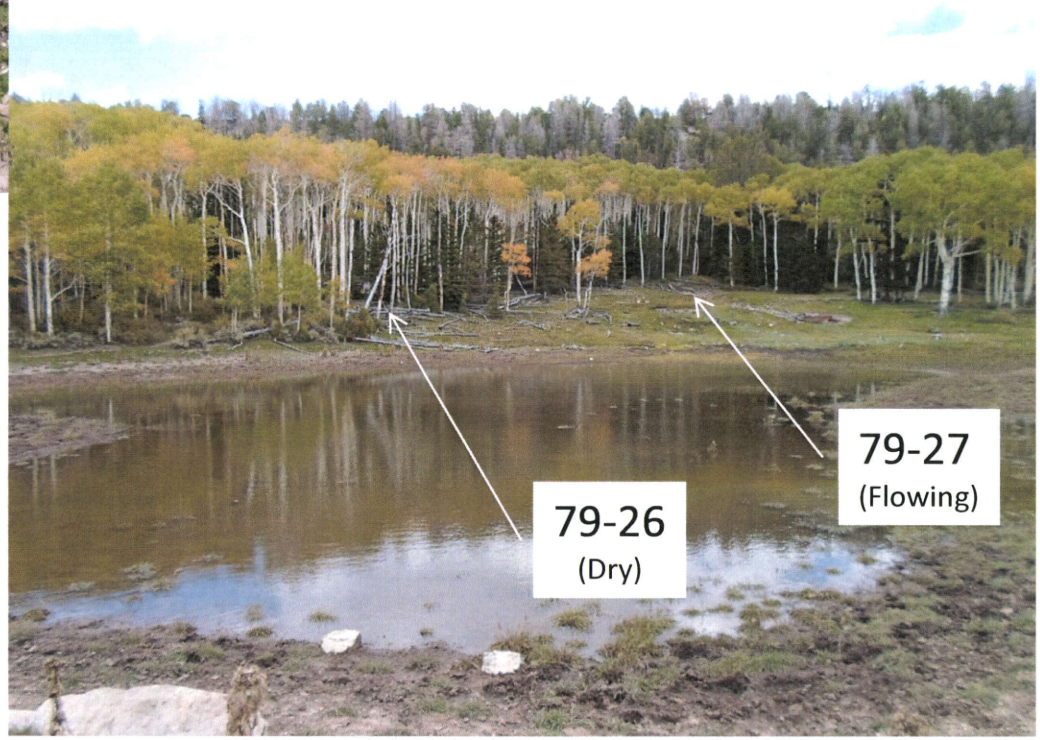
	MAXIMUM	MINIMUM	AVERAGE	# ANALYSIS
BICARBONATE	368	249	320.46	35
CALCIUM	127	33.5	54.45	37
CARBONATE	30	0	4.65	20
CHLORIDE	10	4	6.44	32
CONDUCTIVITY	615	431	523.00	38
DISSOLVED OXYGEN	9.7	5.1	7.61	10
FLOW	10	0.33	3.34	40
HARDNESS	329	198	265.74	35
TOTAL IRON	2.7	0.05	0.46	16
DISSOLVED IRON	0.46	0	0.14	16
MAGNESIUM	37.1	9	31.16	37
DISSOLVED MANGANESE	0.09	0.002	0.02	8
MANGANESE	0.04	0	0.02	19
OIL AND GREASE	0.1	0.1	0.10	1
PH	8.6	6.9	8.10	41
POTASSIUM	7	0.3	1.51	21
SET SOLIDS				
SODIUM	29	11.6	15.52	32
SULFATE	120	8	19.59	33
SUSPENDED SOLIDS	39.4	2	15.42	13
TEMPERATURE				
TOTAL DISSOLVED SOLIDS	482	240	292.94	33

East Mountain Spring: 79-32
Water Quality Data: Operational
Mine Association: Wilberg/Cottonwood
Date of Development: No Developmental Mining
Date of Second Mining: None

Historical Data: 1979 - 2012

	MAXIMUM	MINIMUM	AVERAGE	# ANALYSIS
BICARBONATE	607	338	479.74	27
CALCIUM	261	39.7	90.81	26
CARBONATE	25	0	4.00	10
CHLORIDE	28.7	14	17.99	26
CONDUCTIVITY	1489	700	896.08	26
DISSOLVED OXYGEN	12.3	5.1	7.40	5
FLOW	3	0.23	0.98	27
HARDNESS	698	338	429.77	22
TOTAL IRON	6.87	0.2	2.05	17
DISSOLVED IRON	2.99	0	0.36	16
MAGNESIUM	66.7	14.2	52.17	26
DISSOLVED MANGANESE	0.341	0.018	0.09	11
MANGANESE	0.14	0.003	0.05	9
OIL AND GREASE	0.6	0.6	0.60	1
PH	8.29	6.95	7.83	27
POTASSIUM	8	0.95	2.36	26
SET SOLIDS				
SODIUM	45.55	21	35.52	26
SULFATE	412	24	95.93	27
SUSPENDED SOLIDS	168.8	0.5	22.88	10
TEMPERATURE	56	4.4	17.06	27
TOTAL DISSOLVED SOLIDS	979	327	529.11	27

Spring: 79-26



Elevation: 9,354 feet
Coordinate: N 39°20'18.9“ W 111°10'16.8"
Aspect: West
Associated Formation: North Horn
Note: The area above historic spring location is wet and marshy. However, no flow emanates from this area.

Spring: 79-32

Elevation: 8,898 feet
Coordinate: N 39°20'09.2“ W 111°10'44.9"
Aspect: Southwest
Associated Formation: Base of North Horn
Note: Spring developed by Cattlemen’s Association but not maintained.

Location: Section 15, Township 17 South, Range 7 East, SLB&M. These sites are located within the Deer Creek and Wilberg/Cottonwood mine permit boundary and within the Federal Coal lease U-040151.

Lease Association: Both 79-23 and 79-24 are located in federal coal lease U-040151. The lease was acquired from the Church of Jesus Christ of Latter Day Saints in 1999. Both the Hiawatha and Blind Canyon seams have been mined in this lease. Room and pillar mining began the Blind Canyon Seam in 1974 from Deer Creek's 2nd South Mains. From the Wilberg/Cottonwood Mine, 1 ½ North was advanced in the Hiawatha Seam. Longwall mining occurred east of the springs in the Blind Canyon Seam (Deer Creek 1987) and Hiawatha Seam (Wilberg/Cottonwood Mine 1994).

Subsidence: Maximum subsidence in area east and adjacent to the springs has stabilized at approximately 13 feet. The 2003 Annual Subsidence Report reported that the subsidence has been stable since at least 1995. The springs are outside of the subsided areas.

Additional data from the 2004 Annual Subsidence Report is included herein.

Water Data: Historic water quality data is included for springs 79-23 and 79-24. Data show no abnormalities in the water quality parameters for this area of East Mountain. Historic flow data has been collected since 1983 and has continued through 2012. This information is found on the following page where July spring flow is plotted against precipitation data collected from the East Mountain weather station, as well as the Palmer Drought Index for regions 4, 5, and 6. The East Mountain weather station is located on the southern tip of East Mountain. Spring 79-23 stopped flowing in 1987. There has been no report of flow since that time except for a small flow of 0.2 gpm in 1998. The mode of occurrence for this site is flow along permeable strata underlain by impermeable mudstone which intersects the land surface. The stratigraphic location of this site is the base of the North Horn Formation.

Spring 79-24 stopped flowing in 1989. There has been little report of flow since that time. In 1998, a flow of 1.0 gpm was reported. The mode of occurrence for this site has not been identified. The stratigraphic location of this site is the Price River Formation.

Justification for removal from monitoring: Sites 79-23 and 79-24 have been monitored by Energy West Mining Company since 1979. The springs are located in the base of side drainage of the Left Fork of Grimes Wash. Spring 79-23 is located approximately 1,000 feet up drainage of 79-24. Neither spring is deep seated formational/structural type of system, rather accumulation runoff associated with the small drainage. Recharge is limited and the southern exposure restricts prolonged flow especially during periods of drought. Even in periods of reduced precipitation, it is likely that flow exist for a short time frame coinciding with the snow

melt. However, with the sampling scheduled for the month of July (normal access to East Mountain), flow from this shallow system dissipates prior to the scheduled sampling timeframe.

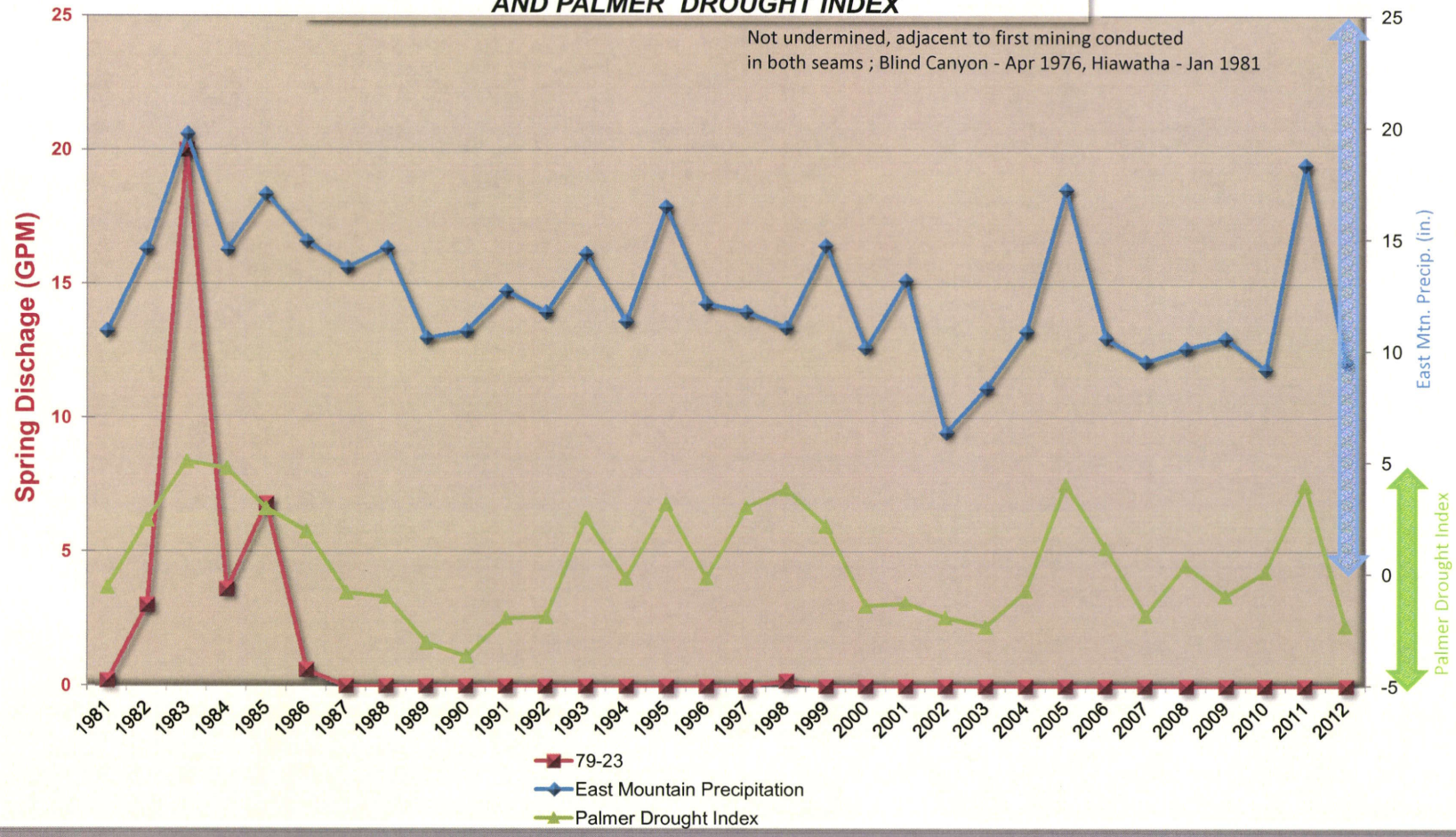
Mining occurred near the area of 79-23 prior to recorded flow (1976-1981). After mining was completed, and when the area experience above normal precipitation, the spring began discharging. This is similar to 79-24 where mining was completed in 1976 in the Blind Canyon seam. Spring discharge was recorded starting in 1981 through1986. Mining in the Hiawatha began in 1989 after spring discharged ceased. This sequence of mining events does not correlate well with the presence or absences of spring discharge. It is therefore believed that mining has not impacted these sites.

Subsidence in the area of the springs has been recorded at approximately one to two feet. No surface cracks have ever been witnessed. It is therefore believed that there have been no impacts due to subsidence.

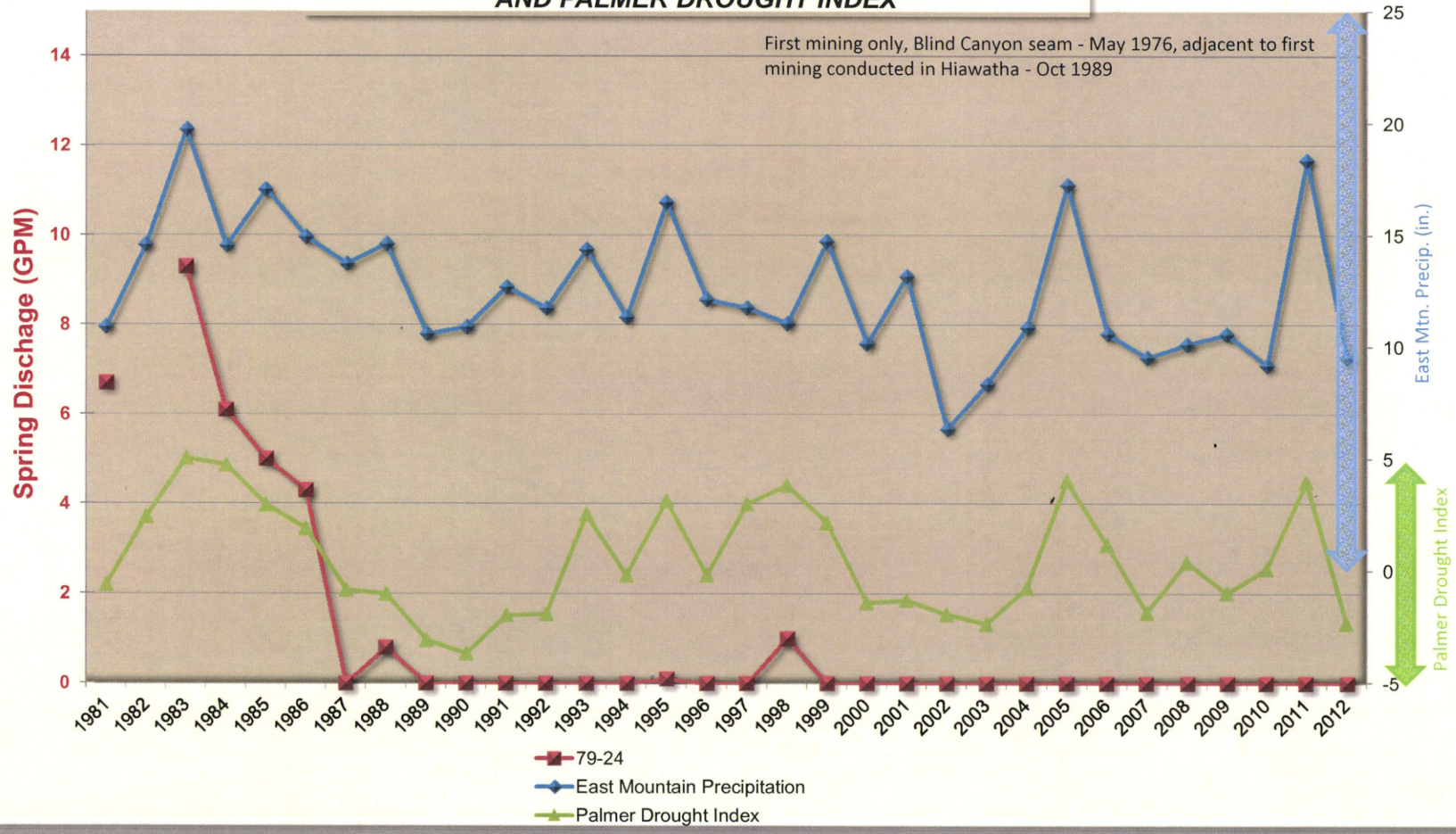
These springs were shown (refer to attached flow chart) to discharge from 1981 through 1986. However, this period of continuous discharge occurred when precipitation (snow pack) was well above normal. Energy West believes that this evidence alone shows that the springs are influenced by climatic conditions and not underground mining operations.

Although these sites are within a current federal coal lease and within the mine permit boundaries, their location is in the southern extents of the Deer Creek permit boundary where no future mining is planned. The area in the vicinity of the springs has been completely mined out in both seams of both mines. Therefore, Energy West is removing these sites from its hydrologic monitoring program and will no longer sample for quality or quantity of their discharge. If the Division does not agree with Energy West's findings, please provide compelling scientific evidence that suggests that our underground mining operations have impacted these sites.

EAST MOUNTAIN SPRINGS
SPRING: 79-23 vs. PRECIPITATION
PEAK FLOW (JULY) vs. EAST MOUNTAIN WEATHER STATION AND PALMER DROUGHT INDEX



EAST MOUNTAIN SPRINGS
SPRING: 79-24 vs. PRECIPITATION
PEAK FLOW (JULY) vs. EAST MOUNTAIN WEATHER STATION AND PALMER DROUGHT INDEX



East Mountain Spring: 79-23
Water Quality Data: Operational
Mine Association: Deer Creek Mine
Date of Development: Blind Canyon Seam: 1974-1975
Date of Second Mining: None

Historical Data: 1979 - 1986

	MAXIMUM	MINIMUM	AVERAGE	# ANALYSIS
BICARBONATE	463	343	413.13	8
CALCIUM	132	58	79.643	7
CARBONATE	1	1	1	1
CHLORIDE	13.9	10.3	11.271	7
CONDUCTIVITY	900	419	691.29	7
DISSOLVED OXYGEN				0
FLOW	20	0.2	5.6125	8
HARDNESS				0
TOTAL IRON				0
DISSOLVED IRON	0.3	0.04	0.0886	7
MAGNESIUM	48.1	22.5	38.286	7
DISSOLVED MANGANESE				0
MANGANESE	0.01	0.01	0.01	1
OIL AND GREASE	0.3	0.3	0.3	1
PH	8.3	7.3	7.725	8
POTASSIUM	7	0.5	1.5414	7
SET SOLIDS				0
SODIUM	15.5	14	14.871	7
SULFATE	91.2	9	27.188	8
SUSPENDED SOLIDS	120	0.5	19.763	8
TEMPERATURE	15.6	5	8.625	8
TOTAL DISSOLVED SOLIDS	410	292	364.25	8

East Mountain Spring: 79-24
Water Quality Data: Operational
Mine Association: Deer Creek Mine
Date of Development: Blind Canyon Seam: 1974-1975, Hiawatha Seam: 1981-1982
Date of Second Mining: None

Historical Data: 1979 - 1988

	MAXIMUM	MINIMUM	AVERAGE	# ANALYSIS
BICARBONATE	414	395	404.5	2
CALCIUM	61.5	61.5	61.5	1
CARBONATE	1	1	1	1
CHLORIDE	16.5	16.5	16.5	1
CONDUCTIVITY	700	700	700	1
DISSOLVED OXYGEN	0			0
FLOW	60	0.75	14.13	5
HARDNESS	342	342	342	1
TOTAL IRON				0
DISSOLVED IRON	7.6	0.16	3.88	2
MAGNESIUM	45.7	45.7	45.7	1
DISSOLVED MANGANESE				0
MANGANESE	0.02	0.02	0.02	1
OIL AND GREASE	0.1	0.1	0.1	1
PH	8.2	8.1	8.15	2
POTASSIUM	2.06	2.06	2.06	1
SET SOLIDS				0
SODIUM	17.8	17.8	17.8	1
SULFATE	52.3	26	39.15	2
SUSPENDED SOLIDS	673.6	30	351.8	2
TEMPERATURE	66	0.6	33.3	2
TOTAL DISSOLVED SOLIDS	584	340	462	2

Deseret Mine – 2nd North

Little Dove Mine – 1st North

FAULT

E 2,110,000

Wilberg Mine

PROFILE

PROFILE

PROFILE

PROFILE

Deer Creek – 2nd East

Deer Creek – 3rd East

Deer Creek – 4th East

Deer Creek – 5th East

Deer Creek – 6th East

Deer Creek – 7th East

Deer Creek – 8th East

Deer Creek – 9th East

Deer Creek – 1st South

Deer Creek – 2nd South

Wilberg Mine – 1st North

Deer Creek – 2nd South

79-23

79-24

E 2,108,000

N 368,000

N 366,000

AREA 2

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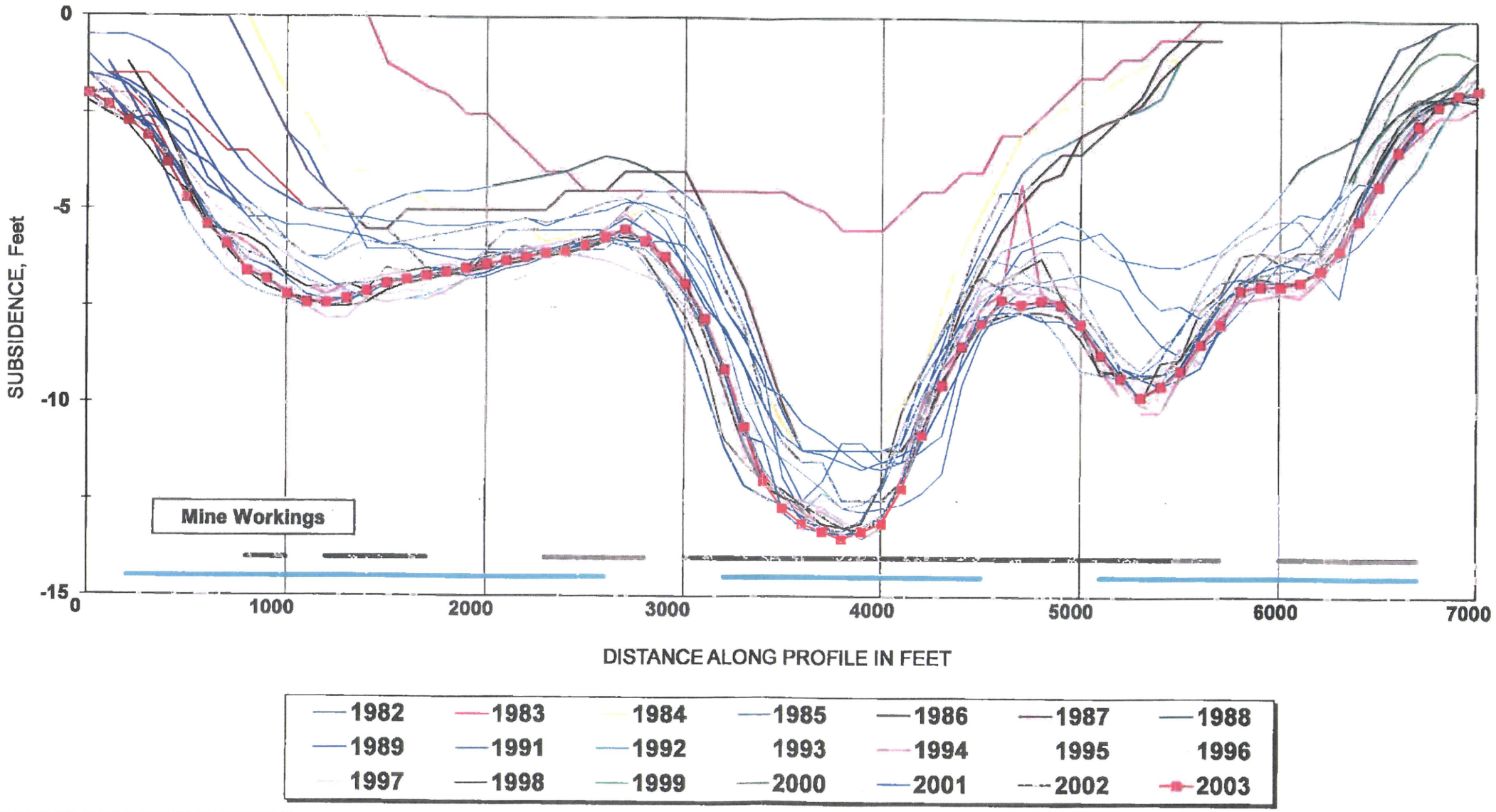
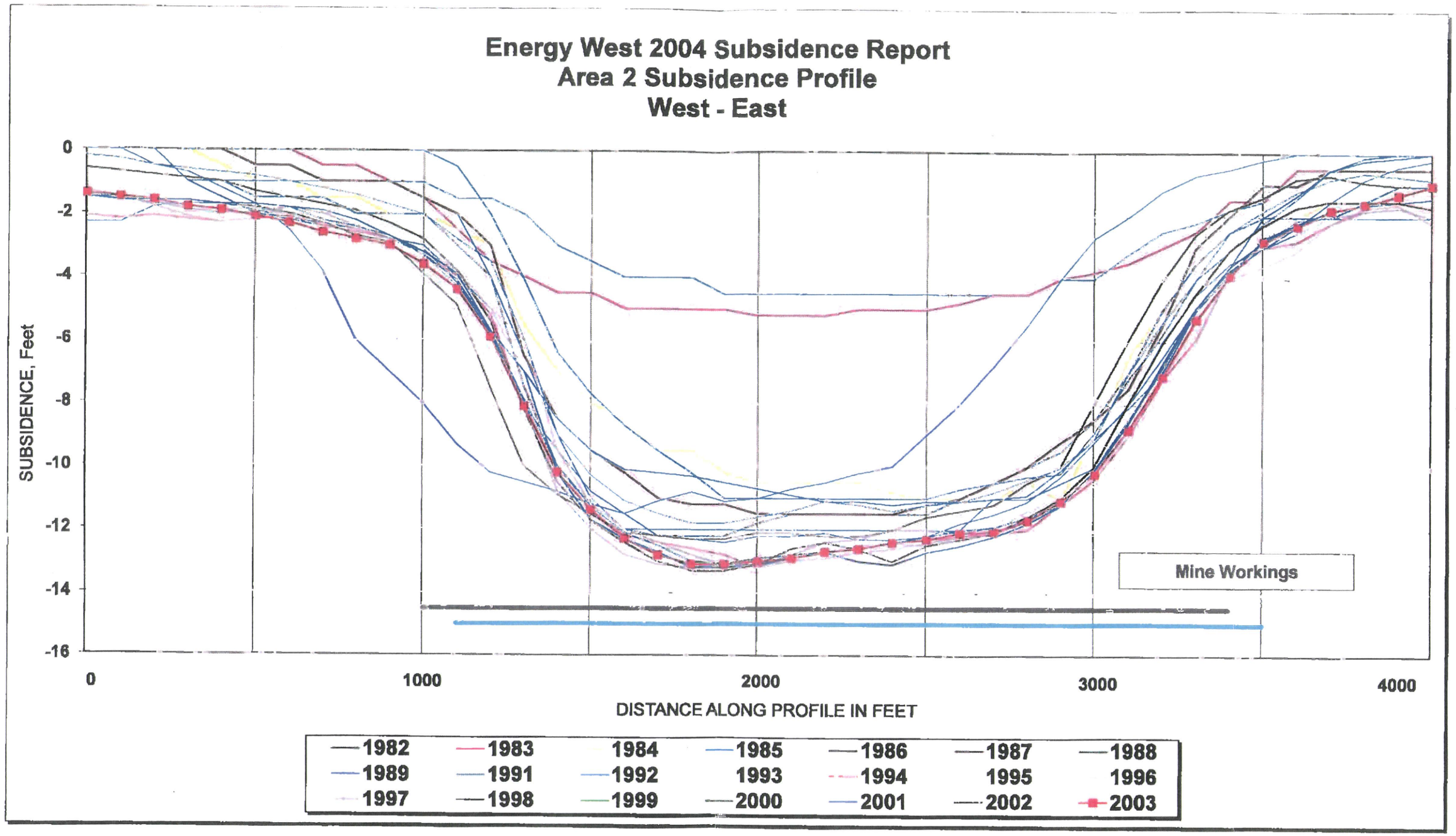
ENERGY WEST
MINING COMPANY
HUNTINGTON, UTAH 84528

2004 SUBSIDENCE – AREA 2
DEER CREEK MINE 5TH–8TH EAST
WILBERG MINE 3RD–13TH RIGHT

DRAWN BY:	K.S.F., K.J.L.	FIGURE 4	
SCALE:	1" =500'	DRAWING #:	
DATE:	MARCH 09, 2005	SHEET 1 OF 1	REV. ___

Energy West 2004 Subsidence Report
Area 2 Subsidence Profile
North - South




Energy West 2004 Subsidence Report
Area 2 Subsidence Profile
West - East
SUBSIDENCE, Feet
0
-2
-4
-6
-8
-10
-12
-14
-16
0
1000
2000
3000
4000
DISTANCE ALONG PROFILE IN FEET
Mine Workings
1982
1983
1984
1985
1986
1987
1988
1989
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003

Spring: 79-23

Elevation: 9,069 feet
Coordinate: N 39°20'26.0“ W 111°07'39.7"
Aspect: South Southeast
Associated Formation: Base of North Horn

Spring: 79-24

Elevation: 9,003 feet
Coordinate: N 39°20'20.2“ W 111°07'42.4"
Aspect: South Southeast
Associated Formation: Price River

Location: Section 16, Township 17 South, Range 7 East, SLB&M. Historically, this site was located within the Deer Creek and Wilberg/Cottonwood mine permit boundaries; however, since relinquishment of lease U-040151, (see below) the sites now lie outside any federal coal lease or mine permit boundary.

Lease Association: Burnt Tree spring was associated with federal coal lease U-040151. PacifiCorp was sublessee to the Church of Jesus Christ of Latter Day Saints which held the Federal Coal Lease. In April 1997, PacifiCorp applied for partial relinquishment of 700 acres from the lease as the area had been mined out or was unmineable due to adverse geologic, engineering, or safety conditions.

Two seams were mined within the vicinity of the Burnt Tree spring; the Blind Canyon Seam from Deer Creek Mine, and the Hiawatha Seam from the Wilberg/Cottonwood Mine. The spring lies directly over the 7th Right mined out longwall panel of the Hiawatha Seam (Wil/Cot) and on the southern edge of the C and D North mined out panels in the Blind Canyon Seam (DC). Refer to the profile attached herein called 2004 Subsidence – Area 11. The stated panel in the Hiawatha Seam was completed in 1993. The stated panel in the Blind Canyon Seam was completed in in 1987.

Subsidence: Maximum subsidence in the mined area stated above reached approximately 11 feet. However, this was in the areas where double seam extraction took place; north of the spring. The attached North/South Profile (2004 Annual Subsidence Report) shows approximately 11 feet of subsidence occurred. The West/East Profile shows approximately 10 of subsidence. Surface fractures were discovered in 1995 approximately 800 feet northwest of Burnt Tree spring. Measurements of the spring discharge throughout the summer of 1993 and 1994 indicated that the fracturing had no effect on the spring. Yearly subsidence reconnaissance indicated that subsidence was substantially complete by 1995. Refer to Supplemental Volume 1, Lease Relinquishment, tab Phase III, tab Data Summary Report.

Additional data from the 2004 Annual Subsidence Report is included herein.

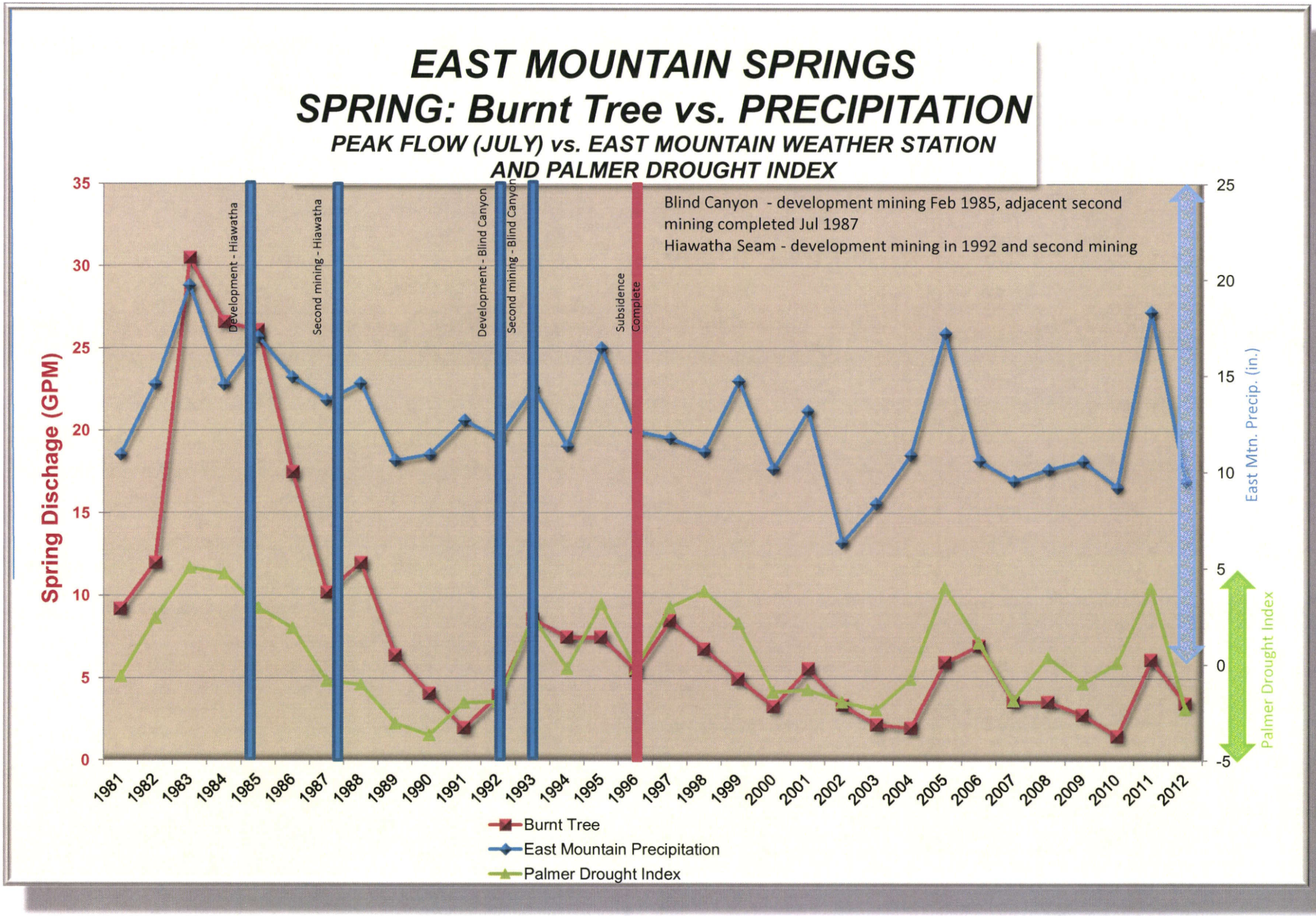
Water Data: Pre- and Post-water quality data is included for Burnt Tree spring. Data show insignificant variances between pre- and post-quality results. Historic flow data has been collected since 1983 and has continued through 2012. This information is found on the following page where July spring flow is plotted against precipitation of the East Mountain weather station, as well as the Palmer Drought Index for regions 4, 5, and 6. The East Mountain weather station is located on the southern tip of East Mountain. Spring flow shows a positive correlation with precipitation. The mode of occurrence for the Burnt Tree spring is permeable fluvial channels that intersect the land surface. The stratigraphic location for Burnt Tree spring is the North Horn Formation.

Justification for removal from monitoring: The Burnt Tree spring has been monitored by Energy West Mining Company since 1979. The site is located on the ridge above Grimes Wash. Historically, the site was developed in the 1940's as a culinary supply for the Deseret/Bee Hive mines. More recently, the site has been developed and is being utilized by the Cattlemen's Association. Recorded discharges from the spring shows that it trends nearly identical to the Palmer Hydrological Drought Index and the East Mountain weather station. This trending seems to indicate that the discharges are climatically controlled.

Like other springs located in the North Horn Formation, the Burnt Tree spring occurs in a permeable fluvial channel that intersects the land surface. The spring is underlined by impermeable mudstones that disconnect shallow formed springs from lower stratigraphic structures.

The site has been undermined in two seams. Subsidence data shows up to approximately 11 feet of subsidence to the northeast of the spring. No surface cracking is evident in the area of spring, however, surface cracks were found approximately 800 feet to the northwest. There have been no reported occurrences in which mining has impacted this site. Historic quality and quantity data has not indicated such impacts to the site.

Since the federal coal lease has been relinquished (with DOGM concurrence) and the site is no longer within the boundaries of a mine permit, Energy West Mining Company retains no legal right of entry, nor control of the site. Therefore, Energy West is removing this site from its hydrologic monitoring program and will no longer sample for quality or quantity of its discharge. If the Division does not agree with Energy West's findings, please provide compelling scientific evidence that suggests that our underground mining operations have impacted this site.


EAST MOUNTAIN SPRINGS
SPRING: Burnt Tree vs. PRECIPITATION
PEAK FLOW (JULY) vs. EAST MOUNTAIN WEATHER STATION
AND PALMER DROUGHT INDEX
Blind Canyon - development mining Feb 1985, adjacent second mining completed Jul 1987
Hiawatha Seam - development mining in 1992 and second mining
Development - Hiawatha
Second mining - Hiawatha
Development - Blind Canyon
Second mining - Blind Canyon
Subsidence Complete
Spring Dischage (GPM)
East Mtn. Precip. (in.)
Palmer Drought Index
Burnt Tree
East Mountain Precipitation
Palmer Drought Index

East Mountain Spring: Burnt Tree
Water Quality Data: Operational
Mine Association: Deer Creek Mine
Date of Development: Blind Canyon Seam: 1987, Hiawatha Seam: 1992
Date of Second Mining: Blind Canyon Seam: 1987, Hiawatha Seam: 1993

Historical Data: 1979 - 2012					Pre-Mining Data: 1979-1986				Post-Mining Data: 1994-2012				
	MAXIMUM	MINIMUM	AVERAGE	# ANALYSIS	MAXIMUM	MINIMUM	AVERAGE	# ANALYSIS	MAXIMUM	MINIMUM	AVERAGE	# ANALYSIS	
BICARBONATE	647	188	320.1	73	397	313	334.88	17	647	258	310.93	41	BICARBONATE
CALCIUM	110	38.5	58.571	80	11	48	69.107	15	57.9	49	53.72	42	CALCIUM
CARBONATE	10	0	1.275	40	1	1	1	1	10	0	1.6111	18	CARBONATE
CHLORIDE	25	2.9	5.3522	69	6.6	2	4.8063	16	7	2.9	3.7564	39	CHLORIDE
CONDUCTIVITY	620	330	513	82	590	410	514.94	16	596	450	528.24	42	CONDUCTIVITY
DISSOLVED OXYGEN	9.6	1	7.2	25	8.3	8.3	8.3	1	9.6	4.2	7.0875	8	DISSOLVED OXYGEN
FLOW	30.5	1.2	7.7831	84	30.5	1.9	16.447	17	12	1.2	5.1424	42	FLOW
HARDNESS	333	224	258.29	68				0	281	229	250.74	42	HARDNESS
TOTAL IRON	0.2	0	0.0869	19				0	0.2	0	0.0806	18	TOTAL IRON
DISSOLVED IRON	3	0	0.138	44	3	0.04	0.2725	16	0.2	0	0.0533	15	DISSOLVED IRON
MAGNESIUM	36.1	11.8	27.74	81	30.6	11.8	24.607	15	35	25.34	28.281	42	MAGNESIUM
DISSOLVED MANGANESE	0.05	0	0.0045	11				0	0.05	0	0.0045	11	DISSOLVED MANGANESE
MANGANESE	0.2	0	0.038	43	0.01	0.01	0.01	1	0.2	0	0.0633	19	MANGANESE
OIL AND GREASE	1.3	0.1	0.7	2	1.3	0.1	0.8	3				0	OIL AND GREASE
PH	8.24	6.8	7.5466	85	8	6.8	7.4872	18	7.99	7.04	7.5451	41	PH
POTASSIUM	8.5	0.02	1.1906	50	8.5	0.46	1.4072	15	5	0.514	1.1964	25	POTASSIUM
SET SOLIDS	0						.	0				0	SET SOLIDS
SODIUM	25	10	16.33	69	25	10	14.34	15	21.49	15	18.015	39	SODIUM
SULFATE	110	0.2	18.215	71	110	7.4	35.539	18	14	7	11.113	39	SULFATE
SUSPENDED SOLIDS	27	0.1	3.95	36	7	0.1	1.9	18	15	4	7	5	SUSPENDED SOLIDS
TEMPERATURE	60.8	3.4	20.381	78	12.8	3.4	6.5	17	60.8	5.1	14.94	42	TEMPERATURE
TOTAL DISSOLVED SOLIDS	367	164	286.04	71	344	258	292.18	17	350	250	282.97	39	TOTAL DISSOLVED SOLIDS

E 2,102,000

E 2,104,000

N 7,196,000

Cottonwood 2nd North

Deer Creek 3rd South

Deer Creek D North

Deer Creek C North

Deer Creek B North

Deer Creek A North

Deer Creek A South

Deer Creek 2nd South

Deer Creek Mine

Cottonwood 10th Right

Cottonwood 11th Right

Cottonwood 12th Right

FRACTURES

BURNT TREE SPRING

FAULT

FAULT

82 52

79 23

AREA 11

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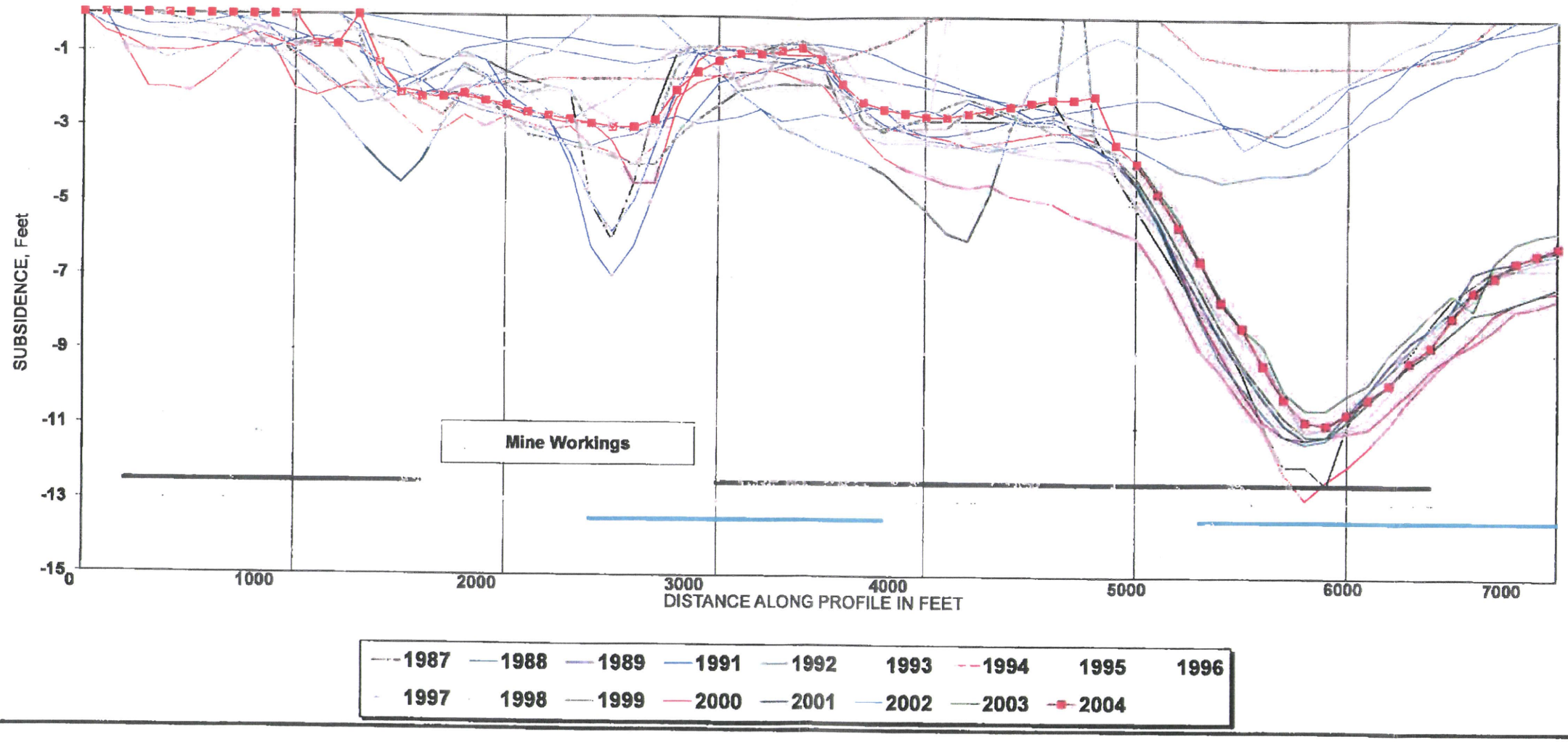
ENERGY WEST MINING COMPANY HUNTINGTON, UTAH 84528	
2004 SUBSIDENCE – AREA 11 *Deer Creek Mine C & D North Panels* *Cottonwood 11th Right Panel*	
DRAWN BY: *K.S.F., K.J.L.*	*FIGURE 7*
SCALE: *1" =500'*	DRAWING #:
DATE: *MARCH 09, 2005*	SHEET *1* OF *1* REV. ___

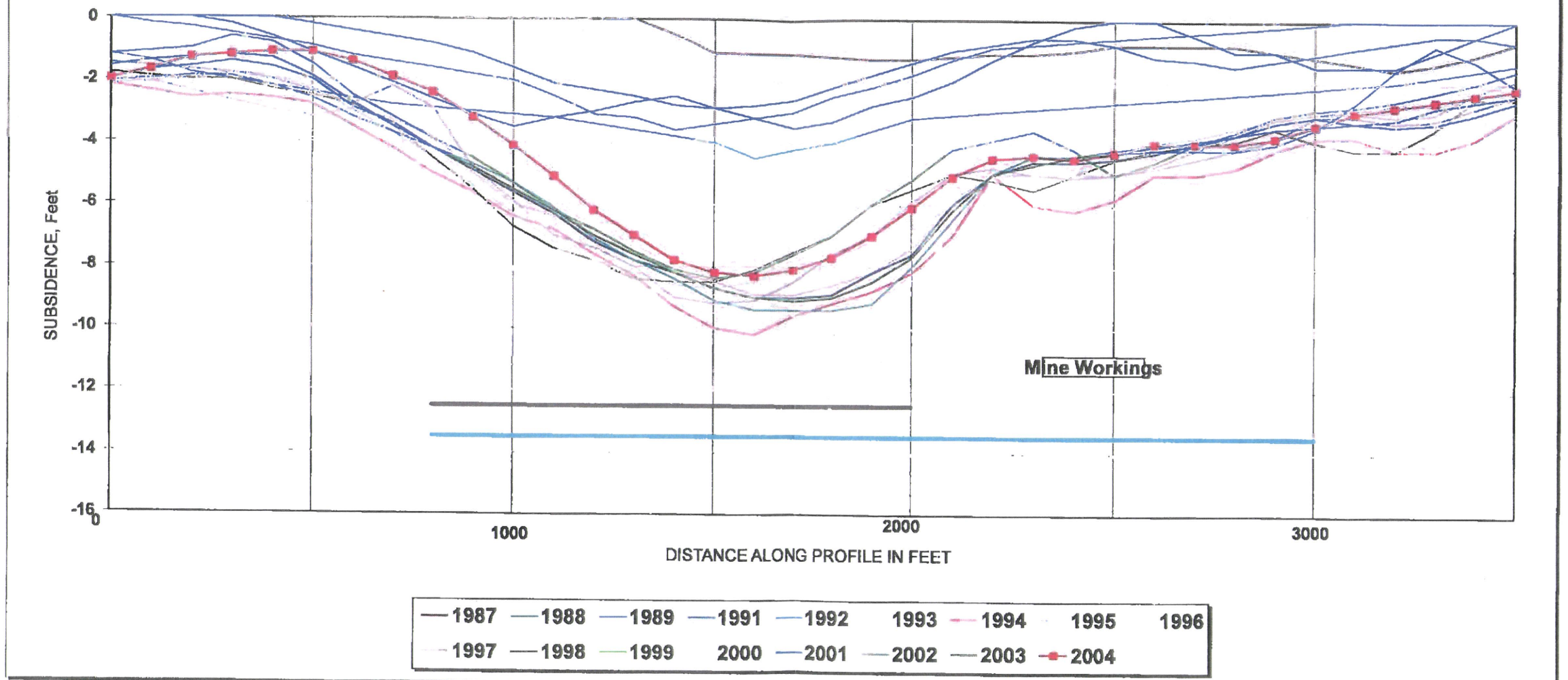
Energy West 2004 Subsidence Report
Area 11 Subsidence Profile
North - South

Chart 8



Energy West 2004 Subsidence Report
Area 11 Subsidence Profile
West - East

Chart 9



Spring: Burnt Tree

Elevation: 9,277 feet
Coordinate: N 39°20'12.6“W 111°08'18.9"
Aspect: Southeast
Associated Formation: North Horn

Location: Sections 20 and 21, Township 17 South, Range 7 East, SLB&M. These sites are located within the Deer Creek and Wilberg/Cottonwood Mine permit boundaries.

Lease Association: Springs 79-2, 79-40, 80-41, and 80-44 are associated with federal coal lease U-040151. PacifiCorp is the leaseholder of U-040151. Spring 80-43 is associated with federal coal lease U-083066. Panel development off of the 3rd South Mains was started in 1980 in the Blind Canyon Seam (DC) for the 1st thru 7th Right longwall panels. These panels undermine all the above stated springs. Extraction of these panels under the springs was completed in 1986. Panel extraction continued northward and was completed in 1991

For development in the Hiawatha Seam (Wilberg/Cottonwood Mine) near the vicinity of the springs, the 2nd thru 6th Left longwall panel began in 1992 and was completed in 1995.

Double seam mining was only conducted below spring 79-2.

Subsidence: Maximum subsidence in the mined area stated above reached approximately 13 feet. This was in areas where double seam extraction took place (3rd thru 5th Right longwall panel (DC) and the 2nd thru 5th Left panel (WIL/CTW)). The attached map (2004 Annual Subsidence Report) shows the springs location relative to the maximum subsidence. Fractures were discovered in 1995 along the western extent of the 5th, 6th, and 7th Right longwall panels. The subsidence was virtually unchanged between 1995 and 2004 as shown in the subsidence profile charts attached herein. Refer to Supplemental Volume 1, Lease Relinquishment, tab Phase III, tab Data Summary Report, pages 18 -23, for more detailed information.

Additional data from the 2004 Annual Subsidence Report is included herein.

Water Data: There are two years of pre-mining water quality data for spring 79-2 as monitoring began in 1979. Underground mining in the vicinity of this spring was completed in 1995. Data show insignificant variances between pre- and post-mining quality results.

Pre-mining water quality data is attached for spring 79-40. Monitoring for quality parameters began in 1979 and continued through 2012. Data show insignificant variances between pre- and post-mining quality results.

Pre-mining water quality data is attached for spring 80-41. Monitoring for quality parameters began in 1980 and continued through 2012. Data show insignificant variances between pre- and post-mining quality results.

Pre-mining water quality data is attached for spring 80-43. Monitoring for quality parameters began in 1980 and continued through 2012. Data show insignificant variances between pre- and post-mining quality results.

Pre-mining water quality data is also attached for spring 80-44. Monitoring for quality parameters began in 1980 and continued through 2012. Data show insignificant variances between pre- and post-mining quality results.

Historic flow data has been collected for springs 79-2, 79-40, 80-41, 80-43, and 80-44. Flows are graphed from 1981 through 2012. This information is include for these springs where July spring flow is plotted against precipitation of the East Mountain weather station, as well as the Palmer Drought Index for regions 4, 5, and 6. The East Mountain weather station is located on the southern tip of East Mountain. Spring flow shows a positive correlation with precipitation

The mode of occurrence for springs 79-2 and 80-43 is permeable fluvial channels that intersect land surface. The stratigraphic location for these springs is the North Horn Formation. The mode of occurrence for 79-40, 80-41, and 80-44 has not been identified and the springs are stratigraphically located in the Price River Formation.

Justification for removal from monitoring: Sites 79-2, 79-40, 80-41, 80-43, and 80-44 have been monitored since 1979 by Energy West Mining Company. All of the springs are located in the upper reaches of the Left Fork of Grimes Wash. As mentioned above, 79-2 and 80-43 are found within the North Horn Formation and occur from fluvial channels that intersect the land surface. These fluvial channels lie on top of impervious mudstones without any hydrologic connection to formations below.

Although the listed springs are located within the drainage area of the Left Fork of the Grimes Wash, two springs, 80-41 and 80-44, are located on a flat bench within the canyon where recharge is limited. Their geographic location restricts prolonged flow, especially during periods of drought. Even in periods of reduced precipitation, it is likely that flow only exists for a short time frame coinciding with the snow melt. However, with the sampling scheduled for the month of July (normal access to East Mountain), flow from this shallow system often dissipates prior to the scheduled sampling timeframe. During normal periods of precipitation, the flat bench becomes saturated and areas of discharge are formed. The gradient near the 80-44 is relatively flat making sample collection difficult. Spring 80-41 is located downslope of the flat bench, thereby making sample collection more representative of the area.

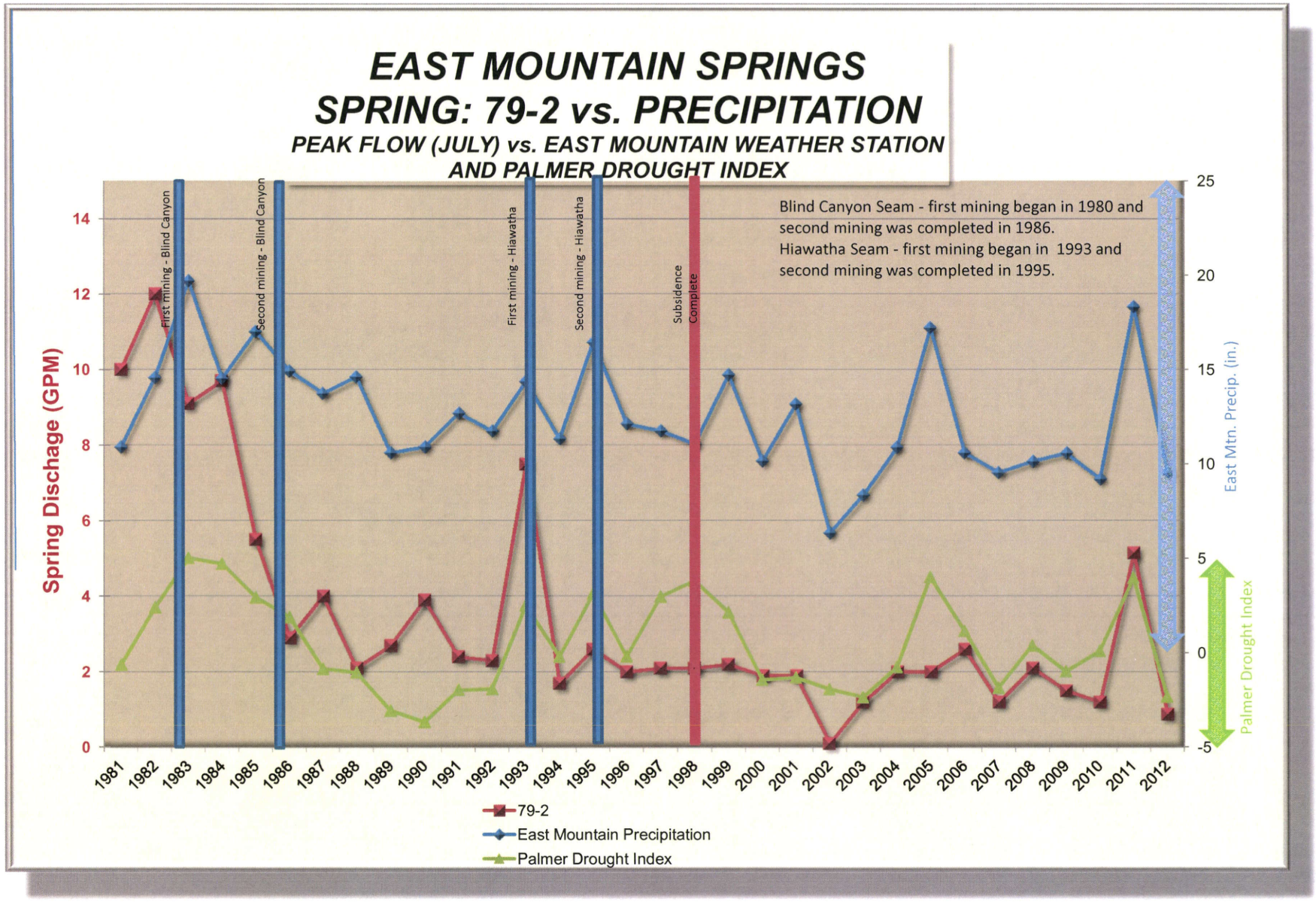
Spring 80-43 is located in the North Horn Formation near the base of the Flagstaff Limestone in the head of the Left Fork of Grimes Wash. Recharge is limited and the eastern exposure restricts prolonged flow especially during periods of drought. Even in periods of decreased precipitation, it is likely that flow only exists for a short time frame coinciding with the snow melt. However, with the sampling scheduled for the month of July (normal access to East Mountain), flow from this shallow system often dissipates prior to the scheduled sampling timeframe. Flow from the

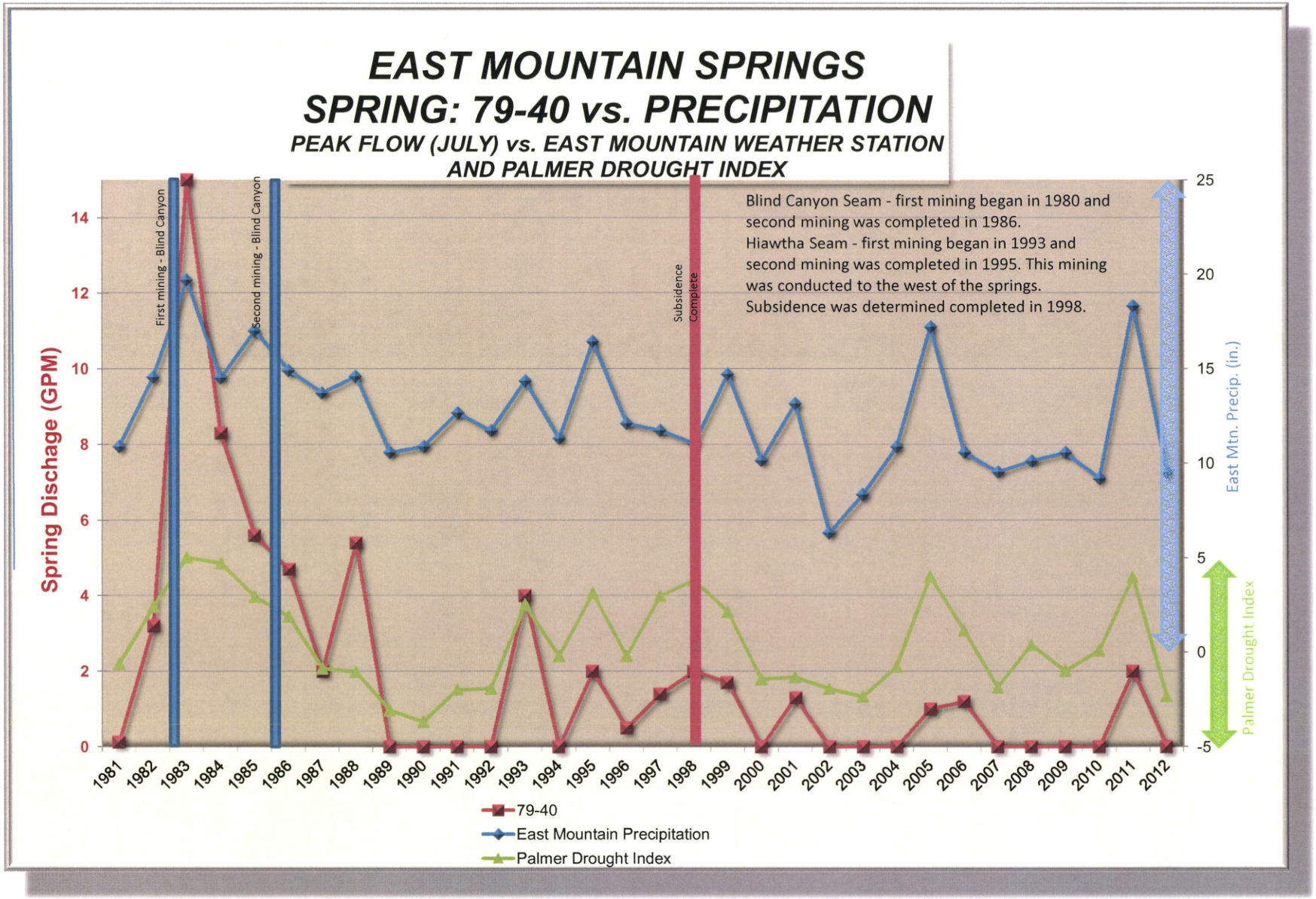
adjacent spring 79-3 is more persistent than 80-43. However, flow from both of these shallow systems is typically short lived and a direct function of the winter snowpack.

All the spring sites are within the same subsidence zone of the Deer Creek and Cottonwood longwall panels. Subsidence ranges between one and one-half feet to nine feet. Spring 80-44 experienced the least subsidence at one and one-half feet.

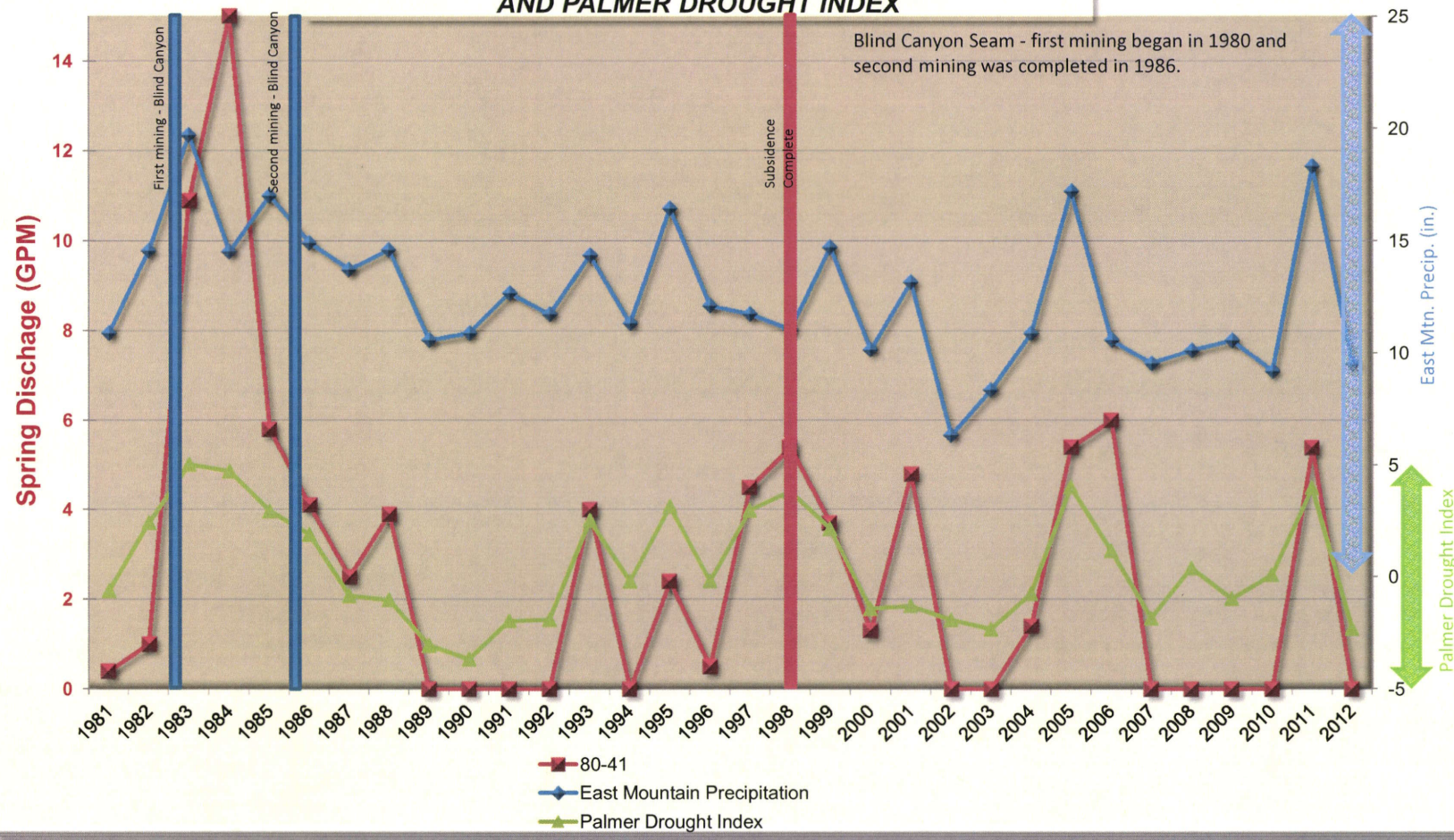
All the sites show decreases to their flow over time. Energy West believes that the decreased flow has been controlled by climatic conditions rather than by subsidence from underground mining operations. The trend of these five springs mimics the trend of springs 79-26 and 79-32 both of which have not been influenced by underground coal mining operations.

With the facts presented, Energy West is removing these sites from its hydrologic monitoring program and will no longer sample for quality or quantity of their discharge. If the Division does not agree with Energy West's findings, please provide compelling scientific evidence that suggests that our underground mining operations have impacted these sites.

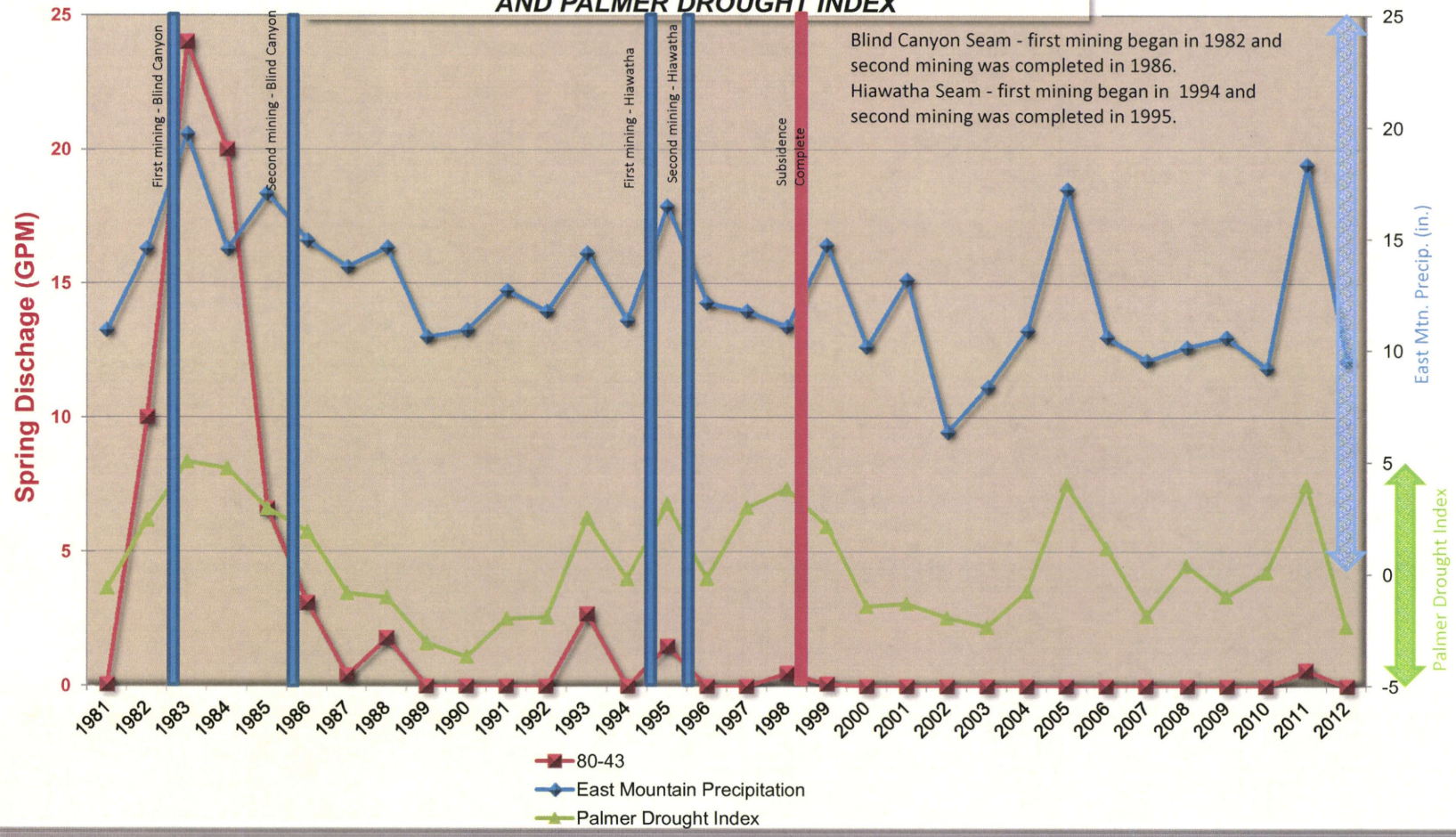

EAST MOUNTAIN SPRINGS
SPRING: 79-2 vs. PRECIPITATION
PEAK FLOW (JULY) vs. EAST MOUNTAIN WEATHER STATION
AND PALMER DROUGHT INDEX
Blind Canyon Seam - first mining began in 1980 and second mining was completed in 1986.
Hiawatha Seam - first mining began in 1993 and second mining was completed in 1995.
First mining - Blind Canyon
Second mining - Blind Canyon
First mining - Hiawatha
Second mining - Hiawatha
Subsidence Complete
Spring Dischage (GPM)
East Mtn. Precip. (in.)
Palmer Drought Index
0
2
4
6
8
10
12
14
-5
0
5
10
15
20
25
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
79-2
East Mountain Precipitation
Palmer Drought Index


EAST MOUNTAIN SPRINGS
SPRING: 79-40 vs. PRECIPITATION
PEAK FLOW (JULY) vs. EAST MOUNTAIN WEATHER STATION
AND PALMER DROUGHT INDEX
Blind Canyon Seam - first mining began in 1980 and second mining was completed in 1986.
Hiawtha Seam - first mining began in 1993 and second mining was completed in 1995. This mining was conducted to the west of the springs.
Subsidence was determined completed in 1998.
First mining - Blind Canyon
Second mining - Blind Canyon
Subsidence Complete
Spring Dischage (GPM)
East Mtn. Precip. (in.)
Palmer Drought Index
79-40
East Mountain Precipitation
Palmer Drought Index

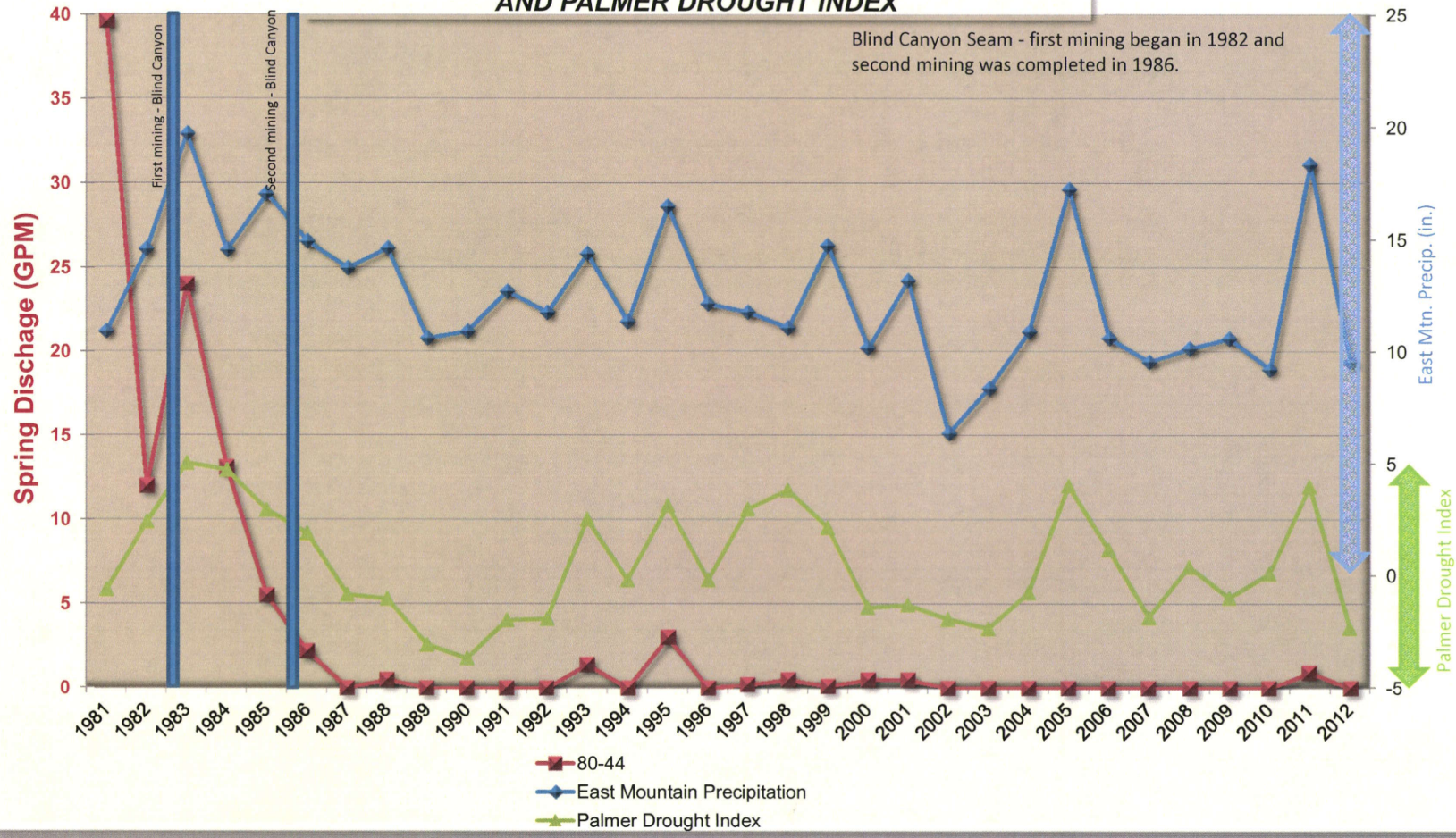
EAST MOUNTAIN SPRINGS
SPRING: 80-41 vs. PRECIPITATION
PEAK FLOW (JULY) vs. EAST MOUNTAIN WEATHER STATION AND PALMER DROUGHT INDEX



EAST MOUNTAIN SPRINGS
SPRING: 80-43 vs. PRECIPITATION
PEAK FLOW (JULY) vs. EAST MOUNTAIN WEATHER STATION AND PALMER DROUGHT INDEX



EAST MOUNTAIN SPRINGS
SPRING: 80-44 vs. PRECIPITATION
PEAK FLOW (JULY) vs. EAST MOUNTAIN WEATHER STATION AND PALMER DROUGHT INDEX



East Mountain Spring: 79-2
Water Quality Data: Operational
Mine Association: Deer Creek Mine/Wilberg/Cottonwood Mine
Date of Development: Blind Canyon Seam: 1980, Hiawatha Seam: 1994
Date of Second Mining: Blind Canyon Seam: 1986, Hiawatha Seam: 1995

Historical Data: 1987 - 2012					Pre-Mining Data: NA			
	MAXIMUM	MINIMUM	AVERAGE	# ANALYSIS	MAXIMUM	MINIMUM	AVERAGE	# ANALYSIS
BICARBONATE	422	278	334.67	51				
CALCIUM	109	55.7	66.937	51				
CARBONATE	10	0	1.28	25				
CHLORIDE	20	1.7	4.0196	51				
CONDUCTIVITY	629	331	545.18	51				
DISSOLVED OXYGEN	10.5	5.7	7.0647	17				
FLOW	7.5	0.36	1.9158	50				
HARDNESS	371	210	250.43	51				
TOTAL IRON	0.2	0	0.0533	15				
DISSOLVED IRON	0.29	0	0.0615	27				
MAGNESIUM	25.7	17	20.191	51				
DISSOLVED MANGANESE	0	0	0	10				
MANGANESE	0.2	0	0.0338	24				
OIL AND GREASE				0				
PH	8.5	6.8	7.4814	50				
POTASSIUM	7.9	0.07	1.0513	33				
SET SOLIDS				0				
SODIUM	43.31	5.2	27.556	51				
SULFATE	50	5	14.792	51				
SUSPENDED SOLIDS	44	1	6.3889	18				
TEMPERATURE	46.4	2.6	17.076	47				
TOTAL DISSOLVED SOLIDS	352	174	304.36	50				

East Mountain Spring: 79-40
Water Quality Data: Operational
Mine Association: Deer Creek Mine/Wilberg/Cottonwood Mine
Date of Development: Blind Canyon Seam: 1980, Hiawatha Seam: 1994
Date of Second Mining: Blind Canyon Seam: 1986, Hiawatha Seam: 1995

Historical Data: 1979 - 2011					Pre-Mining Data: 1979-1981				Post-Mining Data: 1996-2011				
	MAXIMUM	MINIMUM	AVERAGE	# ANALYSIS	MAXIMUM	MINIMUM	AVERAGE	# ANALYSIS	MAXIMUM	MINIMUM	AVERAGE	# ANALYSIS	
BICARBONATE	451	306	402.41	17	422	306	364	2	443	354	403	7	BICARBONATE
CALCIUM	110	41.8	77.629	16	71.6	71.6	71.6	1	87.9	67	79.837	7	CALCIUM
CARBONATE	15	0	4.25	4				0	0	0	0	1	CARBONATE
CHLORIDE	10.6	6	7.3188	16	6.2	6.2	6.2	1	9	6	7.1429	7	CHLORIDE
CONDUCTIVITY	900	523	691.88	16	590	590	590	1	794	523	710.14	7	CONDUCTIVITY
DISSOLVED OXYGEN	8.5	5.2	6.6333	3				0	6.2	6.2	6.2	1	DISSOLVED OXYGEN
FLOW	15	0.13	3.0812	17	0.4	0.13	0.265	2	2	1	1.5071	7	FLOW
HARDNESS	351	194	301.27	11				0	351	270	318.71	7	HARDNESS
TOTAL IRON	0.37	0	0.152	5				0	0.37	0	0.14	4	TOTAL IRON
DISSOLVED IRON	4.2	0	0.495	10	4.2	4.2	4.2	1	0	0	0	1	DISSOLVED IRON
MAGNESIUM	32	18.3	27.054	16	18.3	18.3	18.3	1	32	25	28.994	7	MAGNESIUM
DISSOLVED MANGANESE	0.021	0	0.0077	3				0	0.021	0	0.0077	3	DISSOLVED MANGANESE
MANGANESE	0.1	0	0.0286	5				0	0.33	0	0.0015	2	MANGANESE
OIL AND GREASE	0.1	0.1	0.1	1	0.1	0.1	0.1	1				0	OIL AND GREASE
PH	8.4	7.07	7.7582	17	8.4	8.1	8.2	2	8.02	7.6	7.8114	7	PH
POTASSIUM	7	0.5	1.8342	12	1	1	1	1	6.41	0.86	2.72	3	POTASSIUM
SET SOLIDS				0				0				0	SET SOLIDS
SODIUM	51	11.8	36.646	16	11.8	11.8	11.8	1	42	27.5	35.104	7	SODIUM
SULFATE	139	4.1	38.912	17	30.4	4.1	17.25	2	45	32	37.857	7	SULFATE
SUSPENDED SOLIDS	407.6	0.5	57.567	9	407.6	2	204.8	2				0	SUSPENDED SOLIDS
TEMPERATURE	58	3.9	15.047	17	5	3.9	4.45	2	11.7	4.2	6	7	TEMPERATURE
TOTAL DISSOLVED SOLIDS	450	320	397.12	17	385	333	359	2	450	406	421.14	7	TOTAL DISSOLVED SOLIDS

East Mountain Spring: 80-41
Water Quality Data: Operational
Mine Association: Deer Creek Mine/Wilberg/Cottonwood Mine
Date of Development: Blind Canyon Seam: 1980, Hiawatha Seam: 1994
Date of Second Mining: Blind Canyon Seam: 1986, Hiawatha Seam: 1995

Historical Data: 1980 - 2011					Pre-Mining Data: 1980				Post-Mining Data: 1995 - 2011				
	MAXIMUM	MINIMUM	AVERAGE	# ANALYSIS	MAXIMUM	MINIMUM	AVERAGE	# ANALYSIS	MAXIMUM	MINIMUM	AVERAGE	# ANALYSIS	
BICARBONATE	495	343	411.37	27	495	358	426.5	2	469	343	407.69	16	BICARBONATE
CALCIUM	190	51.5	88.471	27	89.5	63	76.25	2	97.2	77	88.414	16	CALCIUM
CARBONATE	30	0	6.4	5				0	0	0	0	2	CARBONATE
CHLORIDE	13.3	5.7	9.2556	27	13.3	5.7	9.5	2	11	7	8.9938	16	CHLORIDE
CONDUCTIVITY	1000	600	797.19	27	800	600	700	2	942	756	833.25	16	CONDUCTIVITY
DISSOLVED OXYGEN	8.1	5.4	6.4333	3				0	5.8	5.8	5.8	1	DISSOLVED OXYGEN
FLOW	15	0.3	4.0329	28	14	0.4	6.4667	3	6	0.3	2.745	16	FLOW
HARDNESS	433	323	395.25	20				0	433	349	399.69	16	HARDNESS
TOTAL IRON	0.6	0	0.2133	9				0	0.6	0	0.2275	8	TOTAL IRON
DISSOLVED IRON	3	0	0.3125	12	3	3	3	1	0	0	0	2	DISSOLVED IRON
MAGNESIUM	47.1	14	40.42	27	23.6	14	18.8	2	46.6	38	43.459	16	MAGNESIUM
DISSOLVED MANGANESE	0.021	0	0.0076	5				0	0.021	0	0.0076	5	DISSOLVED MANGANESE
MANGANESE	0.1	0	0.0325	4				0	0	0	0	2	MANGANESE
OIL AND GREASE				0				0				0	OIL AND GREASE
PH	8.18	6.9	7.769	26	8	7.4	7.7	2	8.03	7.43	7.7473	15	PH
POTASSIUM	3	0.2	0.9278	18	2	0.6	1.3	2	0.88	0.68	0.7571	7	POTASSIUM
SET SOLIDS				0				0				0	SET SOLIDS
SODIUM	32	6.5	23.707	27	17.4	14	15.7	2	32	19	25.388	16	SODIUM
SULFATE	170	20.2	86.567	27	70	20.2	45.1	2	114	74	90.819	16	SULFATE
SUSPENDED SOLIDS	35.5	0.5	10.136	11	32.5	1	16.75	2				0	SUSPENDED SOLIDS
TEMPERATURE	60.7	2.2	10.13	27	4.4	2.2	3.6667	3	9	2.3	4.3313	16	TEMPERATURE
TOTAL DISSOLVED SOLIDS	551	392	476.3	27	448	396	422	2	551	457	490.44	16	TOTAL DISSOLVED SOLIDS

East Mountain Spring: 80-43
Water Quality Data: Operational
Mine Association: Deer Creek Mine/Wilberg/Cottonwood Mine
Date of Development: Blind Canyon Seam: 1982, Hiawatha Seam: 1994
Date of Second Mining: Blind Canyon Seam: 1986, Hiawatha Seam: 1995

Historical Data: 1980 - 2011					Pre-Mining Data: 1980-1981				Post-Mining Data: 1995 - 2011				
	MAXIMUM	MINIMUM	AVERAGE	# ANALYSIS	MAXIMUM	MINIMUM	AVERAGE	# ANALYSIS	MAXIMUM	MINIMUM	AVERAGE	# ANALYSIS	
BICARBONATE	384	287	348.18	11	380	380	380	1	287	287	287	1	BICARBONATE
CALCIUM	142	48.3	72.022	11	48.3	48.3	48.3	1	70.24	70.24	70.24	1	CALCIUM
CARBONATE	10	0	3	4				0	0	0	0	1	CARBONATE
CHLORIDE	6.7	2.9	4.0636	11	6.7	6.7	6.7	1	3	3	3	1	CHLORIDE
CONDUCTIVITY	600	480	537.91	11	505	505	505	1	549	549	549	1	CONDUCTIVITY
DISSOLVED OXYGEN	10.1	5.7	7.9	2				0				0	DISSOLVED OXYGEN
FLOW	24	0.4	7.3364	11	10	10	10	1	0.6	0.6	0.6	1	FLOW
HARDNESS	280	234	267	5				0	274	274	274	1	HARDNESS
TOTAL IRON	0.3	0.12	0.21	2				0	0.12	0.12	0.12	1	TOTAL IRON
DISSOLVED IRON	102	0	9.3427	11	102	102	102	1	0	0	0	1	DISSOLVED IRON
MAGNESIUM	30	20.4	25.466	11	20.4	20.4	20.4	1	23.93	23.93	23.93	1	MAGNESIUM
DISSOLVED MANGANESE	0.003	0.003	0.003	1				0	0.003	0.003	0.003	1	DISSOLVED MANGANESE
MANGANESE	0.1	0	0.035	4				0	0	0	0	1	MANGANESE
OIL AND GREASE				0				0				0	OIL AND GREASE
PH	7.95	6.75	7.5309	11	7.9	7.9	7.9	1	7.53	7.53	7.53	1	PH
POTASSIUM	3	0.2	1.0409	11	1.8	1.8	1.8	1	1.02	1.02	1.02	1	POTASSIUM
SET SOLIDS				0				0				0	SET SOLIDS
SODIUM	11	5.7	8.4264	11	5.7	5.7	5.7	1	10.81	10.81	10.81	1	SODIUM
SULFATE	160	6	23.109	11	8.2	8.2	8.2	1	10	10	10	1	SULFATE
SUSPENDED SOLIDS	20	0.5	7.4	10	0.5	0.5	0.5	1				0	SUSPENDED SOLIDS
TEMPERATURE	49	3.9	20.091	11	5.6	5.6	5.6	1	7.9	7.9	7.9	1	TEMPERATURE
TOTAL DISSOLVED SOLIDS	391	235	303	11	279	279	279	1	321	321	321	1	TOTAL DISSOLVED SOLIDS

East Mountain Spring: 80-44
Water Quality Data: Operational
Mine Association: Deer Creek Mine/Wilberg/Cottonwood Mine
Date of Development: Blind Canyon Seam: 1982, Hiawatha Seam: 1994
Date of Second Mining: Blind Canyon Seam: 1986, Hiawatha Seam: 1996

Historical Data: 1980 - 2011					Pre-Mining Data: 1980-1981				Post-Mining Data: 1997-2011				
	MAXIMUM	MINIMUM	AVERAGE	# ANALYSIS	MAXIMUM	MINIMUM	AVERAGE	# ANALYSIS	MAXIMUM	MINIMUM	AVERAGE	# ANALYSIS	
BICARBONATE	501	372	436.27	11	501	501	501	1	426	372	399	2	BICARBONATE
CALCIUM	174.3	67.8	97.577	11	67.8	67.8	67.8	1	92.95	79	85.975	2	CALCIUM
CARBONATE	1	0	0.6667	3				0	0	0	0	1	CARBONATE
CHLORIDE	16.4	8	10.873	11	16.4	16.4	16.4	1	11	8	9.5	2	CHLORIDE
CONDUCTIVITY	1100	680	867.18	11	820	820	820	1	913	807	860	2	CONDUCTIVITY
DISSOLVED OXYGEN	6.9	6.8	6.85	2				0	6.8	6.8	6.8	1	DISSOLVED OXYGEN
FLOW	39.6	0.24	10.038	12	20	20	20	2	0.92	0.24	0.58	2	FLOW
HARDNESS	420	350	385.75	4				0	420	350	385	2	HARDNESS
TOTAL IRON	0	0	0	1				0	0	0	0	1	TOTAL IRON
DISSOLVED IRON	0.3	0	0.1	10	0.08	0.08	0.08	1	0	0	0	1	DISSOLVED IRON
MAGNESIUM	52.8	25.1	41.555	11	25.1	25.1	25.1	1	45.7	37	41.35	2	MAGNESIUM
DISSOLVED MANGANESE	0.003	0.003	0.003	1				0	0.003	0.003	0.003	1	DISSOLVED MANGANESE
MANGANESE	0.03	0	0.0125	4				0	0	0	0	1	MANGANESE
OIL AND GREASE				0				0				0	OIL AND GREASE
PH	8.2	7.1	7.8564	11	8.1	8.1	8.1	1	8.12	7.75	7.935	2	PH
POTASSIUM	13	0.76	3.586	10	2.2	2.2	2.2	1	0.76	0.76	0.76	1	POTASSIUM
SET SOLIDS				0				0				0	SET SOLIDS
SODIUM	47.85	17.7	36.177	11	17.7	17.7	17.7	1	47.85	27	37.425	2	SODIUM
SULFATE	335.8	79.8	136.05	11	79.8	79.8	79.8	1	137	110	123.5	2	SULFATE
SUSPENDED SOLIDS	89	0.5	24.389	9	1	1	1	1				0	SUSPENDED SOLIDS
TEMPERATURE	75.4	4	17.22	10	5	5	5	1	11.1	4.4	7.75	2	TEMPERATURE
TOTAL DISSOLVED SOLIDS	607	439	533.91	11	476	476	476	1	578	500	539	2	TOTAL DISSOLVED SOLIDS

Deer Creek Mine – 3rd South

Cottonwood Mine – 2nd North

ALPINE SPRING

MINES SPRING

TEDS NB

E 2,100,000

PROFILE

Deer Creek 17th Right

Deer Creek 16th Right

Deer Creek 15th Right

Deer Creek 14th Right

Deer Creek 13th Right

Deer Creek 12th Right

Deer Creek 11th Right

Deer Creek 10th Right

Deer Creek 9th Right

Deer Creek 8th Right

Deer Creek 7th Right

Deer Creek 6th Right

Deer Creek 5th Right

Deer Creek 4th Right

Deer Creek 3rd Right

Deer Creek 2nd Right

Deer Creek 1st Right

Cottonwood 5th Left

Cottonwood 4th Left

Cottonwood 3rd Left

Cottonwood 2nd Left

Cottonwood 1st West

Cottonwood Main West

FRACTURES

Deer Creek Mine

Deer Creek Mine – 4th South

N 362,000

N 366,000

N 370,000

N

AREA 4

CAD FILE NAME/DISK#: J:\GED\SUBSIDENCE\2004\Area4-2004.DWG

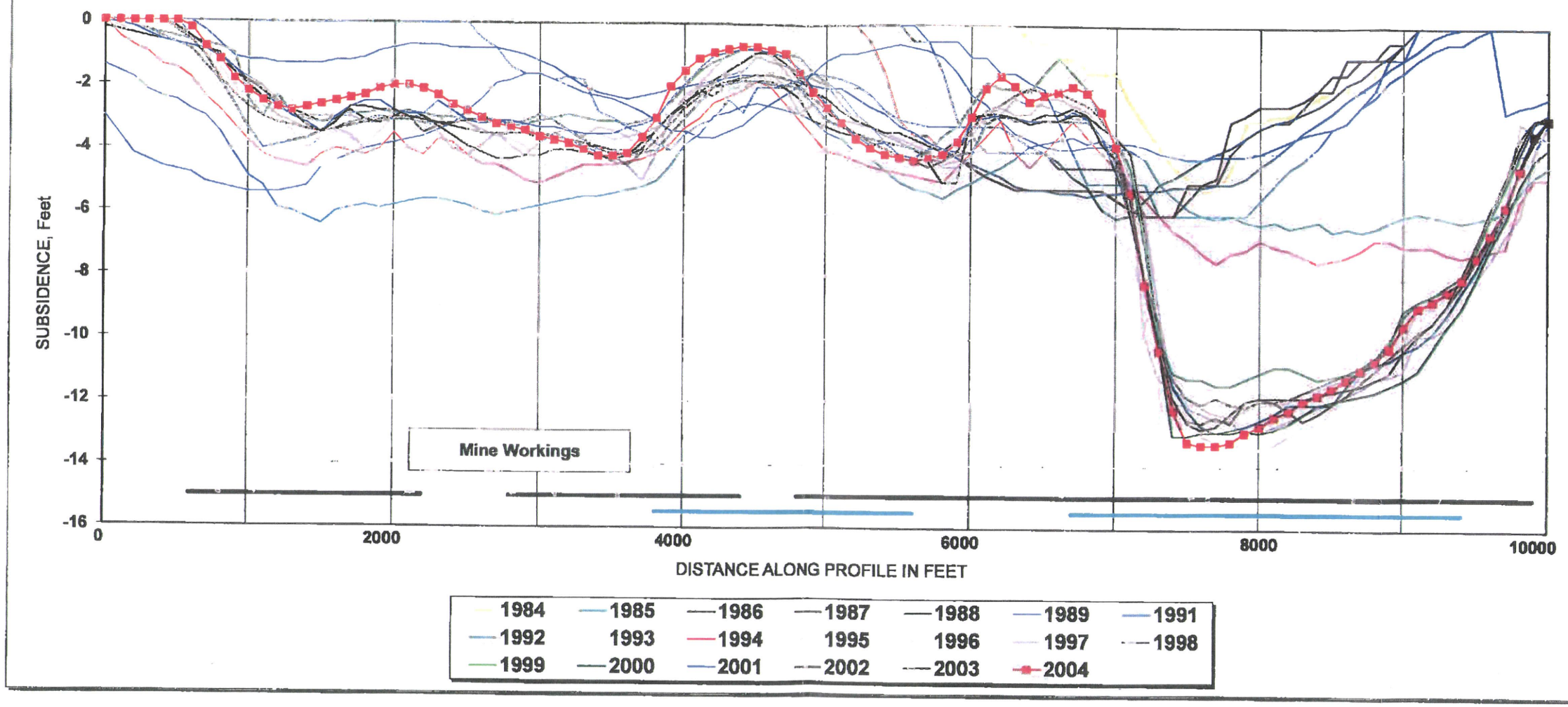
ENERGY WEST
MINING COMPANY
HUNTINGTON, UTAH 84528

2004 SUBSIDENCE – AREA 4
DEER CREEK MINE
2nd–17th Right Longwall Panels

DRAWN BY:	K.S.F., K.J.L.	FIGURE 4	
SCALE:	1"=800'	DRAWING #:	
DATE:	MARCH 09, 2005	SHEET 1 OF 1	REV. ___

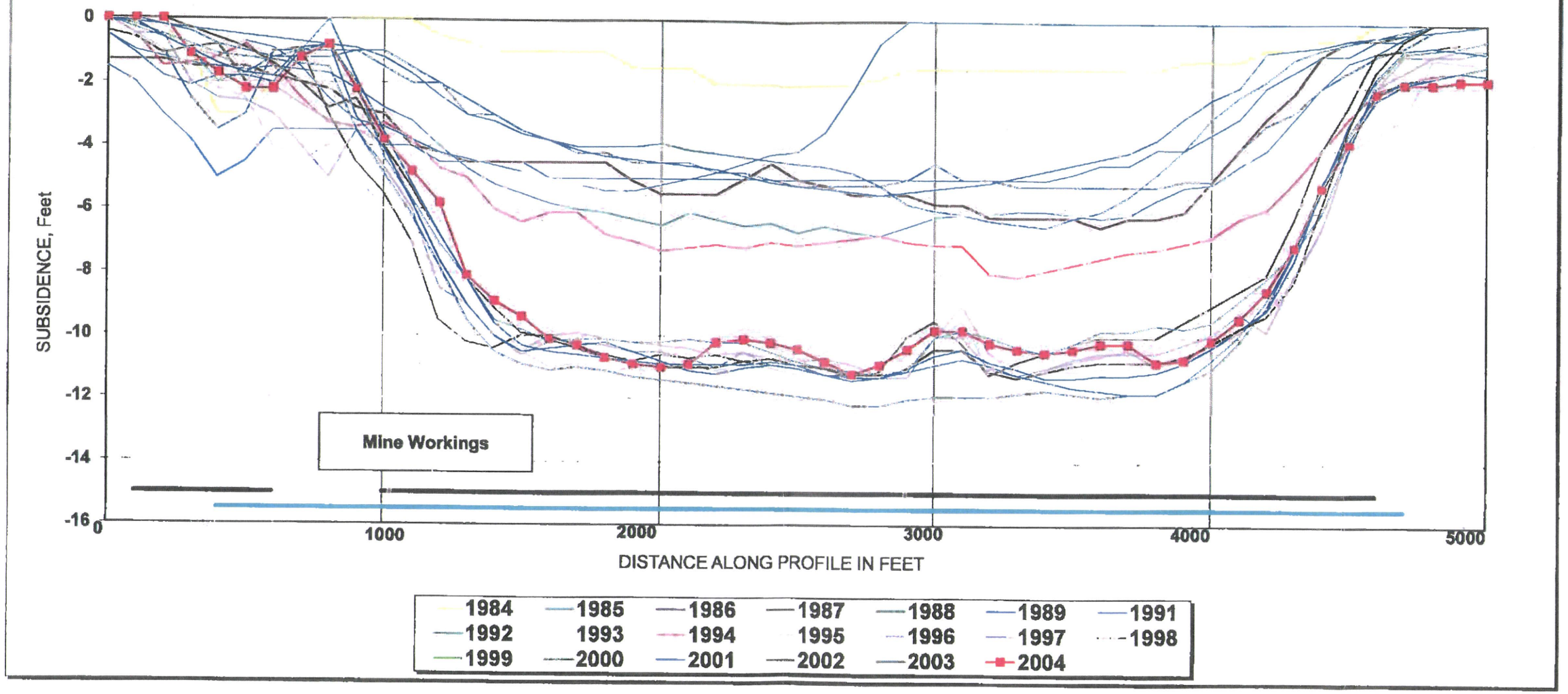
Energy West 2004 Subsidence Report
Area 4 Subsidence Profile
North - South

Chart 2



Energy West 2004 Subsidence Report
Area 4 Subsidence Profile
West - East

Chart 3



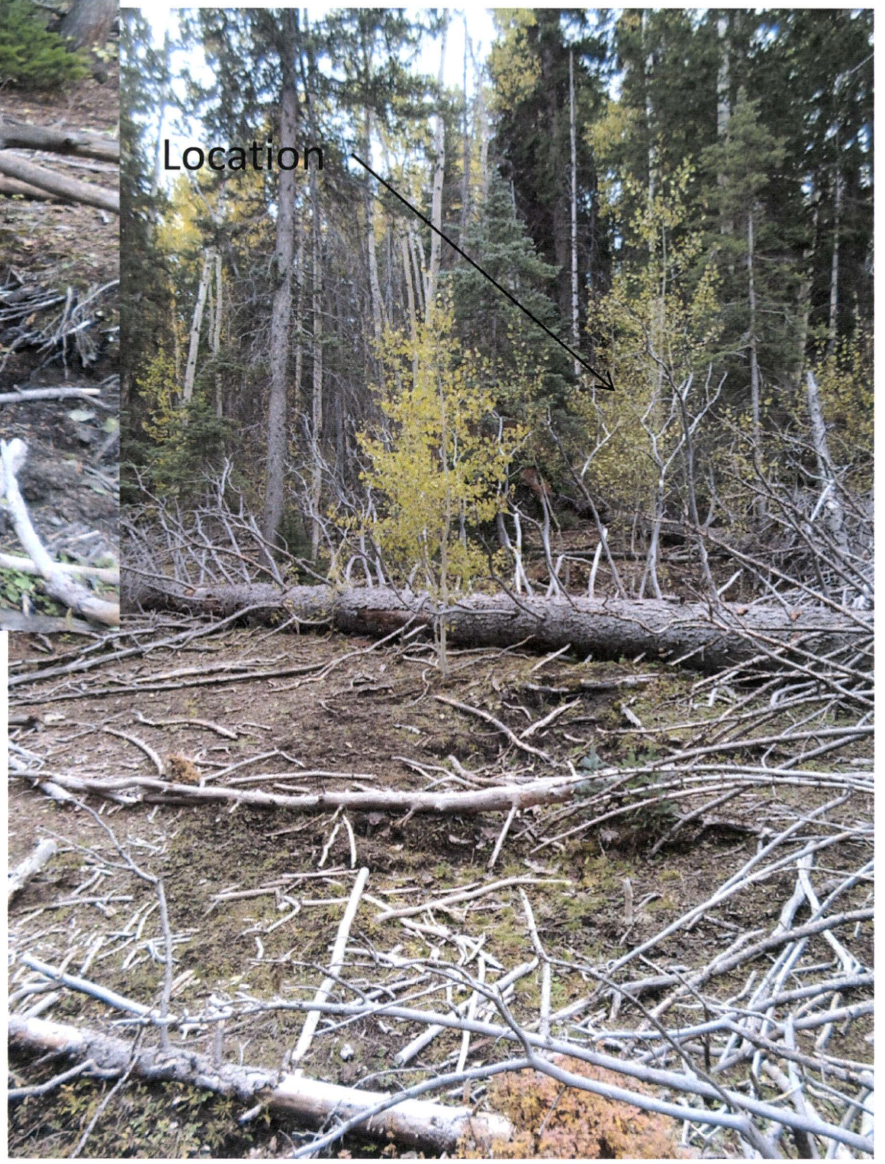
Spring: 79-2
(A.K.A. Surging Spring)

Elevation: 9,355feet
Coordinate: N 39°20'06.9" W 111°08'46.5"
Aspect: Southeast
Associated Formation: North Horn
Note: Area above spring historically was wet and marshy. Lack of precipitation has dried up Cove Reservoir directly above spring.

Spring: 79-40

Elevation: 9,050 feet
Coordinate: N 39°19'45.3“ W 111°09'02.1"
Aspect: Northwest
Associated Formation: Price River
Note: Heavy timbering conducted in this canyon during the 1990’s.

Spring: 80-41



Elevation: 9,035 feet
Coordinate: N 39°19'446.8“ W 111°08‘47.9"
Aspect: North
Associated Formation: Price River
Note: Area below spring (right) has had recorded flow in past. However, no flows are currently present. Timbering operations occurred in this canyon in 1990’s.

Spring: 80-43
(A.K.A. Dead Buck Spring)

Elevation: 9,350 feet
Coordinate: N 39°19'49.2“ W 111°09'29.0"
Aspect: East-facing
Associated Formation: North Horn

Spring: 80-44

Elevation: 8,987 feet
Coordinate: N 39°19'47.5“ W 111°08'42.2"
Aspect: North
Associated Formation: Price River
Note: Area above spring is wet and marshy. However, no flows are present. This is actually 80-44 and not as noted on placard.

Location: Section 20, Township 17 South, Range 7 East, SLB&M. Thise sites are located within the Deer Creek and Wilberg/Cottonwood mine permit boundaries.

Lease Association: Spring 78-28 (a.k.a. Flag Lake) is associated with federal coal lease U-083066. PacifiCorp is the sublessee to the Church of Jesus Christ of Latter Day Saints who is the leaseholder of U-083066. The spring is located above the coal barrier separating the Main West and Trail Mountain Access (TMA) in the Wilberg/Cottonwood Mine. These mains were developed in 1978 and 1993 respectively. The Cottonwood/Wilberg Mine was sealed in 2001. There are no current plans for re-entering this mine.

Subsidence: This area was undermined by room and pillar mining operations only. No subsidence has ever been documented.

Water Data: Pre- and Post-mining water quality data is included for spring 79-28. Historical data show insignificant variances of the results throughout history.

Historic flow data has been collected since 1981 and has continued through 2012. This information is found on the following page where July spring flow is plotted against precipitation of the East Mountain weather station, as well as the Palmer Drought Index for regions 4, 5, and 6. The East Mountain weather station is located on the southern tip of East Mountain. Spring flow has been very consistent over the time period of 1993 through 2012. The mode of occurrence for the springs is permeable fluvial channels that intersect land surface. The stratigraphic location for these springs is the North Horn Formation.

Justification for removal from monitoring: Site 79-28 has been monitored by Energy West Mining Company since 1979. The spring has a west-facing orientation and located on a bench on the western slope of East Mountain. The area where the spring is located is heavily vegetated. These areas tend to delay runoff and produce good spring flows in July.

Like other springs located in the North Horn Formation, spring 79-28 occurs in a permeable fluvial channel that intersects the land surface. The spring is underlined by impermeable mudstones that disconnects shallow formed springs from lower stratigraphic structures.

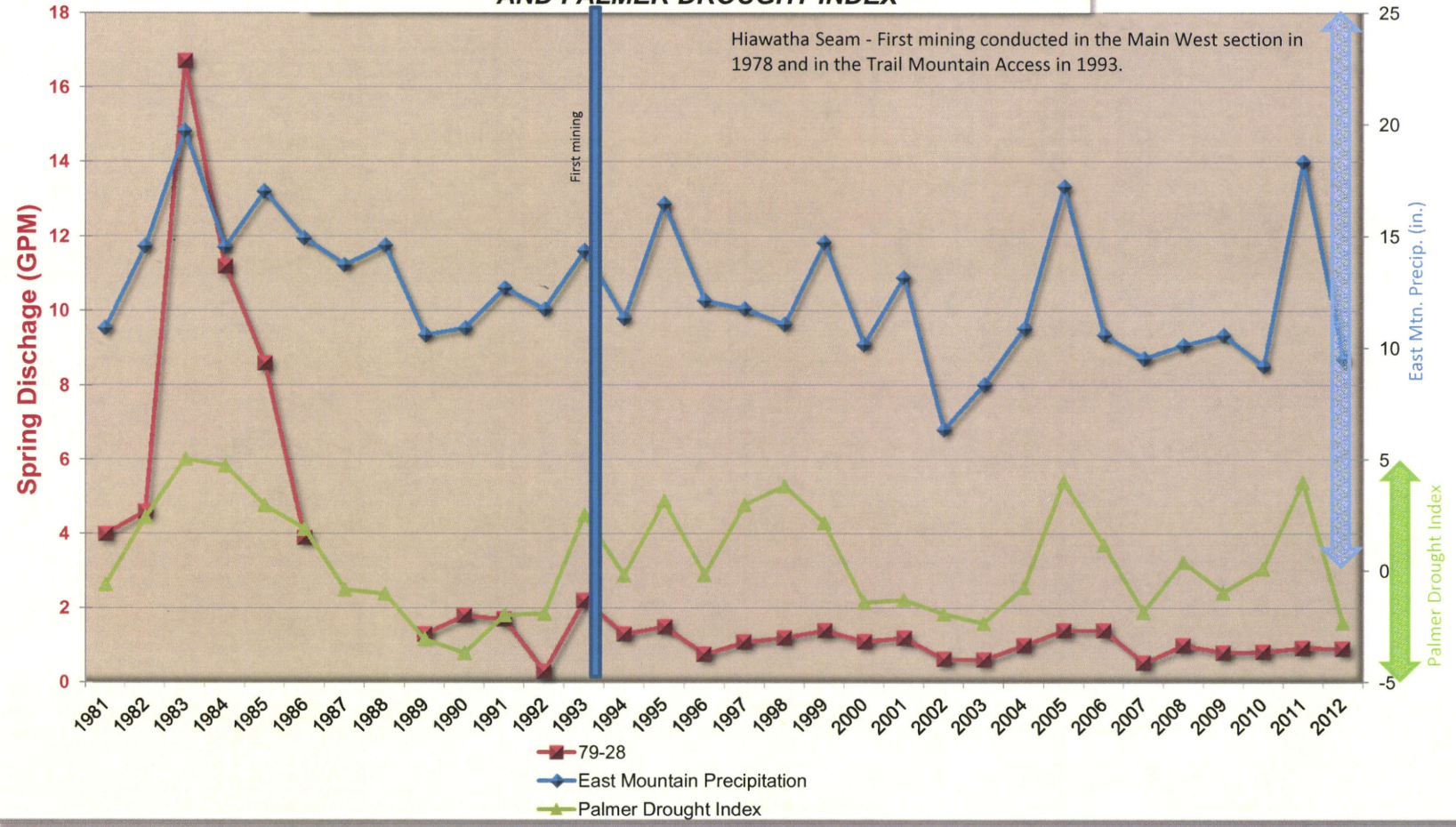
Uncharacteristically, spring 79-28 has had very consistent flow since 1993. Although there has been two major drought periods, it seems flow has not been influenced greatly. Flows have averaged about 1.0 gallon per minute.

The site is located within a current federal coal lease and within the Deer Creek mine and Wilberg/Cottonwood permit boundaries. There are no plans for any future mining in this area as this area has been completely mined out. Permanent seals have been installed underground in the Deer Creek Mine to isolate the area from the rest of the mine. The Wilberg/Cottonwood

Mine has been permanently sealed at its portals. Permanent seals eliminate the potential for any further mine development.

With the facts presented, Energy West is removing this site from its hydrologic monitoring program and will no longer sample for quality or quantity of their discharge. If the Division does not agree with Energy West's findings, please provide compelling scientific evidence that suggests that our underground mining operations have impacted this site.

EAST MOUNTAIN SPRINGS
SPRING: 79-28 vs. PRECIPITATION
PEAK FLOW (JULY) vs. EAST MOUNTAIN WEATHER STATION AND PALMER DROUGHT INDEX



East Mountain Spring: 79-28 (Flag Lake)
Water Quality Data: Operational
Mine Association: Cottonwood/Wilberg & Deer Creek Mines
Date of Development: Hiawatha Seam: 1978 (Main West Section), 1993 (Trail Mountain Access)
Date of Second Mining: None

Notes:

- Spring is located above an unmined block between Main West and TMA.
- Spring flow is very consistent.

Historical Data: 1979 - 2012					Pre-Mining Data: 1979 - 1992				Post-Mining Data: 1993 - 2012			
	MAXIMUM	MINIMUM	AVERAGE	# ANALYSIS	MAXIMUM	MINIMUM	AVERAGE	# ANALYSIS	MAXIMUM	MINIMUM	AVERAGE	# ANALYSIS
BICARBONATE	368	203	277.39	61	368	254	311.68	23	344	203	258.05	38
CALCIUM	126	32.3	47.40	61	126	32.3	63.13	23	43	33.17	38.17	38
CARBONATE	15	0	1.35	19	1	1	1	6	15	0	1.62	13
CHLORIDE	20	10	13.61	61	20	3	14.99	23	15.1	10	12.51	38
CONDUCTIVITY	840	500	700.34	61	800	500	657.52	23	840	607	720.37	38
DISSOLVED OXYGEN	10.2	5.2	6.83	16	7.5	5.4	6.89	8	10.2	5.2	6.85	8
FLOW	43	0.2	2.96	61	43	0.25	6.26	23	2.2	0.2	1.02	38
HARDNESS	428	165	208.53	46	428	165	242.88	8	335	172	201.63	38
TOTAL IRON	8.5	0.05	0.76	32	6.5	0.04	0.669	0	8.5	0.05	0.66	32
DISSOLVED IRON	2.23	0.01	0.17	34	2.23	0.02	0.23	19	2	0	0.04	15
MAGNESIUM	31.6	11.8	25.46	60	31.6	11.8	26.47	22	29	21.75	24.93	38
DISSOLVED MANGANESE	0.13	0	0.02	14					0.13	0	0.01	14
MANGANESE	0.2	0	0.02	22	0.02	0.01	0.01	6	2	0	0.03	16
OIL AND GREASE	0	0		1	0.7	0.7	0.7	1				
PH	8.4	6.9	7.49	60	8.4	6.9	7.45	23	7.91	7.22	7.5	37
POTASSIUM	9	0.04	2.08	58	9	0.04	2.64	20	5	1	1.78	38
SET SOLIDS												
SODIUM	92.8	8.61	72.17	60	92.8	8.61	56.92	22	90.58	68.5	80.64	38
SULFATE	293.8	18	127.14	61	293.8	18	121.72	23	154	90	130.08	38
SUSPENDED SOLIDS	406	0.5	19.73	27	406	0.5	20.87	23	24	4	9.5	4
TEMPERATURE	47.8	2.8	11.91	57	47.8	2.8	13.58	19	46.4	4.8	10.93	38
TOTAL DISSOLVED SOLIDS	522	300	427.23	61	522	338	417.48	23	471	300	431.87	38

Spring: 79-28
(A.K.A. Flag Lake)

Elevation: 9,272 feet
Coordinate: N 39°19'27.8" W 111°10'07.2"
Aspect: West
Associated Formation: North Horn

Location: Section 21, Township 17 South, Range 7 East, SLB&M. These sites are located within the Deer Creek and Wilberg/Cottonwood mine permit boundaries.

Lease Association: Springs 80-46 and 80-47 are associated with federal coal lease U-040151. PacifiCorp is the sublessee to the Church of Jesus Christ of Latter Day Saints which is the leaseholder of the Federal Coal Lease. The springs are located above the coal barrier separating the Main West and 1st West Mains in the Wilberg/Cottonwood Mine. These mains were developed in 1977. Two panels south of the springs (2nd and 3rd West longwall panels) have been completely extracted from the Hiawatha Seam.

Subsidence: Maximum subsidence within the area of the longwall panels reached approximately 3 to 4 feet. No subsidence is reported in the vicinity of the springs. Refer to the 2004 Annual Subsidence Report data which are included herein.

Water Data: Post-mining water quality data is included for springs 80-46 and 80-47. Historical data show insignificant variances of the results throughout history.

Historic flow data has been collected since 1981 and has continued through 2012. This information is found on the following page where July spring flow is plotted against precipitation of the East Mountain weather station, as well as the Palmer Drought Index for regions 4, 5, and 6. The East Mountain weather station is located on the southern tip of East Mountain. Spring flow shows a positive correlation with precipitation. The monitoring location for spring 80-47 was relocated to the east due to private property development. Single point monitoring includes flow from both sources (80-46 and 80-47) and has been referred to as 80-47(refer to photo). The mode of occurrence for the springs is permeable fluvial channels that intersect land surface. The stratigraphic location for these springs is the North Horn Formation.

Justification for removal from monitoring: Sites 80-46 and 80-47 have been monitored by Energy West Mining Company since 1980. The springs have a north-facing orientation and located near the ridge top of the Left Fork of the Grimes Wash. The area where the springs are located are heavily vegetated. These areas tend to delay runoff and produce good spring flows in July.

Like other springs located in the North Horn Formation, springs 80-46 and 80-47 occur in a permeable fluvial channel that intersects the land surface. The springs are underlined by impermeable mudstones that disconnects shallow formed springs from lower stratigraphic structures.

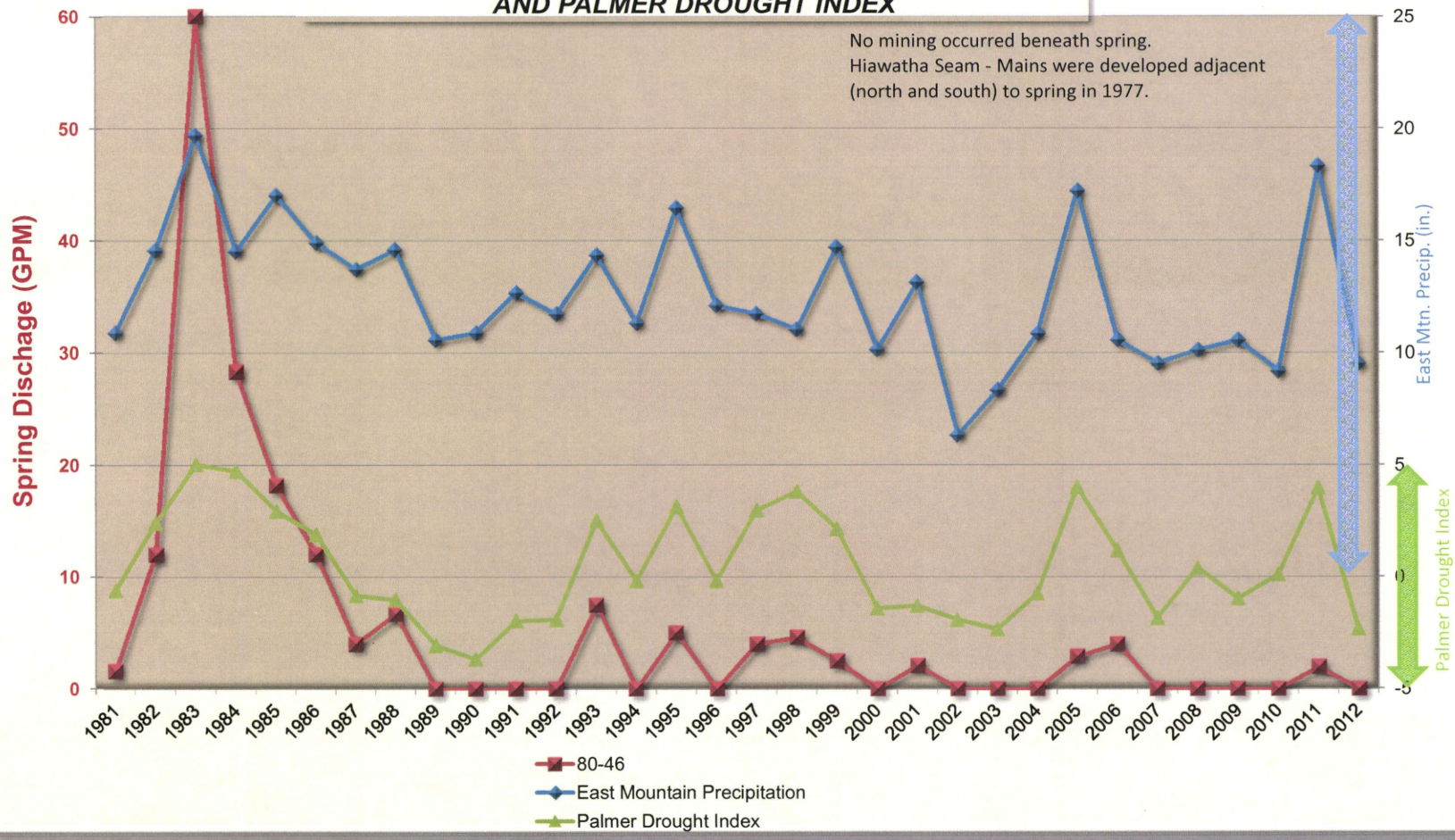
Spring flow is fairly consistent with the reported precipitation from the East Mountain weather station and the Palmer Hydrological Drought Index. The sites are located within a current federal coal lease and within the Deer Creek mine and Wilberg/Cottonwood permit boundaries. There are no plans for any future mining in this area as this area has been completely mined out.

Permanent seals have been installed underground in the Deer Creek Mine to isolate the area from the rest of the mine. The Wilberg/Cottonwood Mine has been permanently sealed at its portals. Permanent seals eliminate the potential for any further mine development.

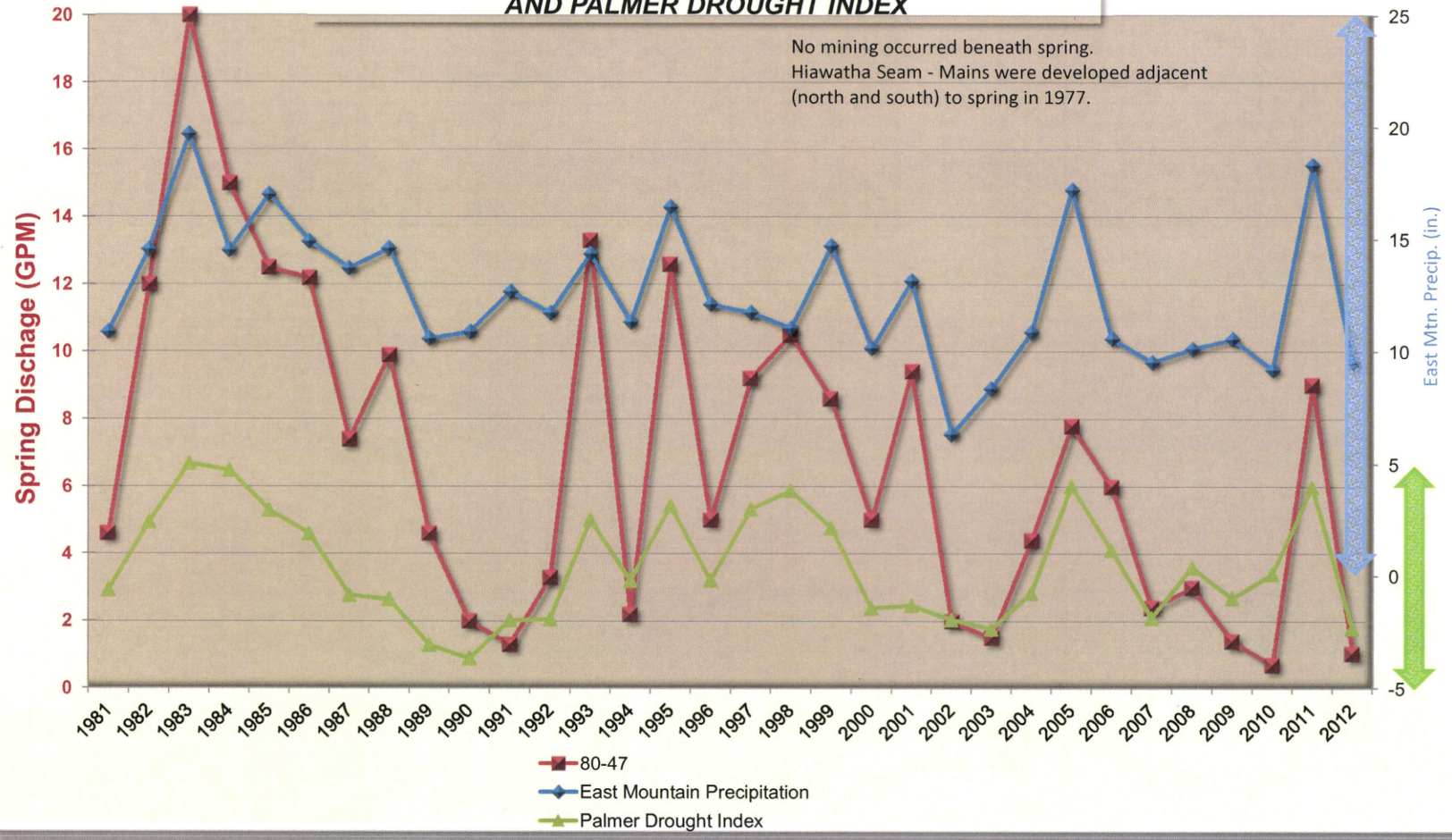
Although the site shows a general decrease to its flow over time, Energy West believes that the decreased flow has been influenced by climatic conditions and not underground mining operations. The decreasing trend of this spring mimics the trend of springs 79-26 and 79-32 both of which have not been undermine by underground coal mining operations.

With the facts presented, Energy West is removing these sites from its hydrologic monitoring program and will no longer sample for quality or quantity of their discharge. If the Division does not agree with Energy West's findings, please provide compelling scientific evidence that suggests that our underground mining operations have impacted these sites.

EAST MOUNTAIN SPRINGS
SPRING: 80-46 vs. PRECIPITATION
PEAK FLOW (JULY) vs. EAST MOUNTAIN WEATHER STATION AND PALMER DROUGHT INDEX



EAST MOUNTAIN SPRINGS
SPRING: 80-47 vs. PRECIPITATION
PEAK FLOW (JULY) vs. EAST MOUNTAIN WEATHER STATION AND PALMER DROUGHT INDEX



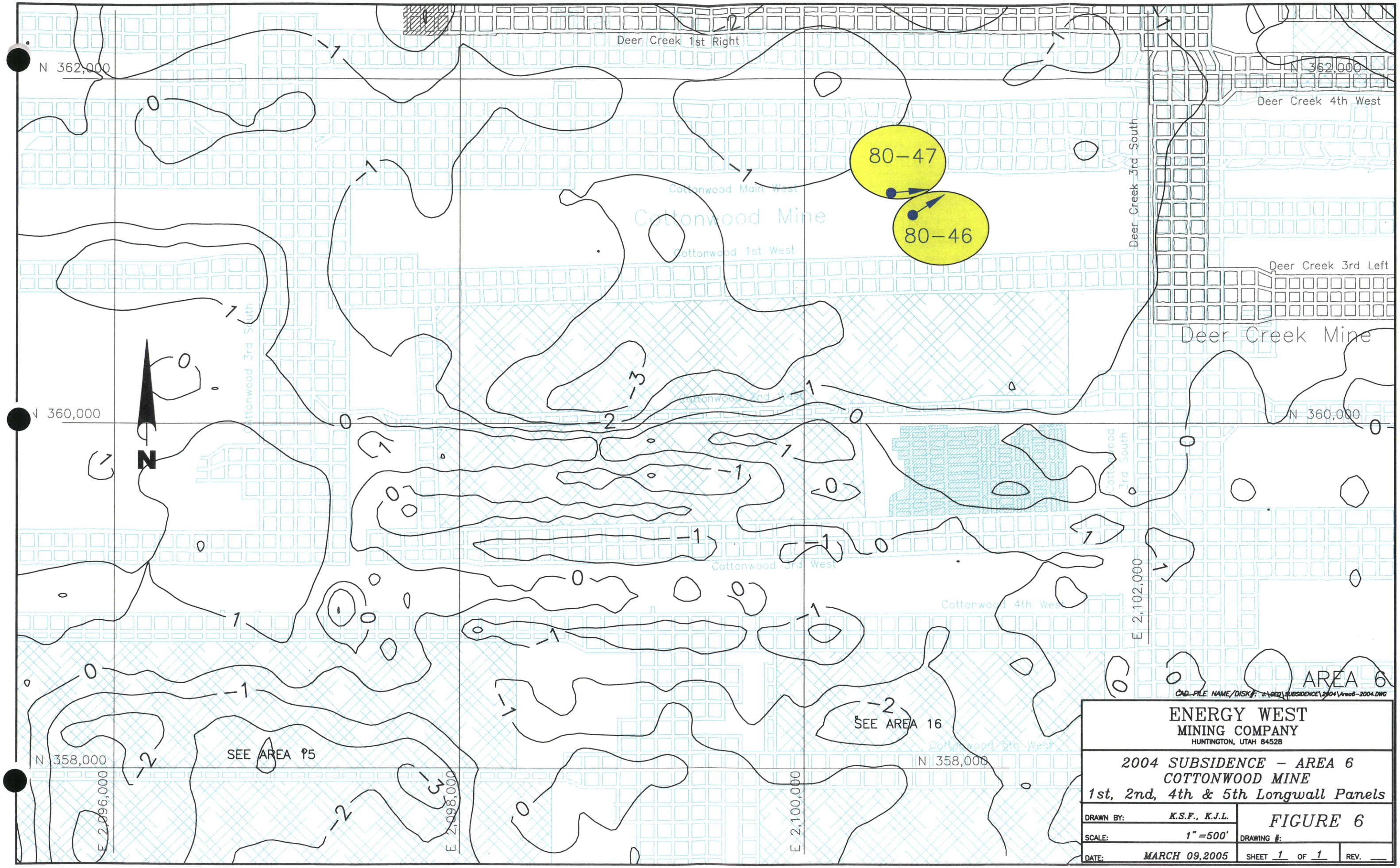
East Mountain Spring: 80-46
Water Quality Data: Operational
Mine Association: Deer Creek Mine/Wilberg/Cottonwood Mine
Date of Development: Adjacent First Mining, 1980
Date of Second Mining:

Historical Data: 1980 - 2012				
	MAXIMUM	MINIMUM	AVERAGE	# ANALYSIS
BICARBONATE	640	277	345.12	25
CALCIUM	94.6	39.7	61.427	27
CARBONATE	5	0	1.6364	11
CHLORIDE	8.5	2.7	4.55	24
CONDUCTIVITY	658	440	549.61	28
DISSOLVED OXYGEN	9.5	5.3	7.375	4
FLOW	60	0.45	9.4733	30
HARDNESS	355	227	280.68	19
TOTAL IRON	0.11	0	0.0775	4
DISSOLVED IRON	3	0	0.23	16
MAGNESIUM	32.8	15	29.045	27
DISSOLVED MANGANESE	0.002	0	0.001	2
MANGANESE	0.1	0	0.0291	11
OIL AND GREASE				0
PH	8	6.7	7.4076	29
POTASSIUM	2	0.4	0.79	18
SET SOLIDS				0
SODIUM	11.44	7.9	9.9054	24
SULFATE	55	1.4	16.308	24
SUSPENDED SOLIDS	14	0.5	3.5667	15
TEMPERATURE	45.86	3.9	18.72	28
TOTAL DISSOLVED SOLIDS	523	260	309.58	24

East Mountain Spring: 80-47
Water Quality Data: Operational
Mine Association: Wilberg/Cottonwood Mine
Date of Development: Adjacent First Mining, 1977
Date of Second Mining:

Historical Data: 1980 - 2012

	MAXIMUM	MINIMUM	AVERAGE	# ANALYSIS
BICARBONATE	467	282	342.16	62
CALCIUM	125	55.2	67.291	62
CARBONATE	20	0	1.7308	26
CHLORIDE	25	2	5.2403	62
CONDUCTIVITY	703	360	565.53	62
DISSOLVED OXYGEN	12.6	4.7	7.5625	16
FLOW	20	0.5	6.143	64
HARDNESS	387	254	290.96	51
TOTAL IRON	0.646	0	0.1855	32
DISSOLVED IRON	1.42	0	0.1327	37
MAGNESIUM	41	26.2	31.418	62
DISSOLVED MANGANESE	0.13	0	0.015	17
MANGANESE	0.2	0	0.0317	27
OIL AND GREASE				0
PH	8.26	6.7	7.65	61
POTASSIUM	7.5	0.32	1.562	47
SET SOLIDS				0
SODIUM	23	11	14.526	62
SULFATE	220.9	1.5	23.344	62
SUSPENDED SOLIDS	220	0.5	19.625	28
TEMPERATURE	54.2	2.6	14.766	58
TOTAL DISSOLVED SOLIDS	1691	265	341.68	62



CAD FILE NAME/DISK#: J:\GEO\SUBSIDENCE\2004\Area6-2004.DWG

ENERGY WEST MINING COMPANY HUNTINGTON, UTAH 84528	
2004 SUBSIDENCE – AREA 6 *COTTONWOOD MINE* *1st, 2nd, 4th & 5th Longwall Panels*	
DRAWN BY: *K.S.F., K.J.L.*	*FIGURE 6*
SCALE: *1" =500'*	DRAWING #:
DATE: *MARCH 09,2005*	SHEET 1 OF 1 — REV. —

Spring: 80-46

Elevation: 9,342 feet
Coordinate: N 39°19'26.4“ W 111°08'51.3"
Aspect: North Northeast
Associated Formation: North Horn
Note: Area below 80-46 and 80-47 is wet and flowing. This occurs approximately 100 feet below original location of springs.

Spring: 80-47
(Historic Location)

Elevation: 9,334 feet
Coordinate: N 39°19'27.7“ W 111°08'52.8"
Aspect: North Northeast
Associated Formation: North Horn
Note: Area below 80-46 and 80-47 is wet and flowing. This occurs approximately 100 feet below original location of springs.

Spring: 80-47
(Combined Single Point Monitoring)

Elevation: 9,315 feet
Coordinate: N 39°19’25.2“ W 111°08’45.8"
Aspect: East
Associated Formation: North Horn

Location: Section 26, Township 17 South, Range 7 East, SLB&M. Historically, the site was located within the Des Bee Dove Mine permit boundary; however, since relinquishment of the federal coal lease, U-02664, and reduction of the permit boundary after final reclamation of the mine site in 2001, this site now lies outside a federal coal lease, as well as the mine permit boundary.

Lease Association: This site was associated with federal coal lease U-02664. The lease was acquired from the Church of Jesus Christ of Latter Day Saints in 1972. Room and pillar mining began in the Little Dove Mine in 1980 in the 2nd North Mains of the Blind Canyon Seam. Retreat mining (pillaring) was completed in this area in 1986.

In the Hiawatha Seam or Deseret Mine, room and pillar mining (adjacent to 82-51) began in 1973 in the 1st North Mains and 1981 in the 2nd North Mains. No retreat mining was conducted in this area of the Deseret Mine.

In December 1995, the BLM approved (with concurrence by USFS and DOGM) a partial relinquishment of 240 acres for U-02664. In February, 2004, the BLM accepted an additional 250 acres. Both approvals were retroactive as of April 24, 1992 (date of application). In September 2011, The BLM accepted relinquishment of the remaining 430 acres of U-02664. The final relinquishment of the remaining acreage was retroactive as of December 15, 2006.

Subsidence: As stated in the 2004 Subsidence Report, submitted May 2005, Area 13 of the Des Bee Dove mine site (and the area of spring 82-51) subsidence in substantially complete. Figures 41, 42, and 43 show a maximum subsidence in Area 13 of approximately 3 feet (refer to Supplemental Volume 1, Lease Relinquishment, tab Phase I&II, tab Profiles and Isograms and also included herein). There is no indication that subsidence has affected the flow quantity of spring 82-51.

Water Data: Historical water quality data is included for spring 82-51. Data show no abnormalities in the water quality parameters for this area of East Mountain. Historic flow data has been collected since 1982 and has continued through 2012. This information is found on the following page where July spring flow is plotted against precipitation data collected from the East Mountain weather station, as well as the Palmer Drought Index for regions 4, 5, and 6. The East Mountain weather station is located on the southern tip of East Mountain. Spring flow shows a positive correlation with precipitation. The mode of occurrence for this site is permeable fluvial channels that intersect the land surface within the stratigraphic location of the Price River Formation.

Justification for removal from monitoring: Site 82-51 has been monitored by Energy West Mining Company since 1982. The spring is located within the Right Fork of the Grimes Wash drainage system. Its orientation is west-facing in an area with moderate vegetative cover. The

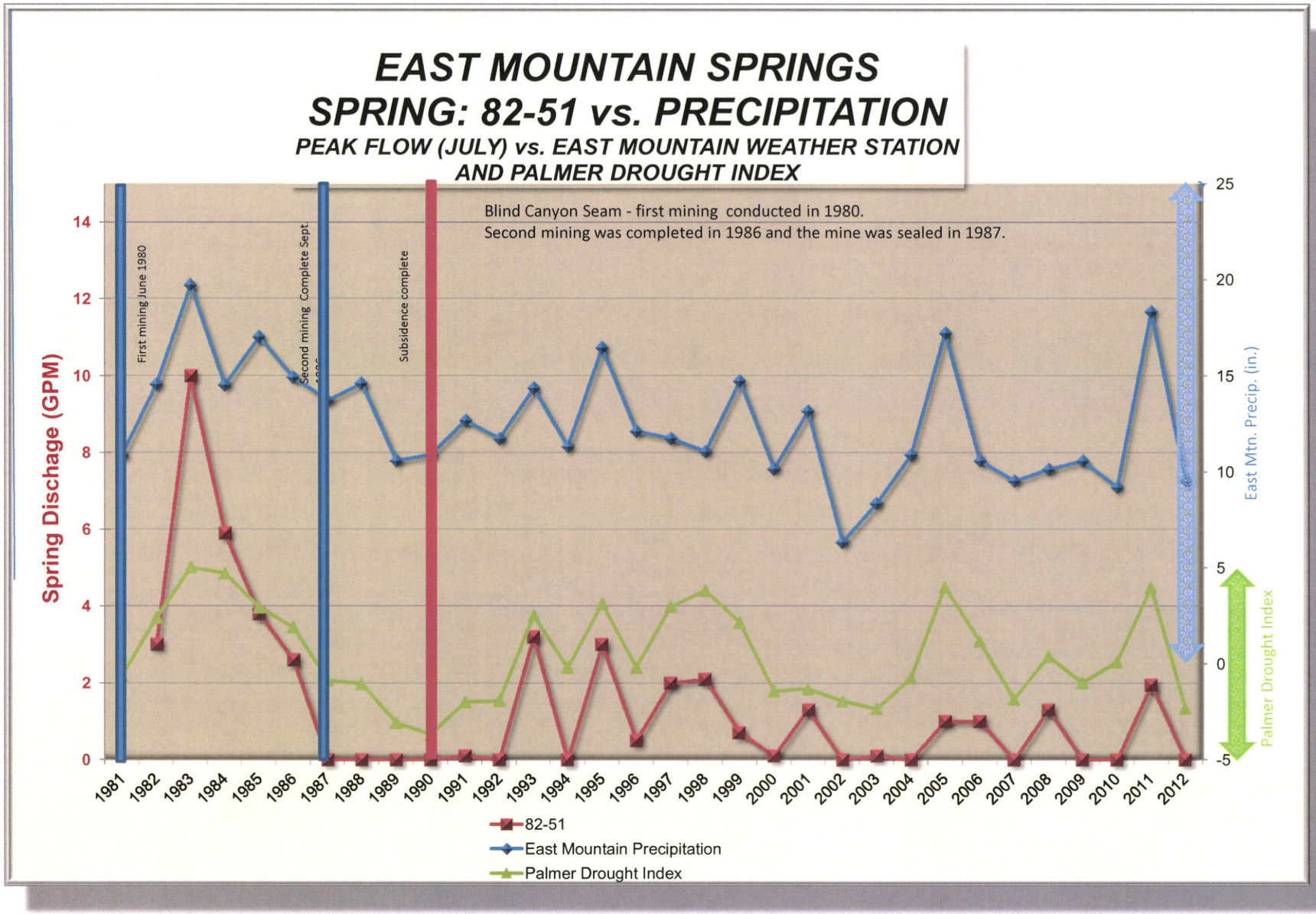
spring has been developed; however, the site has deteriorated rapidly (fence/collection/trough) due to cattle grazing and lack of maintenance.

The attached chart comparing spring flow to precipitation and the Palmer Hydrologic Drought Index shows a very good correlation. 1983 shows unprecedented precipitation with accordingly high discharge from the spring. As the climatic wet period merged to drought, spring flow decreased to zero. This lasted throughout the years of drought. Spring flow continued once climatic wet conditions returned. However, because of the variability of the climatic periods that followed, recharge and discharge of this spring was affected.

Like other springs located in the North Horn Formation, spring 82-51 occurs in a permeable fluvial channel that intersects the land surface. The spring is underlined by impermeable mudstones that disconnect shallow formed springs from lower stratigraphic structures.

Subsidence in the area of the spring has been recorded at approximately three feet. Although the sites show decreases to their flow over time, Energy West believes that the decreased flow has been influenced by climatic conditions and not underground mining operations. The trend of this spring mimics the trend of springs 79-26 and 79-32 both of which have not been undermine by underground coal mining operations.

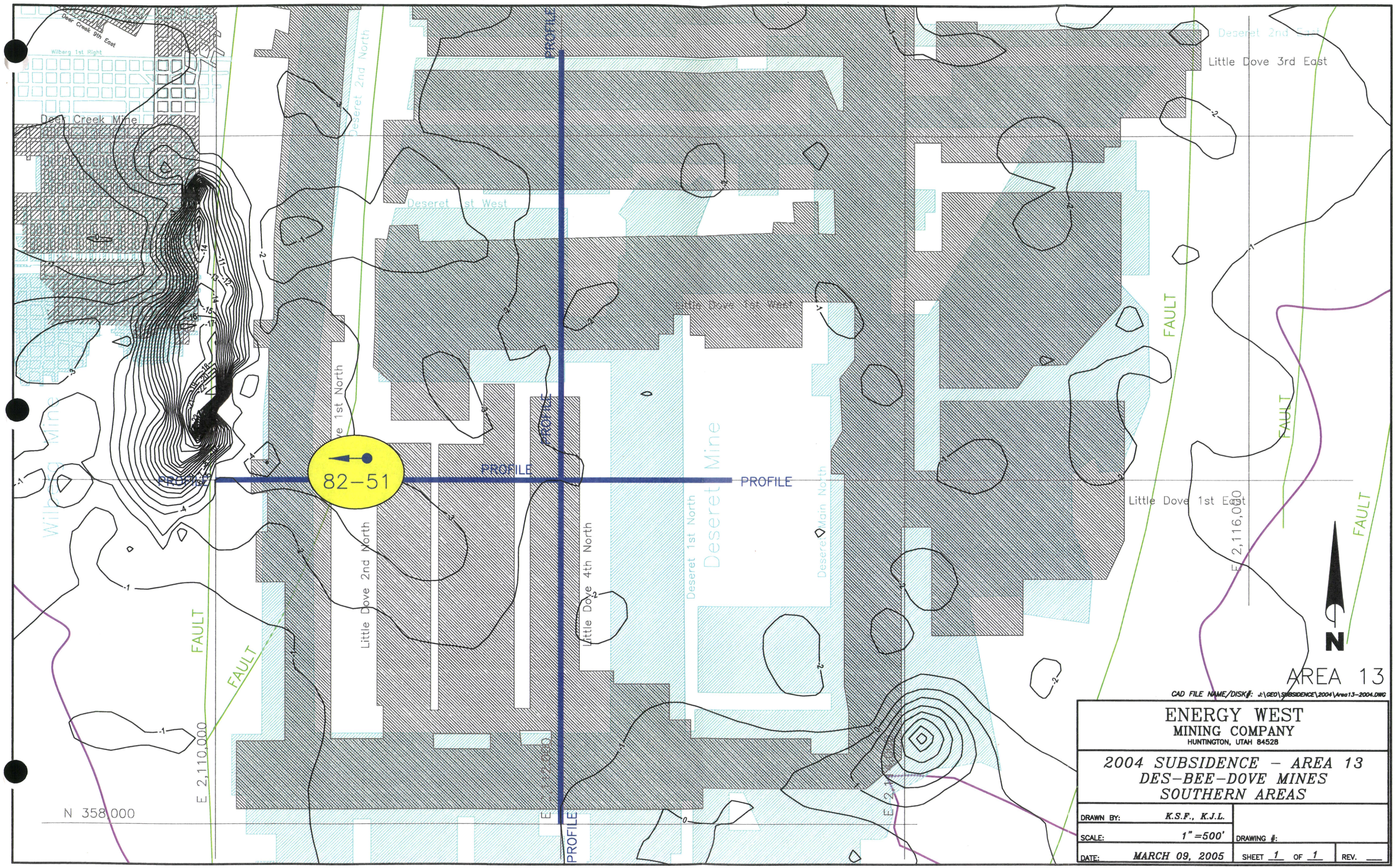
Since the federal coal lease has been relinquished (with concurrence by DOGM) and the site is no longer within the boundaries of a mine permit, Energy West Mining Company retains no legal right of entry to the site, nor control of the site. Energy West is removing this site from its hydrologic monitoring program and will no longer sample for quality or quantity of their discharge. If the Division does not agree with Energy West's findings, please provide compelling scientific evidence that suggests that our underground mining operations have impacted this site.


EAST MOUNTAIN SPRINGS
SPRING: 82-51 vs. PRECIPITATION
PEAK FLOW (JULY) vs. EAST MOUNTAIN WEATHER STATION
AND PALMER DROUGHT INDEX
Blind Canyon Seam - first mining conducted in 1980.
Second mining was completed in 1986 and the mine was sealed in 1987.
First mining June 1980
Second mining Complete Sept.
Subsidence complete
Spring Dischage (GPM)
East Mtn. Precip. (in.)
Palmer Drought Index
0
2
4
6
8
10
12
14
25
20
15
10
5
0
-5
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
82-51
East Mountain Precipitation
Palmer Drought Index

East Mountain Spring: 82-51
Water Quality Data: Operational
Mine Association: Des Bee Dove Mine
Date of Development: Blind Canyon Seam: 1980
Date of Second Mining: Blind Canyon Seam: Completed in 1986

Historical Data: 1980 - 2011

	MAXIMUM	MINIMUM	AVERAGE	# ANALYSIS
BICARBONATE	411	275	346.29	21
CALCIUM	122	46	81.413	21
CARBONATE	20	0	6	6
CHLORIDE	20	7.9	15.467	21
CONDUCTIVITY	1000	562	842.62	21
DISSOLVED OXYGEN	11.9	5.6	7.48	5
FLOW	15	0.14	2.5945	22
HARDNESS	520	295	407.29	17
TOTAL IRON	10.57	0	1.5587	15
DISSOLVED IRON	0.1	0	0.042	10
MAGNESIUM	62.2	41	48.23	21
DISSOLVED MANGANESE	0.242	0	0.0713	7
MANGANESE	0.1	0	0.0243	6
OIL AND GREASE				0
PH	8.35	7.3	7.86	21
POTASSIUM	6.09	0.38	1.5244	16
SET SOLIDS				0
SODIUM	44	20.9	30.115	21
SULFATE	191	14	139.38	21
SUSPENDED SOLIDS	140	2	40.75	6
TEMPERATURE	52.9	3.2	13.162	21
TOTAL DISSOLVED SOLIDS	612	153	518	21

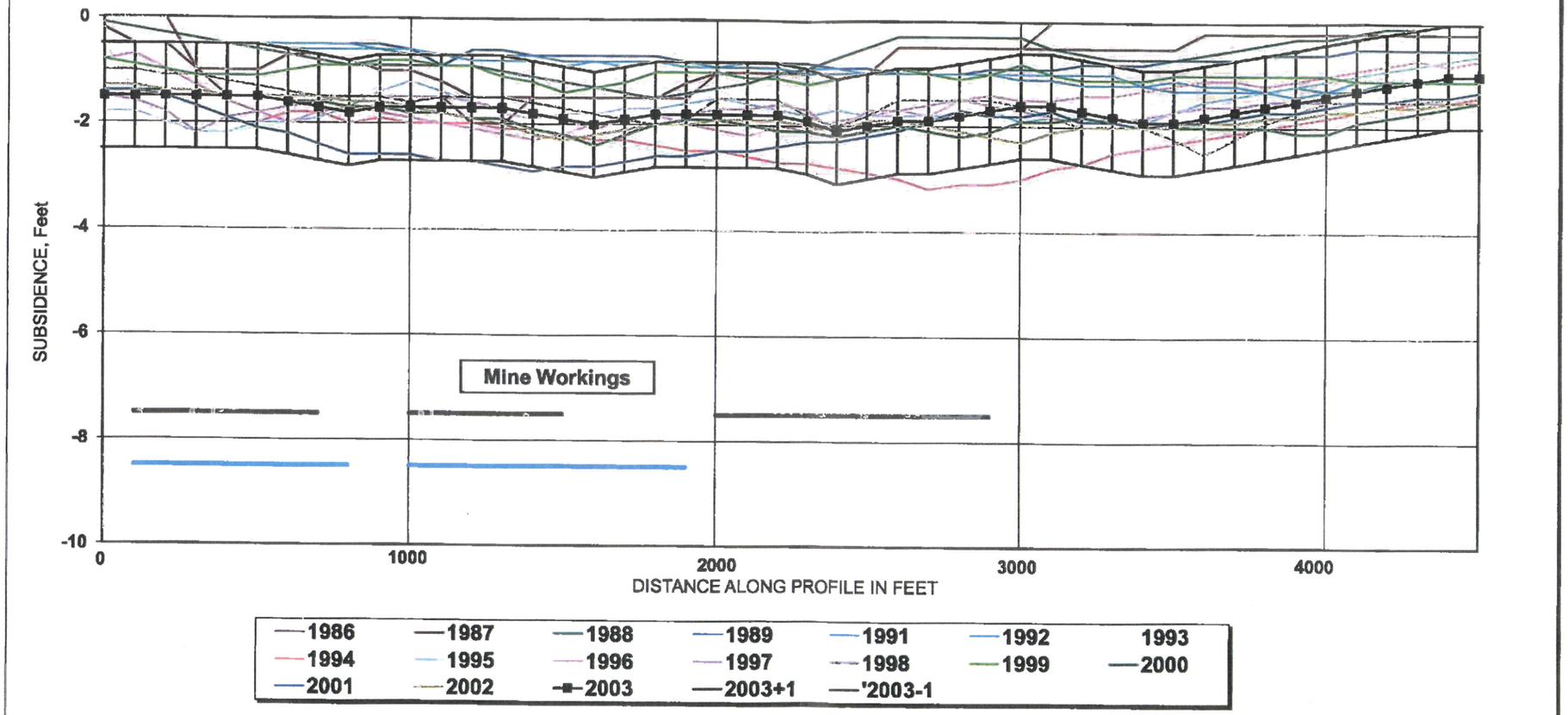


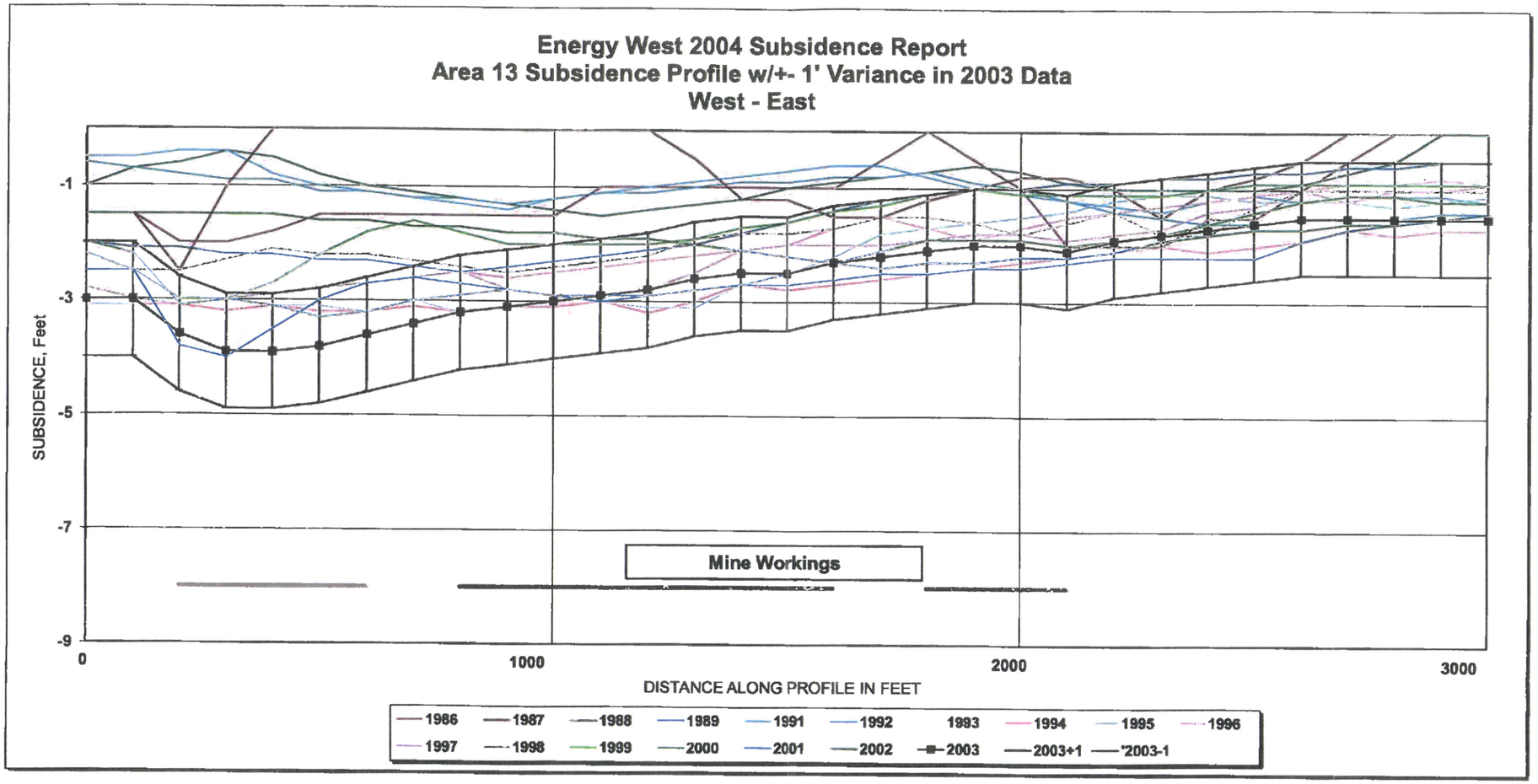
AREA 13

CAD FILE NAME/DISK#: J:\GEO\SUBSIDENCE\2004\Area13-2004.DWG

ENERGY WEST MINING COMPANY HUNTINGTON, UTAH 84528	
2004 SUBSIDENCE – AREA 13 *DES-BEE-DOVE MINES* *SOUTHERN AREAS*	
DRAWN BY: *K.S.F., K.J.L.*	
SCALE: *1" =500'*	DRAWING #:
DATE: *MARCH 09, 2005*	SHEET 1 OF 1 REV.

Energy West 2004 Subsidence Report
Area 13 Subsidence Profile w/+- 1' Variance in 2003 Data
North - South




Energy West 2004 Subsidence Report
Area 13 Subsidence Profile w/+- 1' Variance in 2003 Data
West - East
SUBSIDENCE, Feet
-1
-3
-5
-7
-9
0
1000
2000
3000
DISTANCE ALONG PROFILE IN FEET
Mine Workings
1986
1987
1988
1989
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2003+1
'2003-1

Spring: 82-51

Elevation: 8,960 feet
Coordinate: N 39°19'15.6" W 111°06'43.5"
Aspect: West
Associated Formation: Price River, Bear Cyn Fault Zone

Location: Section 28, Township 17 South, Range 7 East, SLB&M. Historically, the site was located within the Wilberg/Cottonwood Mine permit; however, since relinquishment of lease U-47978, (see below) this site now lies outside any federal coal lease and mine permit boundary.

Lease Association: This site has been associated with federal coal lease U-47978. The lease was acquired in 1981. Development in the 3rd South Mains (in the area of Spring 84-56) began in November 1987. Panel development for the 8th East (longwall panel below spring) began in January 1988. Panel extraction for the 8th East panel was completed in 1989. Both the development and extraction mining were conducted within the Hiawatha Seam only. The spring has been undermined by mining operations.

In December 1995, the BLM approved (with concurrence by USFS and DOGM) a partial relinquishment of 1,347.31 acres for U-47978. The relinquishment was retroactive as of April 24, 1992 (date of application). In March 2004, the BLM again approved a partial relinquishment of 1,820.00 acres. Only 180 acres has been retained for this lease and is part of the Wilberg/Cottonwood Mine permit boundary. The second relinquishment was retroactive as of October 16, 1992.

Subsidence: Refer to the Supplemental Volume 1, Lease Relinquishment, tab Phase I & II, tab Data Summary Report pages 22 - 27. Monitoring shows that the area of the spring has subsided up to 4 feet (1000 foot diameter). but only 2 feet directly beneath the spring. Data from the 2004 Annual Subsidence Report is included herein. There is no indication that subsidence has affected the flow quantity of Spring 84-56.

Water Data: Historic and Post-water quality data is included for spring 84-56. Data show insignificant variances between the historic quality and post-mining quality results. Historic flow data has been collected since 1984 and has continued through 2012. This information is found on the following page where July spring flow is plotted against precipitation data collected from the East Mountain weather station, as well as, the Palmer Drought Index for regions 4, 5, and 6. The East Mountain weather station is located on the southern tip of East Mountain. Spring flow shows a positive correlation with precipitation. The mode of occurrence for this site is permeable fluvial channels that intersect the land surface. The stratigraphic location is within the North Horn Formation.

The U.S. Bureau of Mines completed an independent study (1994) of the mining impacts on the hydrology of East Mountain (Response of Springs to Longwall Coal Mining at the Deer Creek and Cottonwood Mines, Wasatch Plateau, Ut., Information Circular 94005, U.S. Bureau of Mines). This report is included as Appendix A in this submittal. The data in this study was collected by PacifiCorp from springs determined to represent hydrologic conditions on East Mountain. Spring 84-56 was included as part of this study.

Justification for removal from monitoring: Site 84-56 has been monitored by Energy West Mining Company since 1984. The spring is located on an east-facing slope in very heavy vegetative cover and has been developed. However, the site has deteriorated due to cattle grazing and lack of maintenance.

Like other springs located in the North Horn Formation, spring 84-56 occurs in a permeable fluvial channel that intersects the land surface. The spring is underlined by impermeable mudstones that disconnect shallow formed springs from lower stratigraphic structures.

Spring flow is fairly consistent with the reported precipitation from the East Mountain weather station and the Palmer Hydrological Drought Index. However, this site seems more affected by the precipitation deficit than other shallow formed springs.

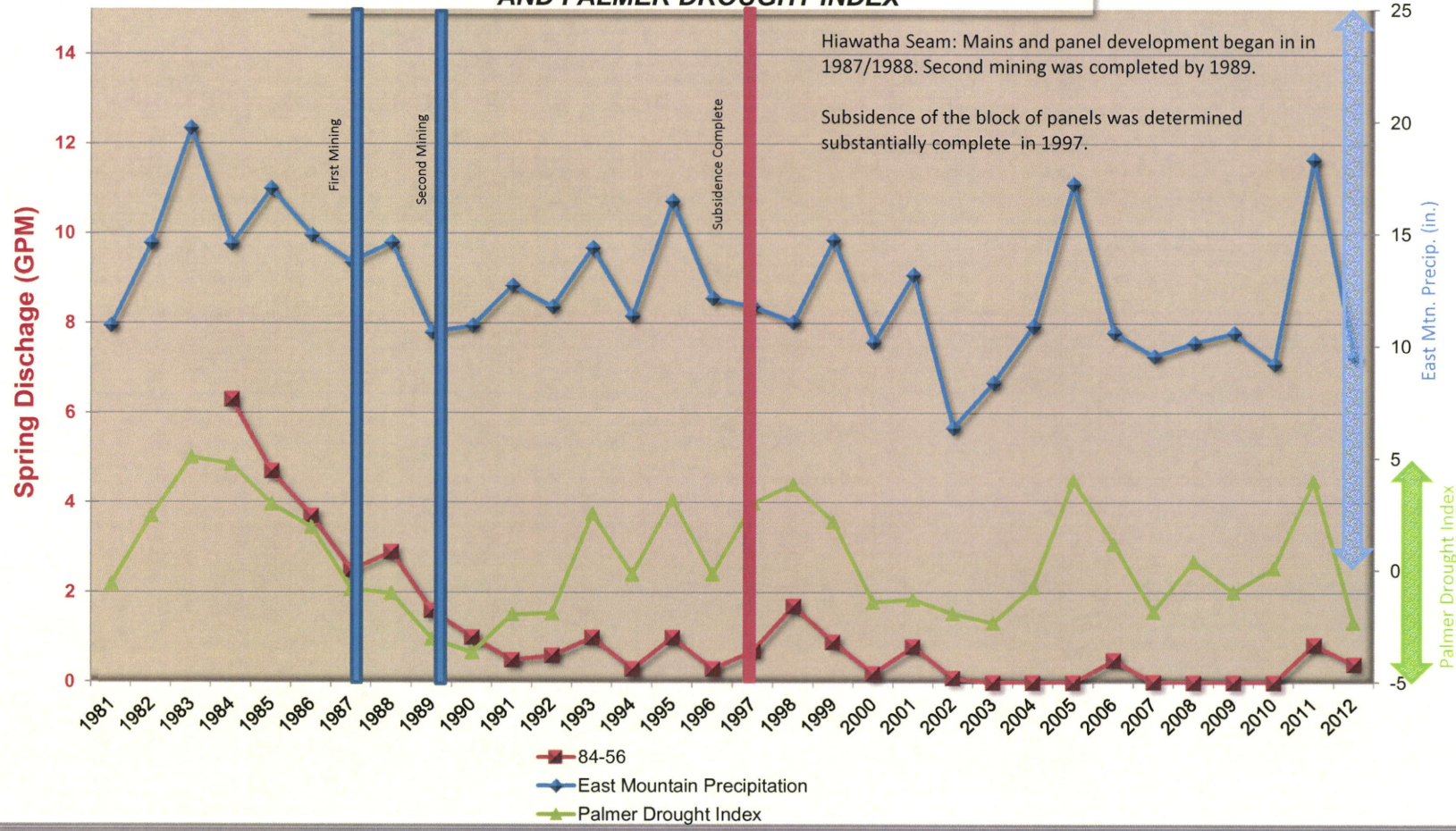
This site is not located within a current federal coal lease and outside the Wilberg/Cottonwood permit boundaries. There are no plans for any future mining in this area as this area has been completely mined out. Permanent seals have been installed underground in the Wilberg/Cottonwood mine complex to isolate the area from the rest of the mine. In 2001, the Wilberg/Cottonwood Mine was permanently sealed at its portals. Permanent seals eliminate the potential for any further mine development.

Although the site shows a general decrease to its flow over time, Energy West believes that the decreased flow has been controlled by climatic conditions and not underground mining operations. The decreasing trend of this spring is similar to the trend of springs 79-26 and 79-32 both of which have not been undermine by underground coal mining operations.

Because the federal coal lease has been relinquished (with concurrence by DOGM) and the site is no longer with the boundaries of a mine permit, Energy West Mining Company retains no legal right of entry to the site, nor control of the site.

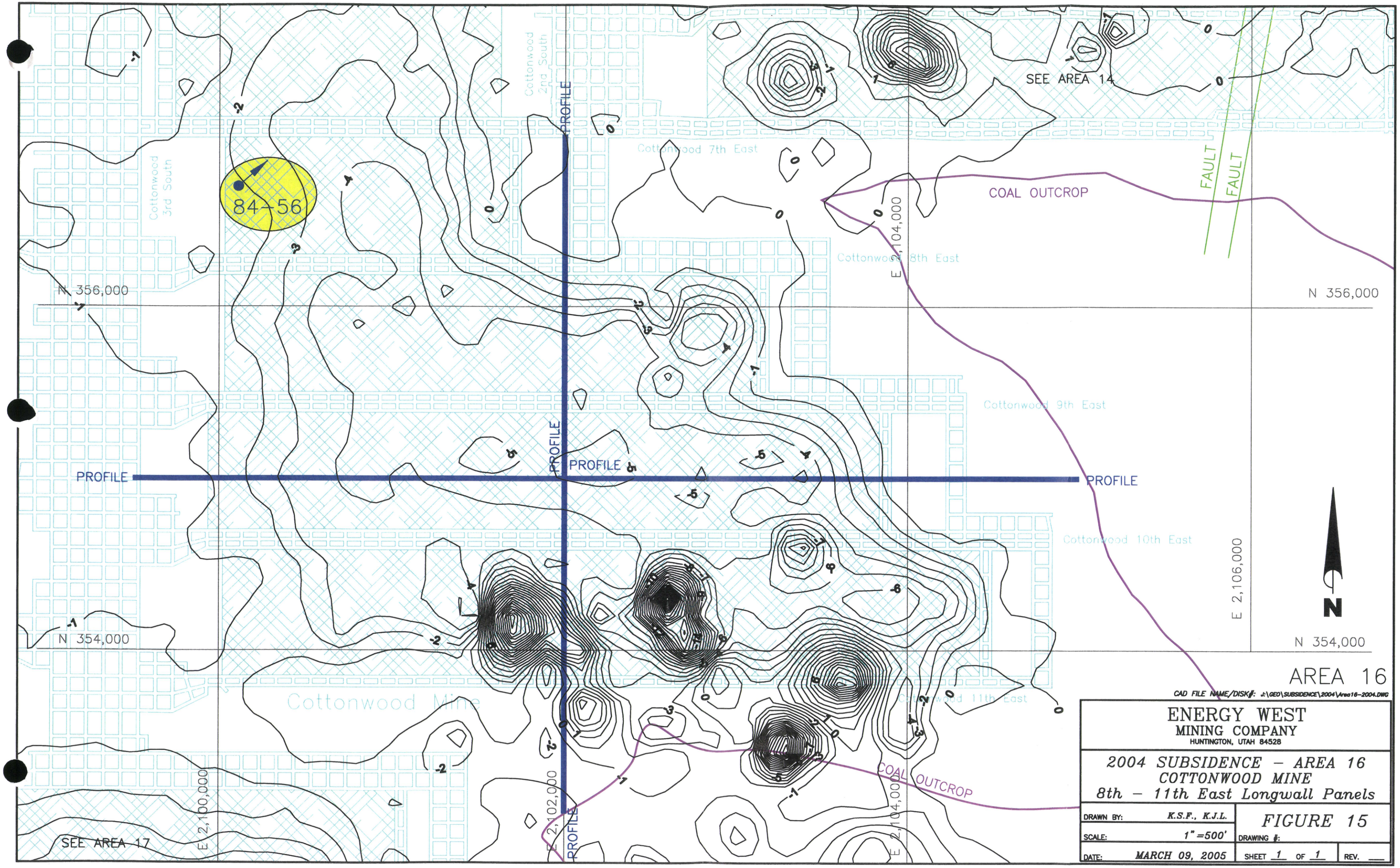
With the facts presented, Energy West is removing this site from its hydrologic monitoring program and will no longer sample for quality or quantity of their discharge. If the Division does not agree with Energy West's findings, please provide compelling scientific evidence that suggests that our underground mining operations have impacted this site.

EAST MOUNTAIN SPRINGS
SPRING: 84-56 vs. PRECIPITATION
PEAK FLOW (JULY) vs. EAST MOUNTAIN WEATHER STATION AND PALMER DROUGHT INDEX



East Mountain Spring: 84-56
Water Quality Data: Operational
Mine Association: Wilberg/Cottonwood
Date of Development: Hiawatha Seam: 1987
Date of Second Mining: Hiawatha Seam: 1989

Historical Data: 1984 - 2012					Pre-Mining Data: 1984-1989				Post-Mining Data: 1990-2012				
	MAXIMUM	MINIMUM	AVERAGE	# ANALYSIS	MAXIMUM	MINIMUM	AVERAGE	# ANALYSIS	MAXIMUM	MINIMUM	AVERAGE	# ANALYSIS	
BICARBONATE	406	266	339.02	43	368	317	345	7	406	266	337.44	34	BICARBONATE
CALCIUM	86.9	39.7	61.146	53	86.9	51.7	63.323	8	85.9	39.7	60.439	40	CALCIUM
CARBONATE	10	0	1.5	34	1	1	1	9	10	0	1.85	20	CARBONATE
CHLORIDE	35	4	9.4585	41	10.2	5	8.3222	7	35	4	9.7781	32	CHLORIDE
CONDUCTIVITY	680	360	554.28	53	680	450	555.54	9	658	360	553.88	40	CONDUCTIVITY
DISSOLVED OXYGEN	9.3	4.9	6.7692	26	9.3	6.5	8.1333	0	9.3	4.9	6.5913	23	DISSOLVED OXYGEN
FLOW	67.1	0.08	2.3644	55	6.3	0.9	2.5347	10	67.1	0.08	23.005	40	FLOW
HARDNESS	387	235	290.33	52	332	270	296.85	8	387	235	288.15	39	HARDNESS
TOTAL IRON	3.8	0	0.4364	11				0	3.8	0	0.4364	11	TOTAL IRON
DISSOLVED IRON	0.2	0	0.0625	24	0.06	0.02	0.0411	7	0.2	0	0.0753	15	DISSOLVED IRON
MAGNESIUM	42	19.8	32.822	53	37.1	20.2	32.154	8	42	19.8	33.039	40	MAGNESIUM
DISSOLVED MANGANESE	0	0	0	4					0	0	0	4	DISSOLVED MANGANESE
MANGANESE	0.2	0	0.0457	35	0.01	0.01	0.01	7	0.2	0	0.0643	23	MANGANESE
OIL AND GREASE													OIL AND GREASE
PH	8.42	6.7	7.478	56	8.42	6.7	7.5606	11	7.8	7	7.445	40	PH
POTASSIUM	5	0.03	1.3737	27	1.1	0.49	0.88	7	5	0.03	1.6206	18	POTASSIUM
SET SOLIDS													SET SOLIDS
SODIUM	20.8	11.7	17.133	41	19.4	15.8	17.424	7	20.8	11.7	17.051	32	SODIUM
SULFATE	100	7	28.168	41	44	19	28.889	7	100	7	27.966	32	SULFATE
SUSPENDED SOLIDS	59	0.5	6.4348	23	59	0.5	8.2222	7	24	1	5.2857	14	SUSPENDED SOLIDS
TEMPERATURE	49.82	3.6	28.263	49	46	5	35.25	11	49.82	3.6	24.875	33	TEMPERATURE
TOTAL DISSOLVED SOLIDS	445	179	322.02	41	455	280	344	7	370	179	315.84	32	TOTAL DISSOLVED SOLIDS



AREA 16

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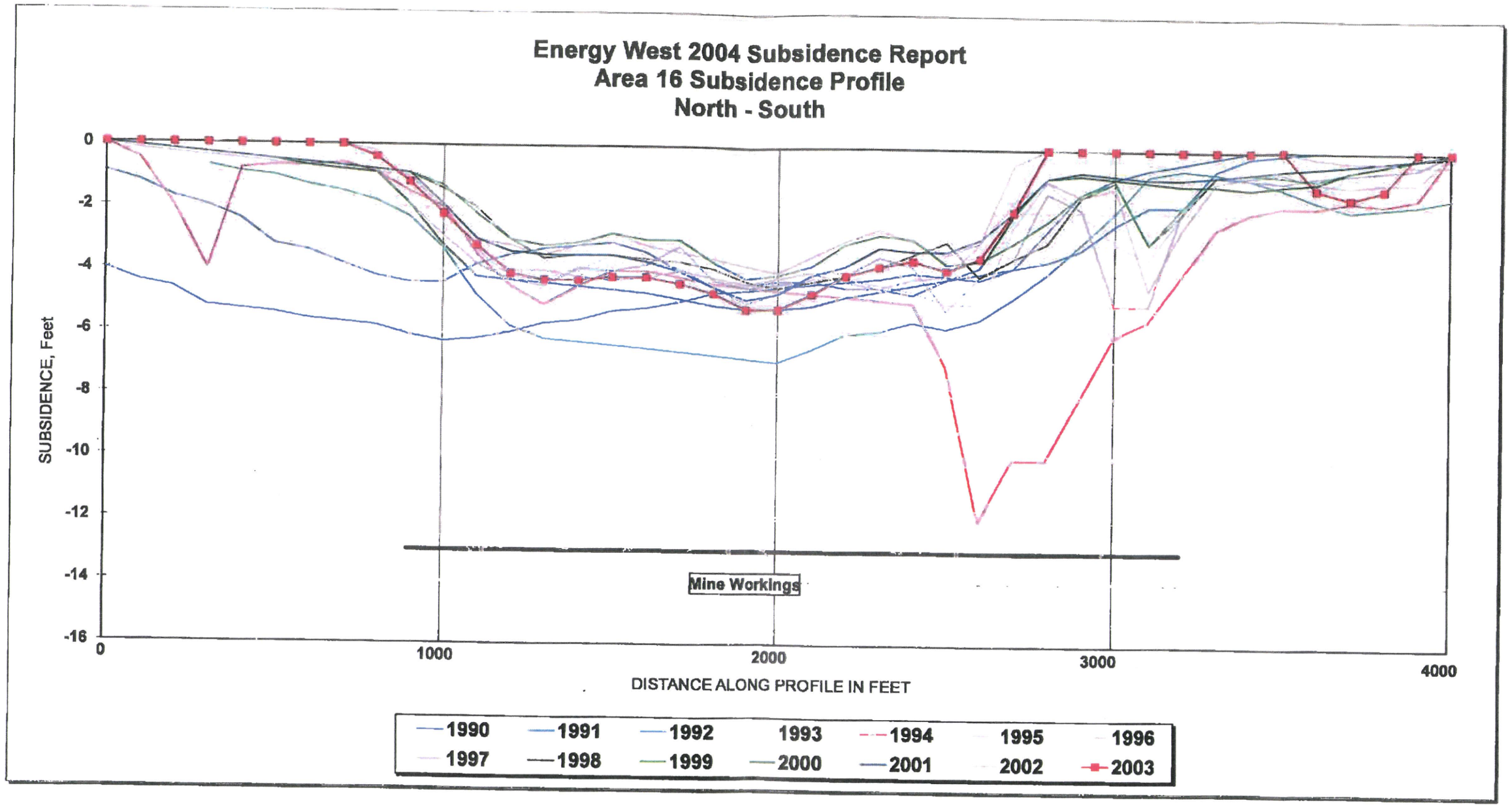
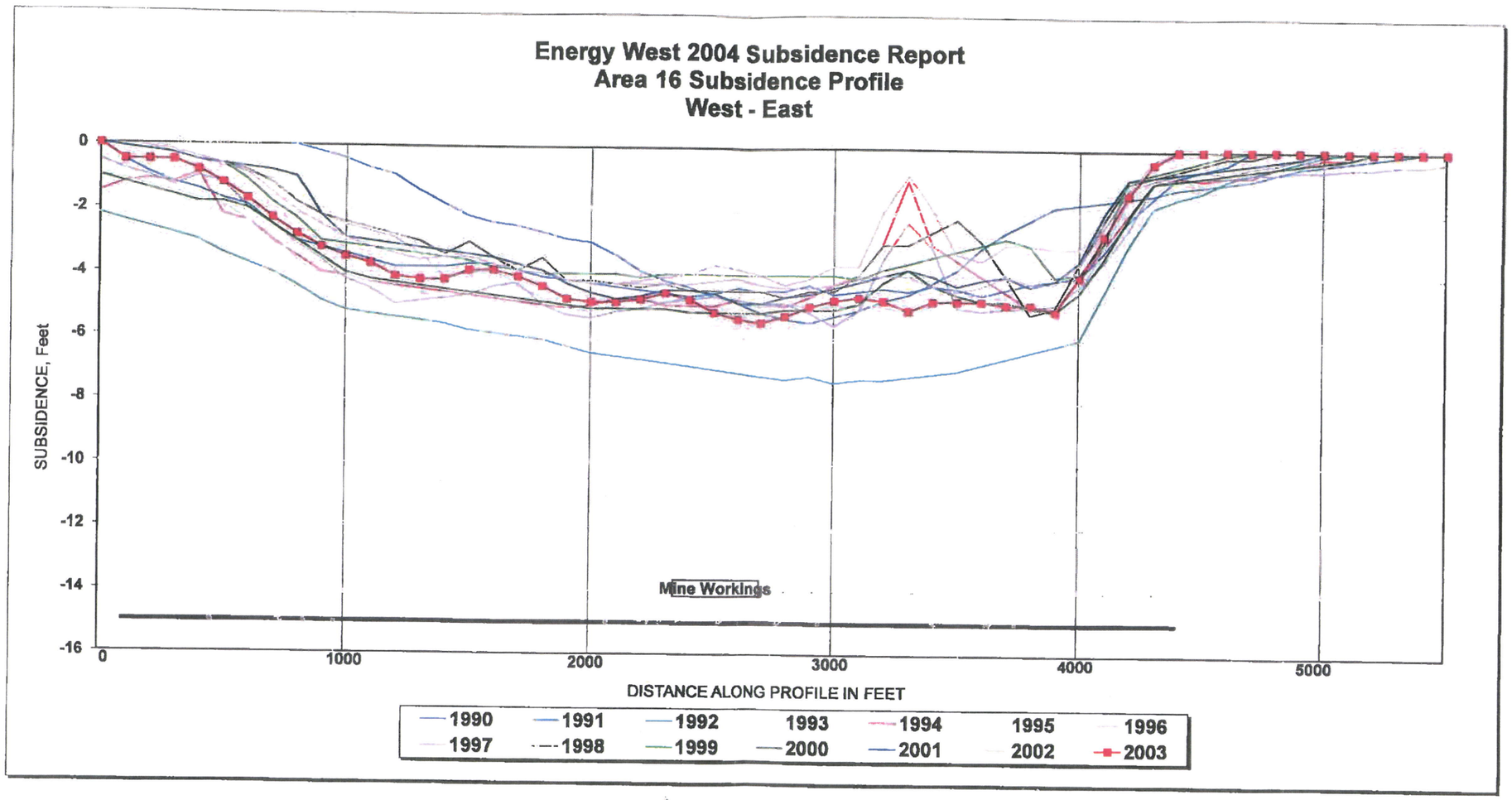
ENERGY WEST
MINING COMPANY
HUNTINGTON, UTAH 84528

2004 SUBSIDENCE – AREA 16
COTTONWOOD MINE
8th – 11th East Longwall Panels

DRAWN BY:	*K.S.F., K.J.L.*	*FIGURE 15*	
SCALE:	*1" =500'*	DRAWING #:	
DATE:	*MARCH 09, 2005*	SHEET 1 OF 1	REV.


Energy West 2004 Subsidence Report
Area 16 Subsidence Profile
North - South
SUBSIDENCE, Feet
0
-2
-4
-6
-8
-10
-12
-14
-16
0
1000
2000
3000
4000
DISTANCE ALONG PROFILE IN FEET
Mine Workings
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003


Energy West 2004 Subsidence Report
Area 16 Subsidence Profile
West - East
SUBSIDENCE, Feet
0
-2
-4
-6
-8
-10
-12
-14
-16
Mine Workings
0
1000
2000
3000
4000
5000
DISTANCE ALONG PROFILE IN FEET
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003

Spring: 84-56

Elevation: 9,357 feet
Coordinate: N 39°18'42.6“ W 111°09'00.3"
Aspect: Northeast
Associated Formation: North Horn

Location: Section 21, Township 17 South, Range 6 East, SLB&M. This site is outside the Trail Mountain mine permit boundary and within the new State Lease ML-51191. The lessee of this lease is PacifiCorp's Fossil Rock Fuel.

Lease Association: This site is associated with State Lease ML-51191. There are currently no mining plans available for this lease.

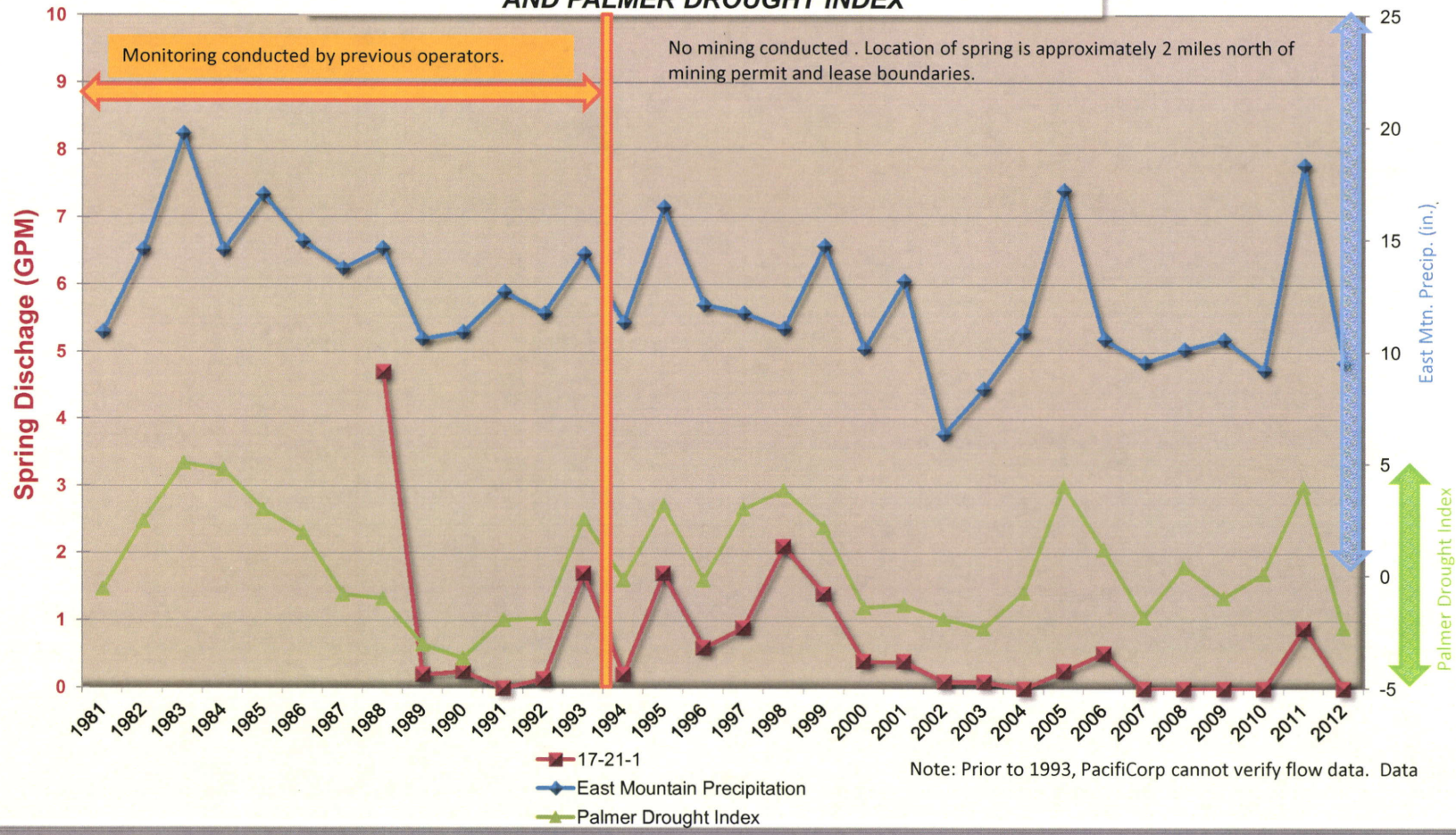
Subsidence: None

Water Data: Water quality data is included for spring 17-21-1. Data show insignificant variances of quality throughout history. Historic flow data has been collected since 1987 and has continued through 2012. This information is found on the following page where July spring flow is plotted against precipitation of the East Mountain weather station, as well as, the Palmer Drought Index for regions 4, 5, and 6. The East Mountain weather station is located on the southern tip of East Mountain. Spring flow shows a positive correlation with precipitation.

Justification for removal from monitoring: Site 17-21-1 has been monitored by Energy West Mining Company since 1993. The spring has not been undermined and is approximately two miles north underground workings. There have been no reported occurrences in which mining has impacted this site. Historic quality and quantity data has not indicated such impacts to the site.

With the facts presented, Energy West is removing this site from its hydrologic monitoring program and will no longer sample for quality or quantity of their discharge. If the Division does not agree with Energy West's findings, please provide compelling scientific evidence that suggests that our underground mining operations have impacted this site.

TRAIL MOUNTAIN SPRINGS
SPRING: 17-21-1 vs. PRECIPITATION
PEAK FLOW (JULY) vs. EAST MOUNTAIN WEATHER STATION AND PALMER DROUGHT INDEX



Note: Prior to 1993, PacifiCorp cannot verify flow data. Data

Trail Mountain Spring: 17-21-1 (T-8)
Water Quality Data: Operational
Mine Association: Trail Mountain Mine
Date of Development: No mining below spring

Notes:

- Out of Lease Boundary
- Out of Permit Boundary
- Not influence by mining (refer to map)

Historical Data: 1987 - 2011

	MAXIMUM	MINIMUM	AVERAGE	# ANALYSIS
BICARBONATE	438	302	387.53	51
CALCIUM	70	7	52.936	51
CARBONATE	5	0	1.1769	13
CHLORIDE	43.1	23	30.696	51
CONDUCTIVITY	882	627	717.9	48
DISSOLVED OXYGEN	10.3	2.1	4.7857	14
FLOW	5	0.06	0.7666	46
HARDNESS	272	207	244.33	46
TOTAL IRON	0.34	0	0.0945	22
DISSOLVED IRON	0.23	0	0.0953	19
MAGNESIUM	59	13	27.883	51
DISSOLVED MANGANESE	0	0	0	3
MANGANESE	0.2	0	0.0506	32
OIL AND GREASE				0
PH	8.2	6.54	7.5925	51
POTASSIUM	5	1	2.047	50
SET SOLIDS				0
SODIUM	70.5	12	61.334	51
SULFATE	40	10	17.894	51
SUSPENDED SOLIDS	20	0.5	5.0536	28
TEMPERATURE	55.2	5.8	17.432	26
TOTAL DISSOLVED SOLIDS	496	310	393.96	51

Spring: 17-21-1

Elevation: 9,371 feet
Coordinate: N 39°20'10.3“ W 111°14'46.3"
Aspect: West-facing
Associated Formation: North Horn

Location: Section 22, Township 17 South, Range 6 East, SLB&M. This site is outside the Trail Mountain mine permit boundary and within the new State Lease ML-51191. The lessee of this lease is PacifiCorp's Fossil Rock Fuel.

Lease Association: This site is associated with State Lease ML-51191. There are currently no mining plans available for this lease.

Subsidence: None

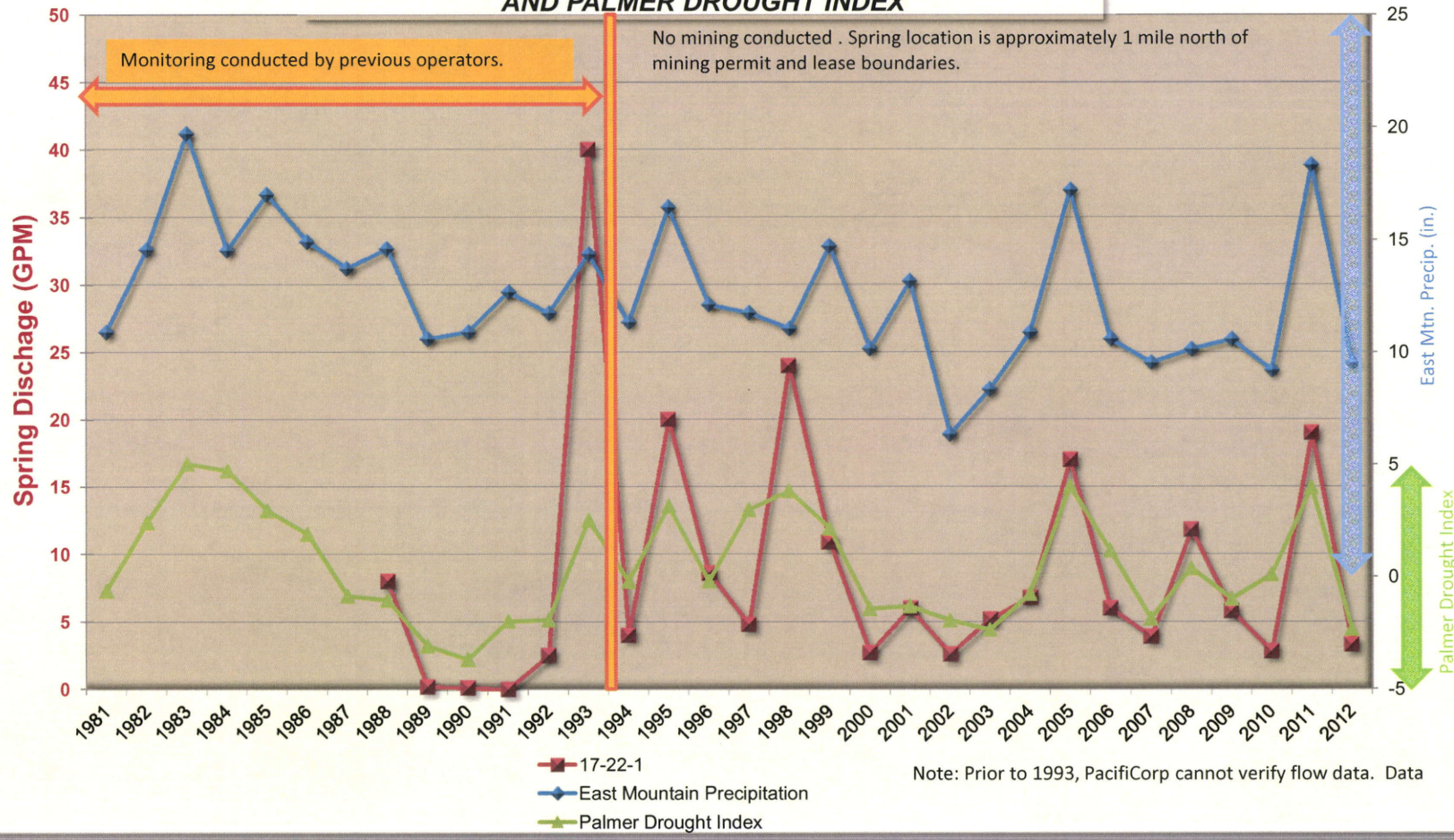
Water Data: Water quality data is included for spring 17-22-1. Data show insignificant variances of quality throughout history. Historic flow data has been collected since 1987 and has continued through 2012. This information is found on the following page where July spring flow is plotted against precipitation of the East Mountain weather station, as well as, the Palmer Drought Index for regions 4, 5, and 6. The East Mountain weather station is located on the southern tip of East Mountain. Spring flow shows a positive correlation with precipitation.

Justification for removal from monitoring: Site 17-22-1 has been monitored by Energy West Mining Company since 1993. The development of the spring is dilapidated whereas the discharge has redirected and surfaces approximately 40 feet south of the original site. The spring still flows to the pond below.

The spring has not been undermined and is one mile from any underground workings. There have been no reported occurrences in which mining has impacted this site. Historic quality and quantity data has not indicated such impacts to the site.

With the facts presented, Energy West is removing this site from its hydrologic monitoring program and will no longer sample for quality or quantity of their discharge. If the Division does not agree with Energy West's findings, please provide compelling scientific evidence that suggests that our underground mining operations have impacted this site.

TRAIL MOUNTAIN SPRINGS
SPRING: 17-22-1 vs. PRECIPITATION
PEAK FLOW (JULY) vs. EAST MOUNTAIN WEATHER STATION AND PALMER DROUGHT INDEX



Note: Prior to 1993, PacifiCorp cannot verify flow data. Data

Trail Mountain Spring: 17-22-1 (T-9)
Water Quality Data: Operational
Mine Association: Trail Mountain Mine
Date of Development: No mining below spring

Notes:

- Out of Lease Boundary
- Out of Permit Boundary
- Not influence by mining (refer to map)

Historical Data: 1987 - 2012

	MAXIMUM	MINIMUM	AVERAGE	# ANALYSIS
BICARBONATE	406	222	307.25	65
CALCIUM	107	21	46.282	65
CARBONATE	24.6	0	2.387	23
CHLORIDE	30	6.9	9.7523	65
CONDUCTIVITY	858	435	538.11	62
DISSOLVED OXYGEN	12.2	3.7	7.5467	15
FLOW	40	0.1	6.5046	63
HARDNESS	338	193	255.22	63
TOTAL IRON	1.6	0	0.2892	36
DISSOLVED IRON	0.2	0	0.0721	29
MAGNESIUM	69	11	34.018	65
DISSOLVED MANGANESE	0.053	0	0.016	18
MANGANESE	0.2	0	0.0439	39
OIL AND GREASE				0
PH	8.8	6.92	7.7994	65
POTASSIUM	5	0.05	1.4642	54
SET SOLIDS	0.1	0.1	0.1	1
SODIUM	118.4	12	20.01	65
SULFATE	200	11	17.675	65
SUSPENDED SOLIDS	112	1	22.44	25
TEMPERATURE	46.76	5.5	12.843	43
TOTAL DISSOLVED SOLIDS	420	230	292.54	65

Spring: 17-22-1

Elevation: 9,242 feet
Coordinate: N 39°19'29.7“ W 111°13'59.0"
Aspect: Southwest-facing
Associated Formation: North Horn
Note: No flow occurs at traditional sampling point (box silted in). However, flow surfaces approximately 40 feet to the south of sample point and flows into pond.

Location: Section 35, Township 17 South, Range 6 East, SLB&M. This site is outside the current Trail Mountain mine permit boundary and outside any federal coal lease.

Lease Association: The springs 17-35-1 and 17-35-2 are located within the former Federal lease UTU-64375 which PacifiCorp was the lessee. In 2009, PacifiCorp applied for partial relinquishment of leases UTU-64375 and UTU-49332 (refer to January 5, 2009 application document "Partial Relinquishment, Federal Coal Lease, UTU-64375" and "Partial Relinquishment, Federal Coal Lease, UTU-49332") as all reserves had been mined and subsidence was substantially complete. The BLM retroactively approved partial relinquishment as of January 9, 2009.

Subsidence: Mining in the 5th Left Mains occurred in 1990 and 1991 and was conducted by Atlantic Richfield Company (ARCO), Mountain Coal Company, Trail Mountain #9. After the purchase of Trail Mountain Mine by PacifiCorp in 1992, PacifiCorp completed development of the 5th Left Mains further to the south and began development of the 1st through 5th East gate roads beginning in 1995. Development of the 10th Right gate roads was started in 1997. Within the area of the springs (within a 1/2 mile diameter), panel development of the 5th Right through 2nd Right gate roads began in 1998 and 1999. Panel extraction began in 5th Right in 1999. The 5th Right, 4th Right, and 3rd Right panels were completely extracted; however, the 2nd Right panel was abandoned in 2000 after retreating only 1,200 feet due to poor mining conditions. The 1st Right panel was extracted in 2001.

At the completion of panel extraction of the 5th Right through 1st Right panels, a maximum of 6 feet of subsidence had occurred. However, only approximately 2 feet of subsidence has been reported in the area of the springs.

Water Data: As mentioned above, PacifiCorp purchased the Trail Mountain Mine in 1992. Its staff began monitoring the surface and groundwater sites in 1993. PacifiCorp could not verify any quantity or quality data prior to the time of purchase. Therefore, for the purposes of this document, data for Trail Mountain Mine monitoring sites begins in 1993 and extends through 2012. Water quality and quantity data is included for spring 17-35-1. Spring 17-35-2 has never reported flow (refer to flow charts).

Water quality shows little variation between pre-mining and post-mining operations. Flow data however, show a significant reduction in flow from 1997 to 2001. Two explanations are needed here. First, as illustrated on the Flow vs. Precipitation chart, spring discharge from 17-35-1 closely mimics the Palmer Drought Index between the years 1992 and 2000. Beginning in 1999, the region started experiencing extreme drought conditions. These drought conditions persisted until 2004. Flow had peaked (3.3 gpm) from spring 17-35-1 in 1997. However, flow steadily

decreased until it discontinued its flow in 2000. The flow at 17-35-1 never recovered even though the indices indicated a wet cycle beginning again in 2004.

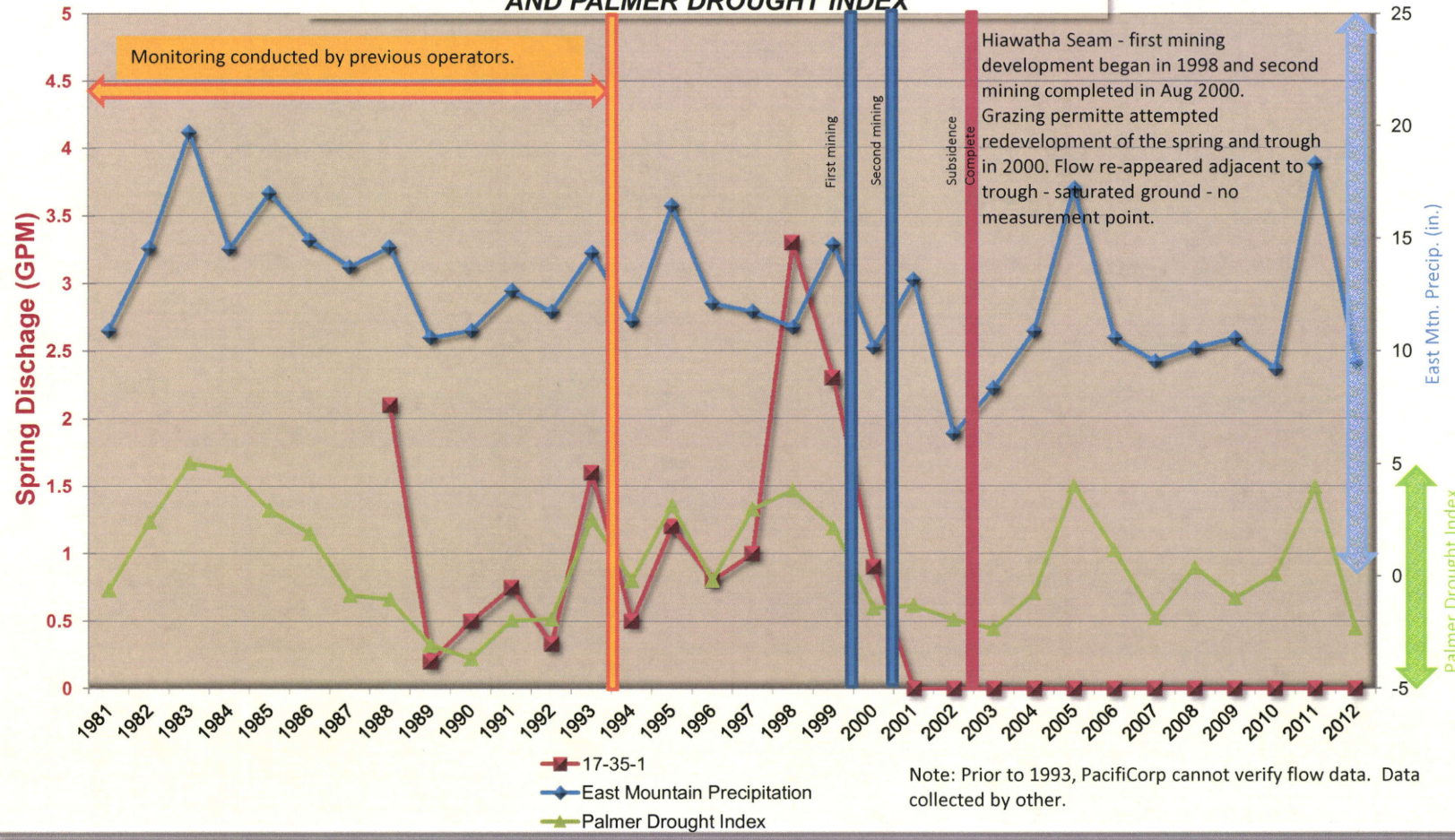
Secondly, during the occurrence of drought conditions between the years 1999 and 2004, the grazing permittee attempted to redevelop this spring and associated trough. Redevelopment activities were conducted in 2000. These activities included installation of a pipeline and refurbishment of the trough. After redevelopment of the spring, there has been no report of discharge from 17-35-1, however, the erosion control contour ditches adjacent to the trough were saturated but allowed no point for measurement. Spring 17-35-2 is located above a small man made pond. This site has no evidence of flow.

Justification for removal from monitoring: Sites 17-35-1 and 17-35-2 has been monitored by Energy West Mining Company since 1992. They are located on a west-facing slope in sparse vegetative cover. The stratigraphic location for the springs are in the North Horn Formation. Like other springs located in the North Horn Formation, these springs are underlined by impermeable mudstones that disconnect shallow formed springs from lower stratigraphic structures.

These springs are not located within a current federal coal lease (relinquished in 2009) and outside the Trail Mountain permit boundaries. There are no plans for any future mining in this area as this area has been completely mined out. Permanent seals have been installed underground in the Trail Mountain Mine to isolate the area from the rest of the mine. In 2001, the Trail Mountain Mine was permanently sealed at its portals. Permanent seals eliminate the potential for any further mine development.

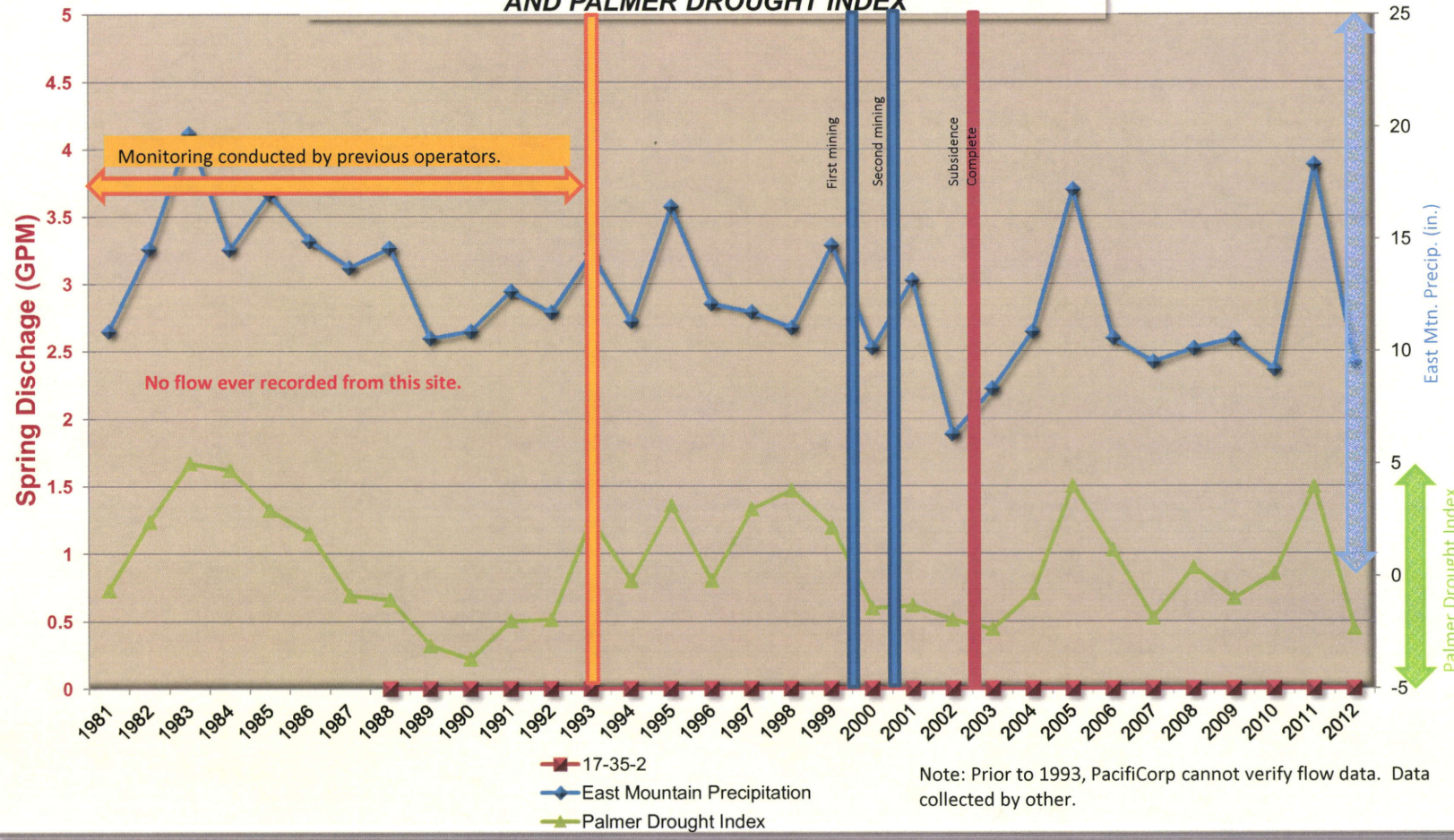
With the above facts presented and since the federal coal lease has been relinquished (with concurrence by DOGM) and the sites are no longer with the boundaries of a mine permit, Energy West Mining Company retains no legal right of entry, nor control of the sites. Therefore, it is requested that the sites be removed from the monitoring program.

TRAIL MOUNTAIN SPRINGS
SPRING: 17-35-1 vs. PRECIPITATION
PEAK FLOW (JULY) vs. EAST MOUNTAIN WEATHER STATION AND PALMER DROUGHT INDEX



Note: Prior to 1993, PacifiCorp cannot verify flow data. Data collected by other.

TRAIL MOUNTAIN SPRINGS
SPRING: 17-35-2 vs. PRECIPITATION
PEAK FLOW (JULY) vs. EAST MOUNTAIN WEATHER STATION AND PALMER DROUGHT INDEX



Note: Prior to 1993, PacifiCorp cannot verify flow data. Data collected by other.

Trail Mountain Spring: 17-35-1 (T-15)
Water Quality Data: Operational
Mine Association: Trail Mountain Mine
Date of Development: Hiawatha Seam: 1998
Date of Second Mining: Hiawatha Seam: 1999-2000

Notes:

- Cattlemen permittees attemped to redevelop spring in 2000
- Spring has not produced flow since 2001
- Pre-mining data includes data collected prior to Energy West

Historical Data: 1992 - 2012					Pre-Mining Data: 1992 - 1998				Post-Mining Data: 1998 - 2012			
	MAXIMUM	MINIMUM	AVERAGE	# ANALYSIS	MAXIMUM	MINIMUM	AVERAGE	# ANALYSIS	MAXIMUM	MINIMUM	AVERAGE	# ANALYSIS
BICARBONATE	441	206	387.6	43	441	206	381.95	37	438	390	422.5	6
CALCIUM	56.1	27	41.612	43	56.1	27	41.41	37	46	40	42.83	6
CARBONATE	18.3	0.1	5.711	18	18.3	0.1	5.71	18				0
CHLORIDE	59	20.3	42.47	43	59	20.3	42.15	37	56	41	44.5	6
CONDUCTIVITY	970	508	770.28	40	970	508	765.24	34	841	707	798.83	6
DISSOLVED OXYGEN	11.9	4.4	7.53	14	11.9	4.4	7.54	14				0
FLOW	5	0.16	1.08	39	5	0.16	0.85	33	3.3	0.86	2.33	6
HARDNESS	297	180	251.31	39	297	180	252.21	33	255	240	246.33	6
TOTAL IRON	6.5	0.04	0.669	21	6.5	0.04	0.669	21				0
DISSOLVED IRON	4.74	0.05	0.48	18	4.74	0.05	0.48	18				0
MAGNESIUM	55	24.4	36.34	43	55	24.4	36.75	37	36	33	33.83	6
DISSOLVED MANGANESE				0				0				0
MANGANESE	0.46	0.01	0.08	33	0.46	0.01	0.08	33				0
OIL AND GREASE				0				0				0
PH	8.75	7.24	7.98	43	8.75	7.24	8.01	37	7.95	7.66	7.83	6
POTASSIUM	5	0.51	1.55	36	5	0.51	1.6	33	1	1	1	3
SET SOLIDS				0				0				0
SODIUM	97.2	12	77.99	43	97.2	12	76.34	37	96	85	88.17	6
SULFATE	85	10.3	45.23	43	85	10.3	44.75	37	63	44	48.17	6
SUSPENDED SOLIDS	488	1	66.11	28	488	1	66.11	28				0
TEMPERATURE	55.6	7.6	24.19	16	55.6	8.2	32.99	10	14.8	7.6	9.52	6
TOTAL DISSOLVED SOLIDS	520	200	441.4	43	520	200	435.05	37	507	456	480.5	6

Trail Mountain Spring: 17-35-2 (T-16)
Water Quality Data: Operational*
Mine Association: Trail Mountain Mine
Date of Development: Hiawatha Seam: 1998
Date of Second Mining: Hiawatha Seam: 2000

Historical Data: 1978 - 2012	No Flow Reported			
	MAXIMUM	MINIMUM	AVERAGE	# ANALYSIS
BICARBONATE				
CALCIUM				
CARBONATE				
CHLORIDE				
CONDUCTIVITY				
DISSOLVED OXYGEN				
FLOW	Damp	Dry		
HARDNESS				
TOTAL IRON				
DISSOLVED IRON				
MAGNESIUM				
DISSOLVED MANGANESE				
MANGANESE				
OIL AND GREASE				
PH				
POTASSIUM				
SET SOLIDS				
SODIUM				
SULFATE				
SUSPENDED SOLIDS				
TEMPERATURE				
TOTAL DISSOLVED SOLIDS				

* No flow ever recorded

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PROFILE

PROFILE

PROFILE

FRACTURES

17-35-1

17-35-2

18-2-1

Trail Mountain 1st Right

Trail Mountain 2nd Right

Trail Mountain 3rd Right

4th Right

5th Left Mains

Trail Mountain 8th Right

Trail Mountain 9th Right

Trail Mountain 1st Left

Trail Mountain 10th Right

Trail Mountain Mine

AREA 24

CAD FILE NAME/DISK#: AREA24_2008.DWG

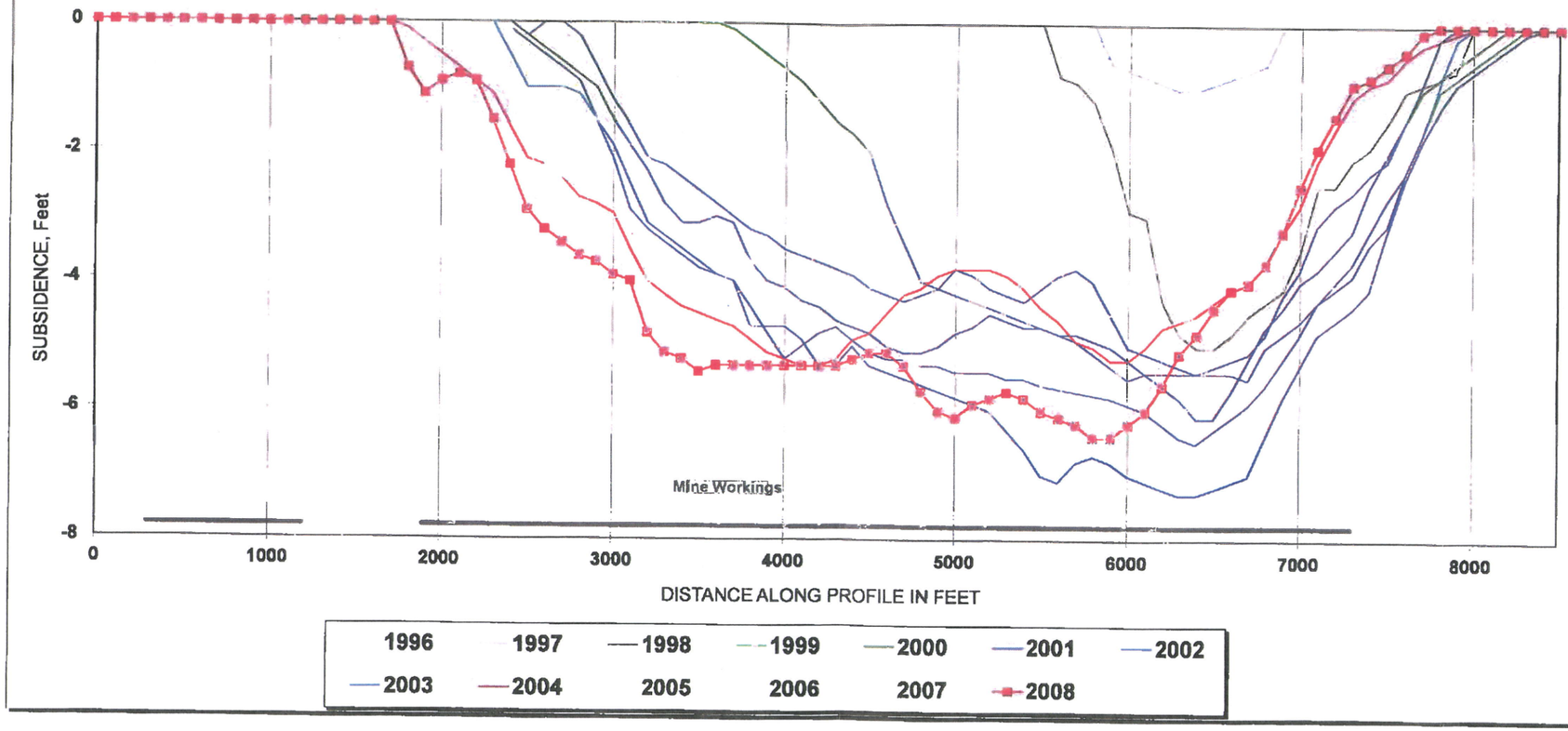
ENERGY WEST MINING COMPANY
A SUBSIDIARY OF PACIFICORP

2008 SUBSIDENCE – AREA 24
TRAIL MOUNTAIN MINE
1ST–10TH RIGHT LONGWALL PANELS

DRAWN BY:	K.S.F., K.J.L.	FIGURE 15	
SCALE:	1"=800'	DRAWING #:	
DATE:	January 09, 2009	SHEET 1 OF 1	REV. ___

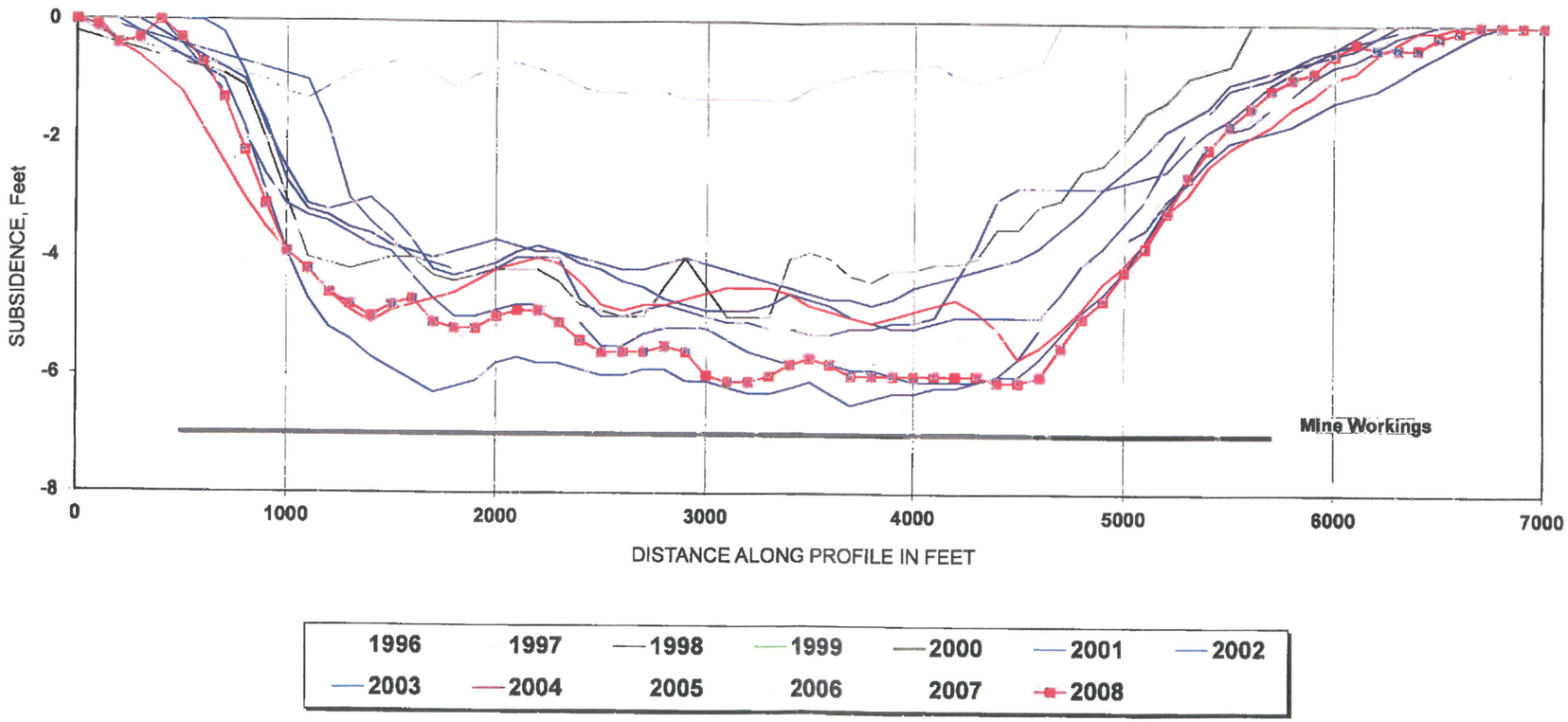
Energy West 2008 Subsidence Report
Area 24 Subsidence Profile
North - South - Trail Mtn. West Side

Chart 22



Energy West 2008 Subsidence Report
Area 24 Subsidence Profile
West - East - Trail Mtn. West Side

Chart 23



Spring: 17-35-1

Elevation: 8,881 feet
Coordinate: N 39°18'13.9“ W 111°13‘02.6"
Aspect: Southwest-facing
Associated Formation: North Horn

Note: Spring developed by cattlemen. Site has not been maintained. A similar developed site about 100 feet above is flowing approximately 1 gpm.

Spring: 17-35-2

Elevation: 8,994 feet
Coordinate: N 39°18'04.0“ W 111°12'46.3"
Aspect: South Southwest
Associated Formation: North Horn

Location: Section 2, Township 18 South, Range 6 East, SLB&M. This site is outside the Trail Mountain mine permit boundary and outside any Federal coal lease.

Lease Association: The spring 18-2-1 is located within the former federal coal lease UTU-64375. PacifiCorp was the lessee. In 2009, PacifiCorp applied for partial relinquishment of lease UTU-64375 and UTU-49332 (refer to January 5, 2009 application document "Partial Relinquishment, Federal Coal Lease, UTU-64375" and "Partial Relinquishment, Federal Coal Lease, UTU-49332") as all reserves had been mined and subsidence was substantially complete. The BLM retroactively approved partial relinquishment as of January 9, 2009.

Subsidence: Panel development began with the advancement of the 8th and 9th Right gateroads in 1996. Panel extraction began in the 9th Right panel in 1997. Extraction of the 8th Right panel followed and was completed in 1998. Subsidence northeast of the spring shows a maximum of approximately 7 feet. Extraction of both panels stopped short (1600 feet in 8th Right and 2600 feet in 9th Right) because of the poor coal quality found. "Subsidence monitoring showed a steady increase (as reported in the 2008 Annual Subsidence Report) in subsidence from 1997 through 2001". The panels below spring 18-2-1 were completely extracted during 1997 and 1998.

The mode of occurrence for this site is permeable fluvial channel that intersect the land surface. The stratigraphic location is the base of the Upper Price River Formation.

Water Data: Pre- and Post-mining water quality data is included for site 18-2-1. Data show insignificant variances of quality throughout history. Historic flow data has been collected since 1988 and has continued through 2012. PacifiCorp cannot verify the flow data prior to its purchase of the Trail Mountain Mine in 1992. High and low flows correspond directly to the high and low reports of the Palmer Hydrological Drought Index. Flow information is found on the following page where July spring flow is plotted against precipitation data collected from the East Mountain weather station, as well as the Palmer Drought Index for regions 4, 5, and 6. The East Mountain weather station is located on the southern tip of East Mountain. Spring flow also shows a positive correlation with precipitation.

Justification for removal from monitoring: Site 18-2-1 has been monitored since 1988. Energy West Mining Company has monitored the spring since 1992. Historic quality and quantity data does not indicated impacts to the site.

Records between 1988 thru 1998 show flows from 0.03 gpm in 1992 to 11 gpm in 1988. The highest flow followed several years of wet to very wet water years. The lowest flows recorded (0 gpm) were found during several dry to extremely dry years.

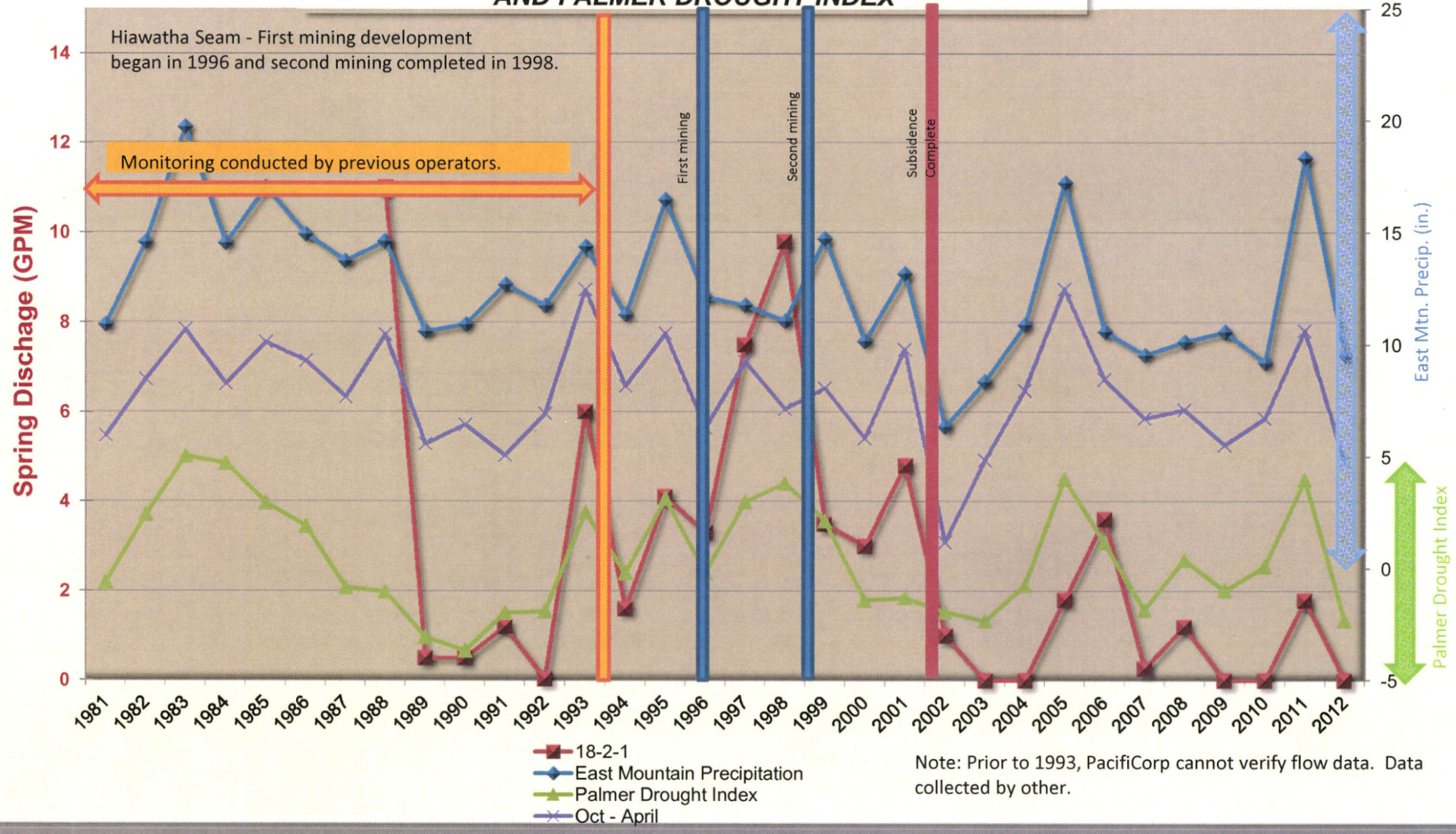
"Subsidence monitoring showed a steady increase (as reported in the 2008 Annual Subsidence Report) in subsidence northwest of the spring from 1997 through 2001". The panels below spring 18-2-1 were completely extracted during 1997 and 1998. During this same time period, spring flow monitoring recorded its second and third highest flows of 7.5 gpm in 1997 and 9.8 in 1998. The Palmer Hydrological Drought Index also reported above normal precipitation for those same years. This pattern suggests that spring flow is most likely regulated by climate rather than impacted by underground mining operations.

Subsidence at the spring was recorded at 1 to 2 feet in 2008 and was considered substantially complete. Lease relinquishment of lease UTU-64375 was retroactively approved on January 9, 2009 by the BLM. The USFS and DOGM concurred with the application which stated that there were no impacts to the natural resources within the area of UTU-64375. Monitoring for subsidence in the area ceased as of 2010.

The lease relinquishment application included a narrative (in Appendix C of the application) which discussed the ground and surface water hydrology of Trail Mountain. The document find no impacts to quality or quantity of ground water discharge within the Trail Mountain property. This narrative is included herein in Appendix D.

Energy West disagrees with the Division that it is necessary to continue monitoring of this location to better evaluate the dry period flows. Energy West is confident that the evidence presented is sufficient to show that there has been no impact to the spring due to underground mining operations.

TRAIL MOUNTAIN SPRINGS
SPRING: 18-2-1 vs. PRECIPITATION
PEAK FLOW (JULY) vs. EAST MOUNTAIN WEATHER STATION AND PALMER DROUGHT INDEX



Note: Prior to 1993, PacifiCorp cannot verify flow data. Data collected by other.

Trail Mountain Spring: 18-2-1 (T-6)
Water Quality Data: Operational
Mine Association: Trail Mountain Mine
Date of Development: Hiawatha Seam: 1996
Date of Second Mining: Hiawatha Seam: 1998

- Historic data includes data collected prior to Energy West Mining Company.

Historical Data: 1987 - 2012					Pre-Mining Data: 1992-1995				Post-Mining Data: 1998-2012				
	MAXIMUM	MINIMUM	AVERAGE	# ANALYSIS	MAXIMUM	MINIMUM	AVERAGE	# ANALYSIS	MAXIMUM	MINIMUM	AVERAGE	# ANALYSIS	
BICARBONATE	452	326	393.49	55	452	350	397.23	13	421	326	374.67	18	BICARBONATE
CALCIUM	80.6	44	61.84	55	67.5	45.7	58.66	13	71.5	56	63.15	18	CALCIUM
CARBONATE	5	0	1.1643	14	5	0.1	1.48	11	0	0	0	3	CARBONATE
CHLORIDE	61.7	38	45.365	55	48.7	38	44.58	13	48	38	43.18	18	CHLORIDE
CONDUCTIVITY	1256	810	974.37	52	969	810	909.85	13	1256	839	1044	18	CONDUCTIVITY
DISSOLVED OXYGEN	12.3	4.6	7.55	14	12.3	4.6	7.7	10				0	DISSOLVED OXYGEN
FLOW	18.9	0.03	3.0457	49	6	0.03	2.04	12	10.2	0.27	2.91	18	FLOW
HARDNESS	461	330	391.02	50	405	330	380.31	13	461	366	404.72	18	HARDNESS
TOTAL IRON	1.28	0	0.1632	25	1.28	0.1	0.29	9	0.06	0	0.02	3	TOTAL IRON
DISSOLVED IRON	0.2	0	0.0889	19	0.2	0.05	0.14	10	0	0	0	3	DISSOLVED IRON
MAGNESIUM	76	45.5	57.368	55	65	50	56.86	13	68.5	55	60.01	18	MAGNESIUM
DISSOLVED MANGANESE	0.005	0	0.0017	3				0	0.005	0	0.0017	3	DISSOLVED MANGANESE
MANGANESE	0.02	0	0.0464	35	0.2	0.02	0.99	13	0.003	0	0.001	3	MANGANESE
OIL AND GREASE				0				0				0	OIL AND GREASE
PH	8.15	7.01	7.742	55	8.15	7.01	7.81	13	7.6	7.28	7.49	18	PH
POTASSIUM	5	0.6	1.5574	42	5	0.6	2.41	13	1.16	0.87	1.04	9	POTASSIUM
SET SOLIDS	0.1	0.1	0.1	1			0.1	0				0	SET SOLIDS
SODIUM	81	53	66.488	55	70	53	61.65	13	75	60	67.04	18	SODIUM
SULFATE	210	80	141.22	55	210	80	131.77	13	196	131	160.57	18	SULFATE
SUSPENDED SOLIDS	560	1	34.603	29	32	2	10.75	12				0	SUSPENDED SOLIDS
TEMPERATURE	56.1	6.1	17.419	28	56.1	36.1	47.36	6	13.5	6.1	9.34	18	TEMPERATURE
TOTAL DISSOLVED SOLIDS	655	480	585.78	55	594	500	564.77	13	655	567	614.22	18	TOTAL DISSOLVED SOLIDS

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PROFILE

PROFILE

PROFILE

PROFILE

FRACTURES

17-35-1

17-35-2

18-2-1

Trail Mountain 1st Right

Trail Mountain 2nd Right

Trail Mountain 3rd Right

4th Right

5th Right

5th Left Mains

Trail Mountain 8th Right

Trail Mountain 9th Right

Trail Mountain 10th Right

Trail Mountain 1st Left

Trail Mountain Mine

AREA 24

CAD FILE NAME/DISK#: AREA24_2008.DWG

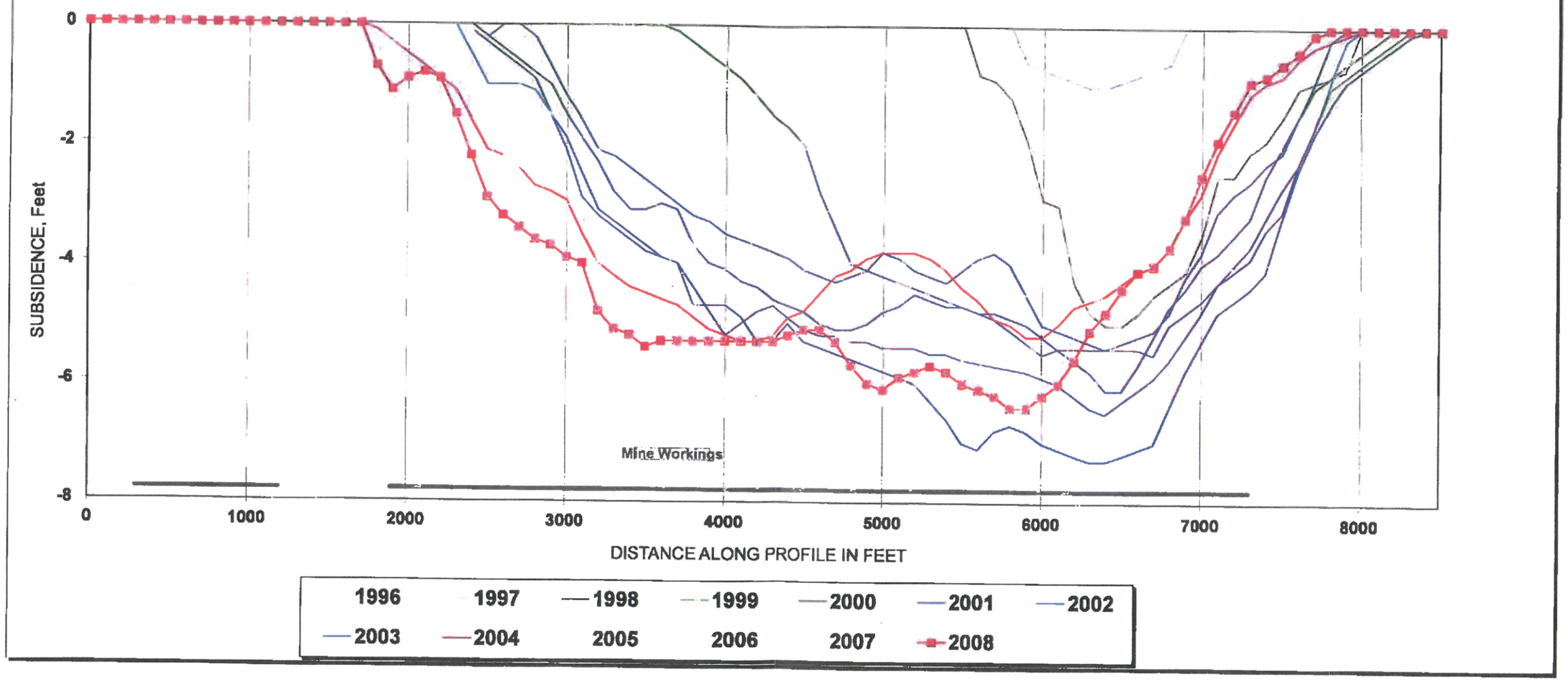
ENERGY WEST MINING COMPANY
A SUBSIDIARY OF PACIFICORP

2008 SUBSIDENCE – AREA 24
TRAIL MOUNTAIN MINE
1ST–10TH RIGHT LONGWALL PANELS

DRAWN BY:	K.S.F., K.J.L.	FIGURE 15	
SCALE:	1" =800'	DRAWING #:	
DATE:	January 09, 2009	SHEET 1 OF 1	REV. ___

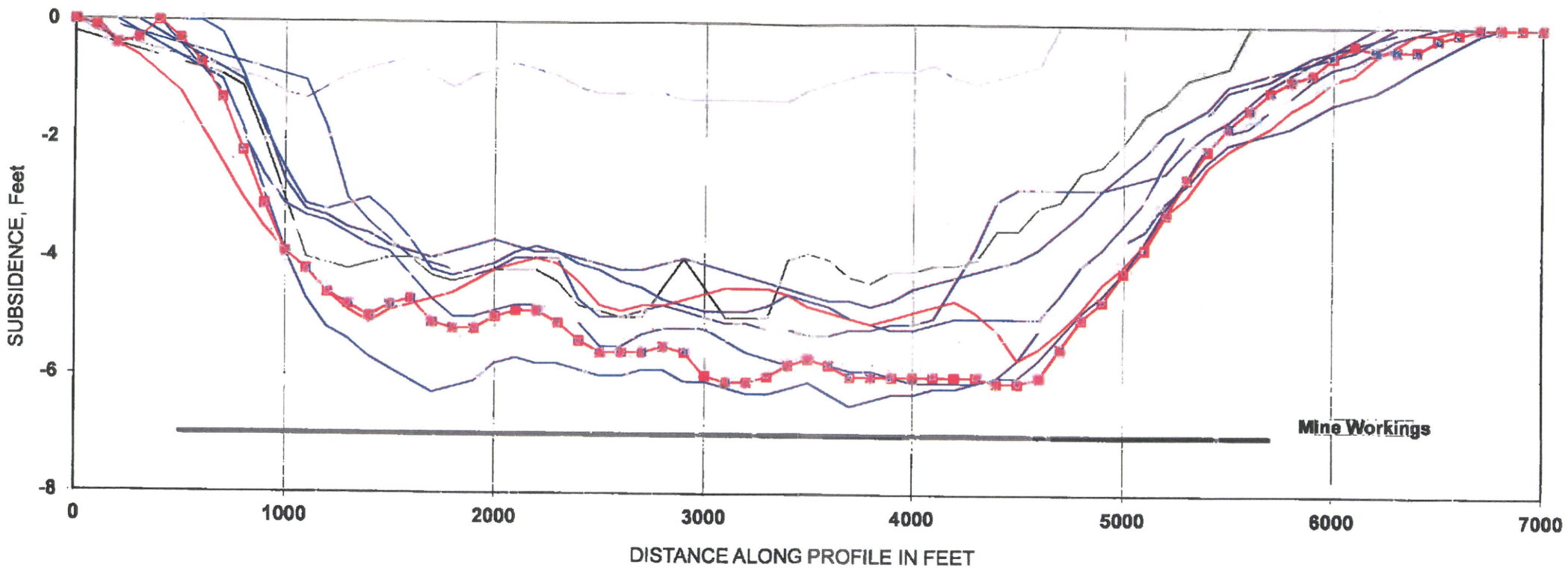
Energy West 2008 Subsidence Report
Area 24 Subsidence Profile
North - South - Trail Mtn. West Side

Chart 2



Energy West 2008 Subsidence Report
Area 24 Subsidence Profile
West - East - Trail Mtn. West Side

Chart 23



Spring: 18-2-1

Elevation: 8,472 feet
Coordinate: N 39°17'36.5“ W 111°13'06.6"
Aspect: South Southwest
Associated Formation: Upper Price River
Note: Spring developed by ECWCD in (?). Site has not been maintained. Collection box filled in with sediment and trough dilapidated.

Trail Mountain Mine Discharge: T-18 or Oliphant Mine

Location: Section 11, Township 18 South, Range 6 East, SLB&M. This site is outside the Trail Mountain mine permit boundary in Straight Canyon.

Lease Association: N/A.

Subsidence: None

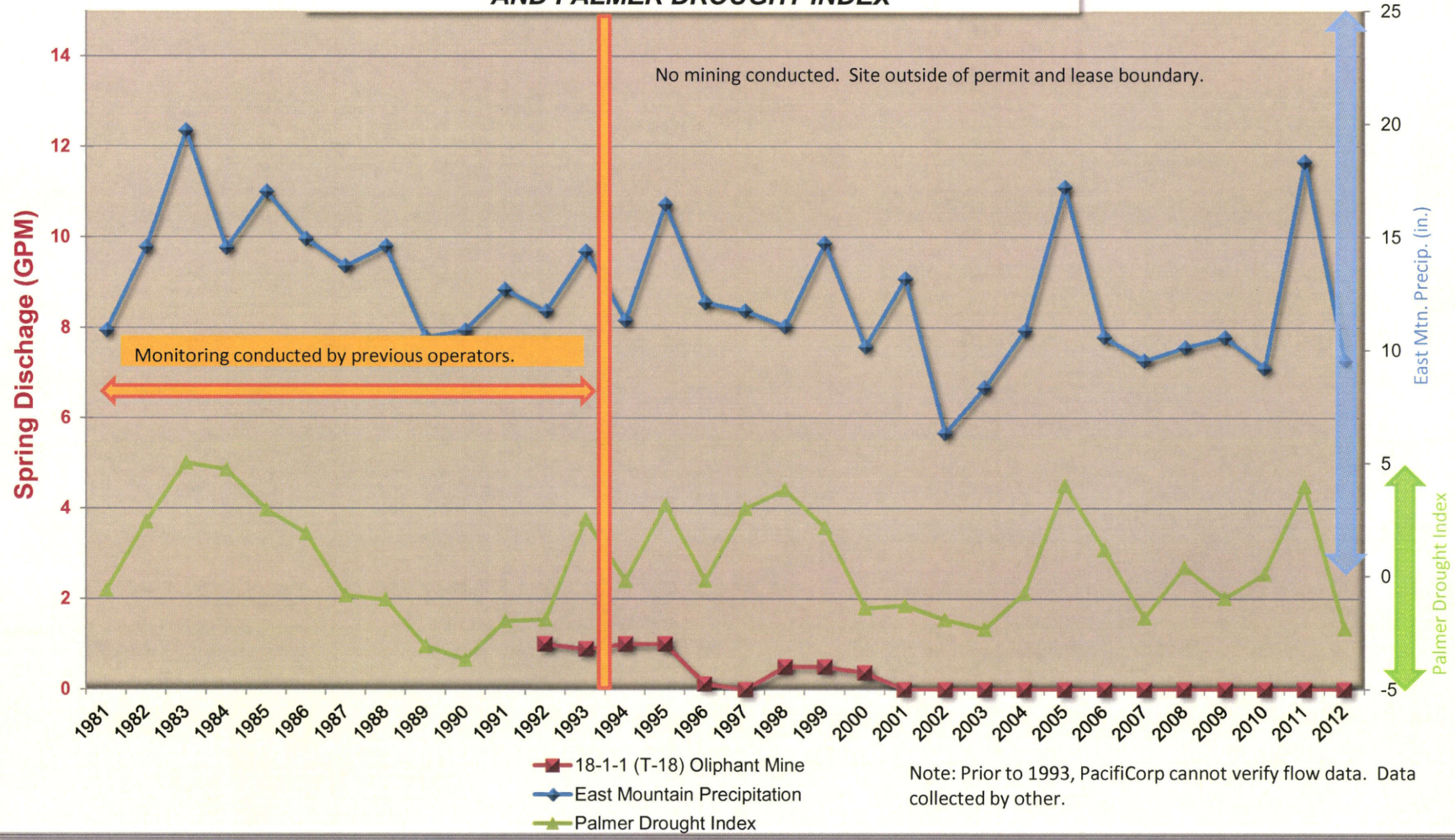
Water Data: Water quality data is included for site 18-1-1 (a.k.a. T-18, Oliphant Mine). Data show insignificant variances of quality throughout history. Historic flow data has been collected since 1988 and has continued through 2012. This information is found on the following page where flow is plotted against precipitation of the East Mountain weather station. The East Mountain weather station is located on the southern tip of East Mountain. The Oliphant Mine portals discharge rarely produced any significant flow.

Justification for removal from monitoring: Site 18-1-1 has been monitored by Energy West Mining Company since 1988. The site is located above the Straight Canyon road in a sealed portal of the Oliphant Mine. The Abandoned Mine Lands program sealed these portals in the 1980's. The portal seal seeps water along the bottom of the seal. During a recent visit to the portal, company officials dug a trench from the portal seal and found that the saturated ground could produce enough flow for measurement (refer to attached picture). A dam was with pipe was placed in the trench and a flow measurement was taken. The flow was measured at ± 1.0 gpm. This flow mimics the historical flows measured between 1992 and 2000.

With this new available flow data, it appears that discharge from the Oliphant Mine portal is consistent as it has always been. The data reported since 2001 has been in error when documented as a seep.

This site is not within PacifiCorp's logical mining unit, or its permit boundary and approximately ½ mile from the Trail Mountain mine workings. Therefore, it is requested that the site be removed from the monitoring program.

TRAIL MOUNTAIN SPRINGS
SPRING: 18-1-1 vs. PRECIPITATION
PEAK FLOW (June) vs. EAST MOUNTAIN WEATHER STATION AND PALMER DROUGHT INDEX



Note: Prior to 1993, PacifiCorp cannot verify flow data. Data collected by other.

Trail Mountain Spring: 18-1-1 (T-18)
Water Quality Data: Operational
Mine Association: Trail Mountain Mine
Date of Development: Off lease, off permit
Date of Second Mining: NA

Notes:

- Data compares quality prior to longwall mining to historic quality data. No flow after 2001.

Historical Data: 1988 - 2001					Pre-Mining Data: 1988-1997			
	MAXIMUM	MINIMUM	AVERAGE	# ANALYSIS	MAXIMUM	MINIMUM	AVERAGE	# ANALYSIS
BICARBONATE	327	214	281.71	45	327	214	282.28	32
CALCIUM	87.9	17.5	59.742	45	87.9	17.5	60.169	32
CARBONATE	30	0.1	12.077	13	30	0.1	12.077	13
CHLORIDE	21	4	8.2733	45	21	5.9	9.1594	32
CONDUCTIVITY	925	482	662.83	42	925	482	665.48	29
DISSOLVED OXYGEN	14.7	3.6	7.8167	12	14.7	3.6	7.8727	11
FLOW	14	0.125	1.9252	45	14	0.125	2.5286	32
HARDNESS	381	282	319.33	45	381	291	327.47	32
TOTAL IRON	0.7	0.01	0.1591	23	0.7	0.01	0.1591	23
DISSOLVED IRON				0				0
MAGNESIUM	67.32	35	41	45	67.32	35.5	42.594	32
DISSOLVED MANGANESE				0				0
MANGANESE	0.2	0.02	0.0638	16	0.2	0.02	0.0638	16
OIL AND GREASE	5	0.4	4.425	8	5	0.4	4.425	8
PH	8.91	7.54	8.1009	45	8.91	7.63	8.2366	32
POTASSIUM	5.42	3	3.8981	43	5.42	3	4.02	31
SET SOLIDS	0.1	0.1	0.1	1	0.1	0.1	0.1	1
SODIUM	31	12	21.084	45	31	12	21.713	32
SULFATE	330	90	123.2	45	173.7	90	119.2	32
SUSPENDED SOLIDS	90	1	22.565	23	90	1	22.565	23
TEMPERATURE	71.6	3	33.748	45	71.6	3.5	44.133	32
TOTAL DISSOLVED SOLIDS	584	354	410.04	45	584	354	417.06	32

Spring: TM-18
Oliphant Mine Discharge

Coal Seam: Hiawatha Seam
Associated Formation: Blackhawk

Note: Seal in portal leaks. Over time sediment buildup did not allow surface flow and field technician reported site as seep. Recently, Energy West personnel shoveled a ditch to concentrate the flow and found the site still produced historic quantities.

Location: Section 3, Township 18 South, Range 6 East, SLB&M. This site is outside the Trail Mountain mine permit boundary in Straight Canyon.

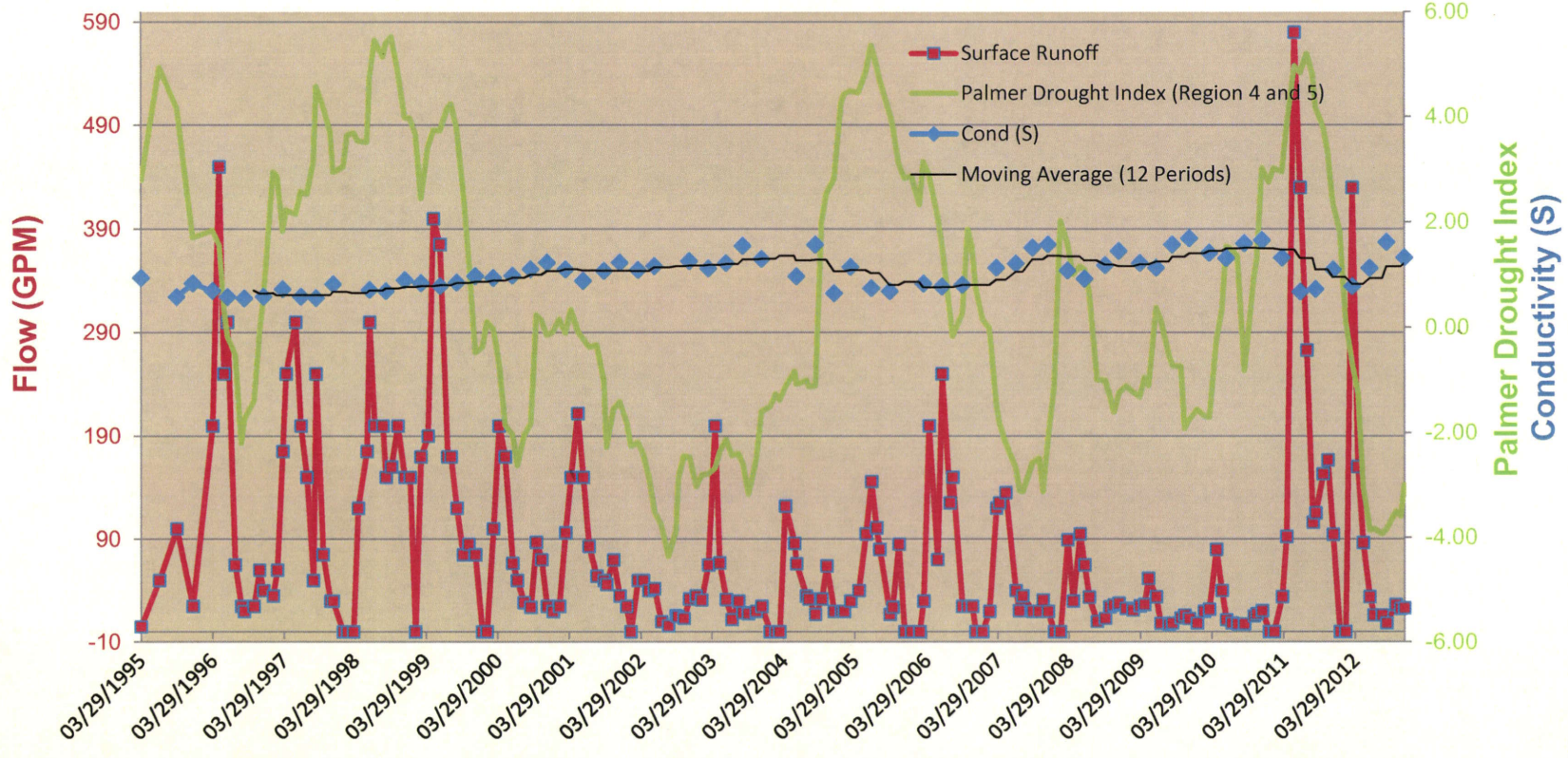
Lease Association: N/A.

Subsidance: None

Water Data: Water quality data is included for site T-19. Data show insignificant variances of quality throughout history. Historic flow data has been collected consistently since 1995 and has continued through 2012. This information is found on the following page where flow is plotted against precipitation of the East Mountain weather station. The East Mountain weather station is located on the southern tip of East Mountain. The surface flow shows a positive correlation with precipitation.

Justification for removal from monitoring: Site T-19 has been monitored by Energy West Mining Company since 1988. There have been no reported occurrences in which mining has impacted this site. Historic quality and quantity data has not indicated such impacts to the site. This site is not within PacifiCorp's logical mining unit or its permit boundary. Therefore, it is requested that the site be removed from the monitoring program.

Trail Mountain Surface Runoff
T-19
Flow vs. Palmer Drought Index



Trail Mountain Spring: **T-19**
Water Quality Data: **Operational**
Mine Association: **Trail Mountain Mine**
Date of Development: **Off lease, off permit**
Date of Second Mining: **NA**

Notes:

- Trail Mountain Mine was place into temporary cessation in May, 2001. The portals were seal as part of closure.

	Pre-Closure Data: 1988 - 2001			Post-Closure Data: 2001-2012		
	MAXIMUM	MINIMUM	AVERAGE	MAXIMUM	MINIMUM	AVERAGE
BICARBONATE	437	190	355.50	500	255	360.60
CALCIUM	92	14.3	46.11	98.9	42.1	65.95
CARBONATE	78	1	16.75	49	0	12.67
CHLORIDE	67.9	20	38.38	43	19	33.13
CONDUCTIVITY	1380	581	926.36	1840	650	1249.84
DISSOLVED OXYGEN	11.7	5.4	8.30	8.1	8.1	8.10
FLOW	375	5	94.51	430	7.67	65.72
HARDNESS	993	178	379.54	906	301	566.96
TOTAL IRON	5.1	0.05	0.77	2.7	0	0.43
DISSOLVED IRON	0.38	0.03	0.16	0.039	0	0.00
MAGNESIUM	92	24	59.04	162	46.93	98.19
DISSOLVED MANGANESE				0.1	0	0.01
MANGANESE	0.2	0.01	0.06	0.053	0	0.00
OIL AND GREASE	5	1	3.99	2	0	0.11
PH	8.87	7.44	8.41	8.68	8.07	8.45
POTASSIUM	30.2	0.7	3.42	10.39	1.75	5.46
SET SOLIDS	0.5	0.5	0.50			
SODIUM	125.2	12	72.82	91.5	33.29	73.37
SULFATE	340	39	155.46	609	63	317.19
SUSPENDED SOLIDS	420	1	83.67	338	0	49.15
TEMPERATURE	71	-1.5	28.91	18.5	0.2	7.73
TOTAL DISSOLVED SOLIDS	910	340	572.13	1256	387	827.73

IC 9405

INFORMATION CIRCULAR/1994

Response of Springs to Longwall Coal Mining at the Deer Creek and Cottonwood Mines, Wasatch Plateau, UT

By Liane L. M. Kadnuck

United States Department of the Interior

Bureau of Mines

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U.S. Department of the Interior
Mission Statement

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally–owned public lands and natural resources. This includes fostering sound use of our land and water resources; protecting our fish, wildlife, and biological diversity; preserving the environmental and cultural values of our national parks and historical places; and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people by encouraging stewardship and citizen participation in their care. The Department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

Cover: Clockwise from top left: topography of East Mountain Summit; typical topography of Wasatch Plateau; surveying instrument in winter snowpack, soure of recharge for local springs; spring 1 and the stock watering pond it creates.

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Information Circular 9405

Response of Springs to Longwall Coal Mining at the Deer Creek and Cottonwood Mines, Wasatch Plateau, UT

By Liane L. M. Kadnuck

UNITED STATES DEPARTMENT OF THE INTERIOR
Bruce Babbitt, Secretary

BUREAU OF MINES

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UNIT OF MEASURE ABBREVIATIONS USED IN THIS REPORT

cm	centimeter	m	meter
km	kilometer	pct	percent
L/s	liter per second		

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SPRING CROSS REFERENCE

U.S. B. M. SPRING ID.	ENERGY WEST ID.
A	ELK SPRINGS
B	SHEBA SPRINGS
C	79-15
D	79-35
E	79-29
F	82-52
G	TED'S TUB
H	79-23
I	BURNT TREE
J	79-2
K	80-44
L	80-41
M	80-46
N	84-56

RESPONSE OF SPRINGS TO LONGWALL COAL MINING AT THE DEER CREEK AND COTTONWOOD MINES, WASATCH PLATEAU, UT

By Liane L. M. Kadnuck[1]

ABSTRACT

This report summarizes the results of a hydrologic research study conducted by the U.S. Bureau of Mines (USBM) in cooperation with Energy West Mining Co. at the Deer Creek and Cottonwood Mines, near Orangeville, UT. The USBM evaluated hydrologic and overburden failure data to assess the response of local ground water to underground coal mining in single- and multiple-seam conditions. Fourteen springs located over the two mines were investigated in the study along with overburden failure response caused by longwall panel extraction. Spring discharge was compared to climatic variation and time of undermining to quantify response to undermining. Spring discharge had been reduced owing to below-normal precipitation during the period evaluated. The response of springs to mining in the vicinity was influenced in part by the thick overburden present at the study site, the presence of hydrophilic clays and mudstones in the overburden stratigraphy, and elevation of the springs above the mine level, which buffered the effects of undermining.

[1]Environmental engineer, Denver Research Center, U.S. Bureau of Mines, Denver, CO.

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INTRODUCTION

To quantify the response of overburden stratigraphy to high-extraction coal mining, the U.S. Bureau of Mines (USBM) initiated a research program to evaluate the effects of mining and associated subsidence in varying geologic conditions. The primary objective of this program is to understand the mechanics of subsidence and overburden failure response resulting from underground mining in Western U.S. coalfields. Previous USBM studies have focused on surface effects of underground coal mining *(1-5)*.[2] Recognizing that subsidence produces alterations in overburden characteristics which in turn produce associated changes in the hydrologic system, the program was expanded to include characterization of the response of hydrologic systems contained in the overburden. This study addresses the effects of overburden failure on hydrologic resources in proximity to a mined area.

This report describes the response of ground water contained in the overburden to underground mining in the Wasatch Plateau Coalfield. The study involved evaluating the response of local ground water resources overlying the Deer Creek and Cottonwood coal mines in Emery County, UT. The goals of this study were to (1) quantify fluctuations in spring discharge associated with undermining, (2) assess longevity of discharge fluctuations, and (3) correlate the stratigraphic locations and elevations of springs in the overburden stratigraphic column with zones of overburden failure.

ACKNOWLEDGMENTS

PacifiCorp's Fuel Resources Division provided valuable assistance in performing this research. Specifically, Chuck Semborski of the Energy West Mining Co. and Rodger Fry of InterWest Mining contributed much of the data and information contained in this report. Without their assistance, this study could not have been undertaken.

DEER CREEK AND COTTONWOOD MINES STUDY SITE

The Deer Creek and Cottonwood Mines are located in the Wasatch Plateau Coalfield in south-central Utah (figure 1). Two major coal seams are mined in the area by Energy West Mining Co., a subsidiary of PacifiCorp.; the Deer Creek Mine operates in the Blind Canyon Seam, and the Cottonwood Mine produces coal from the Hiawatha Seam approximately 26 m below. The Deer Creek Mine overlies and partly overlaps the Cottonwood Mine; hence the study area contains areas of both single- and multiple-seam mining. The mines are located on East Mountain (elevation 2,942 m). The local topography is typified by rugged mountains dissected by stream-incised canyons. The overburden thickness averages 518 m but ranges from 260 to over 700 m, depending on local topography.

Both mines currently extract coal using longwall retreat methods, and each contains areas of past room-and-pillar extraction. The coal is hard, dense, and ranked B to C bituminous. The Deer Creek Mine operates at an average extraction height of 3.3 m, and the Cottonwood Mine has an average extraction height of 2.6 m.

[2]Italic numbers in parentheses refer to items in the list of references preceding the appendix.

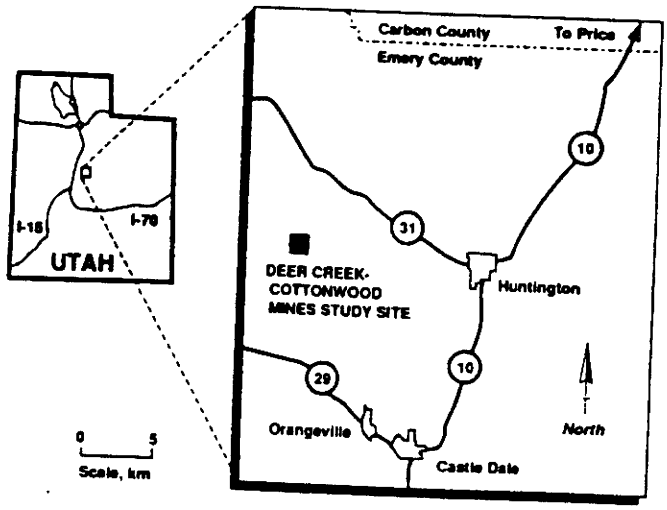

Figure 1.—Project location map.

GEOLOGY

Regional Geology

The mines are located on the Wasatch Plateau, a broad, north-south-trending, flat-topped mesa. The eastern edge of the plateau lies on the western flank of the San Rafael Swell and is typified by gently westward-dipping strata. The western edge of the plateau is complexly faulted and represents the transition between the Colorado plateau

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region and the Great Basin. Geologic units outcropping in the area range in age from Cretaceous to Tertiary, with some thin, unconsolidated Quaternary deposits present in stream valleys.

Local Geology

Exposed strata in the mine area are of sedimentary origin. The economic coal deposits are found in the lower part of the stratigraphic section. Generalized lithologies and thicknesses of each geologic unit are summarized in figure 2 *(6)*.

The youngest geologic unit in the area, the Flagstaff Limestone, is a freshwater limestone that caps portions of the top of East Mountain. The Flagstaff is underlain by the North Horn Formation, a variegated shale and mudstone sequence derived from fluvial and lacustrine origins. The Price River Formation forms a steep, receding slope under the North Horn and consists of a conglomeratic fluvial sandstone with shale layers. The North Horn and Price River Formations each contain claystones and mudstones that are rich in hydrophilic clays. The fluvial Castlegate Sandstone forms a cliff between the Price River and Blackhawk Formations. The Blackhawk Formation is a marginal marine sequence of lenticular sandstone beds and carbonaceous shales with economic coal deposits. The Blackhawk is typified as having fluvial channels scoured into the top of the coal deposits. Underlying the Blackhawk is the Star Point Sandstone, a thinly bedded marine sandstone with shale interbeds at the base where it intertongues with the older Masuk Shale Member of the Mancos Formation.

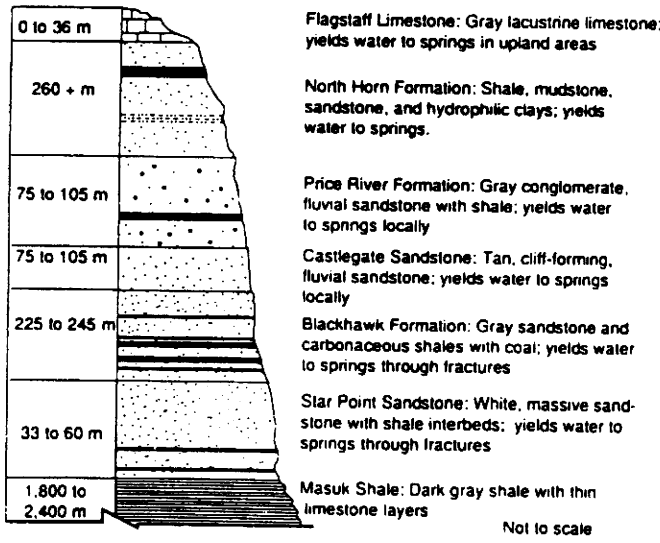

Figure 2.—Generalized overburden stratigraphy (modified from Danielson and others (7)).

The regional dip of the strata is broken by t northeast-trending axis of the Straight Canyon synclir located on the western end of East Mountain. Faulting common on the Wasatch Plateau, and three faults, t Deer Creek, Pleasant Valley, and Roan's Canyon, crossc the permit area *(6)*. Jointing is also prevalent in the ar and joint sets trending northeast-southwest and northwe southeast crosscut the study area. Figure 3 shows t locations and trends of the major structural features.

HYDROLOGIC SYSTEM

Ground Water Hydrology

Ground water occurs in all exposed geologic units d cussed in the previous section in continuous or discc tinuous water-bearing zones. The formations yield grou water from perched zones[3] to springs[4] where the hydrau conductivity of the water-bearing zone is higher than th of the surrounding rock, and where the formations a fractured or faulted. The lateral continuity of the perched water tables is not known, though there is son evidence for limited lateral extent based on springs locat at the same elevation *(6)*. The lateral extent of wate bearing zones is limited based on the discontinuous natu of the local topography. A continuous water-bearing u was found to be present in the Star Point sandsto through drillers' logs and regional ground water studie

Ground water in the area is recharged largely fro precipitation, most of it from snowmelt, which percolat into the subsurface through fractures or matrix flow (9 The flat top of East Mountain allows water to infiltrate the subsurface through fractures exposed at the surfac Some recharge also infiltrates to the subsurface on t mountain flanks. Older units are recharged mainly fro water that migrates through fractures. Impermeable lens of shale and mudstone in the North Horn and Price Riv Formations retard downward migration of water, althou some water is transmitted to the lower geologic uni through continuous fractures. Geotechnical tests pe formed on the North Horn Formation indicated hydr philic or swelling materials were present in the clays an mudstones that swelled 40 pct in the first hour of testin *(10)*. As a result, a large number of springs issue from th North Horn and Price River Formations. The Star Poi Sandstone and the Blackhawk Formation are recharge from overlying units, mainly through faults and fracture *(6)*.

[3]By definition, perched water is "unconfined ground water separate from an underlying main body of ground water by an unsaturated zon *(7)*.

[4]By definition, springs are a place where ground water flows natural from a rock or the soil onto the land surface or into a body of wate and the occurrence depends upon the nature and relationship of rock especially permeable and impermeable strata *(8)*.

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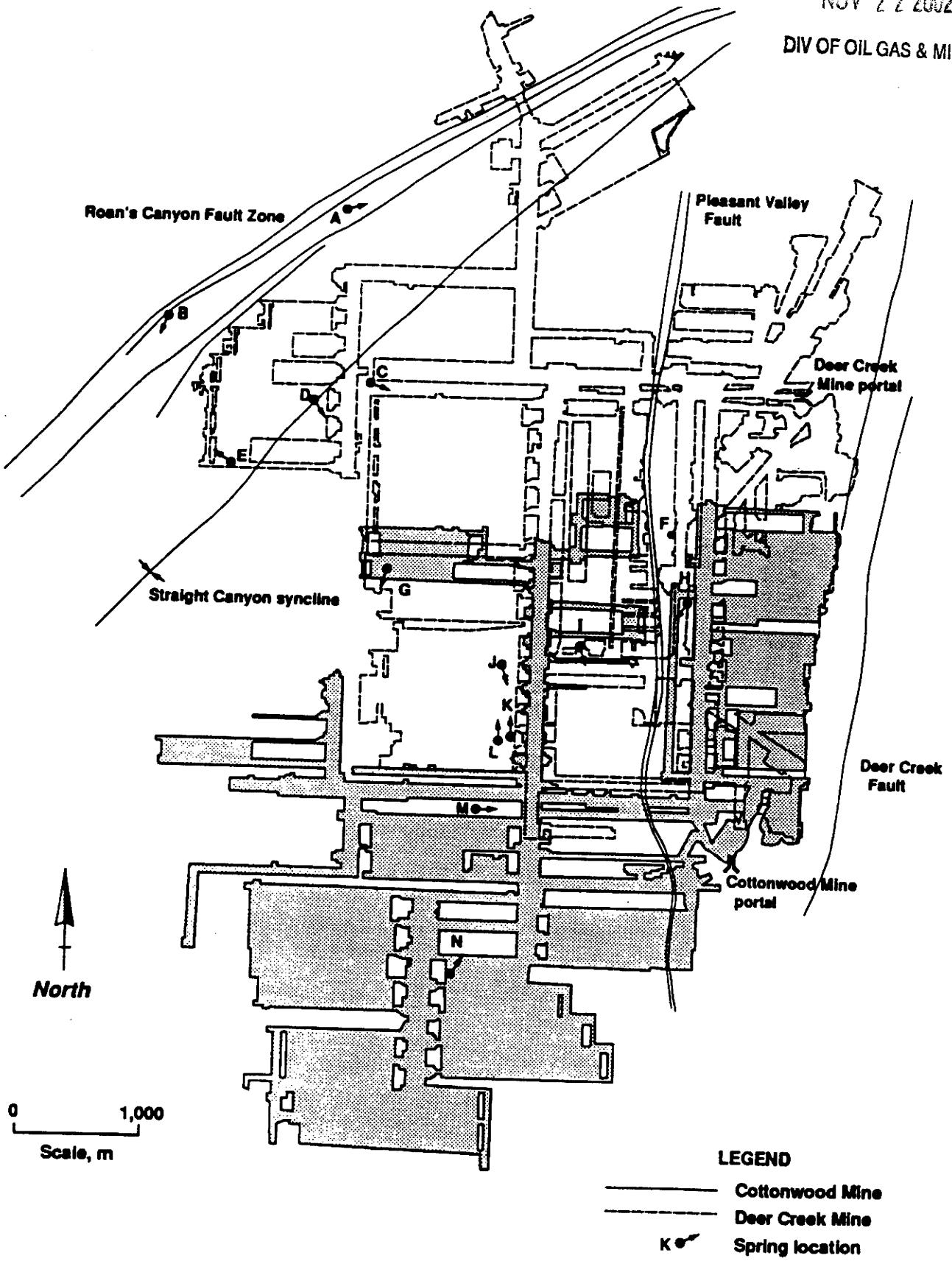

Figure 3.—Mine map showing spring locations.

Water movement is controlled by dip of bedding, primary hydraulic conductivity, and fractures. Regional ground water flow in the immediate area is affected by the Joes Valley and Pleasant Valley fault zones, which are thought to be major conduits of interbasin flow. Water-bearing fractures encountered in the mines further indicate that ground water is transported along faults and fractures *(10)*.

Surface Water Hydrology

As shown on figure 4, East Mountain forms a drainage divide between Huntington Creek to the north and Cottonwood Creek on the south. The north fork of Cottonwood Creek drains the area between Trail and East Mountains, while Huntington Creek drains the area between East Mountain and Gentry Mountain to the north. There are numerous tributaries to these creeks, most of which are ephemeral, flowing only during precipitation events, or intermittent, flowing during wet seasons of the year.

Most of the overland drainage is derived from snowmelt, and most baseflow in the streams originates as ground water discharged from perched aquifers issuing water to springs *(6, 11)*. Large fracture systems associated with the fault zones in the area are thought to control the surface drainage and may intercept creek flow and divert it into other basins. A lineament analysis *(12)* coupled with a drainage trace analysis indicated that the major trunk streams follow a regional northwest-southeast trend and that tributary drainages follow either a north-south, east-west, or northeast-southwest trend. The linearity of the drainage traces suggests that the surface drainage is following fracture or joint systems.

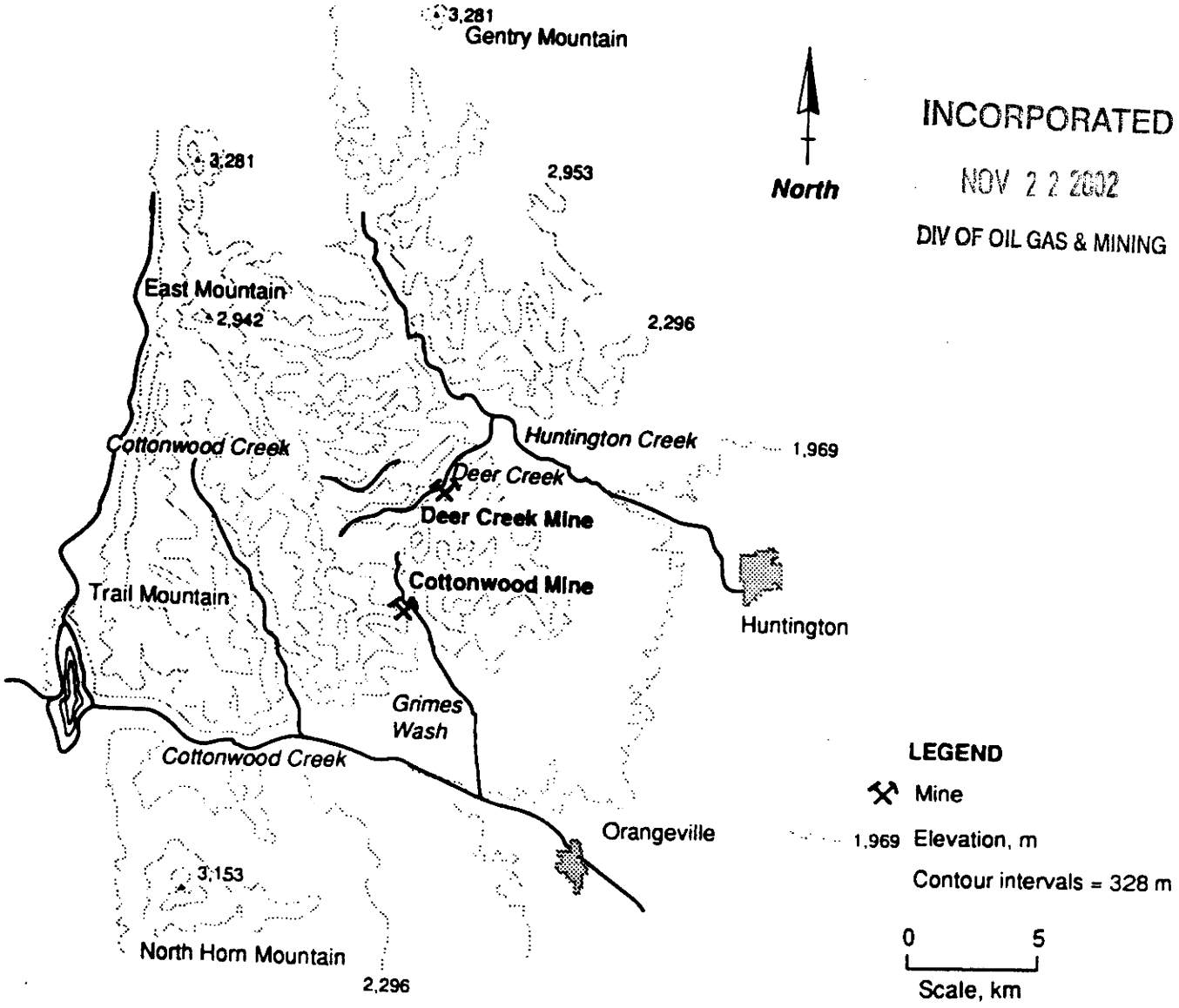

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Figure 4.—Topography of East Mountain showing surface drainage.

HYDROLOGIC DATA COLLECTION

The mining company is required by law to monitor quantity of water resources within the permit area. Monitoring includes spring and stream discharge, piezometric levels in the mine floor, and mine discharge from both the Deer Creek and Cottonwood Mines. This study focused on ground water resources located above the mine level, namely springs, that could potentially be affected by mining. Springs issuing from East Mountain within the Deer Creek and Cottonwood Mines permit area were chosen by PacifiCorp and the Utah Division of Oil, Gas and Mining to be monitored for discharge and water quality. Thirty springs within the permit area are monitored, some on a semiannual basis and some on a monthly basis. Discharge monitoring was started in 1979, and additional springs have been added each year since that time; thus records vary for all the springs monitored. Discharge is measured by weirs, flumes, or manually. The 14 springs selected for use in this study were those with the longest available monitoring records. The springs monitored on a monthly basis are measured from July through October, since they are inaccessible during winter months. Discharge is reported from annual runoff through baseflow in the fall.

The monitoring is performed to allow comparison and assessment of the effects that mining has on the springs. The springs were characterized by mine personnel for issuing mechanism (for example, a fracture or a perched zone), issuing formation, and elevation measurements taken. This information is provided in table 1.

Water enters the mines through faults, fractures, and drill holes, and where localized saturated zones (fluvial sandstone channels) are intercepted by mine workings. Water discharged from the mines is measured at the discharge point on a daily basis and reported as a monthly total. Mine water from the Cottonwood Mine is discharged into Grimes Wash, and water from the Deer Creek Mine is discharged into Huntington Creek (figure 4).

Table 1.—Spring characteristics

Spring	Geologic unit	Issuing mechanism	Elevation, m	Location	Date undermined
A	North Horn	Fracture	2,850	Not in mined area	Not applicable.
B	Flagstaff	..do.	2,969	..do.	Do.
C	North Horn	..do.	2,831	Deer Creek barrier pillar	Do.
D	Flagstaff	Formation contact	2,921	Deer Creek panel	Oct. 1991.
E	North Horn	Perched zone	2,868	..do.	Feb. 1992.
F	Price River	..do.	2,743	Deer Creek barrier pillar	Not applicable.
G	North Horn	Fracture	2,831	Deer Creek panel	Apr. 1988.
H	..do.	Formation contact	2,754	Deer Creek mains, Cottonwood pillar	May 1976.
I	..do.	Perched zone	2,822	Deer Creek submains, Cottonwood panel	Aug. 1993.
J	..do.	..do.	2,831	Deer Creek panel	Aug. 1986.
K	Price River	Fracture	2,737	..do.	Dec. 1982.
L	..do.	Perched zone	2,743	..do.	Aug. 1982.
M	North Horn	..do.	2,850	Cottonwood barrier pillar	Not applicable.
N	..do.	Fracture	2,845	Cottonwood panel	Aug. 1989.

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ANALYSIS OF SPRING RESPONSE TO MINING

RAPHS

This study concentrates on characterizing the impacts mining has on perched water-bearing zones in the overburden. In the study area, water-bearing zones above the mine level issue water to springs, representing an important part of water supply in the region for stream baseflow, agricultural, irrigation, and wildlife habitat purposes. Fourteen springs located on East Mountain were targeted for study based on availability of monitoring records and proximity to the mines and were designated with a letter identifier of A to N. Analysis of spring response followed a method used by Coe and Stowe (*13*), which is one of the few published studies that have examined responses of springs to undermining. This methodology required use of information sets including precipitation, spring discharge, and time of undermining.

This method involved comparing spring discharge hydrographs to precipitation for the period of monitoring. Monthly and total annual precipitation data for water years[5] 1981 to 1993 were utilized and are shown on figure A-1 in the appendix. Precipitation data are collected at a weather station on East Mountain on a daily basis. The availability of seasonal, monthly discharge data dictated using seasonal recession curves to assess mining impacts by determining if the springs departed from normal response. Patterns or trends in the spring discharge recession curves were sought to assess if the springs showed similar responses each year to precipitation, runoff, and baseflow conditions. Curves were compared to one another to discern if springs in the area responded differently based on issuing mechanism (fracture versus perched zone). There did not appear to be large differences in response as a result of issuing mechanism. Several years of data prior to mining were incorporated to establish baseline conditions. Spring discharges, shown as seasonal recession curves, are given on figure A-2.

Initial comparison of spring discharge to precipitation indicated that discharge did not immediately follow precipitation. Therefore, a statistical analysis that cross-correlated precipitation data with spring discharge was performed for two of the springs. This analysis showed that the springs in the study area respond to precipitation events within 6 months to 1 year (*14*). Discharge data for springs I and M were correlated with precipitation; this indicated that there is an approximate 6-month to 1-year lag time between precipitation events and discharge. The lag information was used to better assess variations due to climatic events without confusing them with response that may have been a result of mining. Results of the statistical analysis are given graphically on figure A-3. The graphs show the calculated lag time by offsetting the spring flow hydrograph by 1 year on the precipitation curve; for example, spring flow for 1982 is placed over precipitation for 1981. Local variation of lag time is expected based on differences in elevation, recharge source, and issuing mechanism for each of the springs studied. The statistical correlation gives an indication of the approximate lag time for the area. Figure A-4 gives the statistical results showing match position and correlation coefficient to demonstrate the validity of the correlation of the two data sets.

Spring discharge variation of both preundermining and postundermining was evaluated to identify if the spring discharge changed as the spring was undermined, or as mining progressed close by. Each spring location was compared with a map of mine workings and located with regard to placement over a mine structure such as a panel or a barrier pillar, as shown on figure 3. This information is also listed on table 1. Springs D, E, G, I, J, K, L, and N are located over longwall panels. Springs C, F, H, and M are located over other mine structures such as barrier pillars or mains. Springs A and B are located in an area that has not been undermined and were thus used as controls to identify discharge fluctuations due to climatic events. Spring discharge was carefully compared with precipitation, location of the spring over the extracted area, and time of undermining to assess response.

[5]The water year runs from October 1 to September 30.

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RESULTS AND DISCUSSION

Spring A

Possible responses of springs to coal extraction include enhanced recharge to the spring from dilation of pre-existing fractures, reduction of spring discharge due to drainage into subsidence-induced fractures or dilation of existing fractures, or flow loss along planes of bedding separation *(9)*. Springs located over panels are expected to show a greater response to undermining than those located over mains or barrier pillars since most subsidence, and hence overburden deformation, occurs over the longwall panels. In a study in Appalachia where the overburden ranged from 120 to 245 m, rapid and dramatic decreases in spring discharge were observed as the longwall face passed underneath *(13)*. Trevits and Matetic observed a similar response in water wells located over longwall panels with 70 to 210 m of overburden present *(15)*. With the longwall mining method, subsidence occurs quickly after the coal is extracted as the immediate mine roof caves in behind the active face. Reports from mine personnel indicate that the majority of subsidence occurs at the site over single panels within 1 month after undermining.[6] Previous USBM studies reported that maximum subsidence occurred at these mines within a year where a group of panels had been extracted *(1, 3)*. Given these observations, hydrologic response is expected to occur within a similar timeframe as overburden response. As soon as the overburden fractures and moves in response to coal extraction and roof caving, the hydrologic system is also altered. The expected response of springs would be dramatic changes in discharge after undermining occurred.

Springs A and B were located outside the area disturbed by mining and provided information on the normal seasonal response of springs in the area to precipitation or recharge. From 1986 to 1992, precipitation in the area was 70 to 85 pct of normal. The recession curves for these springs show a general downward trend from 1986, in response to the decreased precipitation during that period. Precipitation increased in 1993 and is shown in the increase in spring discharge on the hydrographs (figure A-2). The shapes of the recession curves show smooth and repeatable patterns for the period of record.

Spring I is used as a water source for a stock watering pond. It was undermined by submains in the Deer Creek Mine in 1985, and by a longwall panel in the Cottonwood Mine in August 1993. It was noted that the recession curves departed from a normal shape coincident with mining activity underneath spring I. However, adjustments of valves and blockage in the pipe installed at the spring also occurred during this time, and available data do not allow for distinguishing the effects of the two activities. Weekly discharge measurements were available after the longwall panel passed underneath. Although surface tension cracks appeared in the vicinity, the spring discharge remained constant at 0.6 L/s. According to aerial surveys, the surface subsidence in the vicinity of spring I ranged from 0.6 to 1.2 m.

Spring E was undermined by a Deer Creek panel in February 1992. This spring exhibited inconsistent recession curves in the 5 years prior to undermining and then had a flat recession curve in the year after undermining. The surface subsidence at spring E was estimated to be 1.6 to 1.8 m. The spring has a very low discharge, making detection of discharge alteration more difficult. It is felt that the discharge alteration for this spring is a result of reduced recharge available from the decrease in precipitation.

Spring N was undermined by a Cottonwood panel in August 1989. The recession curves for the spring have a less consistent shape than those for springs A and B, although the shapes of the spring N curves are repeated over several years. The spring exhibits the same response both before and after undermining and also shows a general downward trend from 1986 due to decreased precipitation. The surface subsidence in the vicinity of spring N was 0.6 to 1.2 m. Given the repeatable nature of the recession curves, spring N does not appear to have been affected by mining.

The remaining springs located over panels and springs located over pillars or mains did not exhibit discernible effects from undermining.

Springs H, K, L, and M exhibited flat recession curves at some point during the period of monitoring. In these cases, the springs were reduced to low or no flow. These springs experienced no-flow conditions for several years corresponding to the drought years. Flow returned in springs K, L, and M in 1993; spring H had not recharged

[6]Personal communication with C. A. Semborski, Energy West Mining Co., Sept. 1993.

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to normal flow by 1993. The flat curves are likely due to depleted recharge from precipitation to the spring source or to depleted storage. Springs D and N each had 1 year where the recession curves were flat, but returned to normally shaped curves the following year. In these cases, the flat recession curves did not correspond to times of undermining. The control springs, A and B, did not show flat recession curves during the period of study, which is likely a result of fracture recharge conditions and locations at high elevations.

The undermined springs do not show the dramatic decreases in flow that have been observed in other studies. The lack of dramatic effects and the limited response observed may be attributed to several factors. One factor is that the springs that have been undermined are situated above the panels at ratios of panel width to overburden thickness (between the spring and the mine level) greater than 1.0. In a study by Tieman and Rauch (*16*), partial to total dewatering was observed in springs that were located above the panels at panel width to overburden ratios of 0.75 to 1.0. Table 2 summarizes the range of panel width to overburden ratios for springs undermined by panels evaluated in this study. Since the ratios are greater than 1.0 for the springs in this study, dewatering would not be anticipated, based on the observations made by Tieman and Rauch. This does not preclude minor discharge variations occurring as a result of strata movement or stress redistribution. Table 2 also lists the estimated surface subsidence in the vicinity of the springs located over panels.

Table 2.—Ratios of panel width to overburden thickness for springs over panels

Spring	Ratio of panel width to overburden thickness	Surface subsidence, m
D	1.1	0.6 - 1.2
E	1.3	1.2 - 1.8
G	1.1	0.6 - 1.2
I	1.2	0.6 - 1.2
J	1.3	0.6 - 1.2
K	1.2	< 0.6
L	1.1	0.6 - 1.2
N	1.1	0.6 - 1.2

The limited response observed for the springs was thought to be influenced by site-specific conditions that buffered the effects of mining.[7] These include the thick overburden present and the presence of formations in the overburden that contain hydrophilic clays and mudstones. Results from other studies have concluded that the presence of hydrophilic clays lessens the extent of strata dewatering (*13, 17*). Additionally, the presence of a massive sandstone layer (the Castlegate Sandstone) can cause bridging in the overburden, thereby limiting subsidence and associated hydrologic response (*1*).

Another factor contributing to the limited spring response was the elevations of the springs above anticipated heights of fracturing and caving in the overburden, as estimated using formulas developed by Peng (*18*). The relationship of fracture height equal to 30 times mining thickness was used. This relationship was developed based on mining conditions common to Eastern U.S. coalfields and does not account for differences in Western U.S. conditions such as the presence of massive sandstones in the overburden or thicker overburden. However, no similar value has been developed for the West, so the published relationship is commonly applied. Use of the relationship indicated that overburden fracturing might occur up to an elevation of 2,400 m from the Deer Creek Mine and up to approximately 2,330 m from the Cottonwood Mine. Spring K was the lowermost spring studied and was located at 2,737 m, 337 m above the computed height of fracturing. For the case that both coal seams had been extracted, gob formation and fracturing associated with mining the second lower seam would be incorporated into the fracturing produced by mining the first upper seam.[7] A conceptual subsurface overburden failure schematic is shown on figure 5.

Although all the springs studied were located at elevations higher than the computed elevations of fracturing in the overburden, the springs were located in a zone of the overburden where, according to Peng, continuous bending of the strata occurs. Preexisting fractures can dilate in response to the bending, causing flow variation. The bending and redistribution of stresses in the overburden can also cause flow variations.

[7]Personal communication with C. Haycocks, Department of Mining Engineering, Virginia Polytechnic Institute, Aug. 1993.

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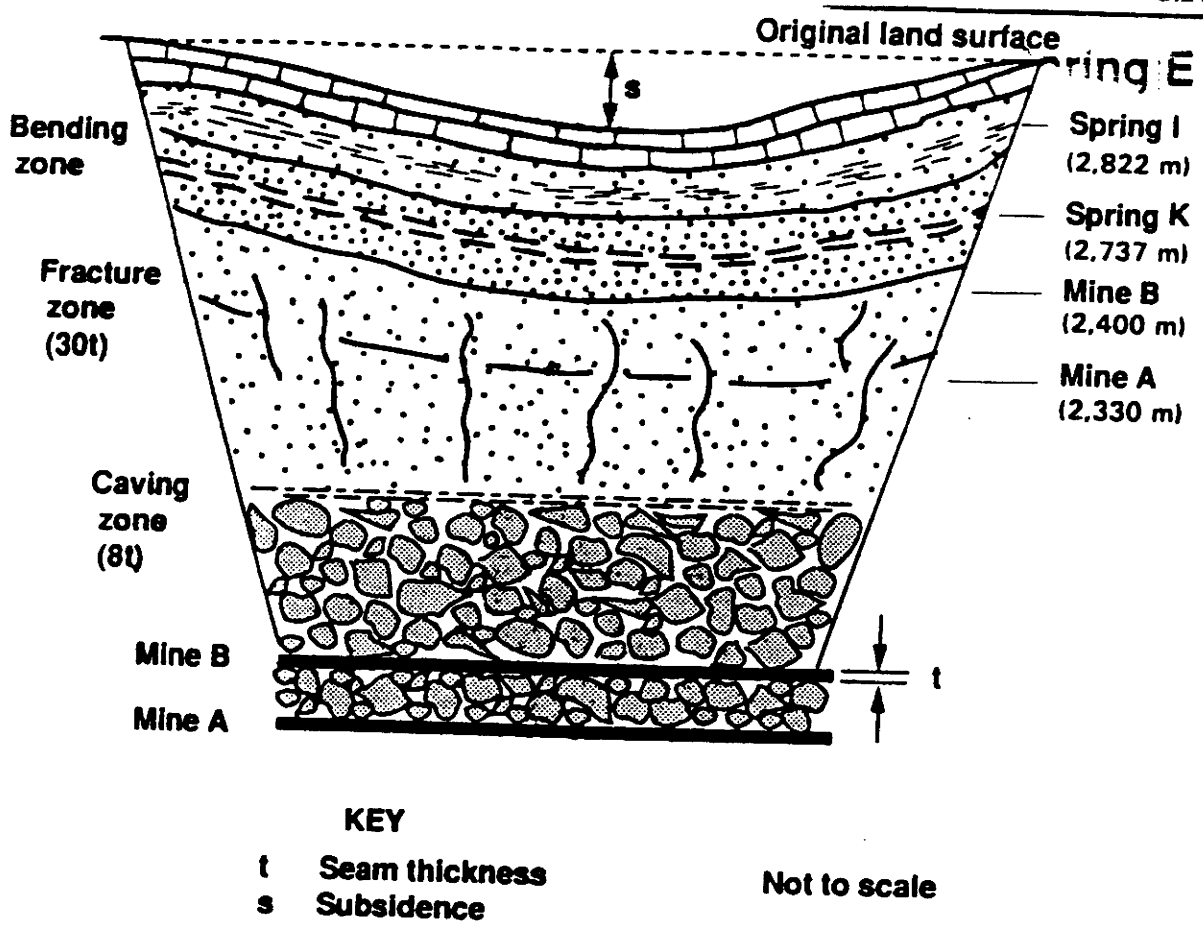

Figure 5.—Conceptual overburden failure schematic.

SUMMARY

The USBM used data available from the Deer Creek and Cottonwood Mines to perform a study of underground coal mining effects on local overburden hydrology. Data used in the study included seasonal and annual spring discharge, precipitation, surface subsidence, and overburden failure mechanics information. These data sets were used to quantify the response of 14 springs to underground mining.

Eight springs occurred over longwall panels. One of the eight, spring I, exhibited a departure from a normal recession curve coincident with the time of mining activity underneath it. Adjustments to valves and blockage of a pipe installed at the spring also occurred in the same time period and contributed to the variations in curve shape. The spring exhibited a constant discharge rate in the weeks after being undermined by a longwall panel, indicating that little variation occurred as a result of mining. The eight springs over panels all occurred at locations where the ratio of panel width to overburden thickness was greater than 1.0, thus limiting dewatering effects, as was observed in previous studies in Eastern U.S. coalfields. Surface subsidence did not appear to play a major role in the response of springs at this site.

Four springs experienced no discharge conditions during the period of study that were attributed to effects of regional decreased precipitation. Springs located over mine structures such as pillars or mains did not exhibit discernible effects from mining. For this study, the long-term availability of water resources was important and therefore dictated examining the seasonal response of springs in relation to mining.

The expected response of springs to undermining would be dramatic alterations in flow, as previously documented in other studies. The lack of observed responses was attributed to geologically driven site-specific conditions that buffered the effects of mining. These conditions included the thickness of overburden between the mine level and the springs, which ranged from 440 to over 600 m. Studies performed in the Appalachian coalfields noted dramatic decreases in spring discharge and water levels in wells

where thinner (70 to 245 m) overburden was present *(13, 15, 17)*. Additionally, the presence of hydrophilic clays and mudstones in the overburden, which act as aquitards retarding the migration of water, likely lessened the vertical extent of strata dewatering, as has been observed in other studies *(17)*. The location of the springs above the estimated elevations of fracturing and caving in the overburden due to subsidence also contributed to the limited effects.

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APPENDIX.—HYDROLOGIC DATA G:

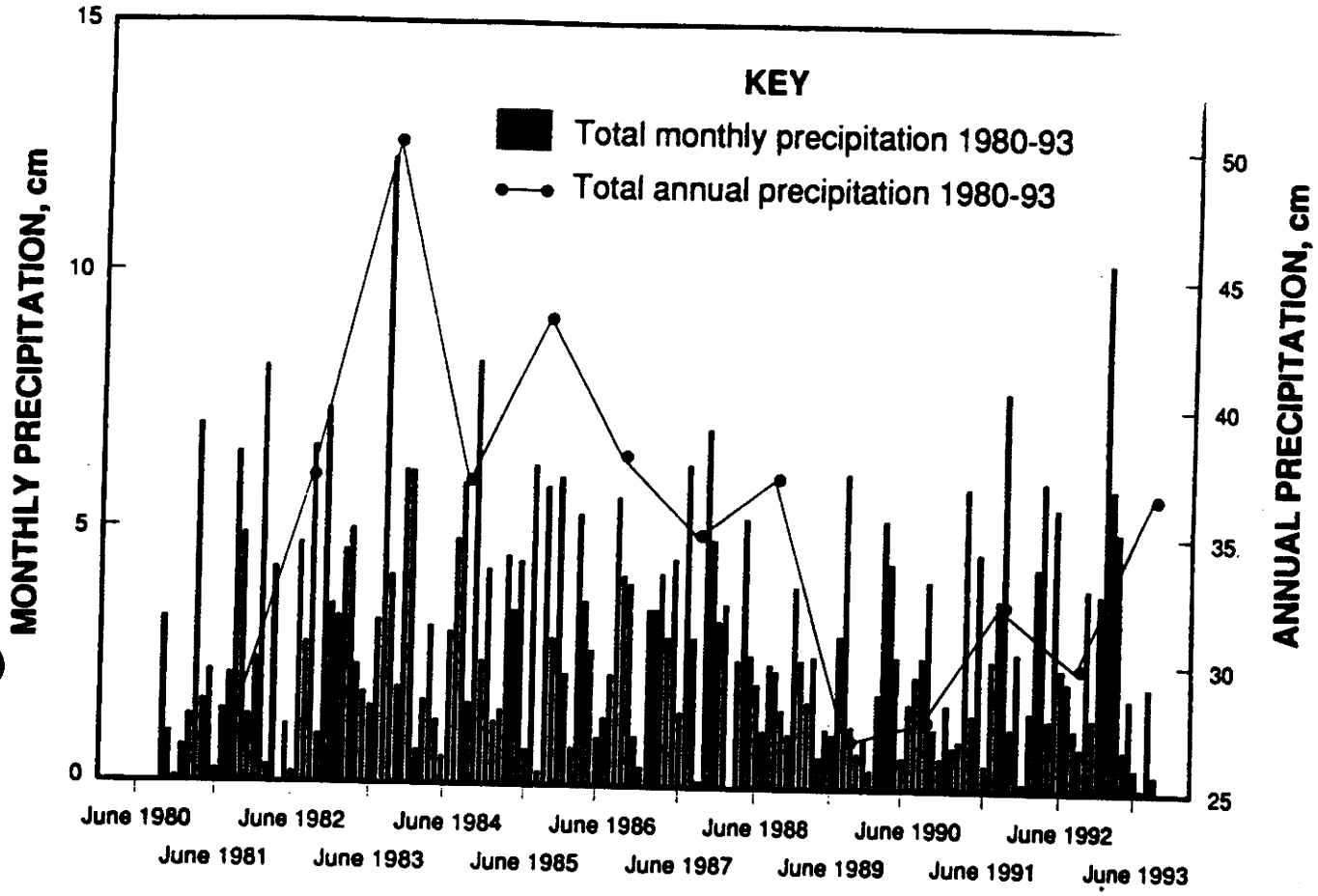

Figure A-1.—East Mountain precipitation for water years 1981-93.

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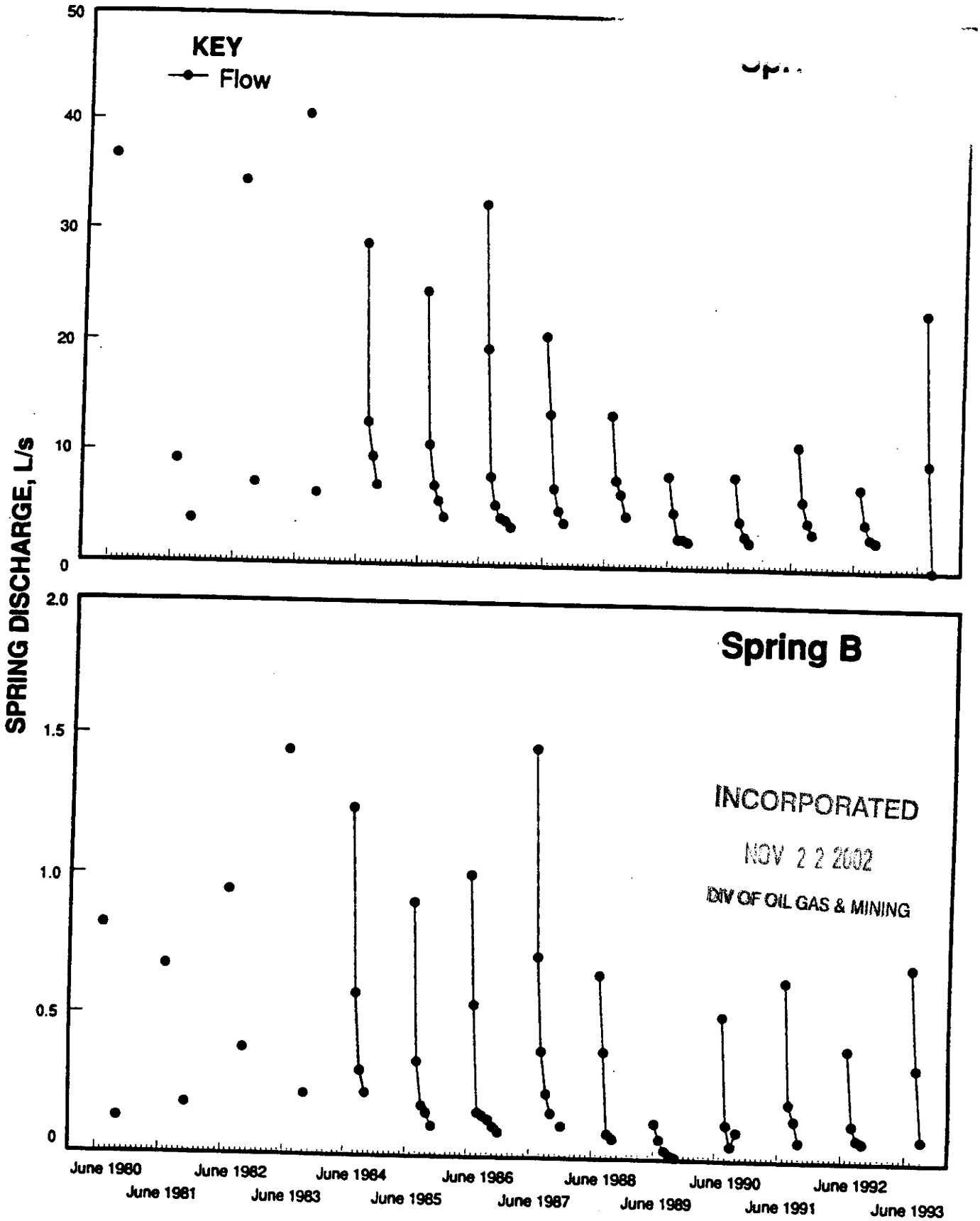

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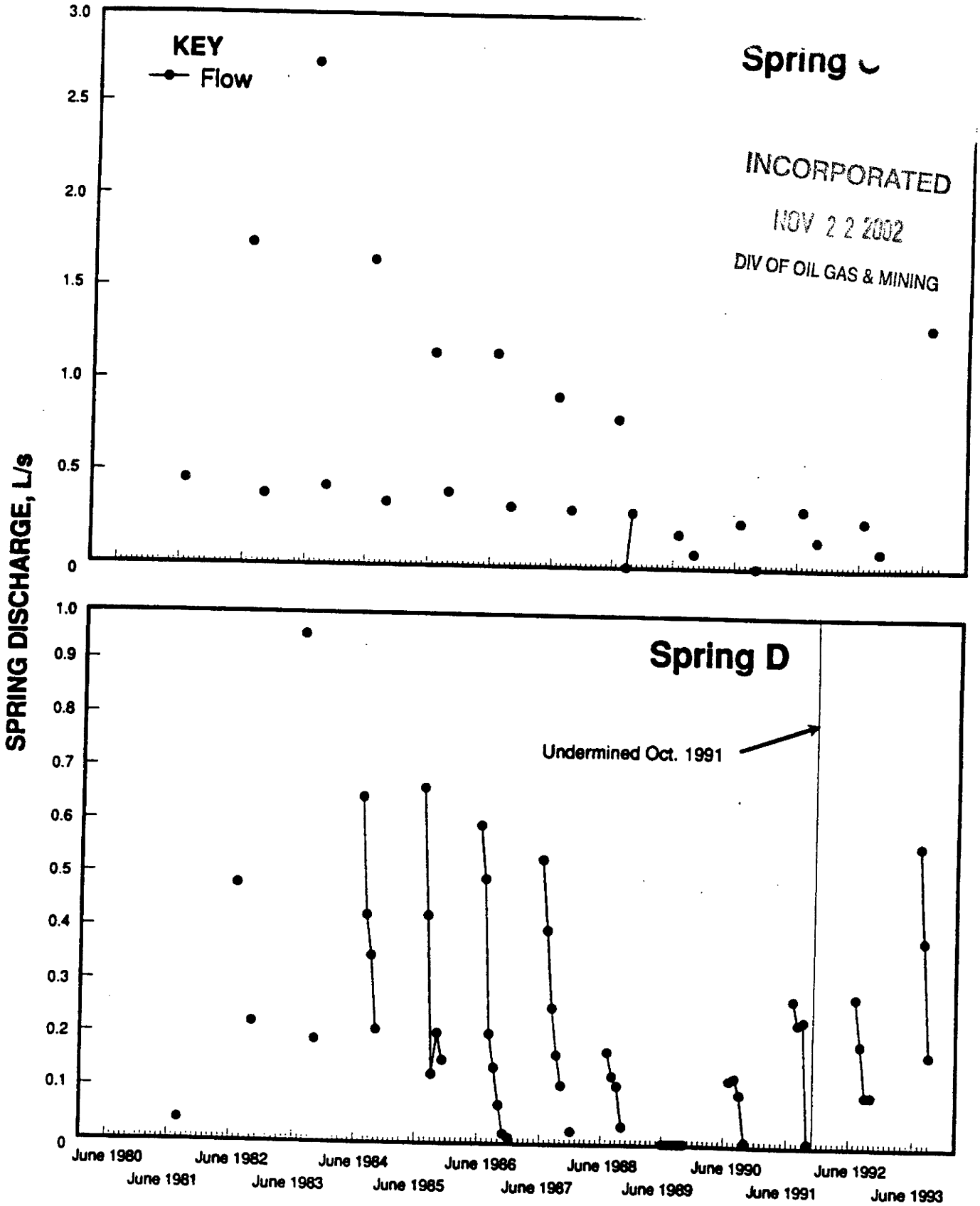
Figure A-2.—Spring discharge hydrographs for water years 1981-93.



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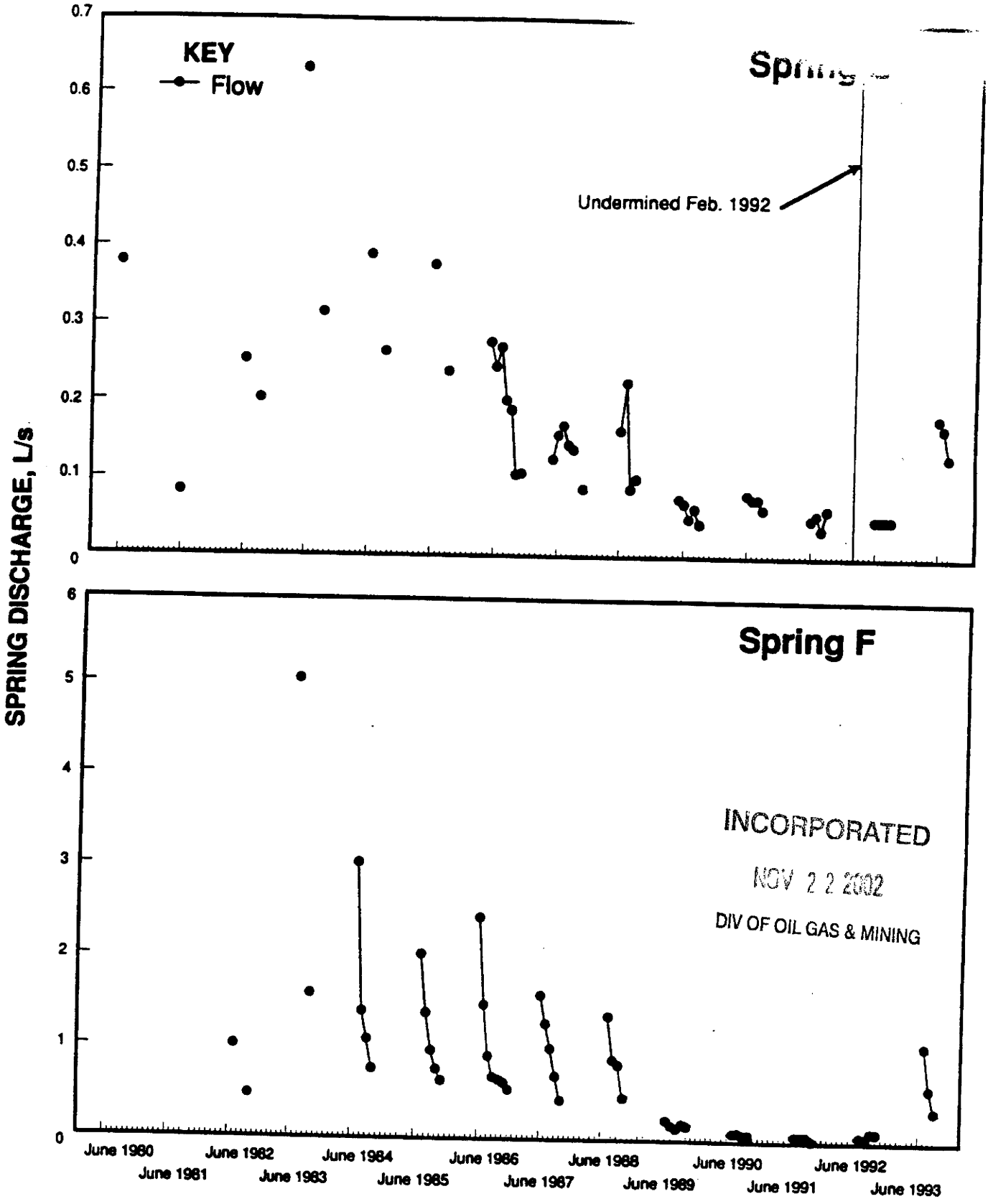

Spring F

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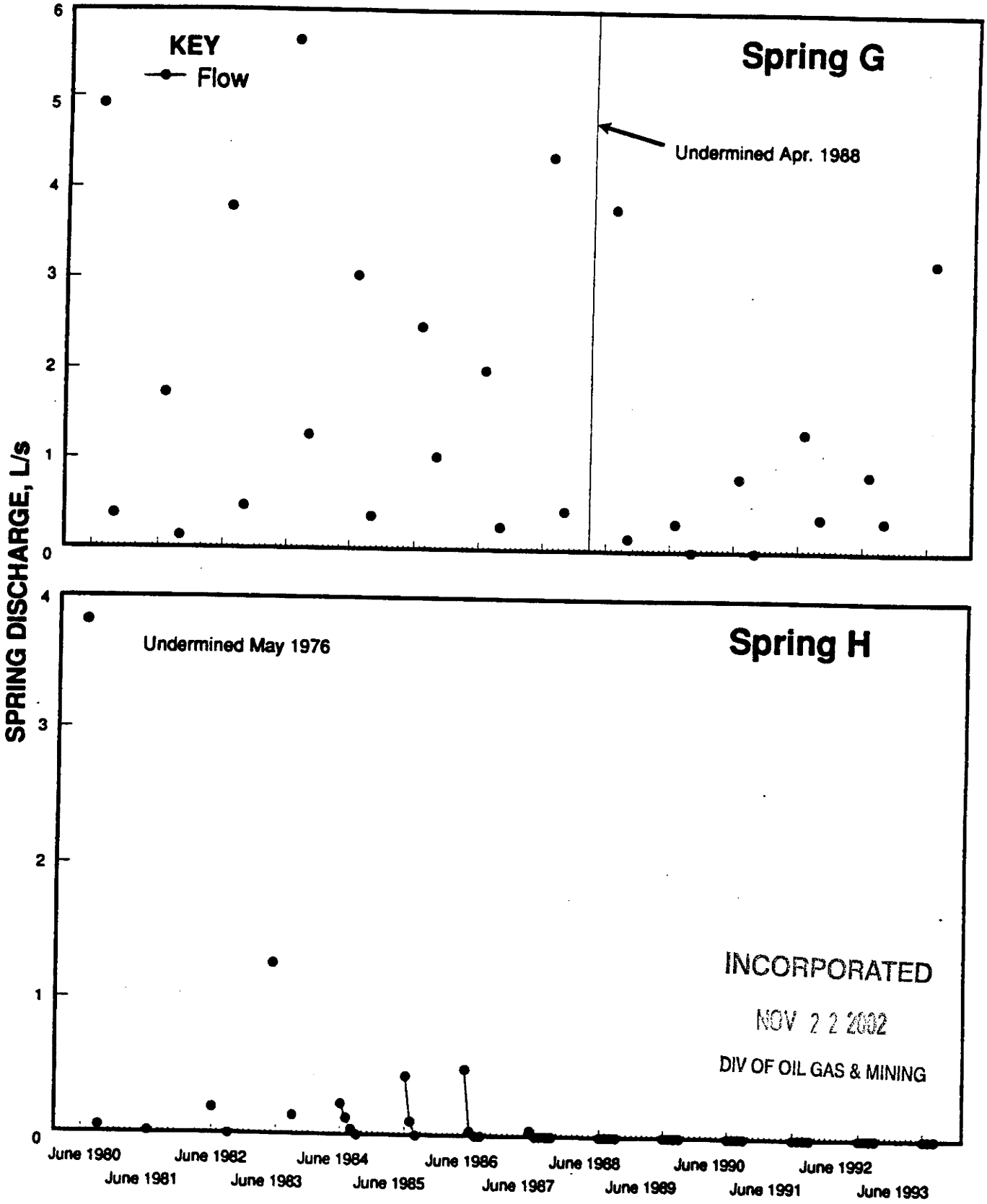

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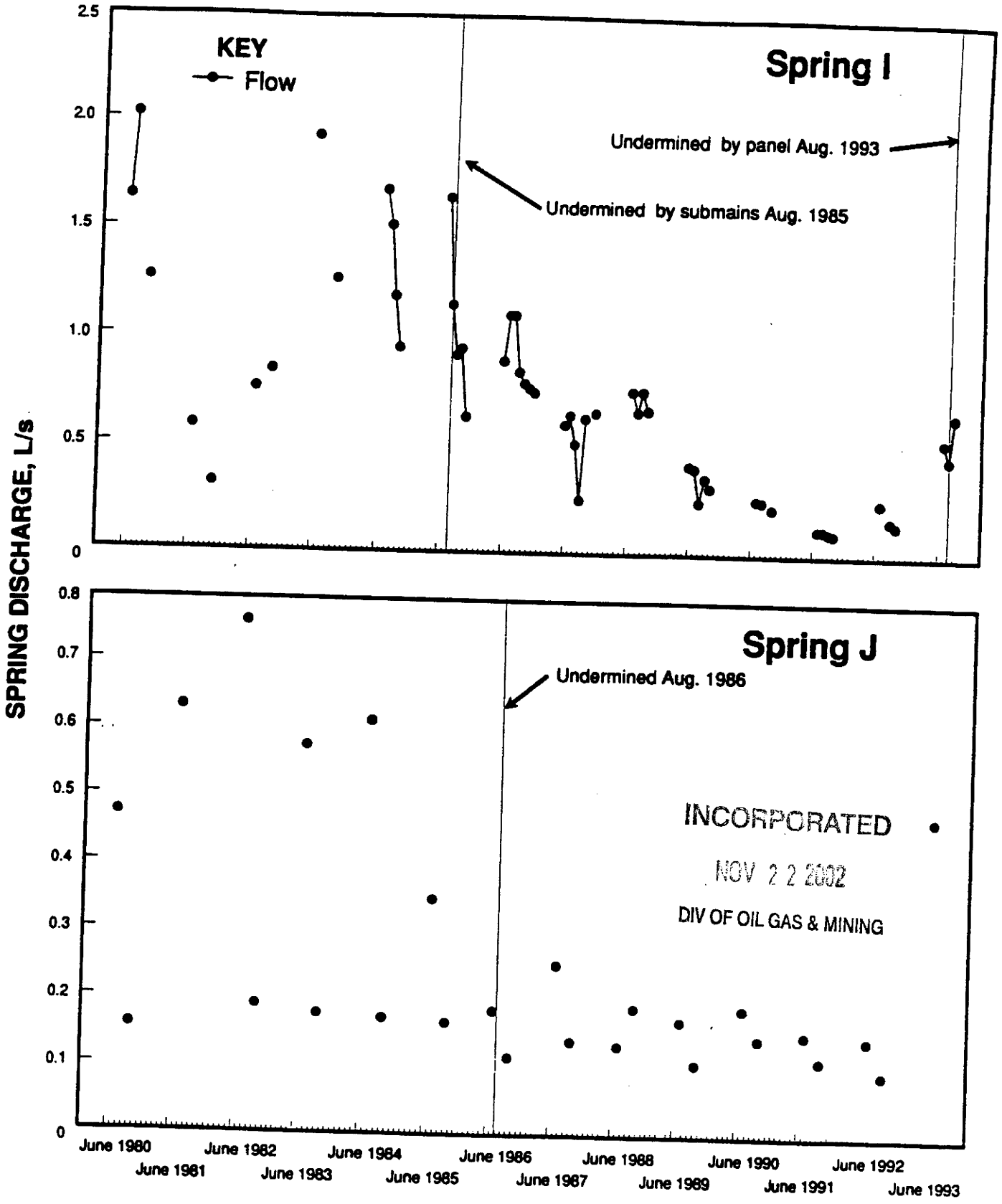

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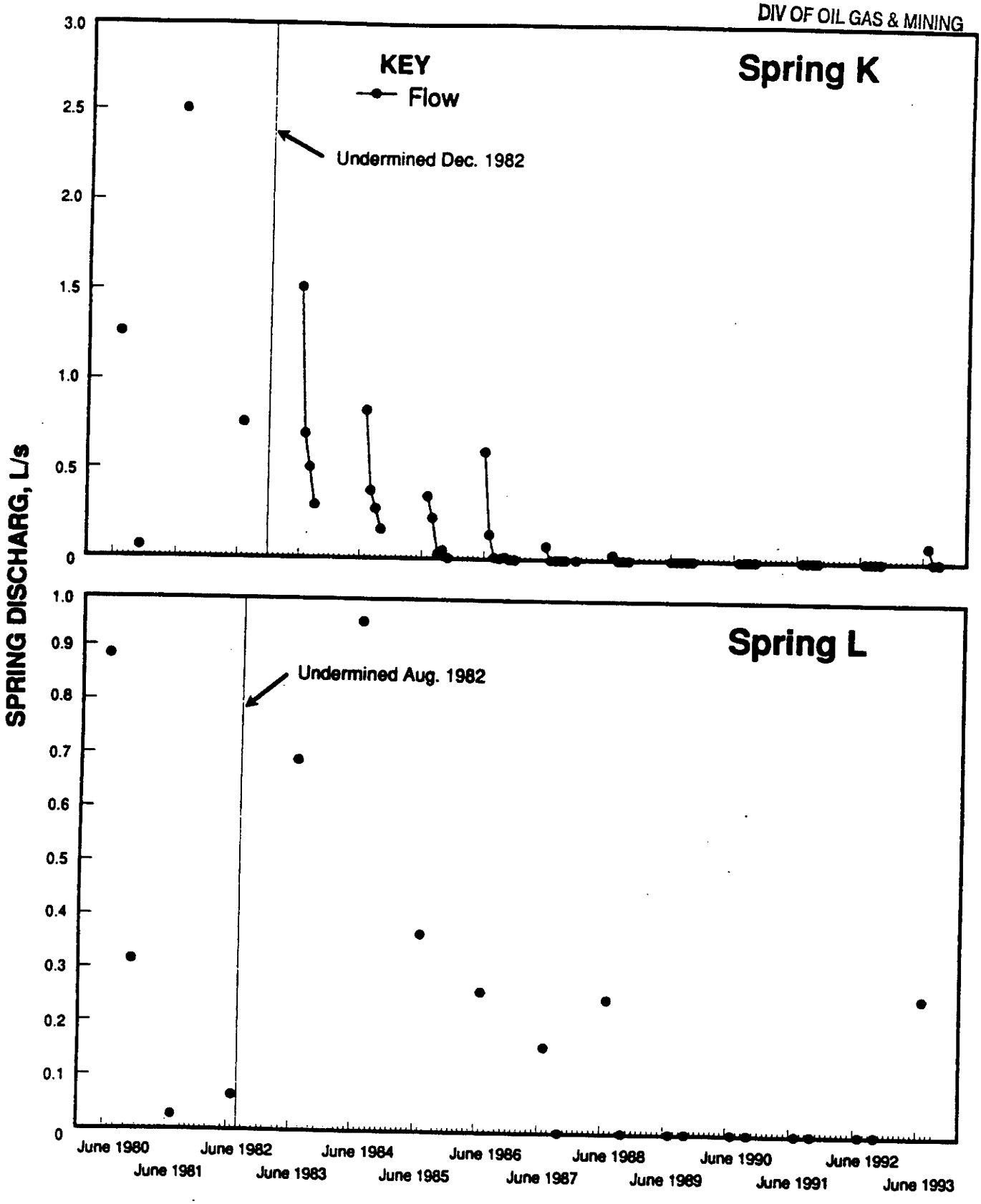

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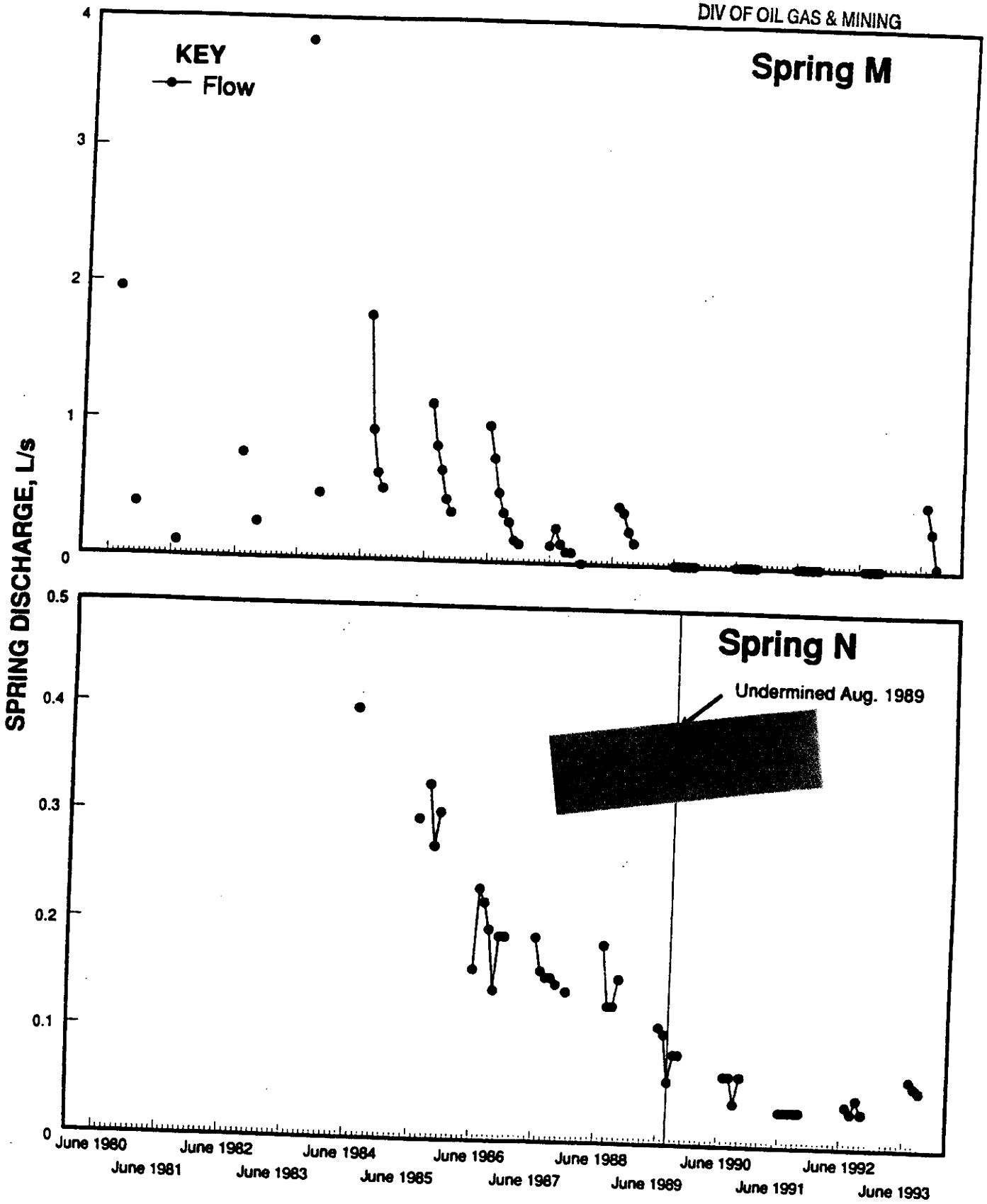

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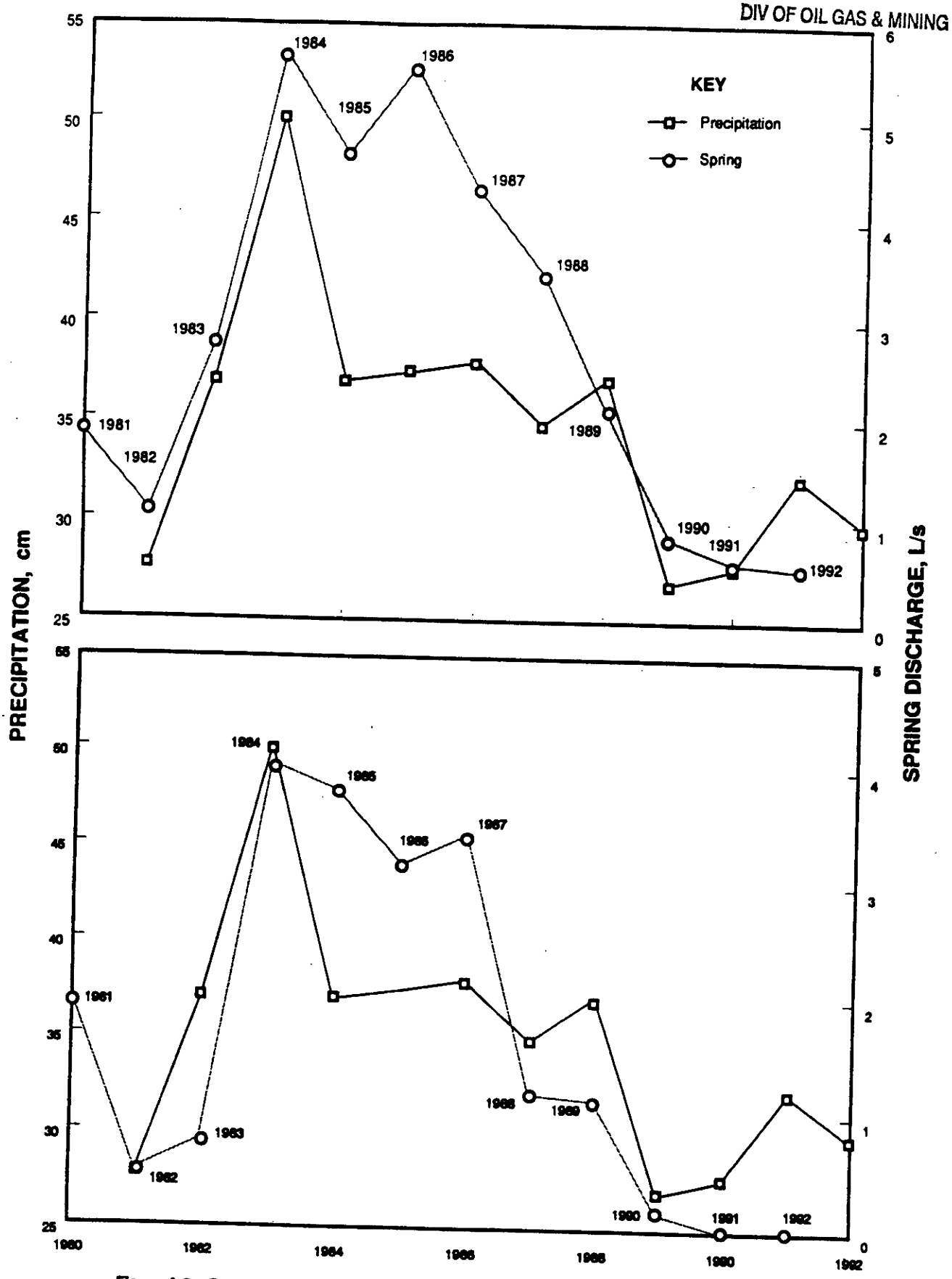

Figure A-3.—Cross-correlated spring and precipitation data. Top, spring I; bottom, spring M.

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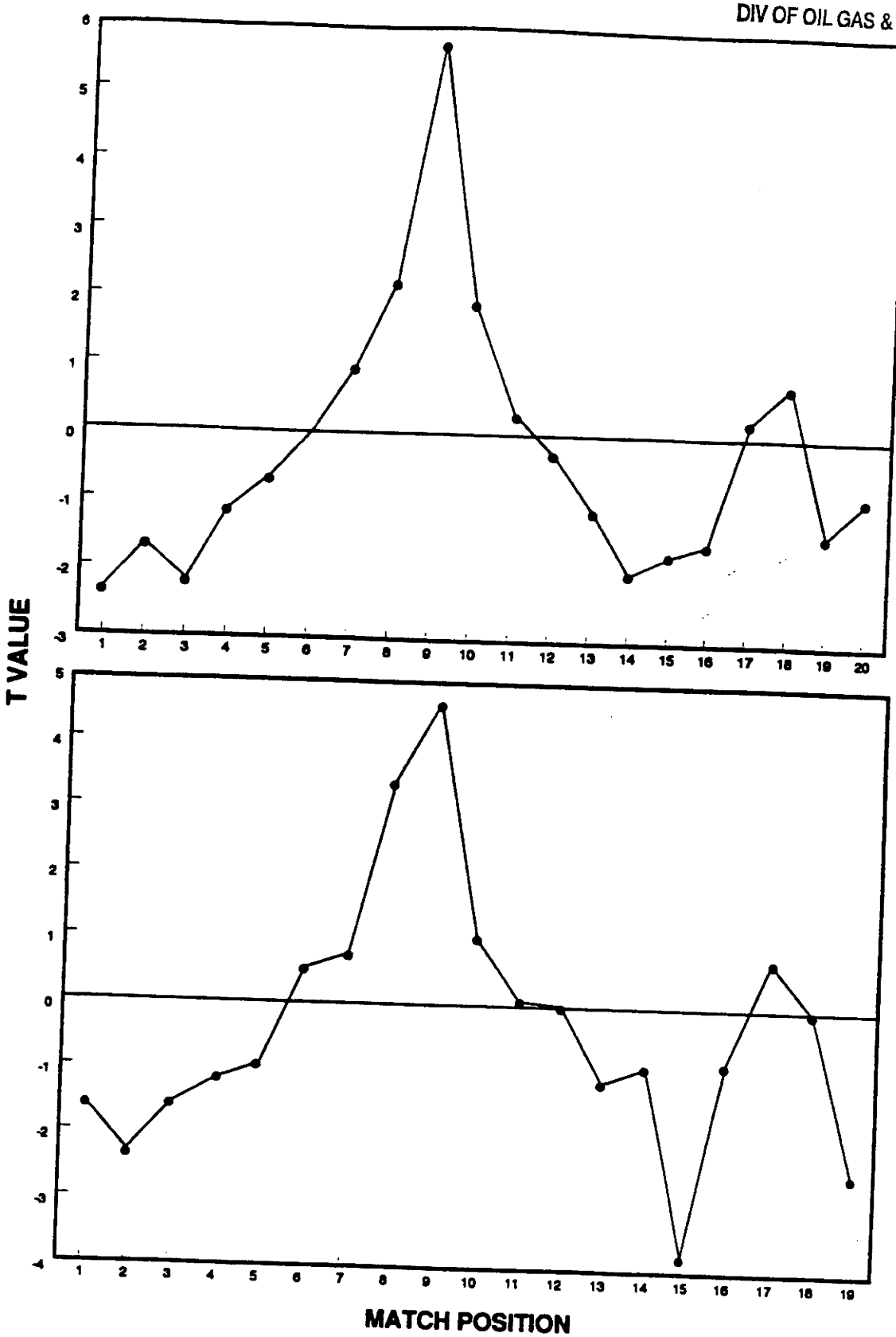

Figure A-4.—Match position versus T value. Top, spring I; bottom, spring M.

Investigation of Surface-Water and Groundwater Systems in the PacifiCorp Lease Area, East and Trail Mountains, Emery County, Utah:

Probable Hydrologic Consequences of Coal Mining in the Trail Mountain LBA and Recommendations for Surface-Water and Groundwater Monitoring

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PacifiCorp, Huntington, Utah

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1. INTRODUCTION

PacifiCorp has operated the Cottonwood, Wilberg, Deer Creek, Des-Bee-Dove, and Trail Mountain mines since 1979. The mines are located in the central Wasatch Plateau west of Huntington, Utah. PacifiCorp is currently planning to expand their Trail Mountain mine north and west to include the Trail Mountain Lease-By-Application (Trail Mountain LBA; Figure 1). This report discusses the hydrology and hydrogeology of the PacifiCorp lease area and the probable hydrological consequences of underground coal mining in the Trail Mountain LBA. This report is divided into 11 sections including this introduction. These sections include:

Section 1 Introduction

Section 2 Project Overview

Section 3 Description of the PacifiCorp Mines

Section 4 Climatic, Physiographic, and Geologic Setting

Section 5 Solute and Isotopic Chemistry

Section 6 Groundwater

Section 7 Surface Water Hydrology

Section 8 Conclusions

Section 9 Probable Hydrologic Consequences

Section 10 Recommended Monitoring Plan

Section 11 References Cited

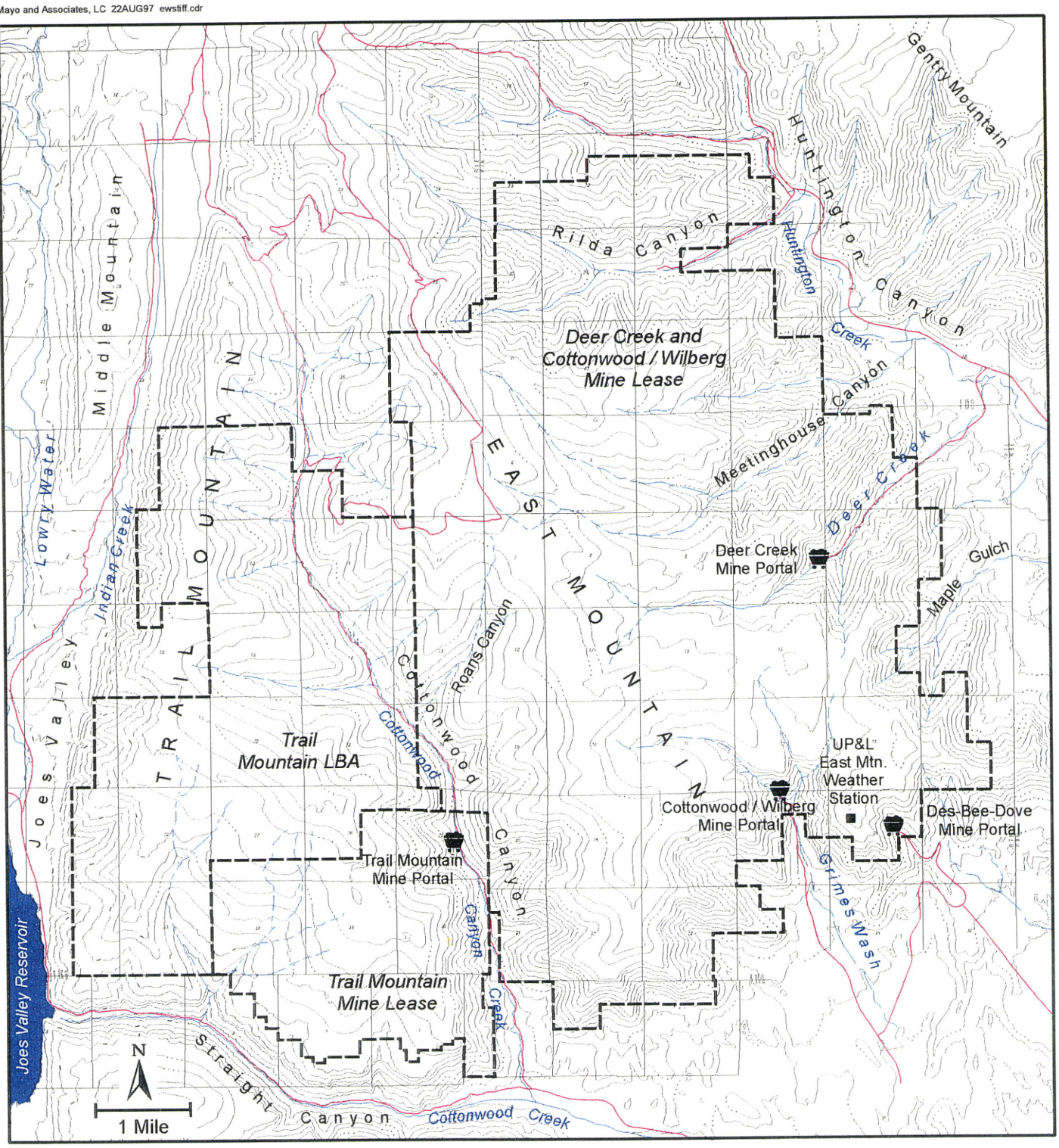


Figure 1 Map showing the principal geographic features, locations of the mine lease areas, and mine portals.

2. PROJECT OVERVIEW

2.1 Purpose of investigation

The purpose of this investigation is to: 1) characterize the hydrology and hydrogeology of the PacifiCorp lease area on East Mountain and Trail Mountain, 2) describe the probable hydrologic consequences of underground coal mining to surface waters and groundwaters within the Trail Mountain LBA, and 3) recommend locations and protocols for surface water and groundwater monitoring for the Trail Mountain LBA.

2.2 Methods of investigation

The hydrology and hydrogeology of the PacifiCorp lease area have been evaluated by analyzing: 1) solute and isotopic compositions of surface waters and groundwaters, 2) surface water and groundwater discharge data, 3) piezometric data, and 4) geologic information. Specific methods of investigation are described below.

2.2.1 Maps and reports

Existing published and unpublished hydrologic, hydrogeologic, and geologic reports and maps were obtained and reviewed.

2.2.2 Compilation of historic water quality, piezometric and stream flow data

PacifiCorp and its predecessors have monitored springs on East and Trail Mountains since 1979. Both baseline and periodic water quality data have been collected from springs, groundwater monitoring wells, streams, in-mine roof drips and wells, and mine-water discharge points. Solute and discharge data have been collected at 14 stream sites, 96 springs,

4 french drains, mine discharge points, and 47 groundwater inflow sites within the mines. In addition to the quarterly monitoring conducted by PacifiCorp, flow, solute, and isotopic data have been collected at various times by government agencies, PacifiCorp personnel, and consultants. Solute and piezometric data are also available for 16 groundwater monitoring wells.

Historical solute, discharge, and water level data were obtained from PacifiCorp in electronic format for use in this investigation. Only those samples for which the complete suite of major ion analyses was available were used for analytical purposes in this investigation. The complete suite of major ions include Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, HCO_3^-, CO_3^{2-}, SO_4^{2-}, and Cl^-.

Mayo and Associates and mine personnel compiled site location data from information and digital drawings provided by the PacifiCorp. These data include state plane coordinates, elevation, geology, occurrence, and height above base of geologic formation.

2.2.3 Collection and analysis of additional solute and isotopic data

As a part of this investigation water samples from 13 springs, 2 wells, 9 in-mine groundwater discharge locations, the portal of the abandoned Oliphant Mine, and 6 snow sites were collected and analyzed for solute and isotopic composition during 1996 and 1997.

Isotopic samples for δ^2H, $\delta^{18}O$, and ^3H analyses were collected, sealed, and preserved in appropriate glass or HDPE plastic bottles. Dissolved inorganic carbon and SO_4^{2-} for $\delta^{13}C$, $\delta^{34}S$, and ^{14}C analysis were precipitated with $BaCl_2 \cdot 2H_2O$.

Stable isotopic analyses for $\delta^{2}H$, $\delta^{18}O$, $\delta^{13}C$, and $\delta^{34}S$ compositions and unstable ^{14}C contents were performed by Geochron Laboratories, Cambridge, Massachusetts. The ^{3}H analyses were performed by the Tritium Laboratory, University of Miami, Florida using electrolytic enrichment and low level counting methods. Laboratory reporting sheets for isotopic analyses are included as Appendix A

2.2.4 Stream gauging

On August 22, 1996, Mayo and Associates and PacifiCorp personnel performed gain-loss measurements on Indian Creek and Cottonwood Creek between Joes Valley Reservoir and the confluence of Cottonwood Creek and Cottonwood Canyon Creek. Measurements were made using a Marsh-McBurney automated pressure transducer flow meter.

2.2.5 Data analysis

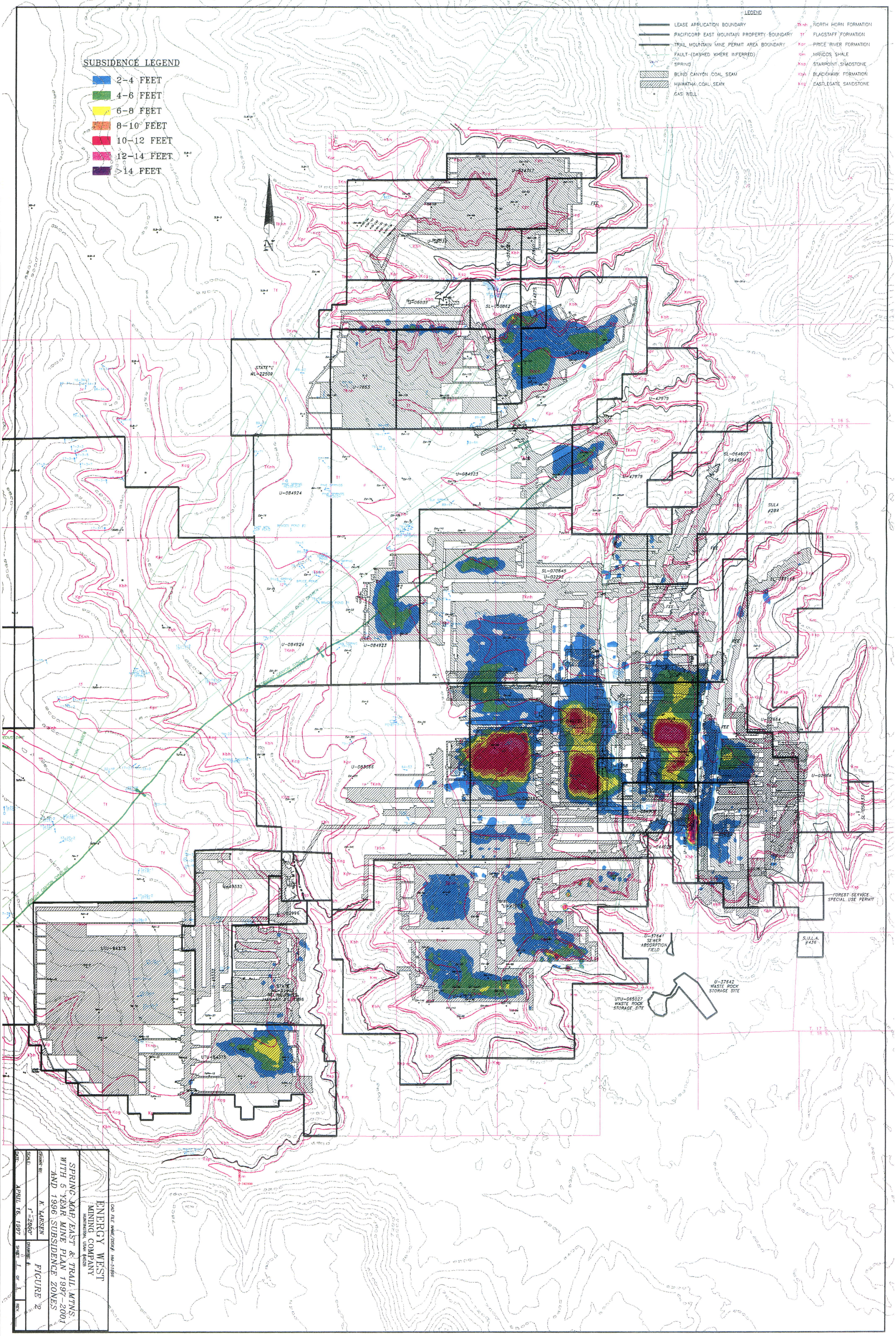
Geochemical, isotopic, discharge, and other data were compiled into electronic format and were analyzed by graphical, statistical, and computer methods. Solute compositions were graphically analyzed using Stiff (1951) and Piper (1944) diagrams. Solute data were analyzed using the computer code WATEQF (Plummer and others, 1976). Groundwater ^{14}C residence times were calculated using methods described by Fontes (1980), Mooke (1980), and Pearson (1970).

3. DESCRIPTION OF THE PACIFICORP MINES

Coal produced from the PacifiCorp mines is used to fire electrical power plants in Carbon and Emery Counties. Presently, PacifiCorp is actively mining in the Trail Mountain and Deer Creek mines. The Wilberg and Cottonwood mines are not currently mined, but are kept open to allow for the operation of a coal haulage beltway through the old mine workings. The Des-Bee-Dove Mine is no longer active and is planned for reclamation in the near future. Currently, all mining at the PacifiCorp mines is carried out using longwall mining techniques. Continuous miners are used only for driving gateroads for longwall panels.

PacifiCorp currently mines approximately 7.5 to 8.0 million tons of coal per year. This production rate has remained relatively constant over the past several years.

Subsidence above mined areas is closely monitored. Previously, surface subsidence monitoring was carried out using traditional survey methods. Currently, subsidence is monitored primarily using photogrammetric techniques. Ground subsidence measured in the lease areas is shown in Figure 2. Subsidence in excess of 15 feet has been measured. The greatest subsidence effects occur in steep cliff areas where the brittle Castlegate Sandstone is exposed and in areas where mining has occurred next to burned coal and less competent clinker beds which readily collapse under mining-induced compression (PacifiCorp, 1996a). To minimize any potential impacts to the steep sandstone cliffs where the Castlegate Sandstone crops out along the edge of the plateau, longwall mining is generally not carried out near cliff areas. Surface fractures are associated with subsidence in steep cliff areas and along the margins of longwall panels.



SUBSIDENCE LEGEND
2-4 FEET
4-6 FEET
6-8 FEET
8-10 FEET
10-12 FEET
12-14 FEET
>14 FEET
LEGEND
LEASE APPLICATION BOUNDARY
PACIFICORP EAST MOUNTAIN PROPERTY BOUNDARY
TRAIL MOUNTAIN MINE PERMIT AREA BOUNDARY
FAULT (DASHED WHERE INFERRED)
SPRING
BLIND CANYON COAL SEAM
HIAWATHA COAL SEAM
GAS WELL
TKnh NORTH HORN FORMATION
Tf FLAGSTAFF FORMATION
Kpr PRICE RIVER FORMATION
Km MANCOS SHALE
Ksp STARPOINT SNADSTONE
Kbh BLACKHAWK FORMATION
Kcg CASTLEGATE SANDSTONE
STATE ML-22509
U-7653
SL-050862
U-47979
SL-064807
SULA #282
U-084924
U-084923
SL-070645
U-02292
U-083066
FEE
FOREST SERVICE SPECIAL USE PERMIT
S.U.L.A. #436
U-37641 SEWER ABSORPTION FIELD
U-37642 WASTE ROCK STORAGE SITE
UTU-065027 WASTE ROCK STORAGE SITE
UTU-64375
STRAIGHT CANYON SYNCLINE
MILL FORK GRABEN
CAD FILE NAME/DISK#: HM-51996
ENERGY WEST MINING COMPANY
HUNTINGTON, UTAH 84528
SPRING MAP/EAST & TRAIL MTNS. WITH 5 YEAR MINE PLAN 1997-2001 AND 1996 SUBSIDENCE ZONES
DRAWN BY: K. LARSEN
SCALE: 1"=2000'
DATE: APRIL 16, 1997
DRAWING #: FIGURE 2
SHEET 1 OF 1
REV.

4. CLIMATIC, PHYSIOGRAPHIC, AND GEOLOGIC SETTING

4.1 Climate

Maximum summertime temperatures in the lowest areas of the lease area commonly exceed 100°F (38°C), while midwinter minimum temperatures well below 0°F (-18°C) are common at higher elevations. Precipitation in the region varies greatly with elevation. Within the permit area mean annual precipitation ranges from about 10 inches in the low elevations to more than 25 inches in the highest elevations (PacifiCorp, 1996b).

Since 1981, PacifiCorp has operated a weather station on East Mountain (Figure 1) at an altitude of 8,985 feet. Long term precipitation data are shown in Figures 3a and 3b. Data from this station indicate that, of the total annual precipitation, about 50% occurs as summer rains, and about 50% as winter snowfall (Figure 3a). Although no measurements of sublimation have been made, it is believed that a significant portion of the winter snowpack is lost to sublimation, particularly on the high plateaus, which are subject to dry winds common to the region. The effects of climatic variability are shown in Figure 3b. Wetter years in the mid-1980s were followed by drier years in the late 1980s and early 1990s.

4.2 Physiography

The PacifiCorp mines are located in the central Wasatch Plateau. The topography of the area consists of narrow, flat-topped mesas surrounded by heavily vegetated slopes that extend to the precipitous cliffs of the eastern escarpment of the plateau. At the base of the plateau lies Castle Valley, which is developed on the Mancos Shale, and is naturally nearly devoid of vegetation. Cottonwood Canyon dissects the study area dividing East Mountain from Trail

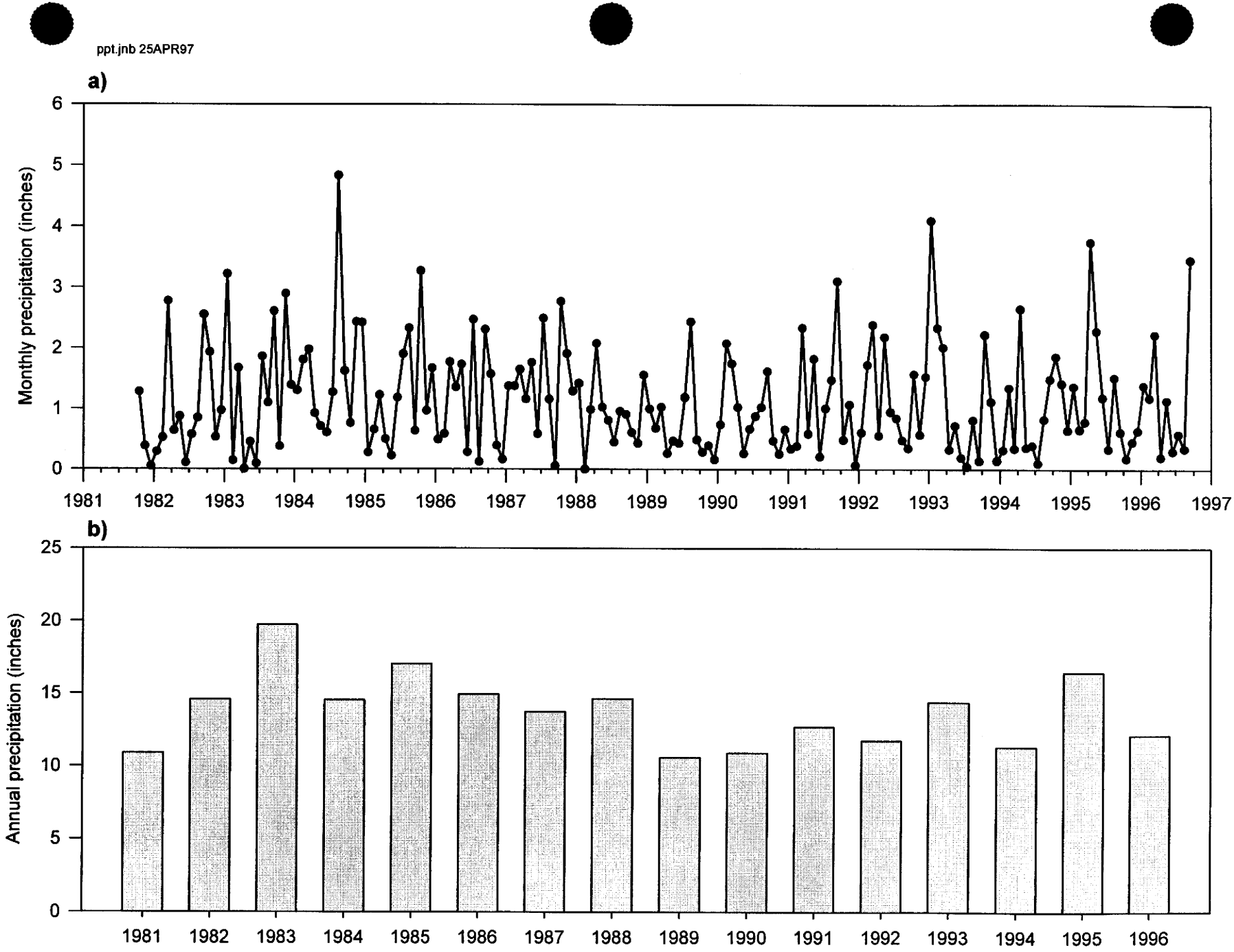


Figure 3 Precipitation at the UP&L East Mountain weather station: a) monthly total and b) annual totals by water year (October-September).

Mountain (Figures 1 and 4). Joes Valley defines the western margin of the study area. Ground elevations in the study area range from approximately 6,800 feet near the base of the plateau in Castle Valley to over 10,600 feet immediately north of Trail Mountain.

4.3 Geology

4.3.1 Stratigraphy

In the mine lease area, seven bedrock formations crop out (Figure 5). In descending order these formations are the: Flagstaff Limestone, North Horn Formation, Price River Formation, Castlegate Sandstone, Blackhawk Formation, Star Point Sandstone, and Mancos Shale (Figure 6). The upland plateau of the lease area is developed on the Flagstaff Limestone, the North Horn Formation, and the Price River Formation. The steep-walled canyons are cut into the Castlegate Sandstone, Blackhawk Formation, and Star Point Sandstone, and the broad expanse of lowland plateau is formed on the Mancos Shale (Figure 5). Geologic cross-sections through the mine lease area are shown in Figures 7a and 7b.

The bedrock formations were deposited during transgressions and regressions of the shoreline of the Western Cretaceous Interior Seaway during the Late Cretaceous and Early Tertiary. This ancient shoreline was located along the eastern edge of the tectonically uplifted mountains of the Sevier Orogenic Belt. Sediments eroded from the uplifted mountains were carried toward the seaway by fluvial systems and deposited as terrestrial, shoreline, marine, and interfingered non-marine and marine sedimentary sequences.

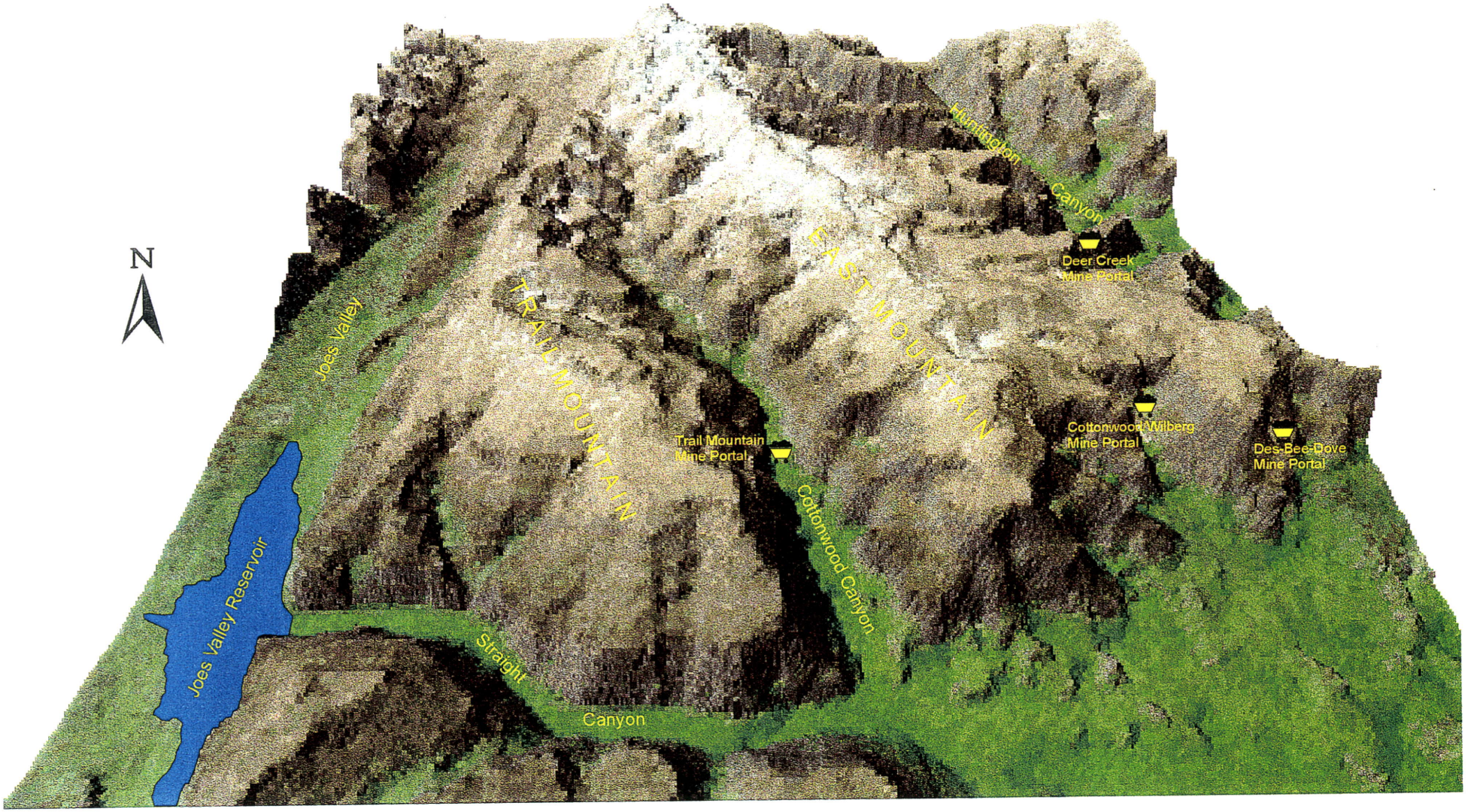


Figure 4 Digital elevation map illustrating topographic features.

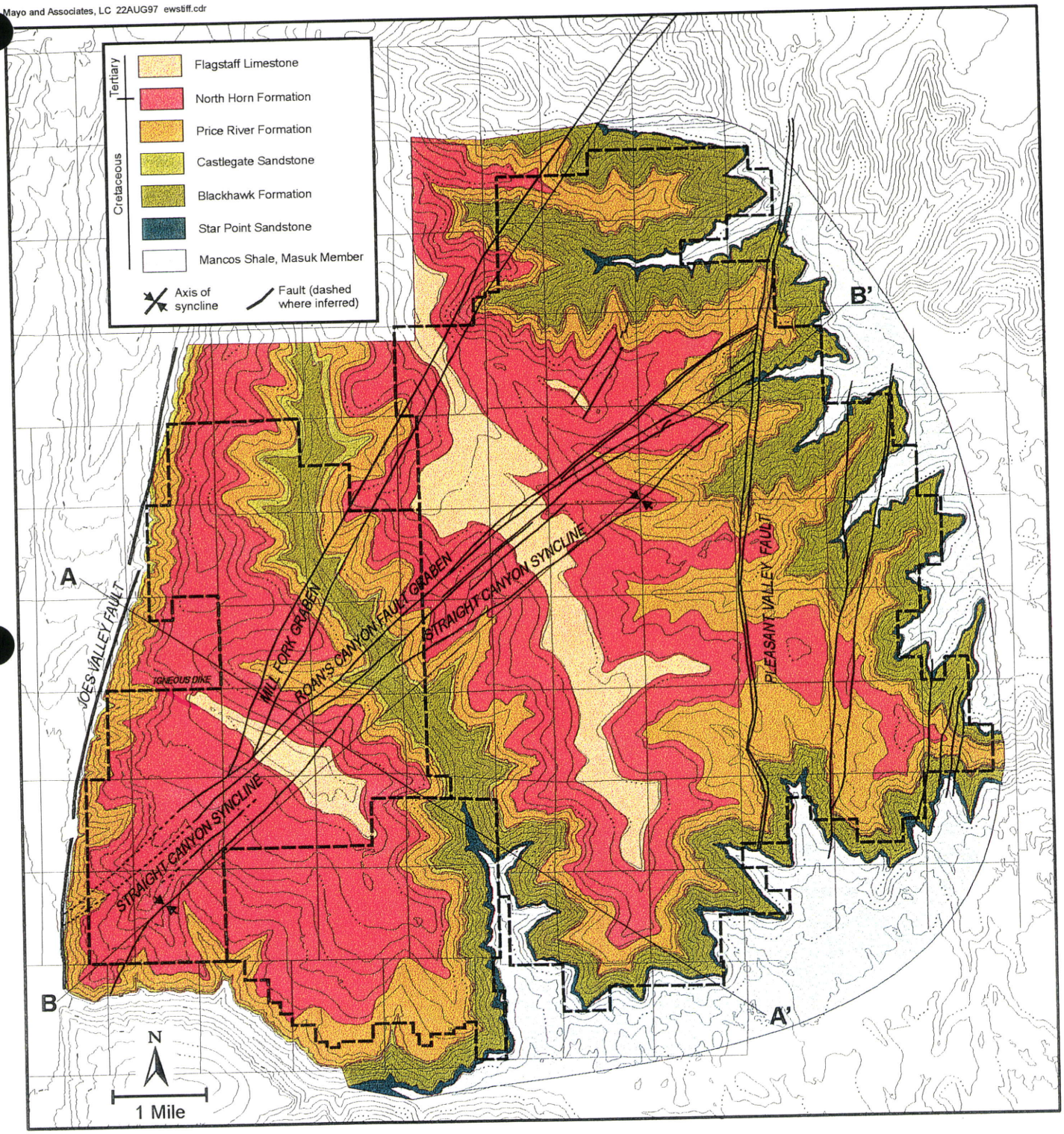


Figure 5 Geologic map of the Energy West lease area. Lines A-A' and B-B' show the location of cross-sections shown on Figure 7.

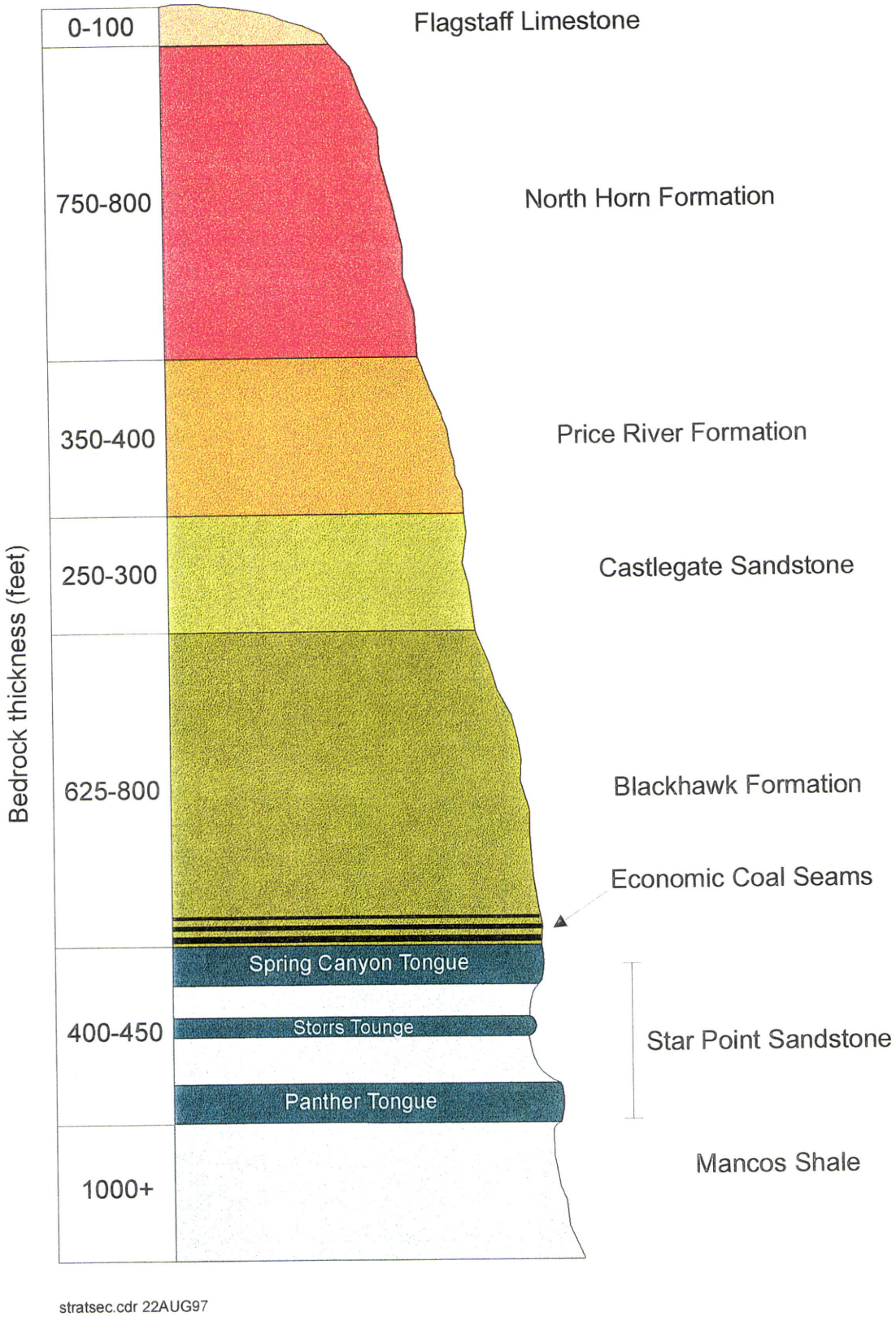


Figure 6 Stratigraphic column of bedrock formations in the mine lease area.

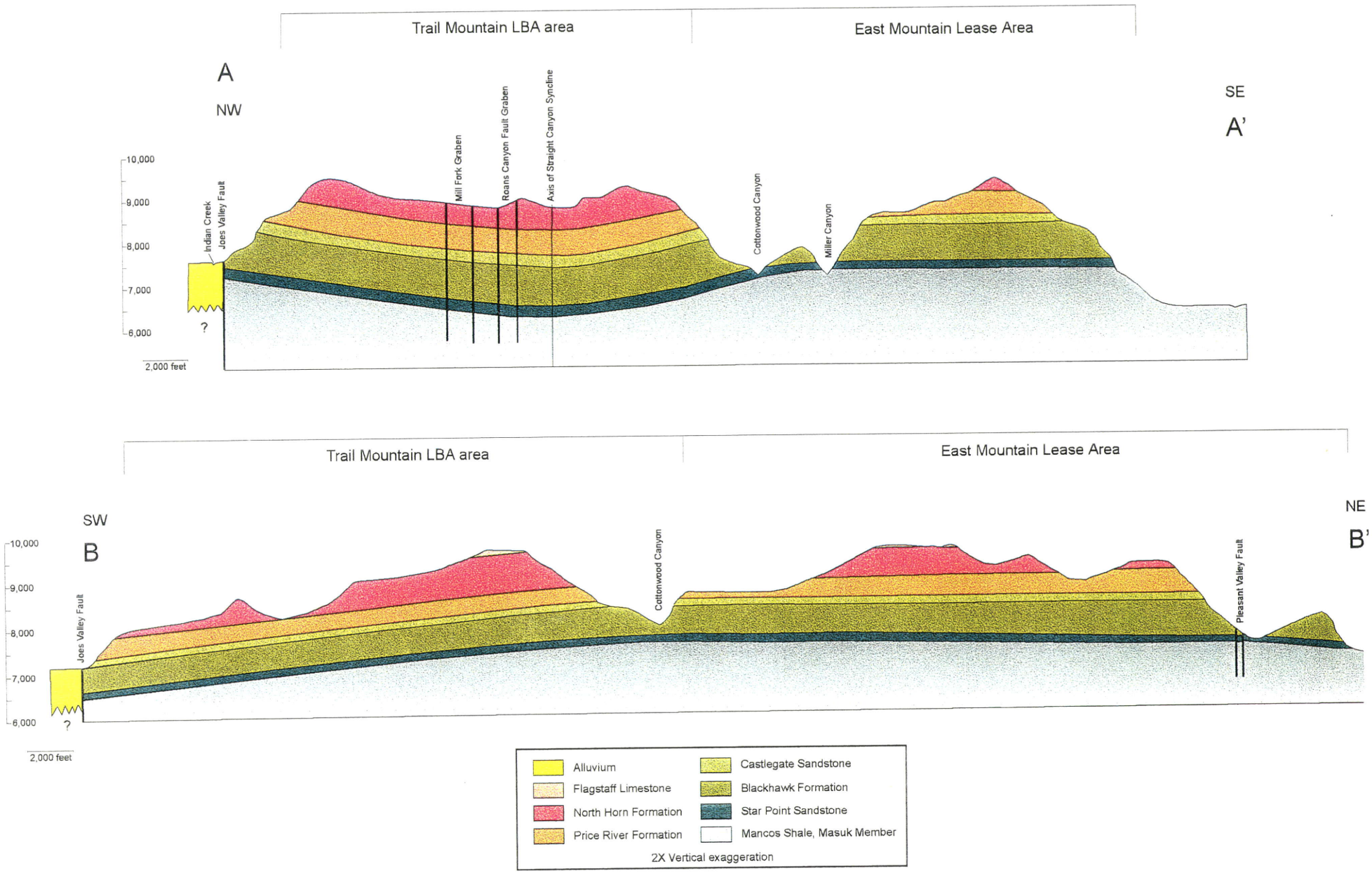


Figure 7 Geologic cross-sections through mine lease area. Cross-sections locations are shown on Figure 5. Figure 7a is a northwest-southeast cross-section perpendicular to the Straight Canyon Syncline. The cross-section in 7b is oriented southwest-northeast parallel to the Straight Canyon Syncline.

On the terrestrial side of the shoreline, sediment deposition occurred in lacustrine (lake carbonates, marls, and sands), alluvial plain (sands and clays), fluvial (stream sands and overbank muds), and carbonaceous backshore (coal swamp) environments. Along the shoreline, marine foreshore deposits (beach sands) accumulated. Offshore, sands swept from the beaches were laid down as bars and blankets of sand in the near-shore shallow marine water. These blankets of sand are known as shoreface deposits. The clay fraction of stream-transported sediments which reached the shoreline was deposited as thick marine muds (shale) in the deeper and more quiescent portions of the seaway. Because the transgression and regression of the shoreline was accompanied by the continued deposition of sediments, a variety of horizontally and vertically discontinuous sediment types occur throughout the coal district. This depositional history has resulted in a heterogeneous rock record that has had a profound effect on the water-bearing characteristics of these rocks.

The internal depositional geometry of the bedrock formations is illustrated in Figure 8. In Figure 8, typical geometric relationships between sandstone channels (white) and intrachannel muds (gray) are shown in the lateral and vertical relations column. In this column, sandstone channels are illustrated as cross-sections cut perpendicular to the long direction of the channel.

The seven bedrock formations are described below from youngest to oldest.

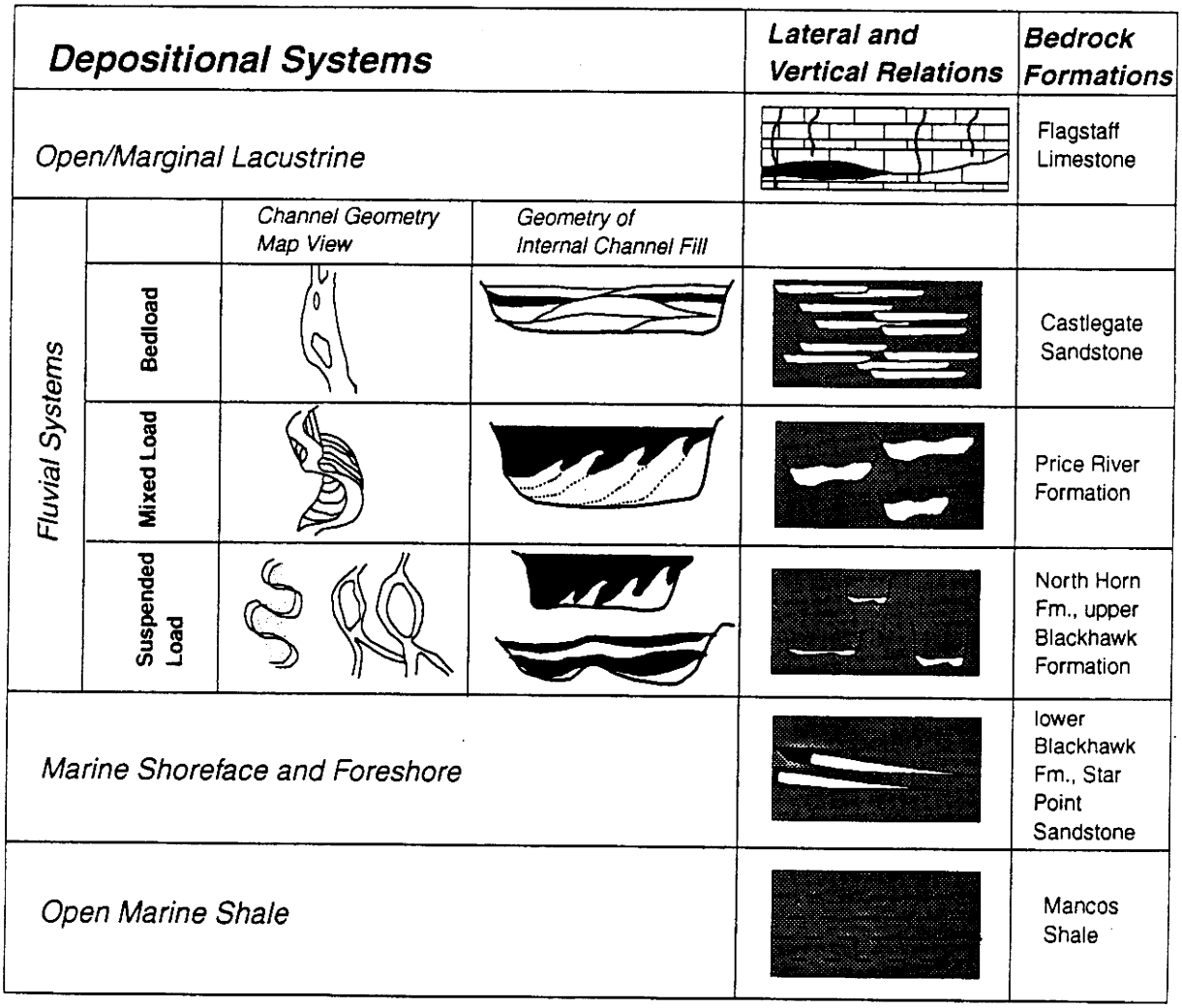


Figure 8 Diagram showing the internal structure of the bedrock formations in the mine lease area. In the geometry of internal channel fill column, mud is shown in black and sand is white. In the lateral and vertical relations column, mudstone is shown in grey and sandstone is shown in white.

4.3.1.1 Flagstaff Limestone (Tertiary Age)

The Flagstaff Limestone, which caps the uppermost portions of the Wasatch Plateau, is the youngest of the bedrock formations exposed in the PacifiCorp lease area (Figure 5). It typically forms a prominent white cliff on top of the plateau. A thickness of 105 feet was measured on Trail Mountain.

The Flagstaff Limestone consists of carbonates, marls, and some thin sandstone stringers deposited in lacustrine, marginal lacustrine, and alluvial plain depositional environments (Garner and Morris, 1996). It primarily consists of light- to medium-gray limestone containing abundant secondary fractures produced during uplift and subaerial exposure. Thin beds of shale and volcanic ash are present in some locations.

4.3.1.2 North Horn Formation (Tertiary-Cretaceous Age)

The North Horn Formation is the caprock of much of East and Trail Mountains where the Flagstaff Limestone has been eroded away. Exposures of the North Horn Formation form purple, red, or brown colored slopes. In the Trail Mountain area, the thickness ranges from 750 to 800 feet and increases to the west.

The North Horn Formation was deposited in an alluvial-plain/suspended-load fluvial channel environment (Figure 8). In such environments layers of mud are more abundant than sands, which occur in sandstone channels. The sandstone channels are generally isolated from each other both laterally and vertically by mud-rich overbank and interfluvial rocks (Galloway, 1977). In the study area the formation consists primarily of shale with discontinuous

sandstone channels, minor lenses of limestone, and conglomerate. Highly bentonitic mudstones, which swell when wetted, are common in the lower two-thirds of the formation.

4.3.1.3 Price River Formation (Cretaceous Age)

The Price River Formation typically forms a steep, receding slope above the Castlegate Sandstone with alternating ledges and slopes resulting from the interbedding of resistant sandstones with less resistant shales and claystones. In the lease area the formation is 350 to 400 feet thick.

The Price River Formation was deposited from mixed-load fluvial channel systems having sandstone/mudstone ratios intermediate between bed-load and suspended-load channel systems (Figure 8). Sandstones and mudstones occur in about equal proportions. Point bars that develop in this type of system are larger than those in suspended-load channel systems. Mudstone drapes created during low flow stages of the active fluvial system separate the sandstones from each other both horizontally and vertically.

4.3.1.4 Castlegate Sandstone (Cretaceous Age)

The Castlegate Sandstone has a distinctive cliff forming habit and typically forms a resistant cliff above the underlying, less resistant Blackhawk Formation. The thickness of the Castlegate Sandstone ranges from 250 to 300 feet in the lease area

The formation was deposited from bed-load fluvial channel systems (Figure 8; Chan and Pfaff, 1991). The Castlegate Sandstone is made up of coarse-grained, often conglomeratic, fluvial

sandstone with some thin interbeds of siltstone and claystone, especially toward the base of the unit. Sandstone dominates over mudstone and individual sand channels may be thin, wide, or interpenetrating. Although the primary porosity is high, the existence of mudstone drapes and pervasive carbonate and silica cement greatly reduces the overall porosity.

4.3.1.5 Blackhawk Formation (Cretaceous Age)

The Blackhawk Formation generally forms a steep, irregular slope between the cliffs of the underlying Star Point Sandstone and the overlying Castlegate Sandstone.

The formation consists of an upper non-marine, suspended-load fluvial portion and a lower marine shoreface and non-marine foreshore portion. Massive, cliff-forming units are common in the upper portion, and thinner-bedded, slope-forming units are common in the lower portion. The thickness of the Blackhawk Formation ranges from 625 to 800 feet in the study area and generally thickens to the northeast. Most of the thicker coal seams occur in the lower 150 feet of the Blackhawk Formation.

The upper portion of the Blackhawk Formation was deposited in an alluvial-plain/suspended-load fluvial channel environment (Figure 8). In these delta and flood-plain environments layers of mud are more abundant than channel sands. Sandstone channels are generally isolated from each other both laterally and vertically by mud-rich overbank and interfluvial rocks (Galloway, 1977). The upper portion of the Blackhawk Formation also contains some thin carbonaceous shale layers and thin coal seams which are not of economic interest.

The lower portion of the Blackhawk Formation contains the mineable coal deposits and consists of more thinly bedded sandstone and shale layers (Johnson, 1978). The coal-bearing units of the lower Blackhawk Formation overlie and are laterally juxtaposed to marine shoreface sandstones of the Blackhawk Formation and Star Point Sandstone. On a large scale, these sandstone bodies are laterally continuous but terminate abruptly into the mud- and organic-rich backshore faces in a landward direction (Van Wagoner and others, 1990). However, individual rock layers are lenticular and discontinuous, with abundant shaley interbeds. The fine- to medium-grained sandstones occur as thin- to massively-bedded paleochannel deposits. The paleochannels increase in frequency, thickness, and lateral extent upward in the formation. There is also a vertical repetition of erosional scours within the upper sandstones (Marley and others, 1979).

The PacifiCorp mine workings are within the Hiawatha and Blind Canyon coal seams. In most locations the Hiawatha seam lies directly on top of the Star Point Sandstone. In some locations, a 0-15 foot thick shaley lagoonal deposit is present between the Hiawatha seam and the top of the Star Point Sandstone. The Blind Canyon seam lies approximately 80 feet above the Hiawatha seam. In the Wasatch Plateau, large areas of the Blackhawk Formation have been baked by natural burning of the coal near the surface. These reddish clinker layers are generally more resistant and form steeper slopes than adjacent unburned layers.

4.3.1.6 Star Point Sandstone (Cretaceous)

The Star Point Sandstone, which is present throughout the area, forms massive cliffs where exposed at the surface. The sandstone was deposited as marine shoreface blanket sands which

are laterally continuous, but thin seaward (east). Landward (west), these sandstones terminate abruptly into the mud- and organic-rich backshore facies (Figure 8; Van Wagoner and others, 1990). Because many of the organic-rich facies have been converted to mineable quality coal, locally the Star Point Sandstone has immediate contact with coal seams. Elsewhere sandstone bodies of the Star Point Sandstone are overlain and underlain by lower shoreface and open marine shales of the Mancos Formation. What this means is that the marine shoreface sandstones are three dimensionally encased by low-permeability marine shales and fine-grained carbonaceous backshore coal-bearing facies.

The Star Point Sandstone thins eastward and merges with the underlying Masuk Member of the Mancos Shale. Three prominent tongues of the Star Point Sandstone interfinger with the Mancos Shale. These three sandstone members, from top to bottom, are the Spring Canyon, Storrs, and Panther Sandstones. In the lease area, the Spring Canyon tongue is approximately 100 feet thick, lies about 80 feet above the Storrs tongue, and consists of massive, fine- to medium-grained sandstone. The Storrs tongue lies about 120 feet above the Panther tongue and consists of 50 feet of soft, friable sandstone. The basal Panther tongue is approximately 100 feet thick and consists of massive, crossbedded delta front sandstones.

4.3.1.7 Masuk Member of the Mancos Shale (Cretaceous Age)

The marine Masuk Member of the Mancos Shale was deposited in an open marine environment. The rock is highly erodeable calcareous, gypsiferous, and carbonaceous dark gray shale. It is continuously exposed along the eastern edge of the Wasatch Plateau. The Masuk member is approximately 1,300 feet thick. Westward thinning wedges of the Masuk

interfinger with tongues of the Star Point Sandstone. Castle Valley, to the east of the study area, is developed on the Mancos Shale.

4.3.2 Structure

The PacifiCorp study area is bounded on the east by the eastern erosional escarpment of the Wasatch Plateau and on the west by the Joes Valley Fault System. The dip of the bedrock is controlled primarily by the Straight Canyon Syncline, which runs diagonally through the middle of the lease area, trending approximately north 50° east and plunging to the southwest (Figure 5). Bedrock located northwest of the syncline axis generally dips toward the southeast, whereas bedrock located southeast of the syncline axis dips toward the northwest. The dips of the rocks throughout the study are gentle, rarely exceeding 6°.

Most faults in the study area trend north-south or northeast-southwest (Figure 5). The most significant is the Joes Valley Fault System, which extends more than 20 miles to the north and 40 miles to the south of the Joes Valley Reservoir dam, and has a reported 2,300 feet of vertical displacement (Davis and Doelling, 1977). Joes Valley is a graben formed on the downthrown block west of the fault; Trail Mountain forms the horst block east of the fault. Much of Joes Valley is filled with alluvium that is juxtaposed against the bedrock formations of Trail Mountain.

The Mill Fork and Roans Canyon Fault systems, which have much less displacement than the Joes Valley System, form narrow grabens in the central portion of Trail Mountain and in the northern portion of East Mountain. The Mill Fork and Roans Canyon Fault systems roughly

parallel the Straight Canyon Syncline (Figure 5) and appear to be scissor faults hinged near the center of Trail Mountain. At the hinge location there is essentially no vertical or horizontal displacement. Maximum displacement on these faults in the lease area is estimated to be 30 feet on the Mill Fork Fault, and 160 feet on the Roans Canyon Fault (Semborski, Personal Communication, 1997).

The Pleasant Valley Fault System, which extends for 20 miles north of the lease area, is located along the eastern edge of East Mountain (Figure 5). In the lease area, displacement is less than 150 feet.

Near surface joint sets trending northeast-southwest, and northwest-southeast are common in the lease area (Kadnuck, 1994). Lineament and drainage trace analysis suggest that the major trunk streams in the lease and adjacent area follow a regional northwest-southeast trend and that these drainages follow fracture or joint systems (Peters and Speirer, 1986).

5. SOLUTE AND ISOTOPE CHEMISTRY

5.1 Explanation of chemical reporting units and terms

Reporting units are milligrams per liter (mg L^{-1}) and milliequivalents per liter (meq L^{-1}) for ionic solutes and per mil (‰) for stable isotopes. Stable isotopic reference standards are Standard Mean Oceanic Water (SMOW) for δ^2H and $\delta^{18}O$, Pee Dee Formation Belemnite (PDB) for $\delta^{13}C$, and the Canyon Diablo Meteorite (CD) for $\delta^{34}S$. The radioactive isotope ^{14}C is reported relative to percent modern (1950) carbon (pmc), and the radioactive isotope ^3H is reported in tritium units (TU). One TU is equivalent to 3.2 pCi L^{-1} (pico-Curies per liter).

In addition to the familiar mg L^{-1} concentration unit, laboratory solute data have been converted to meq L^{-1} for analysis and reporting purposes. The meq L^{-1} unit allows direct comparison of reacting concentrations of cations and anions. Conversion factors between meq L^{-1} and mg L^{-1} for major ions follow:

	meq L^{-1}	mg L^{-1}
Ca^{2+}	1	20.0
Mg^{2+}	1	12.2
Na^{+}	1	23.0
K^{+}	1	39.1
HCO_3^-	1	61.0
SO_4^{2-}	1	48.0
Cl^-	1	35.5

From the conversion factors it is apparent that heavy anion molecules such as SO_4^{2-} and HCO_3^- contribute disproportionately to TDS relative to their reacting cation counterparts, such as Ca^{2+}.

The stable isotopic composition of a sample is reported as the per mil (‰) difference of the sample relative to the isotopic composition of a standard using the delta (δ) notation defined as:

$$\delta = \frac{(R_{sample} - R_{standard})}{(R_{standard})} x1000 \ (‰)$$

Where R = $^{18}O/^{16}O$, $^{2}H/^{1}H$, $^{13}C/^{12}C$, and $^{34}S/^{32}S$. The δ notation is reported in terms of the heavy isotope in the ratio R (i.e., $\delta^{13}C$ for $^{13}C/^{12}C$).

A summary of the application of isotopic methods to hydrogeologic investigations is included as Appendix B. Readers who are not familiar with the use of isotopes in hydrogeologic investigations are encouraged to read Appendix B prior to proceeding with the remainder of this report.

5.2 Chemical evolution of groundwaters

5.2.1 Chemical reactions

Solute compositions of groundwaters are the result of interactions between groundwaters and bedrock lithologies and between groundwaters and atmospheric and soil gases. The general reactions responsible for the chemical evolution of groundwaters in the vicinity of the PacifiCorp lease area and inside the coal mines are described below:

Groundwater acquires most of its $CO_{2(g)}$ in the soil zone where the partial pressures of CO_2 greatly exceeds atmospheric levels. This CO_2 combines with water to form carbonic acid according to

$$CO_{2(g)} + H_2O = H_2CO_3 \quad (1)$$

Carbonic acid dissociates into H^+ and HCO_3^- as

$$H_2CO_3 = HCO_3^- + H^+ \quad (2)$$

The H^+ ions temporarily decrease the pH of the water but are quickly consumed by the dissolution of carbonate minerals that are abundant in the soil zone and in most aquifers. Carbonate mineral dissolution is represented as

$$2H^+ + \underset{\text{(dolomite)}}{CaMg(CO_3)_2} = Ca^{2+} + Mg^{2+} + 2HCO_3^-, \text{ and} \quad (3)$$

$$H^+ + \underset{\text{(calcite)}}{CaCO_3} = Ca^{2+} + HCO_3^-. \quad (4)$$

The net effect of reactions 2 through 4 is to increase the pH and the Ca^{2+}, Mg^{2+}, and HCO_3^- contents of waters. Dissolution of small amounts of gypsum, which is present in many formations in the region, can elevate the Ca^{2+} and SO_4^{2-} contents in the absence of additional $CO_{2(g)}$ and H^+ according to

$$\underset{\text{(gypsum)}}{CaSO_4 \cdot 2H_2O} = Ca^{2+} + SO_4^{2-} + 2H_2O. \quad (5)$$

Elevated Na^+ concentrations may result from either the dissolution of small amounts of very soluble halite or from ion exchange on clay particles or on sodium zeolites. Halite dissolution will increase the overall solute concentration (i.e. TDS) and will yield equal Na^+ and Cl^- contents when the solute compositions are reported in the meq L^{-1} units. Ion exchange will not directly elevate the overall solute content, but will result in increased Na^+ concentrations

at the expense of reduced Ca^{2+} and/or Mg^{2+} concentrations. Halite dissolution may be represented as

$$NaCl = Na^{+} + Cl^{-}, \quad (6)$$

and ion exchange may be represented by reactions involving the sodium zeolite analcime,

$$2NaAlSi_2O_6 \cdot H_2O + Ca^{2+} = Ca(AlSi_2O_6)_2 \cdot H_2O + 2Na^{+}, \quad (7)$$

$$2NaAlSi_2O_6 \cdot H_2O + Mg^{2+} = Mg(AlSi_2O_6)_2 \cdot H_2O + 2Na^{+}, \quad (8)$$

or clay mineral exchange which may be represented as

$$Ca^{2+} + Na\text{-clay} = 2Na^{+} + Ca\text{-clay} \quad (9)$$

$$Mg^{2+} + Na\text{-clay} = 2Na^{+} + Mg\text{-clay} \quad (10)$$

5.2.2 Groundwater solute compositions

Solute compositions of groundwater from 96 springs, 4 french drains, 5 wells and 46 in-mine sampling locations were analyzed as part of this investigation. Spring and well locations are shown on Figure 9. In-mine sampling locations for the Blind Canyon seam in the Deer Creek Mine and for the Hiawatha seam in the Trail Mountain and Cottonwood/Wilberg Mines are show in Figures 10 and 11, respectively.

Mean solute compositions for each spring and well have been calculated for the high-flow and low-flow conditions (Table 1). The highest discharge from springs generally occurs in July (Semborski, 1997, personal communication) and records with sampling dates in May, June, or July are included in the high flow mean. The low flow mean is calculated using records with dates from August to April. In Table 1 groundwaters issuing from the North Horn Formation are classified as either low or high SO_4^{2-} water.

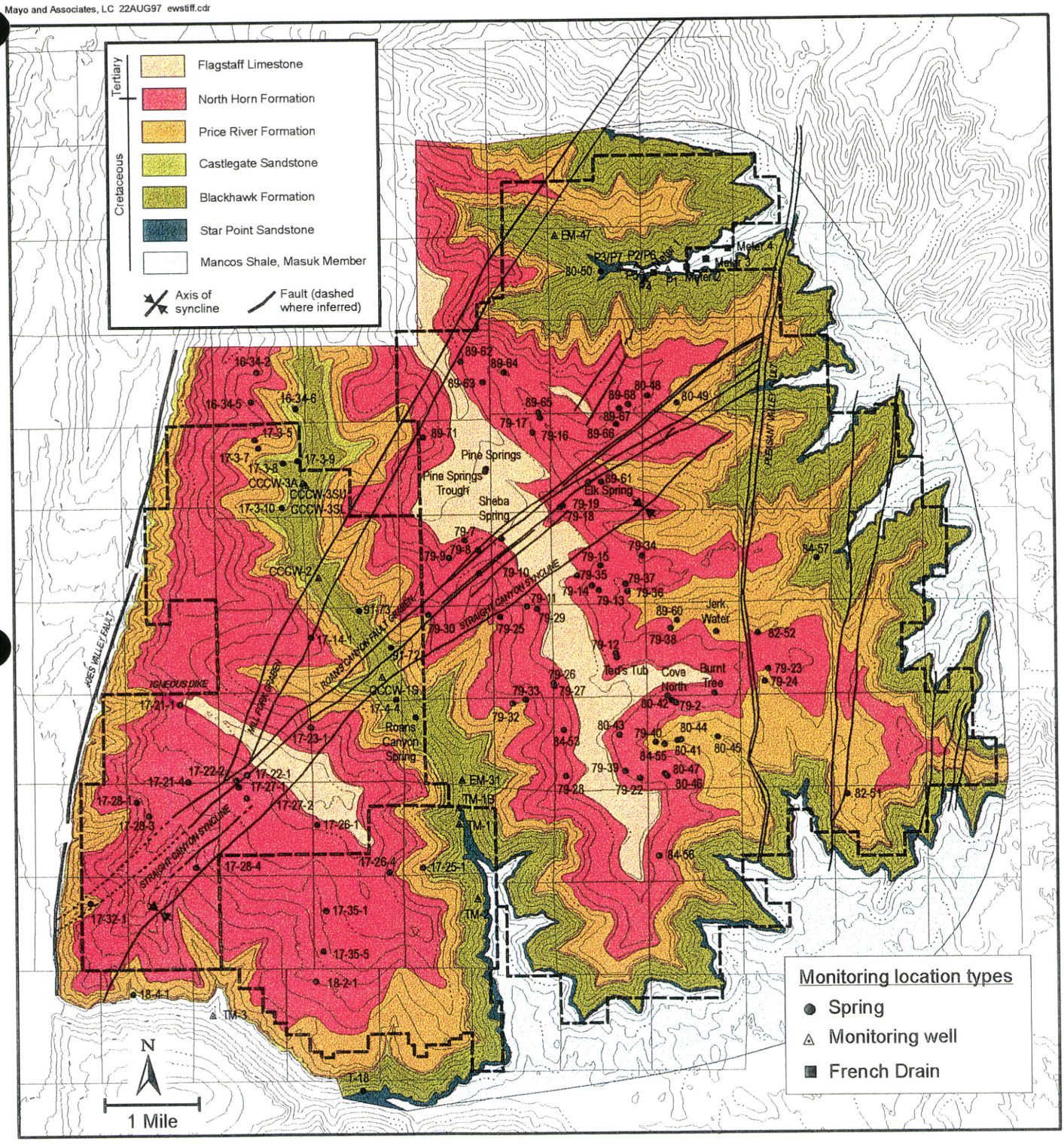


Figure 9 Map showing the locations of springs, monitoring wells, and Rilda Canyon French drains.

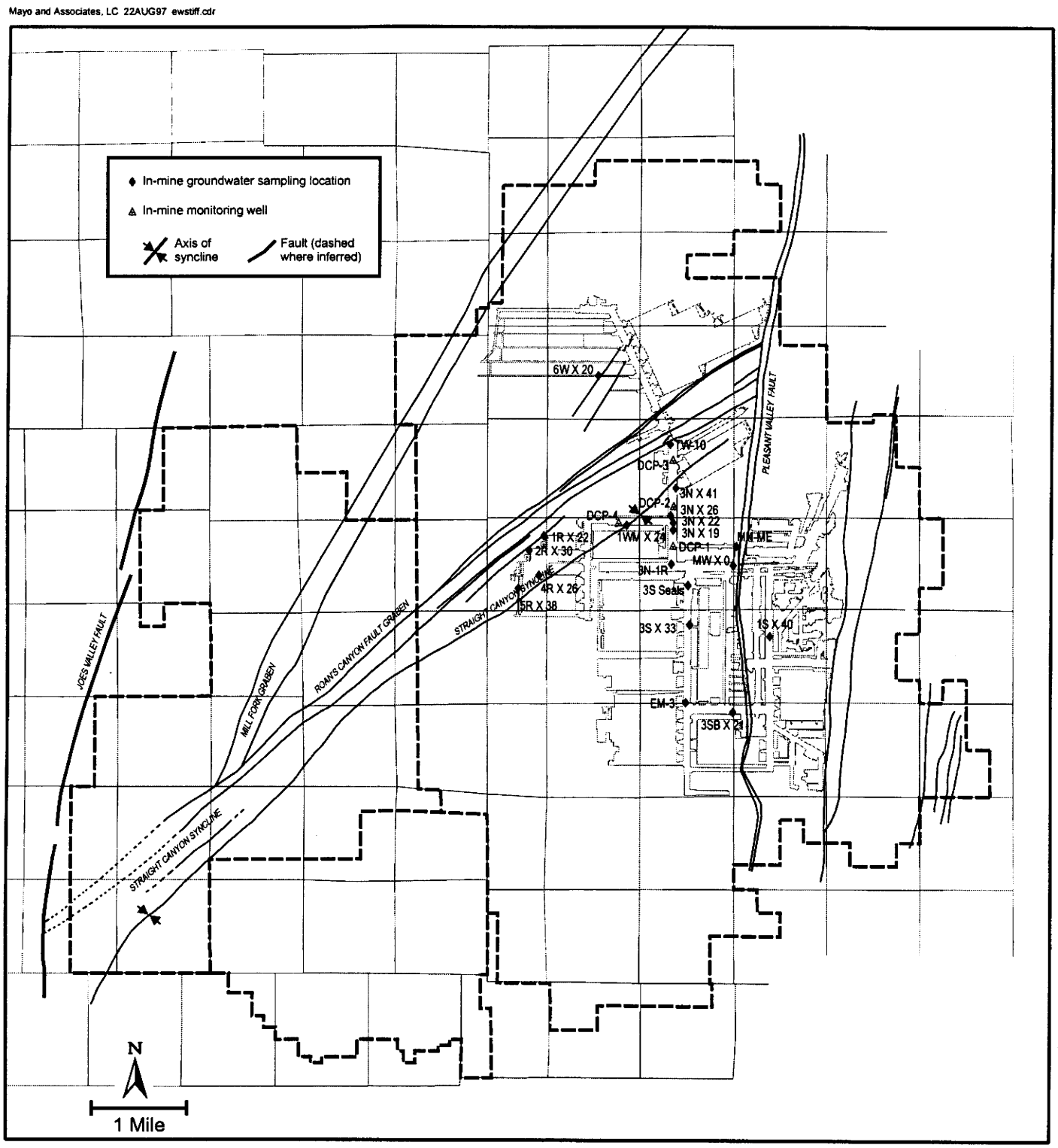


Figure 10 Mine workings of the Deer Creek Mine and locations of in-mine sampling locations and monitoring wells. Mine workings are in the Blind Canyon Seam of the Blackhawk Formation.

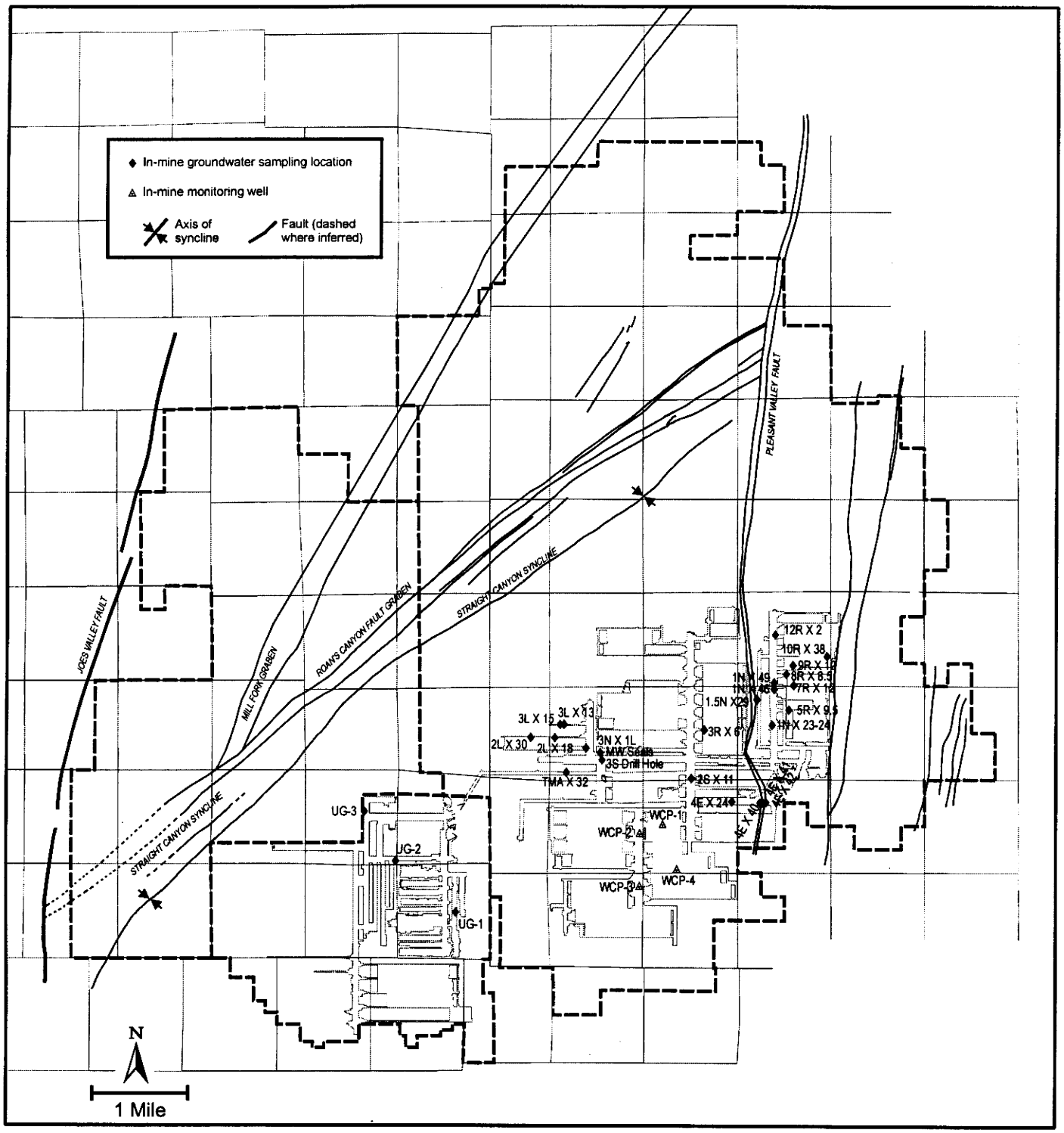


Figure 11 Mine workings of the Trail Mountain and Cottonwood/Wilberg Mines and locations of in-mine sampling locations and monitoring wells. Mine workings are in the Hiawatha Seam of the Blackhawk Formation.

Table 1 Mean solute chemistry of springs during baseflow and highflow conditions

table1.xls 23APR97

Formation	n sites	°C	pH	TDS mg/L	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	HCO_3^{-}	CO_3^{2-}	SO_4^{2-}	Cl^{-}	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	HCO_3^{-}	CO_3^{2-}	SO_4^{2-}	Cl^{-}	Na:Cl
					mg/L								meq/L								
Springs--baseflow																					
Alluvium	2	8.0	7.47	424	81.4	46.1	14.6	2.9	405	0.6	75.8	12.2	4.06	3.79	0.64	0.07	6.63	0.02	1.58	0.34	1.86
Flagstaff	3	6.6	7.57	257	90.4	13.9	6.3	2.8	294	0.4	38.2	5.6	4.51	1.14	0.27	0.07	4.82	0.01	0.80	0.16	1.72
North Horn	47	7.1	7.77	358	81.4	30.5	23.7	1.9	356	0.8	62.9	16.0	4.06	2.51	1.03	0.05	5.84	0.03	1.31	0.45	2.28
low sulfate	33	6.4	7.78	309	69.1	29.0	18.9	1.5	345	0.9	21.0	15.3	3.45	2.38	0.82	0.04	5.65	0.03	0.44	0.43	1.91
high sulfate	14	8.6	7.75	474	110.5	34.2	35.0	2.7	383	0.5	161.4	17.7	5.51	2.81	1.52	0.07	6.28	0.02	3.36	0.50	3.04
Price River	7	8.4	7.70	372	93.2	27.5	16.4	2.3	400	0.5	60.2	9.8	4.65	2.26	0.71	0.06	6.55	0.02	1.25	0.28	2.58
Castlegate/Blackhawk	7	8.2	7.90	359	79.3	34.5	10.7	1.4	357	1.3	46.2	11.5	3.96	2.84	0.47	0.04	5.85	0.04	0.96	0.32	1.44
Blackhawk	2	7.4	7.79	562	82.0	59.3	33.8	4.3	439	0.0	175.3	13.5	4.09	4.88	1.47	0.11	7.20	0.00	3.65	0.38	3.87
Springs--highflow																					
Alluvium	4	8.4	7.47	390	68.9	46.6	13.8	1.5	373	1.1	59.9	11.5	3.44	3.83	0.60	0.04	6.12	0.04	1.25	0.33	1.85
Flagstaff	4	6.4	7.41	260	82.8	11.9	4.9	1.7	275	0.4	32.7	4.0	4.13	0.98	0.21	0.04	4.51	0.01	0.68	0.11	1.88
North Horn	63	8.1	7.68	346	79.5	29.6	19.0	2.6	357	1.1	61.9	10.5	3.97	2.44	0.82	0.07	5.85	0.04	1.29	0.30	2.78
low sulfate	40	8.6	7.69	313	64.7	29.1	15.8	1.6	346	1.5	20.0	10.0	3.23	2.40	0.69	0.04	5.68	0.05	0.42	0.28	2.43
high sulfate	23	7.1	7.66	399	105.7	29.7	24.0	4.3	373	0.5	134.0	11.1	5.27	2.45	1.04	0.11	6.11	0.02	2.79	0.31	3.33
Price River	10	8.1	7.65	442	85.4	36.9	24.9	1.8	418	1.3	61.3	10.6	4.26	3.04	1.08	0.05	6.86	0.04	1.28	0.30	3.61
Castlegate/Blackhawk	2	13.5	8.32	370	50.9	42.8	20.6	2.1	315	2.3	70.5	13.7	2.54	3.52	0.90	0.05	5.16	0.08	1.47	0.39	2.33
Blackhawk	1	7.0	7.50	532	143.0	29.5	46.0	12.0	470	0.0	215.0	10.3	7.14	2.43	2.00	0.31	7.70	0.00	4.48	0.29	6.88

A two-tailed paired t-test comparing the mean high flow and low flow solute concentrations of spring and well waters organized by formation was performed (Table 2). If the t-test values is <0.05 there is a statistical probability that the means of the two populations are different at the 95% confidence interval. Table 2 shows that there is not a statistical difference in the high and low flow solute compositions of groundwater issuing from most formations. Exceptions include TDS, Ca^{2+}, and SO_4^{2-} in alluvial groundwater systems and Cl^- in low sulfate North Horn Formation groundwater. The calculated statistical difference in K^+ in high sulfate North Horn Formation groundwater is not considered valid because the difference is the result of a single sample from spring EMS79-19.

The mean solute compositions of groundwaters issuing from each bedrock source, (regardless of discharge rates) are listed in Table 3 and are illustrated on a trilinear diagram (Figure 12). The solute compositions of groundwater issuing from each spring, well, and in-mine sampling location are illustrated as Stiff diagrams on Figures 13 and 14.

Most groundwater discharging from springs in the study area is of the Ca^{2+}-HCO_3^- or Ca^{2+}-Mg^{2+}-HCO_3^- type. The solute compositions of these waters are due to the dissolution of carbonate minerals in the presence of soil zone CO_2 (Eqs. 1-4). Most groundwaters have Na^+ concentrations 2 to 3 times as great as Cl^- when concentrations are expressed as meq L^{-1} (Table 3). Na:Cl ratios appreciably greater than 1 are interpreted to be the result of ion exchange of Ca^{2+} and Mg^{2+} for Na^+ on clays (Eqs. 9 and 10). Ion exchange appears to be particularly prevalent in the Blackhawk, Price River, and high SO_4^{2-} North Horn spring waters.

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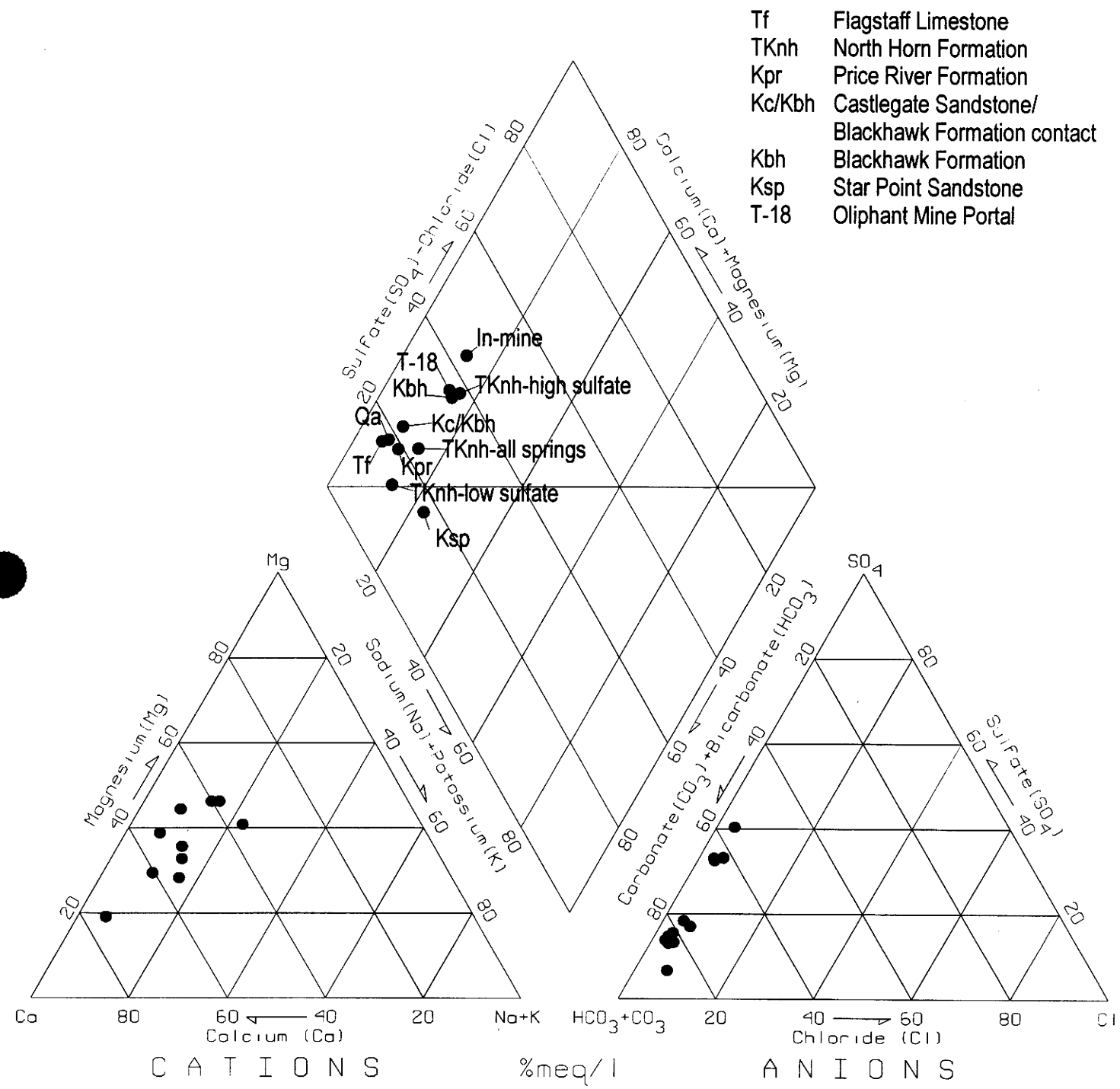

Figure 12 Trilinear diagram of mean solute compositions.

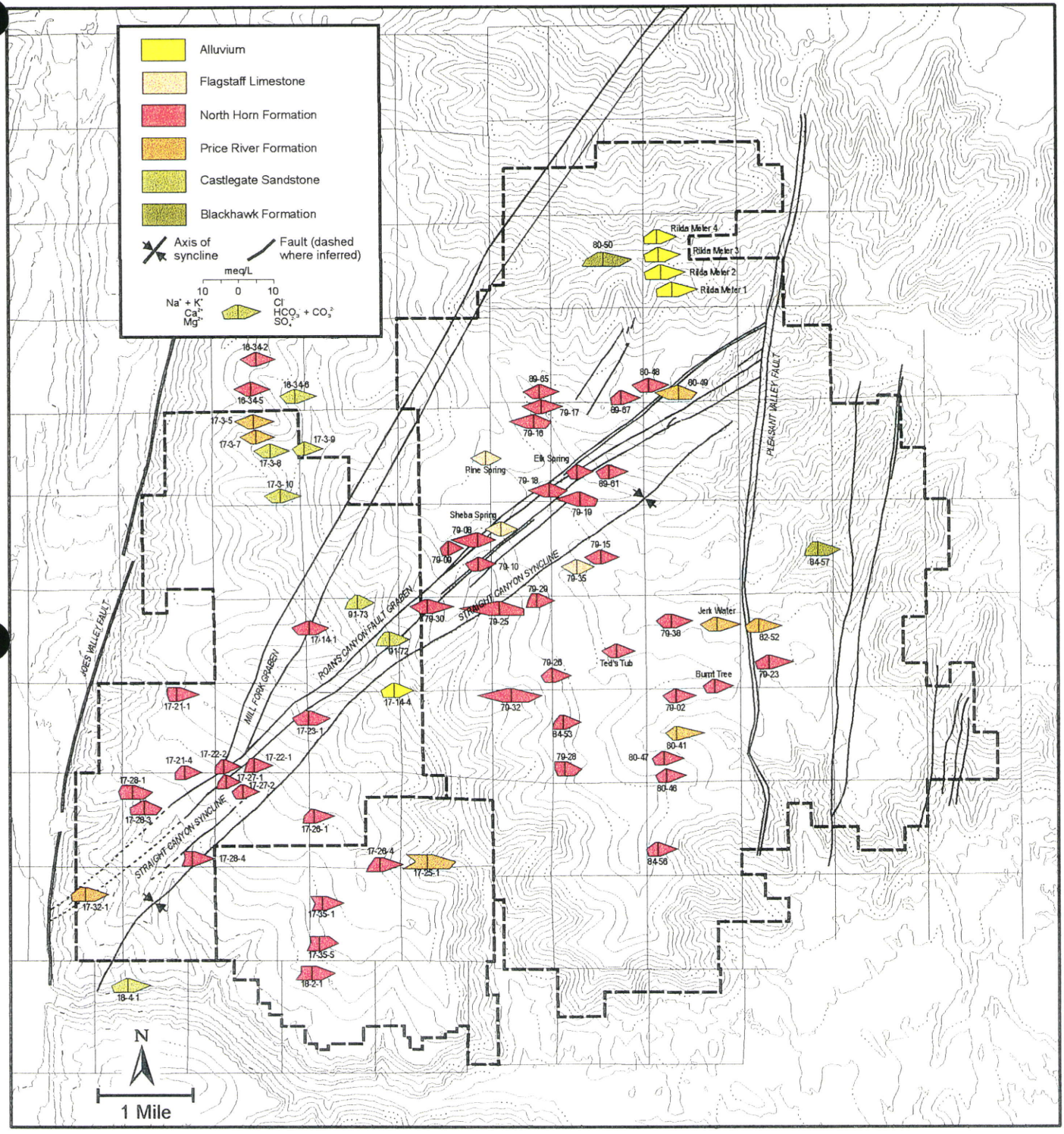

Figure 13 Stiff diagram map of mean spring water compositions for low-flow conditions

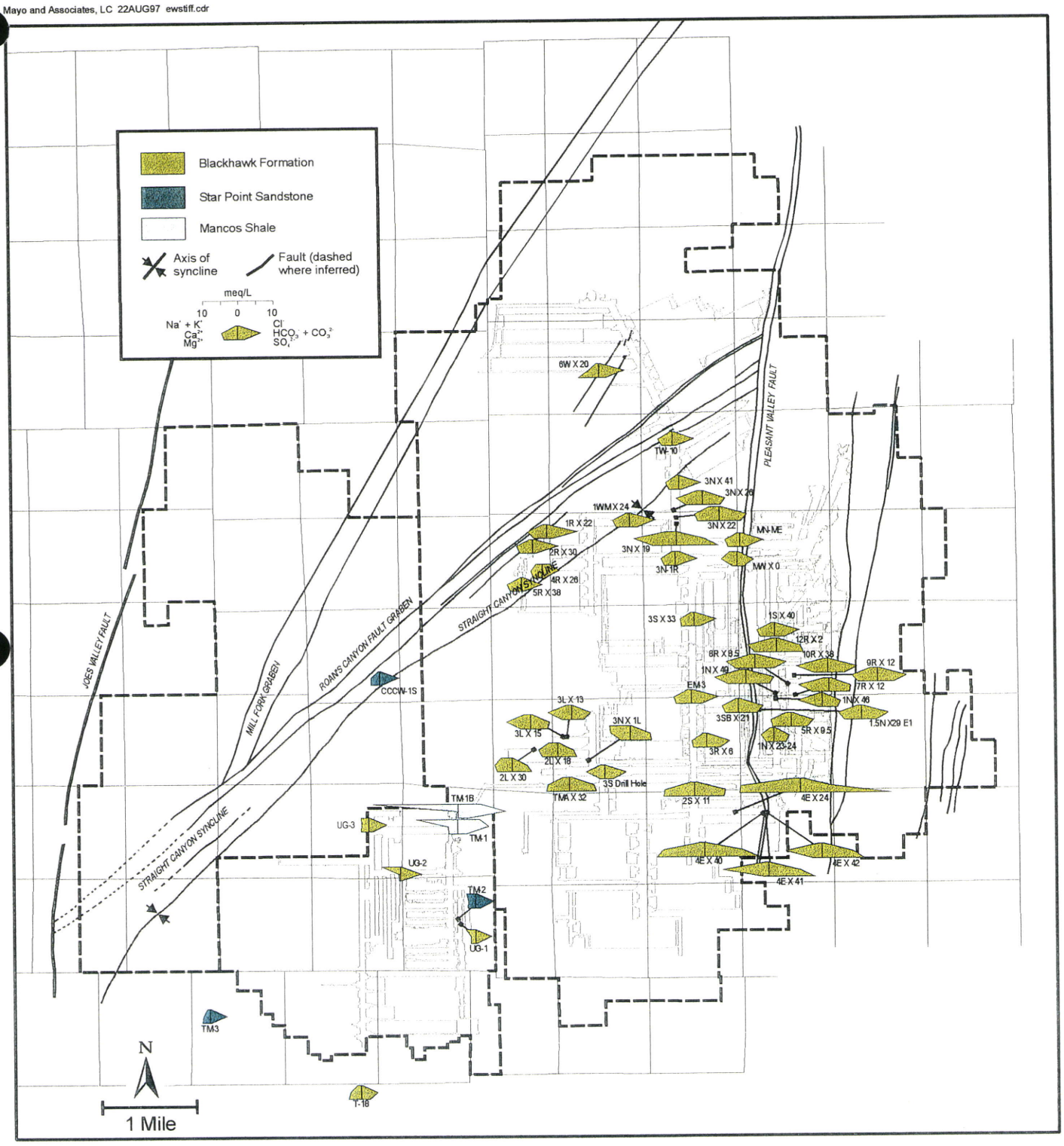

Figure 14 Stiff diagram map of in-mine, monitoring well, and Oliphant Mine (T-18) waters.

Table 2 Paired t-test analysis of spring solute chemistry

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Site	High n	Base n	High TDS	Base TDS	High Ca^{2+}	Base Ca^{2+}	High Mg^{2+}	Base Mg^{2+}	High Na^{+}	Base Na^{+}	High K^{+}	Base K^{+}	High HCO_3^{-}	Base HCO_3^{-}	High SO_4^{2-}	Base SO_4^{2-}	High Cl^{-}	Base Cl^{-}
Alluvium																		
RILDA-METER2	5	16	458.0	480.4	85.2	94.0	50.5	51.6	15.4	14.9	2.4	2.5	409	441	83.0	93.8	9.5	13.7
RILDA-METER3	5	17	375.8	423.3	70.7	80.8	43.9	45.6	12.6	13.4	0.7	2.0	373	398	55.4	76.8	11.4	11.1
RILDA-METER4	4	12	351.8	369.6	66.4	71.6	39.1	42.8	11.3	13.5	1.2	1.9	348	359	42.8	59.7	10.9	13.8
17-14-4	4	7	374.0	391.7	53.3	73.1	52.7	38.9	15.9	15.8	1.8	1.8	362	363	58.3	63.9	14.4	13.7
Paired t-test				**0.034**		**0.039**		**0.683**		**0.400**		**0.174**		**0.090**		**0.029**		**0.289**
Flagstaff Limestone																		
EMS 79-35	12	10	268.8	271.7	83.8	93.8	14.9	16.2	5.3	6.4	0.8	1.7	299	302	25.3	38.9	7.9	6.1
PINE SPRING	5	2	281.6	234.0	87.3	86.0	13.2	15.3	7.3	7.8	3.6	4.6	268	273	56.8	52.5	2.6	3.0
SHEBA SPRINGS	12	19	249.2	264.6	82.2	91.4	9.6	10.1	4.9	4.7	2.4	2.1	272	307	27.9	23.3	4.0	7.7
Paired t-test				**0.663**		**0.241**		**0.108**		**0.350**		**0.311**		**0.292**		**0.816**		**0.671**
Low Sulfate North Horn Formation																		
17-21-1	13	18	388.4	402.1	50.8	55.7	31.6	26.5	63.1	59.1	2.0	2.3	397	398	19.7	17.8	32.2	31.5
17-21-4	2	3	302.5	290.7	47.4	54.0	32.5	32.7	17.6	18.6	2.9	2.3	309	314	18.5	11.0	23.4	25.3
17-22-1	10	19	294.3	325.6	54.4	48.4	38.0	35.3	18.8	27.1	1.6	1.8	357	341	15.8	26.9	10.3	11.8
17-22-2	2	3	300.0	269.0	50.6	49.6	33.5	31.4	11.9	15.6	3.6	2.3	345	313	8.5	8.7	9.3	11.7
17-26-1	4	6	334.0	331.3	52.7	56.2	38.9	38.4	18.2	19.3	1.9	1.7	356	367	27.3	19.8	11.0	10.4
17-26-4	9	11	385.9	392.3	55.7	58.0	47.7	48.9	35.3	32.0	2.0	1.5	380	404	33.8	35.2	27.1	27.9
17-27-1	2	3	253.5	247.0	46.5	45.3	26.5	31.9	10.1	13.1	2.8	2.3	270	280	11.5	10.3	16.0	14.0
17-27-2	2	3	272.5	265.0	43.8	61.2	25.5	22.5	9.7	12.2	2.7	2.3	298	300	14.0	7.3	11.3	12.0
17-28-4	2	4	372.0	363.0	38.7	43.8	42.0	36.6	51.8	52.3	3.0	1.8	367	390	26.5	25.3	21.7	23.3
17-35-1	13	20	411.3	445.9	40.2	41.9	39.0	36.3	72.7	77.4	1.5	1.6	378	381	42.2	47.1	41.4	43.4
BURNT TREE	16	19	293.9	284.6	63.0	65.1	28.0	25.8	14.6	14.1	1.3	1.3	333	330	24.5	26.0	6.8	7.5
ELK SPRING	14	16	270.9	244.6	68.3	63.4	22.1	22.2	7.6	9.0	2.2	1.8	290	292	30.3	19.8	4.5	7.9
EMS 79-02	9	9	294.1	284.6	78.4	75.4	22.4	21.0	15.4	15.0	0.8	2.2	366	366	15.7	12.3	5.7	7.9
EMS 79-10	11	13	288.5	266.0	77.6	74.8	22.3	21.9	5.6	4.5	1.6	2.5	315	323	25.3	9.7	6.9	7.8
EMS 79-15	15	14	298.1	271.3	79.9	94.1	23.3	22.9	8.2	7.5	1.6	1.4	329	329	37.2	19.6	6.4	6.2
EMS 79-23	6	1	371.7	392.0	79.7	79.2	37.9	40.4	14.9	14.8	1.7	0.5	422	433	29.5	30.0	11.2	11.8
EMS 79-26	8	5	295.0	320.8	63.4	67.9	29.1	25.6	14.6	17.4	1.4	2.7	320	337	28.4	36.6	8.3	7.2
EMS 79-38	14	9	364.8	388.6	81.8	86.2	26.9	26.0	38.1	38.1	1.5	2.0	404	389	39.1	62.6	10.2	10.8
EMS 80-46	9	7	306.6	304.9	59.2	63.8	29.2	28.0	9.8	9.8	0.7	0.9	366	353	16.7	18.7	5.6	4.3
EMS 80-47	15	13	350.6	305.4	75.0	68.0	31.8	30.7	15.3	14.4	2.3	1.9	362	356	41.0	26.8	7.7	6.7
EMS 84-53	5	2	295.0	313.0	47.2	51.0	31.2	36.8	18.9	20.4	1.0	1.1	323	331	16.2	37.0	8.5	9.5
EMS 84-56	12	12	332.2	316.3	62.2	65.1	34.7	32.4	16.6	16.8	1.0	1.7	345	349	30.8	26.3	10.9	11.0
EMS 89-61	7	6	294.2	294.3	78.7	72.0	26.7	26.8	7.5	9.2	1.9	1.4	366	343	14.2	16.2	6.4	7.2
EMS 89-65	5	2	302.0	317.5	94.7	90.3	27.0	22.5	3.6	3.5	0.4	0.3	359	363	9.6	17.0	7.6	20.0
EMS 89-67	7	6	282.7	284.3	57.0	57.9	33.0	33.8	11.8	14.2	1.1	2.0	310	343	22.3	21.8	9.2	10.0
TED'S TUB	13	14	288.4	290.6	82.5	85.0	19.0	18.5	8.1	9.8	2.3	1.5	319	333	30.8	25.1	5.6	6.5
Paired t-test				**0.757**		**0.150**		**0.088**		**0.054**		**0.656**		**0.312**		**0.772**		**0.044**
High Sulfate North Horn Formation																		
17-23-1	1	2	398.0	389.5	62.1	89.9	33.0	37.5	13.5	25.2	0.7	1.0	368	386	60.0	110.0	10.1	20.5
17-25-1	6	3	710.6	917.3	81.1	67.3	55.6	83.5	79.5	135.2	2.7	3.1	418	501	266.8	302.0	31.6	55.4
18-2-1	14	20	561.6	579.9	61.3	61.5	57.4	55.8	65.9	67.6	1.6	1.7	400	404	136.4	131.0	47.3	46.3
EMS 79-08	1	1	390.0	206.0	121.5	151.7	28.0	21.4	16.5	3.5	6.5	0.7	289	332	230.4	8.6	4.8	4.9
EMS 79-09	1	1	382.0	240.0	121.0	48.3	28.0	20.1	16.0	5.6	7.0	0.3	317	281	193.0	2.1	5.8	7.2
EMS 79-16	1	1	330.0	391.0	136.0	140.0	21.0	21.5	4.0	2.5	2.0	1.5	321	318	156.0	163.0	3.9	3.3
EMS 79-17	1	1	308.0	269.0	120.0	110.6	17.0	19.2	22.0	3.6	8.5	0.6	333	384	132.0	11.1	3.2	4.9
EMS 79-18	1	2	483.0	314.0	173.0	121.0	18.0	15.4	6.0	2.9	3.0	1.6	320	315	274.0	107.8	2.9	3.4
EMS 79-19	1	2	384.0	371.5	149.0	142.0	8.5	9.3	7.0	6.5	20.0	16.3	306	310	189.0	204.0	2.9	3.1
EMS 79-25	2	1	384.0	610.0	95.6	228.0	22.5	32.0	9.9	9.0	1.6	2.0	423	425	97.1	336.0	11.8	7.9
EMS 79-28	14	12	416.1	414.2	60.8	59.2	27.7	25.2	54.9	66.1	2.6	2.2	311	307	110.9	128.4	14.7	15.9
EMS 79-29	13	13	338.0	320.3	51.2	50.0	35.2	36.9	31.9	33.0	2.4	2.7	326	327	53.0	36.5	19.6	19.5
EMS 79-30	1	1	444.0	461.0	120.0	99.1	41.0	23.3	40.0	15.0	9.0	1.9	487	477	169.0	72.4	10.5	17.8
EMS 79-32	7	2	484.6	648.0	91.5	192.4	49.1	25.9	31.8	24.5	2.5	4.8	469	541	116.3	233.2	19.7	18.7
EMS 80-48	6	4	294.5	304.0	91.9	97.1	31.9	29.6	4.8	4.0	1.0	1.5	356	363	63.8	45.5	7.5	9.1
Paired t-test				**0.791**		**0.551**		**0.700**		**0.995**		**0.040**		**0.096**		**0.459**		**0.134**
Price River Formation																		
EMS 80-41	10	1	461.7	396.0	91.1	63.0	38.2	14.0	22.0	14.0	0.9	2.0	409	495	86.4	20.2	10.0	5.7
EMS 80-49	4	1	349.8	354.0	94.2	136.0	35.5	31.5	10.0	6.5	3.2	10.0	415	329	48.3	173.0	6.7	7.0
EMS 82-52	14	17	379.4	375.1	79.0	78.2	36.0	34.3	25.2	24.5	1.5	1.6	424	416	42.9	36.6	10.1	12.6
JERK WATER SPRING	5	5	371.6	372.8	95.6	96.2	28.1	28.3	17.8	23.9	1.1	1.6	429	428	27.1	52.2	8.2	8.3
Paired t-test				**0.403**		**0.830**		**0.280**		**0.647**		**0.270**		**0.953**		**0.661**		**0.815**
Starpoint Sandstone																		
TM-1	7	23	962.1	950.0	27.5	57.0	36.7	33.1	301.3	272.0	4.4	4.9	592	535	86.7	118.5	198.7	224.0
TM-1B	1	5	1120.0	1370.0	5.0	5.6	2.0	5.7	545.0	551.8	3.0	7.3	862	680	35.0	143.5	124.0	226.7
TM-2	1	6	468.0	366.8	24.0	40.7	45.0	26.8	72.2	57.1	6.1	5.9	326	310	112.6	67.1	16.5	12.2
Paired t-test				**0.708**		**0.203**		**0.448**		**0.354**		**0.395**		**0.229**		**0.551**		**0.325**

High = mean value for high flow period
Base = mean value for baseflow period

Table 3 Mean solute chemistry

table3.xls 23APR97

Formation	n sites	°C	pH	TDS mg/L	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	HCO_3^{-}	CO_3^{2-}	SO_4^{2-}	Cl^{-}	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	HCO_3^{-}	CO_3^{2-}	SO_4^{2-}	Cl^{-}	Na:Cl
					mg/L								meq/L								
Springs																					
Alluvium	5	8.1	7.47	419	78.9	46.8	14.5	2.8	401	0.7	73.1	11.9	3.94	3.85	0.63	0.07	6.58	0.02	1.52	0.33	1.89
Flagstaff	4	6.6	7.45	259	85.3	12.2	5.0	1.8	281	0.4	33.3	4.4	4.25	1.01	0.22	0.05	4.61	0.01	0.69	0.12	1.75
North Horn	69	7.9	7.71	345	80.1	29.7	19.8	2.1	357	1.0	58.3	12.4	3.99	2.44	0.86	0.05	5.85	0.03	1.21	0.35	2.46
low sulfate	44	7.9	7.71	316	65.4	29.2	17.2	1.5	348	1.3	19.3	12.6	3.26	2.40	0.75	0.04	5.70	0.04	0.40	0.36	2.10
high sulfate	25	7.9	7.71	397	105.9	30.5	24.4	3.2	373	0.5	127.0	12.0	5.28	2.51	1.06	0.08	6.11	0.02	2.64	0.34	3.14
Price River	13	8.4	7.70	425	87.6	34.6	22.7	1.6	408	1.2	60.0	10.9	4.37	2.84	0.99	0.04	6.68	0.04	1.25	0.31	3.21
Castlegate/Blackhawk	7	8.8	7.88	358	78.3	34.2	10.7	1.3	356	1.2	45.1	11.2	3.91	2.81	0.47	0.03	5.83	0.04	0.94	0.32	1.48
Blackhawk	2	7.2	7.75	548	89.5	52.3	35.7	5.2	436	0.0	175.5	12.5	4.47	4.30	1.55	0.13	7.15	0.00	3.65	0.35	4.40
In-mine																					
Blackhawk	45	12.2	7.34	636	125.4	52.3	33.5	4.6	414	1.1	235.9	14.3	6.26	4.30	1.46	0.12	6.79	0.04	4.91	0.40	3.61
non-burn-influenced	40	12.3	7.36	524	110.3	45.5	34.6	4.6	396	1.2	173.6	13.6	5.50	3.74	1.50	0.12	6.48	0.04	3.61	0.38	3.92
burn-influenced	5	11.2	7.2	1506	243.3	105.7	25.2	4.8	561	0.7	722.3	19.9	12.14	8.70	1.10	0.12	9.19	0.02	15.04	0.56	1.95
Oliphant Mine Discharge																					
Blackhawk/Star Point	1	9.9	8.21	419	60.8	42.6	21.8	3.8	286	3.7	118.6	9.1	3.03	3.50	0.95	0.10	4.68	0.12	2.47	0.26	3.68
Wells in Spring Canyon Member of Star Point Sandstone																					
Star Point	3	13.0	7.71	323	42.4	28.8	28.1	3.6	318	0.6	39.2	8.3	2.12	2.37	1.22	0.09	5.22	0.02	0.82	0.23	5.24
Wells that intercept the Mancos Shale																					
Star Point/Mancos	2	10.2	8.49	1141	27.8	19.5	414.8	5.7	629	35.7	118.3	213.8	1.39	1.61	18.04	0.15	10.31	1.19	2.46	6.03	2.99

Two types of groundwater issue from the North Horn Formation. The more predominant of the two waters is a Ca^{2+}-Mg^{2+}-HCO_3^- type water with low TDS (Table 3). The second is a Ca^{2+}-HCO_3^--SO_4^{2-} type water which has an elevated TDS as well as elevated Ca^{2+} and SO_4^{2-} concentrations (Table 3). The elevated solute concentrations are interpreted to result from the dissolution of gypsum (Eq. 5). This second group includes waters with SO_4^{2-} concentrations greater than about 50 mg L^{-1}. The distinction between low and high SO_4^{2-} water was determined from an ordered ranking of SO_4^{2-} concentrations (Figure 15).

The Ca^{2+}-HCO_3^--SO_4^{2-} waters issue from two sections of the North Horn Formation. As shown in Figure 16a, high SO_4^{2-} waters are found in springs that issue within 50 feet of the base of the North Horn and between 550 and 600 feet from the base of the formation. Sulfate concentrations do not correlate with discharge rates (Figures 16b and 16c). Although detailed stratigraphic information describing the North Horn Formation is not available, the solute data suggest that there are two gypsiferous sequences in the formation that represent evaporative depositional conditions. Low SO_4^{2-} waters discharge from springs located stratigraphically throughout the formation including from the two sections identified above.

What the distribution of high SO_4^{2-} spring waters means is that flow paths within the North Horn Formation are short and that there is little vertical communication of waters. If water were being communicated vertically, solute concentrations, especially Ca^{2+} and SO_4^{2}, would be more uniform in the formation.

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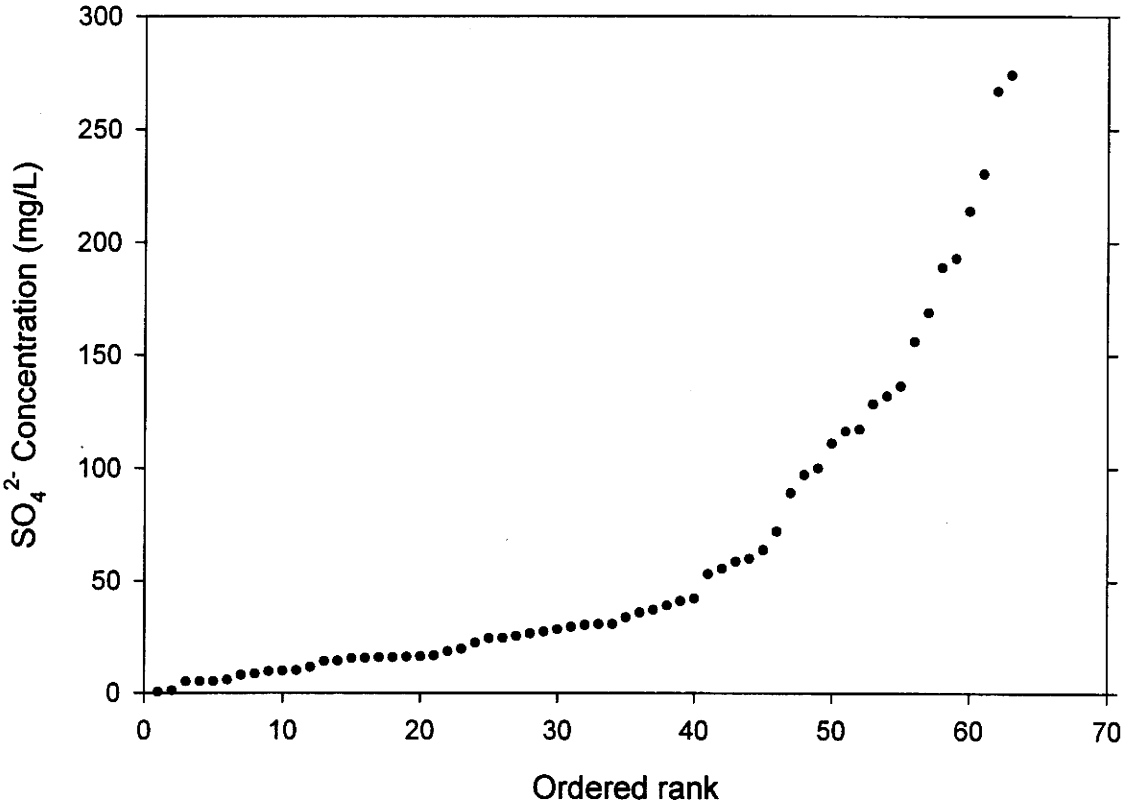

Figure 15 Ordered ranking of SO_4^{2-} concentrations of groundwaters from the North Horn Formation during highflow conditions.

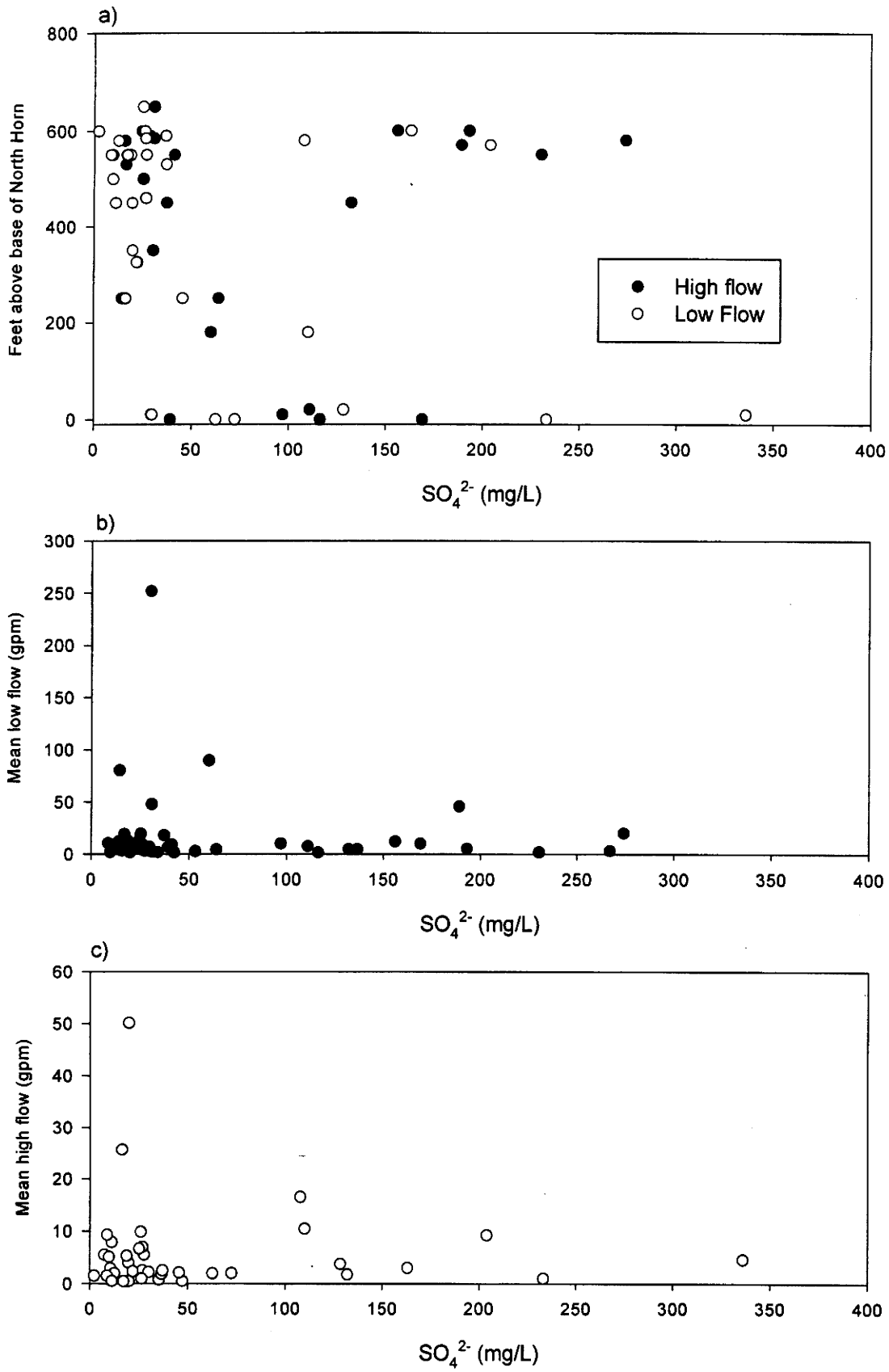

Figure 16 Scatter plots of SO_4^{2-} concentrations in the North Horn Formation vs. stratigraphic location and discharge rate for both low-flow and high-flow conditions.

In-mine roof drip waters and spring waters issuing from the Blackhawk Formation have elevated TDS contents relative to all other groundwater in the study area (Table 3). The elevated TDS is largely the result of elevated Ca^{2+}, Mg^{2+}, Na^{+}, and SO_4^{2-} concentrations (Table 3, Figure 12). These elevated concentrations are the result of a series of interrelated and cascading mineral dissolution and precipitation reactions. These reactions are discussed in detail by Mayo and others (in press). Sources of elevated SO_4^{2-} include the dissolution of evaporative gypsum (Eq. 5), associated with the swamp environments, and the oxidation of pyrite. Gypsum dissolution also elevates the concentration of Ca^{2+} which in turn results in the precipitation of calcite due to the common ion effect. Ca^{2+} and Mg^{2+} are also removed from groundwater by ion exchange on clays and in coal deposits on the Na^{+} zeolite analcime (Eqs. 7-10). The removal of Ca^{2+} and Mg^{2+} triggers the dissolution of additional calcite and dolomite (Eqs. 3 and 4).

Five in-mine samples collected from the Wilberg Mine have very elevated TDS (Table 3; Figure 14). These samples have a mean TDS of about 1,500 mg L^{-1}, which is about 1,000 mg L^{-1} greater than the mean of the other 40 in-mine samples. The samples were collected near an ancient coal burn that has greatly affected their solute compositions.

5.3 δ^2H and $\delta^{18}O$

The δ^2H and $\delta^{18}O$ composition of a water molecule falling as precipitation is determined by the temperature at which nucleation of the water droplet occurs. The stable isotopic compositions of waters are usually analyzed relative to the Meteoric Water Line (MWL). The MWL is empirically derived from the worldwide plotting locations of coastal zone

precipitation and is defined by the equation $\delta^2H = 8\ \delta^{18}O + 10$ (See Appendix B for further discussion of the MWL). Relative to the MWL, precipitation that forms under cooler conditions will plot more negative than precipitation which forms under warmer conditions.

In addition to the nucleation temperature of the water molecule, several other factors may affect the isotopic composition of recharge water. These factors include rainout and orographic effects and the sublimation of snow prior to the springtime snowmelt. Sublimation often causes the isotopic composition of snow to be considerably more negative than the compositions of waters in streams and issuing from springs.

Except for unusual conditions such as geothermal heating above abut 100°C, the δ^2H and $\delta^{18}O$ composition of a groundwater is set at the time of recharge and is not affected by subsurface conditions such as residence time and mineral dissolution and precipitation reactions. In other words, the recharge and flow history of a groundwater can be evaluated independently of the solute content of the water.

The δ^2H and $\delta^{18}O$ composition of both in-mine groundwaters and groundwaters from springs and wells in the lease area are listed in Table 4 and are plotted on Figure 17. All groundwaters in the study area plot near the meteoric water line (MWL) indicating a meteoric recharge origin (i.e. rain and snow; Figure 17). The groundwaters have stable isotopic compositions considerably more positive than snow samples (Table 4). We attribute the differences in the isotopic compositions of snow and groundwater samples to evaporation effects prior to groundwater recharge.

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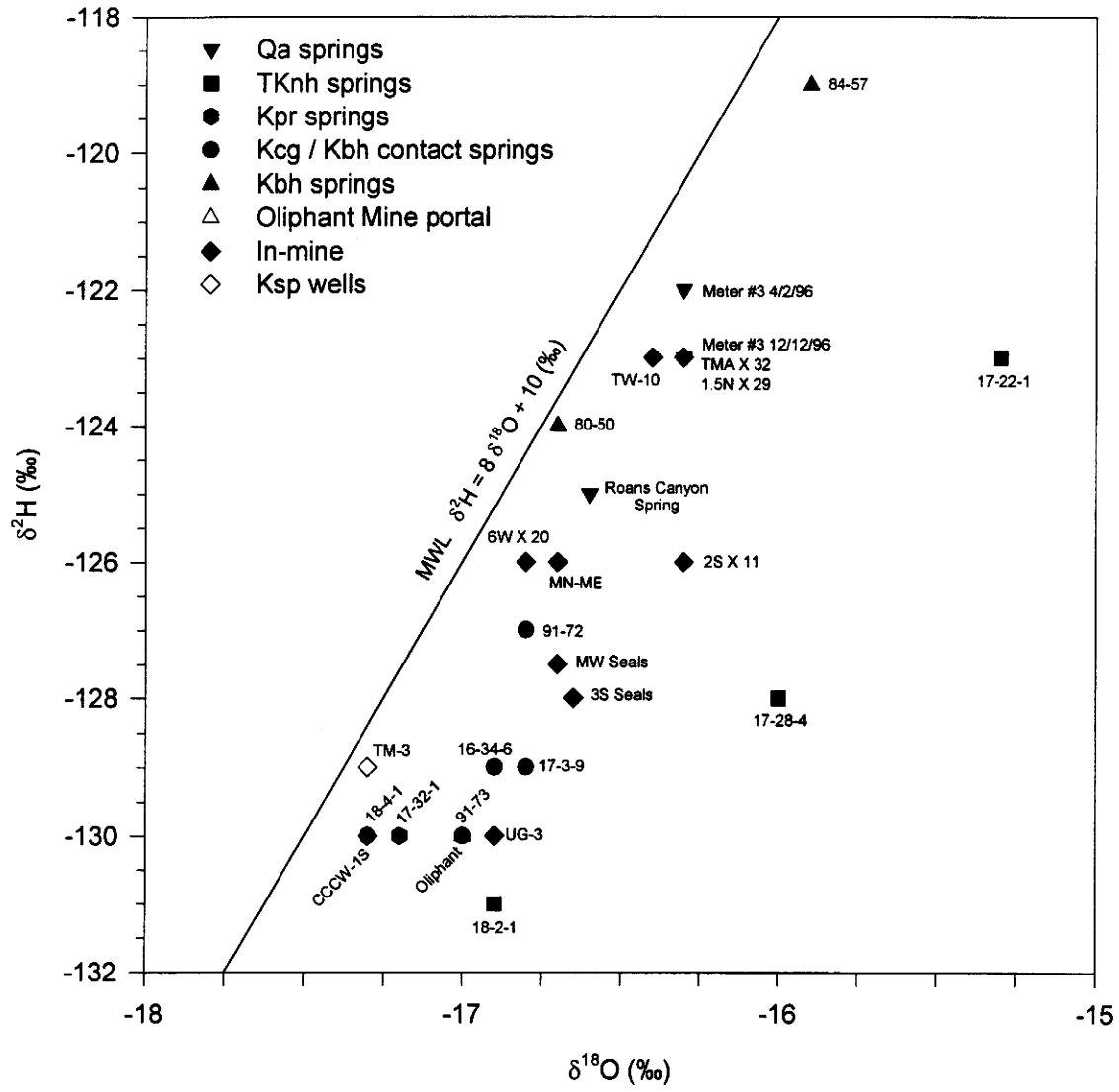

Figure 17 Scatter plot of δ^2H and $\delta^{18}O$ of groundwater samples plotted relative to the meteoric water line (MWL).

Table 4 Isotopic compositions of snow and groundwater

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	Date	$\delta^{2}H$ (‰)	$\delta^{18}O$ (‰)	$\delta^{13}C$ (‰)	$\delta^{34}S$ (‰)	^{14}C (pmc)	^{3}H (TU)
Snow							
DC Portal	2/17/96	-133	-17.7				
E. Joes Valley	2/17/96	-140	-18.5				
E. Mtn	3/21/96	-141	-19.2				8.79
Snow #2	3/21/96	-143	-19.4				7.50
CCC Trail	12/13/96	-140	-18.4				
Cottonwood Canyon	12/13/96	-140	-18.4				
Mean		**-141**	**-18.8**				**8.15**
Alluvial/Blackhawk							
Meter 3	4/2/96	-122	-16.3	-10.9	3.4	82.21	13.7
Meter 3	12/12/96	-123	-16.3	-10.9	8.7	77.66	13.5
Roans Canyon Spring	4/2/96	-125	-16.6	-10.4	-0.4	73.24	11.2
Mean		**-123**	**-16.4**	**-10.7**	**3.9**	**77.70**	**12.8**
North Horn Springs							
17-22-1	8/23/96	-123	-15.3	-10.5	3.0	78.89	18.1
17-28-4	8/23/96	-128	-16.0	-10.3	-2.7	82.93	13.3
18-2-1	8/23/96	-131	-16.9	-11.2	-20.1	76.12	12.2
Mean		**-127**	**-16.1**	**-10.7**	**-6.6**	**79.31**	**14.5**
Price River Springs							
17-32-1	12/13/96	-130	-17.2	-8.6	-13.6	61.55	2.20
Kbh/Kc Contact Springs							
17-3-9	8/23/96	-129	-16.8	-11.2	5.8	91.26	23.0
16-34-6	12/13/96	-129	-16.9	-11.2	16.2	79.12	12.7
91-72	12/14/96	-127	-16.8	-9.9	-4.9	75.47	14.9
91-73	12/15/96	-130	-17.0	-7.9	7.9	79.49	2.63
18-4-1	12/16/96	-130	-17.3	-9.9	0.0	52.65	0.00
Mean		**-129**	**-17.0**	**-10.0**	**5**	**75.60**	**10.6**
Blackhawk Springs							
80-50	12/12/96	-124	-16.7	-9.6	23.2	76.17	10.0
84-57	12/12/96	-119	-15.9	-8.6	1.9	70.55	11.7
Mean		**-122**	**-16.3**	**-9.1**	**13**	**73.36**	**10.9**
In-Mine Roof Drips							
TMA X 32 (Cottonwood)	3/28/96	-123	-16.3	-10.0	21.0	24.97	0.22
2S X 11 (Cottonwood)	3/28/96	-126	-16.3	-7.5	13.3	12.15	0.05
1.5N X 29 (Wilberg)	12/13/96	-123	-16.5	-10.6	6.9	31.97	0.33
UG-3 (Trail Mtn)	3/28/96	-130	-16.9	-14.0	19.0	30.95	0.13
6W X 20 (Deer Creek)	5/2/96	-126	-16.8	-10.3	9.3	42.23	0.14
MN-ME (Deer Creek)	3/29/96	-126	-16.7	-8.1	5.1	22.54	0.10
TW-10 (Deer Creek)	3/29/96	-123	-16.4	-10.5	2.2	62.39	20.8
Mean (w/o TW-10)		**-126**	**-16.6**	**-10.1**	**12.4**	**27.47**	**0.16**
In-Mine Longwall Gob Areas							
MW Seals (Cottonwood)	2/26/97	-128	-16.7	-9.7	11.5	21.99	1.34
3S Seals (Deer Creek)	2/23/97	-128	-16.7	-7.7	13.9	14.40	0.88
Oliphant Mine Discharge							
T-18	12/13/96	-130	-17.0	-15.3	9.8	21.70	0.20
Starpoint Wells							
CCCW-1S	12/9/96	-130	-17.3	-10.3	13.2	46.17	1.10
TM-3	12/11/96	-129	-17.3	-10.3	27.7	24.36	0.00
Mean		**-130**	**-17.3**	**-10.3**	**20.45**	**35.27**	**0.55**

In many groundwater investigations of coal mining areas in the Wasatch Plateau and the Book Cliffs we have found that in-mine groundwaters have isotopic compositions which are distinct from spring and stream waters and which have more negative plotting locations. Although considerable scatter occurs in the δ^2H and $\delta^{18}O$ data from the study area and the data do not fit such a pattern, some preliminary conclusions may be made.

Groundwaters from wells, springs and in-mine samples collected from Trail Mountain tend to have more negative isotopic compositions than do similar samples collected from East Mountain (Figure 17). Such differences may be the result orographic effects associated with the morphology of the lease area and its positioning along the eastern edge of the Wasatch Plateau. Additional sampling needs to be performed to verify this conclusion.

5.4 Groundwater ages (^3H and ^{14}C)

The concept of groundwater age is difficult to define because water arriving at a well or spring seldom travels via pure piston flow. Instead it is usually a mixture of water molecules that recharged at different locations and at different times, thus water has no unique age. It is, therefore, best to think of a groundwater 'age' as the *mean residence time* of the water molecules sampled at the well or spring.

In this investigation, two unstable isotopes, tritium (^3H) and carbon-14 (^{14}C), have been used to evaluate mean residence times. Tritium is a qualitative tool indicating if groundwater has a component of water that recharged since about 1954. Groundwater that recharged prior to about 1954 will contain essentially no tritium. Carbon-14 provides information regarding the

number of years that have elapsed since the groundwater became isolated from soil zone gases and near-surface waters. Like tritium, ^{14}C can indicate if groundwater has a component that recharged since the 1950s. Groundwaters with ^{14}C contents greater than about 50 pmc contain anthropogenic (human-induced) carbon associated with atmospheric nuclear weapons testing. It is not uncommon for groundwater issuing from a spring or occurring in a well to be a mixture of old (i.e. containing no ^{3}H) and younger groundwaters.

Groundwater ages have been calculated for 13 springs, 9 in-mine locations, 2 Star Point Sandstone wells, and the Oliphant Mine discharge (Table 5). All springs waters, except for spring 18-4-1, contain anthropogenic carbon and appreciable amounts of ^{3}H and are, therefore, modern. These springs issue from alluvial systems, the North Horn Formation, the Price River Formation, the Castlegate Sandstone, and Blackhawk Formation.

Spring 18-4-1 issues from the Blackhawk Formation-Castlegate Sandstone contact at the down plunge end of the Straight Canyon Syncline (Figure 13). The spring water does not contain water which recharged since 1954; however, the water was likely recharged less than a few hundred years ago as is indicated by its ^{14}C content.

Most groundwaters collected inside the Cottonwood/Wilberg Mine contain essentially no tritium (Table 5) and have mean ^{14}C ages ranging from 2,000 to 12,000 years. Roof drip waters associated with faults (i.e., 1.5N X 29, 6W X 20, and MN-ME) contain waters 2,000 to 7,000 years old and are not in hydraulic communication with the surface (Table 5).

Table 5 Mean groundwater residence times based on ^{14}C and ^{3}H contents

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	Sample Date	^{14}C (pmc)	^{3}H (TU)	Mean residence time (years)
Alluvial/Blackhawk				
Meter 3	4/2/96	82.21	13.7	Modern
Meter 3	12/12/96	77.66	13.5	Modern
Roans Canyon Spring	4/2/96	73.24	11.2	Modern
North Horn Springs				
17-22-1	8/23/96	78.89	18.1	Modern
17-28-4	8/23/96	82.93	13.3	Modern
18-2-1	8/23/96	76.12	12.2	Modern
Price River Springs				
17-32-1	12/13/96	61.55	2.20	Modern
Kbh/Kc Contact Springs				
17-3-9	8/23/96	91.26	23.0	Modern
16-34-6	12/13/96	79.12	12.7	Modern
91-72	12/14/96	75.47	14.9	Modern
91-73	12/15/96	79.49	2.63	Modern
18-4-1	12/16/96	52.65	0.00	>50
Blackhawk Springs				
80-50	12/12/96	76.17	10.0	Modern
84-57	12/12/96	70.55	11.7	Modern
In-Mine Roof Drips				
TMA X 32 (Cottonwood)	3/28/96	24.97	0.22	6,500
2S X 11 (Cottonwood)	3/28/96	12.15	0.05	12,000
1.5N X 29 (Wilberg)	12/13/96	31.97	0.33	4,500
UG-3 (Trail Mtn)	3/28/96	30.95	0.13	5,500
6W X 20 (Deer Creek)	5/2/96	42.23	0.14	2,000
MN-ME (Deer Creek)	3/29/96	22.54	0.10	7,000
TW-10 (Deer Creek)	3/29/96	62.39	20.8	Modern
In-Mine Longwall Gob Areas				
MW Seals (Cottonwood)	2/26/97	21.99	1.34	8,000
3S Seals (Deer Creek)	2/26/97	14.4	0.88	12,000
Oliphant Mine Discharge				
T-18	12/13/96	21.70	0.20	7,000
Starpoint Wells				
CCCW-1S	12/9/96	46.17	1.10	1,000, mixed
TM-3	12/11/96	24.36	0.00	6,000

A water sample from drill hole TW-10, which intercepts groundwater in the Roans Canon Fault in the Deer Creek mine, contains anthropogenic carbon, appreciable amounts of ^{3}H, and was thus recharged less than 50 years ago. The drill hole intercepted the fault in late 1988 and the initial discharge rate was about 80 gpm. Within about two years the drip rate stabilized at about 4 to 6 gpm. ^{3}H and ^{14}C data indicate that, unlike other mine roof drips and fault waters, the discharge at TW-10 is in hydraulic communication with the surface. However, discharge from TW-10 does not exhibit seasonal fluctuations indicating that the hydrodynamics of this system are buffered. This buffering may be due to a tortuous flow path, which means a longer travel time, or the mixing of modern recharge water with older water. It is possible that the initial water intercepted by the drill hole was of similar old age as other waters encountered in the mine. Prior to intercepting the fault, the fault may have been full and rejected recharge may have occurred. The small, stabilized drip rate, 3-4 gpm, suggests that the impact to near-surface waters is limited. Groundwater associated with the Roans Canyon Fault, which is intercepted by TW-10, is further discussed in Section 6.3.2.2.

Isotopic samples were also collected from gob areas in the Cottonwood and Deer Creek Mines (Figures 10 and 11; Table 4). The gob waters have mean ^{14}C residence times of 8,000 to 12,000 years (Table 5), and they contain approximately 1 TU of ^{3}H. These gob areas received most of their water from fault drainage and a small fraction of their water from process water return flows. The process water was pumped from nearby creeks and is likely responsible for the small ^{3}H contents.

A groundwater sample collected from the Oliphant Mine portal (T-18; Figure 9) has a mean ^{14}C residence time of 7,000 years. The Oliphant Mine is sealed and it is unknown if the discharge water issues from the mine roof or mine floor.

Two wells completed in the Star Point Sandstone, CCCW-1S and TM-3, have mean groundwater residence times of 1,000 and 6,000 years, respectively. These two wells are both completed in the Spring Canyon tongue and appear to be located on approximately the same flow line. CCCW-1S is up gradient and TM-3 is down gradient. Assuming that the two wells intercept groundwater along the same flow line, travel times can be calculated using the method described by Mooke (1980):

$$\Delta T = 8270 \ln (a_{k+1}{}^{14}/a_k{}^{14}) \quad (11)$$

$$\Delta T = 5{,}300 \text{ years}$$

where:

ΔT = travel time (in years)

$a_{k+1}{}^{14}$ = ^{14}C activity of up-gradient sample

$a_k{}^{14}$ = ^{14}C activity of down-gradient sample

Assuming the travel time of 5,300 years and a distance of 4 miles, the calculated flow velocity is approximately 0.25 feet per year.

6. GROUNDWATER

6.1 Groundwater occurrence

Groundwater naturally discharges, in greatly varying quantities, from most formations exposed in Trail and East Mountains. Approximately 75% of the identified springs issue from the North Horn Formation, which comprises nearly the entire plateau surface of East and Trail Mountains. No springs have been identified which discharge from the Star Point Sandstone or the Mancos Shale.

Within the mines, groundwater issues from short-lived roof drips, the mine floors in some locations in the Trail Mountain, Deer Creek, Cottonwood, and Wilberg mines, and from the mine roof and mine floor after encountering some faults. Confined groundwater occurs in monitoring wells in the Star Point Sandstone that have been installed in the mines and elsewhere. Groundwater discharge is generally not associated with the Mancos Shale.

6.2 Spring discharge characteristics

More than 100 spring hydrographs were analyzed as part of this investigation. Approximately 75% of the springs discharge from the North Horn Formation. The remainder discharge from creek bottom alluvial systems, the Flagstaff Limestone, the Price River Formation, the Castlegate Sandstone, and the Blackhawk Formation. No springs have been identified which discharge from the Star Point Sandstone or Mancos Shale within the lease area. Because of the great number of springs for which discharge data are available, hydrographs for only selected representative springs are presented and discussed here. The maximum flow rates for

some springs are probably greater than those reported due to the inaccessibly of many springs until mid-July, after the peak of the snowmelt.

6.2.1 Alluvial Springs

6.2.1.1 Rilda Canyon

The North Emery Water Users Association (NEWUA) Rilda Canyon collection system captures groundwater in a series of french drains (Figure 9) in the shallow alluvium in Rilda Canyon (Meters 1-4). Flow meters were first installed in the piping system in September 1990 and monthly monitoring of these meters has occurred since that time. Meter 2 contains flow from the combined discharge from Side Canyon and from the vicinity of South Spring. Meter 3 measures flow from the central portion of the collection system near Rilda Canyon Creek. Previous to 1995, Meter 4 recorded flow from the north side of Rilda Canyon Creek. In 1995, flow from Meter 4 was combined with flow from Meter 3, and monitoring of Meter 4 was discontinued.

It is apparent from the NEWUA meter discharge hydrographs (Figure 18) that flow in this alluvial groundwater system is highly dependent upon seasonal recharge. Springtime maximum flows as great as about 180 gpm have been recorded at Meter 4 while the base flow discharge at Meter 4 has been a low as 1.5 gpm. The decline in discharge from Meter 2, which has the lowest flows of the NEWUA meters (<20 gpm) from 1990 to 1991 is believed to be the result of maintenance problems with the piping system (Personal communication, Chuck Semborski, 1997).

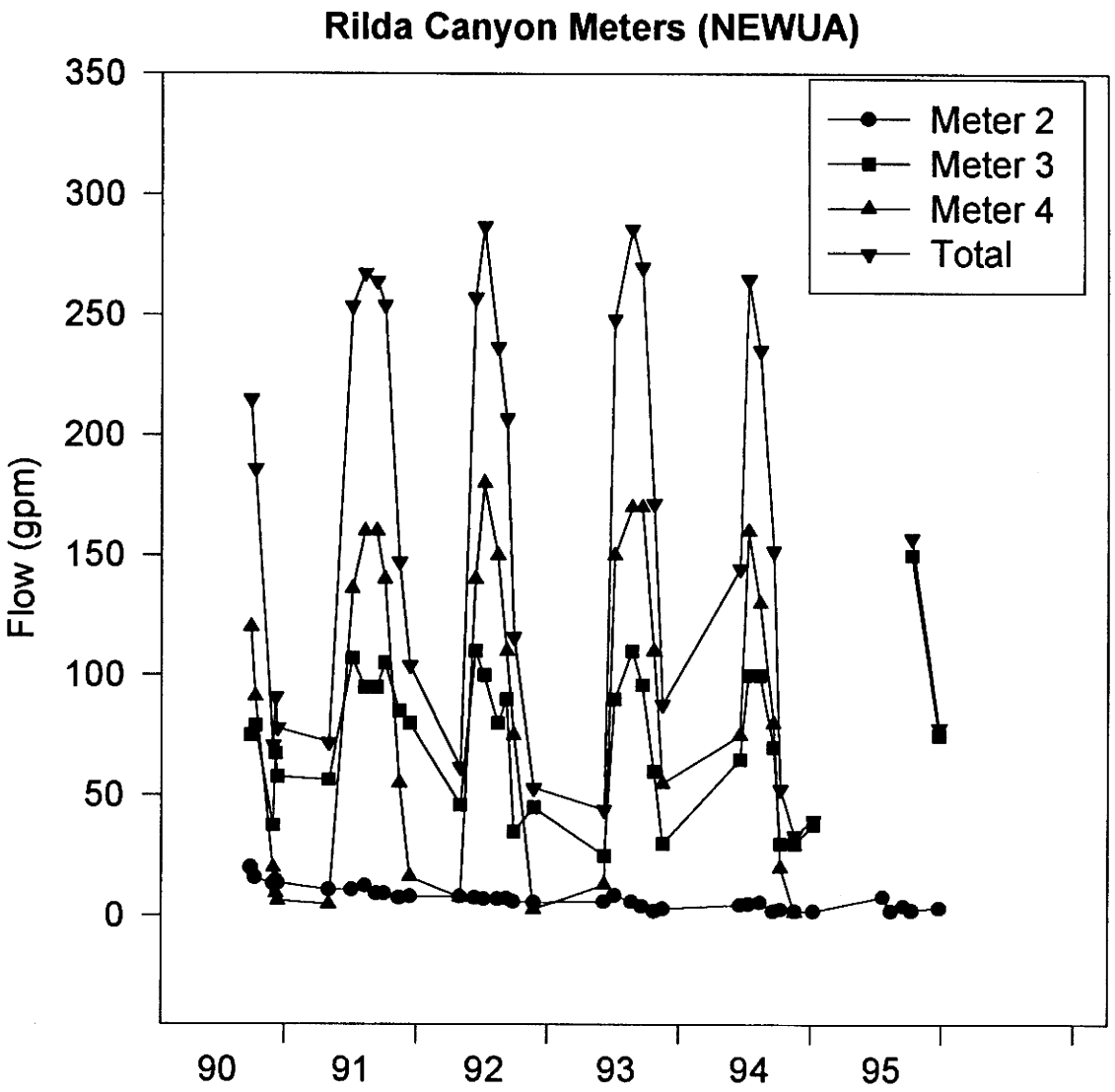

Figure 18 Hydrographs of Rilda Canyon NEWUA meters.

PacifiCorp performed a pump-test during November 1990 in the vicinity of the Rilda Canyon collection system. The results of this testing suggested that at least 90% of the flow to the system could be accounted for by drainage directly from the shallow alluvial sediments (non-bedrock derived). The remaining <10% was believed to be derived from bedrock discharge. However, it was later learned that the thickness of saturated alluvium upgradient from the wells was thicker than that assumed at the time of the testing (Personal communication, Chuck Semborski, 1997). If the greater thickness of saturated alluvium is used in the pump-test equations, a value greater than 90% is calculated for the percentage of flow attributable to alluvial discharge.

Because discharge data for individual meters in the Rilda Canyon collection system are only available since the end of 1990, the effects of long-term climatic fluctuations cannot be determined.

6.2.1.2 Cottonwood Canyon Alluvium

In an attempt to determine the nature of the alluvial groundwater system in Cottonwood Canyon, PacifiCorp carried out a detailed hydrogeologic investigation in 1994. The investigation included construction of monitoring wells, geophysical surveys, and detailed geologic mapping. The results of the geologic mapping, drilling, and resistivity studies indicated that the maximum alluvial thickness in the canyon bottom ranges from 40 to 70 feet. The alluvial sediments consist primarily of lateral and terminal glacial moraine deposits. Below the northwest corner of section 24, the alluvial deposits are fluvial in origin. Nested monitoring wells were installed in the alluvium in Cottonwood Canyon and in the underlying

Spring Canyon member of the Star Point Sandstone. The hydrographs for these wells (discussed in Section 6.4) indicate that the alluvial deposits, which respond to seasonal variations in precipitation, are hydraulically isolated from groundwaters in the underlying Spring Canyon sandstone. The springs discharging near the base of Cottonwood Canyon (e.g. Roans Canyon Spring, Cottonwood Spring) are fed by shallow alluvial systems and are not related to bedrock groundwater systems in the Star Point Sandstone. In 1996, as a part of this investigation, stable and unstable isotopic data were collected from the alluvial groundwater system in Cottonwood Canyon at Roans Spring. The ^{14}C and ^{3}H compositions of this water (Table 5) indicate that it is of modern origin and is not related to the deep groundwater systems encountered within the mines. The interception of groundwaters within the mine workings, therefore, does not adversely impact groundwater flow rates in the alluvial springs in Cottonwood Canyon.

6.2.2 Flagstaff Limestone Springs

Although the Flagstaff Limestone occurs in the highest elevations of the plateau where precipitation is the greatest, only 5 springs have been identified which discharge from the limestone in the mine lease area. Spring discharges respond to both seasonal recharge and climatic factors. Hydrograph recession characteristics indicate that these springs are dependent on annual recharge events. For example, Spring 79-35 had a maximum discharge of about 20 gpm in 1979, but has gone completely dry at least three times since then (Figure 19a). Both climatic and seasonal effects are also illustrated in the Sheba Spring hydrograph (Figure 19b).

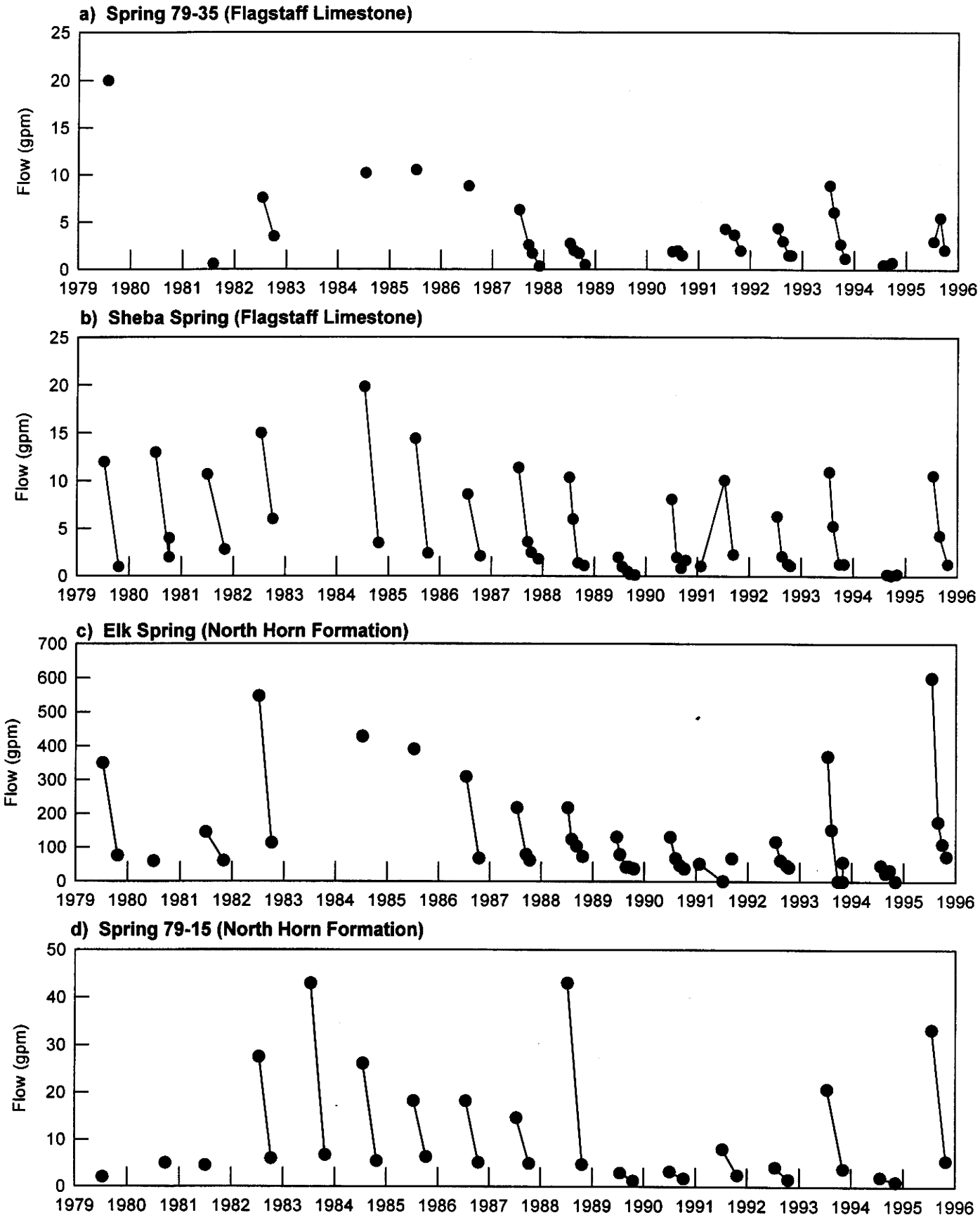

Figure 19 Selected discharge hydrographs for springs issuing from the Flagstaff Limestone, North Horn Formation, Price River Formation, and the Castlegate Sandstone/Blackhawk Formation contact.

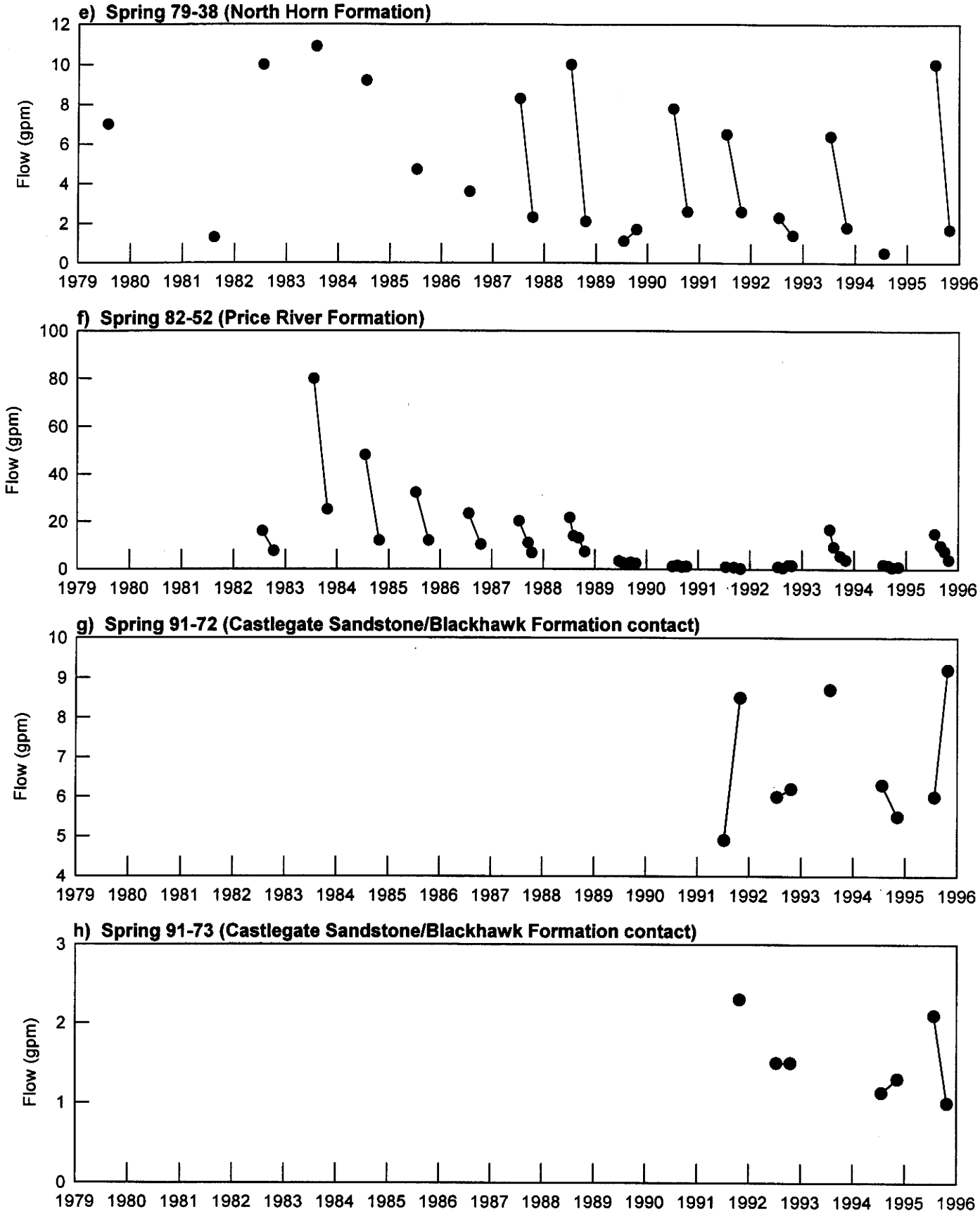

Figure 19 Continued.

The limited number of springs reflects the character of the rock. In the lease area the limestone is relatively thin (<100 feet) and groundwater can only flow in the few fractures which are interconnected. Springs occur where the width of the limestone outcrops is greatest.

6.2.3 North Horn Formation Springs

Seventy-two springs have been identified as discharging from the North Horn Formation. Springs respond to annual recharge from snowmelt events and exhibit a wide range of discharge rates (Figures 19c and 19d). It is not uncommon for these springs to discharge more than 20 gpm during the springtime and to discharge less than 5 gpm during the late fall. The discharge from Elk Spring (Figure 19c) increased from 24 gpm in November 1994 to 600 gpm the following July 1995.

Discharge from most North Horn Formation springs is also dependent on long-term climatic trends. Substantial declines in peak flow discharges are observed in most hydrographs in the late 1980s and spikes in peak flow discharge occurred in the springtime 1994 and 1996 (Figure 19c).

6.2.4 Price River Formation Springs

Thirteen springs have been identified as discharging from the Price River Formation. Although considerably fewer in number than North Horn Formation springs, these springs have similar discharge characteristics as do North Horn Formation springs. Long-term discharge data are only available for one Price River Formation spring. Seasonal variability is

apparent in the hydrograph for Spring 82-52 (Figure 19f) and by comparing maximum and minimum measured discharges of several other springs:

Spring	n	years of record	Maximum (gpm)	Minimum (gpm)	Variability factor
Spring 79-24	5	1979-1988	60	0.7	86
Spring 79-40	11	1979-1995	15	0.1	150
Spring 80-41	12	1980-1995	14	0.4	35
Spring 80-44	10	1980-1993	40	0.5	80
Spring 80-45	5	1980-1985	12	0.5	24
Spring 80-49	5	1981-1994	43	12.0	4
Spring 82-51	7	1980-1995	15	3.0	5
Spring 82-52	46	1982-1995	80	0.2	400
Spring 89-60	6	1989-1995	3	1.0	3
Jerk Water Spring	10	1982-1986	3	2.0	2

where n is the number of measurements, and the variability factor is the maximum measured discharge divided by the minimum measured discharge. Springs with a high variability factor generally are more responsive to seasonal recharge than are springs with a lower variability factor.

Although Spring 17-32-1 (Sportsmans Lodge spring) has a modern ^{14}C age (Table 5) the relatively low ^{3}H content (2.2 TU) suggests a longer flow path than groundwaters in the North Horn Formation.

6.2.5 Blackhawk Formation-Castlegate Sandstone Contact Springs

Seven springs have been identified which discharge from near the Castlegate Sandstone-Blackhawk Formation contact. Limited discharge data are available for two of these (Springs

91-72 and 91-73). Hydrographs for these springs are shown on Figures 19g and 19h. Maximum and minimum measured discharges are listed below:

Spring	n	years record	Maximum (gpm)	Minimum (gpm)	Variability factor
91-72	10	1991-1996	9.2	4.9	1.9
91-73	8	1991-1996	2.3	1.0	2.3

Although the data are limited, the data suggest that the discharges from these springs are somewhat seasonally dependent. Sufficient discharge data is not available to determine the response of these springs to long-term climatic trends.

6.2.6 Blackhawk Formation springs

Only 2 springs (Spring 80-50 and 84-57) have been identified which discharge from the Blackhawk Formation. Only four flow measurements are available from two springs and seasonal discharge data are not available. The discharges measured from these springs are low, averaging only 1.6 gpm.

6.3 In-mine groundwater

PacifiCorp has monitored significant groundwater inflows into each of its mines since 1979. Groundwater encountered within mine openings occurs by three main mechanisms. These mechanisms include: 1) drainage from overlying sandstone channels which are penetrated by roof-bolts and by vertical boring, or which are exposed during mining, 2) interception of water bearing faults and major fracture systems which transmit water from either overlying or

underlying horizons, and 3) upward leakage from the underlying Spring Canyon Member of the Star Point Sandstone.

6.3.1 Sandstone channel groundwater

Numerous sandstone channels directly overlie coal-bearing horizons (Figures 20 and 21). These channels may be several miles long, up to 1000 feet wide and are commonly 25 to 30 feet thick. These channels have varying degrees of water saturation, which results in wet and dry regions of the mine.

It is common in "wet" portions of the mines for roof-drip groundwater to be encountered at the mining-face during mining operations. Most roof-drips typically are short lived, persisting for only a few weeks before the flow completely ceases. Thus, the roof-drips appear to "dry up" behind the mining operations. The discharges from these short-lived inflows into the mine are typically not recorded. In other portions of the mines, the coal seam and adjacent rocks are completely dry.

Occasionally, areas with greater, more persistent inflows are encountered. These sources are usually associated with faults or large sandstone channels that contain greater quantities of water. Such fault-channel systems are discussed in Section 6.3.2.2 below.

Typical hydrographs of roof drips that have not dried up immediately are shown on Figure 22. Carbon-14 ages of 6,500 and 12,000 years (Table 5) have been determined for groundwaters issuing from locations TMA X 32 and 2S X 11, respectively. The discharge

LONG TERM WATER SOURCES

LOCATION NUMBER	LOCATION DESCRIPTION	TYPE
1	MAIN NORTH - MAIN EAST	EXPLORATION BORE HOLE
2	3RD NORTH X-CUT 68 2R (TW-6 DRILL HOLE)	HORIZONTAL DRILL HOLE INTO GRABEN AREA

PIEZOMETRIC DRILL HOLES

LOCATION NUMBER	LOCATION DESCRIPTION	STATUS
DCP-1	3RD NORTH X-CUT 8	ACTIVE
DCP-2	3RD NORTH X-CUT 29	CRUSHED
DCP-3	3RD NORTH X-CUT 55	CRUSHED
DCP-4	FIRST WEST MAINS X-CUT 29	SEALED

MINE WORKINGS UPDATED TO: AUGUST 1, 1997

WATER SOURCES LEGEND

- 2 — LOCATION NUMBER
- 1 — WATER SOURCE TYPE (SEE FIGURE 8, 1982 HYDROLOGIC MONITORING REPORT)
- LONG TERM MONITORING LOCATION
- PAST MONITORING LOCATION (NOW DRY)
- 79 — LAST YEAR OF MEASURABLE FLOW
- * — PIEZOMETRIC DRILL HOLE STUDY LOCATION '86 LAST YEAR OF MEASUREMENT WATER SOURCE TYPE (SEE FIGURE 8 - 1982 HYDROLOGIC MONITORING REPORT)
- 1 — SANDSTONE CHANNEL
- 2 — FAULT
- 3 — JOINTS AND FRACTURES
- 4A — ROOF BOLT HOLE
- 4B — EXPLORATION BORE HOLE

LEGEND

- PACIFICORP EAST MOUNTAIN PROPERTY BOUNDARY
- FEDERAL LEASE BOUNDARY
- U-044025 — LEASE NUMBERS
- FAULT (DASHED WHERE INFERRED)
- SANDSTONE CHANNELS
- EM-35 ⊕ — DRILL HOLES
- SECTION LINES
- 23 — SECTION NUMBERS
- CURRENT FLOW
- IN-MINE DRILL HOLE

U-024317 · U-06039 · U-7653 · U-084923 · U-084924 · U-083066 · U-1358 · U-02664 · U-044025 · U-47978 · U-47979 · SL-051221 · U-2810 · U-014275 · SL-050862 · SL-070645 · U-02292 · SL-064607 · 064621 · SULA #284 · SL-066116 · SL-064900 · FEE · R.6 E. · R.7 E.

EAST MOUNTAIN PROPERTY
BLIND CANYON COAL SEAM
IN-MINE WATER MONITORING LOCATIONS

FIGURE 20

ENERGY WEST MINING COMPANY
HUNTINGTON, UTAH 84528

DRAWN BY: K. LARSEN
SCALE: NTS
DRAWING #
DATE: DECEMBER 30, 1996
SHEET 1 OF 1
REV.
CAD FILE NAME/DSK#: HM-2

STATE
ML-22509

U-7653

U-024319

U-47979

SL-064607
064621

U-084923

U-084924

U-47979

SULA
#284

LEFT FORK FAULT GRABEN

ROAN'S CANYON FAULT GRABEN

STRAIGHT CANYON SYNCLINE

DETAILED INFORMATION NOT AVAILABLE IN THIS AREA

SL-070645
U-02292

FEE

SL-066116

U-02664

U-083066

U-04015

U-1358

U-044025

U-47978

DETAILED INFORMATION NOT AVAILABLE IN THIS AREA

R. 6 E.
R. 7 E.

OLD JOHNSON MINE

T. 17 S.
T. 18 S.

N

LONG TERM WATER SOURCES

LOCATION NUMBER	LOCATION DESCRIPTION	TYPE
1	2ND SOUTH X-CUT 11 IR, + 9-12s	IN-MINE DRILL HOLE
2	TRAIL MOUNTAIN ACCESS X-CUT 32	SANDSTONE CHANNEL

PIEZOMETRIC DRILL HOLES

LOCATION NUMBER	LOCATION DESCRIPTION	STATUS
WCP-1	6TH WEST X-CUT 16 IR	SEALED
WCP-2	3RD SOUTH X-CUT 14 IR	SEALED
WCP-3	3RD SOUTH X-CUT 44 IR	SEALED
WCP-4	4TH EAST X-CUT 19 IR	SEALED

WATER SOURCES LEGEND

- 2 — LOCATION NUMBER
- 1 — WATER SOURCE TYPE (SEE FIGURE 8, 1982 HYDROLOGIC MONITORING REPORT)
- LONG TERM MONITORING LOCATION
- PAST MONITORING LOCATION (NOW DRY)
- 79 — LAST YEAR OF MEASURABLE FLOW
- 1 — SANDSTONE CHANNEL
- 2 — FAULT
- 3 — JOINTS AND FRACTURES
- 4A — ROOF BOLT HOLE
- 4B — EXPLORATION BORE HOLE

MINE WORKINGS UPDATED TO: DECEMBER 1, 1996

LEGEND

- PACIFICORP EAST MOUNTAIN PROPERTY BOUNDARY
- FEDERAL LEASE BOUNDARY
- U-044025 — LEASE NUMBERS
- FAULT (DASHED WHERE INFERRED)
- SANDSTONE CHANNELS
- EM-35 ● — DRILL HOLES
- SECTION LINES
- 23 — SECTION NUMBERS
- DIRECTION OF CURRENT
- IN-MINE DRILL HOLES

ENERGY WEST
MINING COMPANY
HUNTINGTON, UTAH 84528

COAL MINE CODE NO. 042

EAST MOUNTAIN PROPERTY
HIAWATHA COAL SEAM
IN-MINE WATER MONITORING LOCATIONS

FIGURE 21

SCALE: 1"=1000'
DRAWN BY: K. LARSEN
DRAWING #:
DATE REVISED ON 1996

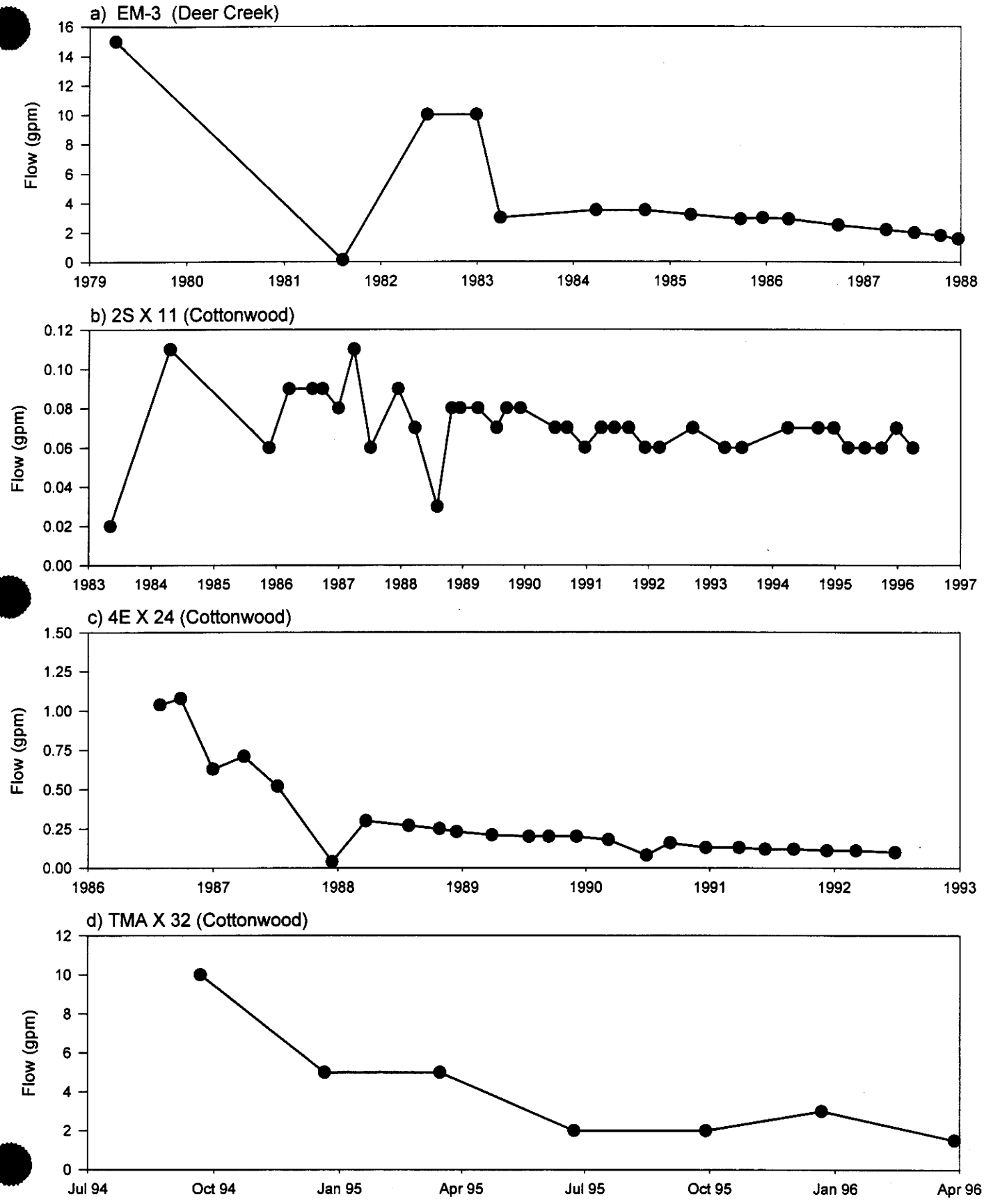

Figure 22 Hydrographs of selected roof drips.

declines of the hydrographs typically follow an exponential decay, with the greatest flow occurring immediately after the source is completely exposed and then falling off rapidly. The tail end of the discharge hydrograph typically trails off gradually, with slowly decreasing rates of discharge. Near the end of the discharge recession, the discharge hydrograph may appear nearly flat. Occasionally, a hydrograph may show a marked increase in discharge after the initial peak has passed. This is usually due to a change in the geometry of the system due to mining activities in the vicinity of the discharge.

In an attempt to quantitatively evaluate saturated sandstone channels, a dripping channel in the 6th West area of the Deer Creek Mine was investigated (site 6W X 20; Figure 10). The channel, located near a minor fault with very limited displacement, has the dimensions of >2,000 feet in length, 150 feet in width and a maximum thickness of 25 feet. An array of up-hole monitoring wells was installed across the width of the channel. The wells were 15 to 25 feet deep and were open along their entire depth. Each well was equipped with a shutoff valve and pressure gauge. The idea was to conduct a pump test by letting selected wells gravity drain and simultaneously measuring pressure change in nearby wells. Because a maximum of about 2 psi was recorded in the well (i.e. $\approx$ 5 feet of water) we were unable to conduct the test. What the well did demonstrate was that the sandstone channel was not fully saturated and it was a perched, unconfined groundwater system. Water issuing from the channel has a mean ^{14}C age of 2,000 years (Table 5). The perched, unconfined groundwater system evaluated in the 6th West area is consistent with the commonly observed roof drip conditions.

6.3.2 Fault water

Groundwater has been encountered in 3 faults in the PacifiCorp mines. These include the Pleasant Valley Fault in the both the Deer Creek Mine and Cottonwood/Wilberg Mine, the Roans Canyon Fault, and the Left Fork Graben in the Deer Creek Mine. The groundwater flow regimes associated with each of these faults are described below.

6.3.2.1 Pleasant Valley Fault

The Pleasant Valley Fault is a north-south trending fault, which is exposed in both the Wilberg and Deer Creek Mines (Figure 5). The fault was first encountered in the early 1970s by Peabody Coal Co. during the construction of rock slopes and has been encountered in at least 4 different locations in the Wilberg Mine. When the fault was first crossed during mining, groundwater discharge primarily occurred as floor upwelling in the Wilberg mine and as roof drips in the Deer Creek Mine. The discharge rate was small and never exceeded 50 gpm in any location. PacifiCorp's initial monitoring location in the Wilberg Mine discharged 50 gpm. Within 2 or 3 months, the flow from the fault had diminished greatly and the sampling point became only a puddle on the floor (Semborski, Personal Communication, 1997). Groundwater discharge rates from other locations on the Pleasant Valley Fault are also small but are more constant. Groundwater discharging from Pleasant Valley Fault sampled as part of this investigation is of ancient origin.

Three samples of fault-related groundwater were collected as part of this investigation for radiocarbon dating (6W X 20 and MN-ME in the Deer Creek Mine, and 1.5N X 29 Fault in the Wilberg Mine; Table 5). The recession hydrograph for MN-ME (Figure 23) shows that

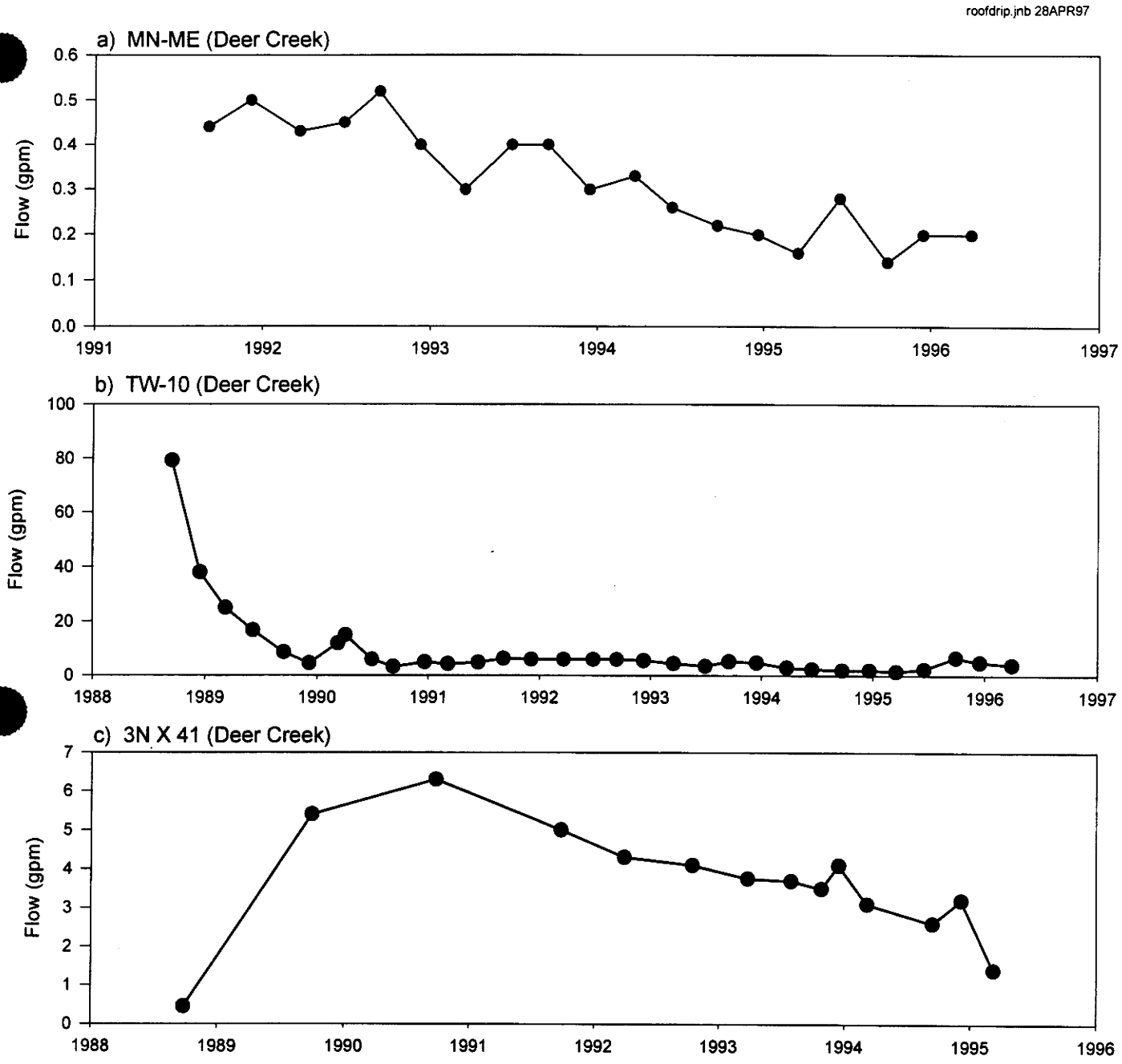

Figure 23 Hydrographs of selected in-mine roof drips associated with faults

discharge has steadily declined from about 0.5 to 0.2 gpm over 4 years. Groundwater issuing from 6W X 20, MN-ME and 1.5N X 29 have ^{14}C ages of 2,000, 7,000 and 4,500 years, respectively (Table 5).

6.3.2.2 Roans Canyon Fault

The Roans Canyon fault system forms a graben which trends in a northeasterly direction through the middle of Trail Mountain and northern East Mountain (Figure 5). The fault is parallel with and adjacent to the axis of the Straight Canyon Syncline. The Roans Canyon Fault was first encountered in the Deer Creek Mine in a series of horizontal drill holes completed in 1985. A second series of horizontal drill holes penetrated the fault system in 1989. The purpose of these drill holes was to evaluate the porosity of the fault system and to evaluate the potential for dewatering of the fault ahead of mining operations. Limited lateral communication along the fault system was suggested by the fact that discharge from drill holes located only 200 feet apart did not significantly affect the discharge rates of the individual holes.

The fault was first encountered in a mine opening in 1st Right in January 1990. Substantial groundwater inflows of several hundred gallons per minute occurred in each of the entries. The water discharging from the fault was entirely from the roof and appeared to be related to a large, overlying sandstone channel. A small sympathetic fault with less than 5 feet of offset associated with the Roans Canyon Fault was subsequently encountered in the 2nd Right entries in April 1990. Peak discharge from was estimated at 5,000 gpm (Semborski, Personal Communication, 1997). The last measurement of discharge from the fault zone, from an

established monitoring point in 1989, was 150 gpm. Currently, the discharge from the fault zone is believed to be less than 150 gpm. The large discharge rate from the Roans Canyon Fault had a profound effect on the discharge rate from the Deer Creek Mine (Figure 24).

Groundwater from the Roans Canyon Fault was encountered with a series of test wells including TW-10, a 1,100 foot long horizontal hole drilled into the fault system in the Deer Creek Mine (Figure 10). It was apparent during drilling that groundwater issuing from TW-10 was from a sandstone channel that had been highly fractured. Ubiquitous iron oxide in the fractured sandstone indicated that water in the fracture had been in good communication with atmospheric gases (Semborski, Personal Communication, 1997). Although TW-10 is under considerable cover (1,200 feet), it is located near the cliff faces. The cliff face rocks are extremely fractured and open to recharge water. The average temperature of groundwater from TW-10 is 7.7°C while the average temperature of other groundwaters in the Deer Creek Mine is 11.8°C. The cooler temperature of water from TW-10 relative to other in-mine groundwaters is attributed to the location of TW-10 near cliff faces.

The discharge rate from TW-10 has declined from about 80 gpm in 1989 to about 5-6 gpm in 1997 (Figure 23). Groundwater sampled from this location in 1996 contained anthropogenic ^{14}C and had a ^{3}H content of 20.8 TU (Table 5). These data indicate that groundwater now discharging from TW-10 is in hydraulic communication with recent recharge water. Discharge from TW-10 does not exhibit seasonal fluctuations indicating that the hydrodynamics of this system are buffered. This buffering may be due to a tortuous flow

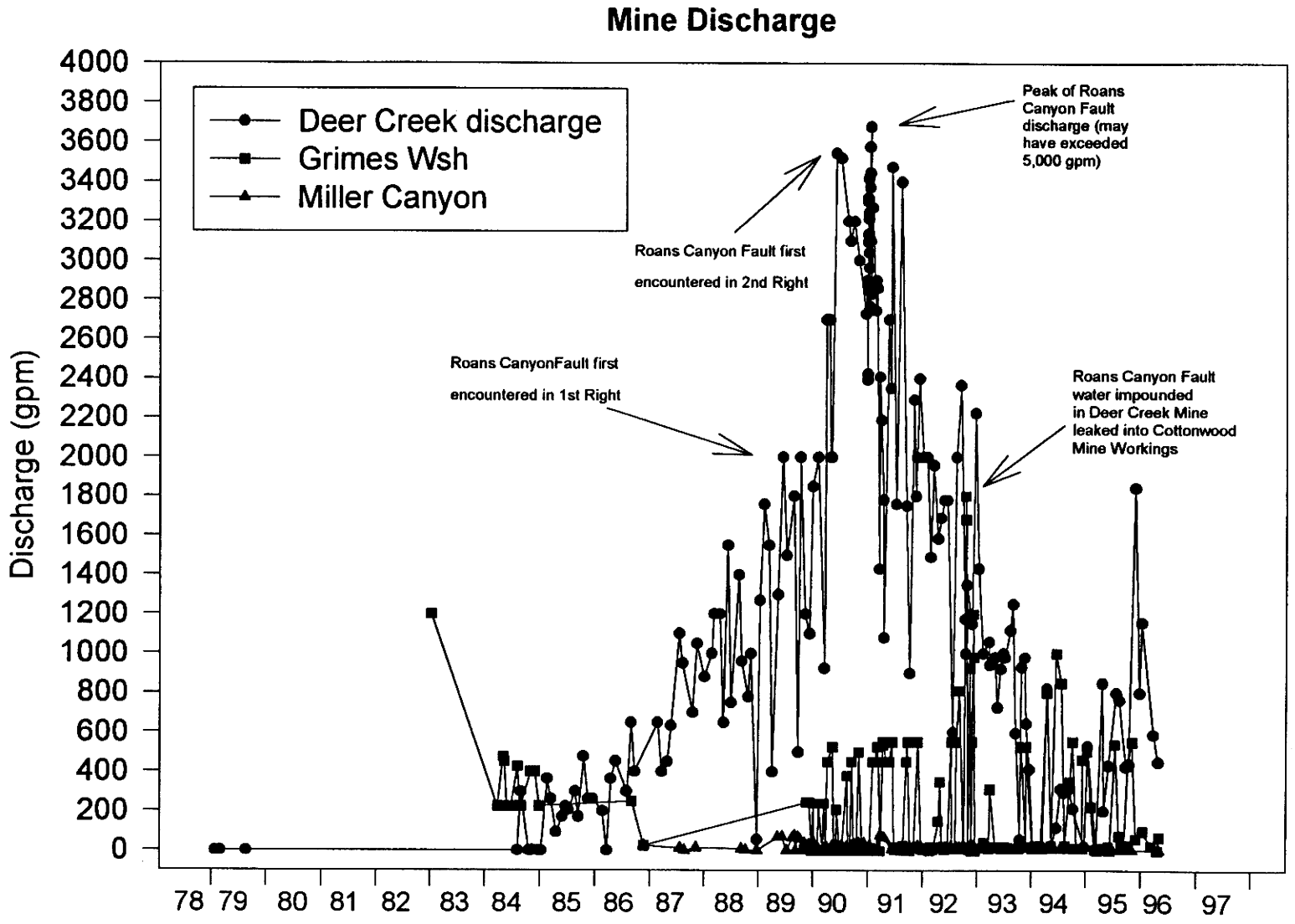

Figure 24 Mine discharge hydrograph.

path, which means a longer travel time, or the mixing of modern recharge water with older water. It is possible that the initial water intercepted by the drill hole was of similar old age as other waters encountered in the mine. Prior to intercepting the fault, the fault may have been full and rejected recharge may have occurred.

In an attempt to determine whether groundwaters discharging from the Roans Canyon Fault deeper within the mine, away from the cliff face, are tied to active, modern groundwater systems, a sample of the longwall gob water (3S Seals) in the Deer Creek Mine was collected and analyzed for isotopic composition. It is important to note, however, that this water is a composite sample of groundwater discharging from the fault and other in-mine sources, and a small percentage of Huntington Creek water used as process water in mining operations. The ^{14}C age of this sample is 12,000 years, with a tritium content of 0.9 TU (Table 5). We believe that the small component of tritium in the water is derived from the creek water. Therefore, we conclude that the groundwater in the Roans Canyon Fault deep within the mine, away from cliff faces, is of ancient origin and is likely not related to overlying shallow groundwater systems.

6.4 Well hydrographs

Historic water-level monitoring information is available for 16 wells from the study area. These wells monitor groundwater levels in alluvial systems, the Blackhawk Formation, and the Star Point Sandstone.

6.4.1 Alluvial system wells

6.4.1.1 Cottonwood Canyon

PacifiCorp currently monitors three wells completed in alluvium in Cottonwood Canyon. These include CCCW-1A, CCCW-2A, and CCCW-3A (Figure 9). Well screen intervals and gravel pack intervals are:

Well	Screen interval (ft)	Gravel pack (ft)
CCCW-1A	96 – 126	40-136
CCCW-2A	96-126	42-136
CCCW-3A	51 – 81	83-101

Hydrographs for each of these wells (Figure 25) show responses to annual precipitation. The somewhat muted hydrograph responses may be the result of depth of the screened intervals.

6.4.1.2 Rilda Canyon

Seven shallow wells were constructed in alluvium in Rilda Canyon in the mid 1980s (Figure 9). Hydrographs for these wells, identified as P-1 through P-7, are shown in Figure 26. All of the wells show the effects of annual precipitation. The hydrographs for P-1 and P-5 show less response to seasonal precipitation than do the other hydrographs. Well P-1 is located downgradient and is likely affected by the discharge from a series of upgradient springs. Well P-5 is located in the creek bottom near the NEWUA collection system. Previous researchers have suggested that the smaller hydraulic fluctuations observed in these wells are likely due to the situation of the wells in the narrow creek bottom above bedrock highs where alluvial groundwater is forced to flow near the surface (Semborski, Personal Communication, 1997).

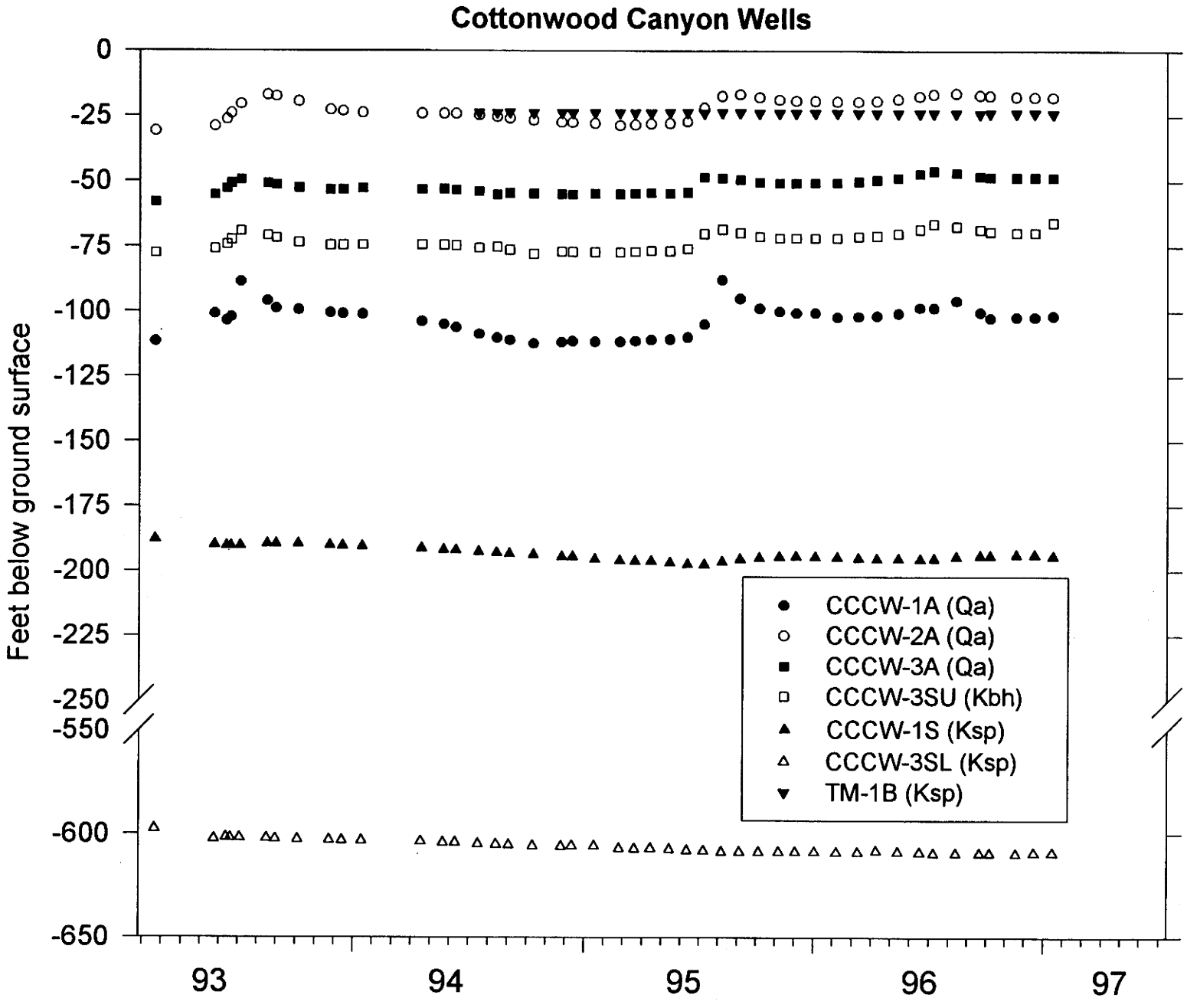

Figure 25 Hydrographs of wells in Cottonwood Canyon.

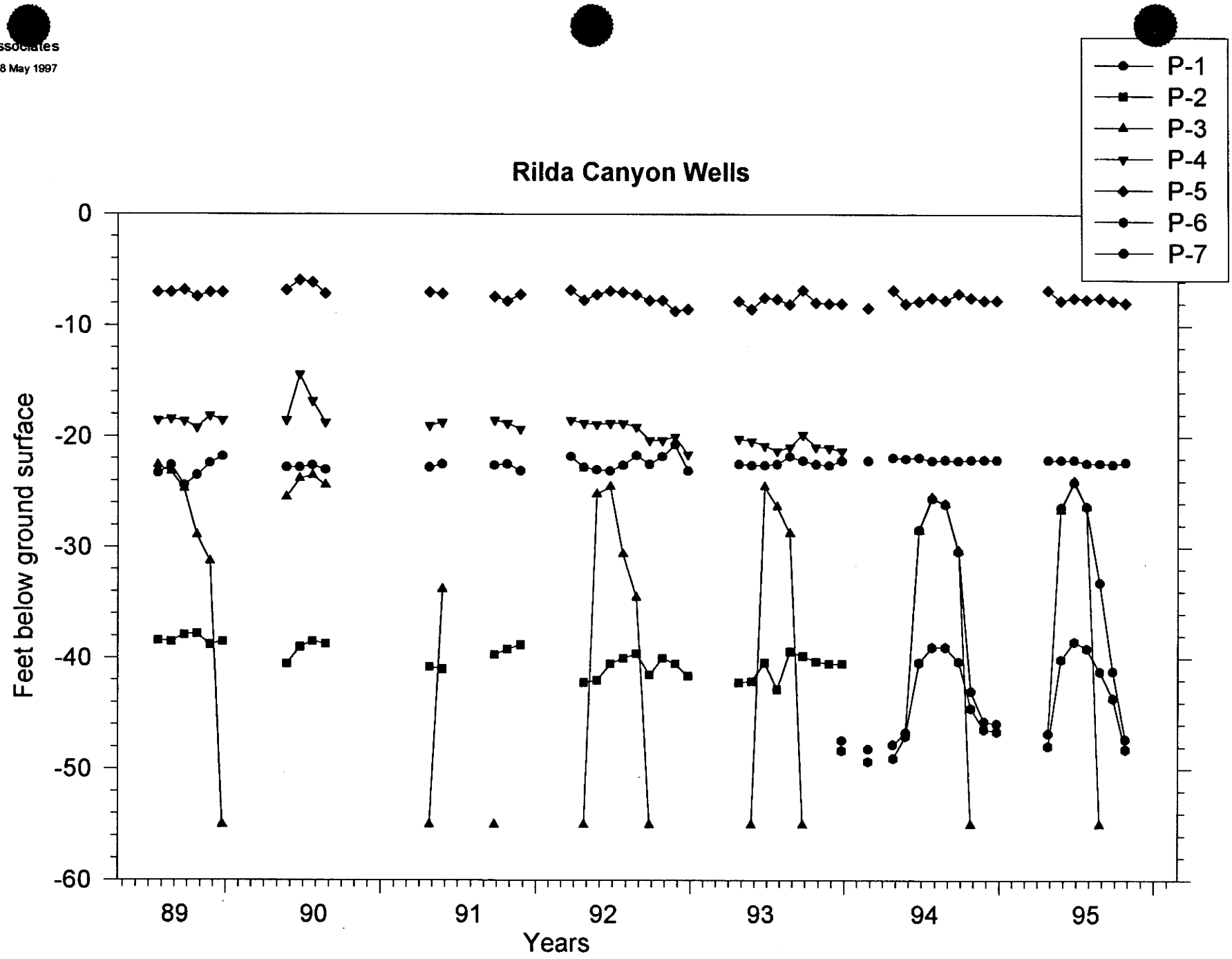

Figure 26 Hydrographs of Rilda Canyon monitoring wells.

6.4.2 Blackhawk Formation wells

Only 1 well, CCCW-3SU, monitors groundwater levels in the lower Blackhawk Formation. The well head is situated atop alluvial deposits in the bottom of Cottonwood Canyon (Figure 9). The well hydrograph (Figure 25) suggests that the formation responds to annual precipitation. However, we attribute the seasonal responses to hydraulic communication between overlying alluvial sediments and the well gravel-pack. The hydrograph response is similar to hydrographs in nearby alluvial system wells and the distance from the base of the alluvial deposits to the top of the gravel-pack zone is only 27 feet. We believe that the water level fluctuations are due to the seasonal groundwater fluctuations in the creek-bottom alluvium.

6.4.3 Star Point Sandstone Wells

Six monitoring wells have been completed in the Star Point Sandstone from the surface. The locations of the wells are shown on Figure 9, and each well is described below:

6.4.3.1 Well CCCW-1S

Well CCCW-1S is located in Cottonwood Canyon near the axis of the Straight Canyon Syncline (Figure 9). The well has a total depth of 720 feet, and is screened between 655 to 705 feet in the Spring Canyon Member. There is approximately 475 feet of potentiometric pressure in water in the well and the potentiometric level declined slightly, approximately 10 feet, between early 1993 and early 1995. Since then the water level in the well has remained relatively constant (Figure 25). The well hydrograph does not respond to seasonal recharge.

6.4.3.2 Well CCCW-3S L

Well CCCW-3SL is located in Cottonwood Canyon (Figure 9). The well has a total depth of 730 feet, and is screened between 680 and 730 feet in the Spring Canyon Member. The well is part of a multiple completion well with well CCCW-3SU. There is approximately 80 feet of potentiometric pressure in water in the well and the potentiometric level declined slightly, approximately 5 feet, between early 1993 and early 1994. Since then the water level in the well has remained relatively constant (Figure 25). The well hydrograph does not respond to seasonal recharge.

6.4.3.3 Well TM-1B

Well TM-1B is located in Cottonwood Canyon stratigraphically below the portal of the Trail Mountain Mine (Figure 9). The well has a total depth of 500 feet, and is screened between 380 and 460 feet in the Panther Tongue. There is approximately 350 feet of potentiometric pressure in water in the well. The potentiometric level has remained constant and the well hydrograph does not respond to seasonal recharge (Figure 25).

6.4.3.4 Well TM-3

Well TM-3 is located at the south end of the Trail Mountain Lease in Straight Canyon (Figure 9). A hydrograph for this well is shown in Figure 27a. The well has a total depth of 560 feet, and is screened between 505 and 555 feet in the Spring Canyon Member. When first completed in September 1993, the well flowed freely at the surface and maintained a constant shut-in pressure of 64 psi (approximately 150 feet) for several years. The well was opened in December 1996 and allowed to free flow at approximately 20 gpm for one week to

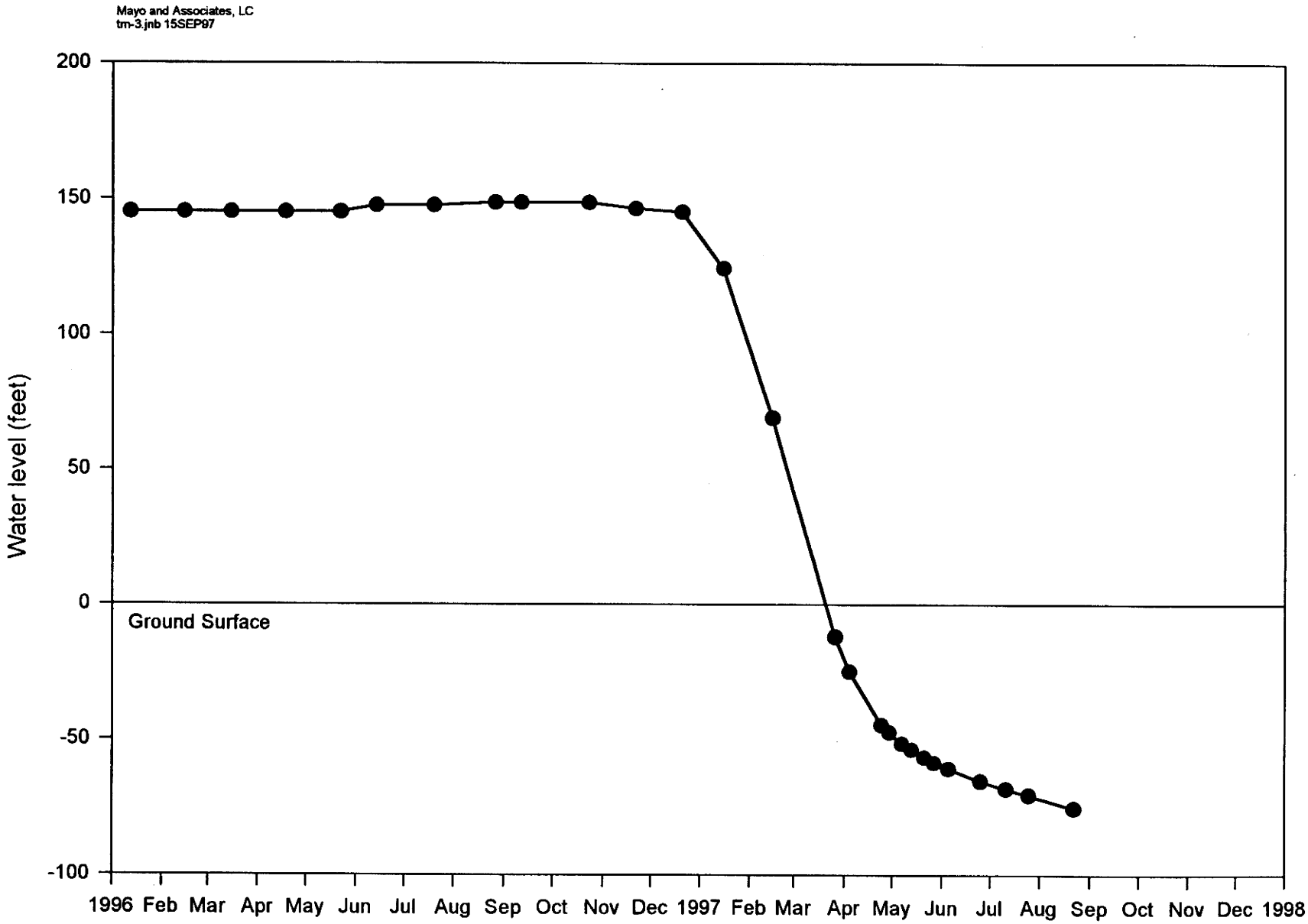

Figure 27a Hydrograph of well TM-3, which monitors water levels in the Spring Canyon Member of the Starpoint Sandstone.

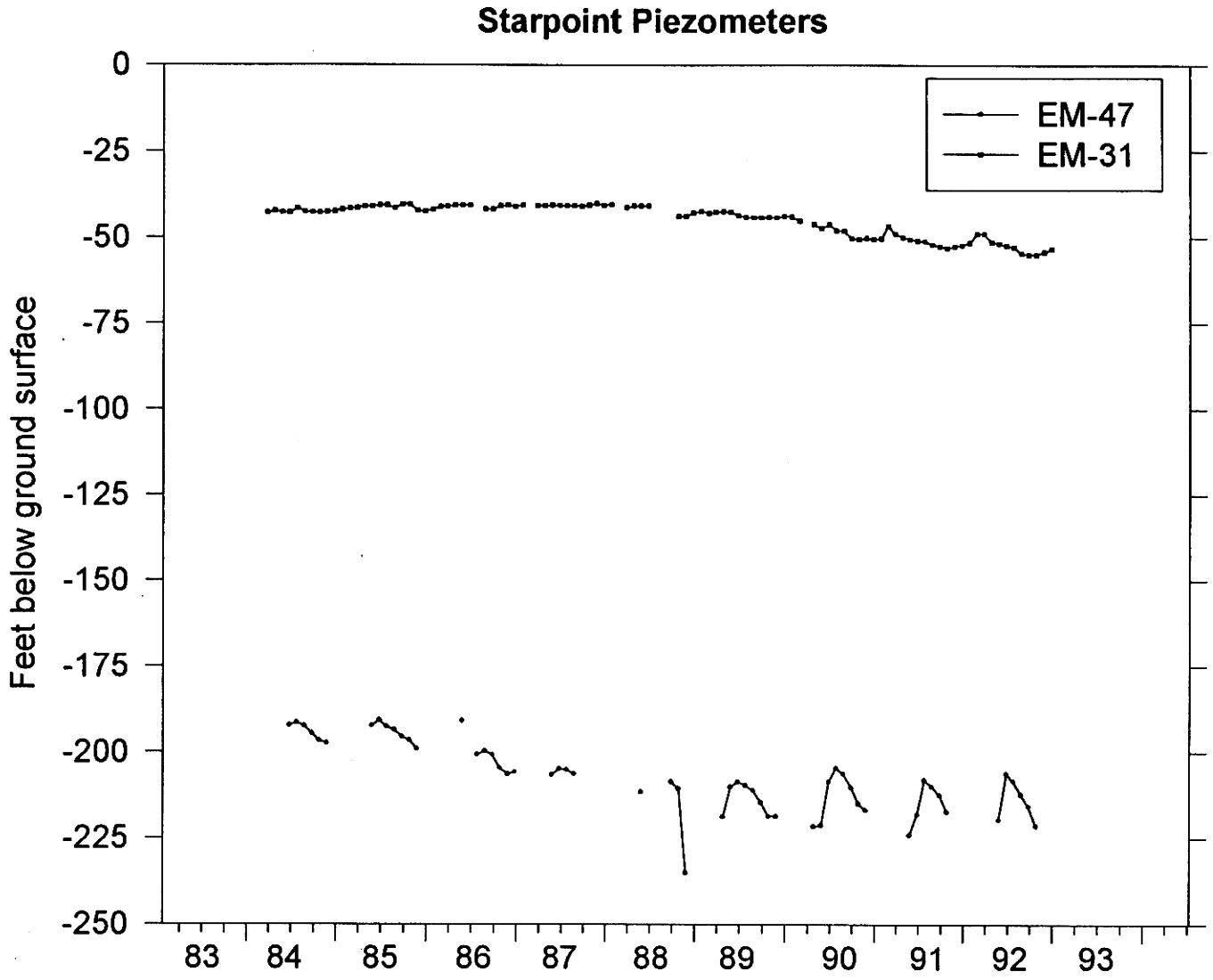

Figure 27b Hydrographs of water levels in two Star Point Sandstone piezometers.

facilitate chemical and isotopic sampling. After the sampling, the well was again shut in and the hydraulic head has decreased steadily since that time. On 22 August 1997, the water level had declined to 75 feet below land surface (Semborski, Personal Communication, 1997).

Although the cause of the reduction of hydraulic head is problematic, it is likely that the decrease is the result of depressurization of the Spring Canyon Member in the vicinity of the well. Mining operations in the Hiawatha seam in the southern portion of the Trail Mountain Mine are currently located approximately 0.5 miles northeast of well TM-3. In the Trail Mountain Mine the Hiawatha seam is located directly on the Spring Canyon Member. Approximately 200 to 300 gpm of groundwater upwells from the Spring Canyon Member to the mine floor in the current mining area. Because the current mining area is located up dip of well TM-3, mining is likely the cause of the depressurization.

Prior to mining, the elevation of the potentiometric level in TM-3 was 6900 feet. The top of the Spring Canyon Member is exposed in Cottonwood Creek 1.7 miles southeast of TM-3 at an elevation of 6500 feet. Because the Spring Canyon Member crops out below the potentiometric level reflected by TM-3, there is a hydrodynamic potential for water to discharge from the Spring Canyon Member to Cottonwood Creek. However, we believe that very little, if any, groundwater discharges to Cottonwood Creek from this horizon and therefore depressurization of the Spring Canyon Member will not decrease flow in Cottonwood Creek. Two lines of evidence support this conclusion. First, natural groundwater discharge would be indicated by springs in the Spring Canyon Member; however no springs have been identified in this unit in the vicinity of Cottonwood Creek (Semborski,

Personal Communication, 1997). Second, we have calculated a maximum potential discharge of 1 gpm based on the assumptions described below. This discharge rate was calculated using Darcy's law:

$$Q = K I A,$$

where,

Q = discharge rate

K = hydraulic conductivity

I = gradient

A= cross sectional area.

PacifiCorp (1994) calculated a hydraulic conductivity of 4.3×10^{-6} feet sec^{-1} for the Spring Canyon Member from a recovery test conducted on well TM-3. A gradient of 0.05 was calculated from the difference between the pre-mining elevation of the potentiometric level in TM-3 (6900 feet) and the outcrop elevation of the Spring Canyon Member in Cottonwood Creek (6450 feet) divided by the distance separating these two points (9000 feet). A cross sectional area of 10,000 ft^2 was calculated using the thickness of the Spring Canyon Member (100 feet) and a 100-foot exposure width.

6.4.3.5 Well EM-31

Well EM-31 is located in Cottonwood Canyon (Figure 9). The well head is located on alluvial deposits just above the Trail Mountain Mine portals. The thickness of the alluvium at the well head is 20 feet. A 20-foot thick layer of sandstone and a 10-foot thick sequence of

interbedded siltstone and mudstone underlie the alluvium. The well was has a total depth of 280 feet. Although the well casing is perforated from 190 to 250 feet, the gravel-pack zone extends from 50 feet to 280 feet which provides opportunity for vertical communication between saturated horizons. The hydrograph of EM-31 (Figure 27b) shows that the well responds subtly to annual precipitation and long-term climatic cycles. We believe that these hydraulic responses are due in large part to hydraulic communication between the gravel-pack zone and shallow, overlying groundwater systems. The Star Point Sandstone, in other locations, does not respond to annual precipitation or climatic trends.

6.4.3.6 EM-47

Well EM-47 is located in Rilda Canyon (Figure 9). The well head is located in alluvial deposits near Rilda Canyon Creek. The well has a total depth of 300 feet, and is screened between 210 and 270 feet in the Spring Canyon Tongue. Water levels in the well respond to annual precipitation events, and since about 1986 there has been a general decline in water levels (Figure 27b). The annual responses are attributed to well completion problems rather than to fluctuations in water levels in the Spring Canyon Member. The coarse gravel-pack interval in this well is from 50 to 300 feet. The gravel used was 0.25 to 0.375 inches in diameter. The thickness of the alluvium at the surface is 25 feet, and the bedrock underlying the alluvium is a continuous sandstone layer that extends to a depth of 70 feet. Thus there is only 25 feet of sandstone separating the gravel-pack from the surface alluvium. The general decline in water surface elevation since about 1986 may be the result of climatic variability.

6.4.4 In-mine piezometers

6.4.4.1 Deer Creek Mine

In late 1989 four piezometers were constructed in the Deer Creek Mine to monitor groundwater levels in the lower portion of the Blackhawk Formation and in the Spring Canyon Member of the Star Point Sandstone beneath the mine workings. The piezometers designated DCP-1 through DCP-4, and are all located in the 3rd North/1st West Mains area (Figure 10). Each of the wells has a 20-foot surface casing and is open for 150 feet below that. Thus, each of the wells is open to Blackhawk Formation sandstones and claystones located above the Hiawatha seam, the Hiawatha coal seam, and the Spring Canyon Member of the Star Point Sandstone. What this means is that water levels represent composite hydraulic heads and are not necessarily representative of the Spring Canyon Member or the lower Blackhawk Formation.

Two of the piezometers (DCP-1 and DCP-4) had initial static water levels which rose to the bottom of the mine workings (Blind Canyon seam), and two of the piezometers (DCP-2 and DCP-3) had initial static water levels which rose to the middle of the lower portion of the Blackhawk Formation. Between mid-1990 and mid-1993 a transient potentiometric level decline occurred in Wells DCP-1, DCP-3, and DCP-4 (Figure 28). Mine workings containing DCP-2 and DCP-4 were sealed in late 1991, workings containing DCP-3 were sealed in late 1993, and data collection ended. By early 1997 the potentiometric level in DCP-1 recovered to the initial static level.

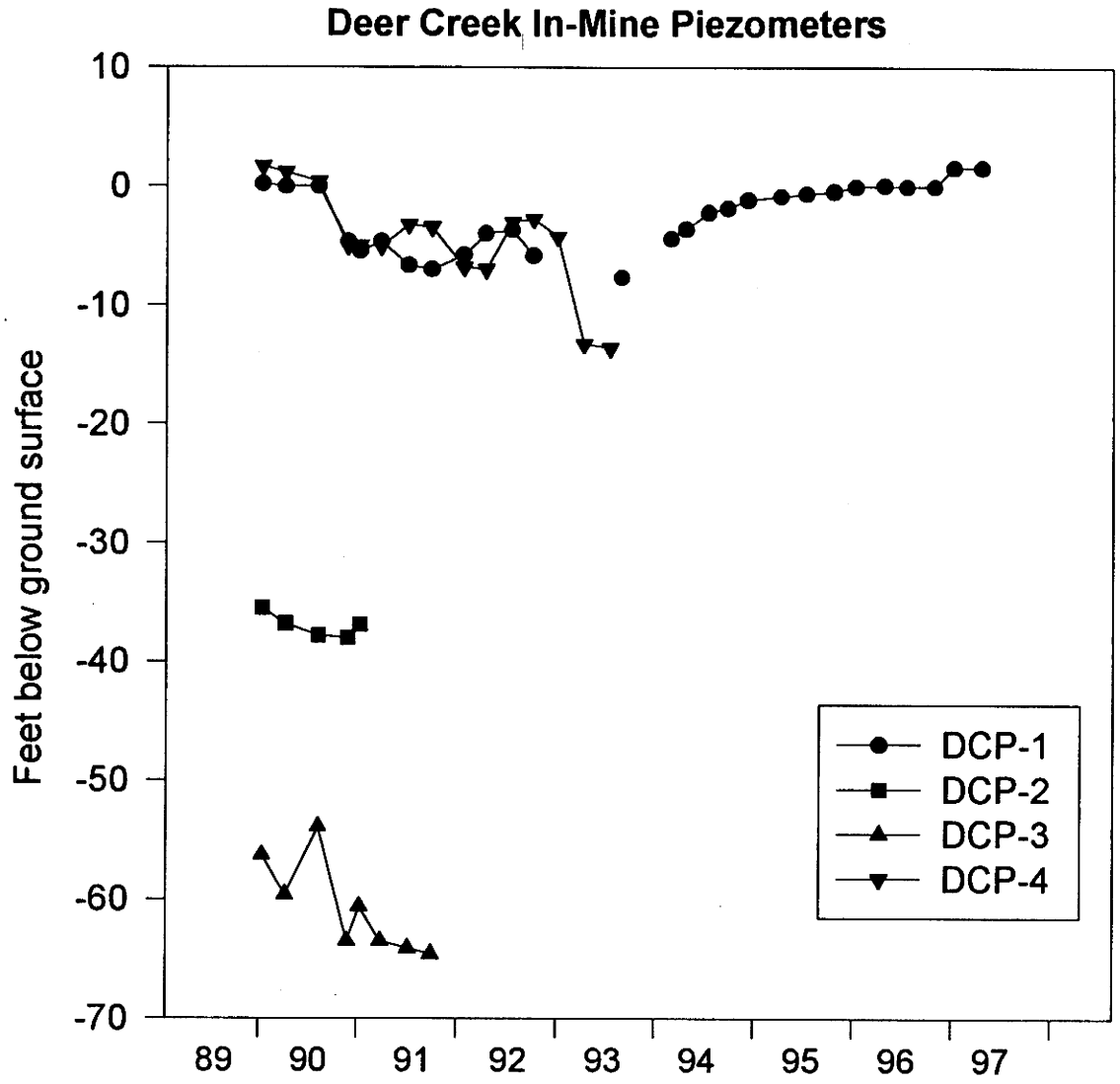

Figure 28 Hydrographs of water levels in in-mine piezometers in the Deer Creek Mine.

There are two possible causes of the transient response. The potentiometric decline approximately coincides with the Roans Canyon Fault dewatering. However, it is difficult to envision a correlative mechanism. The fault drained a sandstone channel located above Blind Canyon Seam and the piezometers are located below the seam 0.3 to 1 mile southwest of the fault. If the decline were related to fault dewatering, there is not a mechanism for piezometric recovery.

The transient response is most likely related to mining along the Straight Canyon Syncline in an area located down dip and to the west of the piezometers and not to depressurization and subsequent repressurization of the Spring Canyon Member. During mining, considerable floor water was encountered. Upon completion of mining, the area was sealed and flooded. We believe that the piezometric decline was the result of the down gradient depressurization and recovery in the lower portion of the Blackhawk Formation.

6.4.4.2 Cottonwood Mine piezometers

In late 1989 four piezometers (WCP-1 through WCP-4) were constructed in the Cottonwood Mine to monitor groundwater levels in the Spring Canyon Member of the Star Point Sandstone (Figure 11). Each of the wells has a 10-foot surface casing and is open holes for 60 to 130 feet below that. Thus, each of the wells is open to Spring Canyon Member and interbedded clays separating the Spring Canyon Member from the Storrs Member. Well WCP-1 is also open to the upper portion of the Storrs Tongue. The workings containing the piezometers were progressively sealed starting in late 1989 to late 1990 and data are not available after that.

Potentiometric levels in wells WCP-2, WCP-3, and WCP-4 show no seasonal variations. Water levels increased slightly in WCP-3 and WCP-4 (Figure 29). The potentiometric record for WCP-1 suggests some fluctuation in the hydraulic head in the well. However, it is believed that the fluctuations in head are the result of a malfunctioning pressure transducer and are not representative of actual conditions in the formation. The pressure transducer was replaced in early 1990. Seasonal variations in potentiometric levels are not observed.

6.5 Steady state recharge-discharge rates in-mine groundwaters

The fact that in-mine groundwaters do not have infinite ^{14}C ages means that there must at some time have been some hydraulic communication between the near-surface and in-mine (deep) groundwater systems. We believe that this communication most likely occurred during a cooler, wetter climatic cycle, when more water was available for groundwater recharge.

An alternative way to view the deep groundwater regime is that the groundwater is in constant flux and that the rate of groundwater movement is slow. If we make the assumption that the water discharging in the mine from deep systems is in equilibrium with its recharge, it is possible to calculate an estimate of the steady-state throughput of the system. These calculations are based on an estimate of the total volume of water in storage in the system being drained, and the calculated radiocarbon age of the water. In the nearby Bear Canyon Mine we calculated a steady state recharge-discharge rate of 1.2 gpm for a sandstone channel containing about 1 billion gallons of water. The 3,250-foot long channel, located above the Blind Canyon seam, contained groundwater with a mean residence time of 1,500 years. These types of calculations give an approximation of the *maximum* flux of water through the

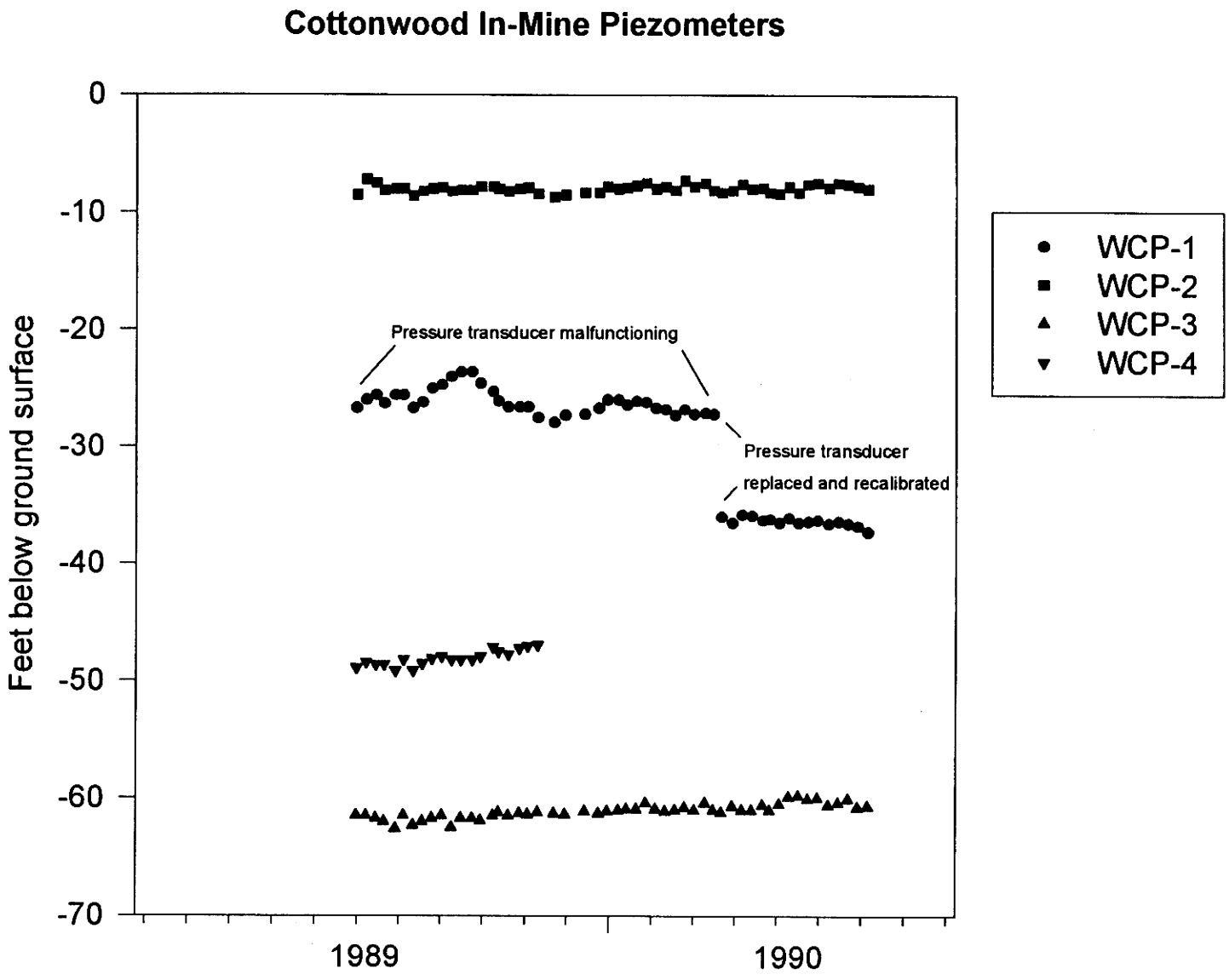

Figure 29 Hydrographs of water levels in in-mine piezometers in the Cottonwood Mine.

system *if* deep systems were currently in hydraulic communication with adjacent active systems. However, we believe that the actual flux of groundwater through these systems is generally less than that calculated because we do not believe that the deep systems are currently in communication with the near-surface systems.

Similar steady state recharge-discharge rate calculations for the Roans Canyon and Pleasant Valley faults, and typical sandstone channels located above the mined coal seams are shown below:

6.5.1 Faults

Roans Canyon Fault/Straight Canyon Syncline:

The largest single influx of water into the mine, about 5×10^9 gallons, was from the Roans Canyon Fault/Straight Canyon Syncline. Carbon-14 ages are not available directly from groundwaters issuing from the fault/syncline. However, water from longwall gob areas (3S Seals and MW Seals), which contain mostly Roans Canyon Fault/Straight Canyon Syncline discharge water, have ^{14}C ages of 8,000 and 12,000 years (Table 5). Based on these data a range of values for steady state recharge-discharge conditions are:

$$\frac{5 \times 10^9 \text{ gallons (storage capacity)}}{8{,}000 \text{ years } (4.2 \times 10^9 \text{ minutes; residence time})} = 1.23 \text{ gpm}$$

$$\frac{5 \times 10^9 \text{ gallons (storage capacity)}}{12{,}000 \text{ years } (6.3 \times 10^9 \text{ minutes; residence time})} = 0.79 \text{ gpm}$$

Pleasant Valley Fault:

Only small discharges have been measured from the Pleasant Valley fault. A more reasonable estimate of the discharge from the Pleasant Valley fault is 25 gpm for 20 years. Groundwater ^{14}C ages of 4,500 to 7,000 years have been calculated for sites 1.5N X 29 (Wilberg Mine) and MN-ME (Deer Creek Mine), respectively (Table 5). Based on these data a range of values for steady state recharge-discharge conditions are:

$$\frac{2.6 \times 10^8 \text{ gallons (storage capacity)}}{7{,}000 \text{ years } (3.7 \times 10^9 \text{ minutes; residence time})} = 0.07 \text{ gpm}$$

$$\frac{2.6 \times 10^8 \text{ gallons (storage capacity)}}{4{,}500 \text{ years } (2{,}4 \times 10^9 \text{ minutes; residence time})} = 0.11 \text{ gpm}$$

6.5.2 Sandstone Channels

Drip rate data and ^{14}C ages are available for three sandstone channels. The channels have been monitored at locations 2S X 11 (Cottonwood Mine), TMA X 32 (Cottonwood Mine) and UG-3 (Trail Mountain Mine). Additional groundwater storage data and the ^{14}C groundwater age is available from 6W X 20 (Deer Creek Mine). Steady state recharge-discharge rate calculations are shown below:

2S X 11 (Cottonwood Mine):

The roof drip (Figure 22a) shows a gradual decline from about 0.11 gpm in 1984 to about 0.06 gpm in 1996. The hydrograph recession suggests the drip will dry flow for

about 30 total years. Based on a mean drip rate of 0.06 gpm the total discharge will be 9.5×10^6 gallons.

$$\frac{9.5 \times 10^6 \text{ gallons (storage capacity)}}{12{,}000 \text{ years } (6.3 \times 10^9 \text{ minutes; residence time})} = 0.002 \text{ gpm}$$

Assuming the drip at 2S X 11 only represented 10% of the total volume of water in the channel the steady state recharge-discharge rate would be 0.02 gpm. If the drip only represented 1% of the total volume of water in the channel the steady state recharge-discharge rate would be 0.2 gpm.

TMA x 32 (Cottonwood Mine):

The roof drip (Figure 22d) shows a decline from about 10 gpm in October 1994 to 2 gpm in April 1996. The hydrograph recession suggests that the drip will flow for 5 years or less and the average drip rate will be 1 gpm or less. Based on a mean drip rate of 1 gpm the total discharge will be 2.6×10^6 gallons.

$$\frac{2.6 \times 10^6 \text{ gallons (storage capacity)}}{6{,}500 \text{ years } (3.4 \times 10^9 \text{ minutes; residence time})} = 0.001 \text{ gpm}$$

Assuming the drip at TMA X 32 only represented 10% of the total volume of water in the channel the steady state recharge-discharge rate would be 0.01 gpm. If the drip only represented 1% of the total volume of water in the channel the steady state recharge-discharge rate would be 0.1 gpm..

UG-3 (Trail Mountain Mine):

Reliable hydrograph data are not available for UG-3. Monitoring by PacifiCorp first occurred in May 1990 when a flow of 25 gpm was measured. In mid-1995 the drip had declined to about 5 gpm. Assuming a drip life of 20 years and a mean drip rate of 5 gpm the total discharge will be 5.3×10^7 gallons.

$$\frac{5.3 \times 10^7 \text{ gallons (storage capacity)}}{5{,}500 \text{ years } (2.9 \times 10^9 \text{ minutes; residence time})} = 0.018 \text{ gpm}$$

assuming the drip at UG-3 only represented 10% of the total volume of water in the channel the steady state recharge-discharge rate would be 0.18 gpm. If the drip only represented 1% of the total volume of water in the channel the steady state recharge-discharge rate would be 1.8 gpm.

6.6 Discussion

The overall pattern of groundwater flow and surface water-groundwater interactions in the mine lease area can be described by a fairly simple conceptual model involving both active and inactive groundwater flow regimes (Figure 30). Active regime groundwater flow systems contain abundant ^3H, have excellent hydraulic communication with the surface and thus are dependent on annual recharge events and are affected by short term climatic variability. Groundwater in these systems circulates shallowly and has short flow paths. The active regime includes alluvial groundwater, all of the Flagstaff Limestone, near-surface exposures of all other bedrock formations except, perhaps, the Mancos Shale. The "near surface" extends

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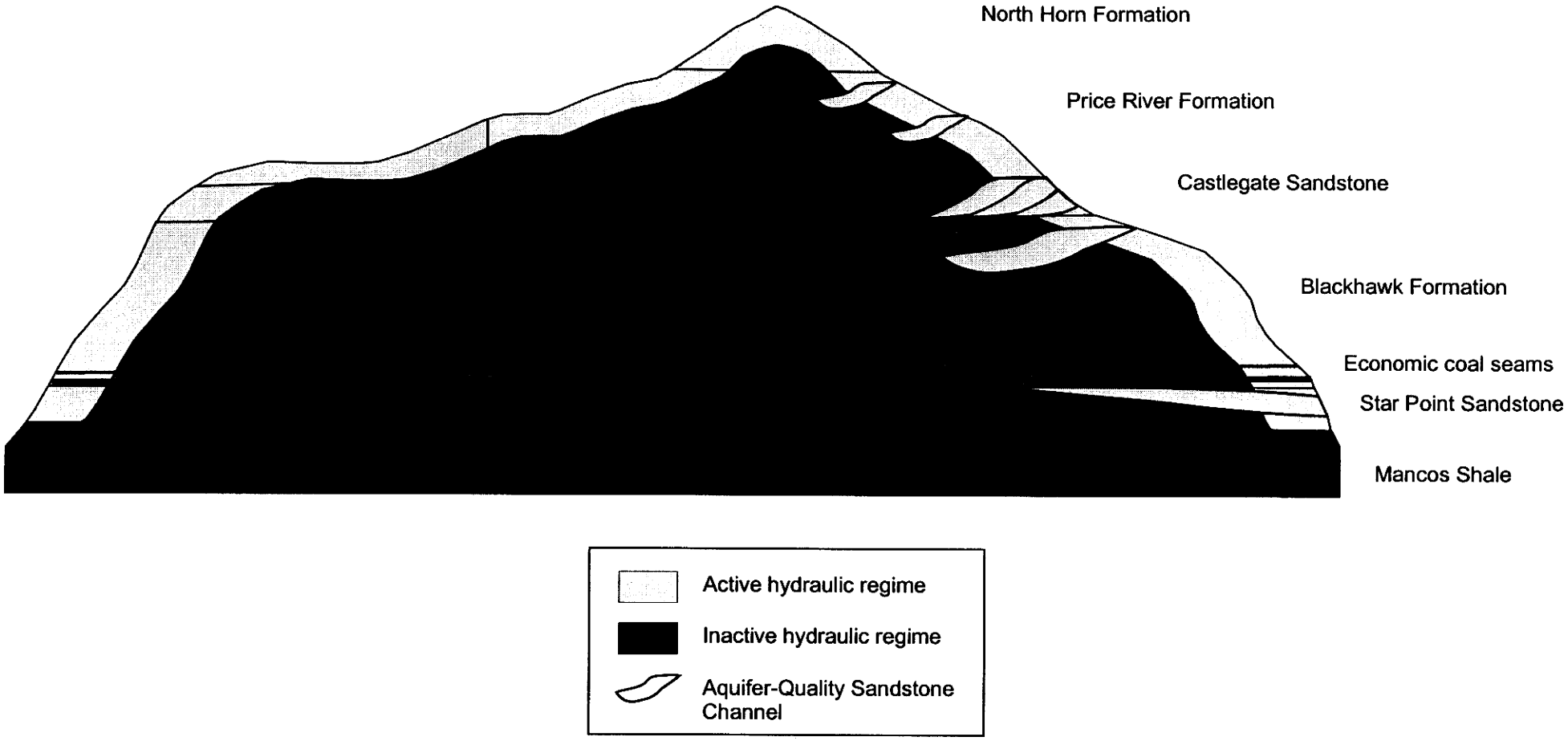

Figure 30 Conceptual model of active and inactive groundwater flow regimes in the mine lease area.

about 500 to 1,000 feet into cliff faces and is controlled by fracturing, weathering, and the surface exposures of fluvial channel sands. Further into the cliff faces the discontinuous character of the channel sands prevents active groundwater flow.

Inactive groundwater flow regimes contain old groundwater (i.e. 2,000 to 12,000 years), have very limited hydraulic communication with the surface and with other active groundwater flow systems, and are not influenced by either annual recharge events or short term climatic variability. Groundwater in these systems tends to occur in sandstone channels in the North Horn, Price River, and Blackhawk Formations which are not in direct hydraulic communication with the surface (i.e. greater than about 500 to 1,000 feet from cliff faces). These sandstone channels are vertically and horizontally isolated from each other and when encountered in mine workings are usually drained quickly. The blanket sands of the Star Point Sandstone are also largely in the inactive zone. For the most part faults encountered in mine workings are part of the inactive regime.

A report by the U.S. Geological Survey (Lines, 1985) states that there exists a regional aquifer in the lower Blackhawk Formation and Star Point Sandstone in the Wasatch Plateau. Lines also postulates that the regional aquifer is recharged by the downward migration of groundwaters from overlying perched groundwater systems in the North Horn and Price River Formations. For several reasons, we believe that these ideas are incorrect. Groundwaters encountered within mine openings in the lowermost Blackhawk Formation occur primarily within discontinuous sandstone channels. It is not uncommon for some of these channels to be completely dry, while others are partially or completely filled with water. Between these

sandstone channels, the surrounding shales and claystones of the Blackhawk Formation are usually dry. The discontinuous nature of the saturated sediments in the lowermost Blackhawk Formation, and the unconfined conditions under which these groundwaters exist do not support the idea of a deep, regional system with groundwater flowing from areas of recharge to areas of discharge. Additionally, the radiocarbon and tritium age dating of waters from the lower Blackhawk Formation (Section 5.4) indicates that, while the groundwaters from the shallow perched groundwater systems are modern (post-1954), groundwaters from the Blackhawk Formation and Star Point Sandstone are thousands of years old. Because the mine workings do not intercept the Star Point Sandstone, less is known about the continuity of groundwater systems there. However, groundwaters in the Star Point Sandstone are thousands of years old (section 5.4) and occur in laterally discontinuous sandstone tongues bounded by nearly impermeable shale units of the Mancos Shale. Because of the lateral discontinuity of these tongues, regional groundwater flow regimes cannot develop.

We believe that the presence of swelling clays and impermeable shales in the rocks in the unsaturated zone between the overlying perched systems and the Blackhawk Formation effectively prohibit downward vertical migration of waters from the perched systems. Lines (1985) analyzed cores taken from well (D-17-6)27bda-1 and found the hydraulic conductivities of the shales and siltstones to be very low (i.e. 10^{-7} to 10^{-8} ft/day). One shale sample was found to be effectively impermeable even when a hydraulic pressure of 5,000 psi was applied.

Because there are no areally extensive groundwater regimes in the lower Blackhawk Formation or Star Point Sandstone within the lease area, it is not possible to draw meaningful potentiometric surface maps of these systems.

Lines (1985) also reported that water was likely leaking from the Joes Valley Reservoir downward into the "lower Blackhawk / Star Point aquifer" in Straight Canyon. We believe that this is incorrect. Groundwater collected from well TM-3, which is completed in the Star Point Sandstone, in Straight Canyon just below the reservoir has a radiocarbon age of 6,000 years, while water in Joes Valley Reservoir is of modern origin. Water levels in TM-3 do not respond to seasonal fluctuations in the water level in Joes Valley Reservoir, indicating that there is little or no hydraulic communication between the reservoir and water in the Star Point Sandstone. Groundwater was sampled at UG-3 in the lower Blackhawk Formation in the Trail Mountain Mine. This water has a radiocarbon age of 5,500 years, which is likewise not consistent with water from the reservoir.

7. SURFACE WATER HYDROLOGY

The PacifiCorp lease area is located in the San Rafael River basin and is drained by two tributary drainage systems: Huntington Creek and Cottonwood Creek. Huntington Creek merges with Cottonwood Creek and Ferron Creek approximately 10 miles southeast of the study area forming the San Rafael River.

During the snowmelt period, ephemeral, intermittent, and perennial streams carry large quantities of runoff water from the highlands of the Wasatch Plateau. As the temperatures warm in the spring and summer months, snow pack melts and both stream flows and spring discharges decrease dramatically.

The northeastern portion of East Mountain is part of the Huntington Creek drainage system. Major tributaries include Rilda Canyon, Meetinghouse, and Deer Creeks (Figure 31). The southwestern portion of East Mountain is drained by Grimes Wash, which is tributary to Cottonwood Creek. The western portion of East Mountain and the eastern portion of Trail Mountain drain into Cottonwood Canyon Creek, which flows south into Cottonwood Creek. The west slope of Trail Mountain drains westward via ephemeral streams into Indian Creek in Joes Valley. These and other surface waters are retained by Joes Valley Reservoir, which in turn discharges into Cottonwood Creek.

The hydrology of each drainage basin is described below.

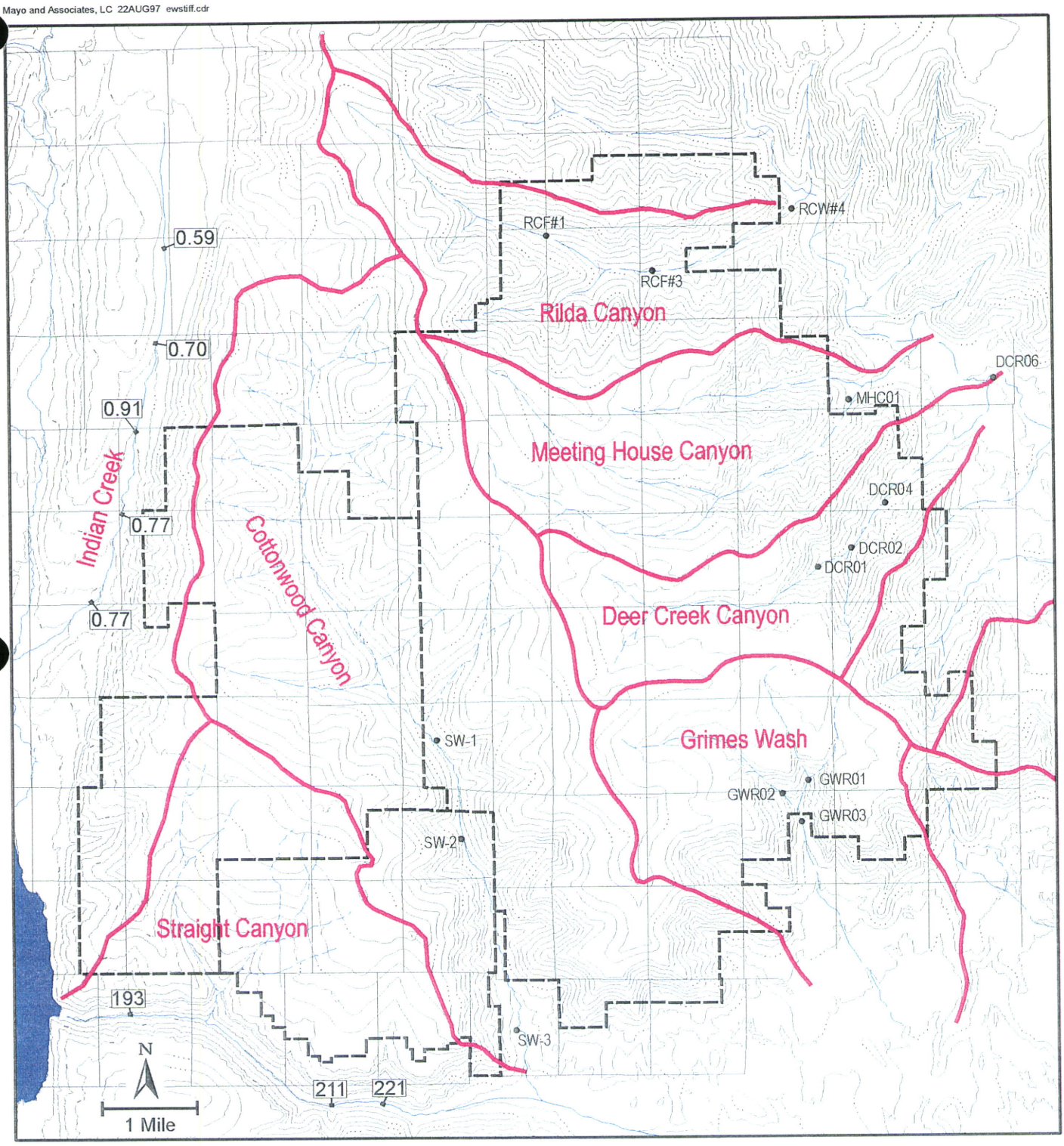

Figure 31 Map showing drainage basins, surface water monitoring locations, and results of gain-loss measurements on Indian Creek and Cottonwood Creek in Straight Canyon. Flow measurements are reported in CFS.

7.1 Huntington Creek Drainage System

7.1.1 Rilda Canyon Creek

The Rilda Canyon Creek drainage overlies the workings of the Deer Creek Mine. Since 1989, monthly flow measurements have been made at monitoring sites RCF1, RCF2, RCF3, and RCW4 (Figure 31). RCF1 is the uppermost monitoring station and RCF2 and RCF3 are located downstream near the North Emery Water Users Association (NEWUA) near-surface water collection system. RCF4 is located below the lease boundary near the confluence with Huntington Creek. Rilda Creek is ephemeral above RCF2 near the NEWUA collection system and is a gaining perennial stream below RCF2. The upper, losing reach of the stream flows across alluvium deposited on the Blackhawk Formation and Star Point Sandstone, whereas the gaining reach of the stream flows on alluvium deposited on Mancos Shale. Discharge in Rilda Creek varies greatly by season (Figure 32). For example, in 1995 discharge at RCF3 was 4,500 gpm in June and was only 149 gpm in September.

7.1.2 Meetinghouse Creek

Ephemeral Meetinghouse Creek overlies portions of both Deer Creek and Cottonwood mines. PacifiCorp has performed monthly flow measurements at monitoring site MHC01 since 1986 (Figure 31). The maximum measured discharge was 6,800 gpm in September 1991; however, there is commonly no flow in the creek during the late summer, fall, and winter (Figure 33). The absence of flow during the dry months means that the North Horn, Price River, Castlegate, Blackhawk and Star Point Formations do not contribute appreciable baseflow to the creek.

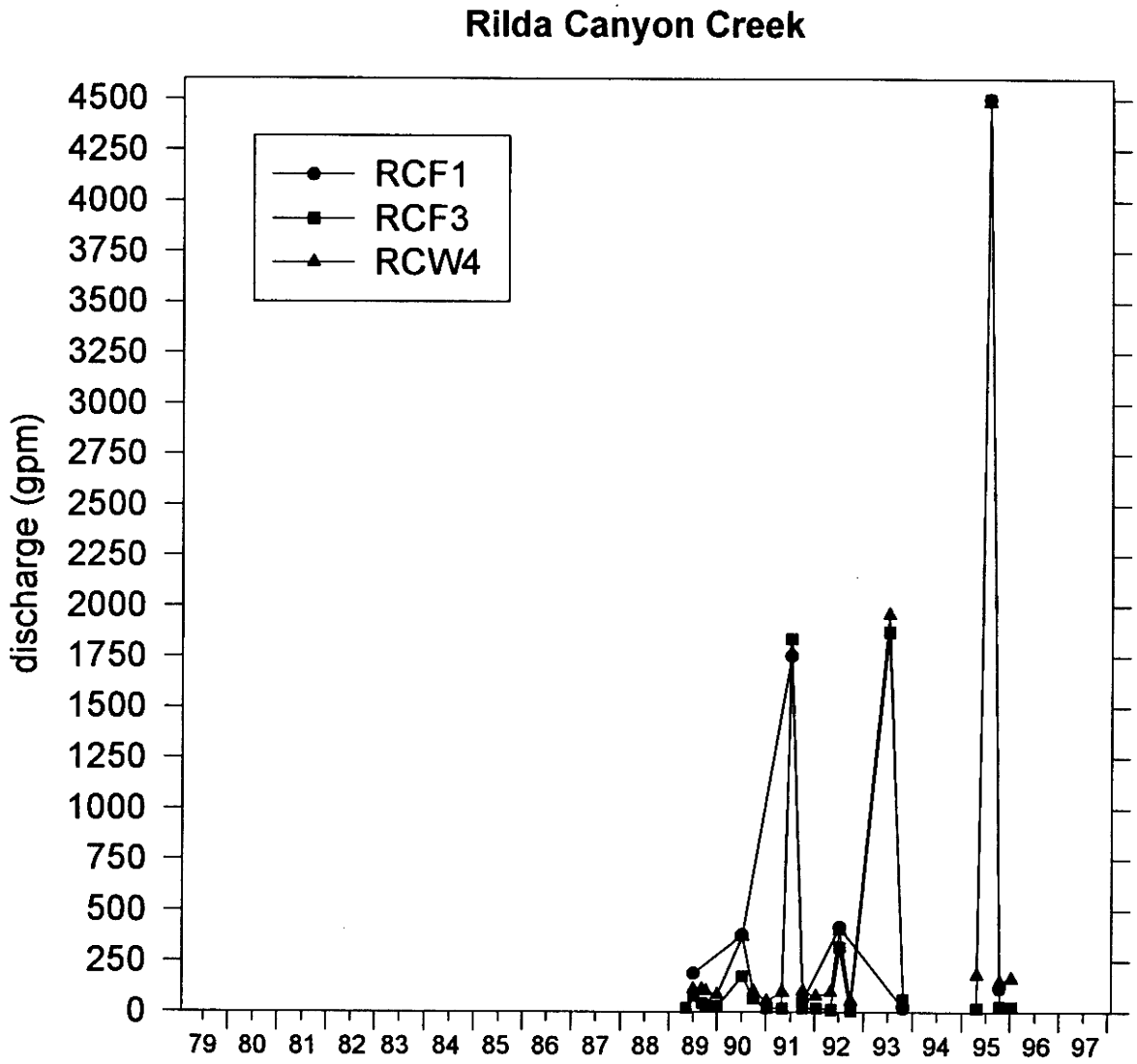

Figure 32 Instantaneous stream-discharge hydrographs for Rilda Canyon Creek.

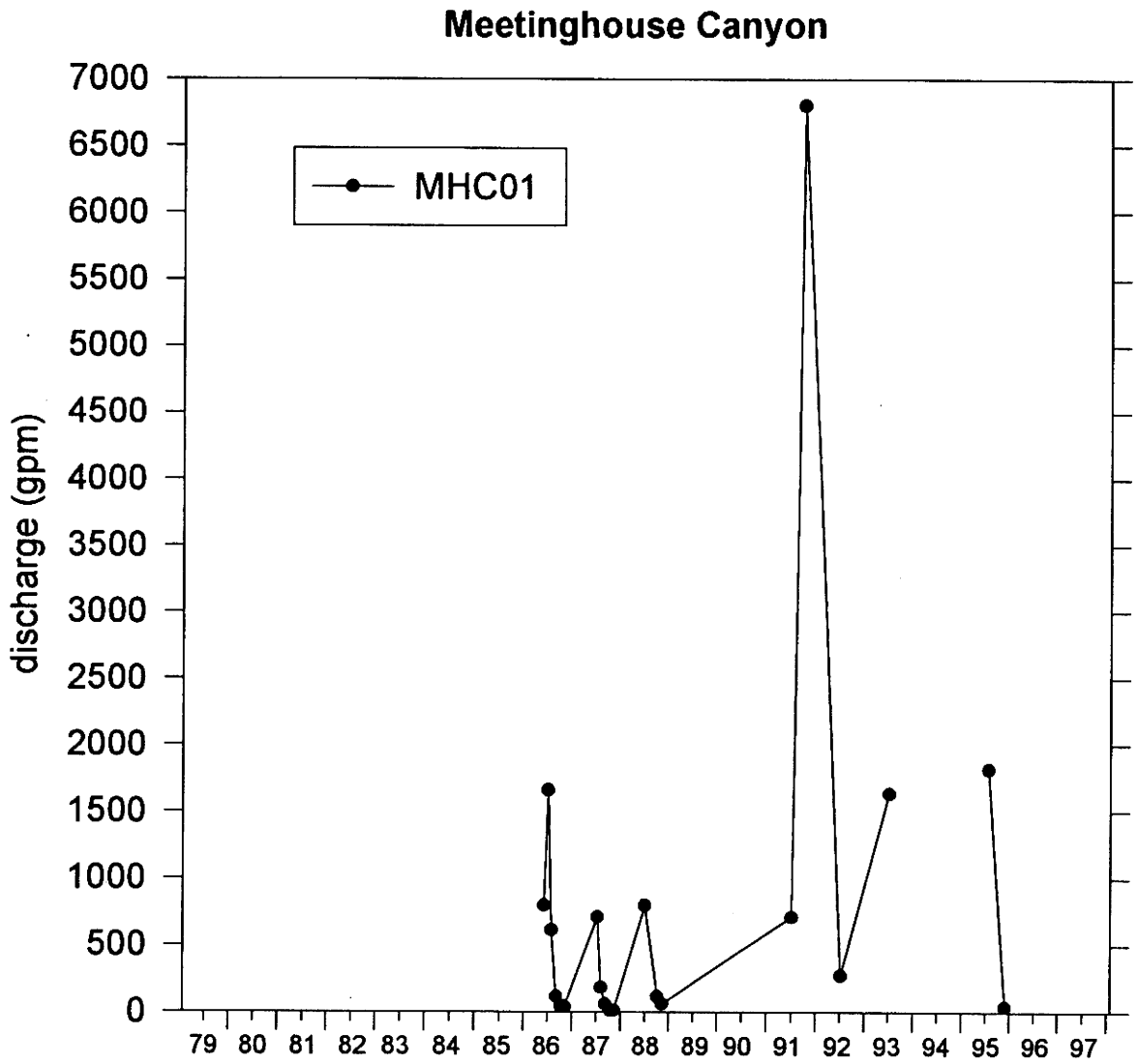

Figure 33 Instantaneous stream-discharge hydrographs for Meetinghouse Canyon Creek.

7.1.3 Deer Creek

Ephemeral Deer Creek overlies portions of both Deer Creek and Cottonwood mines. Discharge is measured monthly at DCR01 (located above the lease area), DCR04 (located at the lower lease boundary), and DCR06 (located below the mine; Figure 31). Flows in Deer Creek range from no discharge during dry years (both above and below Deer Creek Mine) to several thousand gpm during the springtime in wet years (Figure 34). The lack of flow during the dry months indicates that the North Horn, Price River, Castlegate, Blackhawk and Star Point formations do not contribute appreciable base flow to the creek.

7.2 Cottonwood Creek Drainage

7.2.1 Cottonwood Canyon Creek

Cottonwood Creek in Cottonwood Canyon drains the western slopes of East Mountain and most of Trail Mountain (Figure 31). The drainage area is underlain by mine workings of the Trail Mountain and Cottonwood mines. Cottonwood Canyon Creek is ephemeral from its headwaters to near SW-1 and is intermittent from that point to the confluence with Cottonwood Creek in Straight Canyon. Monitoring station SW-1 is located near the lease boundary in the Blackhawk Formation, SW-2 is located within the lease area in the Star Point Sandstone, and SW-3 is located about 1 mile down-stream from the lease boundary in the Mancos Shale (Figure 31). Flow in Cottonwood Canyon Creek varies in response to both season and long-term climate trends (Figure 35). Discharge at SW-1 was measured at 2,500 gpm in 1995. A minimum flow of 3 gpm was measured at SW-1 in 1993. The near absence of flow during dry periods suggests that there is no appreciable contribution to flow from bedrock groundwater systems.

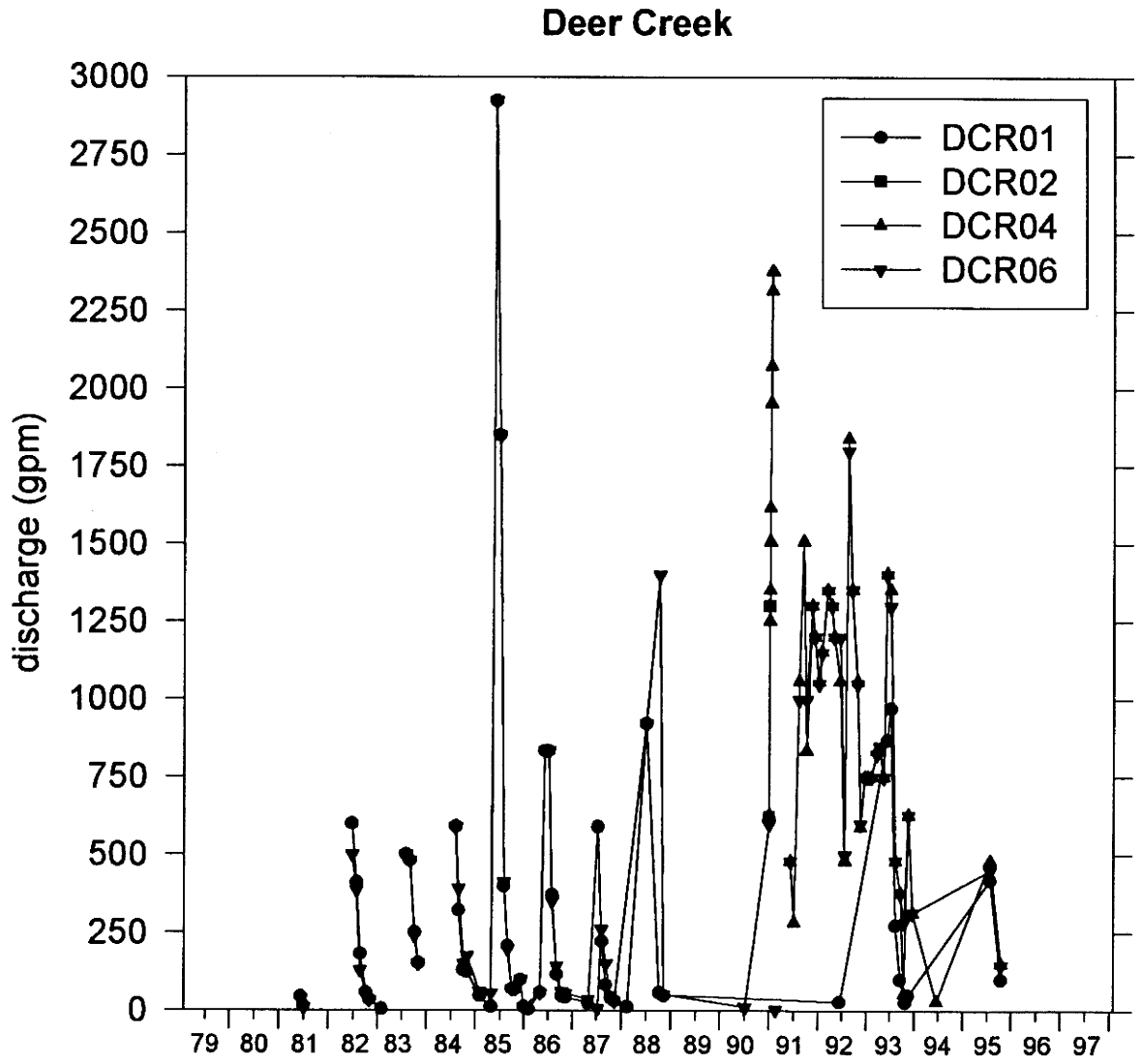

Figure 34 Instantaneous stream-discharge hydrographs for Deer Creek.

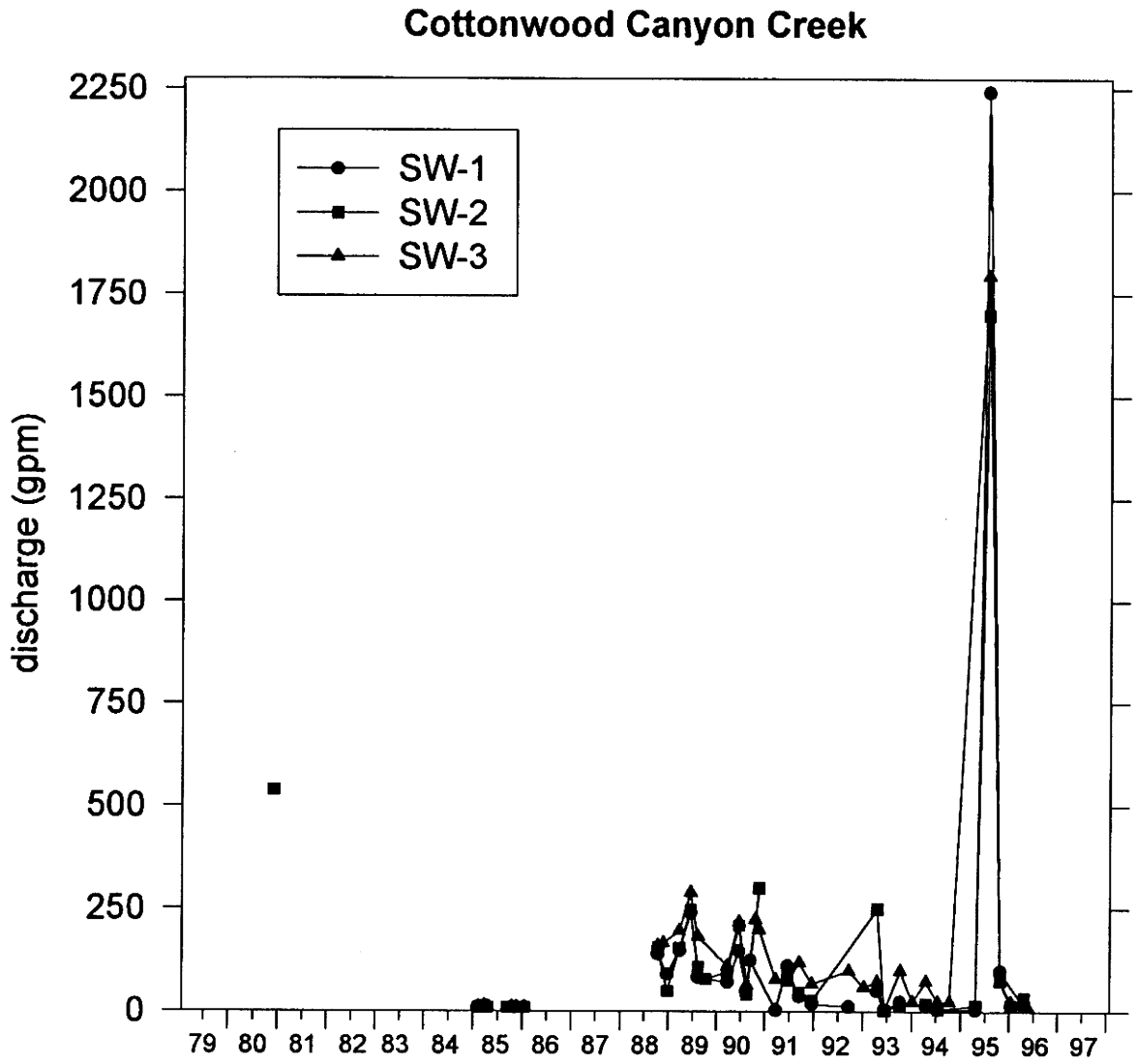

Figure 35 Instantaneous stream-discharge hydrographs for Cottonwood Canyon Creek.

7.2.2 Grimes Wash

Grimes Wash is an ephemeral tributary to Cottonwood Creek. Flow is measured at GWR01 (upper right fork), GWR02 (upper left fork), and GWR03 (below the mine; Figure 31). The right and left forks of Grimes Wash are usually dry except during the springtime snowmelt season. Flow at GWR03 is sustained by discharge from the Wilberg/Cottonwood Mine discharge. Flows in excess of 3,000 gpm during the spring runoff have been measured above the mine (Figure 36). Discharge below the mine is sometimes nearly absent during dry months. The lack of flow below the mine suggests that bedrock groundwater systems are not contributing substantially to the baseflow of the creek.

7.3 Bedrock Contribution to Streamflow

In an attempt to quantify the contributions of bedrock formations to the baseflow of creeks in the study area, Mayo and Associates performed gain-loss measurements on Cottonwood Creek in Straight Canyon and Indian Creek. The location of flow gaging stations and the measured flow rates are indicated on Figure 31. Discharge was gauged at three locations along Cottonwood Creek in Straight Canyon corresponding, from west to east, to the bedrock formation contacts at the top and bottom of the Blackhawk Formation and the bottom of the Star Point Sandstone. From the top of the Blackhawk Formation to the bottom of the Star Point Sandstone the measured flow of Cottonwood Creek increased by almost 15%. Whether this increase represents baseflow contributions from the Blackhawk Formation and Star Point Sandstone or measurement error is uncertain. Lines (1985) reported no significant gains along this same stretch when he gauged streamflows in 1981 and 1982. Lines does report flow increases along the stretch from the top of the Blackhawk Formation to the bottom of

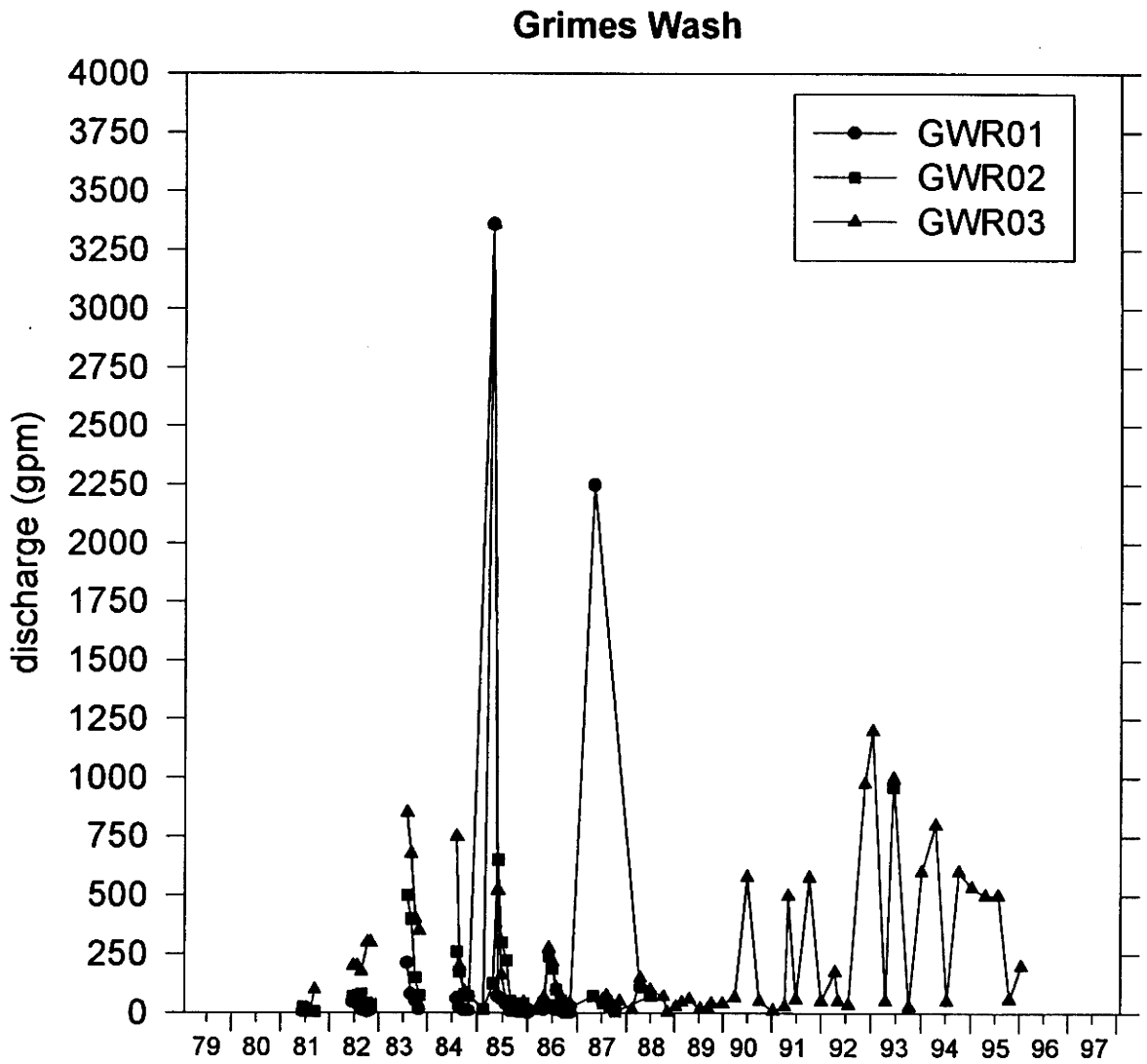

Figure 36 Instantaneous stream-discharge hydrographs for Grimes Wash.

the Star Point Sandstone to Cottonwood Creek in Cottonwood Canyon in 1981 and 1982. This increase is likely a result of interflow contribution or the forcing of water flowing through the alluvium to the surface due to decreased permeability of alluvial sediments derived from the Mancos Shale.

Flow measurements on Indian Creek indicated gains and losses that are greater than the error of measurement. The significance of these fluctuations is difficult to assess because the stream flows entirely on alluvial deposits and has abundant bank vegetation. Gains and losses could be accounted for by flow through alluvial sediments and transpiration by plants. Lines (1985) found only small gains and losses along Indian Creek in 1981 and 1982.

7.4 Discussion

Most of the recharge to creeks within the lease areas occurs from springtime snowmelt and from summer thunderstorms. Discharge rates in the creeks are extremely variable, and the creeks exhibit rapid response to snowmelt and thunderstorm events. The creeks are mostly ephemeral, and are not supported by bedrock groundwater discharge. Recharge to creeks in the study area is not sustained by bedrock groundwater systems and thus, most creeks sometimes dry out completely during the late summer and fall months or during periods of prolonged drought. Most of the streams within the lease areas are losing in their upper reaches and some are gaining in their lower reaches as they cross the Mancos Shale. The stream flow lost in the upper, ephemeral reaches is probably lost to alluvium (Semborski, Personal communication, 1997). As the creeks flow over the impermeable clayey sediments

of the Mancos Shale, the water in the alluvium is forced to the surface and becomes part of the above-ground flow in the creek.

There is no evidence of substantial bedrock discharge from Blackhawk Formation or Star Point Sandstone groundwater systems to the creeks in the lease areas. It is important to note, however, that this does not preclude near-surface drainage of saturated shallow bedrock and interflow. Likewise, we do not believe that creek water flowing in the alluvium is recharging deep bedrock formation groundwater systems in appreciable quantities.

The lack of hydraulic communication between creeks and deep bedrock groundwater systems has important implications to potential mining-related impacts to creek flow. The lack of a significant bedrock-derived baseflow component of creek discharge suggests that mining operations (i.e. the interception of deep groundwater systems in the Blackhawk Formation) will not adversely impact creek flows in the lease areas.

8. CONCLUSIONS

1. The δ^2H and $\delta^{18}O$ compositions demonstrate that all groundwaters are of meteoric origin (i.e. snow and rain).

2. Active and inactive groundwater regimes occur in the mine lease area.

3. The active regime includes alluvial groundwater, groundwater in the Flagstaff Formation, and all near surface exposures of the other bedrock formations except, perhaps, the Mancos Shale. The near surface extends about 500 to 1,000 feet into cliff faces. Groundwaters in the active regime contain abundant ^3H and anthropogenic ^{14}C.

4. Comparison of long-term discharge hydrographs with precipitation records demonstrates that active regime groundwaters: 1) are in direct hydraulic communication with the surface, 2) are recharged by modern precipitation, and 3) have large fluctuations in spring discharge rates which can be attributed to seasonal and climatic variability. High-flow/low-flow discharge rates vary as greatly as 600 gpm to nearly dry; however, most high flow rates are less than 50 gpm.

5. Despite the seasonal variability in discharge rates, the solute concentrations of active region groundwaters do not exhibit significant seasonal variability.

6. The inactive regime includes groundwater in sandstone channels in the North Horn, Price River, and Blackhawk Formations which are not in direct hydraulic communication with the surface (i.e. greater than about 500 to 1,000 feet from cliff faces). Mine workings are largely part of the inactive regime. The sandstone channels are vertically and horizontally isolated from each other and when encountered in mine workings are usually drained quickly. Coal seams are hydraulic barriers to groundwater flow. The blanket sands of the Star Point Sandstone are also largely in

the inactive zone. Except where exposed near cliff faces, faults encountered in mine workings are part of the inactive regime. Except near cliff faces, faults are not conduits for vertical hydraulic communication between otherwise hydraulically isolated pockets of groundwater.

7. Inactive region groundwater systems contain old groundwater (i.e. 2,000 to 12,000 years), and are not influenced by annual recharge events or short term climatic variability.

8. In-mine inactive regime groundwaters occur in nearly stagnant, isolated zones which have extremely limited hydraulic communication with other inactive regime groundwaters in the vicinity of mine workings and with near-surface active regime groundwaters as evidenced by the following:

   a) Groundwaters discharging into mine openings have ^{14}C ages ranging from 2,000 to 12,000 years

   b) Roof drip rates rapidly decline when water is encountered in the mine indicating that the saturated zone above the coal seam is not hydraulically continuous and has a limited vertical and horizontal extent.

   c) Unsaturated conditions have been identified in boreholes drilled vertically into sandstone channels located above coal seams.

9. The fact that inactive region groundwaters encountered in mine openings do not have an infinite age means that, at some time, there has been some hydraulic communication with the surface. This communication is extremely limited as illustrated by calculated steady state recharge-discharge rates of faults and sandstone channels in the inactive zone which range from 0.001 to 1.23 gpm.

10. Groundwater in the Star Point Sandstone is part of the inactive regime as evidenced by the 6,000 year ^{14}C age of the sample from well TM-3. In the down dip direction along the axis of the Straight Canyon Syncline, potentiometric pressures in the Spring Canyon member results in upwelling of groundwater into Hiawatha seam mine openings. Such upwelling may locally reduce the pressure in the Spring Canyon member.

11. Areally extensive groundwater regimes in the lower Blackhawk Formation and Star Point Sandstone do not exist within the lease area. Therefore, it is not meaningful to create piezometric surface maps of these systems.

12. Streamflow is dependent on snow melt, precipitation and thunderstorm activity. There is no apparent hydraulic communication between streamflow and groundwater encountered in mine openings.

13. The groundwater discharging into the Rilda Canyon alluvial collection system is of modern origin and is closely tied to seasonal recharge. This is evidenced by its modern radiocarbon and ^{3}H contents and by the discharge hydrographs. The alluvial groundwater is not related to the groundwater encountered in the mines.

14. The groundwater discharging in Cottonwood Canyon near Cottonwood Spring and Roans Spring discharges from glacial deposits and is of modern origin. The radiocarbon and ^{3}H contents of this water indicate a modern origin. The water in the shallow glacial deposits is not related to the groundwater encountered in the mines.

9. PROBABLE HYDROLOGIC CONSEQUENCES

This section describes the probable hydrologic consequences (PHC) of underground coal mining in the Trail Mountain LBA. The determination of the PHC is required by part R645-301-728 of the State of Utah Coal Mining Rules. This determination is based on the data and information presented in Sections 1-8 of this document. A recommended monitoring plan, as required by part R645-301-730.200 of the coal mining rules, is presented in Section 10 of this report.

This description of the PHC is based on the idea that the behavior of hydrologic and hydrogeologic systems in the Trail Mountain LBA is similar to those in East Mountain and the southern portion of Trail Mountain. These areas are nearly identical climatically, physiographically, and stratigraphically, and share many of the same geologic structures. Thus, the hydrologic consequences of underground coal mining in the Trail Mountain LBA will be similar to those at the Deer Creek, Cottonwood, Wilberg, and Trail Mountain mines.

9.1 Potential adverse impacts to the hydrologic balance (section 728.310)

The hydrologic balance is the sum of the flow interactions between surface waters and groundwaters and between various groundwater flow systems. Underground coal mining has the potential to impact the hydrologic balance by:

1. decreasing creek flows and spring discharges by capturing surface waters and/or groundwaters,
2. increasing creek flows by accelerating the rate of groundwater discharge from the mined horizon of the Blackhawk Formation, and

3. increasing groundwater recharge rates to overlying groundwater systems.

Subsidence-related fracturing can affect the hydrologic balance by capturing surface waters and/or groundwaters. In order for fracturing to reduce creek flows and spring discharges, such disturbances would have to result in the propagation of zones of increased vertical hydraulic conductivity. We do not believe that mining activities in the current PacifiCorp lease area have so affected surface and groundwater flows. The basis of this finding is discussed below.

The layout of the PacifiCorp mine plan is designed to minimize subsidence impacts to the steep cliffs of the Castlegate Sandstone (Chapter 3). As a result, nearly all subsidence that has been measured to date (Figure 2) occurs where the North Horn and, to a lesser extent, the Price River Formations are exposed at the surface. Vertical fractures are less likely to extend from the mined horizon into these formations because 1) the thickness of the overburden is from 900 to in excess of 2500 feet and 2) the North Horn Formation contains abundant clayey units that exhibit plastic deformation and swell when wetted (Section 4.3.1.2). This is extremely significant because more than 90% of the springs identified on East and Trail Mountains occur in the Price River and North Horn Formations and the overlying Flagstaff Limestone (Table A-1). These springs are effectively isolated from subsidence-related fracturing.

Numerous springs on East Mountain and several springs on Trail Mountain have been undermined. A smaller number of springs discharge from areas that have experienced

subsidence. As part of this investigation the hydrographs of these springs have been reviewed within the context of the mining history. Although some springs discharge from areas that have subsided as much as 10-12 feet, there is no evidence of discharge declines that can be attributed to mining-induced subsidence or fracturing.

Similarly, ephemeral and intermittent sections of Deer Creek and Grimes Wash have been subsided by as much as 10 feet (Figure 2). These creeks show no discharge declines that are attributable to mining-induced subsidence (Sections 7.1.3 and 7.2.2). Underground mining in the Trail Mountain LBA has the potential to impact intermittent side drainages that are tributary to Cottonwood Canyon Creek, intermittent tributaries to Cottonwood Canyon in Straight Canyon, and, possibly, Indian Creek. However, we do not anticipate that creek flows will be reduced by subsidence-related impacts to any of these creeks. Longwall mining does not occur beneath perennial streams, thus subsidence-related fracturing does not directly capture creek flows. Indian Creek lies beyond the western boundary of the lease area and no perennial streams discharge into the creek from within the Trail Mountain LBA. The boundary of the new LBA has been drawn so as to maintain at least a 1000-foot barrier between mine workings and the Joes Valley Fault system and Joes Valley. Therefore, the potential to detrimentally impact flows to Indian Creek in Joes Valley is negligible.

Appreciable amounts of groundwater are intercepted by underground coal mining. Mining quickly dewaters the saturated horizon immediately above the mined horizon and this water is not replaced as evidenced by the rapid decline and often complete drying of roof drips. In-mine groundwater occurs in isolated, inactive systems as demonstrated by the small ^{3}H

content and radiocarbon ages of mine waters which range from 2,000 to 12,000 years (Section 5.4), with the exception of one site which is discussed below. This indicates that in-mine waters are not in hydraulic connection with near-surface spring waters that respond to seasonal and climatic changes and contain anthropogenic carbon and appreciable amounts of ^{3}H.

Some in-mine groundwater sources have sustained discharges. Steady state calculations (Section 6.5.2) indicate that the recharge rate of 0.001 to 1.23 gpm could sustain these systems. What this means is that the amount of water being communicated from active near-surface groundwater systems to inactive deep systems is negligible. The interception of deep groundwater by mining is not removing water from overlying horizons.

Large groundwater inflows associated with the Roans Canyon fault system and Straight Canyon Syncline have occurred in the Deer Creek Mine (Section 6.3.2.2). Hydrologic concerns regarding the large-volume fault inflows are 1) the capture of water supplying baseflow to creeks or springs, and 2) the discharge of large volumes of fault-related water to creeks. In general, we do not believe that fault-discharge waters are tied to active, modern groundwater systems. Wells drilled into the fault system demonstrate that there is limited lateral communication along the fault system and the radiocarbon age of large volume fault-discharge waters are 8,000 to 12,000 years (Section 5.4).

Modern water does discharge from one point along the Roans Canyon Fault (site TW-10). However, this site is not representative of fault water discharge to the mine. TW-10 is a

horizontal dewatering well that intercepts fractured near-surface cliff rocks. The well is drilled from a rock tunnel driven across the fault to access blocks of coal north of the Roans Canyon Fault. The Deer Creek mine plan has been designed to avoid mining through the Roans Canyon Fault system, minimizing the amount of fault-related water that can be intercepted by mining. The discharge from TW-10 has stabilized at 4-5 gpm suggesting that the impact to near-surface waters is limited.

Mining in the Trail Mountain LBA will encounter the southwestern arms of both the Roans Canyon and Mill Fork fault zones. The Roans Canyon and Mill Fork fault systems are scissor faults hinged near the center of Trail Mountain. There is little vertical offset on these faults in Trail Mountain meaning that these faults may play a much smaller role in the transmission and storage of large quantities of groundwater than was seen in the Deer Creek Mine. However, the southwestern arm of the Roans Canyon fault zone is adjacent to the plunging end of the Straight Canyon Syncline, which is associated with higher confined groundwater pressures. Large quantities of water may be encountered if the Roans Canyon fault zone is intercepted in southwestern Trail Mountain.

Similarly, large quantities of water may be associated with the Star Point Sandstone on the southwesternmost section of the Straight Canyon Syncline. Mining of the Hiawatha Seam removes the confining layer and allows water to seep up into the floor of the mine. We anticipate that any water associated with the Roans Canyon Fault, the Mill Fork Fault, of the Straight Canyon Syncline that is encountered by mining in the southwestern Trail Mountain

will be part of an inactive groundwater system. Therefore, the removal of this water will not affect near-surface active groundwater systems.

The mining plan for the Trail Mountain LBA will be designed such as to minimize encounters with the Roans Canyon and Mill Fork faults. Additionally, wells will be drilled ahead of mining to evaluate potential high volume discharge areas. These areas will be grouted as mining progresses through such locations. Thus, no large groundwater inflows, such as were experienced in the Deer Creek Mine, are anticipated in the Trail Mountain Mine.

9.2 Presence of acid-forming or toxic-forming materials (728.320)

Acid-forming materials in western coal mines generally consist of sulfide minerals, which, when exposed to air and water, are oxidized causing the production of H^+ ions (acid). The sulfide mineral pyrite (FeS_2) has been identified in the PacifiCorp mines. Although the oxidation of pyrite occurs in the mine, acidic waters are not observed in the mine. The acid is quickly consumed by dissolution of abundant, naturally occurring carbonate minerals (Eqs. 3 and 4). Iron is readily precipitated as iron-hydroxide and excess iron is not observed in the mine discharge water.

No other acid-forming materials or any toxic-forming materials have been identified or are suspected to exist in materials disturbed by mining.

9.3 Impact of coal mining on sediment yield from disturbed areas (728.331)

The sediment load of streams can be impacted by increased sediment yield from areas disturbed by mining activities. Disturbed areas include: 1) surface workings, 2) mined-out areas, 3) subsided landscape above mine workings, and 4) sediment load from mine discharge water. Sediment yield from surface workings is minimized by sediment control structures that are installed and maintained according to the specifications in the mine permit. The sediment yield of mine discharge water is minimized through the use of sediment ponds. The sediment load of mine discharge water is monitored monthly according to UPDES permit specifications.

The sediment load of ephemeral and intermittent streams can be increased or decreased as a result of subsidence. Subsidence can locally increase stream gradients, causing higher flow velocities in the stream channel and greater sediment entrainment. The extent to which this phenomenon occurs in the lease area is not known; however, the impact would be localized and short-lived. The sediment load of ephemeral and intermittent streams would be decreased where subsidence causes water to be impounded. Here, stream flows would be decreased and sediment would be deposited in the impoundment. This occurrence would also be short-lived.

9.4 Impacts to important water quality parameters (728.332)

Solute and trace element composition and field parameters of springs, creeks, and mine discharge water have been monitored periodically to detect impacts to water quality. Inspection of the field parameters and solute and trace element composition of springs indicates no mining-related impacts on spring water quality. (It is difficult to envision a

mechanism to affect the water quality of springs in horizons above the mine). Similarly, water quality in creeks above the mine water discharge points has not been impacted.

As mining had progressed into areas near the axis of the Straight Canyon Syncline, groundwater discharge into the mine has exceeded in-mine water requirements and water will be discharged into Cottonwood Canyon Creek. The quality of groundwater intercepted in the Trail Mountain Mine is similar to water that is currently being discharged from the Deer Creek and Cottonwood Mines. This water meets secondary drinking water quality standards and does not have detrimental impacts to the quality of receiving waters. The quality of water discharged by the Trail Mountain Mine will be monitored periodically and be subject to UPDES permit specifications.

9.5 Flooding or streamflow alteration (728.333)

As mining has progressed into areas near the axis of the Straight Canyon Syncline, groundwater discharge into the mine has exceeded in-mine water requirements and water will be discharged into Cottonwood Canyon Creek. The amount of water that will be discharged is difficult to determine. We expect that the discharge will be much less than maximum flows during the springtime runoff and during summer thundershowers. We do not expect that flooding or streamflow alteration will result from mine water discharge to Cottonwood Canyon Creek.

9.6 Groundwater and surface water availability (728.334)

Mining in the new Trail Mountain LBA will not significantly affect the availability of groundwater. As described in Section 6.3, groundwaters in the lower Blackhawk Formation exist in highly compartmentalized partitions, both vertically and horizontally, and the formation does not act as a hydraulically continuous aquifer. The groundwater systems in the Blackhawk Formation were also demonstrated to be hydraulically isolated from overlying, modern groundwaters. The effects of locally dewatering the Blackhawk Formation adjacent to mine openings will not have any significant impact on groundwater availability in the region surrounding the mine.

There are no groundwater supply wells in the mine lease area. The removal of water from horizons immediately above and below the mined horizon will not impact any water supplies. Rather, underground mining makes water available from the Blackhawk Formation that was previously inaccessible.

10. RECOMMENDED MONITORING PLAN

The proposed monitoring program for wells, springs, and streams in the Trail Mountain LBA is shown in Figure 37 and is summarized in Tables 6, 7, and 8 and is described below.

10.1 Springs

We recommend that 8 springs be monitored within the Trail Mountain LBA. The proposed spring monitoring program is designed to provide verification that

1. groundwater systems in the formations overlying mined areas operate independently of Blackhawk Formation groundwater systems in the mine,
2. the temporal variability of spring discharges are due to climatic variability (i.e. wet and dry years), and
3. mining will not affect groundwater systems in overlying formations.

The spring monitoring locations have been chosen to provide information from each geologic formation and each significant hydrogeologic feature. Locations within each of the bedrock formations are recommended (with the exception of the Flagstaff Limestone from which no springs are known to discharge). Monitoring locations in the vicinity of the Roans Canyon Fault Graben within each of the North Horn, Price River, and Blackhawk Formations are included.

The chemical character of springs discharging from East and Trail Mountains is well documented. Many of these springs have been continuously monitored for solute chemistry for more than 20 years. As discussed in section 5.2.2, significant temporal variations in the

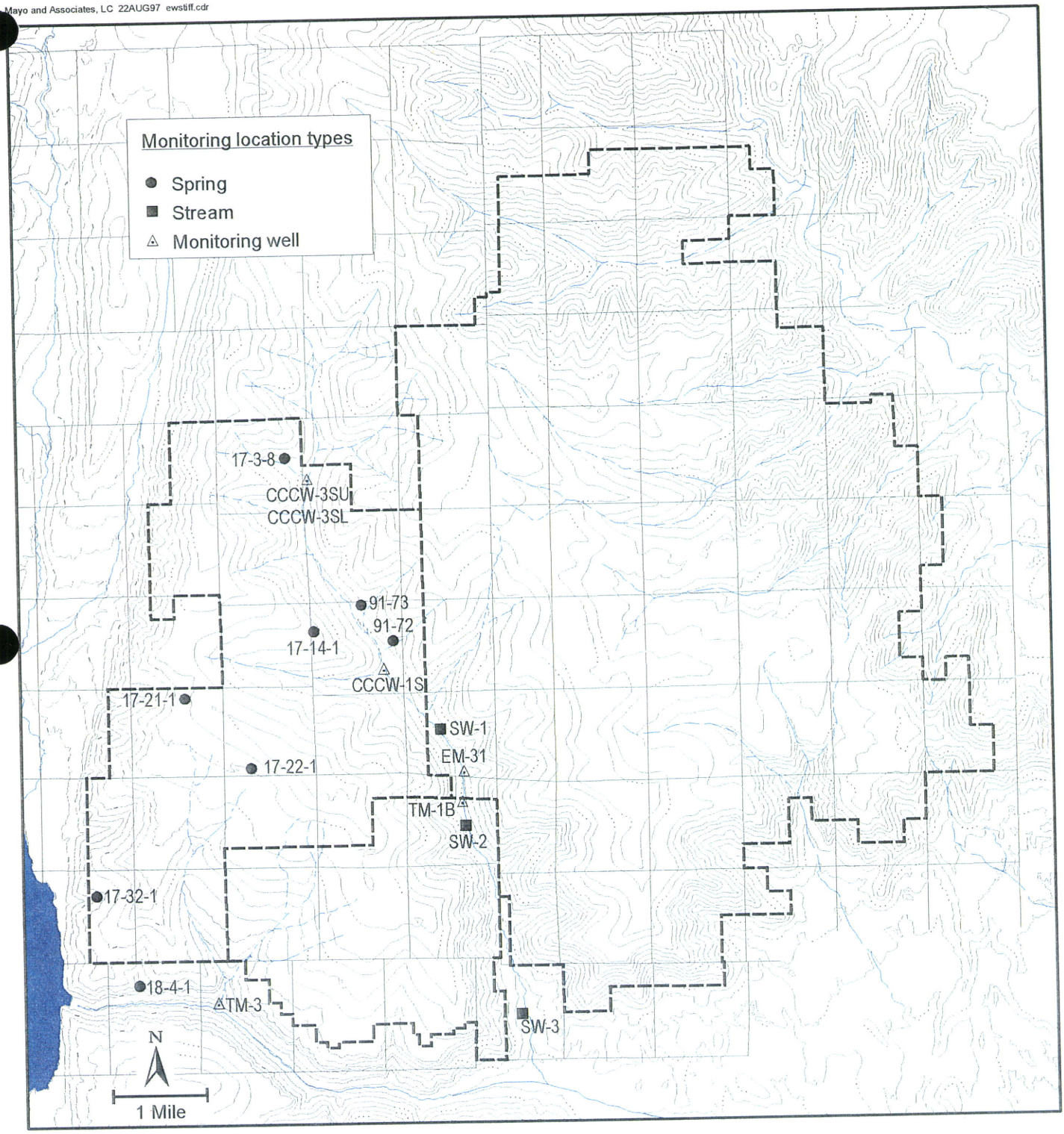

Figure 37 Proposed hydrologic monitoring plan for Trail Mountain LBA

solute chemical composition of springs does not exist. As discussed in Chapter 6 of this report, the active groundwater systems from which most springs in the lease area discharge are not in hydraulic communication with the deep, inactive zone groundwaters encountered in the mine. There is no reasonably likely mechanism by which mining activities can adversely impact the solute composition of groundwater discharging from springs overlying the mine workings. For these reasons we believe that long-term chemical monitoring of these springs is not particularly useful. We, therefore, recommend that the springs in the Trail Mountain LBA be monitored for flow and operational water quality parameters for a period of two years. During this two-year period the baseline chemical composition of the springs will be documented. Following two years of monitoring for operational water quality parameters, the springs need only be monitored for flow and field parameters.

10.1.1 North Horn Formation

We recommend that three springs be monitored within the North Horn Formation. These springs include 17-14-1, 17-21-1, and 17-22-1. It was demonstrated in this investigation that the active-zone groundwater systems of the North Horn Formation are not in hydraulic communication with the groundwater systems encountered within the mine. It was likewise demonstrated that the possibility of mining related subsidence fractures intercepting flow to the North Horn Formation springs is minimal. We, therefore, do not anticipate any detrimental impacts on the flow or solute chemistry of these springs. However, to document the responses of these springs to long-term fluctuations in climate, and to verify that subsidence fractures do not adversely impact spring flows, we recommend that these springs be regularly monitored.

10.1.2 Price River Formation

We recommend that spring 17-32-1 in the Price River Formation be regularly monitored. This spring has historically been utilized as a domestic water source and will likely have sustained flow throughout the year. Spring 17-32-1 discharges near the distal, down-gradient end of the Straight Canyon Syncline in the Roans Canyon Fault Graben.

10.1.3 Castlegate Sandstone and Blackhawk Formation

We recommend the monitoring of four springs near the formational contact between the Castlegate Sandstone and Blackhawk Formation. These include 17-3-8, 91-72, 91-73, and 18-4-1. Spring 18-4-1 discharges from the Castlegate Sandstone near the distal end of the Straight Canyon Syncline. Spring 17-14-2 discharges from the Blackhawk Formation within the Roans Canyon Fault Graben in Cottonwood Canyon. Spring 17-3-8 discharges from the Blackhawk Formation on the western slope of Cottonwood Canyon. Spring 17-14-2 discharges from a shallow, active system on the eastern slope of Cottonwood Canyon.

10.2 Creeks

We recommend regular monitoring of sites SW-1, SW-2, and SW-3 on Cottonwood Canyon Creek. SW-1 is located at the approximate first occurrence of flow in the creek. SW-2 is located within the existing Trail Mountain permit area below the mine discharge points UPDES 001 and 002. SW-3 is located below the mine permit area near the confluence with Cottonwood Creek.

Indian Creek lies beyond the western boundary of the lease area and no perennial streams discharge into the creek from within the Trail Mountain LBA. Likewise, no major springs have been identified which discharge from the western flanks of Trail Mountain that would be available for monitoring. The western boundaries of the LBA have been drawn such that projected mining areas will maintain at least a 1000-foot barrier between mine openings and the Joes Valley Fault. Therefore, the potential to detrimentally impact flows in Indian Creek is negligible and regular monitoring of Indian Creek is not recommended.

Reliable flow monitoring of the upper reaches of Cottonwood Creek below the Joes Valley Reservoir discharge is not possible. Detrimental impacts on the creek flow would need to be determined by stream gauging at an upstream point (at the reservoir discharge) and at a point approximately two miles downstream. We believe that the magnitude of any potential impact on flow to the creek would be many times less than the error of the flow measurement using best available technology. Based on the information gained in this investigation, we do not anticipate significant detrimental impacts on the creek. We, therefore, do not recommend any monitoring of Cottonwood Creek.

10.3 Wells

We recommend the monitoring of six wells within the new Trail Mountain LBA. These include four wells (TM-3, TM-1B, CCCW-3SL, and CCCW-1S) in the Star Point Sandstone below the mined horizon, and two (EM-31, CCCW-3SU) in the Blackhawk Formation.

Table 6 Recommended monitoring locations and protocols.

MONITORING PROTOCOLS

Water level and flow measurements

A Monitoring well: quarterly water level measurements
B Stream: quarterly discharge measurements
C Spring: quarterly discharge measurements

Water quality

1 Stream: quarterly water quality operational laboratory measurements
2 Spring: quarterly water quality operational laboratory measurements for two (2) years, then reverting to field parameters only

MONITORING LOCATIONS AND PROTOCOLS

Monitoring Well	Protocol	Comments
TM-1B	A	Screened in Star Point Sandstone
TM-3	A	Screened in Star Point Sandstone
EM-31	A	Screened in Blackhawk Formation and Star Point Sandstone
CCCW-3S L	A	Screened in Star Point Sandstone
CCCW-3S U	A	Screened in Blackhawk Formation
CCCW-1S	A	Screened in Star Point Sandstone
Streams		
SW-1	B,1	Cottonwood Canyon Creek (upper, first perennial)
SW-2	B,1	Cottonwood Canyon Creek (below UPDES 001 and 002)
SW-3	B,1	Cottonwood Canyon Creek (below lease)
Springs		
17-14-1	C,2	North Horn Formation
17-21-1	C,2	North Horn Formation
17-22-1	C,2	North Horn Formation
17-32-1	C,2	Price River Formation
17-3-8	C,2	Castlegate/Blackhawk contact
17-14-2	C,2	Castlegate/Blackhawk contact
17-14-3	C,2	Castlegate/Blackhawk contact
18-4-1	C,2	Castlegate/Blackhawk contact

Table 7 Recommended groundwater operational water quality monitoring

FIELD MEASUREMENTS	REPORTED AS
pH	pH units
Specific Conductivity	µs/cm @ 25°C
Temperature	°C

LABORATORY MEASUREMENTS	
Total Dissolved Solids	mg L^{-1}
Carbonate	mg L^{-1}
Bicarbonate	mg L^{-1}
Calcium (dissolved)	mg L^{-1}
Chloride	mg L^{-1}
Iron (total)	mg L^{-1} (3rd quarter only)
Magnesium (dissolved)	mg L^{-1}
Manganese (total)	mg L^{-1} (3rd quarter only)
Potassium (dissolved)	mg L^{-1}
Sodium (dissolved)	mg L^{-1}
Sulfate	mg L^{-1}
Cations	meq L^{-1}
Anions	meq L^{-1}

Table 8 Recommended surface water operational water quality monitoring

FIELD MEASUREMENTS	REPORTED AS
pH	pH units
Specific Conductivity	µs/cm @ 25°C
Dissolved Oxygen	mg L^{-1}
Temperature	°C
LABORATORY MEASUREMENTS	
Total Dissolved Solids	mg L^{-1}
Carbonate	mg L^{-1}
Bicarbonate	mg L^{-1}
Calcium (dissolved)	mg L^{-1}
Chloride	mg L^{-1}
Iron (total)	mg L^{-1}
Magnesium (dissolved)	mg L^{-1}
Manganese (total)	mg L^{-1}
Potassium (dissolved)	mg L^{-1}
Sodium (dissolved)	mg L^{-1}
Sulfate	mg L^{-1}
Oil and grease	mg L^{-1}
Cations	meq L^{-1}
Anions	meq L^{-1}

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Appendix A

Isotope laboratory analytical reporting sheets

Application of Selected Isotopes to Hydrogeologic Problems

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Oxygen-18 ($\delta^{18}O$) and deuterium ($\delta^{2}H$)

Worldwide, the $\delta^{2}H$ and $\delta^{18}O$ of precipitation (rain and snow) generally follow the empirical relationship:

$$\delta^{2}H = s\,(\delta^{18}O) + d\ (‰)$$

Where s is the slope and d is the deuterium excess (Merlivant and Jouzel, 1983). Craig (1961) and Dansgaard (1964) have shown that, on the global scale, s approximates 8 and d approximates 10 for coastal meteoric water. The meteoric water line (MWL) is therefore defined as:

$$\delta^{2}H = 8(\delta^{18}O) + 10\ (‰)$$

The $\delta^{18}O$ and $\delta^{2}H$ composition of groundwaters can be used to help evaluate the origin and flow and mixing patterns of groundwaters. Groundwater recharged during cooler climates or at higher elevations will have more negative isotopic compositions than groundwater which recharged during warmer climates or at lower elevations. Groundwaters which have been heated above about 100°C during deep circulation will exhibit a positive $\delta^{18}O$ shift relative to the $\delta^{2}H$ composition. Groundwater of non-meteoric origin (i.e. connate and magmatic) will not plot along the MWL.

Carbon-13 ($\delta^{13}C$)

Most groundwater acquires 50 percent of its carbon from soil zone water and 50 percent of its carbon from the dissolution of carbonate minerals in the soil zone or aquifer skeleton. Because the $\delta^{13}C$ of marine carbonate minerals is about 0 ‰ (Muller and Mayo, 1986) and soil zone CO_2 gas has a $\delta^{13}C$ of -18 to -27 ‰, most groundwaters have a $\delta^{13}C$ of ≈ -9 to -13 ‰.

Sulfur-34 ($\delta^{34}S$)

The anticipated range of $\delta^{34}S$ values in Mesozoic early Tertiary gypsum and anhydrite is +10 to +20 ‰ (Holser and Kaplan, 1966). At non-thermal aquifer temperatures, isotopic fractionation accompanying gypsum dissolution may be represented as:

$$\underset{(\delta^{34}S\ = +15\ ‰)}{CaSO_{4(s)}} \quad \overset{^{34}S\ \text{enrichment}}{\Rightarrow} \quad \underset{(\delta^{34}S = +9\ ‰)}{Ca^{2+} + SO_4^{2-}}$$

where the value $\delta^{34}S \approx +15$ ‰ has been arbitrarily selected.

The typical $\delta^{34}S$ value of magmatic pyrite is about 0 ‰ (Faure, 1986). A $\delta^{34}S$ of -2.2 ‰ has been reported for pyrite in the Park City, Utah District (Thode and others, 1961). Mayo and Klauk (1991) found a mean $\delta^{34}S$ of +1.3 ‰ in groundwater from non-carbonate (crystalline rock) aquifers in north central Utah. Mayo and Kravits (unpublished data) found a $\delta^{34}S$ value of pyrite in the SUFCO coal mine, Utah of +3.4 ‰. Sulfur isotopic fractionation does not accompany the dissolution of pyrite.

Tritium (^3H)

Tritium (^3H), the radioactive isotope of hydrogen, has been used in groundwater investigations to differentiate between groundwaters which recharged prior to or after the advent of atmospheric thermonuclear weapons testing. Tritium, whose half-life is 12.26 years, forms naturally in the upper stratosphere by the interaction of ^{14}N with cosmic ray neutrons according to the reaction:

$$^{14}N + n \Rightarrow {}^3H + {}^{12}C$$

Tritium is rapidly incorporated into water molecules and is removed from the atmosphere by precipitation.

Prior to the advent of atmospheric thermonuclear weapons testing in 1952, tritium activity in precipitation ranged from 4 to 25 tritium units (TU). One TU equals one ^3H atom per 10^8 hydrogen atoms. In mountainous areas, larger natural concentrations have been observed (Fontes, 1983). During the peak of atmospheric weapons testing, tritium levels in precipitation rose to m ore than 2,200 TU in some northern hemisphere locations (Fontes, 1983). As of 1987, the ^3H concentrations in rain water varied from 25 to 50 TU. Unpublished data of 1991 and 1992 snow samples collected in the central Wasatch Range, Utah have ^3H concentrations of 20 TU or more.

Carbon-14 (^{14}C)

Carbon-14, the radioactive isotope of carbon, has a half-life of 5730 ± 30 years (Godwin, 1962). Carbon-14 is produced in the upper atmosphere by a variety of reactions that involve the collision of cosmic radiation (neutrons) with stable isotopes of nitrogen, oxygen, and carbon. The most important of these reactions is between neutrons and ^{14}N according to the reaction:

$$n + {}^{14}N \Rightarrow {}^{14}C + p$$

where n is a neutron and p is a proton (Libby, 1955). Carbon-14 is incorporated into $CO_{2(g)}$ and rapidly mixes throughout the atmosphere and hydrosphere where steady state equilibrium between ^{14}C production and ^{14}C decay is attained (Faure, 1986).

The pre-industrial revolution atmospheric ^{14}C content has been assigned the steady state value of 100 percent modern carbon (pmc). The burning of fossil fuels and the advent of atmospheric thermonuclear weapons testing greatly altered the ^{14}C activity in post-industrial revolution atmosphere. Burning of fossil fuels, whose ^{14}C had previously completely decayed away, decreased the ^{14}C content in the troposphere in the northern hemisphere by about 3% (Houtermans and others, 1967). Atmospheric weapons testing greatly increased the atmospheric ^{14}C activity by the mid 1960's (Ferronsky and Polyakov, 1982).

The post-industrial revolution atmospheric ^{14}C perturbations and laboratory measurement error in measuring the ^{14}C content of groundwater make the reliable lower limit for ^{14}C dating about 450 years. The upper limit of ^{14}C dating, using conventional laboratory analytical methods, is about 35,000 years.

Estimating the age of dead wood or other organic carbon is relatively simple. The ^{14}C activity of pre-industrial revolution organic material is assumed to be 100 pmc. The radiocarbon date is then corrected for systematic variations in atmospheric ^{14}C that have been established by comparing tree ring dates of the wood of Sequoia and Bristlecone Pines with their corresponding radiocarbon ages (LaMarche and Harlan, 1973; Michael and Ralf, 1970).

Estimating the radiocarbon age of groundwaters is not as straightforward as estimating the age of dead organic matter. Groundwater acquires carbon from numerous sources, many of which had initial ^{14}C activities of less than 100 pmc. The ^{14}C content of groundwater is affected by four factors:

1) the addition of "live" carbon (i.e., $^{14}C \approx 100$ pmc) from the biogenic production of $CO_{2(g)}$ in the soil zone,
2) the addition of "dead" carbon from the weathering of minerals in the soil zone and the dissolution of carbonate minerals in the soil zone or aquifer (i.e., $^{14}C \approx 0$ pmc),
3) the addition of "dead" carbon from the soil or aquifer during isotopic exchange reactions, and
4) the addition of both "live" and "dead" carbon by other processes.

The crux of dating groundwater is estimating the initial ^{14}C activity (A_o) of the water at the time of recharge. This may be accomplished by using the solute and isotopic chemistries of the groundwater and applying correction procedures. Correction procedures for estimating A_o are in the form of mathematical equations that attempt to account for the contribution of "dead" carbon and ^{14}C from various sources, and for the effects of the isotopic exchange and fractionation processes.

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Appendix B

Application of selected isotopes to hydrogeologic problems

Cross-reference Information

Laboratory reporting sheet description	Database description
Cottonwood Mine Main West Seals	MW Seals
Deer Creek 3rd South Seals	3S Seals
TMA	TMA X 32
Roans Spring	Roans Canyon Spring
2nd S XC11	2S X 11
6th West Fault	6W X 20
Wilberg Fault E1 X29	1.5N X 29
Rilda Canyon Meter #3	NEWUA meter #3

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STABLE ISOTOPE RATIO ANALYSES

REPORT OF ANALYTICAL WORK

Submitted by: Kelly Payne
Mayo and Associates
710 East 100 North
Lindon, UT 84042

Date Received: 12/10/96
Date Reported: 01/03/97
Your Reference: Letter of
Dec. 2, 1996
Energy West

Our Lab. Number	Your Sample Number	Description	δD*			δ^{18}O*		
HOR-91670	EW-TM-17-3-9	Water	-129	-129	**	-16.8		
HOR-91671	EW-TM-17-22-1	Water	-122	-123	**	-15.3		
HOR-91672	EW-TM-17-28-4	Water	-128	-128	**	-16.0	-16.0	**
HOR-91673	EW-TM-18-2-1	Water	-131			-16.9		

** Duplicate preparations and analyses.

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

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

Where:

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

And:

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

**Double atom ratio

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STABLE ISOTOPE RATIO ANALYSES

REPORT OF ANALYTICAL WORK

Submitted by: Kelly Payne
Mayo and Associates
710 East 100 North
Lindon, UT 84042

Date Received: 12/19/96
Date Reported: 01/10/97
Your Reference: Letter of
16 DEC 1996
Energy West

Our Lab. Number	Your Sample Number	Description	δD*	$\delta^{18}O$*
HOR-91770	91-73	Water	-130	-17.0
HOR-91771	18-4-1	Water	-130	-17.3
HOR-91772	91-72	Water	-127	-16.7 -16.8 **
HOR-91773	16-34-6	Water	-129	-16.9
HOR-91774	~~CCW-15~~ CCCW-15 KLP	Water	-130	-17.3
HOR-91775	17-32-1	Water	-130	-17.2
HOR-91776	~~TW-3~~ TM-3 KLP	Water	-129	-17.3
HOR-91777	80-50	Water	-124	-16.7
HOR-91778	84-57	Water	-119 -119 **	-15.9
HOR-91779	Rilda Canyon Meter #3	Water	-123	-16.3
HOR-91780	Wilberg Fault E1 XC29	Water	-123	-16.2 -16.3 **
HOR-91781	T-18 Oliphant Spring	Water	-130	-17.0

** Duplicate preparations and analyses.

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

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

Where:

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

And:

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

**Double atom ratio

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Date Reported: 01/10/97
Your Reference: Letter of
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Energy West

Our Lab. Number	Your Sample Number	Description	δD*	δ^{18}O*
HOR-91782	CCC Trail Snow	Water	-139 -141 **	-18.4
HOR-91783	Cottonwood Canyon Snow	Water	-140	-18.4

** Duplicate preparations and analyses.

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

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

Where:

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

And:

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

**Double atom ratio

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Submitted by: Kelly Payne
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Lindon, UT 84042

Date Received: 08/16/96
Date Reported: 02/24/97
Your Reference:

NB: The hydrogen isotope results for these samples, previously reported on 29 AUG 96, were incorrect. The samples have been re-analyzed and the new hydrogen results are reported below:

Our Lab. Number	Your Sample Number	Description	δD^*	$\delta^{18}O^*$
HOR-90674	East Mtn Snow #1	Water	-141 -140 **	-19.2
HOR-90675	Snow #2	Water	-143	-19.4
HOR-90676	Deer Creek Mine Portal Snow	Water	-133	-17.7
HOR-90677	E. Joe's Valley Res.	Water	-140	-18.5
HOR-90678	Roans Spring	Water	-125 -125 **	-16.6
HOR-90679	NEWUA Meter #3	Water	-122	-16.3
HOR-90680	TMA	Water	-123	-16.3
HOR-90681	2nd S. XC11	Water	-126	-16.3
HOR-90682	UG - 3	Water	-130	-16.9 -16.9 **
HOR-90683	MN - ME	Water	-126	-16.7
HOR-90684	TW - 10	Water	-123	-16.4
HOR-90685	6th West Fault	Water	-126	-16.8

** Duplicate preparations and analyses.

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

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

Where:

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

And:

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

**Double atom ratio

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STABLE ISOTOPE RATIO ANALYSES

REPORT OF ANALYTICAL WORK

Submitted by: Kelly Payne
Mayo and Associates
710 East 100 North
Lindon, UT 84042

Date Received: 03/06/97
Date Reported: 03/28/97
Your Reference: Letter of March 3, 1997 Energy West

Our Lab. Number	Your Sample Number	Description	δD^*			$\delta^{18}O^*$	
HOR-92620	Cottonwood Mine Main West Seals	Water	-128	-127	**	-16.7	
HOR-92621	Deer Creek 3rd South Seals	Water	-128			-16.7	-16.6 **

** Duplicate analyses on separate aliquots of original sample.

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

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

Where:

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

And:

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

**Double atom ratio

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STABLE ISOTOPE RATIO ANALYSES

REPORT OF ANALYTICAL WORK

Submitted by: Kelly Payne
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710 East 100 North
Lindon, UT 84042

Date Received: 08/16/96
Date Reported: 09/12/96
Your Reference: Letter of Aug. 13

Our Lab. Number	Your Sample Number	Description	$\delta^{34}S$*
SR-90686	Roans Spring	$BaSO_4$	-0.4
SR-90687	Meter #3	$BaSO_4$	+3.4
SR-90688	TMA	$BaSO_4$	+21.0 +21.0 **
SR-90689	2nd S. XC11	$BaSO_4$	+13.3
SR-90690	UG - 3	$BaSO_4$	+19.0
SR-90691	MN - ME	$BaSO_4$	+5.1
SR-90692	TW - 10	$BaSO_4$	+2.2
SR-90693	6th West Fault	$BaSO_4$	+9.3

** Duplicate preparations and analyses.

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

$$\delta^{34}S_{sample}‰ = \left[\frac{^{34}S/^{32}S_{sample}}{^{34}S/^{32}S_{standard}} - 1 \right] \times 1000$$

Where:

$^{34}S/^{32}S$ standard is Cañon Diablo troilite

And:

$^{34}S/^{32}S = 0.0450045$

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STABLE ISOTOPE RATIO ANALYSES — REPORT OF ANALYTICAL WORK

Submitted by: Kelly Payne
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Lindon, UT 84042

Date Received: 12/19/96
Date Reported: 02/04/97
Your Reference: Letter of
16 DEC 1996
Energy West

Our Lab. Number	Your Sample Number	Description	$\delta^{34}S$*
SR-91758	91-73	$BaSO_4$	+ 7.9
SR-91759	18-4-1	$BaSO_4$	0.0
SR-91760	91-72	$BaSO_4$	- 4.9
SR-91761	16-34-6	$BaSO_4$	+16.2
SR-91762	~~CCW-15~~ cccw-1S KLP	$BaSO_4$	+13.2
SR-91763	17-32-1	$BaSO_4$	-13.7 -13.5 **
SR-91764	~~TW-3~~ TM-3 KLP	$BaSO_4$	+27.7
SR-91765	80-50	$BaSO_4$	+23.2
SR-91766	84-57	$BaSO_4$	+ 1.9
SR-91767	Rilda Canyon Meter #3	$BaSO_4$	+ 8.7
SR-91768	Wilberg Fault E1 XC29	$BaSO_4$	+ 6.9
SR-91769	T-18 Oliphant Spring	$BaSO_4$	+ 9.8

** Duplicate preparations and analyses.

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

$$\delta^{34}S_{sample}‰ = \left[\frac{^{34}S/^{32}S_{sample}}{^{34}S/^{32}S_{standard}} - 1 \right] \times 1000$$

Where:

$^{34}S/^{32}S$ standard is Cañon Diablo troilite

And:

$^{34}S/^{32}S$ = 0.0450045

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STABLE ISOTOPE RATIO ANALYSES

REPORT OF ANALYTICAL WORK

Submitted by: Kelly Payne
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Date Received: 12/10/96
Date Reported: 01/03/97
Your Reference: Letter of
Dec. 2, 1996
Energy West

Our Lab. Number	Your Sample Number	Description	$\delta^{34}S$*
SR-91666	EW-TM-17-3-9	$BaSO_4$	+5.8
SR-91667	EW-TM-17-22-1	$BaSO_4$	+3.1 +2.9 **
SR-91668	EW-TM-17-28-4	$BaSO_4$	-2.7
SR-91669	EW-TM-18-2-1	$BaSO_4$	-20.1

** Duplicate preparations and analyses.

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

$$\delta^{34}S_{sample}‰ = \left[\frac{^{34}S/^{32}S_{sample}}{^{34}S/^{32}S_{standard}} - 1 \right] \times 1000$$

Where:

$^{34}S/^{32}S$ standard is Cañon Diablo troilite

And:

$^{34}S/^{32}S = 0.0450045$

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STABLE ISOTOPE RATIO ANALYSES

REPORT OF ANALYTICAL WORK

Submitted by: Kelly Payne
Mayo and Associates
710 East 100 North
Lindon, UT 84042

Date Received: 03/06/97
Date Reported: 04/14/97
Your Reference: Letter of March 3, 1997 Energy West

Our Lab. Number	Your Sample Number	Description	$\delta^{34}S$*
SR-92622	Cottonwood Mine Main West Seals	$BaSO_4$	+11.5
SR-92623	Deer Creek 3rd South Seals	$BaSO_4$	+13.8 +13.9 **

** Duplicate analyses on separate aliquots of sample.

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

$$\delta^{34}S_{sample}‰ = \left[\frac{^{34}S/^{32}S_{sample}}{^{34}S/^{32}S_{standard}} - 1 \right] \times 1000$$

Where:

$^{34}S/^{32}S$ standard is Cañon Diablo troilite

And:

$^{34}S/^{32}S = 0.0450045$

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RADIOCARBON AGE DETERMINATION — REPORT OF ANALYTICAL WORK

Our Sample No. GX-22180

Date Received: 08/16/96

Your Reference: letter of 08/13/96

Date Reported: 08/27/96

Submitted by: Mr. Kelly Payne
Mayo & Associates
710 East 100 North
Lindon, Utah 84042

Sample Name: TMA (Cottonwood)
groundwater precipitate

AGE = 11,150 +/- 285 C-14 years BP (C-13 corrected).
(24.97 +/- 0.88) % of the modern (1950) C-14 activity.

Description: Sample of groundwater precipitate.

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

Comment:

$\delta^{13}C_{PDB}$ = -10.0 ‰

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

The age is referenced to the year A.D. 1950.

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RADIOCARBON AGE DETERMINATION — REPORT OF ANALYTICAL WORK

Our Sample No. GX-22181 — Date Received: 08/16/96

Your Reference: letter of 08/13/96 — Date Reported: 08/27/96

Submitted by: Mr. Kelly Payne
Mayo & Associates
710 East 100 North
Lindon, Utah 84042

Sample Name: 2nd S. XC11 (Cottonwood)
groundwater precipitate

AGE = 16,930 +/- 470 C-14 years BP (C-13 corrected).
(12.15 +/- 0.70) % of the modern (1950) C-14 activity.

Description: Sample of groundwater precipitate.

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

Comment:

$\delta^{13}C_{PDB}$ = - 7.5 ‰

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

The age is referenced to the year A.D. 1950.

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RADIOCARBON AGE DETERMINATION — REPORT OF ANALYTICAL WORK

Our Sample No. GX-22182 — Date Received: 08/16/96

Your Reference: letter of 08/13/96 — Date Reported: 08/27/96

Submitted by: Mr. Kelly Payne
Mayo & Associates
710 East 100 North
Lindon, Utah 84042

Sample Name: UG-3 (Trail Mtn.)
groundwater precipitate

AGE = 9,420 +/- 290 C-14 years BP (C-13 corrected).
(30.95 +/- 1.12) % of the modern (1950) C-14 activity.

Description: Sample of groundwater precipitate.

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

Comment:

$\delta^{13}C_{PDB}$ = -14.0 ‰

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

The age is referenced to the year A.D. 1950.

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RADIOCARBON AGE DETERMINATION — REPORT OF ANALYTICAL WORK

Our Sample No. GX-22183 — Date Received: 08/16/96

Your Reference: letter of 08/13/96 — Date Reported: 08/27/96

Submitted by: Mr. Kelly Payne
Mayo & Associates
710 East 100 North
Lindon, Utah 84042

Sample Name: TW-10 (Deer Creek)
groundwater precipitate

AGE = 3,790 +/- 150 C-14 years BP (C-13 corrected).
(62.39 +/- 1.19) % of the modern (1950) C-14 activity.

Description: Sample of groundwater precipitate.

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

Comment:

$\delta^{13}C_{PDB}$ = -10.5 ‰

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

The age is referenced to the year A.D. 1950.

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RADIOCARBON AGE DETERMINATION — REPORT OF ANALYTICAL WORK

Our Sample No. GX-22184 — Date Received: 08/16/96

Your Reference: letter of 08/13/96 — Date Reported: 08/27/96

Submitted by: Mr. Kelly Payne
Mayo & Associates
710 East 100 North
Lindon, Utah 84042

Sample Name: 6th West Fault (Deer Creek)
groundwater precipitate

AGE = 6,930 +/- 280 C-14 years BP (C-13 corrected).
(42.23 +/- 1.47) % of the modern (1950) C-14 activity.

Description: Sample of groundwater precipitate.

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

Comment: Small sample; approximately 0.62 grams carbon.

$\delta^{13}C_{PDB}$ = -10.3 ‰

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.

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RADIOCARBON AGE DETERMINATION — REPORT OF ANALYTICAL WORK

Our Sample No. GX-22271 — Date Received: 08/16/96

Your Reference: telephone instructions 09/16/96 — Date Reported: 09/30/96

Submitted by: Mr. Kelly Payne
Mayo & Associates
710 East 100 North
Lindon, Utah 84042

Sample Name: Roans Spring
groundwater precipitate

AGE = 2,500 +/- 120 C-14 years BP (C-13 corrected).
(73.24 +/- 1.11) % of the modern (1950) C-14 activity.

Description: Sample of groundwater precipitate.

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

Comment:

$\delta^{13}C_{PDB}$ = -10.4 ‰

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

The age is referenced to the year A.D. 1950.

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RADIOCARBON AGE DETERMINATION — REPORT OF ANALYTICAL WORK

Our Sample No. GX-22273 — Date Received: 08/16/96

Your Reference: telephone instructions 09/16/96 — Date Reported: 09/30/96

Submitted by: Mr. Kelly Payne
Mayo & Associates
710 East 100 North
Lindon, Utah 84042

Sample Name: MN-ME
groundwater precipitate

AGE = 11,970 +/- 540 C-14 years BP (C-13 corrected).
(22.54 +/- 1.51) % of the modern (1950) C-14 activity.

Description: Sample of groundwater precipitate.

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

Comment: Small sample; approximately 0.60 grams carbon.

$\delta^{13}C_{PDB} = -8.1$ ‰

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

The age is referenced to the year A.D. 1950.

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RADIOCARBON AGE DETERMINATION

REPORT OF ANALYTICAL WORK

Our Sample No. GX-22666

Date Received: 12/10/96

Your Reference: letter of 12/02/96

Date Reported: 12/24/96

Submitted by: Mr. Kelly Payne
Mayo & Associates
710 East 100 North
Lindon, Utah 84042

Sample Name: EW-TM-17-3-9
groundwater precipitate

AGE = 735 +/- 145 C-14 years BP (C-13 corrected).
(91.26 +/- 1.64) % of the modern (1950) C-14 activity.

Description: Sample of groundwater precipitate.

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

Comment: Relatively small sample; approximately 0.84 grams carbon.

$\delta^{13}C_{PDB} = -11.2$ ‰

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

The age is referenced to the year A.D. 1950.

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RADIOCARBON AGE DETERMINATION — REPORT OF ANALYTICAL WORK

Our Sample No. GX-22667 — Date Received: 12/10/96

Your Reference: letter of 12/02/96 — Date Reported: 12/24/96

Submitted by: Mr. Kelly Payne
Mayo & Associates
710 East 100 North
Lindon, Utah 84042

Sample Name: EW-TM-17-22-1
groundwater precipitate

AGE = 1,905 +/- 175 C-14 years BP (C-13 corrected).
(78.89 +/- 1.70) % of the modern (1950) C-14 activity.

Description: Sample of groundwater precipitate.

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

Comment: Small sample; approximately 0.74 grams carbon.

$\delta^{13}C_{PDB} = -10.5$ ‰

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

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RADIOCARBON AGE DETERMINATION — REPORT OF ANALYTICAL WORK

Our Sample No. GX-22668 — Date Received: 12/10/96

Your Reference: letter of 12/02/96 — Date Reported: 12/24/96

Submitted by: Mr. Kelly Payne
Mayo & Associates
710 East 100 North
Lindon, Utah 84042

Sample Name: EW-TM-17-28-4
groundwater precipitate

AGE = 1,500 +/- 180 C-14 years BP (C-13 corrected).
(82.93 +/- 1.84) % of the modern (1950) C-14 activity.

Description: Sample of groundwater precipitate.

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

Comment:

$\delta^{13}C_{PDB} = -10.3$ ‰

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.

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RADIOCARBON AGE DETERMINATION — REPORT OF ANALYTICAL WORK

Our Sample No. GX-22669 — Date Received: 12/10/96

Your Reference: letter of 12/02/96 — Date Reported: 12/24/96

Submitted by: Mr. Kelly Payne
Mayo & Associates
710 East 100 North
Lindon, Utah 84042

Sample Name: EW-TM-18-2-1
groundwater precipitate

AGE = 2,190 +/- 195 C-14 years BP (C-13 corrected).
(76.12 +/- 1.83) % of the modern (1950) C-14 activity.

Description: Sample of groundwater precipitate.

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

Comment: Relatively small sample; approximately 0.94 grams carbon.

$\delta^{13}C_{PDB} = -11.2$ ‰

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

The age is referenced to the year A.D. 1950.

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RADIOCARBON AGE DETERMINATION — REPORT OF ANALYTICAL WORK

Our Sample No. GX-22675

Date Received: 12/19/96

Your Reference: letter of 12/16/96

Date Reported: 01/09/97

Submitted by: Mr. Kelly Payne
Mayo & Associates
710 East 100 North
Lindon, Utah 84042

Sample Name: Energy West 91-73
groundwater precipitate

AGE = 1,840 +/- 140 C-14 years BP (C-13 corrected).
(79.49 +/- 1.38) % of the modern (1950) C-14 activity.

Description: Sample of groundwater precipitate.

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

Comment: Small sample; approximately 0.76 grams carbon.

$\delta^{13}C_{PDB} = -7.9$ ‰

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

The age is referenced to the year A.D. 1950.

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RADIOCARBON AGE DETERMINATION — REPORT OF ANALYTICAL WORK

Our Sample No. GX-22676 — Date Received: 12/19/96

Your Reference: letter of 12/16/96 — Date Reported: 01/09/97

Submitted by: Mr. Kelly Payne
Mayo & Associates
710 East 100 North
Lindon, Utah 84042

Sample Name: Energy West 18-4-1
groundwater precipitate

AGE = 5,155 +/- 155 C-14 years BP (C-13 corrected).
(52.65 +/- 1.03) % of the modern (1950) C-14 activity.

Description: Sample of groundwater precipitate.

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

Comment: Relatively small sample; approximately 0.95 grams carbon.

$\delta^{13}C_{PDB}$ = - 9.9 ‰

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

The age is referenced to the year A.D. 1950.

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RADIOCARBON AGE DETERMINATION — REPORT OF ANALYTICAL WORK

Our Sample No. GX-22677 — Date Received: 12/19/96

Your Reference: letter of 12/16/96 — Date Reported: 01/09/97

Submitted by: Mr. Kelly Payne
Mayo & Associates
710 East 100 North
Lindon, Utah 84042

Sample Name: Energy West 91-72
groundwater precipitate

AGE = 2,260 +/- 135 C-14 years BP (C-13 corrected).
(75.47 +/- 1.24) % of the modern (1950) C-14 activity.

Description: Sample of groundwater precipitate.

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

Comment:

$\delta^{13}C_{PDB} = -9.9$ ‰

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

The age is referenced to the year A.D. 1950.

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RADIOCARBON AGE DETERMINATION — REPORT OF ANALYTICAL WORK

Our Sample No. GX-22678 — Date Received: 12/19/96

Your Reference: letter of 12/16/96 — Date Reported: 01/09/97

Submitted by: Mr. Kelly Payne
Mayo & Associates
710 East 100 North
Lindon, Utah 84042

Sample Name: Energy West 16-34-6
groundwater precipitate

AGE = 1,880 +/- 190 C-14 years BP (C-13 corrected).
(79.12 +/- 1.87) % of the modern (1950) C-14 activity.

Description: Sample of groundwater precipitate.

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

Comment:

$\delta^{13}C_{PDB} = -11.2$ ‰

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

The age is referenced to the year A.D. 1950.

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RADIOCARBON AGE DETERMINATION — REPORT OF ANALYTICAL WORK

Our Sample No. GX-22679 — Date Received: 12/19/96

Your Reference: letter of 12/16/96 — Date Reported: 01/09/97

Submitted by: Mr. Kelly Payne
Mayo & Associates
710 East 100 North
Lindon, Utah 84042

Sample Name: Energy West ~~GCCW-15~~ CCCW-15 KLP
groundwater precipitate

AGE = 6,210 +/- 210 C-14 years BP (C-13 corrected).
(46.17 +/- 1.23) % of the modern (1950) C-14 activity.

Description: Sample of groundwater precipitate.

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

Comment: Small sample; approximately 0.79 grams carbon.

$\delta^{13}C_{PDB} = -10.3$ ‰

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.

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RADIOCARBON AGE DETERMINATION — REPORT OF ANALYTICAL WORK

Our Sample No. GX-22680 — Date Received: 12/19/96

Your Reference: letter of 12/16/96 — Date Reported: 01/09/97

Submitted by: Mr. Kelly Payne
Mayo & Associates
710 East 100 North
Lindon, Utah 84042

Sample Name: Energy West 17-32-1
groundwater precipitate

AGE = 3,900 +/- 190 C-14 years BP (C-13 corrected).
(61.55 +/- 1.48) % of the modern (1950) C-14 activity.

Description: Sample of groundwater precipitate.

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

Comment:

$\delta^{13}C_{PDB} = -8.6$ ‰

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

The age is referenced to the year A.D. 1950.

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RADIOCARBON AGE DETERMINATION

REPORT OF ANALYTICAL WORK

Our Sample No. GX-22681

Date Received: 12/19/96

Your Reference: letter of 12/16/96

Date Reported: 01/09/97

Submitted by: Mr. Kelly Payne
Mayo & Associates
710 East 100 North
Lindon, Utah 84042

Sample Name: Energy West ~~TW-3~~ TM-3 KLP
groundwater precipitate

AGE = 11,340 +/- 280 C-14 years BP (C-13 corrected).
(24.36 +/- 0.84) % of the modern (1950) C-14 activity.

Description: Sample of groundwater precipitate.

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

Comment:

$\delta^{13}C_{PDB} = -10.3$ ‰

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.

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RADIOCARBON AGE DETERMINATION

REPORT OF ANALYTICAL WORK

Our Sample No. GX-22682

Date Received: 12/19/96

Your Reference: letter of 12/16/96

Date Reported: 01/09/97

Submitted by: Mr. Kelly Payne
Mayo & Associates
710 East 100 North
Lindon, Utah 84042

Sample Name: Energy West 80-50
groundwater precipitate

AGE = 2,190 +/- 130 C-14 years BP (C-13 corrected).
(76.17 +/- 1.24) % of the modern (1950) C-14 activity.

Description: Sample of groundwater precipitate.

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

Comment: Relatively small sample; approximately 0.95 grams carbon.

$\delta^{13}C_{PDB}$ = - 9.6 ‰

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

The age is referenced to the year A.D. 1950.

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RADIOCARBON AGE DETERMINATION — REPORT OF ANALYTICAL WORK

Our Sample No. GX-22683

Date Received: 12/19/96

Your Reference: letter of 12/16/96

Date Reported: 01/09/97

Submitted by: Mr. Kelly Payne
Mayo & Associates
710 East 100 North
Lindon, Utah 84042

Sample Name: Energy West 84-57
groundwater precipitate

AGE = 2,805 +/- 125 C-14 years BP (C-13 corrected).
(70.55 +/- 1.11) % of the modern (1950) C-14 activity.

Description: Sample of groundwater precipitate.

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

Comment:

$\delta^{13}C_{PDB}$ = - 8.6 ‰

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

The age is referenced to the year A.D. 1950.

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RADIOCARBON AGE DETERMINATION

REPORT OF ANALYTICAL WORK

Our Sample No. GX-22684

Date Received: 12/19/96

Your Reference: letter of 12/16/96

Date Reported: 01/09/97

Submitted by: Mr. Kelly Payne
Mayo & Associates
710 East 100 North
Lindon, Utah 84042

Sample Name: Energy West Rilda Canyon Meter #3
groundwater precipitate

AGE = 2,030 +/- 160 C-14 years BP (C-13 corrected).
(77.66 +/- 1.53) % of the modern (1950) C-14 activity.

Description: Sample of groundwater precipitate.

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

Comment: Small sample; approximately 0.66 grams carbon.

$\delta^{13}C_{PDB} = -10.9$ ‰

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

The age is referenced to the year A.D. 1950.

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RADIOCARBON AGE DETERMINATION

REPORT OF ANALYTICAL WORK

Our Sample No. GX-22685

Date Received: 12/19/96

Your Reference: letter of 12/16/96

Date Reported: 01/09/97

Submitted by: Mr. Kelly Payne
Mayo & Associates
710 East 100 North
Lindon, Utah 84042

Sample Name: Energy West Wilberg Fault E1 XC29
groundwater precipitate

AGE = 9,160 +/- 240 C-14 years BP (C-13 corrected).
(31.97 +/- 0.95) % of the modern (1950) C-14 activity.

Description: Sample of groundwater precipitate.

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

Comment:

$\delta^{13}C_{PDB} = -10.6$ ‰

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

The age is referenced to the year A.D. 1950.

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RADIOCARBON AGE DETERMINATION — REPORT OF ANALYTICAL WORK

Our Sample No. GX-22686 — Date Received: 12/19/96

Your Reference: letter of 12/16/96 — Date Reported: 01/09/97

Submitted by: Mr. Kelly Payne
Mayo & Associates
710 East 100 North
Lindon, Utah 84042

Sample Name: Energy West T-18 Oliphant Spring groundwater precipitate

AGE = 12,270 +/- 490 C-14 years BP (C-13 corrected).
(21.70 +/- 1.33) % of the modern (1950) C-14 activity.

Description: Sample of groundwater precipitate.

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

Comment:

$\delta^{13}C_{PDB} = -15.3$ ‰

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.

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RADIOCARBON AGE DETERMINATION — REPORT OF ANALYTICAL WORK

Our Sample No. GX-22916 — Date Received: 03/06/97

Your Reference: letter of 03/03/97 — Date Reported: 04/03/97

Submitted by: Mr. Kelly Payne
Mayo & Associates
710 East 100 North
Lindon, Utah 84042

Sample Name: Energy West Cottonwood Mine Main West Seals groundwater precipitate

AGE = 12,170 +/- 440 C-14 years BP (C-13 corrected).
(21.99 +/- 1.20)% of the modern (1950) C-14 activity.

Description: Sample of groundwater precipitate.

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

Comment:

$\delta^{13}C_{PDB} = -9.7$ ‰

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

The age is referenced to the year A.D. 1950.

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RADIOCARBON AGE DETERMINATION — REPORT OF ANALYTICAL WORK

Our Sample No. GX-22917 — Date Received: 03/06/97

Your Reference: letter of 03/03/97 — Date Reported: 04/03/97

Submitted by: Mr. Kelly Payne
Mayo & Associates
710 East 100 North
Lindon, Utah 84042

Sample Name: Energy West Deer Creek 3rd South Seals groundwater precipitate

AGE = 15,570 +/- 390 C-14 years BP (C-13 corrected).
(14.40 +/- 0.70)% of the modern (1950) C-14 activity.

Description: Sample of groundwater precipitate.

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

Comment:

$\delta^{13}C_{PDB} = -7.7$ ‰

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

The age is referenced to the year A.D. 1950.

UNIVERSITY OF Miami

October 10, 1996

TRITIUM LABORATORY

Data Release #96-80
Job # 878

MAYO & ASSOCIATES
TRITIUM SAMPLES

Dr. H. Gote Ostlund
Head, Tritium Laboratory

Distribution:
Kelly Payne ✓
Mayo & Associates
710 East 100 North
Lindon, UT 84042

Energy West Mining Co.
ATTN: Chuck Semborski
P.O. Box 310
Huntington UT 84528

Rosenstiel School of Marine and Atmospheric Science
Tritium Laboratory
4600 Rickenbacker Causeway
Miami, Florida 33149-1098
(305) 361-4100
Fax (305) 361-4112

Client: MAYO AND ASSOCIATES - ENERGY WEST
Recvd : 96/08/22
Job# : 878
Final : 96/10/09

Purchase Order: 960103
Contact: K. Payne, 801/785-2385,-2387(f)
710 E. 100 N., Lindon, UT 84042
FOR: Energy West Mining Co., 801/637-7925

Cust	LABEL INFO	JOB.SX	REFDATE	QUANT	ELYS		TU	eTU
MAYO -	EAST MT. SNOW #1	878.01	960315	1000	275		8.79	0.29
MAYO -	SNOW #2	878.02	960315	1000	275		7.50	0.25
MAYO -	ROANS SPRING	878.03	960402	1000	275		11.2	0.4
MAYO -	NEWUA METER 3	878.04	960402	1000	226	*	13.7	0.5
MAYO -	TMA	878.05	960328	1000	274	*	0.22	0.09
MAYO -	2nd S XC11	878.06	960328	1000	270		0.05	0.09
MAYO -	UG-3	878.07	960328	1000	250	*	0.13	0.09
MAYO -	MN-ME	878.08	960329	1000	235	*	0.10	0.09
MAYO -	TW-10	878.09	960329	1000	275		20.8	0.7
MAYO -	6th WEST FAULT	878.10	960502	1000	245	*	0.14	0.09

* Average of duplicate runs

UNIVERSITY OF Miami

January 3, 1997

TRITIUM LABORATORY

Data Release #97-16
Job # 911

MAYO & ASSOCIATES
TRITIUM SAMPLES

Dr H. Gote Ostlund
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Client: MAYO and ASSOCIATES - ENERGY WEST
Recvd : 96/12/05
Job# : 911
Final : 97/01/02

Purchase Order: 96-0108
Contact: E. Petersen, K. Payne, 801/796-0211
710 East 100 North (F)/785-2387
Lindon, Utah 84042

Cust	LABEL INFO	JOB.SX	REFDATE	QUANT	ELYS	TU	eTU
MAYO-	EW-TM-17-3-9	911.01	960823	1000	275	23.0	0.8
MAYO-	EW-TM-17-22-1	911.02	960823	1000	275	18.1	0.6
MAYO-	EW-TM-17-28-4	911.03	950823	1000	274	13.3	0.4
MAYO-	EW-TM-18-2-1	911.04	950823	1000	275	12.2	0.4

UNIVERSITY OF Miami

February 20, 1997

TRITIUM LABORATORY

Data Release #97-20
Job # 916

MAYO & ASSOCIATES
TRITIUM SAMPLES

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Miami, Florida 33149-1098
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Client: MAYO and ASSOCIATES - ENERGY WEST
Recvd : 96/12/19
Job# : 916
Final : 97/02/18

Purchase Order: 96-0108
Contact: E. Petersen, K. Payne, 801/796-0211
710 East 100 North (F)/785-2387
Lindon, Utah 84042

Cust	LABEL INFO	JOB.SX	REFDATE	QUANT	ELYS	TU	eTU
MAYO ENERGY W.-	91-73	916.01	961213	1000	250	2.63*	0.10
MAYO ENERGY W.-	18-4-1	916.02	961213	1000	275	-0.01	0.09
MAYO ENERGY W.-	91-72	916.03	961213	1000	253	14.9	0.5
MAYO ENERGY W.-	16-34-6 KLP	916.04	961213	1000	267	12.7	0.4
MAYO ENERGY W.-	~~GGW-15~~ CCCW-15	916.05	961209	1000	250	1.10*	0.09
MAYO ENERGY W.-	17-32-1	916.06	961213	1000	276	2.20	0.12
MAYO ENERGY W.-	~~TW-3~~ TM-3 KLP	916.07	961211	1000	265	-0.07	0.09
MAYO ENERGY W.-	80-50	916.08	961212	1000	254	10.0	0.3
MAYO ENERGY W.-	84-57	916.09	961212	1000	275	11.7	0.4
MAYO ENERGY W.-	RILDA CAN.M.3	916.10	961212	1000	275	13.5	0.4
MAYO ENERGY W.-	WILBERG FEXC29	916.11	961213	1000	275	0.33*	0.09
MAYO ENERGY W.-	T-18 OLI SPRING	916.12	961213	1000	272	0.20*	0.09

* Average of duplicate runs

UNIVERSITY OF Miami

E. WEST

April 8, 1997

TRITIUM LABORATORY

Data Release #97-38
Job # 935

MAYO & ASSOCIATES
TRITIUM SAMPLES

Dr. H. Gote Ostlund
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Miami, Florida 33149-1098
(305) 361-4100
Fax (305) 361-4112

Client: MAYO and ASSOCIATES - ENERGY WEST
Recvd : 97/03/06
Job# : 935
Final : 97/04/07

Purchase Order: 97-102
Contact: E. Petersen, K. Payne, 801/796-0211
710 East 100 North (F)/785-2387
Lindon, Utah 84042

Cust	LABEL INFO	JOB.SX	REFDATE	QUANT	ELYS	TU	eTU
MAYO	-COTTONWD MINE MWSEALS	935.01	970226	1000	275	1.34	0.09
MAYO	-DEER CREEK 3 SO SEALS	935.02	970226	1000	250	0.88*	0.09

* Average of duplicate runs

BLM MOU UT930-FY9701 No. 10-MOU-97-001

MEMORANDUM OF UNDERSTANDING

among:

USDI, Bureau of Land Management, Utah
USDA, Forest Service, Intermountain Region
State of Utah - Division of Oil, Gas and Mining

concerning:

PROCESSING OF REQUESTS TO RELINQUISH FEDERAL COAL LEASES

I. Purpose. This Memorandum of Understanding (MOU) provides procedures and guidance for coordination and cooperation among the Bureau of Land Management (BLM), the Forest Service (FS), and the Utah Division of Oil Gas and Mining (DOGM) on the procedures for processing Federal coal lease relinquishment requests where the Federal lessee no longer wishes to retain a lease or leases.

II. Objective. The processing of a coal lease relinquishment action requires input from the various agencies. The objectives of this MOU are to establish the roles to be played and procedures to be followed by its signatory agencies when responding to relinquishment of a Federal coal lease (I) to insure the protection of public lands and resources in a manner that will not impair the public interest and (II) to allow the agencies to function in a more timely, effective, efficient and consistent manner, so that the rights of both the lessee and the public are protected.

III. Authority.

A. Federal Land Policy and Management Act of 1976.

B. Mineral Leasing Act of 1920, as amended.

C. Federal Coal Leasing Amendments Act of 1975.

D. National Forest Management Act of 1974.

E. Utah Coal Mining Control and Reclamation Act and the Cooperative Agreement with the Office of Surface Mining. (Surface Mining Control and Reclamation Act), (SMCRA), PL 95-87.

IV. Procedure. The signatory agencies have met at various times to develop consistent procedures for the processing of Federal coal lease relinquishments. Nothing in this MOU shall be construed to require more from a Federal coal lessee than currently required by law, the terms and conditions of the lease instrument, or the current regulations at 43 CFR 3452. The issues and agreed upon procedures are as follows:

FAX NO. 4300300 PRICE FIELD OFFICE 1:47 PM 28-MAY-98 WED

ISSUE AND PROBLEM STATEMENT:

An issue has developed in Utah concerning the relinquishment of all or part of Federal coal leases on which a company has completed mining and applies for relinquishment. The interested agencies in this matter are: the BLM, FS and Utah DOGM. The primary concern is whether the lessee has met the terms and conditions of the lease, and that prior to relinquishment, impacts on the surface and other resources have been fully delineated and mitigated, if necessary. BLM's existing regulations in 43 CFR 3452.1-3 indicate "no relinquishment shall be approved until the Authorized Officer determines that the relinquishment will not impair the public interest."

BLM has received several applications to relinquish all or parts of Federal coal leases on which underground mining has been concluded or the lease is no longer needed. The companies indicate no remaining interest in maintaining the leases or portions of leases and a desire to reduce Federal lease holdings and costs of holding leases. Initial review of some of the applications indicate concern by State and Federal agencies as to whether lease terms have been met and the potential impacts of mining have been identified.

The criteria for accepting relinquishment are currently contained in 43 CFR 3452.1-3 which indicate approval by the Authorized Officer (AO) is dependent on the following:

- The relinquishment will not impair the public interest,
- The accrued rentals and royalties have been paid, and
- All the obligations of the lessee under the regulations and terms of the lease have been met.

BLM's existing performance standards for underground mines in 43 CFR 3484.1(c)(2) require controlled subsidence and maintenance of the value and use of surface lands consistent with Surface Mining Control and Reclamation Act (SMCRA) requirements and applicable requirements of an approved State program.

The agencies wish to determine the point in time after completion of mining that the authorized officer can find the lessee has met the terms and conditions of the lease and impacts to the surface have been evaluated for possible restoration or mitigation. The agencies have agreed a consistent procedure is necessary to evaluate whether subsidence is substantially complete and impacts from subsidence have been properly treated before lease relinquishment.

FEDERAL COAL LESSEE INPUT TO RELINQUISHMENTS:

Federal coal leases have no expiration dates and remain a valid right of the lessee until lease relinquishment is accepted by the Authorized Officer, a lease is canceled for noncompliance by official action, or terminates by law. Existing Federal Regulations in 43 CFR 3452 are vague as to what information a Federal coal lessee will submit with a request for relinquishment. In order for the signatory agencies to effectively evaluate whether a request for relinquishment is appropriate, it may be

necessary for the coal lessee to submit additional information, as provided by regulation, that will provide a final report concerning mining that has occurred and documentation of surface impacts. To assist Federal coal lessees on relinquishment matters, a checklist is provided to guide lessees in data documentation for relinquishment. (See Attachment 1)

AGENCY RESPONSIBILITIES:

BLM will: Serve as Lead Agency in processing coal lease relinquishment applications by providing initial review and ensuring compliance with applicable BLM regulations including seeking additional data documentation as allowed by regulation. BLM will coordinate review by other parties to the MOU and promptly issue decisions when all inputs are available from other agencies. When BLM is the surface management agency, BLM will review lease stipulations that have been made part of the Federal coal lease and determine whether the lessee has satisfied all terms and conditions of the lease, and whether the surface is stable and surface reclamation, resource restoration or mitigation has been satisfactorily accomplished. In the event reclamation or restoration is necessary to obtain AO approval, signatory agencies will meet to outline requirements before relinquishment will be accepted.

USES will: When the surface management agency, provide prompt review of applications and data provided by the company and BLM. The FS will be in a position to make a determination after the data documentation has been provided and the surface has been examined. This would normally be 3 to 6 months after receiving a request depending on the accessibility to the area. The FS will review special lease stipulations that have been made a part of Federal coal leases and determine whether the lessee has satisfied terms and conditions of these stipulations. In responding to BLM, the FS, will indicate one of the following: (1) the terms and conditions of the special lease stipulations have been met, (2) the lease area is not stable and adequate time has not lapsed to adequately evaluate potential impacts on other Federal resources, (3) surface reclamation, resource restoration or mitigation is necessary on the lease which will have to be satisfactorily accomplished before relinquishment is acceptable, or (4) sufficient data has not been provided for the FS to make a recommendation. In the event surface reclamation is believed to be required, the FS and DOGM will consult on this matter.

Utah DOGM will: As the mine permitting regulatory authority, require restoration of surface area as required by its authority or by the surface management agency, and will determine whether lease relinquishment would conflict with administration of the mine permit.

STANDARDS FOR RELINQUISHMENT CONSIDERATION:

SUBSIDENCE AND SURFACE STABILIZATION

It has been established that where underground coal mining has occurred, the mining activity has caused surface subsidence ranging from 0 to over 100 percent of the

thickness of the coal removed. The amount is dependent on a wide range of conditions including: the coal field, percent of coal extracted, mining method, overburden thickness, strength of the overburden, length of the mined face, number of seams mined, existence of faults and areas of burned coal and other factors. Monitoring by the mining operators and special studies in the Wasatch Plateau Coal Field indicate that under normal conditions, the surface subsides 35 to 70 percent of the mining height. Surface subsidence may take from a matter of a few months to a few years before active subsidence is complete. Subsidence in the Book Cliffs Coal Field has been less pronounced.

In order for the AO to accept relinquishment of underground mined leases, the parties to this MOU have agreed that a coal lessee may, under current regulations and as a general guide, be required to retain leases or portions of leases throughout the period that active subsidence is continuing until the surface has substantially stabilized. This will be done by showing the cumulative subsidence during this monitoring period (3 years) has been 1 foot or less under normal circumstances. The operator/lessee will demonstrate this through analysis of data collected during the subsidence monitoring program. BLM may request additional raw data be submitted for independent analysis if questions remain on meeting this condition. Anomalies that create uncertainty will require additional analysis and discussion between the agencies and the operator/lessee before a final decision on lease relinquishment is made.

MONITORING STUDIES

Lease stipulations and DOGM permits require monitoring studies that document baseline conditions and locate, measure, and quantify the progressive and final effects of underground mining on the topographic surface, underground and surface hydrology, vegetation and surface improvements. Monitoring plans are usually specified in the approved Mining and Reclamation Plan. The parties of this MOU have agreed that under normal circumstances, a minimum time period for continuation of monitoring studies after mining is completed is for three years. During this time period, the operator/lessee will establish that the surface has substantially stabilized as defined above. For unusual circumstances such as block rotation on an escarpment and where concerns extend beyond this three year period, the signatory agencies will meet with the company on the ground to discuss those items not consistent with lease requirement, and will establish time frames for extending the monitoring period. If any changes in the monitoring program are needed to determine the extent or cause of detected impacts, they will be noted at this time. Hydrologic monitoring within or adjacent to a relinquished lease would need to continue if required to monitor the impacts associated with adjacent leases or permit areas as indicated in SMCRA.

EVALUATION OF POTENTIAL IMPACTS FROM MINING

Lease stipulations and Mining and Reclamation Plans require operators/lessees to establish baseline data for natural resources and monitor potential impacts throughout the life of a lease. The signatory agencies to this MOU have agreed that in order for

the AO to evaluate relinquishment applications and as allowed by law, it will be necessary for lessees to document known and potential impacts at the conclusion of mining after apparent stabilization of the surface. The surface management agency and BLM in conjunction with DOGM will review relevant reports submitted for adequacy and accuracy. Within the monitoring period after active subsidence is complete, the surface management agency in conjunction with other agencies as needed will evaluate reports submitted by the lessee regarding the impacts of mining. This evaluation will be based on a final monitoring report which will summarize all monitoring studies available from the operator and additional documentation from the relinquishment application. The surface management agency will use all available data to evaluate whether adverse impacts to the surface or other resources will require reclamation, restoration or mitigation. The agencies will complete the analysis within a 6 to 12 month period. Where the FS is the surface management agency, a written determination by the FS will be provided to the BLM, State Director. BLM field offices will provide similar documentation pertaining to evaluation of impacts and recommendations to the AO.

Impacts to Surface Topography:

Utilizing monitoring studies the operator has provided and additional documentation provided with the relinquishment application, the surface management agency will inspect impacted and high risk areas to evaluate the significance of the disturbance and possible need for restoration and/or mitigation. The rule of reasonableness will apply with analysis of relative impact to the land surface and resources including the potential for creating or leaving unsafe conditions for users of Federal land.

Impacts to Ground and Surface Water Hydrology:

Among the more difficult impact evaluations, will be that of examining possible consequences of disturbing surface and groundwater. Utilizing baseline studies as to the location, quality and quantity of water, along with monitoring information and key information such as precipitation, the lessee will identify possible deviations from the anticipated normal situation. The lessee will submit the information to the AO. This would normally be provided within six months after the final monitoring period. Additional State or Federal agency expertise may be consulted, if necessary. Changes in the baseline water situation that can be attributed to mining will be identified. The Surface Management Agency will evaluate possible impacts to other resources and possible need for restoration/mitigation. In the event that adverse impact on the hydrology and other resources has occurred, the lessee shall follow the mitigation plan contained in the approved Mining and Reclamation Plan.

Impacts to Vegetation:

Utilizing the baseline established for vegetation and annual monitoring reports, the lessee will document any change to vegetation for analysis by the AO and the surface management agency. Agency assessment will occur as soon as possible after the

monitoring period to determine the need for reclamation, normally within a 6-12 month period.

Impacts to Surface Improvements:

Surface improvements in the lease area influenced by underground mining that are owned by the government or private parties will be evaluated utilizing all available information. A final inspection will be conducted by the signatory agencies once subsidence is established to be substantially complete to identify improvements that will require restoration.

V. Administration.

A. Nothing in this MOU will be construed as effecting the authorities of the participants or as binding beyond their respective authorities or to require any of the participants to obligate or expend funds in excess of available appropriations.

B. Conflicts between the participants concerning procedures under this MOU which cannot be resolved at the operational level will be referred to successively higher levels, as necessary, for resolution.

C. The participants will review this MOU at least every 5 years to determine its adequacy, effectiveness and continuing need.

D. The terms of this MOU may be renegotiated at any time at the initiative of one or more of its participants, following at least 30 days notice to the other participants.

E. This MOU may be canceled at any time by one or more of its participants, following at least 30 days notice to the other participants.

F. Any participant may propose changes to this MOU during its term. Such changes will be in the form of an amendment and will become effective upon signature by all of the participants.

G. This MOU will become effective upon signature by all of its participants.

APPROVED:

G. William Lamb
Utah State Director, BLM

9/12/96
Date

Dale Bosworth
Regional Forester, USFS Region IV

10/2/96
Date

James W. Carter
Director, Utah Div. Oil, Gas & Mining

9/11/96
Date

(1) Attachment: Checklist for Data Documentation in Federal Coal Lease Relinquishment.

ATTACHMENT 1

CHECKLIST FOR DATA DOCUMENTATION BY LESSEE IN FEDERAL COAL LEASE RELINQUISHMENT

Coal lease number.
Lessee name and address.
DOGM mine number.
Has lessee or (if previously assigned) the former lessee, conducted mining or any surface disturbing activity on this lease?

(Continue if mining/activity has occurred)

Type of mining conducted.
Date of initial mining.
Date of last mining.
Number of seams mined.
Range of thickness of coal removed.
Has subsidence occurred on this lease?

(Continue if subsidence has occurred)

Provide maps that note surface impacts on the lease.
Provide subsidence development curves.
Statement as to whether active subsidence has concluded.
Date and location as to where and when last subsidence occurred.
Note any Federal resources that might have been adversely impacted by subsidence (hydrologic resources, vegetation, improvements, etc.)
Note any impacts to private improvements.
Provide documentation as to how impacts were measured.
Plan for mitigation/restoration.

Trail Mountain Mine
Federal Coal Lease UTU-64375 Lease Relinquishment
Appendix C

Evaluation of Impacts to Ground and Surface Water Hydrology

The following section provides a detailed description of the hydrology, including groundwater and surface water quality and quantity, of the land within UTU-64375 and surrounding area.

Since 1979 detailed data on the hydrology of the East Mountain and Trail Mountain areas have been collected, compiled, and analyzed by PacifiCorp and several government agencies. Information collected by PacifiCorp is the result of exploratory drilling, field investigations, geologic mapping, aerial photography, spring surveys, groundwater tests, monitoring of numerous wells and stream stations, climatological monitoring, and investigations by independent consultants. The data collection program is part of a complete Hydrologic Monitoring Program which has been approved by the State of Utah, Division of Oil, Gas and Mining (DOGM) and the Office of Surface Mining (OSM). All data collected have been and will continue to be submitted to OSM, DOGM, United States Forest Service (USFS), and the Bureau of Land Management (BLM) each year in the annual Hydrologic Monitoring reports.

Hydrologic monitoring plan for the Trail Mountain Mine is specified in Volume 9 Hydrologic Section: Appendix A in the approved Mining and Reclamation Plan (MRP).

As outlined by the BLM, the interested parties have agreed that under normal circumstances, the minimum time period for continued monitoring will be three years. During this time period the operator/lessee will establish that the surface has substantially stabilized according to Appendix "A".

The following sections will describe and provide detail concerning the groundwater and surface water resources within and adjacent to Federal Lease UTU-64375.

Groundwater:

Groundwater resources of the Trail Mountain mine are limited and are controlled by the terrain, slope aspect and geologic structures. Terrain of Federal Lease UTU-64375 ranges from flat to narrow ridge tops with gentle slopes in the upland parts of the area to very steep side slope conditions along the margins of the lease. The topography and slope aspect limit the amount of recharge to the area.

Strata in the Trail Mountain permit area are gently down-folded in the area of the Straight Canyon Syncline which is present in the central portion of Trail Mountain. Axis of the Straight Canyon Syncline is located approximately 1 mile west/northwest of Lease UTU-64375. The bearing of the Straight Canyon Syncline is approximately N30^{O}E and the structure plunges to the

southwest. Dips in the syncline range from two to six degrees with the north limb dipping the steepest.

In the area south of the Straight Canyon Syncline the coal seam dips gently in a northwest direction toward the syncline; however, to the northwest of the Straight Canyon Syncline the Hiawatha seam dips in a southeast direction at three to five degrees.

A northeast-southwest trending fault system, the Roans Canyon Graben, is present along the axis of the Straight Canyon Syncline. In the central portion of East Mountain the fault system contains up to six normal faults having displacements ranging from a few feet to over 150 feet. Coal deposits present to the north of the fault have been accessed through rock tunnels driven from the 3rd North section of the Deer Creek Mine.

The rock formations exposed in the Trail Mountain area range from Upper Cretaceous to Tertiary in age (see Figure HF-2). The formations, in ascending order, are the Masuk Shale member of the Mancos Shale, Star Point Sandstone, Blackhawk, Castlegate Sandstone Sandstone, Upper Price River, North Horn, and Flagstaff Limestone. The coal deposits are restricted to the lower portion of the Blackhawk Formation.

The Masuk Shale is the upper member of the Mancos Shale and consists of light to medium gray marine mudstones. Usually this formation weathers readily, forming slopes which are often covered by debris. It is generally devoid of water.

Overlying and intertonguing with the Masuk Shale is the Star Point Sandstone. In the East Mountain area the Star Point consists of three or more cliff-forming massive sandstones totaling about 400 feet in thickness. Generally, the sandstones are fine to medium-grained and moderately well-sorted. The upper contact of the Star Point Sandstone is usually quite abrupt and readily identifiable on the outcrop. Even though the Star Point Formation exists throughout the entire Trail Mountain property, the low permeability and lack of recharge limit its usefulness as a water producing aquifer. Permeability and the limiting factors of recharge, i.e., very little outcrop exposure and limited vertical groundwater migration caused by the mudstone layers of the North Horn and Blackhawk formations. Locally, the Star Point Sandstone exhibits aquifer characteristics

The Blackhawk Formation consists of alternating mudstones, siltstones, sandstones, and coal. Although coal is generally found throughout the Blackhawk Formation, the economic seams are restricted to the lower 150 feet of the formation. The sandstones contained within the Blackhawk Formation are fluvial and increase in number in the upper portions of the formation. Many of the tabular sandstone channels form local perched water tables. The total thickness of the Blackhawk Formation in the Trail Mountain area is about 750 feet.

The Castlegate Sandstone Sandstone, the lower member of the Price River Formation, generally caps the escarpment which surrounds the eastern limit of the property. The Castlegate Sandstone consists of about 250 feet of coarse-grained, light gray, fluvial sandstones; pebble conglomerates; and subordinate zones of mudstones.

The Upper Price River Formation, which overlies the Castlegate Sandstone, is about 350 feet thick and forms slopes which extend upward from the Castlegate Sandstone escarpment. Although some mudstones are present, fine-grained, poorly sorted sandstones dominate the Upper Price River Formation.

The North Horn Formation is about 850 to 900 feet thick in the Trail Mountain area. Mudstones dominate the rock types present and are generally gray to light brown in color. Localized, lenticular sandstone channels are present throughout the formation. The sandstone beds are more common near the upper and lower contacts of the formation.

The Flagstaff Formation is the youngest formation exposed in the permit area and consists of white to light gray lacustrine limestone. An erosional remnant of 100 to 150 feet of this formation remains, forming a cap on the highest plateaus.

Waters entering the groundwater system are mostly from snow melt. The amount of water which enters the groundwater system is highly variable from one site to another. The low surface relief on the top of Trail Mountain encourages the infiltration of melting snow. Conversely, the many areas with steep slopes have a much more limited infiltration opportunity. All of the geologic formations which surface in the area have relatively low permeability which further reduces the amount of water entering the groundwater system. Probably less than five percent of the annual precipitation recharges the groundwater supply (Price and Arnow, 1974; U. S. Geological Survey, 1979).

Geology controls the movement of groundwater. Because of the low permeability of the consolidated sedimentary rocks in the Trail Mountain area, groundwater movement is primarily "through fractures, through openings between beds, and, in the case of the Flagstaff Limestone, through solution openings" (Danielson et al., 1981, p. 25).

The majority of the groundwater which infiltrates the Flagstaff Limestone flows down vertical fractures which intersect sandstone channel systems in the North Horn Formation. The majority of the groundwater reaching this point intersects the surface in springs located in the North Horn Formation. Very little recharge intersects the Price River Formation and Castlegate Sandstone; consequently, they are not water saturated where intersected in the numerous drill holes penetrating those units. The remaining water then flows downdip (to the southwest) from the northern reaches of Trail Mountain until it intersects the trace of the northeast trending Roans Canyon Fault Graben.. The system acts as an aquiclude because swelling bentonitic clays along the fault prohibit most of the water from penetrating across the fault. Most of the recharge south of the Roans Canyon Fault System comes from the snow melt directly above. The same mode of water migration occurs there as to the north; but, when the water intersects the sandstone channels, it migrates toward the canyons which surround and dissects Trail Mountain.

Data have been collected from numerous coal exploration drill holes, from within the mine workings, from surface drainages, and from the springs in the area. The data have identified two separate isolated aquifer systems on the Trail Mountain property; the first is localized perched

water tables in the North Horn Formation, and the second is a combination of localized perched water tables in the Blackhawk Formation and the Star Point Sandstone which exhibits some limited potential as a regional aquifer. Stratigraphy is the main controlling factor restricting groundwater movement and development of regional and perched aquifer systems within the Trail Mountain property. The following is a description of the various formations and how they influence the groundwater systems. The description is in descending order, which parallels the general groundwater flow.

Flagstaff Limestone

This formation displays a strong joint pattern which permits good groundwater movement both vertically and horizontally through the formation.

North Horn Formation

This formation is comprised of a variety of rock types which range from highly calcareous sandstone to mudstone. Its permeability is variable.

Lenticular sandstone channels are oftentimes present in the upper and lower portions of the formation. Water which percolates down fractures from the overlying Flagstaff Limestone works its way into the sandstones, forming the perched water tables. The actual lateral extent, or correlation, between the perched water tables has not been identified; and it is not practical to do so because the tables are limited in extent and variable in stratigraphic location. Many springs have been identified where the sandstone channels intersect the land surface.

The lower two-thirds (upper Cretaceous in age) of the formation is generally highly bentonitic mudstone which is impermeable. It is likely that this material is acting as an aquiclude, preventing adequate recharge from reaching the Upper Price River Formation or Castlegate Sandstone below. (The bentonitic mudstone will be discussed in detail in the PHC.) The mudstones present swell when they come in contact with water. Therefore, vertical migration of water along fractures through this material is limited because the fractures are sealed by the swelling clays.

The depth of the aquifers in the North Horn Formation is variable due to the rugged topography. The localized perched water tables may either intersect the surface of the ground or be covered by as much as 1,000 feet of overburden. They are located at least 1,400 feet above the coal seam to be mined. Communication of water between the perched aquifers in the North Horn Formation and the water flowing into the mine is limited in quantity and occurs very slowly. The monitoring of the numerous springs located on Trail Mountain gives PacifiCorp the ability to assess any effects that mining might have on the North Horn Formation perched aquifers.

With the data available it is not possible to compile a piezometric map of the water-bearing strata in the North Horn Formation because the channels are discontinuous and not interconnected.

Upper Price River Formation

The Upper Price River Formation is comprised predominantly of sandstone but commonly contains mudstone beds between the point bar deposits. It is generally void of water because it lacks adequate recharge.

Castlegate Sandstone

The formation is thought to be fairly permeable but, where it has been intersected by drill holes, has never been found to be water-saturated. It is oftentimes dry or slightly damp in some zones. It is void of significant water because it lacks adequate recharge.

Blackhawk Formation

The Blackhawk Formation contains only perched or limited aquifers which exist within the strata overlying the coal seams and the upper portion of the Star Point Sandstone Formation. The perched aquifers exist as fluvial channels (ancient river systems) which overlie and scour into the underlying strata. These channel systems were part of a deltaic depositional setting active during and after the coal-forming peat accumulation. The largest influx of water encountered during the mining process occurs beneath the fluvial channels. The sandstone channels are mainly composed of a fine- to medium-grained sand with similar characteristics to the Star Point Sandstone Formation. The semi-permeable and porous nature of the channels allows an effective route for water transport. Other constituents of the Blackhawk Formation (i.e., mudstone, carbonaceous mudstone, coal seams, and interbedded mudstones/siltstone and sandstones) generally act as aquicludes which impede vertical groundwater flow to the lower stratigraphic units. In areas other than where faulting and fracturing have created secondary permeability, the migration of water from the perched aquifers-sandstone channel systems of the Blackhawk Formation to the Star Point Sandstone Formation is limited. Extensive mining in the Trail Mountain mine, which produces coal from the Hiawatha seam, is stratigraphically located on top of the upper member of the Star Point Formation Sandstone. Only minor quantities of groundwater have been produced from the Star Point Sandstone Formation. The coal seams of the Blackhawk Formation are effective in impeding vertical groundwater movement. In many areas in the mine where roof coal was left in place because of abundant thickness or as an additional effort to support the immediate roof, production of groundwater occurred only when roof support was installed or when a roof failure occurred exposing the overlying sandstone channel systems. Listed below are hydrologic characteristics of individual rock types reported by the USGS, Open File 84-067.

Lithology: Sh, shale; Slt, siltstone; Ss, sandstone; f, fine grained; m, medium grained.
Hydraulic conductivity: I, impermeable to water even at a pressure of 5,000 pounds per square inch.

Geologic unit	Lithology	Depth below land surface (feet)	Porosity (percent)	Hydraulic conductivity (feet per day)	
				Horizontal	Vertical
Blackhawk Formation	Ss, f	1,521	14	$1.5x10^{-2}$	$3.7x10^{-3}$
	Slt	1,545	3	$9.3x10^{-8}$	$1.2x10^{-7}$
	Sh	1,786	2	I	I
	Ss, f	1,792	14	$1.1x10^{-2}$	$3.9x10^{-3}$
	Sh	2,170	4	$1.1x10^{-8}$	---
	Slt	2,265	2	$2.0x10^{-7}$	$2.2x10^{-6}$
Star Point Sandstone	Ss, m	2,466	17	$3.1x10^{-2}$	$1.1x10^{-2}$
	Ss, m	2,493	11	$1.5x10^{-2}$	$6.6x10^{-3}$

Based on current data, several observations have been made concerning the Blackhawk water-bearing strata. The sandstone, which is semi-permeable and porous, affords an effective route of water transport; while relatively impervious shale in the Blackhawk Formation prevents significant downward movement of the percolating water. Of the water-producing areas, those closest to the active mining face exhibit the greatest flows. As mining advances the area adjacent to the active face continues to be excessively wet, and previously mined wet areas experience a decrease in flow. It appears that the water source is being dewatered since mined out areas of the mine do not continue to produce water indefinitely. The water source must be either of limited extent, e.g., a perched aquifer, or have a limited recharge capacity

Although much of the water transfer within the Blackhawk Formation is through fractures or faults, data indicate that recharge to the Blackhawk is limited because of the above confining formations and many of the fractures become sealed by swelling bentonitic clays which stop or limit the water transfer, confirmation of which exists along the numerous faults and fractures over the area. Very few springs are found within the Blackhawk except along the extensive faults in the Wasatch Plateau. The fractures sealed readily because of the ability of the shaley layers to swell and decompose to form an impervious clay, preventing significant downward percolation, collection, or conveyance of water along faults in the Blackhawk Formation.

Star Point Sandstone

The Star Point Sandstone Formation overlies and intertongues with the Masuk Shale. The formation is approximately 150 to 200 feet in thickness and consists of at least three upward

coarsening sandstone units. Mudstone units of the Masuk Shale are present above the lower two sandstone members of the Star Point Sandstone Formation due to the interfingering nature of the contact between the two units.

The Star Point Sandstone Formation, which immediately underlies the Hiawatha Coal Seam, exhibits some characteristics of an aquifer but experiences little recharge. Studies conducted by the USGS indicate that the Star Point Sandstone Formation is of low permeability, thus limiting its usefulness as a water-producing aquifer. Most of the water discharge from the Star Point Formation is where it has been intersected by the major canyons in the plateau or where faulting has caused secondary permeability. Drill holes completed in the Trail Mountain vicinity defined the piezometric gradient in the lower Blackhawk Star Point Formation System and confirmed the groundwater flow to conform with the topographic relief and structural features, i.e., regional dip, Straight Canyon Syncline, and regional faulting. This, plus the fact that the Star Point Formation is only slightly to moderately permeable, allows only limited flow of groundwater through the formation.

Water in most of the Blackhawk-Star Point aquifer is confined under pressure between shale and siltstone beds within the aquifer (USGS Lines, Open File Report 84-067). Water is released from storage from confined aquifers mainly by compression of the sandstones and less permeable, confining beds as pressure in the aquifer declines. The quantity of water that can be released from storage is dependent on the storage coefficient, which is about $1x10^{-6}$ per foot of thickness for most confined aquifers (Lohman, 1971, p. 8). Data collected by PacifiCorp on the Roans Canyon Fault System in 1988, 3rd North fault crossing, confirmed the USGS storage coefficient estimations, with values ranging from $1.6x10^{-4}$ to $7.0x10^{-6}$. Transmissivity values computed for pump tests conducted by the USGS on Trail Mountain on non-fully penetrating wells in the Blackhawk-Star Point aquifer ranged from 0.7 to 100 ft^2/day with a majority of the two results ranging from 1 to 10 ft^2/day. The computed transmissivity of 100 ft^2/day was greater than the laboratory data (listed early in this section) and was believed to be due to secondary permeability in the form of fractures. Transmissivity results ranging from 0.7 to 10 ft^2/day are indicative of the low permeability rock in most of the cretaceous and tertiary strata within the Wasatch Plateau.

Federal Lease UTU-64375 – Groundwater Resources

As a result of the limited recharge and geologic structures, only six low flow groundwater sources (spring 17-35-1, 17-35-2, 17-35-3, 17-35-4, 17-35-5 and 18-2-1) are located within the lease area (see Trail Mountain Spring Data – Mining History). All of these springs are located within the area to be relinquished. Flow ceased after 2001 after repairs were made by the cattle association to the spring. Groundwater now issues 1/8 mile to the east of the original location, flowing at rate of 0.5 gpm (2008).

Spring 17-35-1 is located in the SWNW ¼ of Section 35 on a scrub/sagebrush-covered slope at an elevation of 8850 feet above mean sea level (see Hydrologic Drainage Map in this appendix). Recharge of the spring is from the east. The spring is located in the North Horn Formation in the

head of small drainage system. Flow ceased after 2001 after repairs were made by the cattle association to the spring. Groundwater now issues 1/8 mile to the east of the original location, flowing at rate of 0.5 gpm (2008).

Spring 17-25-2 is located in the SENW ¼ of Section 35 on a gentle grass covered slope at an elevation of 9000 feet above mean sea level (see Hydrologic Drainage Map in this Appendix). Recharge of the spring is from the east. The spring is located in the North Horn Formation. This spring site was originally established prior to PacifiCorp's acquisition of the property. The site is located in a small drainage feeding a developed pond. Flow has never been observed at this site.

Springs 17-35-3 – 17-35-5 are all located in the SW ¼ of Section 35 on a west facing slope covered with sage/grass and sparse conifer trees at an elevation of 8700 feet above mean sea level (see Hydrologic Drainage Map in this Appendix). Recharge to these springs is from the east. These springs are located in the North Horn Formation. Monitoring sites 17-35-3 – 17-35-5 were originally established prior to PacifiCorp's acquisition of the property and are not included in the hydrologic monitoring program. Visual inspections during annual routine monitoring indicates that these springs low output springs, typically <1 gpm, similar to 18-2-1.

Spring 18-2-1 is located in the NENW ¼ of Section 2 on a gentle south facing grass covered slope at an elevation of 8400 feet above mean sea level (see Hydrologic Drainage Map in this Appendix). Recharge of the spring is from the north. The spring is located in the Upper Price River Formation. Site development of 18-2-1 consisted of field fence to protect the source area and piping of the outfall to a trough located to the south. Since the site was originally included with the Trail Mountain Monitoring Program, site development has deteriorated to its present condition, the diversion is no longer functioning and the fencing is no longer protecting the source. In addition, this site was selected by the Emery Conservancy District for inclusion in the automated hydrologic monitoring network. This equipment also has been compromised and is no longer functioning.

Monitoring of springs 17-35-1, 17-35-2 and 18-2-1 was initiated in1992 (under PacifiCorp ownership) and has continued though 2008. In addition to the DOGM monitored springs, Energy West identified and monitored springs adjacent to Lease UTU-64375 in preparation of future leasing. Quality and quantity data for these adjacent springs is provided to assist in elevating potential mining related impacts. Quality from all of the monitored springs has remained consistent from the pre-second mining to post-retreat mining, refer to following enclosed tables and graphs. Outflow from the springs is highly dependent upon yearly precipitation for its recharge and quantity measurements are consistent with the precipitation values recorded at the East Mountain Weather Station; refer to the enclosed hydrographs. Hydrologic monitoring completed on the Trail Mountain property has failed to identify any changes in the quantity or quality of groundwater discharge from the springs which have been monitored.

TRAIL MOUNTAIN SPRING DATA

SPRING	MINING HISTORY		STATUS	LOCATION			Approximate Subsidence (feet)
	Type of Mining	Date of Mining		Sec.	T.	R.	
Federal Lease UTU-64375							
17-35-1*	Longwall Panels 3rd Right	July 2000	Within Relinquishment	35	17S	6E	1
17-35-2*	Longwall Panels 4th Right	February 2000	Within Relinquishment	35	17S	6E	<1
17-35-3**	Longwall Panels 4th Right	January 2000	Within Relinquishment	35	17S	6E	4.5
17-35-4**	Gateroad Development 6th Right	July 1999	Within Relinquishment	35	17S	6E	6
17-35-5**	Longwall Panels 6th Right	January 1999	Within Relinquishment	35	17S	6E	5
18-2-1*	Longwall Panels 8th Right	August 1997	Within Relinquishment	2	18S	6E	1.5
17-26-2***	Not Undermined	NA	Within ½ mile Offset	26	17S	6E	0
17-28-4***	Not Undermined	NA	Within ½ mile Offset	28	17S	6E	0

* Included within DOGM monitoring program

** Not included within DOGM monitoring program

*** Baseline monitoring conducted: pre/post mining

Federal Lease: UTU-64375

Pre-Mining

Water Quality Report:

04-Dec-08

LOCATION:17-35-1

HISTORICAL DATA FOR DATE: 19770101 THROUGH 19921130

PARAMETER	MAXIMUM	MINIMUM	AVERAGE	# ANALYSES
BICARB:	441	283	390.869	23
CALCIUM:	56.1	27	42.1521	23
CARBONATE:	18.3	0.1	7.98181	11
CHLORIDE:	59	20.3	43.8478	23
CONDUCT:	970	508	757.05	20
DISS_OXY:				0
FLOW:	5	0.16	0.85736	19
HARDNESS:	297	235	269.631	19
IRON_TOT:	6.5	0.04	0.86933	15
IRON_DISS:	4.74	0.05	0.90875	8
MAGNESIUM:	55	24.4	40.2447	23
MANG_DISS:				0
MANGANESE:	0.46	0.01	5.78260	23
OIL_GREASE				0
PH:	8.75	7.4	8.10826	23
POTASSIUM:	2.8	0.51	1.31136	22
SET_SOLIDS:				0
SODIUM:	97.2	12	72.7434	23
SULFATE:	65	10.3	42.2086	23
SUSPENDED:	488	1	100.333	18
TEMP_WATE				0
TDS:	520	200	437.304	23

Federal Lease: UTU-64375
Pre-Mining

Water Quality Report:

04-Dec-08

LOCATION: 17-35-2

HISTORICAL DATA FOR DATE: 19770101 THROUGH 19921130

NO DATA

Federal Lease: UTU-64375

Pre-Mining

Water Quality Report:

04-Dec-08

LOCATION: 17-35-3

HISTORICAL DATA FOR DATE: 19770101 THROUGH 19921130

NO DATA

Federal Lease: UTU-64375

Pre-Mining

Water Quality Report:

04-Dec-08

LOCATION: 17-35-4

HISTORICAL DATA FOR DATE: 19770101 THROUGH 19921130

NO DATA

Federal Lease: UTU-64375

Pre-Mining

Water Quality Report:

04-Dec-08

LOCATION: 17-35-5 HISTORICAL DATA FOR DATE: 19770101 THROUGH 19921130

PARAMETER	MAXIMUM	MINIMUM	AVERAGE	# ANALYSES	
BICARB:	334	334	334	1	
CALCIUM:	50	50	50	1	
CARBONATE:				0	
CHLORIDE:	96	96	96	1	
CONDUCT:	870	870	870	1	
DISS_OXY:				0	
FLOW:				0	
HARDNESS:				0	
IRON_TOT:	0.05	0.05	0.05	1	
IRON_DISS:				0	
MAGNESIUM:	43.8	43.8	43.8	1	
MANG_DISS:				0	
MANGANESE:	0.01	0.01	0.01	1	
OIL_GREASE				0	
PH:	8.01	8.01	8.01	1	
POTASSIUM:	1.3	1.3	1.3	1	
SET_SOLIDS:				0	
SODIUM:	58.3	58.3	58.3	1	
SULFATE:	24	24	24	1	
SUSPENDED:	11	11	11	1	1
TEMP_WATE				0	
TDS:	416	416	416	1	

Federal Lease: UTU-64375

Pre-Mining

Water Quality Report:

04-Dec-08

LOCATION: 18-2-1

HISTORICAL DATA FOR DATE: 19770101 THROUGH 19921130

PARAMETER	MAXIMUM	MINIMUM	AVERAGE	# ANALYSES
BICARB:	431	350	406.826	23
CALCIUM:	80.6	44	63.1956	23
CARBONATE:	0.1	0.1	0.1	3
CHLORIDE:	61.7	40	47.8695	23
CONDUCT:	1060	862	951.15	20
DISS_OXY:				0
FLOW:	18.9	0.03	3.31411	17
HARDNESS:	421	351	391.833	18
IRON_TOT:	1.28	0.04	0.18875	16
IRON_DISS:	0.05	0.05	0.05	6
MAGNESIUM:	76	45.5	56.5217	23
MANG_DISS:				0
MANGANESE:	0.03	0.01	1.86363	22
OIL_GREASE				0
PH:	8.13	7.01	7.80434	23
POTASSIUM:	2.35	0.78	1.27347	23
SET_SOLIDS:	0.1	0.1	0.1	1
SODIUM:	81	60.7	69.4173	23
SULFATE:	149	121	133.817	23
SUSPENDED:	560	1	44.925	20
TEMP_WATE				0
TDS:	644	480	577.913	23

Federal Lease: UTU-64375

Adjacent to Lease - Pre-Mining

Water Quality Report:

04-Dec-08

LOCATION: 17-26-1 HISTORICAL DATA FOR DATE: 19770101 THROUGH 19921130

PARAMETER	MAXIMUM	MINIMUM	AVERAGE	# ANALYSES
BICARB:	385	360	375.5	6
CALCIUM:	60	56	58.4	6
CARBONATE:				0
CHLORIDE:	12.3	10	11.1333	6
CONDUCT:	610	500	575	6
DISS_OXY:	5.7	5.7	5.7	1
FLOW:	0.1	0.1	0.1	1
HARDNESS:	267	267	267	1
IRON_TOT:	0.05	0.05	0.05	5
IRON_DISS:	0.05	0.05	0.05	1
MAGNESIUM:	42.6	29.4	38.45	6
MANG_DISS:				0
MANGANESE:	0.01	0.01	0.01	5
OIL_GREASE				0
PH:	7.84	7.34	7.645	6
POTASSIUM:	1.1	0.8	0.9	5
SET_SOLIDS:				0
SODIUM:	25.12	17.3	18.92	6
SULFATE:	40	10	24.8166	6
SUSPENDED:	12	5	6.4	5
TEMP_WATE				0
TDS:	412	324	351.333	6

Federal Lease: UTU-64375

Adjacent to Lease - Pre-Mining

Water Quality Report:

04-Dec-08

LOCATION: 17-26-2

HISTORICAL DATA FOR DATE: 19770101 THROUGH 19921130

NO DATA

Federal Lease: UTU-64375

Adjacent to Lease - Pre-Mining

Water Quality Report:

04-Dec-08

LOCATION: 17-28-4 HISTORICAL DATA FOR DATE: 19770101 THROUGH 19921130

PARAMETER	MAXIMUM	MINIMUM	AVERAGE	# ANALYSES
BICARB:	369	369	369	1
CALCIUM:	49.1	49.1	49.1	1
CARBONATE:				0
CHLORIDE:	30	30	30	1
CONDUCT:	510	510	510	1
DISS_OXY:	6.2	6.2	6.2	1
FLOW:	1.7	1.7	1.7	1
HARDNESS:	248	248	248	1
IRON_TOT:				0
IRON_DISS:				0
MAGNESIUM:	30.4	30.4	30.4	1
MANG_DISS:				0
MANGANESE:				0
OIL_GREASE				0
PH:	8.17	8.17	8.17	1
POTASSIUM:				0
SET_SOLIDS:				0
SODIUM:	58.37	58.37	58.37	1
SULFATE:	29	29	29	1
SUSPENDED:	6	6	6	1
TEMP_WATE				0
TDS:	365	365	365	1

Federal Lease: UTU-64375

Adjacent to Lease - Pre-Mining

Water Quality Report:

04-Dec-08

LOCATION: 17-22-1 HISTORICAL DATA FOR DATE: 19770101 THROUGH 19921130

PARAMETER	MAXIMUM	MINIMUM	AVERAGE	# ANALYSES
BICARB:	406	342	382.722	18
CALCIUM:	107	21	55.9555	18
CARBONATE:	24.6	0.1	6.225	4
CHLORIDE:	30	8.4	11.6111	18
CONDUCT:	697	556	612.6	15
DISS_OXY:	3.7	3.7	3.7	1
FLOW:	22.1	0.1	4.17875	16
HARDNESS:	338	240	299.4375	16
IRON_TOT:	1.12	0.04	0.27333	9
IRON_DISS:	0.14	0.05	0.06375	8
MAGNESIUM:	69	11	38.1877	18
MANG_DISS:				0
MANGANESE:	0.03	0.01	2.07142	14
OIL_GREASE				0
PH:	8.54	7.02	7.79722	18
POTASSIUM:	2.2	0.05	1.13941	17
SET_SOLIDS:	0.1	0.1	0.1	1
SODIUM:	118.4	12	28.4672	18
SULFATE:	200	13	27.2166	18
SUSPENDED:	73	1	15.2	15
TEMP_WATE				0
TDS:	420	262	340.388	18

Federal Lease: UTU-64375

Adjacent to Lease - Pre-Mining

Water Quality Report:

04-Dec-08

LOCATION: 17-22-2 HISTORICAL DATA FOR DATE: 19770101 THROUGH 19921130

PARAMETER	MAXIMUM	MINIMUM	AVERAGE	# ANALYSES
BICARB:	305	305	305	1
CALCIUM:	45.8	45.8	45.8	1
CARBONATE:				0
CHLORIDE:	15	15	15	1
CONDUCT:	410	410	410	1
DISS_OXY:	9.1	9.1	9.1	1
FLOW:	3.8	3.8	3.8	1
HARDNESS:	214	214	214	1
IRON_TOT:				0
IRON_DISS:	0.03	0.03	0.03	1
MAGNESIUM:	24.1	24.1	24.1	1
MANG_DISS:				0
MANGANESE:	0.2	0.2	0.2	1
OIL_GREASE				0
PH:	8.04	8.04	8.04	1
POTASSIUM:				0
SET_SOLIDS:				0
SODIUM:	20.88	20.88	20.88	1
SULFATE:	8	8	8	1
SUSPENDED:	8	8	8	1
TEMP_WATE				0
TDS:	247	247	247	1

Federal Lease: UTU-64375

Adjacent to Lease - Pre-Mining

Water Quality Report:

04-Dec-08

LOCATION: 17-27-1 HISTORICAL DATA FOR DATE: 19770101 THROUGH 19921130

PARAMETER	MAXIMUM	MINIMUM	AVERAGE	# ANALYSES
BICARB:	283	283	283	1
CALCIUM:	43.9	43.9	43.9	1
CARBONATE:				0
CHLORIDE:	15	15	15	1
CONDUCT:	400	400	400	1
DISS_OXY:	8.6	8.6	8.6	1
FLOW:	2.1	2.1	2.1	1
HARDNESS:	215	215	215	1
IRON_TOT:				0
IRON_DISS:				0
MAGNESIUM:	25.6	25.6	25.6	1
MANG_DISS:				0
MANGANESE:	0.17	0.17	0.17	1
OIL_GREASE				0
PH:	7.88	7.88	7.88	1
POTASSIUM:				0
SET_SOLIDS:				0
SODIUM:	14.25	14.25	14.25	1
SULFATE:	12	12	12	1
SUSPENDED:	11	11	11	1
TEMP_WATE				0
TDS:	233	233	233	1

Federal Lease: UTU-64375

Adjacent to Lease - Pre-Mining

Water Quality Report:

04-Dec-08

LOCATION: 17-27-2 HISTORICAL DATA FOR DATE: 19770101 THROUGH 19921130

PARAMETER	MAXIMUM	MINIMUM	AVERAGE	# ANALYSES
BICARB:	311	311	311	1
CALCIUM:	67.7	67.7	67.7	1
CARBONATE:				0
CHLORIDE:	15	15	15	1
CONDUCT:	410	410	410	1
DISS_OXY:	8.9	8.9	8.9	1
FLOW:	5	5	5	1
HARDNESS:	245	245	245	1
IRON_TOT:				0
IRON_DISS:	0.26	0.26	0.26	1
MAGNESIUM:	18.4	18.4	18.4	1
MANG_DISS:				0
MANGANESE:	0.02	0.02	0.02	1
OIL_GREASE				0
PH:	8.26	8.26	8.26	1
POTASSIUM:				0
SET_SOLIDS:				0
SODIUM:	12.6	12.6	12.6	1
SULFATE:	2	2	2	1
SUSPENDED:	25	25	25	1
TEMP_WATE				0
TDS:	213	213	213	1

Federal Lease: UTU-64375

Post-Mining

Water Quality Report:

04-Dec-08

LOCATION: 17-35-1

HISTORICAL DATA FOR DATE: 20000701 THROUGH 20081231

PARAMETER	MAXIMUM	MINIMUM	AVERAGE	# ANALYSES
BICARB:	438	438	438	1
CALCIUM:	40	40	40	1
CARBONATE:				0
CHLORIDE:	44	44	44	1
CONDUCT:	841	841	841	1
DISS_OXY:				0
FLOW:	0.86	0.86	0.86	1
HARDNESS:	248	248	248	1
IRON_TOT:				0
IRON_DISS:				0
MAGNESIUM:	36	36	36	1
MANG_DISS:				0
MANGANESE:				0
OIL_GREASE				0
PH:	7.85	7.85	7.85	1
POTASSIUM:	1	1	1	1
SET_SOLIDS:				0
SODIUM:	96	96	96	1
SULFATE:	46	46	46	1
SUSPENDED:				0
TEMP_WATE	14.8	14.8	14.8	1
TDS:	507	507	507	1

Federal Lease: UTU-64375

Post-Mining

Water Quality Report:

04-Dec-08

LOCATION: 17-35-2

HISTORICAL DATA FOR DATE: 20000201 THROUGH 20081231

NO DATA

Federal Lease: UTU-64375

Post-Mining

Water Quality Report:

04-Dec-08

LOCATION: 17-35-3

HISTORICAL DATA FOR DATE: 20000201 THROUGH 20081231

NO DATA

Federal Lease: UTU-64375

Post-Mining

Water Quality Report:

04-Dec-08

LOCATION: 17-35-4

HISTORICAL DATA FOR DATE:19990701 THROUGH 20081231

NO DATA

Federal Lease: UTU-64375

Post-Mining

Water Quality Report:

04-Dec-08

LOCATION: 17-35-5 HISTORICAL DATA FOR DATE: 19990101 THROUGH 20081231

NO DATA

Federal Lease: UTU-64375

Post-Mining

Water Quality Report:

04-Dec-08

LOCATION: 18-2-1 HISTORICAL DATA FOR DATE: 19970831 THROUGH 20081231

PARAMETER	MAXIMUM	MINIMUM	AVERAGE	# ANALYSES
BICARB:	421	326	381	17
CALCIUM:	71.5	56	62.4288	17
CARBONATE:	0	0	0	1
CHLORIDE:	48	38	43.1941	17
CONDUCT:	1256	839	1037.23	17
DISS_OXY:	6	6	6	1
FLOW:	10.2	0.27	3.21	17
HARDNESS:	461	356	398.294	17
IRON_TOT:	0.06	0.06	0.06	1
IRON_DISS:	0	0	0	1
MAGNESIUM:	68.5	52	58.8976	17
MANG_DISS:	0	0	0	1
MANGANESE:	0	0	0	1
OIL_GREASE				0
PH:	7.6	7.28	7.48117	17
POTASSIUM:	1.16	0.87	1.01285	7
SET_SOLIDS:				0
SODIUM:	75	59	66.6852	17
SULFATE:	196	116	157.129	17
SUSPENDED:				0
TEMP_WATE	13.5	6.1	9.04117	17
TDS:	651	560	606.588	17

Federal Lease: UTU-64375

Adjacent to Lease - Post-Mining

Water Quality Report:

04-Dec-08

LOCATION: 17-26-1 HISTORICAL DATA FOR DATE: 20010531 THROUGH 20081231

PARAMETER	MAXIMUM	MINIMUM	AVERAGE	# ANALYSES
BICARB:	310	304	306.333	3
CALCIUM:	57.5	56.7	57.09	3
CARBONATE:				0
CHLORIDE:	8	7	7.33333	3
CONDUCT:	694	648	669.666	3
DISS_OXY:				0
FLOW:	6.6	1	3	3
HARDNESS:	307	302	304.333	3
IRON_TOT:				0
IRON_DISS:				0
MAGNESIUM:	39.7	38.9	39.24	3
MANG_DISS:	0.006	0.005	5.33333	3
MANGANESE:	0.006	0.002	4.33333	3
OIL_GREASE				0
PH:	7.46	7.25	7.36666	3
POTASSIUM:	0.79	0.62	0.69666	3
SET_SOLIDS:				0
SODIUM:	17.8	14.4	16.4166	3
SULFATE:	17	17	17	3
SUSPENDED:				0
TEMP_WATE	9.8	5.7	8.23333	3
TDS:	357	296	326	3

Federal Lease: UTU-64375

Adjacent to Lease: Post-Mining

Water Quality Report:

04-Dec-08

LOCATION: 17-26-2 HISTORICAL DATA FOR DATE: 20010531 THROUGH 20081231

PARAMETER	MAXIMUM	MINIMUM	AVERAGE	# ANALYSES
BICARB:	434	393	415.75	4
CALCIUM:	72.7	66	68.4075	4
CARBONATE:				0
CHLORIDE:	15	12	13.25	4
CONDUCT:	962	817	916	4
DISS_OXY:				0
FLOW:	15.4	1.8	6.7	4
HARDNESS:	391	350	365.5	4
IRON_TOT:	0.44	0.2	0.32	2
IRON_DISS:				0
MAGNESIUM:	50.8	44.9	47.26	4
MANG_DISS:	0.005	0.004	0.0045	2
MANGANESE:	0.003	0.003	0.003	1
OIL_GREASE				0
PH:	8.33	7.33	7.86	4
POTASSIUM:	1.14	0.98	1.0675	4
SET_SOLIDS:				0
SODIUM:	58.6	50.95	54.3875	4
SULFATE:	37	31	34.25	4
SUSPENDED:				0
TEMP_WATE	8.7	6.2	7.15	4
TDS:	509	456	477.75	4

Federal Lease: UTU-64375

Adjacent to Lease: Post-Mining

Water Quality Report:

04-Dec-08

LOCATION: 17-28-4 HISTORICAL DATA FOR DATE: 20010531 THROUGH 20081231

PARAMETER	MAXIMUM	MINIMUM	AVERAGE	# ANALYSES
BICARB:	403	258	342	4
CALCIUM:	51.5	35.3	44.5225	4
CARBONATE:	30	30	30	1
CHLORIDE:	35	20	28.75	4
CONDUCT:	951	689	834.5	4
DISS_OXY:				0
FLOW:	5.7	1.1	2.95	4
HARDNESS:	344	248	299.5	4
IRON_TOT:	0.61	0.31	0.46	2
IRON_DISS:				0
MAGNESIUM:	52.3	38.9	45.7475	4
MANG_DISS:	0.016	0.012	0.014	2
MANGANESE:				0
OIL_GREASE				0
PH:	8.6	8.23	8.3525	4
POTASSIUM:	1.07	0.72	0.8925	4
SET_SOLIDS:				0
SODIUM:	73.05	52.2	61.4375	4
SULFATE:	53	27	38.5	4
SUSPENDED:				0
TEMP_WATE	11.4	7.6	9.325	4
TDS:	545	370	443.25	4

Federal Lease: UTU-64375

Adjacent to Lease: Post-Mining

Water Quality Report:

04-Dec-08

LOCATION: 17-22-1 HISTORICAL DATA FOR DATE: 20010531 THROUGH 20081231

PARAMETER	MAXIMUM	MINIMUM	AVERAGE	# ANALYSES
BICARB:	315	239	265.529	17
CALCIUM:	44.8	41	43.2517	17
CARBONATE:	14	0	4.66666	3
CHLORIDE:	9	6.9	7.64117	17
CONDUCT:	603	489	528.235	17
DISS_OXY:				0
FLOW:	17	2.4	6.17764	17
HARDNESS:	251	229	241	17
IRON_TOT:	1.15	0	0.274	10
IRON_DISS:	0.02	0	6.66666	3
MAGNESIUM:	33.8	30.7	32.2782	17
MANG_DISS:	0.021	0	0.0103	10
MANGANESE:	0.044	0	9.71428	7
OIL_GREASE				0
PH:	8.18	7.38	7.85588	17
POTASSIUM:	1.18	0.84	0.98414	14
SET_SOLIDS:				0
SODIUM:	18.76	13.9	16.4523	17
SULFATE:	13	11	12.2352	17
SUSPENDED:				0
TEMP_WATE	8.9	5.5	7.26941	17
TDS:	305	235	272.882	17

Federal Lease: UTU-64375

Adjacent to Lease: Post-Mining

Water Quality Report:

04-Dec-08

LOCATION: 17-22-2 HISTORICAL DATA FOR DATE: 20010531 THROUGH 20081231

PARAMETER	MAXIMUM	MINIMUM	AVERAGE	# ANALYSES
BICARB:	299	254	274.8	5
CALCIUM:	56.4	46.1	50.84	5
CARBONATE:	10	10	10	1
CHLORIDE:	7	6	6.8	5
CONDUCT:	618	527	576.8	5
DISS_OXY:				0
FLOW:	14.5	6.9	10.1	5
HARDNESS:	300	253	272.2	5
IRON_TOT:	0.68	0.12	0.354	5
IRON_DISS:				0
MAGNESIUM:	38.6	33.4	35.274	5
MANG_DISS:	0.047	0.015	0.0304	5
MANGANESE:	0.012	0.002	6.33333	3
OIL_GREASE				0
PH:	8.29	7.83	8.052	5
POTASSIUM:	1.42	0.94	1.11	5
SET_SOLIDS:				0
SODIUM:	13.8	11.19	12.718	5
SULFATE:	9	6	7	5
SUSPENDED:				0
TEMP_WATE	12.2	5.7	8.52	5
TDS:	324	248	299.4	5

Federal Lease: UTU-64375

Adjacent to Lease: Post-Mining

Water Quality Report:

04-Dec-08

LOCATION: 17-27-1 HISTORICAL DATA FOR DATE: 20010531 THROUGH 20081231

PARAMETER	MAXIMUM	MINIMUM	AVERAGE	# ANALYSES
BICARB:	265	230	242.25	4
CALCIUM:	60.7	39.3	45.5725	4
CARBONATE:				0
CHLORIDE:	11	9	10.5	4
CONDUCT:	546	521	528.25	4
DISS_OXY:				0
FLOW:	6	1.8	3.9	4
HARDNESS:	262	223	240	4
IRON_TOT:	0.89	0.09	0.3275	4
IRON_DISS:				0
MAGNESIUM:	33.8	26.8	30.6075	4
MANG_DISS:	0.008	0.003	4.66666	3
MANGANESE:				0
OIL_GREASE				0
PH:	8.05	7.83	7.94	4
POTASSIUM:	0.73	0.44	0.6325	4
SET_SOLIDS:				0
SODIUM:	14.7	12.04	12.96	4
SULFATE:	11	9	9.5	4
SUSPENDED:				0
TEMP_WATE	8.9	5.8	6.975	4
TDS:	289	217	252	4

Federal Lease: UTU-64375

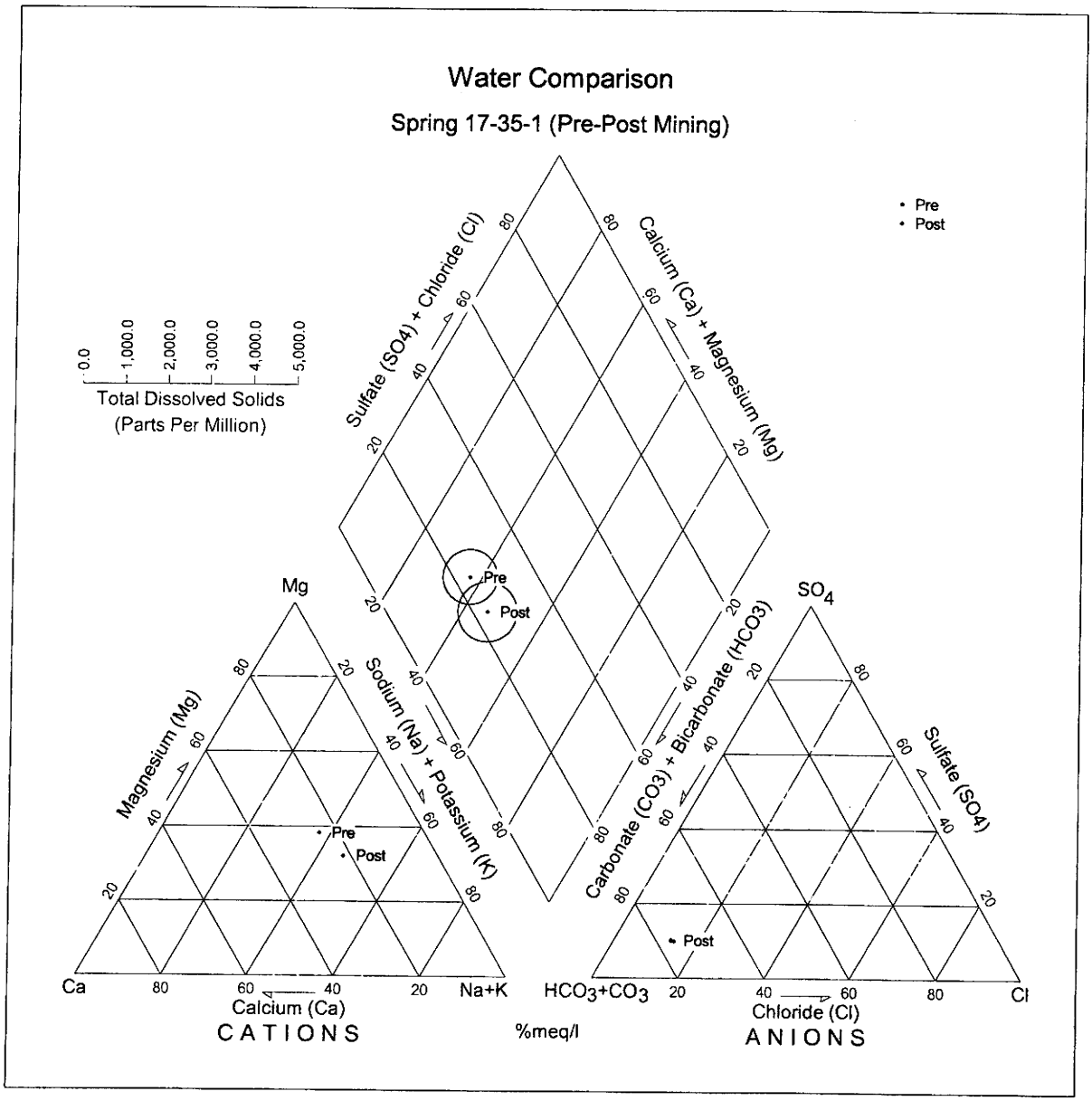
Adjacent to Lease: Post-Mining

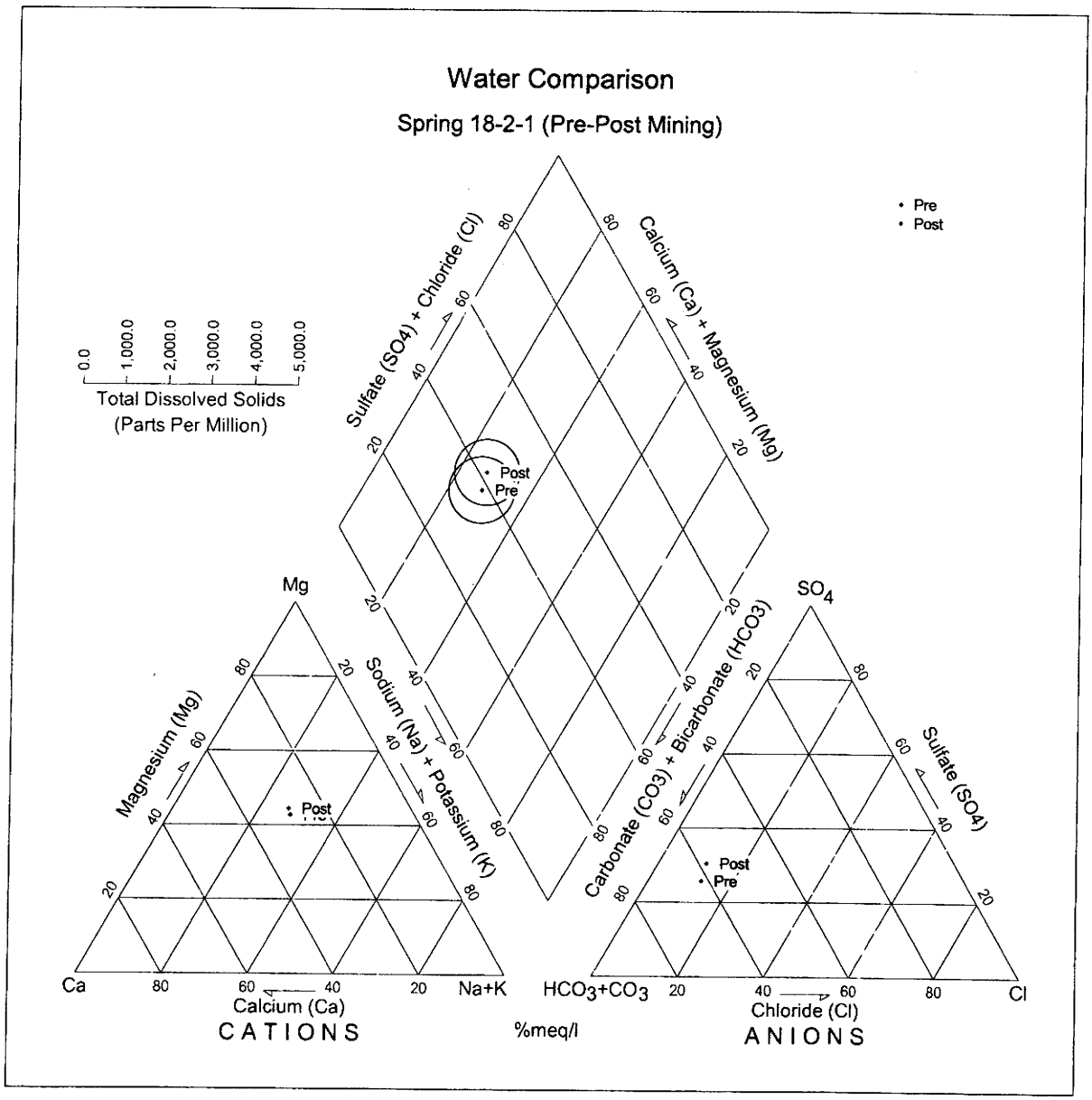
Water Quality Report:

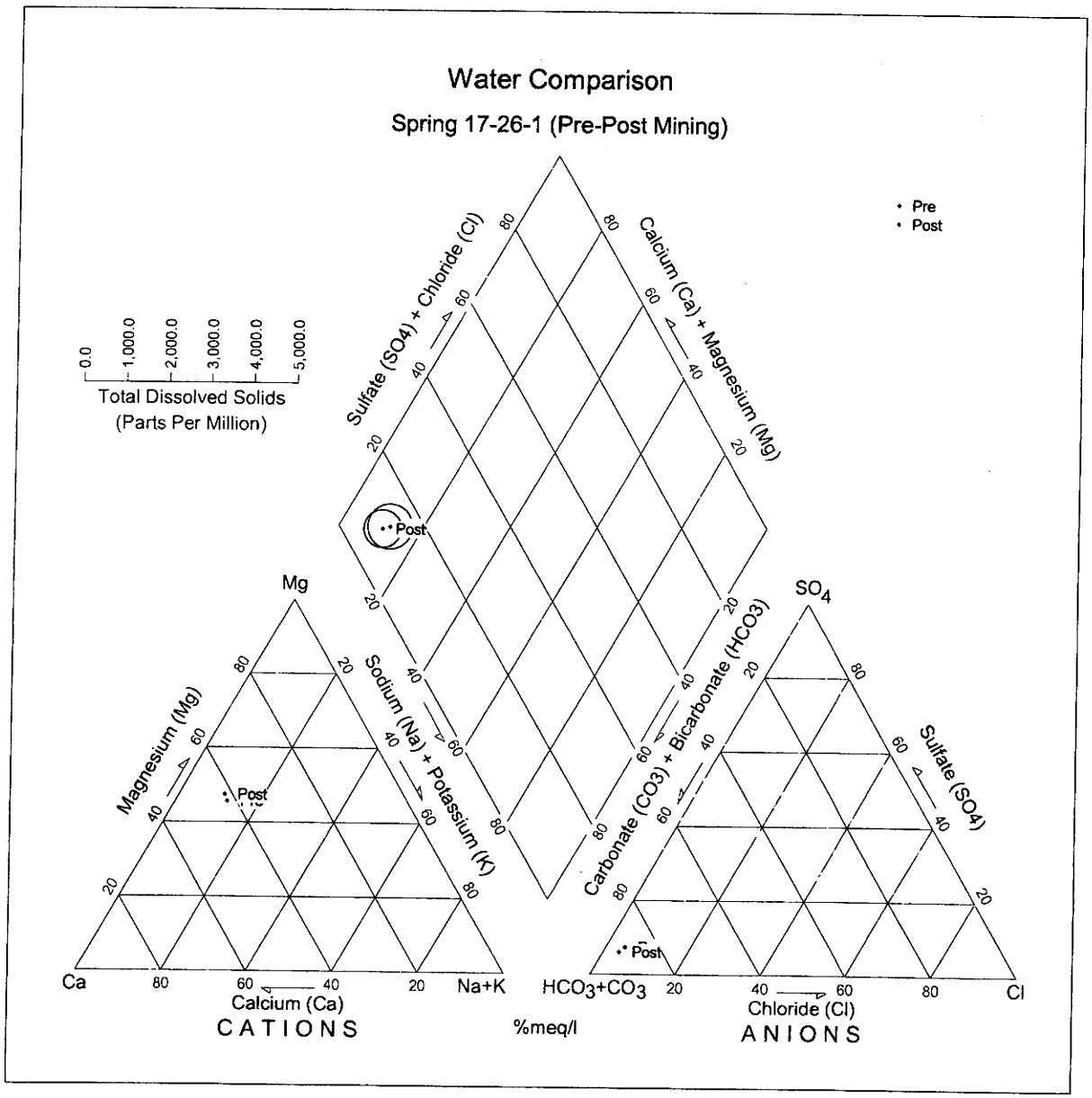
04-Dec-08

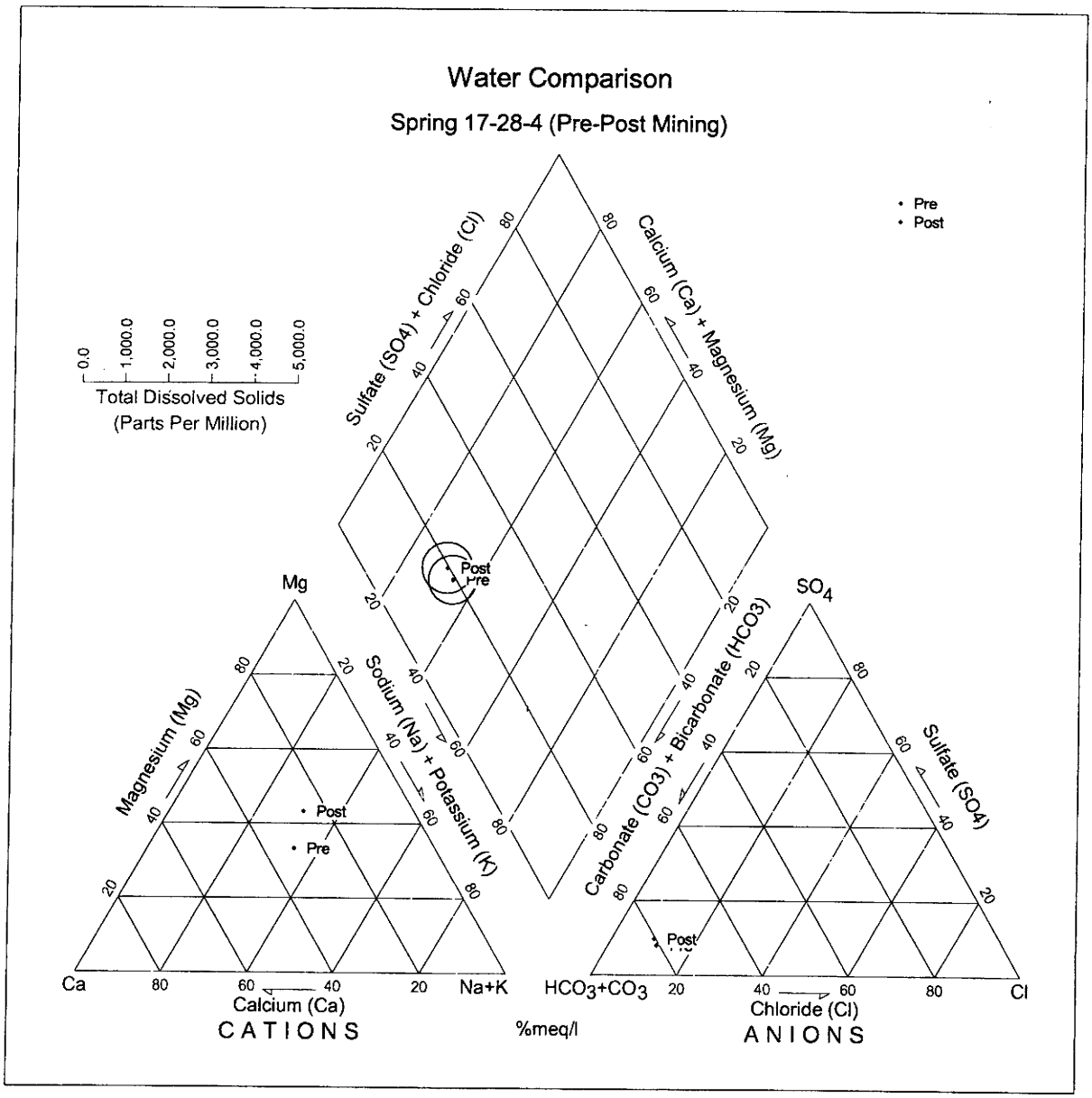
LOCATION: 17-27-2 HISTORICAL DATA FOR DATE: 20010531 THROUGH 20081231

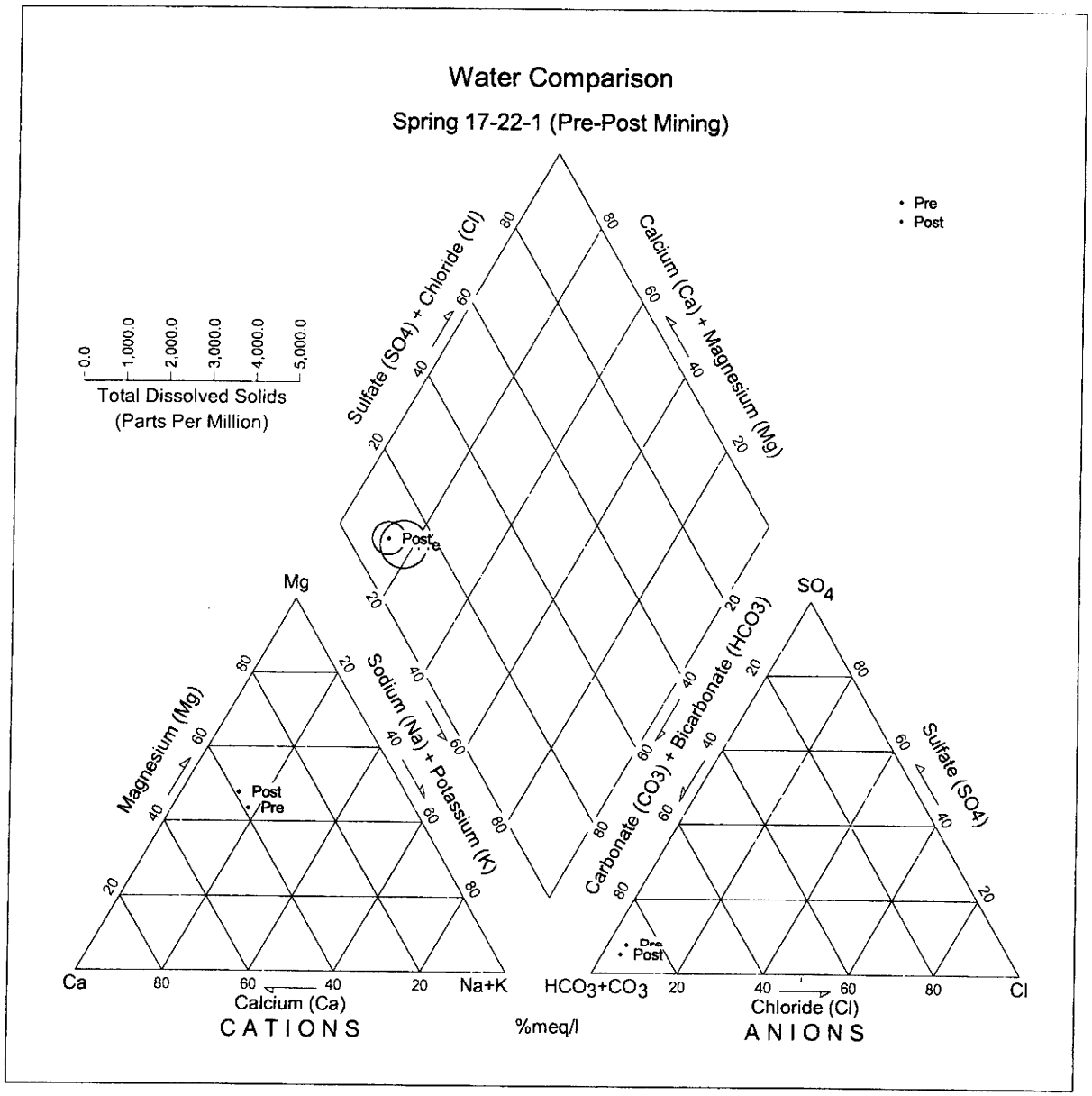
PARAMETER	MAXIMUM	MINIMUM	AVERAGE	# ANALYSES
BICARB:	262	257	259	4
CALCIUM:	65.4	60.52	63.23	4
CARBONATE:				0
CHLORIDE:	8	7	7.25	4
CONDUCT:	609	535	571.25	4
DISS_OXY:				0
FLOW:	13.5	7.5	10.4	4
HARDNESS:	272	252	261.5	4
IRON_TOT:	0.14	0.09	0.10666	3
IRON_DISS:				0
MAGNESIUM:	26.5	23.8	25.1975	4
MANG_DISS:	0.002	0.002	0.002	3
MANGANESE:				0
OIL_GREASE				0
PH:	7.72	7.34	7.505	4
POTASSIUM:	0.49	0.37	0.4375	4
SET_SOLIDS:				0
SODIUM:	12.1	10.91	11.7025	4
SULFATE:	11	10	10.75	4
SUSPENDED:				0
TEMP_WATE	6.9	5.9	6.3	4
TDS:	299	258	276.5	4

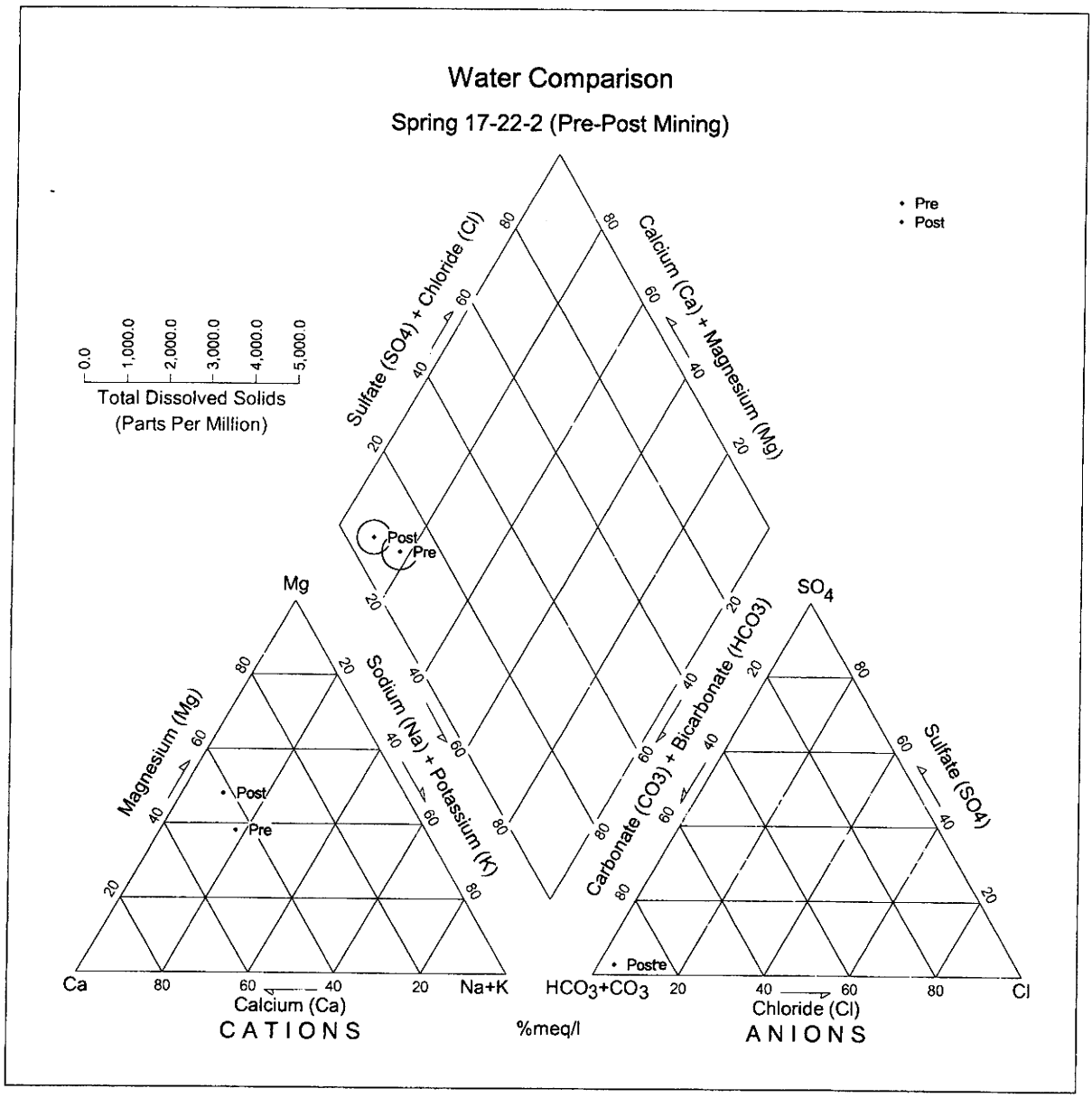

Water Comparison
Spring 17-35-1 (Pre-Post Mining)
Pre
Post
0.0
1,000.0
2,000.0
3,000.0
4,000.0
5,000.0
Total Dissolved Solids
(Parts Per Million)
Sulfate (SO4) + Chloride (Cl)
Calcium (Ca) + Magnesium (Mg)
Carbonate (CO3) + Bicarbonate (HCO3)
Sodium (Na) + Potassium (K)
Mg
Magnesium (Mg)
Ca
Calcium (Ca)
Na+K
CATIONS
%meq/l
SO4
Sulfate (SO4)
HCO3+CO3
Chloride (Cl)
Cl
ANIONS

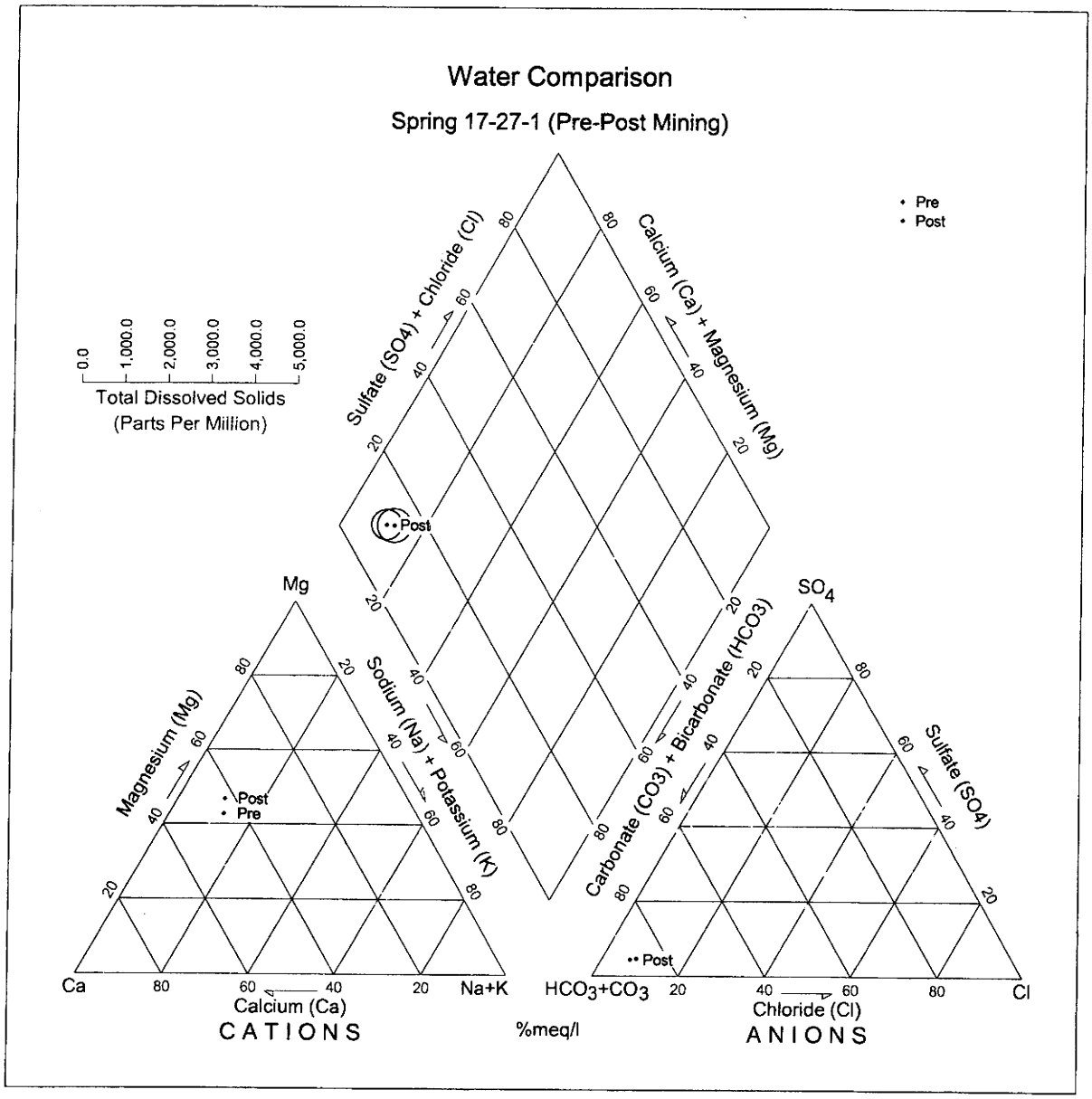

Water Comparison
Spring 18-2-1 (Pre-Post Mining)
Pre
Post
0.0
1,000.0
2,000.0
3,000.0
4,000.0
5,000.0
Total Dissolved Solids
(Parts Per Million)
Sulfate (SO4) + Chloride (Cl)
Calcium (Ca) + Magnesium (Mg)
Sodium (Na) + Potassium (K)
Carbonate (CO3) + Bicarbonate (HCO3)
Mg
Magnesium (Mg)
Ca
Calcium (Ca)
Na+K
CATIONS
%meq/l
SO4
Sulfate (SO4)
Cl
Chloride (Cl)
HCO3+CO3
ANIONS

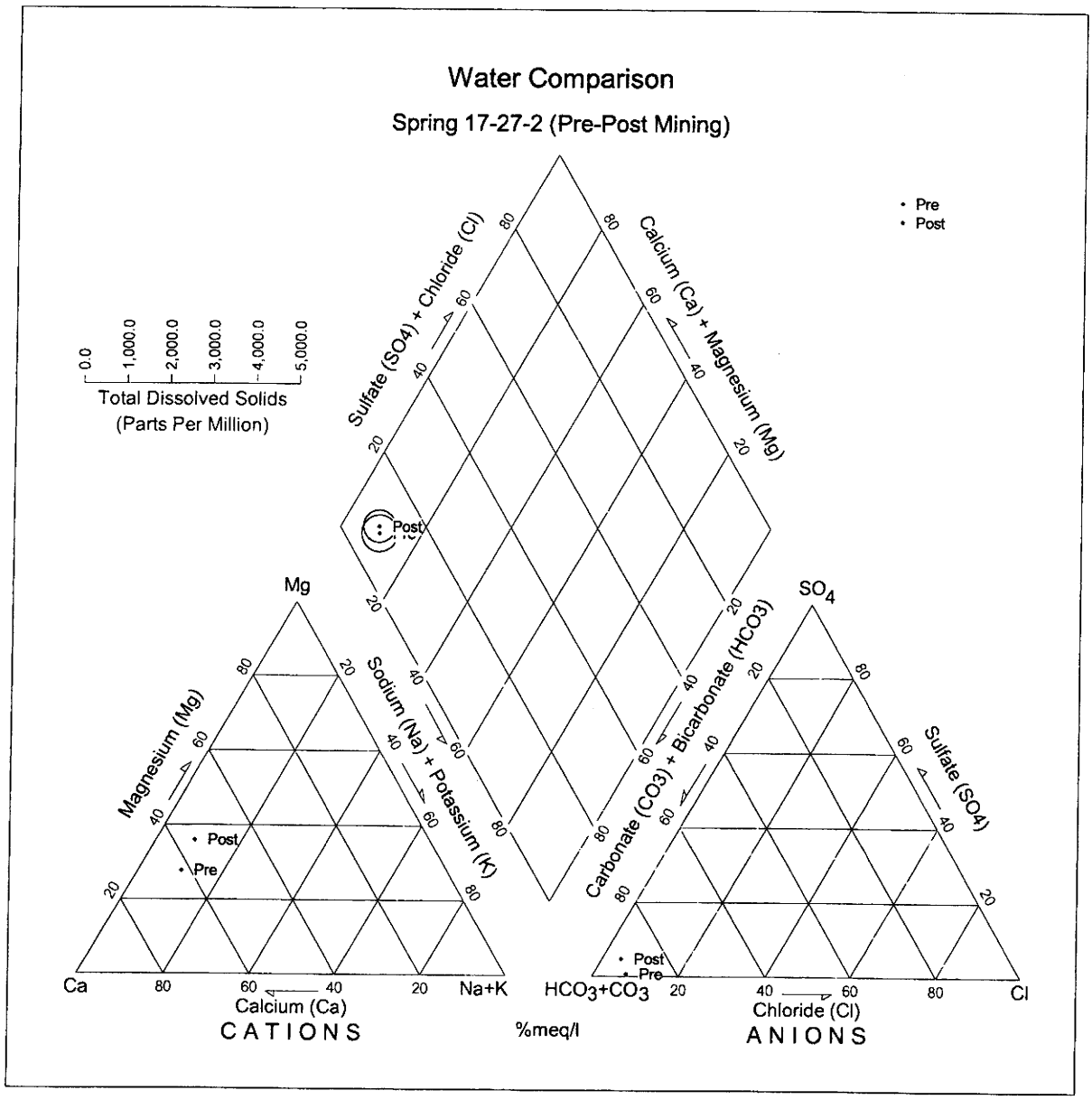

Water Comparison
Spring 17-26-1 (Pre-Post Mining)
• Pre
• Post
0.0
1,000.0
2,000.0
3,000.0
4,000.0
5,000.0
Total Dissolved Solids
(Parts Per Million)
Sulfate (SO4) + Chloride (Cl)
Calcium (Ca) + Magnesium (Mg)
Carbonate (CO3) + Bicarbonate (HCO3)
Sodium (Na) + Potassium (K)
Post
Mg
Magnesium (Mg)
Ca
Calcium (Ca)
Na+K
CATIONS
%meq/l
SO4
Sulfate (SO4)
Cl
Chloride (Cl)
HCO3+CO3
ANIONS


Water Comparison
Spring 17-28-4 (Pre-Post Mining)
Pre
Post
0.0
1,000.0
2,000.0
3,000.0
4,000.0
5,000.0
Total Dissolved Solids
(Parts Per Million)
Sulfate (SO4) + Chloride (Cl)
Calcium (Ca) + Magnesium (Mg)
Carbonate (CO3) + Bicarbonate (HCO3)
Sodium (Na) + Potassium (K)
Mg
Magnesium (Mg)
Ca
Calcium (Ca)
Na+K
CATIONS
%meq/l
SO4
Sulfate (SO4)
HCO3+CO3
Chloride (Cl)
Cl
ANIONS
Post
Pre


Water Comparison
Spring 17-22-1 (Pre-Post Mining)
Pre
Post
0.0
1,000.0
2,000.0
3,000.0
4,000.0
5,000.0
Total Dissolved Solids
(Parts Per Million)
Sulfate (SO4) + Chloride (Cl)
Calcium (Ca) + Magnesium (Mg)
Carbonate (CO3) + Bicarbonate (HCO3)
Sodium (Na) + Potassium (K)
Mg
Magnesium (Mg)
Ca
Calcium (Ca)
Na+K
CATIONS
SO4
Sulfate (SO4)
Cl
Chloride (Cl)
HCO3+CO3
ANIONS
%meq/l
20
40
60
80


Water Comparison
Spring 17-22-2 (Pre-Post Mining)
• Pre
• Post
0.0
1,000.0
2,000.0
3,000.0
4,000.0
5,000.0
Total Dissolved Solids
(Parts Per Million)
Sulfate (SO4) + Chloride (Cl)
Calcium (Ca) + Magnesium (Mg)
Post
Pre
Mg
Magnesium (Mg)
Sodium (Na) + Potassium (K)
Post
Pre
Ca
Calcium (Ca)
Na+K
CATIONS
%meq/l
SO4
Carbonate (CO3) + Bicarbonate (HCO3)
Sulfate (SO4)
Poste
HCO3+CO3
Chloride (Cl)
Cl
ANIONS

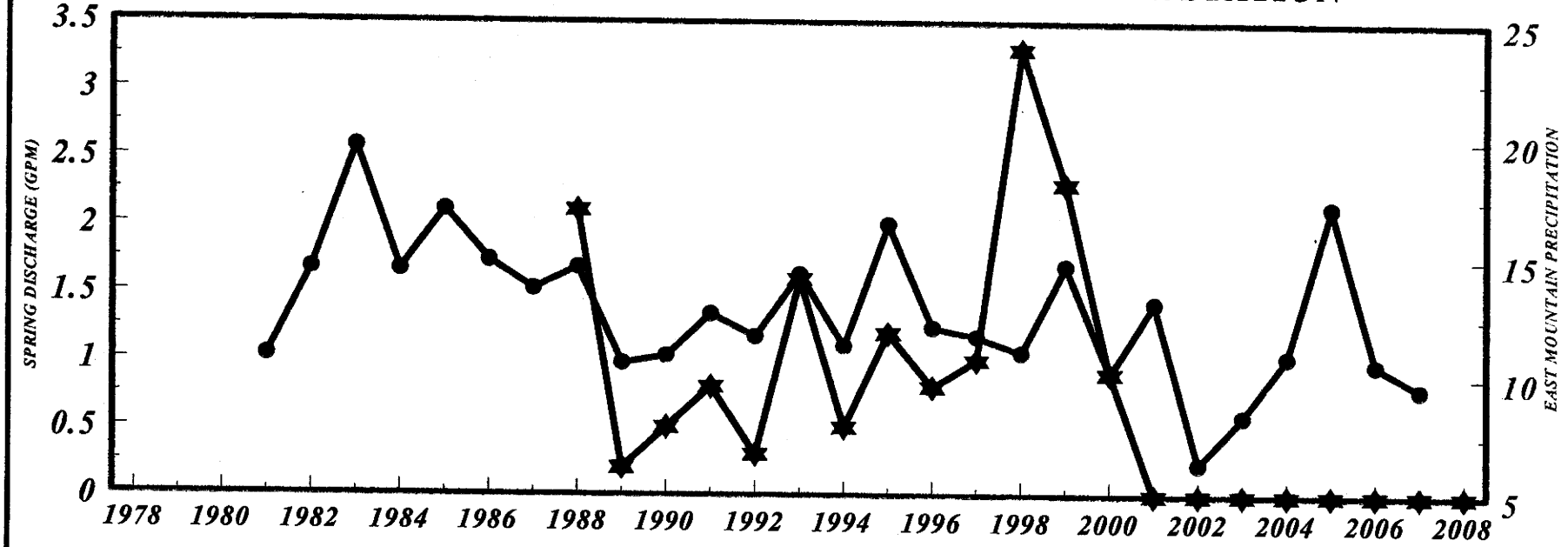

Water Comparison
Spring 17-27-1 (Pre-Post Mining)
Pre
Post
0.0
1,000.0
2,000.0
3,000.0
4,000.0
5,000.0
Total Dissolved Solids
(Parts Per Million)
Sulfate (SO4) + Chloride (Cl)
Calcium (Ca) + Magnesium (Mg)
Sodium (Na) + Potassium (K)
Carbonate (CO3) + Bicarbonate (HCO3)
Post
Mg
Magnesium (Mg)
Post
Pre
Ca
Calcium (Ca)
CATIONS
Na+K
SO4
Sulfate (SO4)
Post
HCO3+CO3
Chloride (Cl)
ANIONS
Cl
%meq/l


Water Comparison
Spring 17-27-2 (Pre-Post Mining)
Pre
Post
0.0
1,000.0
2,000.0
3,000.0
4,000.0
5,000.0
Total Dissolved Solids
(Parts Per Million)
Sulfate (SO4) + Chloride (Cl)
Calcium (Ca) + Magnesium (Mg)
Carbonate (CO3) + Bicarbonate (HCO3)
Sodium (Na) + Potassium (K)
Post
Mg
Magnesium (Mg)
Ca
Calcium (Ca)
Na+K
CATIONS
%meq/l
SO4
Sulfate (SO4)
HCO3+CO3
Chloride (Cl)
Cl
ANIONS

TRAIL MOUNTAIN SPRINGS

Spring 17-35-1 vs. Precipitation

PEAK FLOW (JULY) vs. EAST MOUNTAIN WEATHER STATION



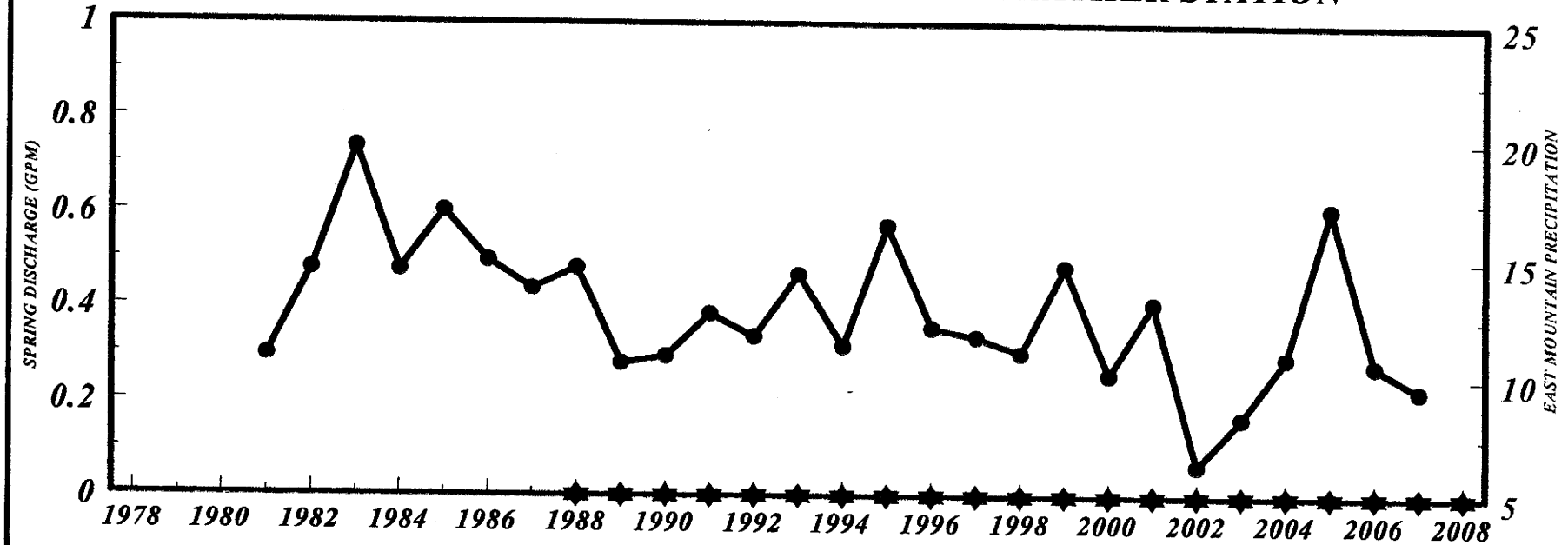
17-35-1 — EAST MTN PRECIPITATION

Flow ceased after repairs were made by Cattle Association to the spring. Groundwater now issuing 1/8 mile to the east of the original location, flowing at rate of 0.5 gpm

TRAIL MOUNTAIN SPRINGS

Spring 17-35-2 vs. Precipitation

PEAK FLOW (JULY) vs. EAST MOUNTAIN WEATHER STATION



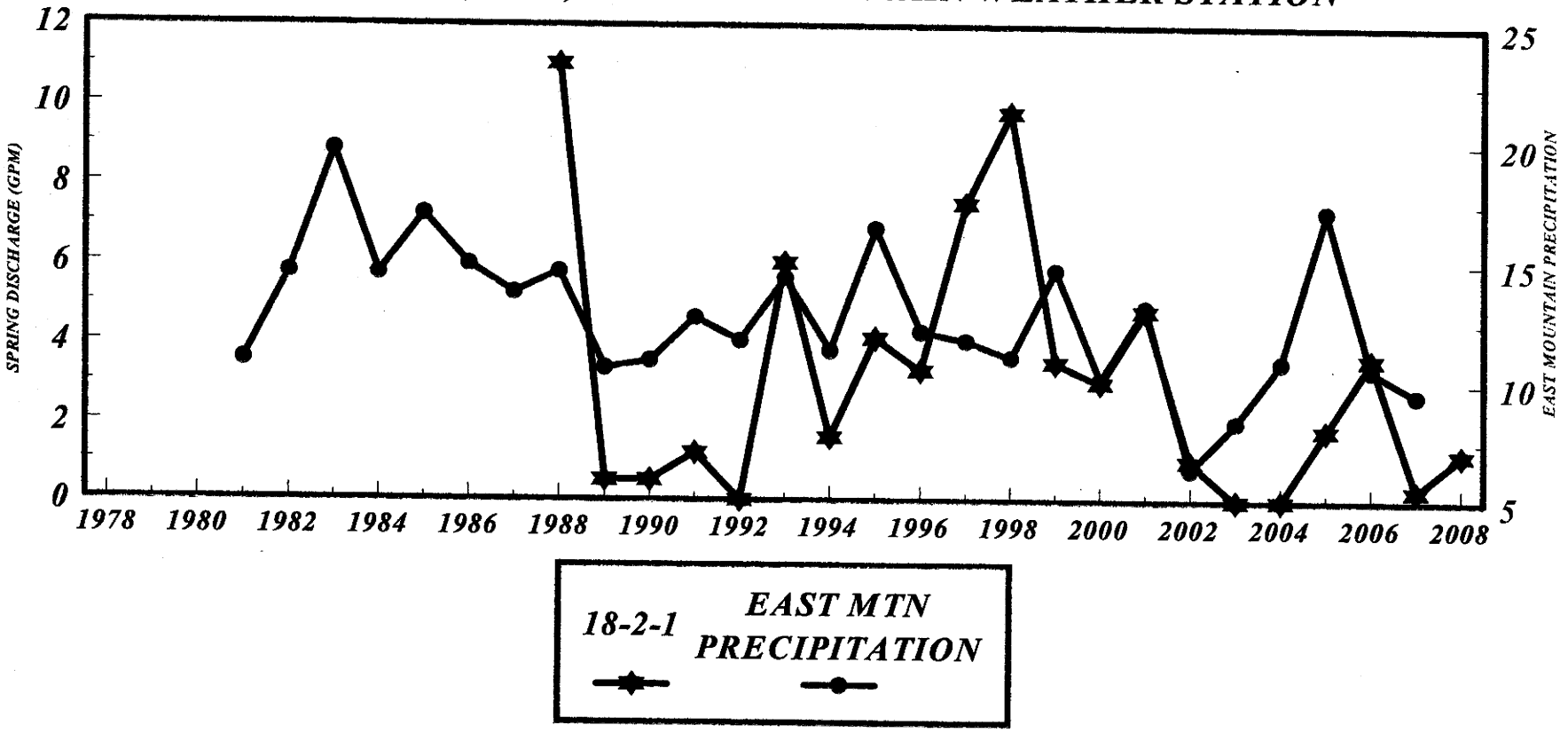
17-35-2 — EAST MTN PRECIPITATION

Monitoring site established in small drainage feeding developed pond, flow has not been observed at this site

TRAIL MOUNTAIN SPRINGS

Spring 18-2-1 vs. Precipitation

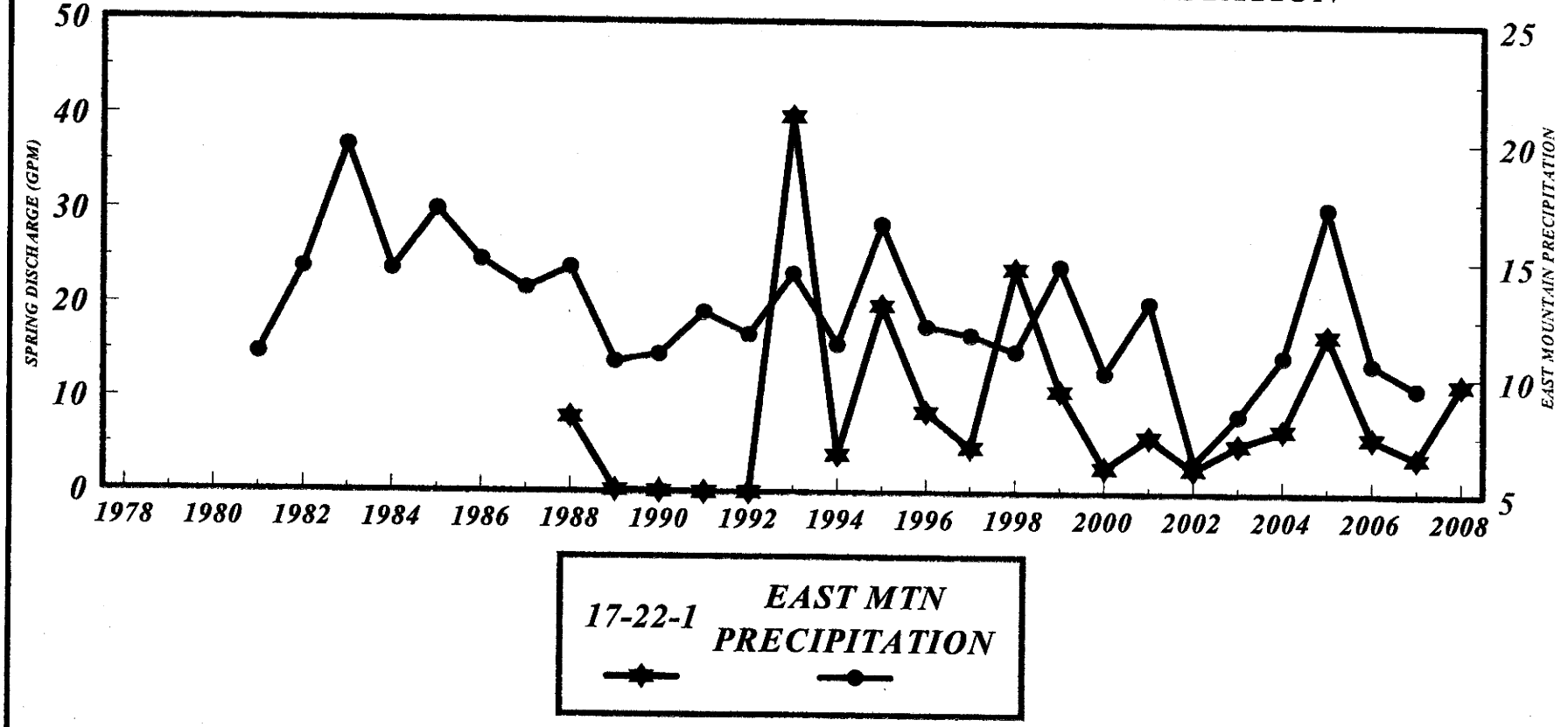
PEAK FLOW (JULY) vs. EAST MOUNTAIN WEATHER STATION



TRAIL MOUNTAIN SPRINGS

Spring 17-22-1 vs. Precipitation

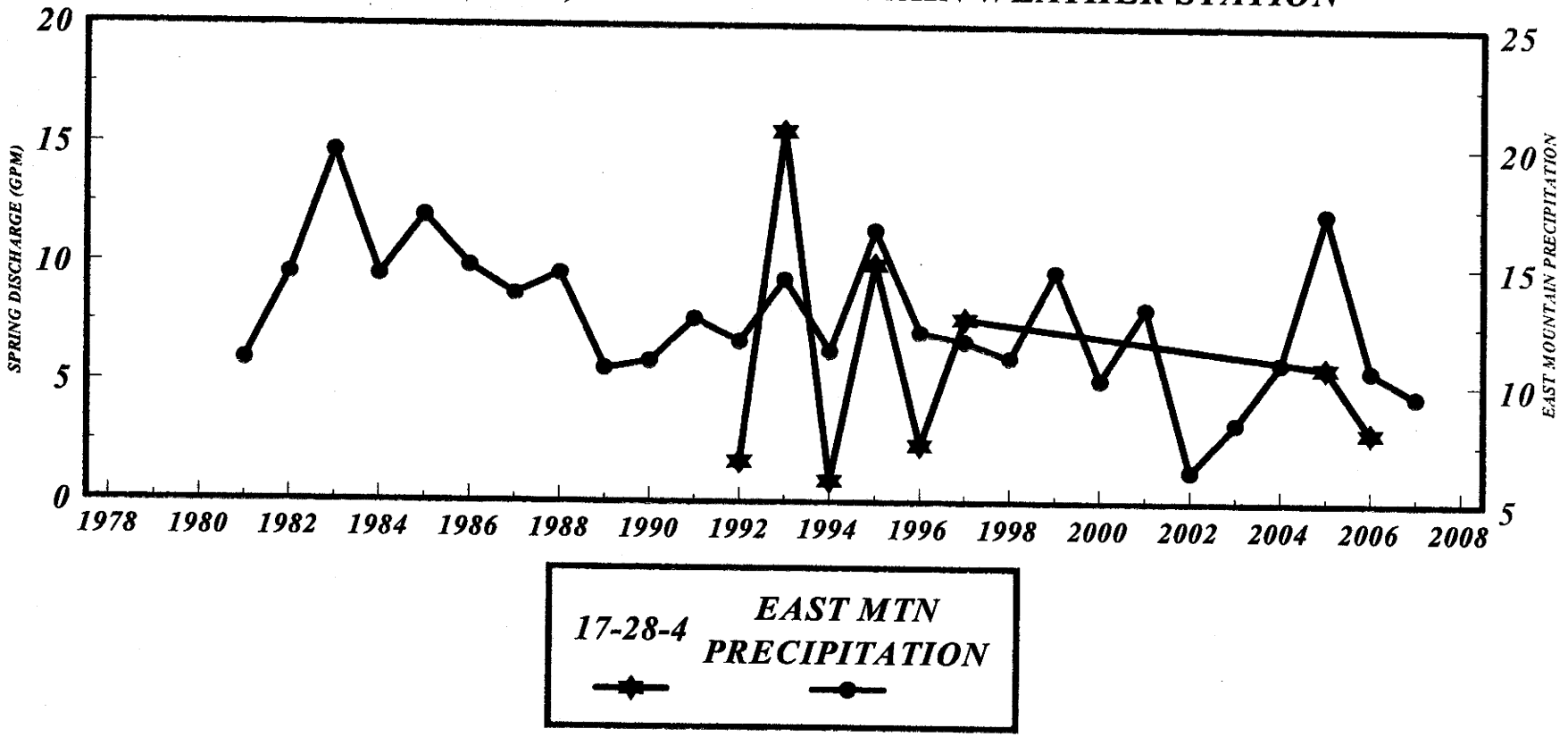
PEAK FLOW (JULY) vs. EAST MOUNTAIN WEATHER STATION



TRAIL MOUNTAIN SPRINGS

Spring 17-28-4 vs. Precipitation

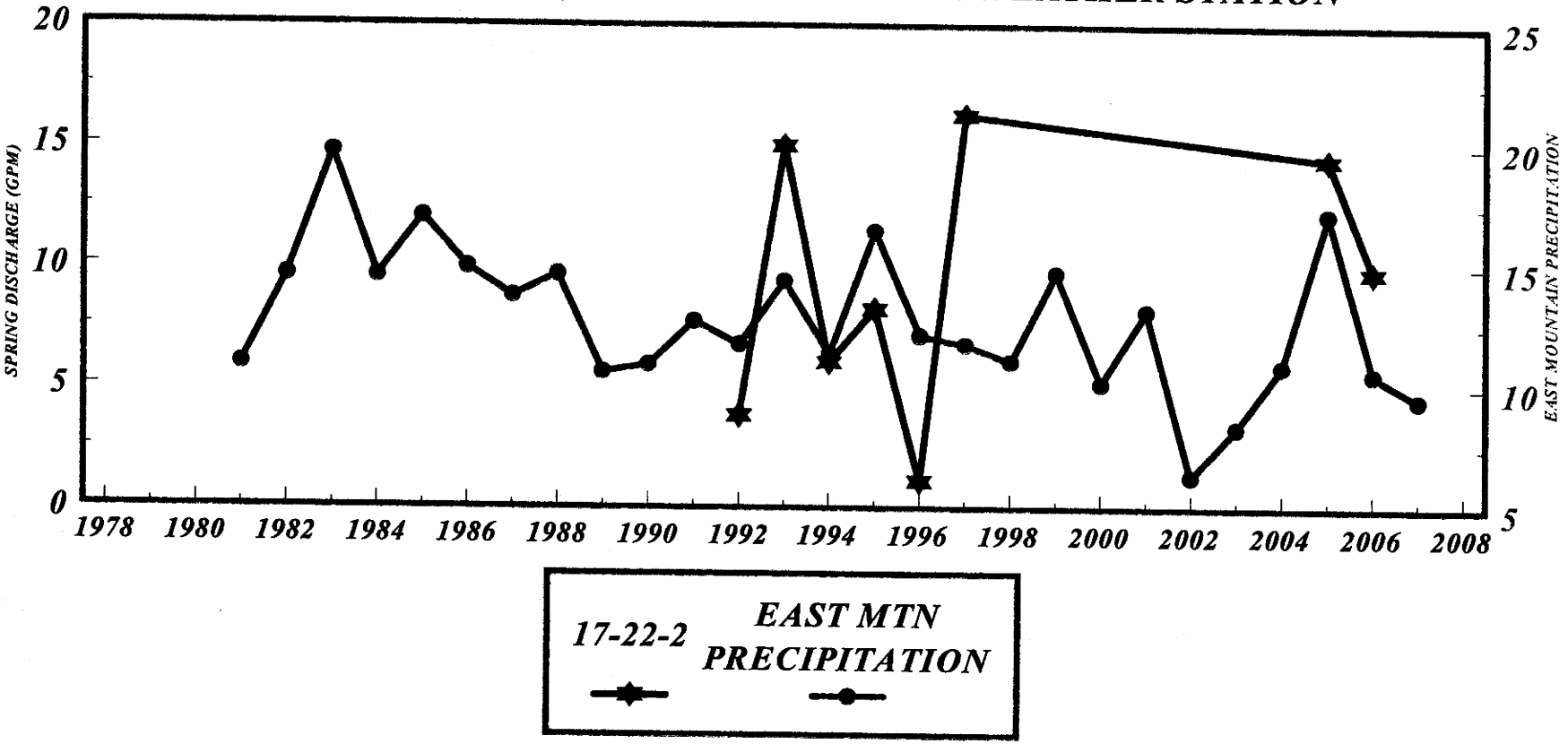
PEAK FLOW (JULY) vs. EAST MOUNTAIN WEATHER STATION



TRAIL MOUNTAIN SPRINGS

Spring 17-22-2 vs. Precipitation

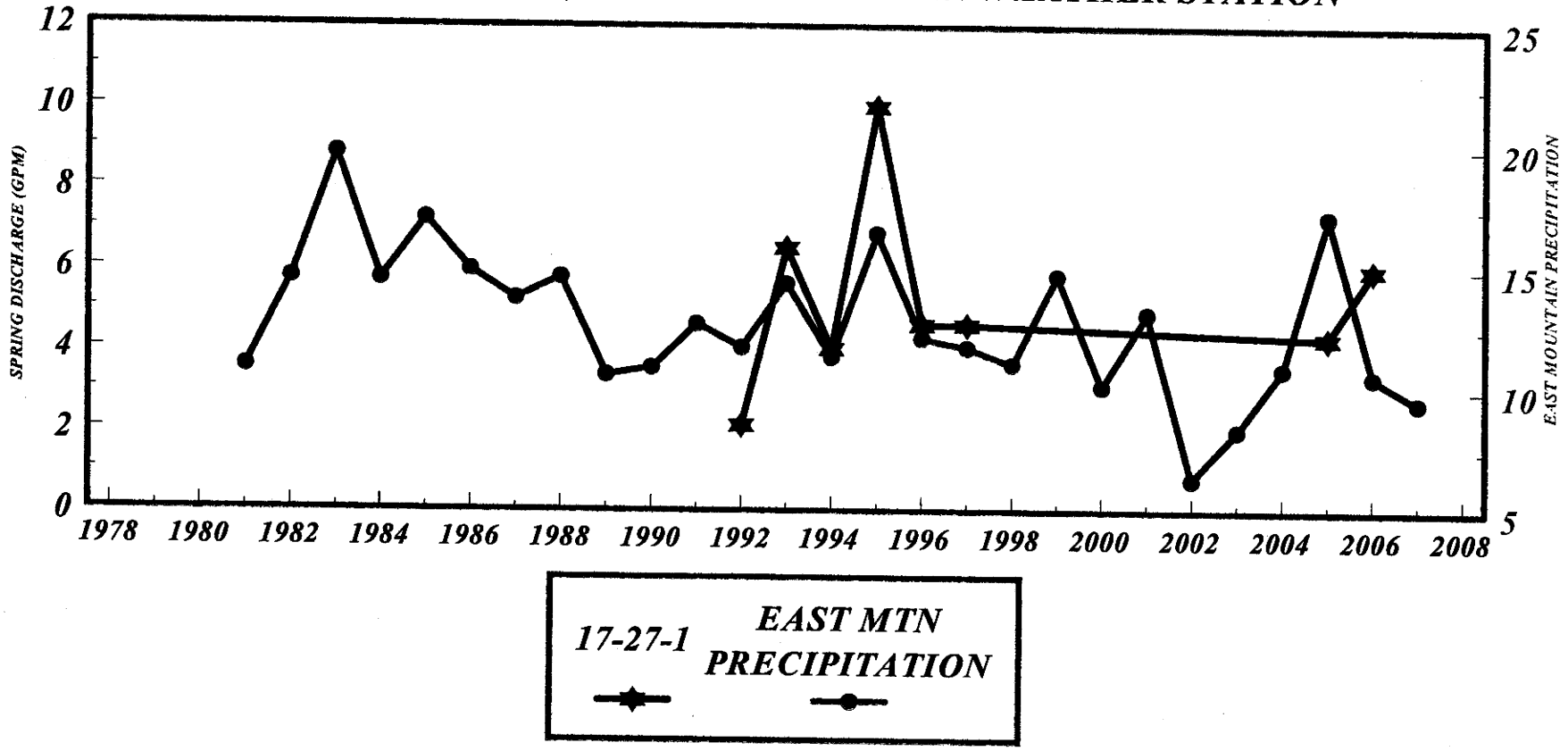
PEAK FLOW (JULY) vs. EAST MOUNTAIN WEATHER STATION



TRAIL MOUNTAIN SPRINGS

Spring 17-27-1 vs. Precipitation

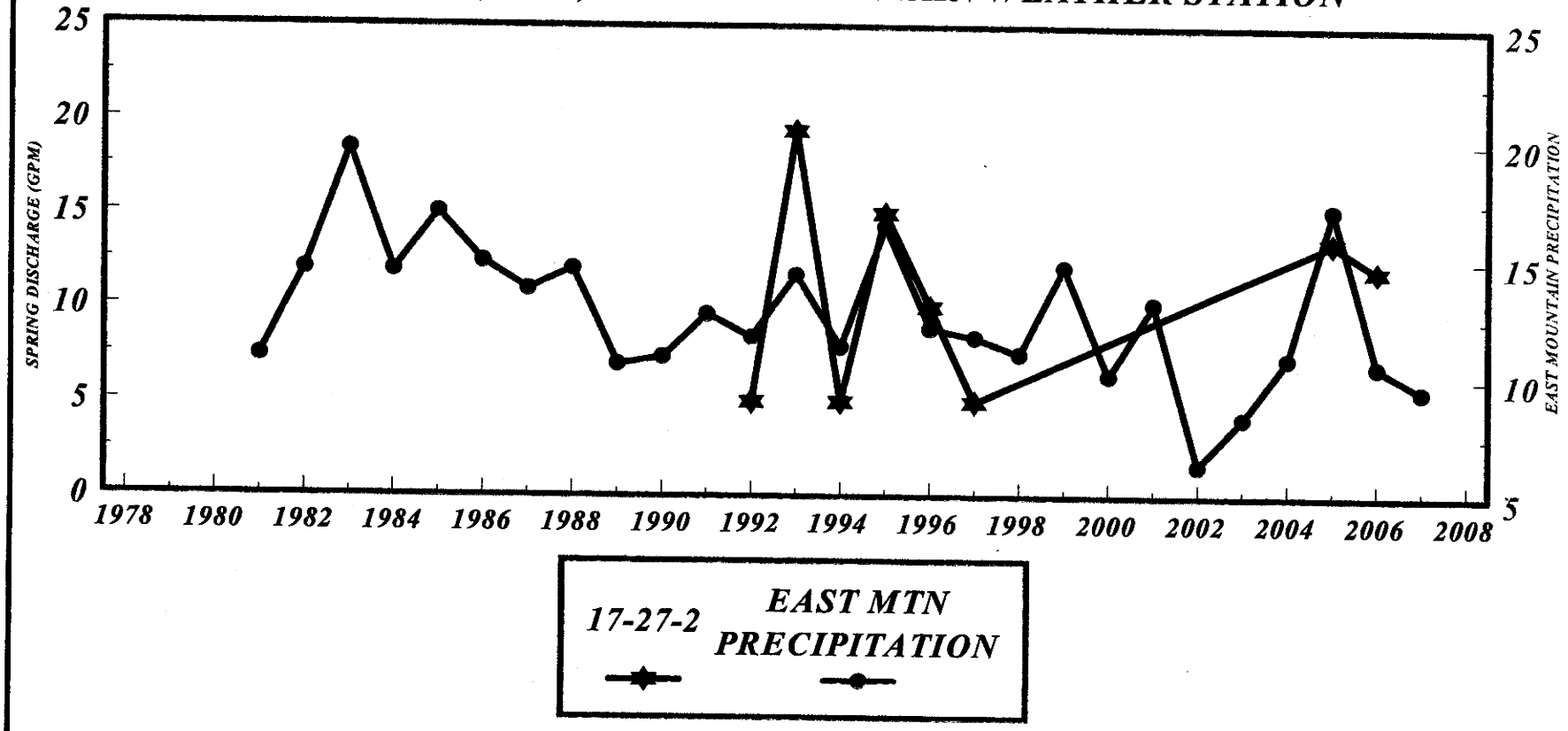
PEAK FLOW (JULY) vs. EAST MOUNTAIN WEATHER STATION



TRAIL MOUNTAIN SPRINGS

Spring 17-27-2 vs. Precipitation

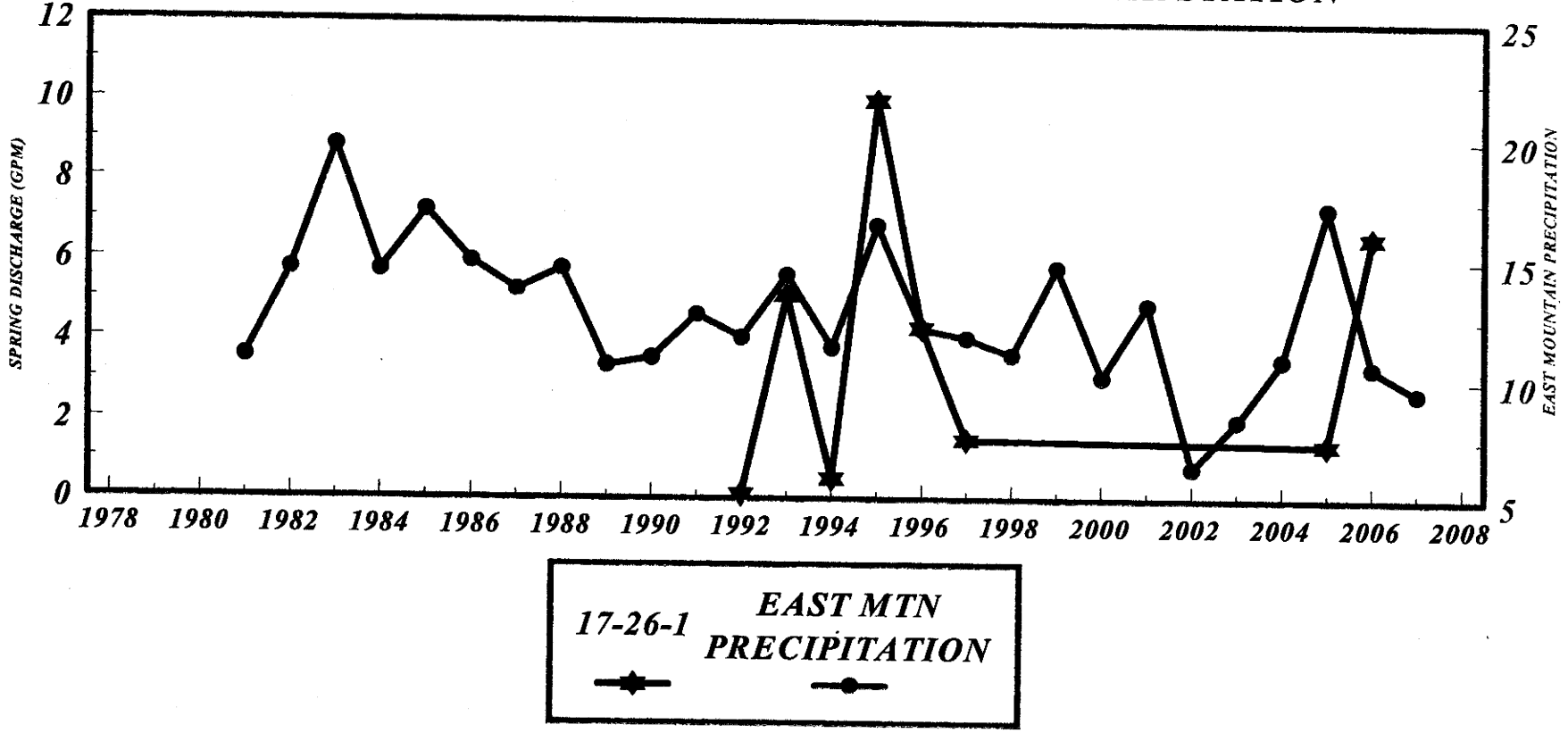
PEAK FLOW (JULY) vs. EAST MOUNTAIN WEATHER STATION



TRAIL MOUNTAIN SPRINGS

Spring 17-26-1 vs. Precipitation

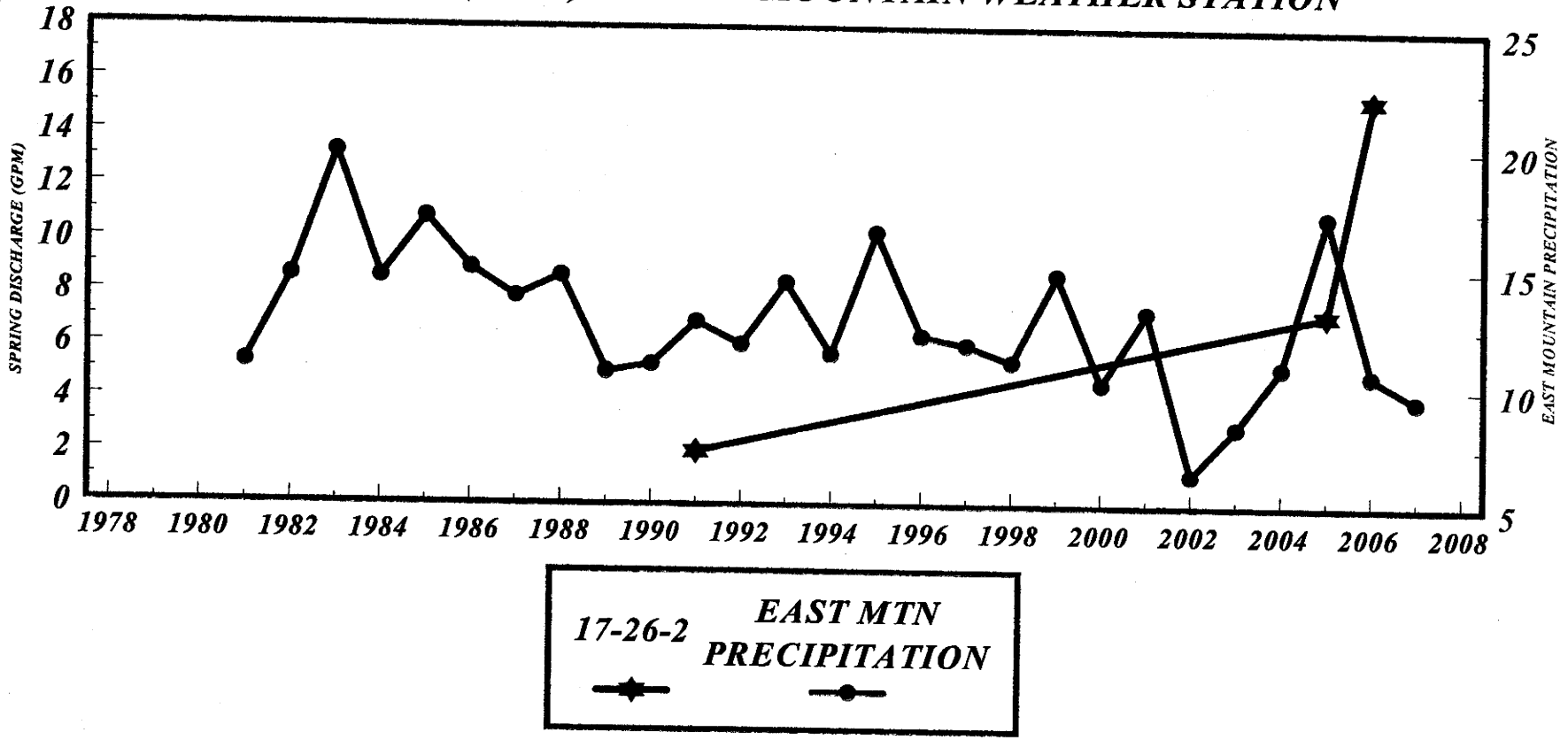
PEAK FLOW (JULY) vs. EAST MOUNTAIN WEATHER STATION



TRAIL MOUNTAIN SPRINGS

Spring 17-26-2 vs. Precipitation

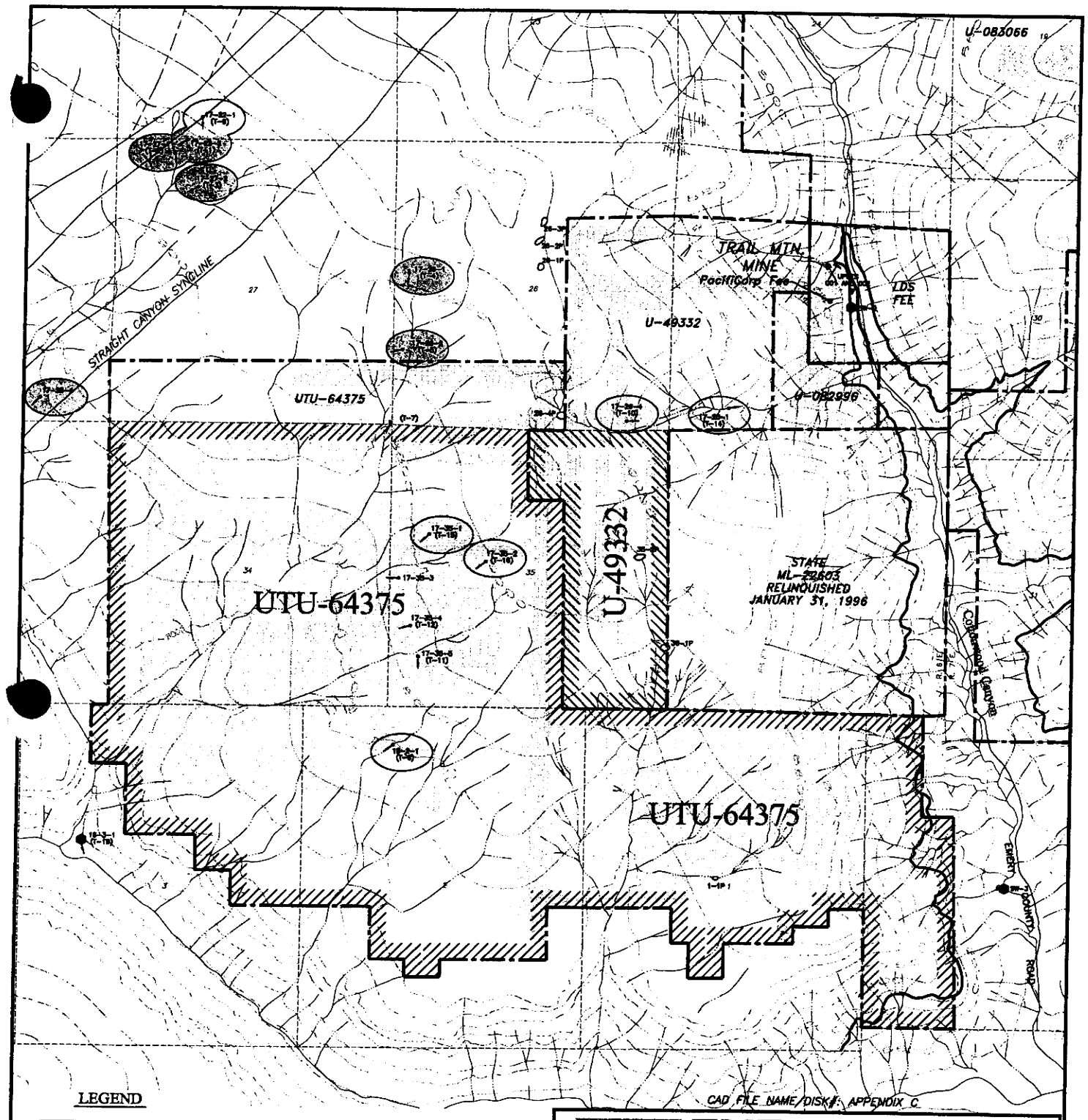
PEAK FLOW (JULY) vs. EAST MOUNTAIN WEATHER STATION



Surface Hydrology

The Trail Mountain Mine area is located in the headwater region of the San Rafael River Basin. The surface drainage system of the Federal Lease UTU-64375 forms part of the Cottonwood Creek drainage.

All drainages in and adjacent to Lease UTU-64375 are ephemeral. The majority of the surface flow from the lease block drains to the west in un-named drainages which report to Cottonwood Creek. As detailed in Appendices A and B, subsidence is limited and affects of subsidence did not alter surface flow characteristics of the ephemeral drainages.



LEGEND

- EXISTING MINE WORKINGS
- PROPOSED LEASE RELINQUISHMENT AREA FOR FEDERAL LEASE UTU-64375
- PROPOSED LEASE RELINQUISHMENT AREA FOR FEDERAL LEASE U-49332
- INCLUDED IN TM DOGM MONITORING
- BASELINE MONITORED PRE/POST MINING
- SURFACE SITE

CAD FILE NAME/DISK #: APPENDIX C

ENERGY WEST MINING COMPANY
A SUBSIDIARY OF PACIFICORP

TRAIL MOUNTAIN MINE PROPERTY
PROPOSED LEASE RELINQUISHMENT AREA
HYDROLOGIC DRAINAGE MAP

DRAWN BY: K. LARSEN		APPENDIX C
SCALE: 1" =1/2 MILE		DRAWING #:
DATE: NOVEMBER 7, 2008	SHEET 1 OF 1	REV.