FINAL REPORT

GEOMORPHIC, HYDRAULIC AND LATERAL MIGRATION CHARACTERISTICS OF THE COLORADO RIVER MOAB, UTAH

Prepared for

Canonie Environmental and Atlas Corporation

Prepared by

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MEI Ref. No. 94-02

May, 1994

Mussetter Engineering Inc.

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1. INTRODUCTION

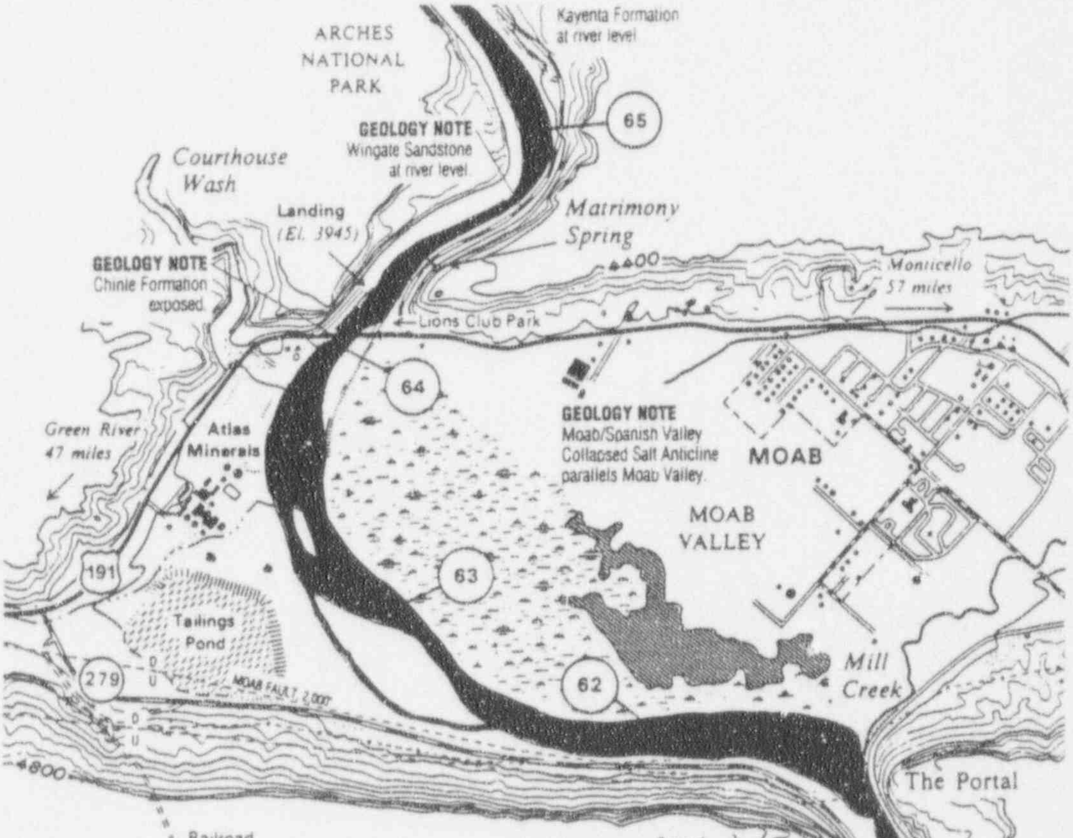
1.1 Study Purpose and Background

An analysis of the geomorphic, hydraulic and lateral migration characteristics of the Colorado River near Moab, Utah was performed by Mussetter Engineering, Inc. (MEI). The purpose of the study was to evaluate the potential for lateral migration of the river toward the Atlas Corporation tailings pile located in the right overbank approximately 1.7 miles northwest of Moab. (**Figure 1.1**)

Previous studies by Canonie Environmental (hereinafter referred to as Canonie) associated with the design of the reclamation plan for the uranium mill and tailings disposal area (Canonie, 1989 and 1992) concluded that the river is unlikely to erode in the direction of the tailings pile during the design life of the project. In reviewing the reclamation plan and supporting documentation, the Nuclear Regulatory Commission (NRC) found insufficient basis for this conclusion and requested additional information to either substantiate the conclusion or show that "the potential for long-term bank erosion and changes in the river's position in the valley", including the effects of the Probable Maximum Flood (PMF), had been considered in the proposed reclamation plan design. (NRC, 1993 and 1994) In their comments, the NRC specifically questioned whether the basic data and assumptions used to evaluate the hydraulic characteristics of the river were valid.

At the request of Canonie and Atlas Corporation, the MEI study team performed a preliminary evaluation of the available information, including an earlier "Geomorphic Evaluation of the Long Term Stability of Atlas Minerals Uranium Mill Site, Moab, Utah" prepared by Water Engineering and Technology, Inc. in 1981. (Harvey and Schumm, 1981) The preliminary evaluation indicated that, in spite of the bend in the river adjacent to the tailings pile, lateral migration into the tailings pile is unlikely. This conclusion was based on several factors, including:

1. the presence of bedrock outcrop just up- and downstream of the site which fix the position of the river at these locations, limiting the amount of curvature that can reasonably develop between the bedrock controls,



* Circled numbers are river miles upstream of the Colorado/Green River confluence.

Figure 1.1. Location map of the project site (from Belknap, 1991).

2. the presence of Moab Marsh on the inside of the bend opposite the tailings pile which is believed to be inundated relatively frequently during high flow periods, providing significant flood relief and releasing energy from the river channel that would otherwise be directed toward the outside of the bend,

3. the hydraulic control caused by the constriction at the Portal, downstream of the site, which creates backwater conditions at high discharges, reducing the flow velocity within the channel and limiting the erosive power of the flow, and

4. the presence of the alluvial fan on which the tailings pile is located which counteracts lateral migration of the river.

This study involved a detailed evaluation of these factors and other available information to verify or refute the above stated preliminary conclusions.

1.2 Study Team and Authorization

This study was performed by Drs. Robert A. Mussetter, P.E. and Michael D. Harvey, P.G. for Canonie Environmental and Atlas Corporation. Dr. Stanley A. Schumm provided valuable input during the analysis and reviewed the final results and conclusions.

1.3 Scope of Work

The following tasks were performed to accomplish the purposes of this study:

1. The study team attended a meeting with Canonie and Atlas Corporation at the project site to discuss the project goals, approach and available data,

2. Available data were collected and reviewed. These data included:

    a. historical aerial photography of the study reach,

    b. previous hydrologic analyses, including gage records for the Colorado River at Cisco gage, estimates of peak discharges for the 500-year flood and PMF.

    c. topographic mapping of the Moab Marsh area recently prepared by the U.S. Bureau of Reclamation (BOR, 1994) based on aerial photography taken in January, 1994.

    d. River cross section and high-water mark data collected by Keogh Land Surveying on April 5-8, 1994.

    e. previous reports and/or analyses of geologic, geomorphic, hydraulic and channel stability conditions in the vicinity of the project site.

3. A field reconnaissance of the project site was performed by the project team on April 4-6, 1994 to evaluate the existing condition of the channel banks and to obtain information for use in the geomorphic, hydraulic and bank stability analyses. The field reconnaissance was performed in conjunction with the cross section surveys discussed above.

4. A geomorphic analysis of the river in the project area was performed to confirm or refute the observations listed in paragraph 1.1.

5. A hydraulic model of the study reach was developed and calibrated using the Corps of Engineers HEC-2 computer program, the surveyed cross sectional data, available topographic mapping (USBR, 1994; IntraSearch, 1981, U.S. Geologic Survey, 1985), plans for the U.S. Highway 191 bridge obtained from the Utah Department of Highways and Transportation and observations during the field reconnaissance. The study reach for the HEC-2 hydraulic model extends from the hydraulic control at the Portal upstream through the U.S. Highway 191 bridge.

6. An analysis of the vertical and lateral stability of the study reach was conducted using results of the geomorphic analysis, the calibrated hydraulic model, and the estimates of the total work expended on the channel bank adjacent to the tailings pile for the range of flows up to and including the PMF.

2. GEOLOGIC AND GEOMORPHIC CHARACTERISTICS OF STUDY REACH

2.1 Geologic Setting

The project reach of the Colorado River that extends from the U.S. Highway 191 Bridge to the Portals, a distance of about 3 river miles, is located in Grand County, Utah within the northern portion of the Moab-Spanish Valley structural and topographic depression formed on the collapsed crest of a north-south trending salt anticline. The crest of the anticline is broken by several braided en-echelon normal faults that are downthrown to the northeast and which parallel the crest (Joesting et al.,1966). Low synclines parallel the structure on the northeast and southwest sides. The project reach is located within the Canyonlands section of the Colorado Plateau Physiographic Province (Fenneman,1931) which comprises a plateau varying in elevation from about 5,000 to 7,000 feet that has been epeirogenically upwarped and folded. The region is characterized geomorphically by deeply incised canyons, plateaus on local upfolds, hogbacks on plateau margins and lacolithic mountains rising above the plateau.

A detailed and in-depth discussion of the regional and local geology of the project reach was presented in the Safety Analysis Report prepared for Atlas Minerals Division (Dames and Moore,1975). Locally three roughly-parallel, northwest-trending normal faults, which have been downthrown on the northeast sides, have been mapped (Williams,1964). The northernmost fault is of relatively small displacement (100 feet) and it dies out on the Moab anticline. The two southern faults are spurs of the Moab Fault, which extends for about 12 miles northwest of the river. Adjacent to the Moab Wash alluvial fan displacement of the southern fault spur is about 300 feet. The northern fault spur is poorly exposed northwest of the river but the displacement has been estimated to be on the order of 700 feet (Dames and Moore,1975). The faults cannot be dated because of the absence of Tertiary age rocks in the section, but there is no evidence of displacement of Recent alluvium. It is highly unlikely given the lack of evidence of displacement of Recent alluvium that fault-induced changes in the location of the river will occur.

The project reach of the river is bounded to the north by the coalesced alluvial fans of Moab Wash (Drainage Area 8 square miles) and Courthouse Wash (Drainage Area 170 square miles); to the east by vertical cliffs composed of the Wingate (aeolian sandstone) and Kayenta (interbedded siltstones and sandstones) Formations; to the west by cliffs composed of taluscovered slopes underlain by Cutler-Rico (limestones, sandstones, conglomerates, shales), Moenkopi (interbedded sandstones and siltstones) and Chinle (siltstones, sandstones, conglomerates) Formations; and to the south by a large topographic depression locally referred to as Moab Marsh (**Figure 2.1**). The entrance (east) to and exit (west) from the valley are bedrock controlled and therefore the potential for lateral migration of the river within the valley is severely constrained by inlet trajectory and the distance between the bedrock-fixed inlet and exit control points.

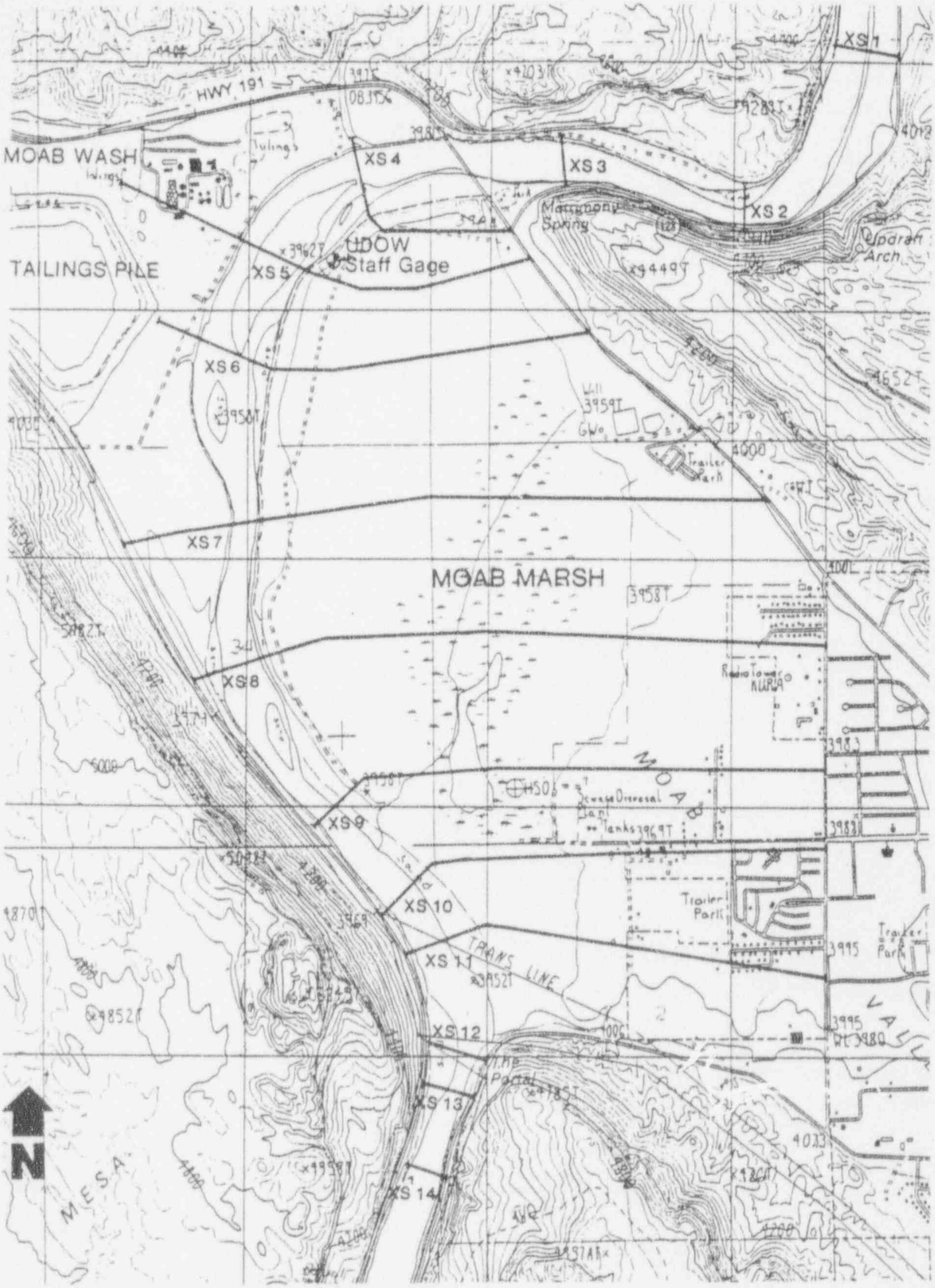
2.2. Geomorphic Setting

A field inspection of the project area was conducted by Drs. R.A. Mussetter and M.D. Harvey between April 4 and 6, 1994. Areas traversed by foot included the Moab Wash fan, Moab Marsh and both banks of the Colorado River between the Highway 191 bridge and the Portals. The river itself was traversed by boat from approximately 1 river mile upstream of the bridge to just downstream of the Portals as part of the topographic survey effort. High-water marks from both the 1993 runoff season (Qpk~ 48,900 cfs) and 1984 runoff season (Qpk~70,300 cfs) were identified during the field inspection for use in subsequent hydraulic model calibration.

For the purposes of this investigation of the bank erosion potential of the Colorado River within Moab-Spanish Valley (Figure 2.1) there are four geomorphic units that require consideration: 1) Colorado River, 2) Moab Wash-Courthouse Wash alluvial fan complex, 3) talus-mantled slopes on the right bank of the river downstream of the tailings pile, and 4) Moab Marsh-Moab Slough complex.

2.2.1. Colorado River

Within the overall project reach the Colorado River can be subdivided into three subreaches. Upstream of the Highway 191 Bridge the river is bedrock bounded within a canyon and the hydraulic characteristics and consequent sediment transport are controlled by the bedrock geometry (Harvey et al., 1993). At least within the time frames being considered in this investigation (1,000 years in accordance with 10CFR40, Appendix A), there is very little potential for significant erosion of the bedrock and lateral migration of the river, and therefore, the alignment of the river (northwest) as it enters the alluvial subreach is fixed (between cross sections 3 and 4, Figure 2.1).



SCALE: 1" = 2000'

Figure 2.1. Map of the study reach showing the location of cross sections and other significant features.

The alluvial subreach extends from the Highway 191 bridge downstream to the Portals (cross section 12, Figure 2.1). The left bank (looking downstream) and overbank area (Moab Marsh) is composed entirely of relatively fine grained (sands, clays and silts) alluvium. Topographically, the left overbank area has been modified with a system of levees and by the construction of fish rearing ponds. The levee that extends for the entire length of the left bank from the Highway 191 bridge to the Moab Slough outfall channel is severely breached in the vicinity of cross section 5 (Figure 2.1) and a large sandy crevasse splay deposit has formed on the landward side of the breach. Breaching of the levee occurred during the 1984 runoff season. The levee is also multiply breached between cross sections 8 and 9. The right bank of the river is composed of a mixture of vertically and laterally accreted Colorado River alluvium (sands, silts and clays) and alluvial fan sediments (range from small boulders to clays) between the bridge and cross section 6. From cross section 6 to cross section 8 the bank is composed of fine-grained Colorado River alluvium, the result of bank attachment of a mid-channel bar and subsequent infilling of the former channel. The accreted sediments that have been stabilized by tamarisk are lapped onto a mixture of fan and river sediments.

The remainder of the right bank is primarily composed of a mixture of alluvial and colluvial materials that tend to be self-armoring. The downstream-most portion of the river within the project reach (cross sections 12,13,14) is again bedrock bounded. The relatively acute bend in the river at the Portals (approximately 60 degrees) has a major effect on backwater generation at higher flows (Harvey et al.,1993). All of the alluvial and intermixed alluvial and fan sediments have been densely colonized with tamarisk.

Within the project reach of the river there are a number of large mid-channel and bank-attached bars that are composed primarily of sand. The presence of the bars and the time-sequential photographic evidence of lateral accretion of the right bank indicate that the reach is net aggradational, the result of backwater generated at the Portals during flow events when significant sediment transport is occurring. Bar heights are very close to the bankfull elevation and 1993 high-water marks are located very near the highest point on the bars. The elevations of the bars and the persistence of both willows and tamarisks on their higher surfaces provides strong evidence that the bed of the river does not degrade generally during flood events.

2.2.2. Moab Wash-Courthouse Wash Alluvial Fan Complex

Courthouse Wash historically has had a significant effect on the location of the river. Prior to 1956 the alignment of the river was very similar to that of the present between cross sections

4 and 6. A large flood on Courthouse Wash caused significant deposition at its mouth and this deflected the channel of the Colorado River to the south. The dumped-rock dike constructed across the mouth of the slough at cross section 4 by Atlas Corporation was emplaced to return the river to its former location to enable water to be pumped from the river. The pre-1956 flood on the Wash demonstrates that the tributary fans on the north side of the river have the ability to deflect the river to the south which counteracts in the long term the effects of any lateral erosion by the river.

Review of available historical photographs indicates that the right bank segment between cross sections 5 and 6 has remained remarkably fixed spatially. Field inspection indicated that the toe of the bank in this reach is comprised of coarse grained (up to small boulders) fan sediments derived from Moab Wash. The persistence of the river in this location indicates that the natural bank armoring is sufficient to prevent bank erosion and retreat during the range of flows (less than bankfull) when the erosive forces are highest. As is shown in a later section of the report (Chapter 5) the bank shear is reduced at higher than bankfull discharges, and therefore, the coarse grained fan sediments will be able to prevent lateral migration of the river at the higher discharges as well.

The probability that both the fan progradation process and natural armoring of the fan margin will continue in the future is enhanced by the presence of the tailings pile. The tailings pile occupies a significant portion of the natural fan surface, thereby eliminating an equivalent area for deposition of fan sediments. Reduced fan area will effectively force deposition to occur over a smaller area and will tend to force the fan to prograde further out into the Colorado River (Fischer and Harvey,1990). Further, increased deposition on the residual fan area will tend to cause vertical accretion of the fan surface thereby reducing the flooding depths and forcing more flow to the south into the Moab Marsh. Confinement of flows on the fan increases the probability of down-fan transport of coarse sediments regardless of whether they are being transported by Newtonian (fluvial) or non-Newtonian (mud/debris) flows. The greater the proportion of coarse sediments being transported down-fan to the Colorado River the greater the probability of reinforcement of the self-armoring process.

2.2.3. Talus-Mantled Slopes

The right bank of the Colorado river between cross sections 8 and 11 is composed of interbedded colluvium and alluvium. The colluvium contains very large sandstone blocks derived from slope retreat and failure of sandstone units within the formations that comprise the western cliffs. Although the associated alluvium and finer grained colluvium can be eroded by the river, the presence of the coarse material ensures that ultimately a self-armoring condition is developed. Even if the self-armoring failed to eventuate the river would only be able to migrate a short distance to the west before it encountered in-situ bedrock. The relative resistance of the right bank of the river in this location ensures that the potential length of the river, and therefore its ability to develop further sinuosity, is very limited.

2.2.4. Moab Marsh-Moab Slough Complex

Moab Marsh and Moab Slough constitute a topographic depression on the left bank of the river from the highway bridge crossing to cross section 12 at the Portals. Attempts to use the area for agriculture resulted in the construction of a ring levee that paralleled the left bank of the river. Prior to construction of the levee overbank flows into the marsh occurred at a discharge of about 40,000 cfs. However, after construction of the levee and prior to its failure in the vicinity of cross section 5 in 1984, flows of about 70,000 cfs were contained within the river channel. The greater in-bank flows would have increased the erosion potential for the right bank, but the historical evidence indicates that even under these conditions the right bank experienced accretion and not erosion.

Field observation confirms that significant amounts of flow exit the river channel at the approximate location of cross section 5. The flow paths into the marsh are very clearly defined by sand splays. Silt lines on vegetation (cottonwoods, Russian olives and tamarisk) on the northern margin of the more or less perennial open-water portion of the marsh indicate that there were flow depths on the order of 4 to 5 feet in this part of the marsh during the 1993 runoff season. However, there was no field evidence such as accumulation of debris on the upstream side of trees, that the flows had any great velocity. Rather the evidence indicates that the water was ponded which corroborates the backwater conditions demonstrated by the results of the hydraulic modelling (Chapter 4).

3. HYDROLOGY

A range of flows, up to and including the PMF, were used to evaluate the hydraulic and channel stability conditions within the study reach. Estimates of flood peak discharges were taken from previous studies (Canonie, 1989 and 1992) and from data measured at the Colorado River at Cisco gage. The specific values used in this study are summarized in **Table 3.1**.

Table 3.1. Summary of Flood Peak Discharges

Event	Peak Discharge (cfs)
1993	48,900
1983	61,900
1984	70,300
1917 (recorded maximum flow)	76,800
500-year (USGS)	123,500
PMF (Atlas Corporation)	178,000
PMF (NRC)	300,000

Depending on the particular hydraulic characteristics of the reach, smaller discharges that occur for longer durations on a frequent basis may be more significant to channel stability than the infrequent flood flow discharges. The record of mean daily flows at the Cisco gage was therefore analyzed to determine the relative frequency and duration of the range of discharges that have occurred in the study area. The Cisco gage is located just upstream of the Dewey Bridge approximately 31 miles upstream of the U.S. Highway 191 Bridge and is the closest Colorado River gage to the study reach. Since there are no significant tributaries between the gage and the study reach, the Cisco flow record is believed to be representative of the flows at the site. Although this gage has been in operation since 1914, only the 35 year period since 1959 was considered in the analysis because upstream flow regulation, which began at about that time, has significantly changed the flow characteristics. (Cooperand Severn, 1994) A mean daily flow duration curve for the Cisco gage for the period 1959 through mid-1993 was developed for this project. (**Figure 3.1**)

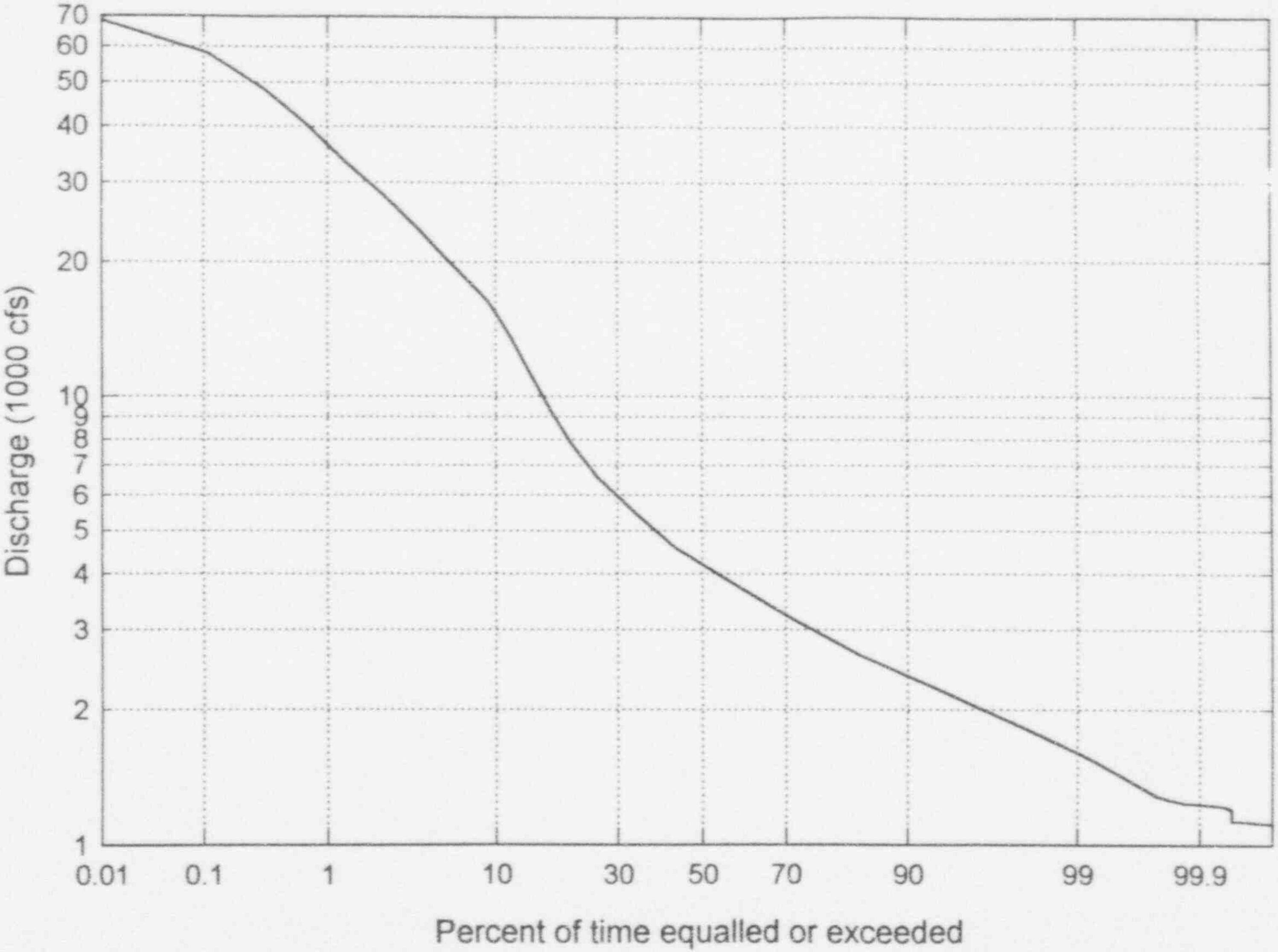


Figure 3.1 Duration curve of mean daily flows, Colorado River at Cisco, Utah, 1959-1993.

The daily flow duration analysis indicates that the median flow during the 1959 to 1993 time period was approximately 4,100 cfs. Flows exceeded 16,000 cfs approximately 10 percent of the time and 36,000 cfs approximately 1 percent of the time. The average flow during the period was 6720 cfs and the minimum and maximum mean daily flows were 1070 cfs and 69,500 cfs, respectively. Use of the flood peak discharges and mean daily flow duration curve in performing the hydraulic and lateral erosion analyses conducted is discussed in subsequent chapters.

4. HYDRAULIC ANALYSIS

A model of the study reach was developed and calibrated using the Corps of Engineers HEC-2 computer program to evaluate the hydraulic characteristics of the river for the range of flows considered in this study. The HEC-2 results were used to estimate the variation in bed and bank shear stress and work applied to the channel banks for a range of discharges. The study reach for the model extended from the downstream hydraulic control at the Portal upstream through the U.S. Highway 191 bridge.

The HEC-2 program uses the one-dimensional, standard-step method to predict the steady-state water-surface profile and corresponding average flow velocities, depths and channel topwidths for given input discharges at specific locations along the reach. Rigid boundary conditions are assumed in the HEC-2 computations.

4.1 Hydraulic Model Set-up and Assumptions

Required input data for the HEC-2 hydraulic model include cross section profiles of the river and overbanks, estimates of the channel roughness (Manning's n), expansion and contraction losses, and identification of channel bank stations and ineffective flow areas. Cross sectional data used to develop the model were taken from a variety of sources. Fourteen cross sections of the active river channel were surveyed specifically for this project during the week of April 4, 1994 by Keogh Land Surveying, Moab, Utah. The surveyed cross sections were tied to the State Plane Coordinate system providing horizontal, as well as vertical control. These cross sections were extended a sufficient distance into both overbanks to contain the maximum discharge considered in the modeling using data from available topographic mapping (USBR, 1994; IntraSearch, 1981, U.S. Geologic Survey, 1985). Plans for the U.S. Highway 191 bridge were obtained from the Utah Department of Highways and Transportation.

The USBR (1994) mapping, based on aerial photography taken in January , 1994, was recently prepared in conjunction with the Upper Colorado River endangered fish recovery program. This mapping included the river channel and most of Moab Marsh at a scale of 1"=200' with a 2' contour interval. The IntraSearch (1981) mapping, provided to MEI by Canonie, covered the Moab mill site at a scale of 1"=400' with a 2' contour interval. Based on the results of preliminary model runs, it was necessary to further extend some of the cross sections beyond the coverage on the available, larger scale mapping using the USGS 7½ minute map of the Moab Quadrangle.

Figure 2.1 shows the location of the surveyed cross sections and the orientation of the corresponding overbank extensions. Profile plots of the cross sections are provided in Appendix A. Channel roughness (Manning n) values and expansion and contraction loss coefficients were initially estimated from observations during the field reconnaissance and later adjusted during the calibration process to obtain modeled water-surface profiles that matched, as closely as practical, measured water-surface elevations and high-water marks. Relationships for estimating the flow depth in sand-bed streams developed by Brownlie (1983) were used to validate the range of main channel Manning n values used in the model and to aid in evaluating the expected variation in roughness with discharge associated with changes in bed form.

Overbank Manning n values were selected based primarily on the type and relative density of vegetation. Standard references, including Chow (1959) and Henderson (1966), and previous experience of the study team were used in selecting appropriate resistance values. Because the overbank roughness varies significantly due to changes in the type and density of vegetation, NH cards, which provide a means of specifying the roughness values between specific stations along the cross sections, were used at most cross sections in lieu of the normal NC cards which only distinguish between the main channel and overbanks. Details of the n-value selection process are discussed in the next section in relation to calibration of the model.

Encroachments were used at appropriate locations in the model to eliminate ineffective flow areas. The effective flow width in the left overbank at cross section 11 was established by assuming a 1:1 contraction ratio upstream of the Portal, resulting in a maximum overbank width of approximately 1500 feet. Because of the effect of the U.S. Highway 191 bridge and left bank levee just downstream of the bridge, flows were confined to the main channel at cross sections 4 and 5 and the HEC-2 split flow option, assuming weir flow over the levee, was used to estimate the amount of flow reaching the left overbank in this portion of the study reach. The weir profile was established based on the elevations along the top of the levee. A relatively low weir coefficient of 1.0 was used because of the very high roughness along the top of the levee caused by dense vegetation. This approach confines all flow to the main channel until the levee is overtopped. When overtopping occurs, flows overtopping the levee are removed from the main channel at cross sections 4 and 5. The total flow is returned to the river and overbanks at cross section 6.

During flood flows, when the water-surface elevations between cross section 4 and the bridge are higher than the top of the levee, the discharge in the left overbank at cross section 4 and 5 will be controlled by the amount of flow that can spill over the levee and not by downstream conditions. This modeling approach is, therefore, believed to be the most realistic of the options available with the one-dimensional HEC-2 program.

4.2 Calibration of the Hydraulic Model

Calibration of the HEC-2 model was accomplished by comparing the predicted water-surface elevations with measured water-surface elevations and high-water marks along the study reach. The water-surface elevations at each cross section at the time of the survey were used to calibrate the model for a discharge of approximately 4000 cfs. (Measured flows at the Cisco gage during the survey period varied from 3890 cfs to 4080 cfs, according to USGS records.) In addition, a staff gage was installed in 1993 along the left side of the channel just upstream of cross section 5 (see Figure 2.1) in conjunction with studies of Moab Marsh being conducted for the Upper Colorado River endangered fish recovery program. This staff gage will be subsequently referred to as the Utah Division of Wildlife (UDOW) staff gage. A rating curve for UDOW staff gage was developed by correlating water surface elevations measured during the 1993 runoff period with recorded flows at the Cisco gage. (Cooper and Severn, 1994) This rating curve provided excellent data with which to calibrate the HEC-2 model for flows up to approximately 48,000 cfs.

Observations during the field reconnaissance indicated that the left bank levee just downstream of the U.S. Highway 191 bridge did not overtop during the 1984 flood, which had a peak discharge of 70,300 cfs and is the largest recorded discharge since construction of the levee. Old high-water marks near the top of the levee along the upstream side, however indicate that overtopping was imminent. Other high-water marks were noted during the cross section surveys, but were of less value because of uncertainty regarding the specific flows with which they should be correlated.

In calibrating the HEC-2 model, an initial Manning n value of 0.03 was used for areas within the main channel that are essentially devoid of vegetation. Initial values used in the overbanks and vegetated portions of the main channel ranged from 0.05 in areas with grassy type vegetation to 0.15 in areas with thick stands of tamarisk or willow of more than a foot in height. Calibration of the model was achieved by adjusting all of the n-values by a constant factor until the predicted water-surface elevations matched, to the extent practical, the corresponding measured elevations and high-water marks. The main channel n values that produced the most reasonable calibration varied from 0.025 at a discharge of 4000 cfs to a maximum of 0.032 at 15,000 cfs and reducing progressively back to 0.025 at discharges of 70,000 cfs and greater.

Figure 4.1 is a profile plot of the channel thalweg, the measured water-surface elevations

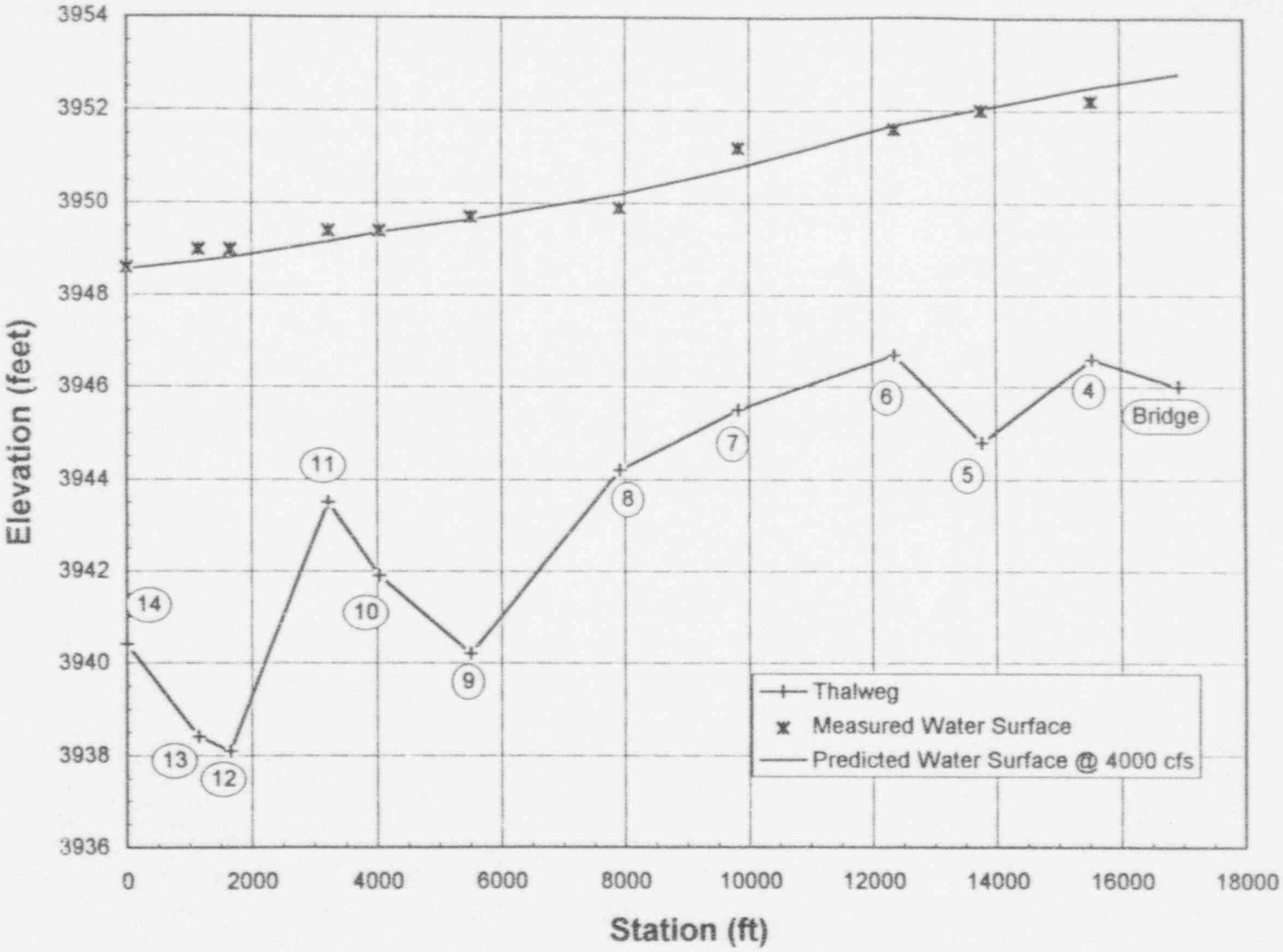


Figure 4.1 Profile plot of channel thalweg, measured water surface elevations, and predicted water surface profile in the study reach. (Discharge = 4,000 cfs)

at the time of the cross section surveys, and the calibrated water-surface profile through the study reach at a discharge of 4,000 cfs. **Figure 4.2** shows the predicted water-surface elevations for discharges ranging from 4,000 cfs to 48,900 cfs at cross section 5 and the water-surface elevations measured during the 1993 runoff season at the UDOW staff gage just upstream of cross section 5. These figures show excellent agreement between the predicted and measured elevations. The approximate magnitude and variation in main channel Manning n-value with discharge was further verified using the Brownlie (1983) relationship. Based on the predicted flow depths in the main channel, this relationship predicted values ranging from 0.025 to 0.035 with the average values for all cross sections in the reach increasing from approximately 0.027 at 4,000 cfs to a maximum of 0.032 at 30,000 cfs and reducing to about 0.029 at the higher modeled discharges. Considering the complexity of the flow and variation in roughness within the study reach, the values used in the calibrated model and those predicted by the Brownlie relationship are considered to be very consistent.

4.3 Modeling Results

After calibration of the HEC-2 model, runs were made for discharges ranging from 1,000 cfs through the NRC estimated PMF discharge of 300,000 cfs. Water-surface profiles for selected discharges within this range are plotted in **Figure 4.3**. The water-surface profiles clearly show the backwater effect caused by the constriction at the Portal (~cross section 12) at high flows. For the two lower discharges of 4,000 cfs and 20,000 cfs shown on the plot, the water-surface profiles are relatively uniform and are roughly parallel to the average bed slope through the reach. At a discharge of 45,000 cfs, the water-surface slope between cross sections 12 and 13 begins to steepen because of the constriction, and the slope of the water surface upstream of cross section 12 begins to flatten in comparison with the average slope through the reach. This phenomenon becomes more pronounced at higher flows. At the extreme discharges associated with the 500-year flood and PMF the study reach between the Portal and U.S. Highway 191 bridge, for practical purposes, becomes a lake.

A plot of cross section 6, which is directly adjacent to the tailings pile is shown in **Figure 4.4** along with the estimated water-surface elevations for discharges of 4,000 cfs, 48,900 cfs (the 1993 peak discharge), 70,300 cfs (the 1984 peak discharge), 123,500 cfs (the USGS estimated 500-year flood peak) and 300,000 cfs (the NRC estimated PMF peak). This figure shows that the left bank is overtopped by a small amount at about 48,900 cfs. In fact, review of the detailed HEC-2 output for other discharges indicates that overbank flows along the left side into Moab Marsh begin at about 40,000 cfs which is consistent with local observations. At 70,300 cfs, the flow

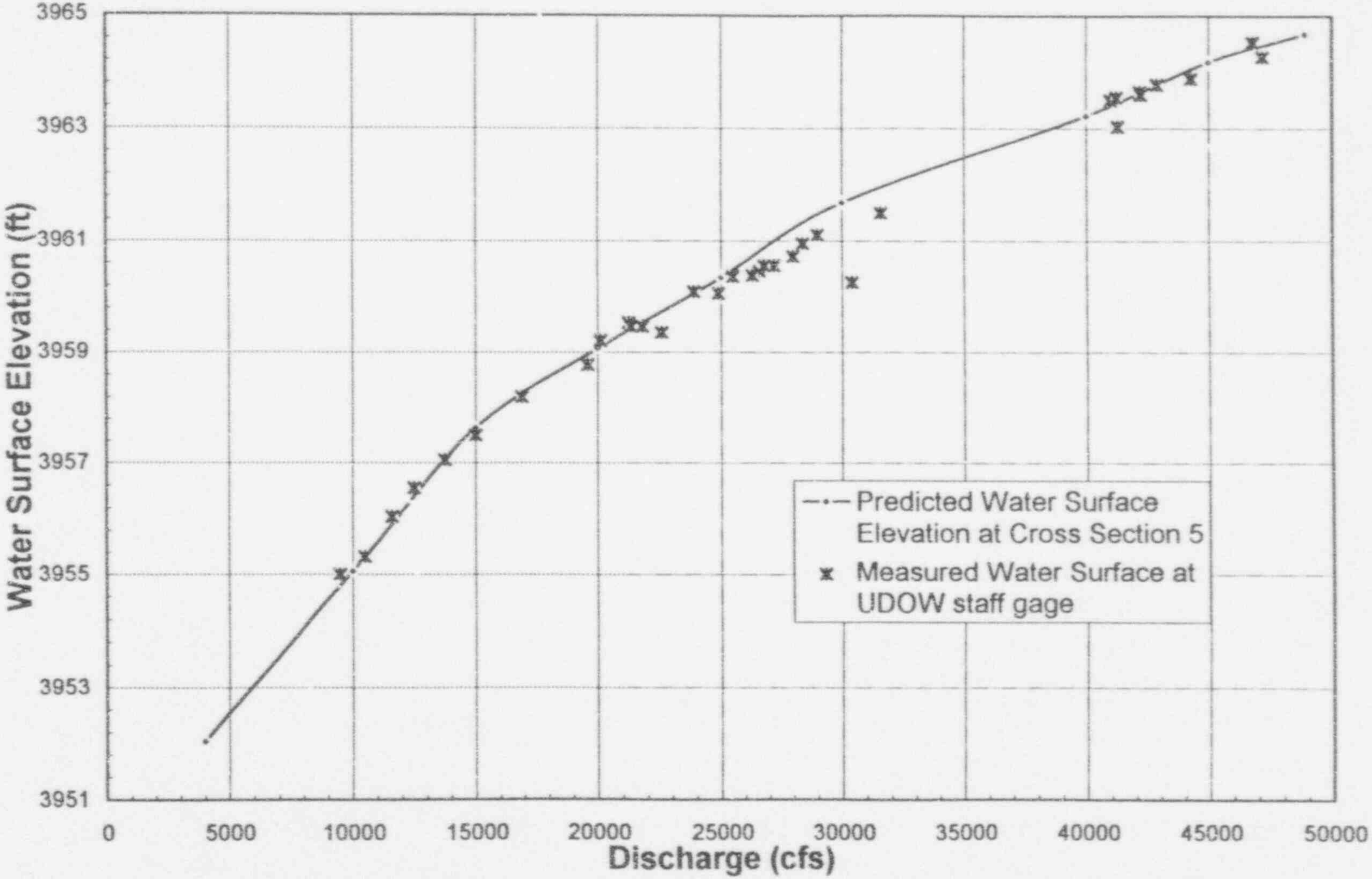


Figure 4.2 Measured water surface elevations during 1993 runoff period at UDOW staff gage and predicted water surface elevations at cross section 5.

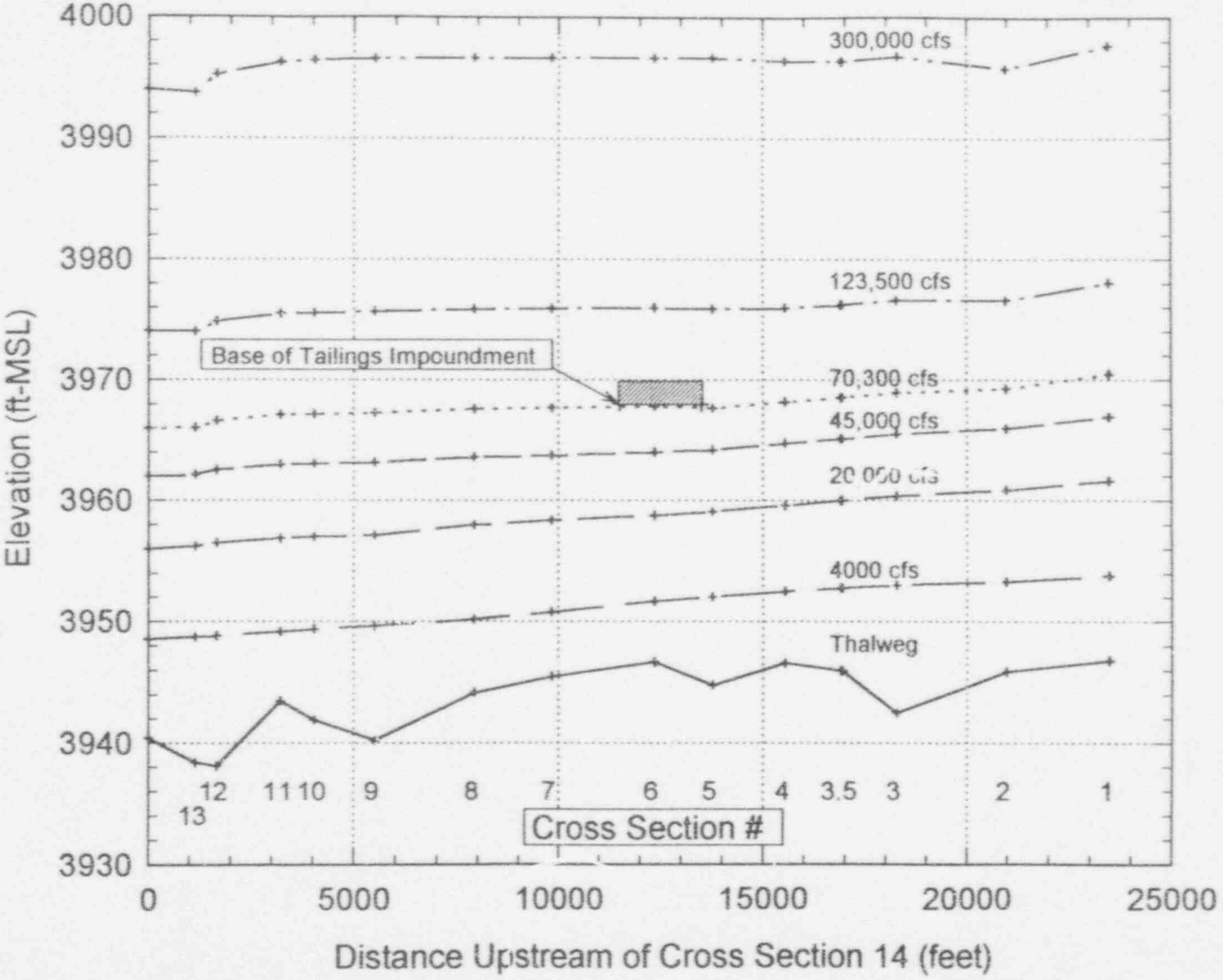


Figure 4.3 Predicted water surface profiles for the study reach for 6 discharges ranging from 4,000 cfs to 300,000 cfs.

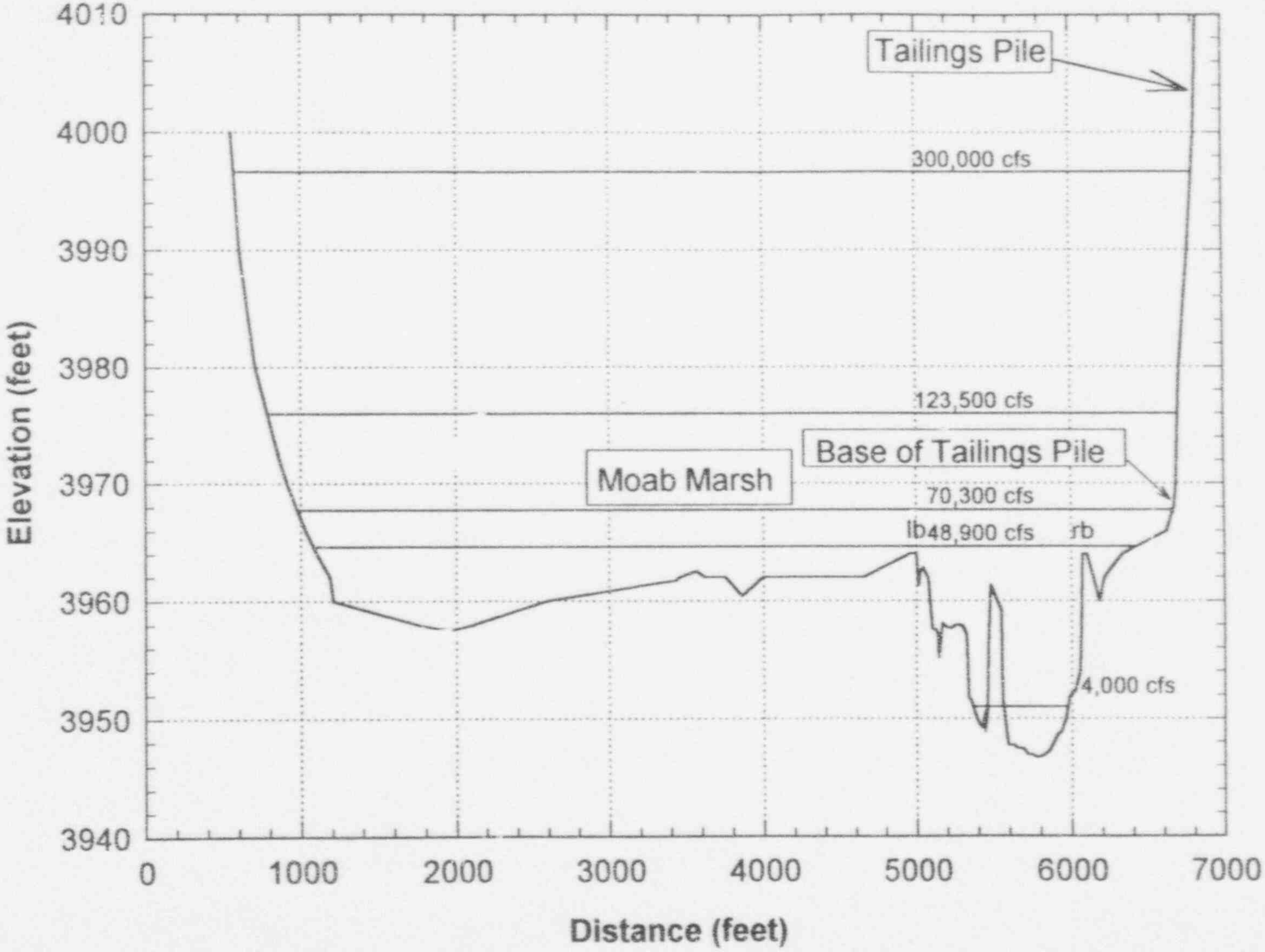


Figure 4.4 Profile of cross section 6 showing the predicted water surface elevations for 6 discharges ranging from 4,000 cfs to 300,000 cfs. (Note: lb and rb refer to the left and right overbank stations used in the HEC-2 model.)

appears to reach the toe of the tailings pile, which again is consistent with local observations during the 1984 flood.

The effect of the backwater and the significant amount of flow into Moab Marsh in the left overbank at flows greater than about 40,000 cfs on the flow velocities in the main channel is illustrated in **Figure 4.5**. The values shown in this figure represent the average velocity in the active, unvegetated portion of the main channel in areas where a divided flow condition or dense, woody vegetation (tamarisk or willows) exists within the bank stations defined in the HEC-2 model. These values were determined using conveyance weighting techniques for the appropriate portion of the main channel and are, in general, higher than the main channel average velocities listed in the HEC-2 output. The values shown in the figure are more representative of conditions along the flow path that controls the erosion potential along the right bank because the low velocity zones caused by the vegetation and the split flow paths along the left side of the main channel are not considered in the averaging. (The average conditions computed by the HEC-2 program for the main channel include the entire area between the defined bank stations.)

One or both of the physical conditions described above occur at all of the cross sections between cross section 8 and the U.S. Highway 191 bridge. At cross sections 4, 7 and 8, dense vegetation occurs in the low bank area along the left side of the channel. At cross section 5, a mid-channel bar covered with dense tamarisk divides the flow, with the main flow path being along the right side of the channel. This bar persists because of a rock dike constructed by the Atlas Corporation in the 1960's to insure adequate flow for their pump intake adjacent to the mill. Cross section 6 is located at the downstream end of this bar.

Figure 4.5 shows that the main channel velocity at the Portal (cross section 12) increases monotonically with discharge from about 1.3 fps at 4,000 cfs to nearly 13 fps at 300,000 cfs. Between cross sections 6 and 10, where the left overbank is very wide (Moab Marsh), average main channel velocities for the range of discharges between 20,000 cfs and 300,000 cfs do not vary significantly and are generally less than 4 fps. Average main channel velocities at cross section 5 increase to a maximum of about 7 fps at a discharge of about 70,000 cfs and then reduce significantly to approximately 3 fps at 300,000 cfs due to the downstream backwater.

Figure 4.5 indicates that the main channel velocity is relatively constant through the reach between the U.S. Highway 191 bridge and the Portal at low to moderate flows (<~10,000 to 15,000 cfs), but, at higher flows, is significantly lower than occurs up- and downstream of the study reach. The sediment transport capacity of a sand bed river is proportional to the velocity to the 3 to 5

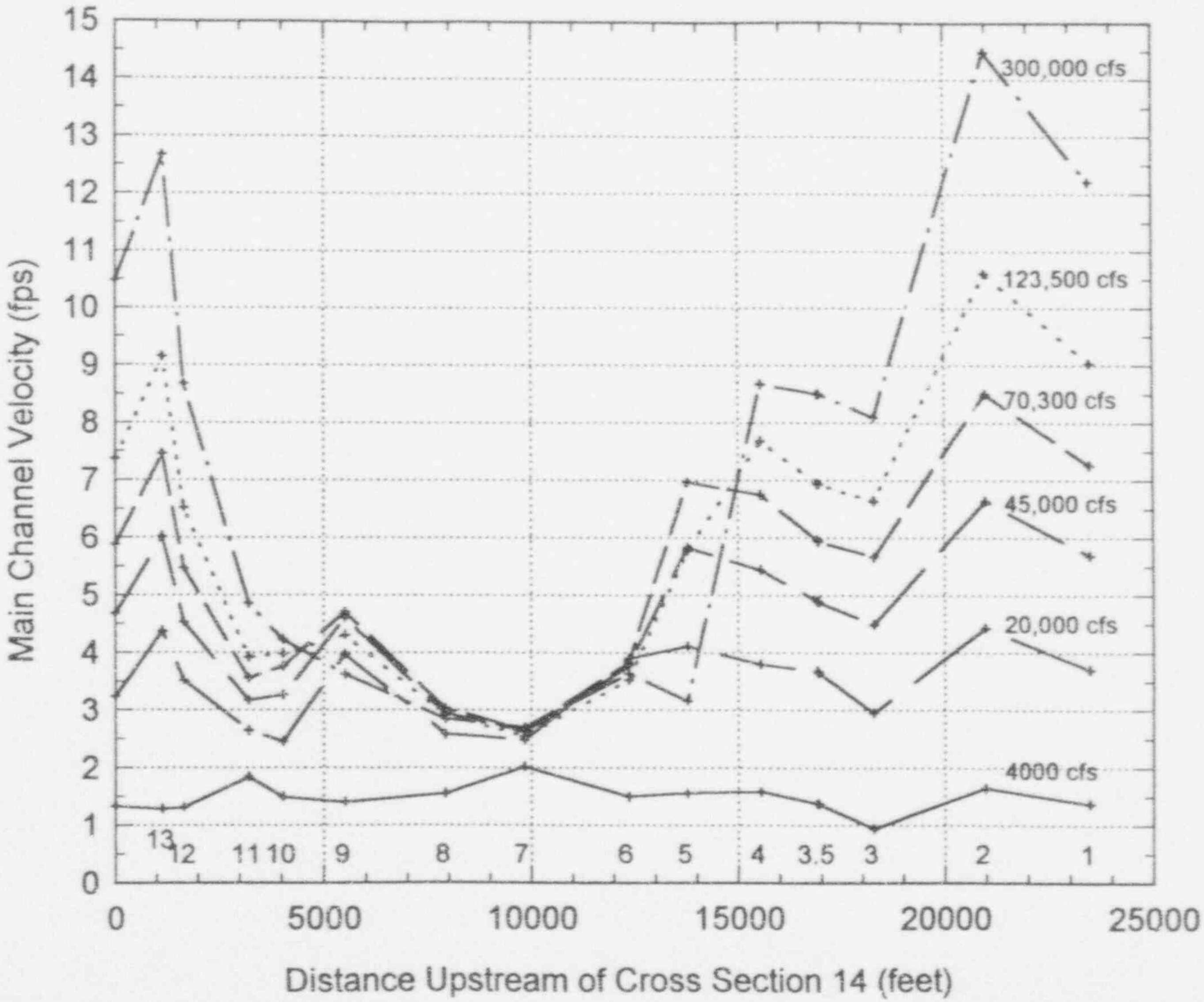


Figure 4.5 Velocity profiles for the study reach for 6 discharges ranging from 4,000 cfs to 300,000 cfs.

power. This suggests that the entire study reach is in equilibrium (i.e. no net aggradation or degradation) for flows that occur on a relatively frequent basis (flow in the river was less than 16,000 cfs approximately 90% of the time between 1959 and 1993 - Figure 3.1), but is depositional at higher flows. This observation indicates that the channel bed within the reach will not generally scour under flood conditions, except in localized areas around obstructions. Since any minor loss of channel capacity associated with deposition during flood flows will force more water into Moab Marsh, the rigid boundary assumption used in the HEC-2 modeling results in predicted flow velocities that are realistic, but probably conservatively high.

Analyses performed by Canonie Environmental and used to design protection for the toe of the tailings pile for the reclamation plan indicated that velocities in the area adjacent to the tailings pile will be less than 1.5 fps during the PMF peak of 300,000 cfs. The hydraulic model results from this study indicate that the average velocity in the right overbank adjacent to the impoundment will be less than 1 fps at this discharge. The maximum velocity directly adjacent to the toe of the embankment for this flow is estimated to be approximately 1.6 fps, based on the incremental conveyance in this localized area. The flow velocity that would affect the toe of the impoundment used by Canonie is, therefore consistent with the results of this study.

5. Analysis of Lateral Migration Potential

5.1 Geomorphic Factors Affecting Lateral Migration Potential

The various geomorphic units that have the potential to affect lateral migration of the Colorado River within the project reach were identified and discussed in Chapter 2. The lateral migration potential in the project reach provides an excellent example of the problems introduced by geomorphic complexity in predicting the behavior of the river (Schumm,1991). In an alluvial river with all the degrees of freedom for adjustment (Richards,1982), the location of the tailings pile on the outside of a bend would be a matter for concern. However, any analysis of the lateral migration potential of the Colorado River within the project reach must consider that the river in this reach is constrained and does not have all the degrees of freedom for adjustment.

The factors that tend to mitigate against free meandering of the river within the project reach include the following:

1. The entry to and exit from Moab-Spanish Valley are controlled by bedrock outcrop.

2. The Moab Wash-Courthouse Wash fans form the right bank of the river from the U.S. Highway 191 bridge to about cross section 8. The natural tendency of the fans to prograde is enhanced by reduction in depositional area caused by the presence of the tailings pile. The fan margins contain coarse grained sediments that have formed a natural armor on the right bank of the river. Confinement of the flows on the fan by the tailings pile will enhance down-fan delivery of the coarser sediments that will reinforce the natural toe armor. Vertical accretion of the fan surface tends to reduce flow depths on the right bank and force more flow towards Moab Marsh on the left bank.

3. The presence of very coarse grained colluvial deposits on the right bank of the river between cross sections 8 and 11 has formed a natural armor that prevents westward migration of the river and any ability to increase the length of the flow path through the valley and hence increase the sinuosity of the river. Even if the armor were to be breached, the bedrock that underlies the mixed alluvial-colluvial deposits would prevent westward migration of the river.

4. Finally, the presence of the Moab Marsh-Moab Slough complex on the left bank of the river and its ability to store considerable volumes of overbank flow prevents the generation of high shear stress on the right bank of the river. In combination, all of these factors tend to make the potential for lateral migration of the river towards the tailings pile extremely low. The historical and field evidence, even in the period when the left bank levee was unbreached when the in-channel shear stresses would have been higher than they are under present conditions, indicates that the primary process on the right bank has been lateral accretion and not erosion.

5.2 Hydraulic Factors Affecting Lateral Migration Potential

5.2.1 Computational Concepts

Evaluation of the potential for bank erosion at a given location must consider both the duration and magnitude of flows during the time period under consideration. In addition, the relative effect of the range of possible flow events must also be considered since the infrequent, high discharges associated with a particular "design" event are not necessarily the most significant in causing bank erosion and lateral adjustment of the channel. This is in contrast to most bank protection design procedures which only consider conditions for a specific design discharge.

An analytical procedure for computing the total work applied to the channel banks, and thus incorporating the effects of both magnitude and duration, was developed by Harvey and Mussetter (1993). The results of these computations can be used as an index of the erosive power of the flow.

Work is defined here as the product of the stream power expended on the banks and the incremental time over which it is applied. Stream power is the product of the average main channel velocity (V_{ch}) and the shear stress acting on the bed (τ_{bed})or banks (τ_{bank}). For a given flood event, the total work at a given bank location can be determined by integrating the stream power over the entire hydrograph:

$$W = \int (V_{ch}\ \tau_x) dt \tag{5.1}$$

where W is the total work performed at a specified bank location, the subscript x refers to the bed or banks and dt is the incremental time. The bed and bank shear stresses are computed as:

$$\tau_{bed} = \gamma\ d_h\ S_f \tag{5.2}$$

and,

$$\tau_{bank} = K_b\ \tau_{bed} \tag{5.3}$$

where γ is the unit weight of water (62.4 lb/ft^3), d_h is the hydraulic depth, S_f is the energy slope, and K_b is a factor that accounts for the effect of channel curvature on the shear stress acting on the outside of a channel bend. The hydraulic depth (d_h) is the ratio of cross sectional area and flow topwidth in the unvegetated portion of the main channel along the right bank, as discussed in Chapter 4. K_b depends on the ratio of the radius of curvature (R_c) to the channel topwidth (W_{ch}) at each location and was determined from **Figure 5.1** (Soil Conservation Service, 1977).

Equations 5.2 and 5.3 were used to evaluate the variation in shear stress applied to the channel bed and banks for the range of flows based on the HEC-2 results. These values were then used to estimate the average annual work applied to the channel banks at each location and the relative contribution of each range of discharge to the total by applying Equation 5.1 over the annual flow duration curve (Figure 3.1). Computations were not performed for individual flood events because extreme flood hydrographs for the study reach were not available, and as will be seen in the following discussion, the extreme discharges associated with those floods contribute very little to the overall bank erosion potential in the study reach.

5.2.2 Variation in Bed Shear Stress with Discharge

The variation in bed shear stress with discharge obtained by applying Equation 5.3, for cross sections 4 through 7 and cross section 12 is shown in **Figure 5.2**. The figure further illustrates the effect of backwater caused by the downstream constriction and significant overbank flows into Moab Marsh at high discharges on the energy available to erode the channel boundary. Similar to the velocity variation discussed in the previous chapter (see Figure 4.5), the bed shear stress at cross section 12 near the Portal increases monotonically with discharge over the full range of flows, reaching a maximum of about 0.6 psf at 300,000 cfs. At cross section 7, the bed shear stress increases slightly between 1,500 cfs and 45,000 cfs, reaching a maximum of only approximately 0.1 psf and then reducing to less than 0.05 psf for higher discharges. At cross section 6, which is adjacent to the tailings pile, the shear stress increases with discharge up to 30,000 cfs and then drops abruptly at higher flows. The peak shear stress at this location is approximately 0.36 psf. It is important to note that shear stresses in this range appear to occur over only a very narrow range of flows. The bed shear reduces from approximately 0.16 psf at 40,000 cfs to approximately 0.05 psf at 300,000 cfs. At cross section 5, which is upstream of the tailings pile, the bed shear stress increases with discharge to a maximum of about 0.32 psf at ~70,000 cfs and then reduces significantly at higher discharges. Finally, at cross section 4, the bed shear increases monotonically through the full range of discharges, reaching a maximum of 0.38 at 300,000 cfs. The rate of increase in shear stress for discharge greater than approximately 70,000 cfs at this location, however, is small in comparison to locations where the river is bounded on both sides by the canyon walls (e.g. cross section 12) because of flows overtopping the left bank levee. The maximum shear stress at cross section 4 at 300,000 cfs is therefore much lower

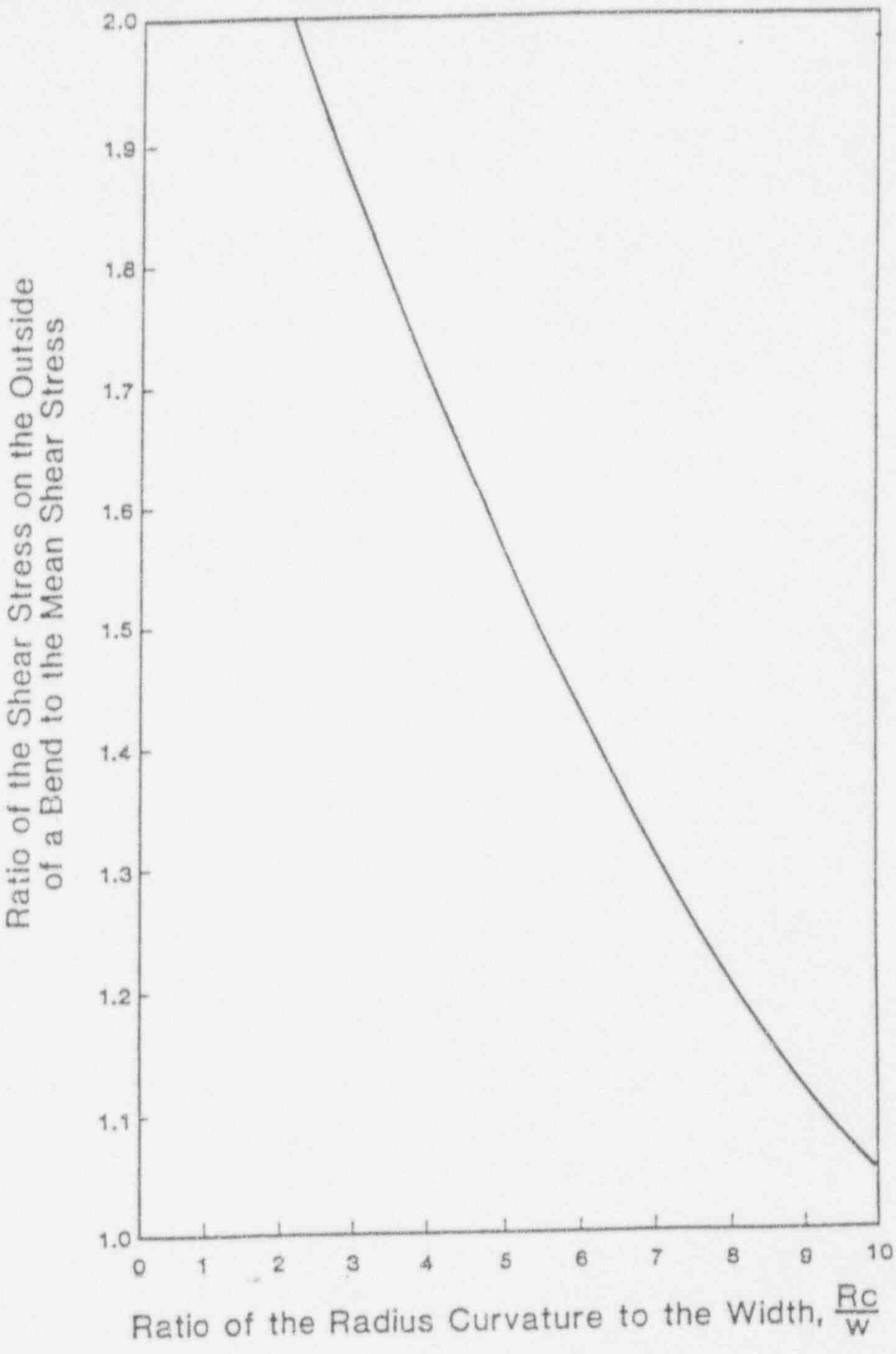


Figure 5.1 Relationship between average bed shear stress and shear stress on the outside of a channel bend (from Soil Conservation Service, 1977)

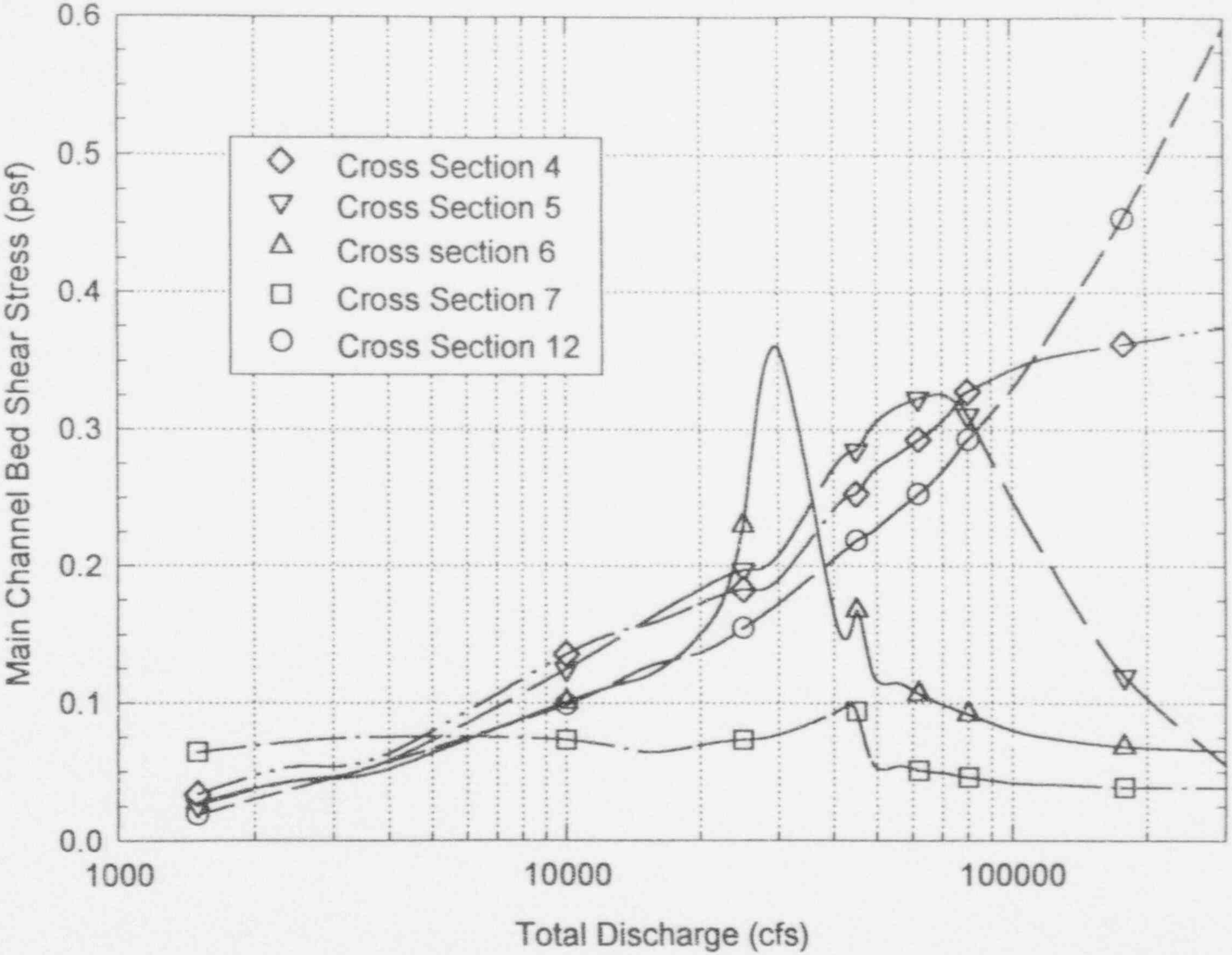


Figure 5.2 Variation in bed shear stress in the main channel at cross section 4, 5, 6, 7, and 12.

than for the corresponding discharge at cross section 12.

These results indicate that the maximum shear stress in the river adjacent to the tailings pile (based on conditions at cross section 6) occurs at discharges less than the bankfull discharge of this reach which is approximately 40,000 cfs. Flows in the range between approximately 28,000 cfs and 34,000 cfs at this location occurred on average approximately 1 percent of the time or about 4 days per year during the period 1959 to 1993. The range of flows of approximately 50,000 cfs to 80,000 cfs associated with the maximum shear stress in the reach just upstream of the tailings pile (based on conditions at cross section 5) occurred relatively infrequently during this period. The maximum instantaneous flow of 70,300 cfs occurred during the 1984 flood, as previously discussed, and flow exceeded 50,000 cfs only about 0.3% of the time, or about 1 day per year on average. This range of flows is, however considerably less than the extreme flood peak discharges on which the reclamation plan design is based.

In general, the bed shear stress results indicate that the maximum erosive power of the river in the reach near the tailings pile occurs at moderate discharges that have historically occurred on a relatively frequent basis (at least a few days per year). Due to the downstream backwater conditions and significant overbank flows in Moab Marsh, the shear stress in the river is very low at higher discharges associated with the extreme flood events.

5.2.3 Evaluation of Work Applied to the Channel Banks

The average annual work applied to the channel bed and right bank at cross sections 4 through 10 is shown in **Figure 5.3**. These results were obtained by integrating Equation 5.1 over the annual flow duration curve. The channel radius of curvature (R_c) used to obtain K_b was determined from measurements taken from the USBR 1"=200' scale topographic maps. (USBR, 1994) The channel in this reach was divided into five subreaches, each with relatively consistent channel curvature. These subreaches and their corresponding R_c values are shown in **Figure 5.4**. The estimated radius of curvature varies from 2500 feet in the vicinity of cross section 4 and 5, upstream of the tailings pile to 7500 feet near cross section 6 adjacent to the tailings pile. Near cross section 7, downstream of the tailings pile, the estimated radius is approximately 5500 feet and near cross section 8, the radius is approximately 3500 feet. The channel is nearly straight at cross sections 9 and 10.

The results shown in Figure 5.3 indicate that the largest amount of work applied to both the bed and right bank occurs at cross sections 4 and 5 upstream of the tailings pile. The values at this location are approximately 35 percent (bed) and 50 percent (right bank) greater than the

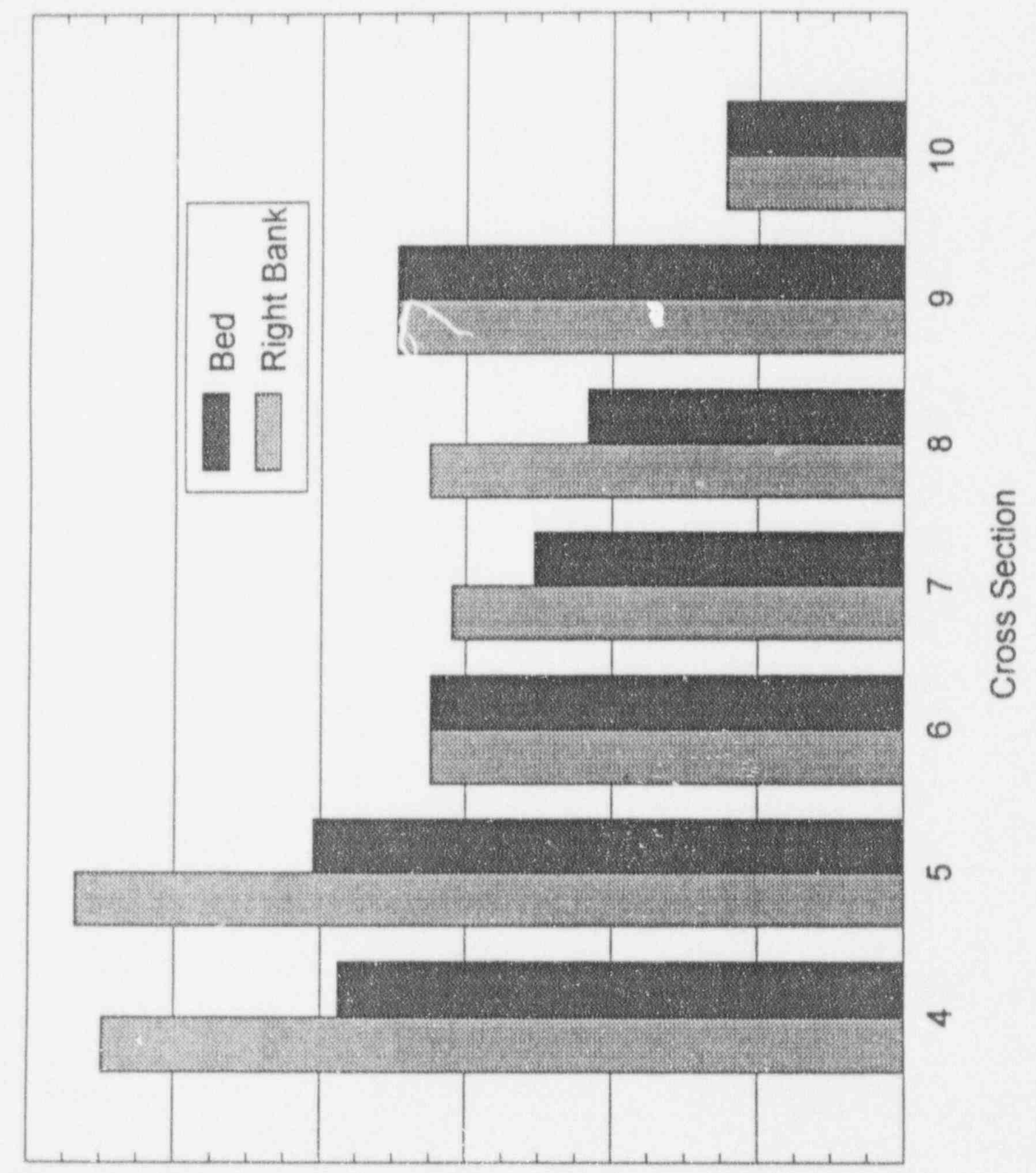


Figure 5.3 Average annual work applied to the channel bed and banks at cross section 4 through 10.

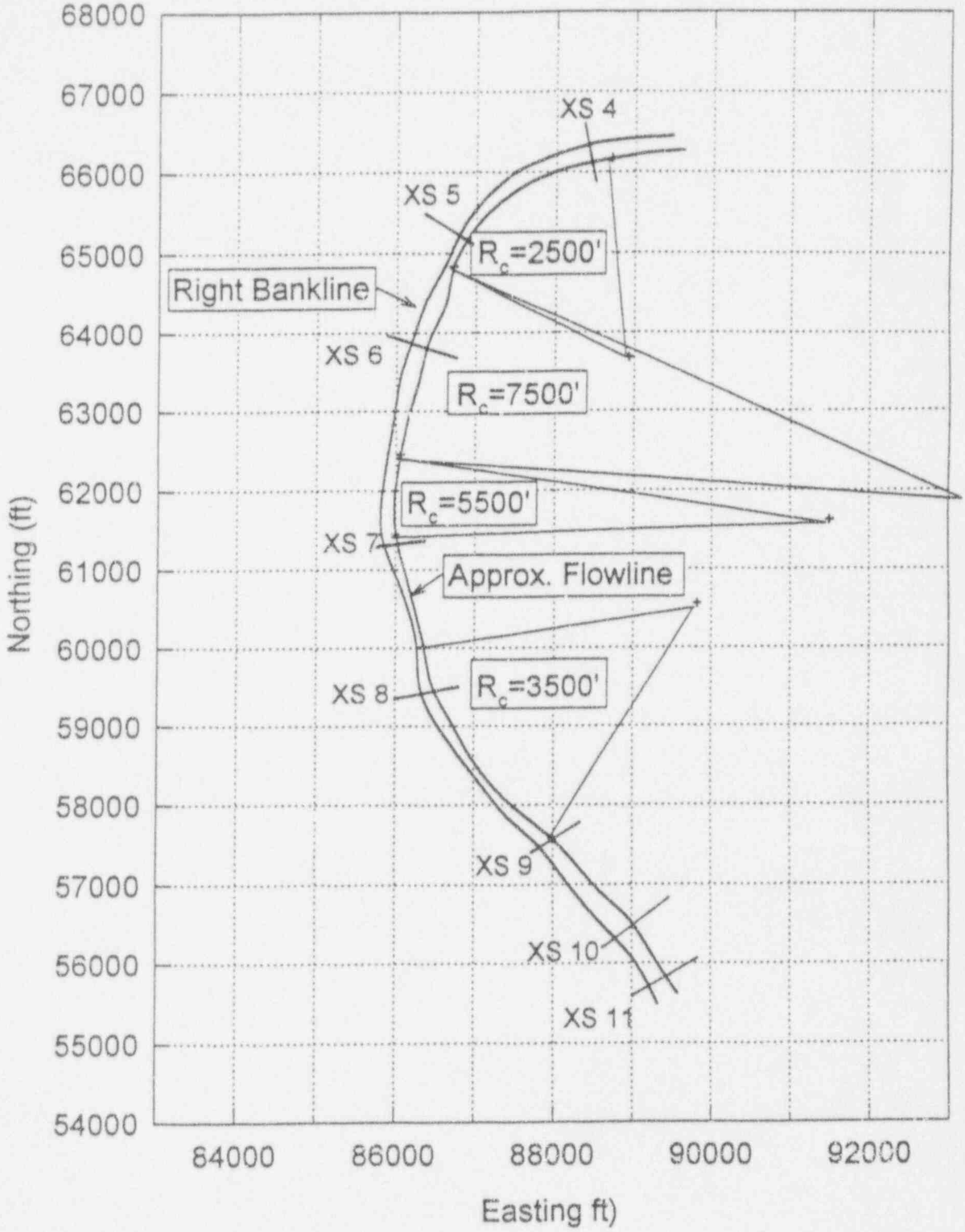


Figure 5.4 Alignment of the right bankline and approximate flowline and channel radius of curvature along the study reach.

average for the reach, reflecting the effects of the constriction through the U.S. Highway 191 bridge and the left bank levee at this location. As discussed in the geomorphic evaluation, Courthouse Wash and Moab Wash enter the Colorado River in this reach, delivering significant quantities of coarse material to the alluvial fan and preventing lateral migration of the bank at this location. At cross section 6, adjacent to the tailings pile, the work on the channel bed is approximately 10 percent greater, and on the right bank is approximately 10 percent less, than the average for the reach. (The magnitude of the work values are the same for both cases because the ratio of radius of curvature to width at this cross section exceeds 10, and thus K_b=1, for the full range of flows.) The work values for cross sections 7 and 8, downstream of the tailings pile, are generally less than the average for the reach. The lower than average bank work values from cross section 6 to 8 correlate well with the observed historical lateral accretion on the right bank that has taken place in this subreach.

The contribution to the total work on the banks at cross section 4 through 7 for the range of flows that occurred in the river between 1959 and 1993 is shown in **Figures 5.5** through **5.8**. In all four cases, the maximum contribution to the total work occurs at discharges near 4,500 cfs which is slightly greater than the median discharge during the 1959 to 1993 period. (See Figure 3.1) At cross sections 4, 5 and 6, a significant secondary peak occurs at approximately 20,000 cfs. Flows up to the bankfull discharge of approximately 40,000 cfs contribute 95 percent or more of the average annual work on the right bank through this reach.

Considering the hydraulic modeling, shear stress and bank work results in combination, it can be concluded that:

1. The study reach between the Portal and U.S. Highway 191 bridge is in approximate vertical equilibrium for flows less than about 15,000 cfs.

2. The reach is aggradational at higher flows because of the downstream backwater and significant overbank flows into Moab Marsh. This is corroborated by the presence of numerous mid-channel bars within the reach that were undoubtedly deposited during high flow periods.

3. The maximum stress on the channel banks adjacent to the tailings pile occurs at discharges less than the bankfull discharge of this reach of 40,000 cfs. Between the tailings pile and U.S. Highway 191 bridge, the maximum stress on the banks occurs at discharges between bankfull and about 70,000 cfs. The stress reduces significantly at higher discharges.

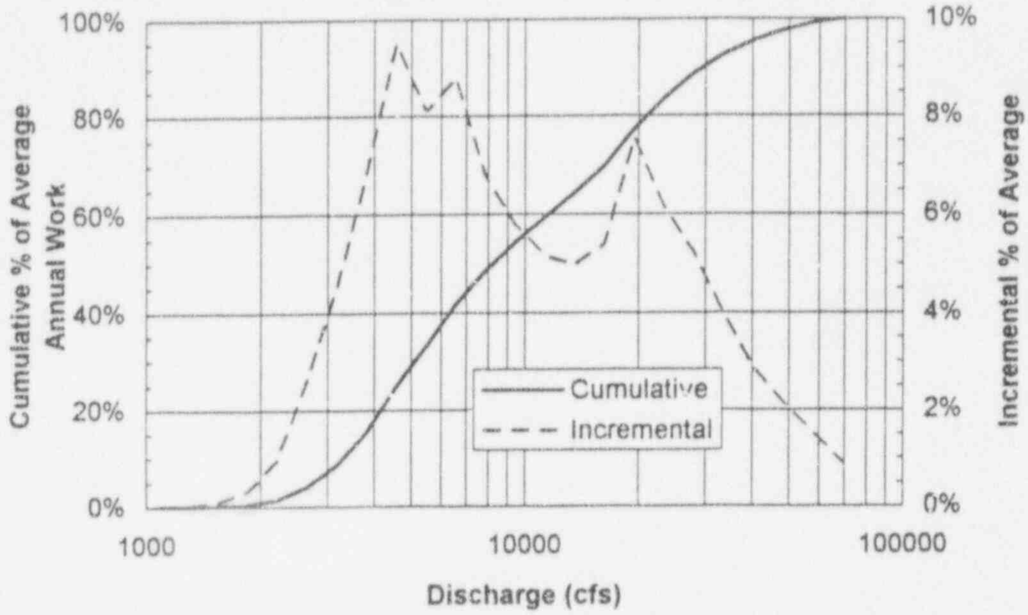


Figure 5.5 Variation in incremental and cumulative percentage of the average annual work on the right channel bank with discharge at cross section 4.

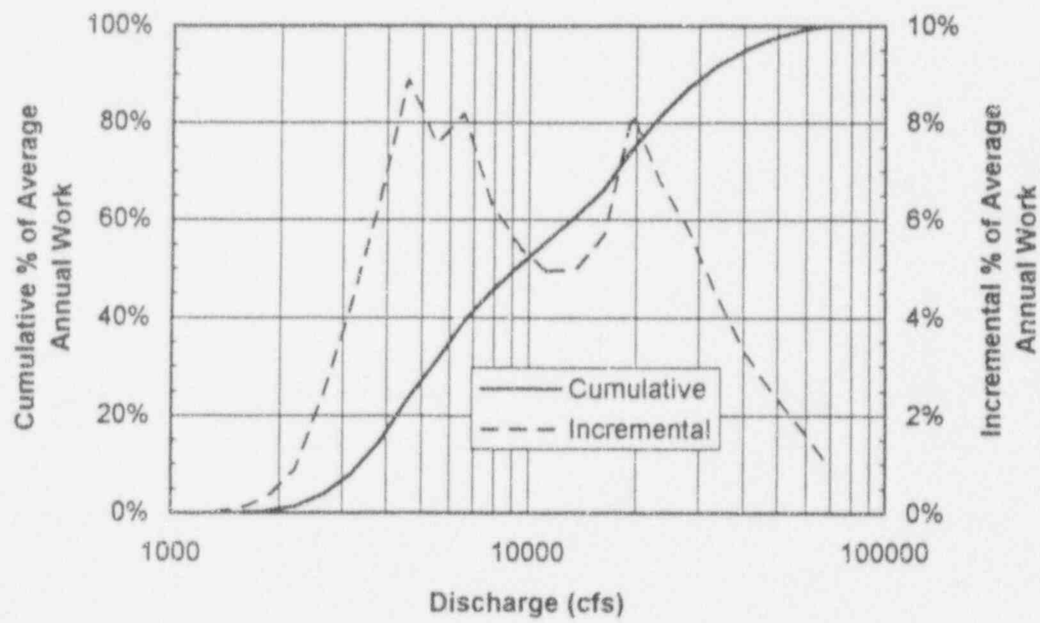


Figure 5.6 Variation in incremental and cumulative percentage of the average annual work on the right channel bank with discharge at cross section 5.

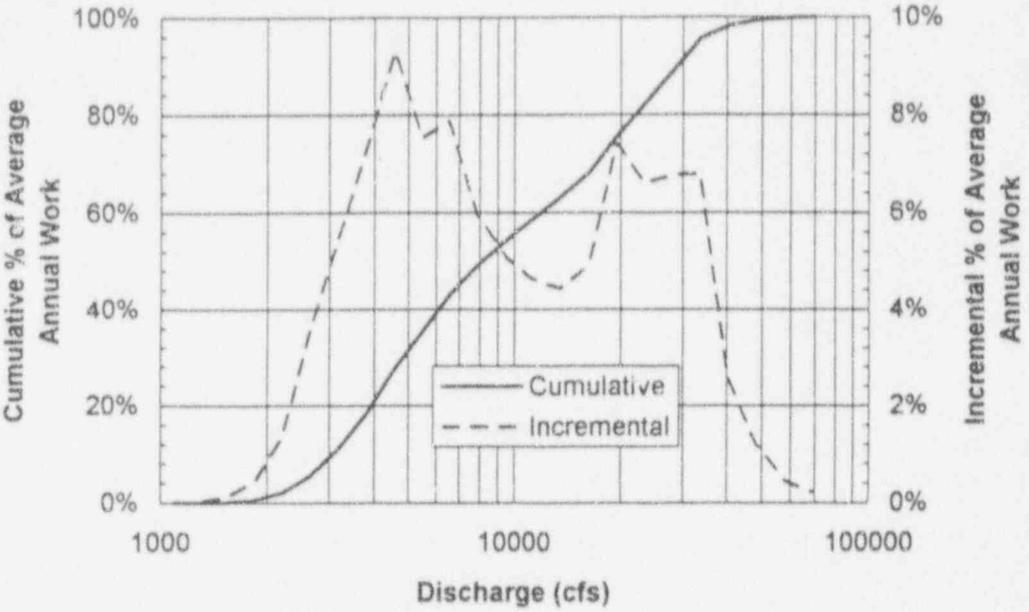


Figure 5.7 Variation in incremental and cumulative percentage of the average annual work on the right channel bank with discharge at cross section 6.

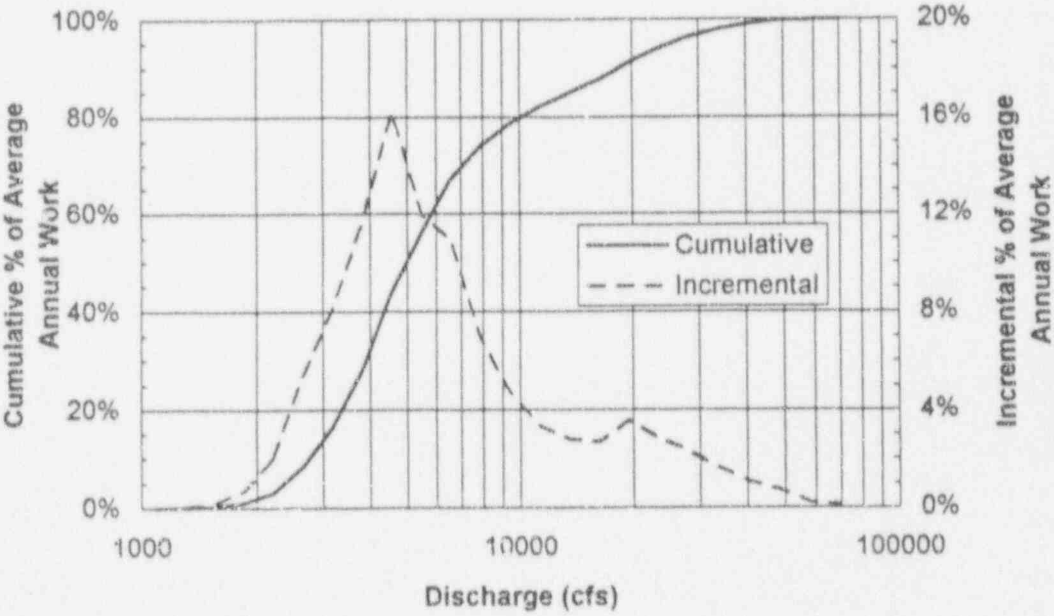


Figure 5.8 Variation in incremental and cumulative percentage of the average annual work on the right channel bank with discharge at cross section 7.

4 Flows in the range of the median discharge of about 4,000 to 4,500 cfs make the largest incremental contribution to the total work on the channel banks in the vicinity of and upstream of the tailings pile. A secondary peak occurs at a discharge of approximately 20,000 cfs, which is roughly half the bankfull discharge, at cross section 4, 5, and 6.

5. Over 95 percent of the total work expended on the right bank is done at flows less than the bankfull discharge. Larger discharges contribute very little due to a combination of reduced shear stress and flow velocity because of the downstream backwater and significant flow into Moab Marsh and their relatively infrequent occurrence.

6. SUMMARY AND CONCLUSIONS

The observations and analyses presented in the preceding chapters indicate that lateral migration of the Colorado River toward the tailings pile is very unlikely during the 1,000 year time frame (per 10CFR40, Appendix A). The reasons for this conclusion are summarized, as follows:

1. In contrast to a river with all of the degrees of freedom for adjustment, the Colorado River, within the project reach, has limited degrees of freedom for adjustment because of constraints imposed by non-fluvial factors. The length of the river and therefore its ability to develop a sinuous planform is constrained by bedrock inlet and outlet conditions to and from Moab-Spanish Valley, respectively.

2. The area on which the tailings pile and old mill site are located is an alluvial fan developed by flows from Moab Wash and Courthouse Wash. Both of the washes have delivered significant quantities of sediment to this area historically, and will continue to do so, unless significant changes occur in the upstream watersheds. This sediment includes some very coarse material that is currently buried beneath the site and is evident in the toe of the river bank adjacent to the tailings pile. Interaction between the river flows and the fan sediments has resulted in the development of a natural toe armor that has maintained the alignment of the river bank between cross sections 4 and 5 through the period of record,

3. Sediment input from Courthouse Wash, which enters the river at cross section 4 contributes a counterbalancing effect to lateral migration similar to Moab Wash. Sediment delivery from Courthouse Wash in about 1956 forced the channel of the Colorado River to the south and necessitated construction of a rock dike across the mouth of the new channel to return the river to its former alignment that would permit water withdrawal for the mill.

4. The combined effects of the backwater caused by the constriction at the Portals and overbank flows into Moab Marsh along the left side of the channel significantly reduce the stress on the right channel bank adjacent to the tailings pile at flows greater than about 30,000 cfs. Historical and field evidence indicates that the dominant process along the right bank of the river has been lateral accretion of sediments and not bank erosion.

5. The average flow velocity in the right overbank near the tailings pile, predicted by the hydraulic model used for this study, was less than 1 fps and the maximum predicted velocity directly adjacent to the toe of the tailings pile was approximately 1.6 fps. These results are not significantly different from the velocities used by Canonie in designing toe protection for the embankment in the reclamation plan.

6. Over 95 percent of the total work on the channel banks, which considers both the magnitude and duration of flows, on an average annual basis occurs at discharges less than the bankfull flow of approximately 40,000 cfs. Because of the hydraulic effects discussed in 4. above, the contribution of flows associated with extreme flood events is expected to be minimal.

7. Historical evidence indicates that the channel is not presently migrating in the direction of the tailings pile. Prior to failure of the left bank levee in the approximate location of cross section 5 in 1984, the shear stress on the right bank would have been higher than it is under current conditions or before the levee was

constructed because flows up to about 70,000 cfs were contained within the channel. Field and historical evidence indicate that even under the pre-levee failure condition, the dominant process was lateral accretion on the right bank.

8. **Since the flows that occur in the river on a frequent basis are responsible for virtually all of the work done on the channel banks and the physical factors that cause higher flows to exert very little stress on the right bank are permanent features related to the geology of the site, there is no reason to believe that a tendency for lateral migration of the river toward the tailings pile will occur in the future.**

7. REFERENCES

Belknap, 1991. "Canyonlands River Guide," Westwater Books, Evergreen, Colorado.

Brownlie, W.R., 1983. "Flow Depth in Sand-Bed Channels," ASCE, Journal of the Hydraulic Engineering, v. 109, no. HY7, pp. 959-990.

Canonie Environmental, 1989. "Response to NRC Comments, Reclamation Plan Uranium Mill and Tailings Disposal Area."

Canonie Environmental, 1992. "Atlas Corporation Reclamation Plan, Uranium Mill and Tailing Disposal Area," pp 34-37 and Appendix F.

Chow, V.T., 1959. Open-channel Hydraulics, McGraw-Hill Book Company.

Cooper, D.J. and C. Severn, 1994. "Ecological Characteristics of Wetlands at the Moab Slough, Moab, Utah," prepared for Recovery Program for the Endangered Fishes of the Upper Colorado River, February.

Dames and Moore, 1975. Safety Analysis Report, Atlas Minerals Division, Atlas Corporation, Moab Uranium Mill, 438 p.

Fenneman, N.M., 1931. Physiography of Western United States. McGraw-Hill Book Co., New York.

Fischer, K.J. and Harvey, M.D., 1990. Geomorphic and stratigraphic evidence for sediment transport processes on a valley fan, southern Utah, Proc. symp. Hydrology and Hydraulics of Arid Lands, ASCE Hydraulics Div., R.H. French (Ed), 700-705.

Harvey, M.D. and S.A. Schumm, 1981. "Geomorphic Evaluation of the Long Term Stability of Atlas Minerals Uranium Mill Site, Moab, Utah," prepared by Water Engineering and Technology, Inc. for Woodward-Clyde Consultants.

Harvey, M.D., Mussetter, R.A. and Wick, E., 1993. A physical process-biological response model for spawning habitat formation for the endangered Colorado squawfish, Rivers, v.4, No.2, 114-131.

Harvey, M.D. and R.A. Mussetter, 1993. "Geomorphic, Sediment Engineering, and Channel Stability Analyses, American and Sacramento River, California Project," prepared by Resource Consultants & Engineers, Inc. for the Sacramento District, Corps of Engineers.

Henderson, F. M., 1966. Open Channel Flow, The Macmillan Company.

IntraSearch, Inc., 1981. 1"=200', 2' contour mapping of the Moab Uranium Mill Site Area (reduced to 1"=400' scale).

Joesting, J.R., Case, J.E. and Plouff, D., 1966. Regional geophysical investigations of the Moab-Needles Area, Utah, U.S. Geological Survey Prof. Paper 516-C.

Nuclear Regulatory Commission, 1994. Letter to Mr Richard Blubaugh, Atlas Corporation and enclosure, "Additional questions and comments, surface water hydrology and erosion protection."

Nuclear Regulatory Commission, 1993. "Request for information - faulting, seismic and geomorphic consideration", Enclosure 1.

Richards, K., 1982. Rivers: Form and Process in Alluvial Channels, Methuen and Co. New York.

Schumm, S.A., 1991. To Interpret the Earth: Ten Ways To Be Wrong, Cambridge Univ. Press.

Soil Conservation Service, 1977. "Design of Open Channel," Technical Release 25, U.S. Department of Agriculture, Engineering Division, Washington, D.C.

U.S. Geological Survey, 1985. Moab Quadrangle, Utah-Grand County, 7½ minute series (topographic) maps.

U.S. Bureau of Reclamation, 1994. 1"=200' scale, 2' contour mapping of Moab Marsh.

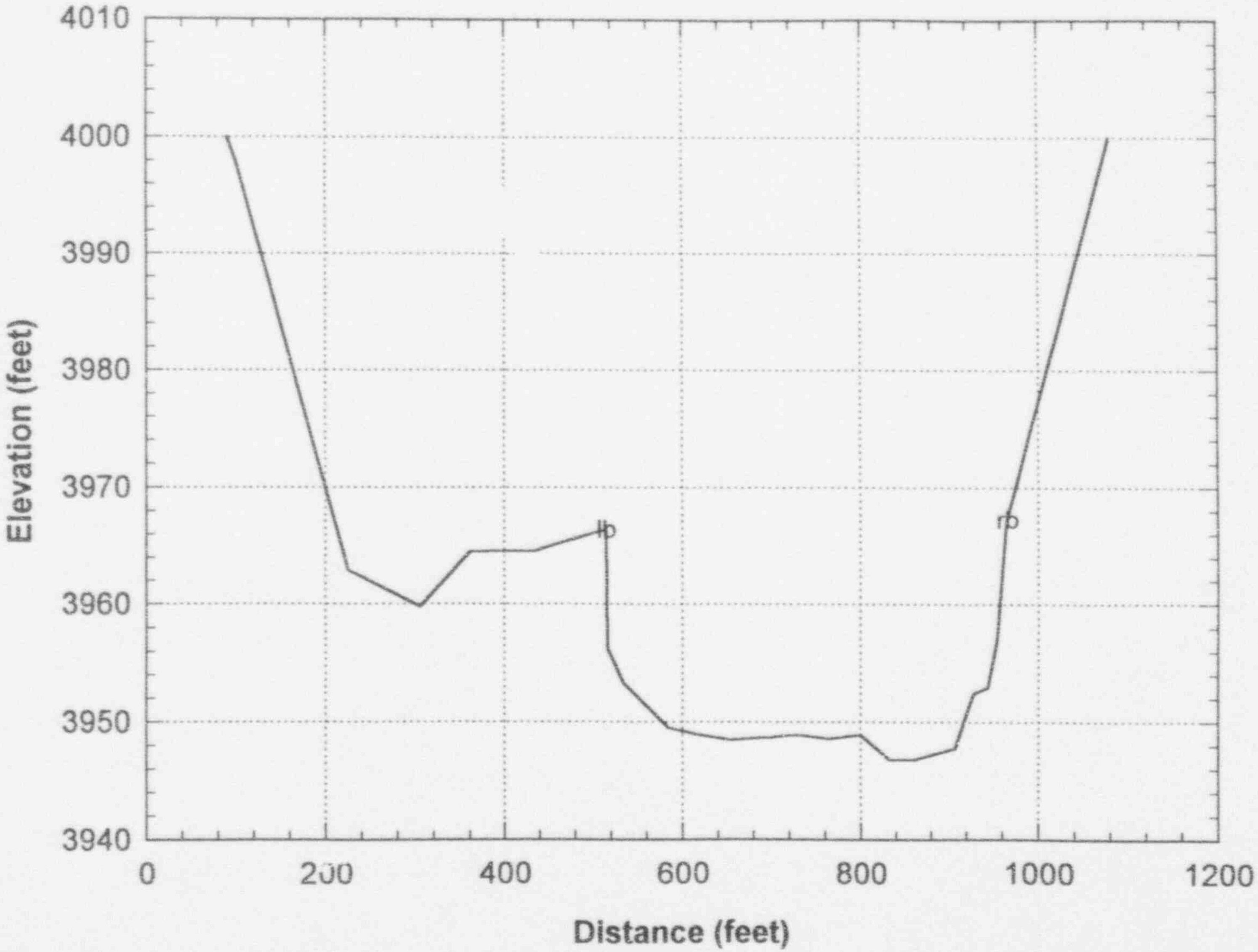
U.S.Army Corps of Engineers, 1990. "Hec-2, Water Surface Profiles, User's Manual," Hydrologic Engineering Center.

Williams, P.L., 1964. Geology, Structure and Uranium deposits of the Moab Quadrangle, Colorado and Utah, U.S. Geological Survey Map I-360, Scale 1:250,000, 2 sheets.

APPENDIX A

CROSS SECTION PLOTS

CROSS SECTION 1



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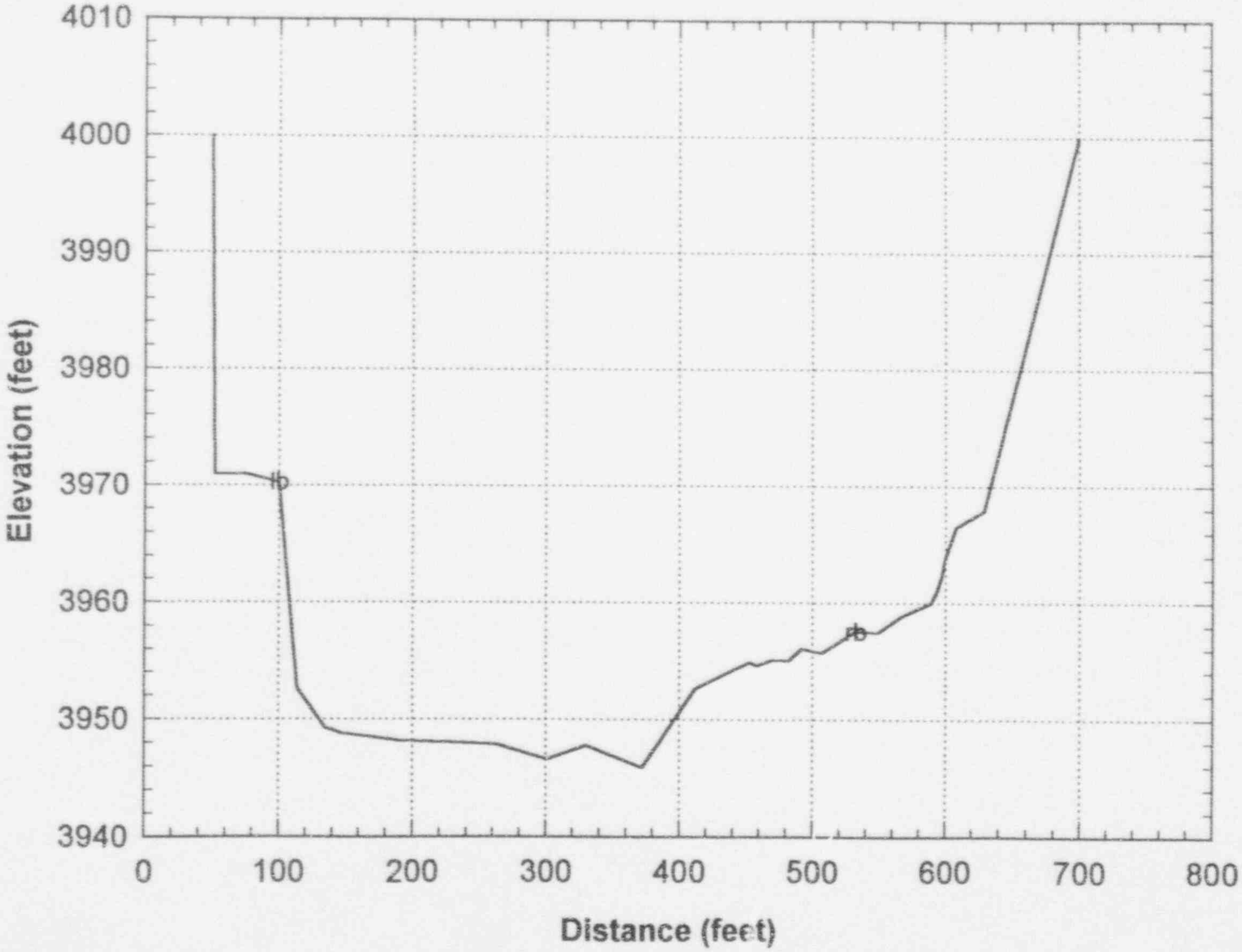

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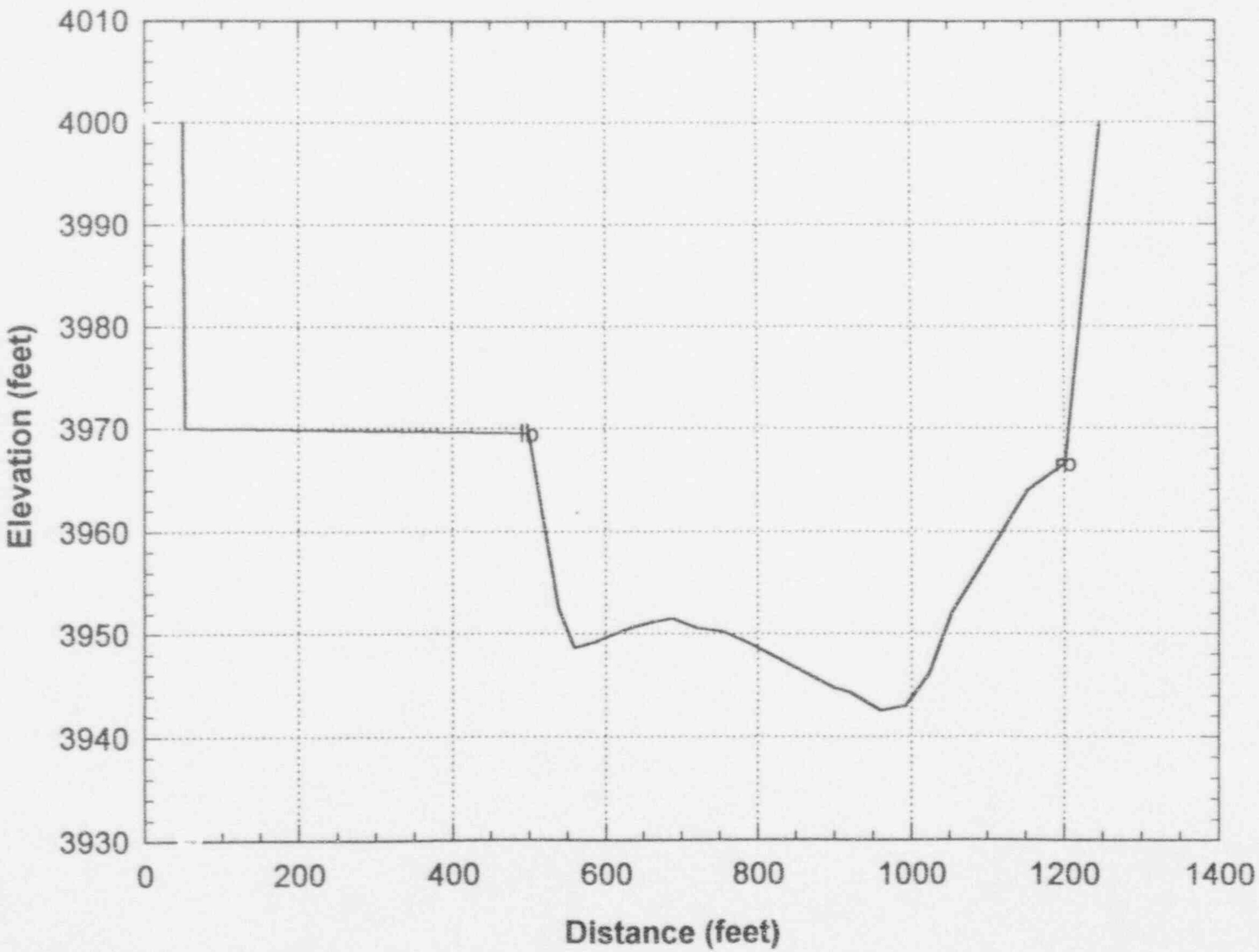

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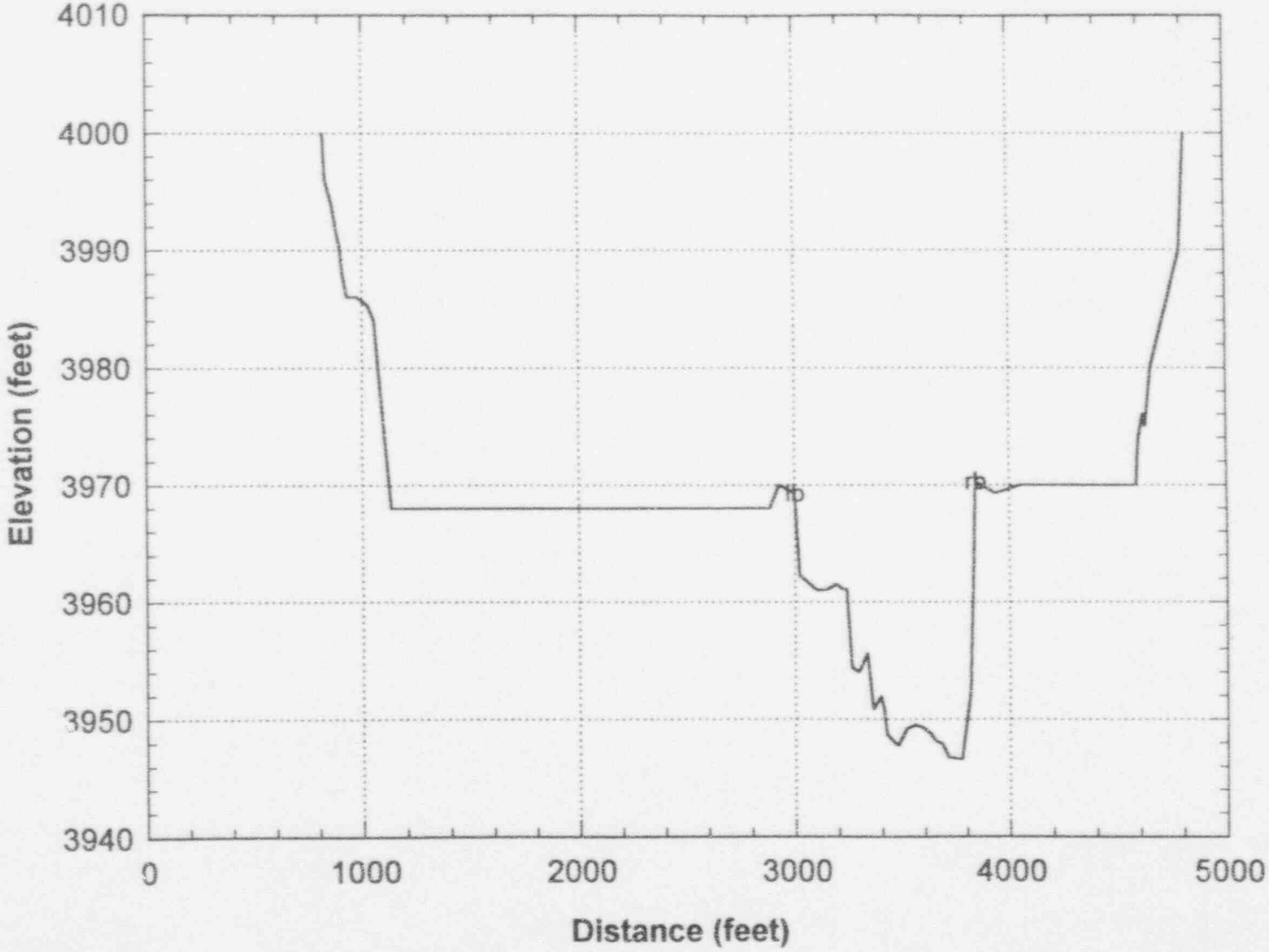

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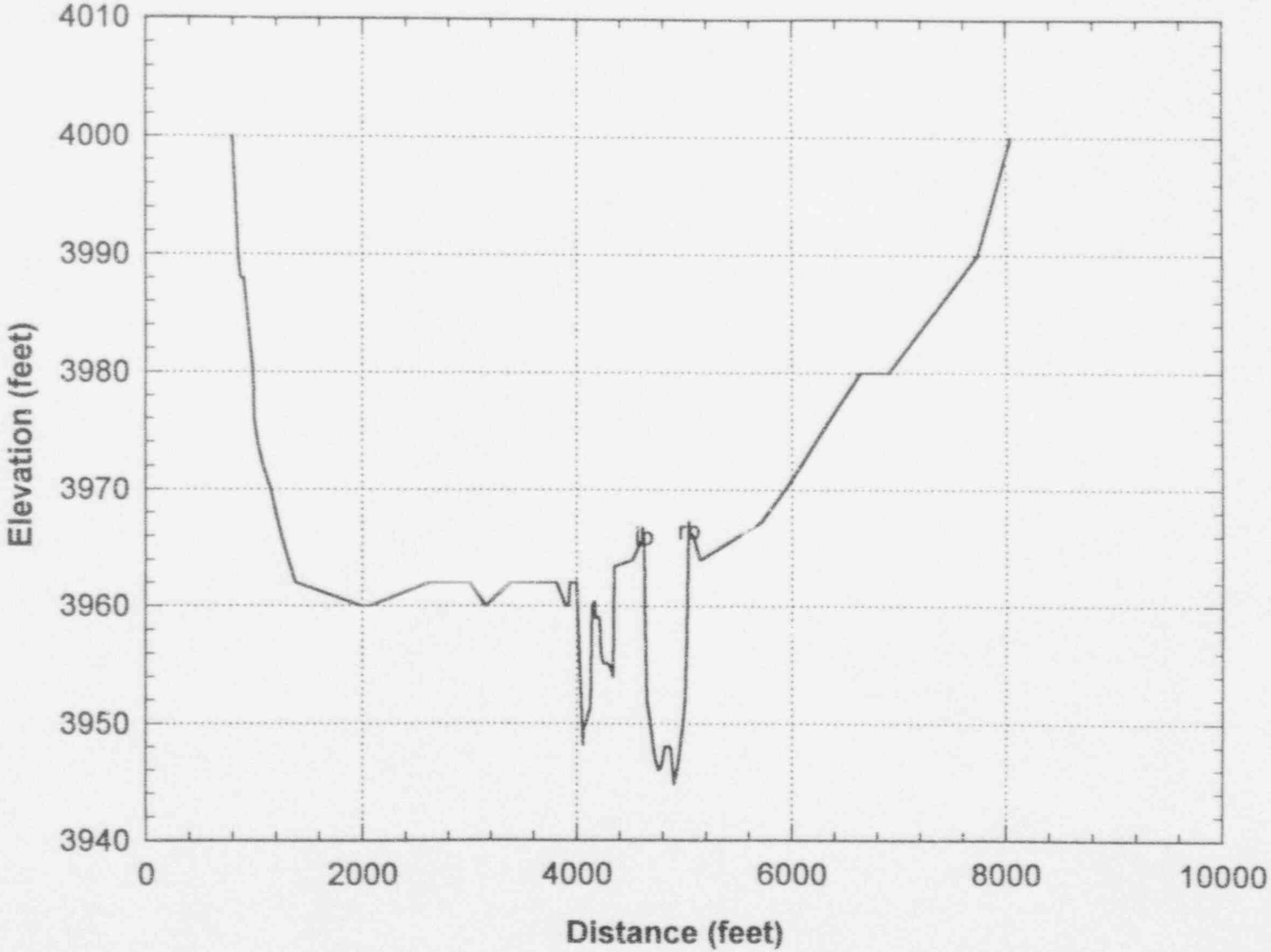

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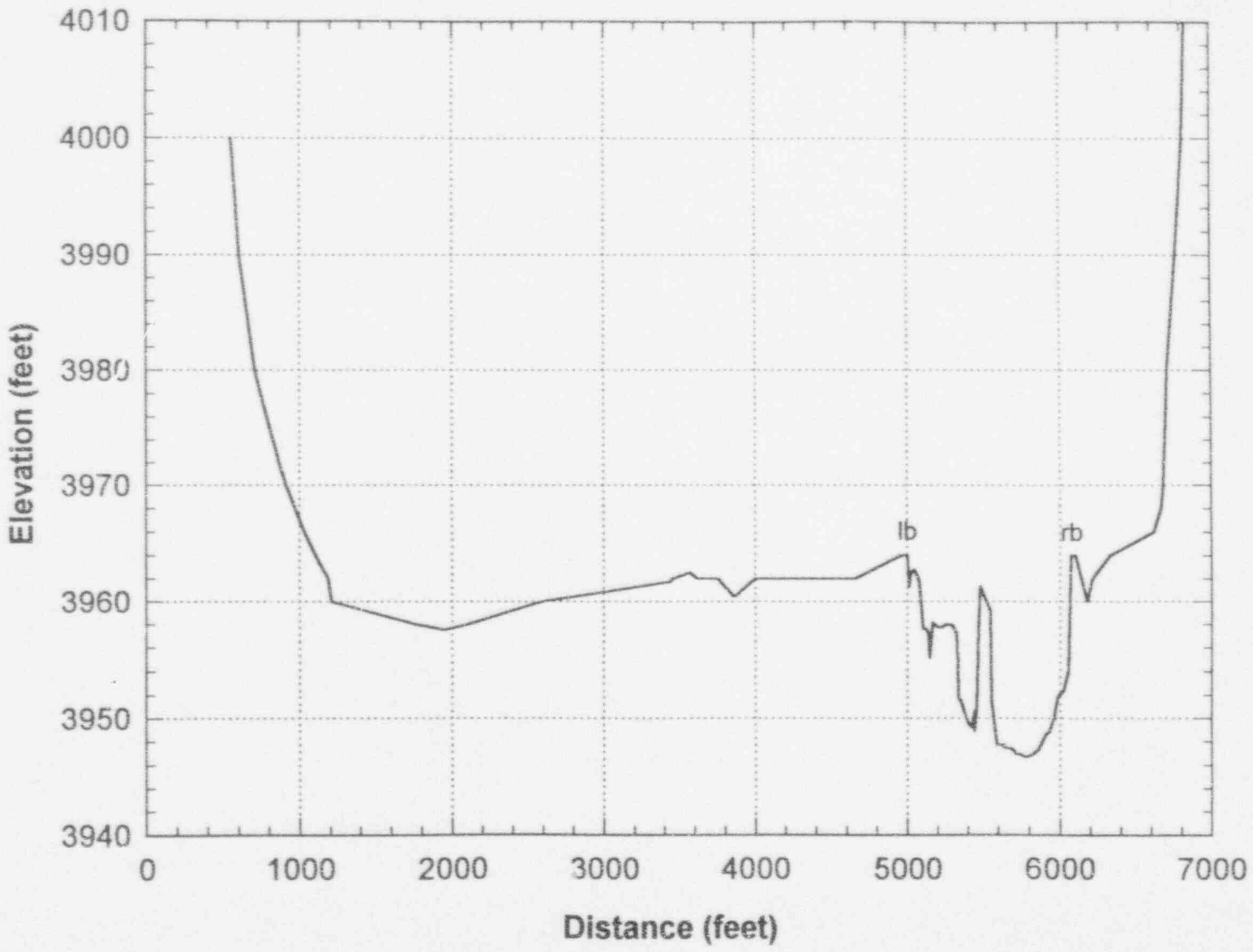

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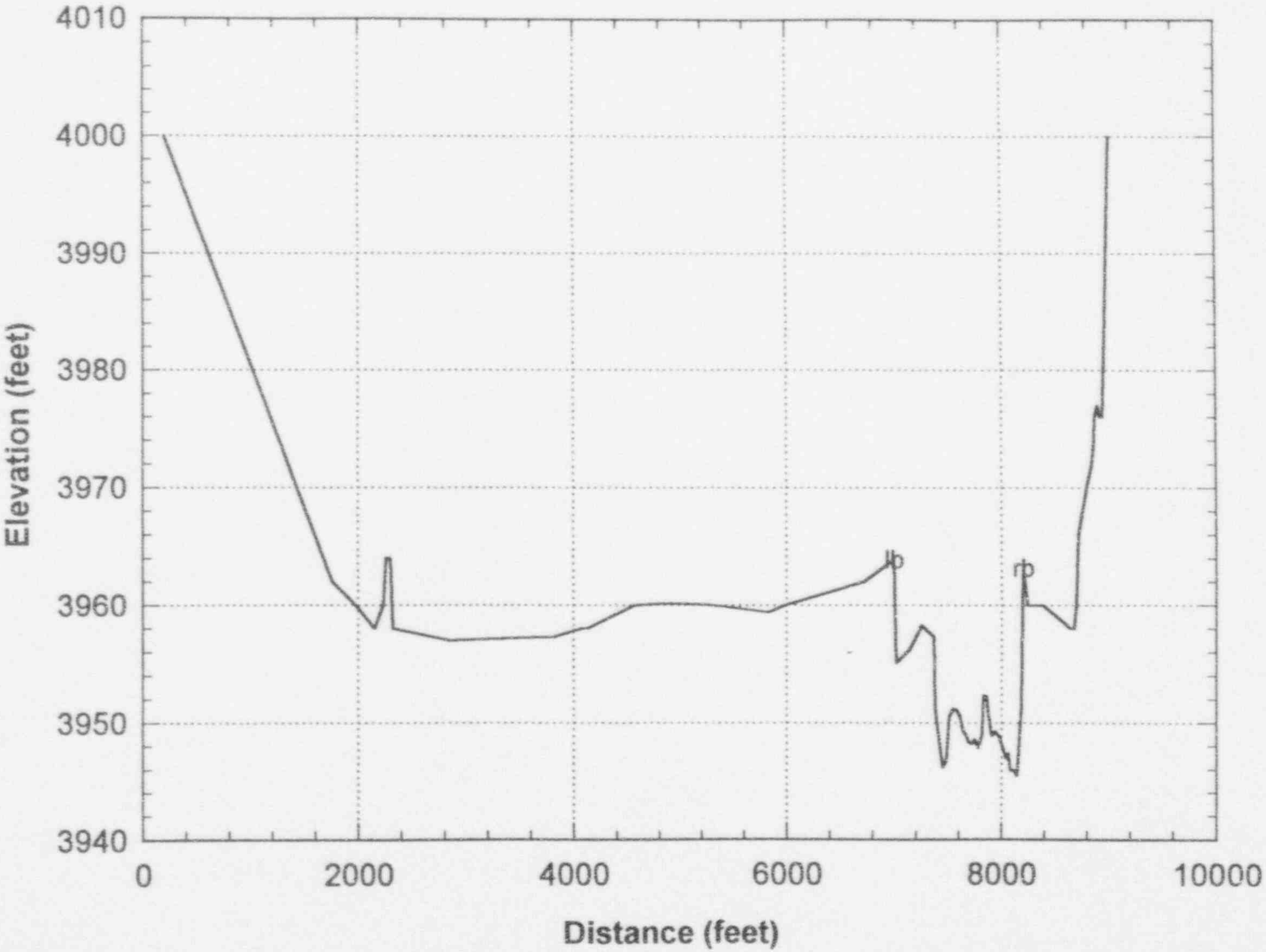

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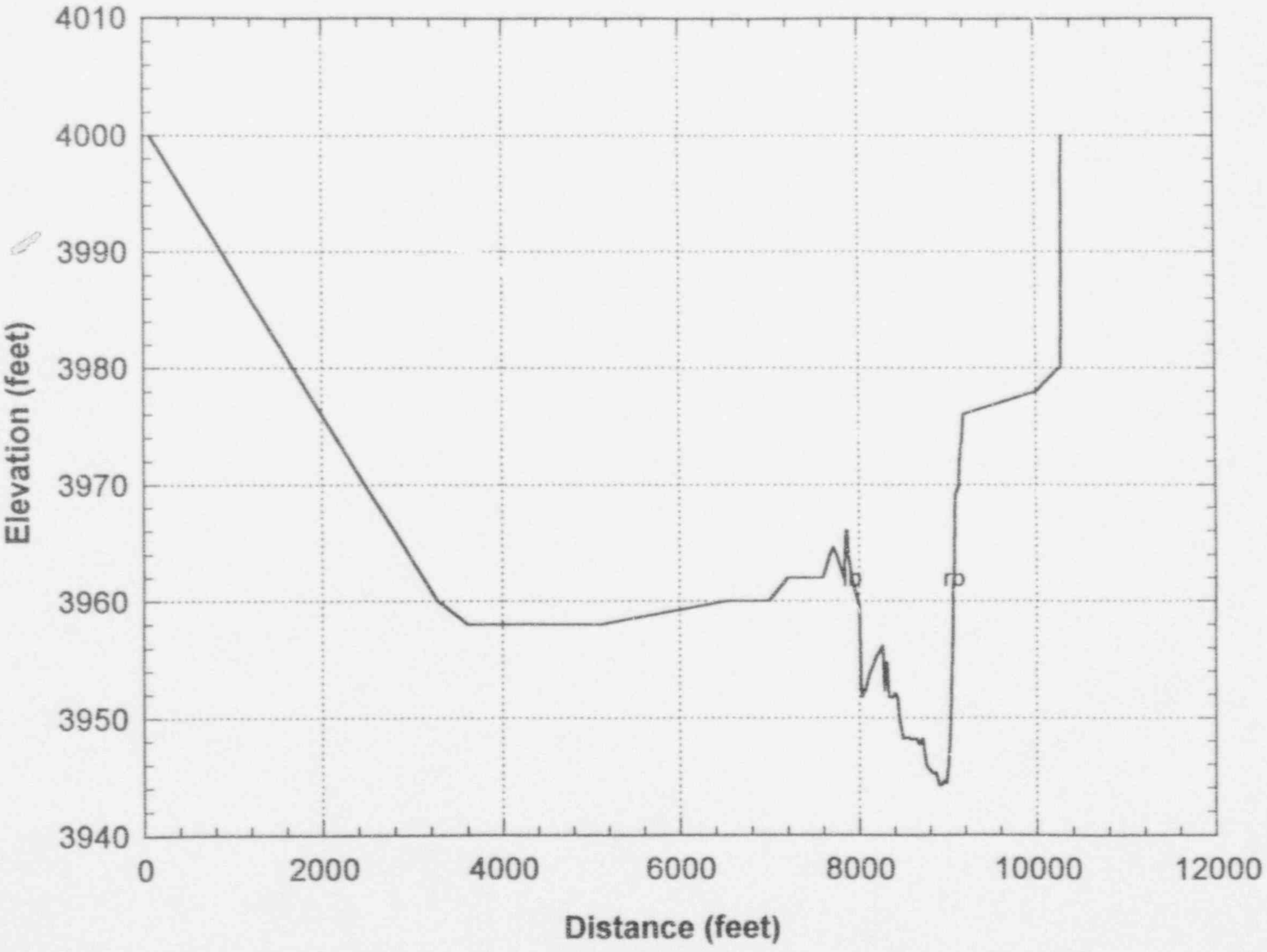

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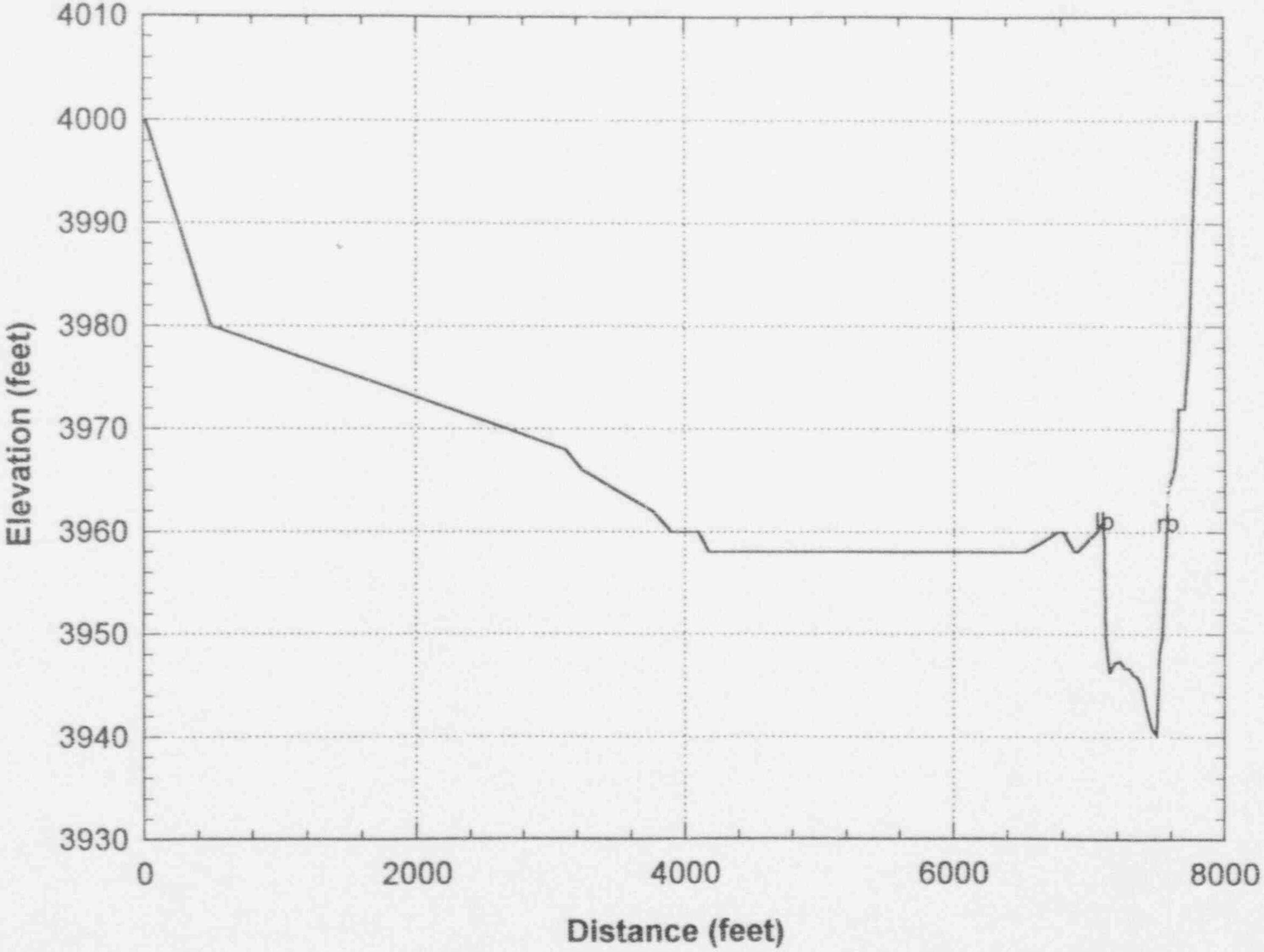

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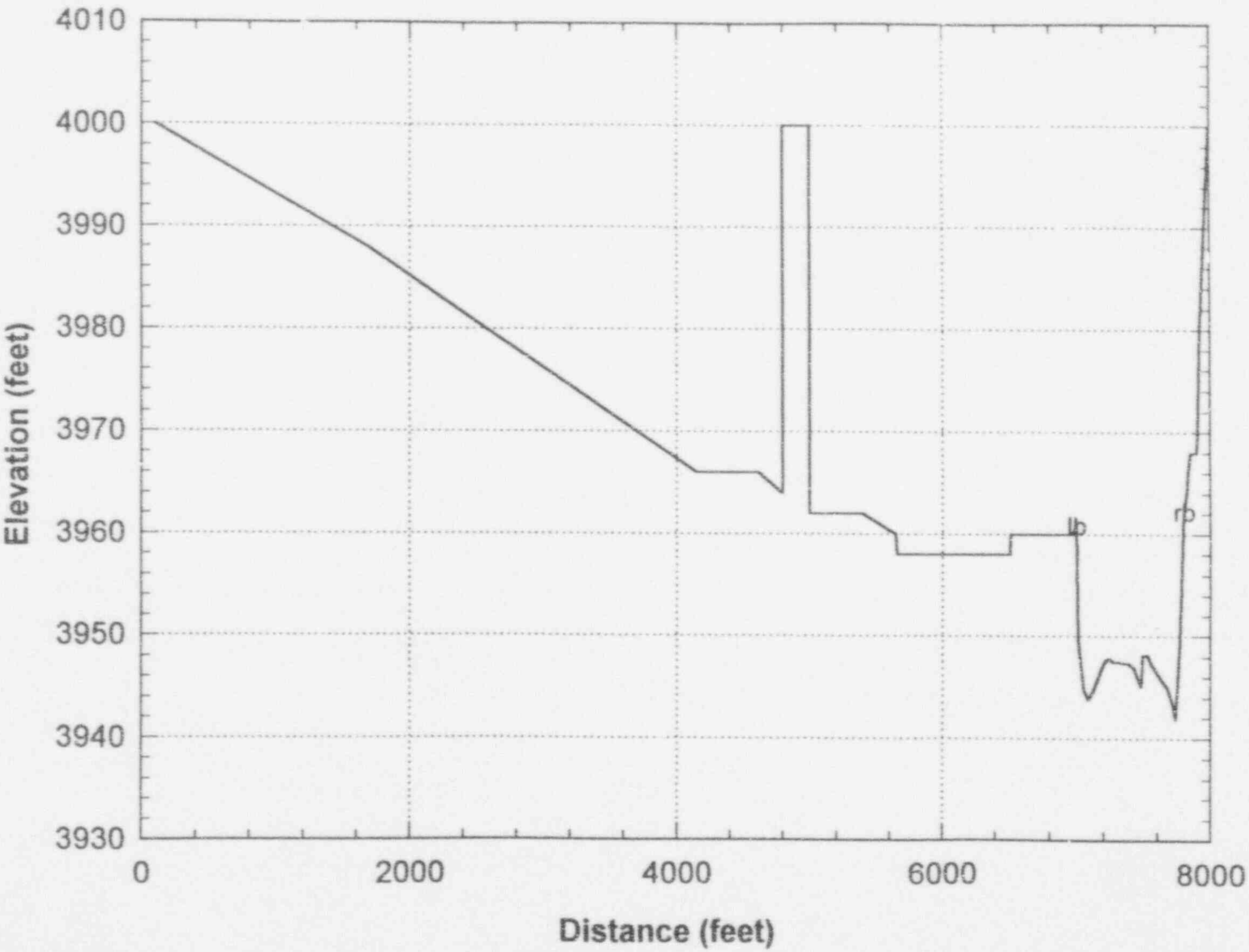
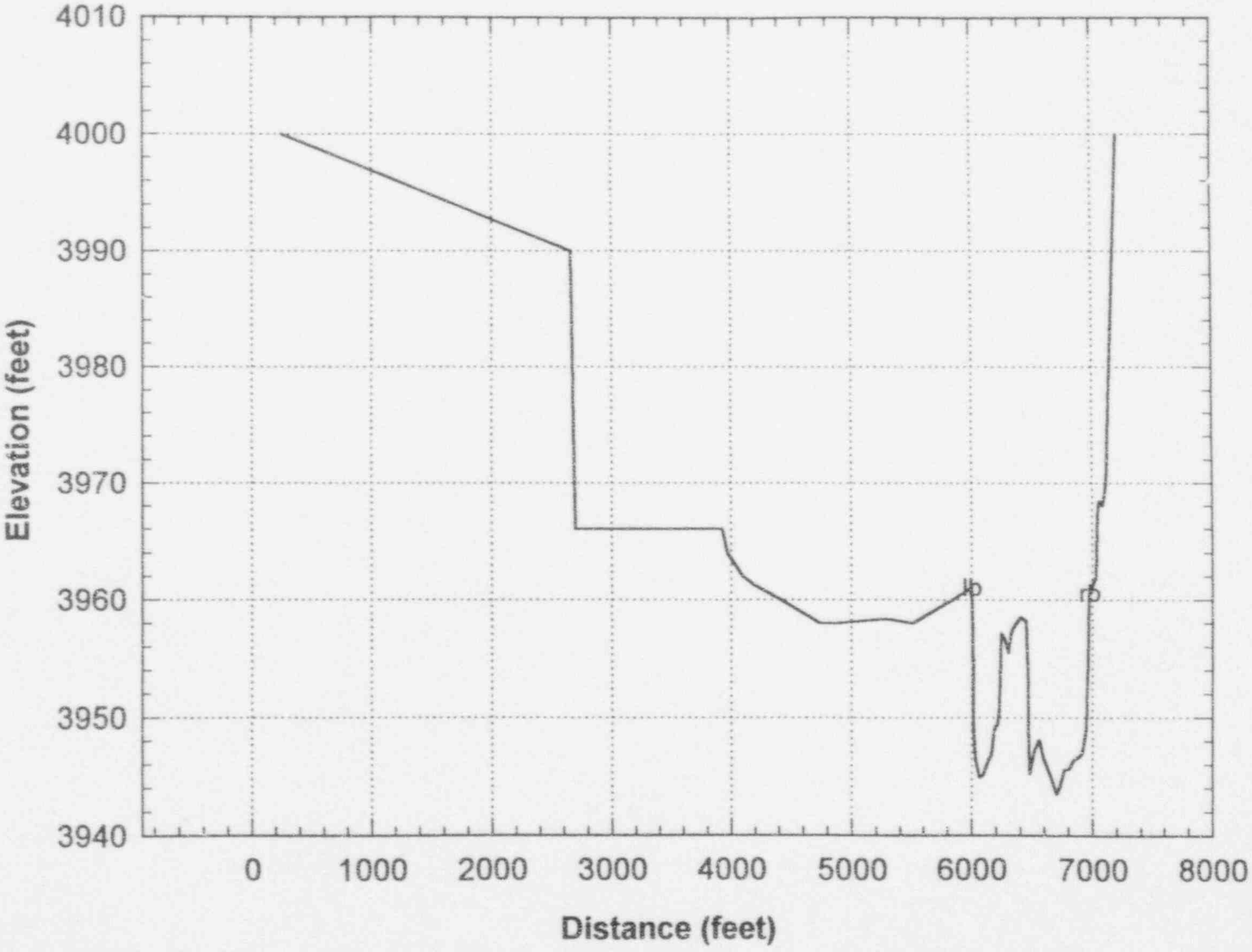
Final Report May, 1994

CROSS SECTION 10

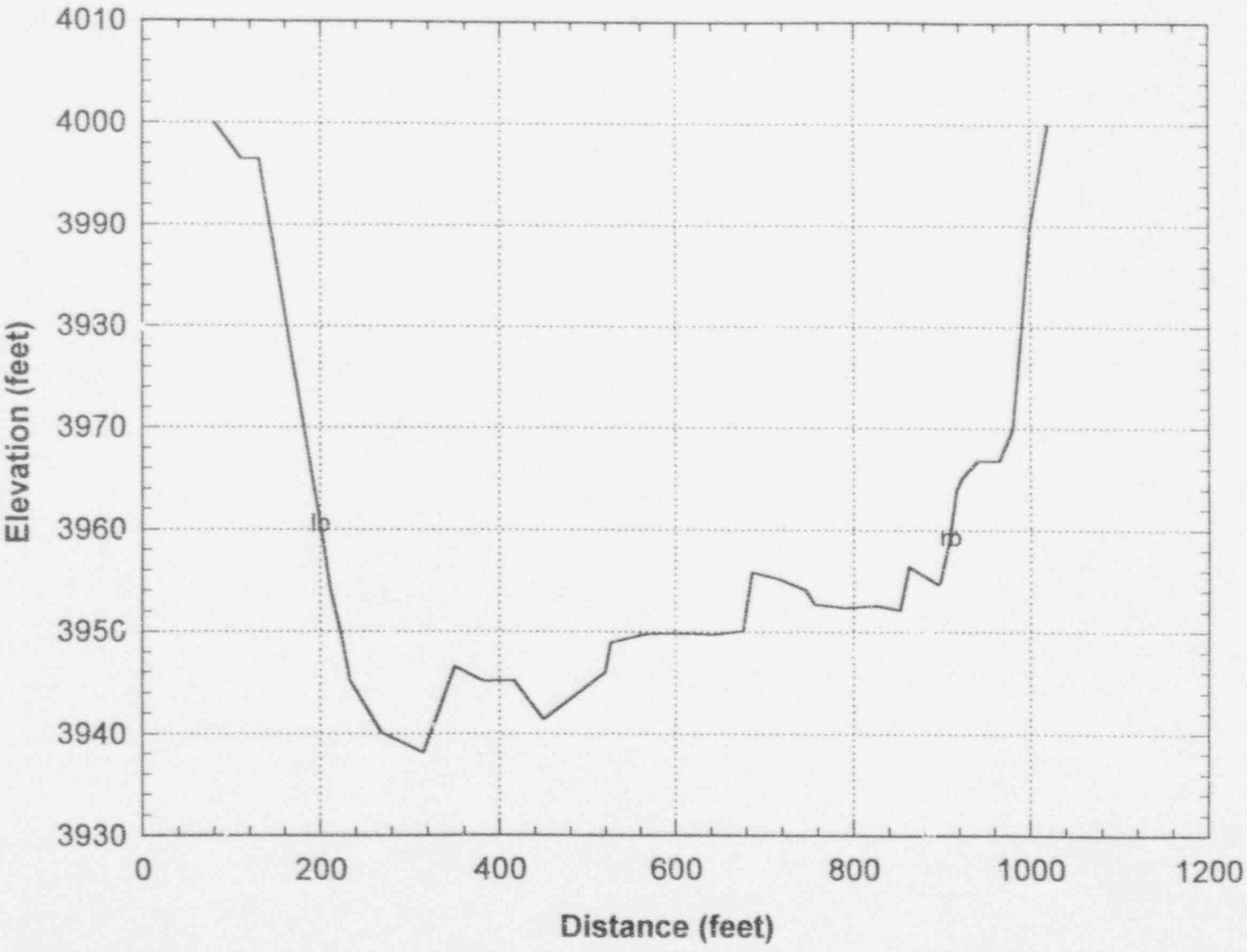


Mussetter Engineering, Inc.
Final Report May, 1994

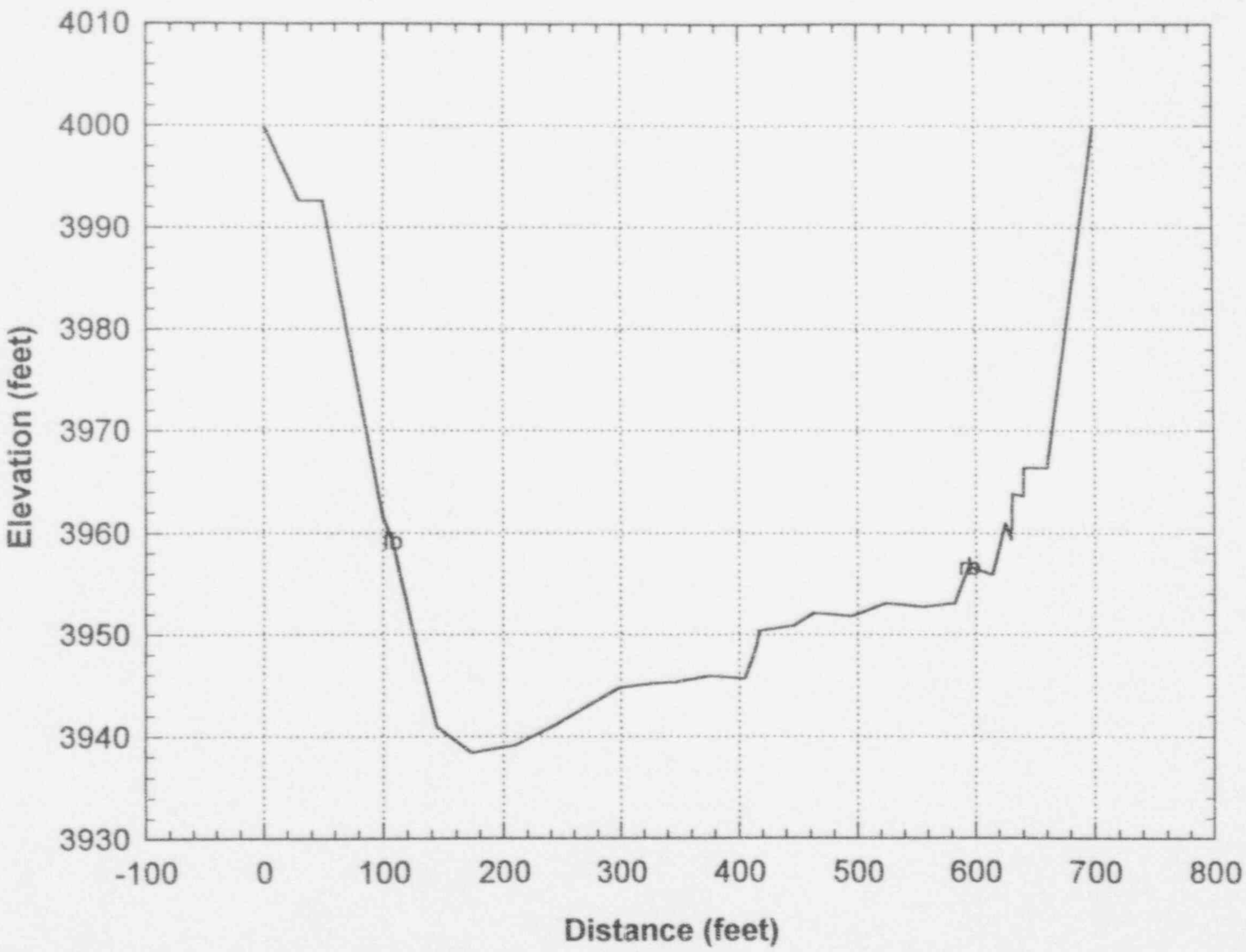
CROSS SECTION 11

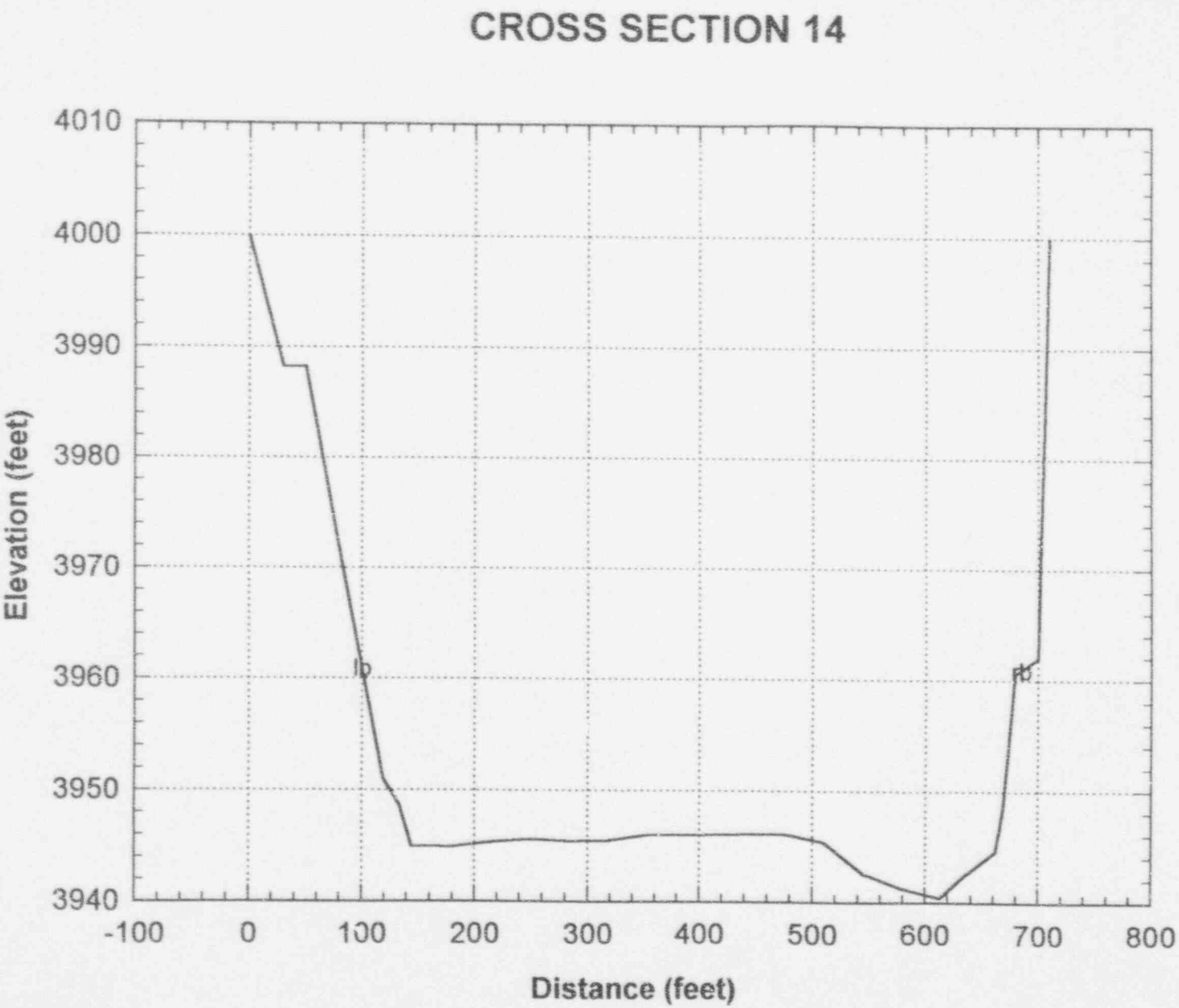


CROSS SECTION 12



CROSS SECTION 13




CROSS SECTION 14
4010
4000
3990
3980
3970
3960
3950
3940
Elevation (feet)
lb
rb
-100
0
100
200
300
400
500
600
700
800
Distance (feet)

APPENDIX B

HEC-2 OUTPUT FILE FOR SELECTED DISCHARGES

```
1*********************************************          *****************************************
* HEC-2 WATER SURFACE PROFILES          *          * ARMY CORPS OF ENGINEERS      *
*                                       *            * HYDROLOGIC ENGINEERING CENTER    *
* Version   4.5.1;  September 1990      *          * 609 SECOND STREET, SUITE D      *
*                                       *            * DAVIS, CALIFORNIA 95616-4687     *
* RUN DATE    26MAY94    TIME  09:25:51 *                  *      (916) 756-1104         *
********************************************          *****************************************


                 X    X XXXXXXX  XXXXX          XXXXX
                 X    X X     X  X        X  X
                 X    X X     X              X
                 XXXXXXX XXXX   X        XXXXX   XXXXX
                 X    X X     X          X
                 X    X X     X   X       X
                 X    X XXXXXXX  XXXXX          XXXXXXX
END OF BANNER
1
  26MAY94      09:25:51                                              PAGE   1



                                                THIS RUN EXECUTED 26MAY94    09:25:51
*************************************
 HEC-2 WATER SURFACE PROFILES

 Version   4.5.1;  September 1990
*************************************



SPLIT FLOW BEING PERFORMED


SF


JC
JP

TW  Weir flow from left bank between cross section 4 and 5
WS    5   13775   15545   12360     1.0
WC  8440  3962.8   8470   3964   8480   3966   8500   3968   9520   3968
1
  26MAY94      09:25:51                                              PAGE   2


T1  Hydraulic analysis for Atlas Mineral Tailings Pile, Moab, Utah
T2  Mussetter Engineering, Inc. (Project 94.02)
T3       Colorado River, Moab, UT
T4  Prepared by Bob Mussetter (4/94)

J1  ICHECK    INQ     NINV    IDIR    STRT    METRIC   HVINS    Q      WSEL    FQ
```

```
     0       2       0       0   .00018                    3948.6

J2  NPROF    IPLOT    PRFVS    XSECV    XSECH    FN     ALLDC    IBW     CHNIM    ITRACE

     1       0       -1       0          .8333     -1


NC     .08      .08      .03      .1       .3
QT      6     4000.   20000.    48900    70300.   123500.   178000.   300000.
X1      0       27     100.     684.
GR   4000.0      0.   3988.2     30.    3988.2     50.    3960.9     100.   3951.0     119.
GR   3948.6     134.   3945.0    144.    3944.9    179.    3945.3     213.   3945.6     250.
GR   3945.4     284.   3945.5    319.    3946.0    354.    3946.0     395.   3946.1     434.
GR   3946.1     476.   3945.4    510.    3942.6    544.    3941.3     578.   3940.4     613.
GR   3942.4     634.   3944.6    662.    3948.6    669.    3960.6     679.   3960.9     684.
GR   3962.0     700.   4000.0    710.
  Surveyed cross section 13

X1    1145      34     108.     594.    1145.    1145.    1145.
GR   4000.0      0.   3992.6     30.    3992.6     50.    3961.5     100.   3959.2     108.
GR   3949.2     127.   3940.9    144.    3938.4    173.    3939.1     209.   3941.2     245.
GR   3943.0     272.   3944.7    298.    3945.1    322.    3945.3     347.   3945.8     376.
GR   3945.6     405.   3947.5    411.    3949.1    415.    3950.4     417.   3950.9     446.
GR   3952.1     463.   3951.8    495.    3953.1    524.    3952.7     556.   3953.1     582.
GR   3956.7     594.   3955.9    614.    3960.9    625.    3959.4     630.   3963.8     631.
GR   3963.6     640.   3966.4    640.    3966.4    660.    4000.0     700.

NH      6      .08     200.     .03     526.      .05     862.      .15     923.      .02
NH    940.     .08     1020.
  Surveyed cross section 12
X1    1660      38      200      909     515.     515.     515.
GR    4000      80    3996.5     110    3996.5     130    3960.6     200    3954.3     211
GR    3949     225    3945.2     233    3940.1     268    3938.1     315    3946.5     350
GR   3945.1    382    3945.2     416    3941.4     449    3943.8     486     3946      519
GR   3948.9    526    3949.8     566    3949.9     606    3949.7     642    3950.1     676
GR   3955.8    686    3955.2     716    3954.1     746    3952.7     756    3952.4     790
GR   3952.6    825    3952.2     852    3956.4     862    3954.6     897    3959.3     909
GR   3963.9    916    3965.2     923    3966.8     940    3966.8     965     3970      980
GR    3980     990     3990     1000     4000     1020

NC      .1      .08      .03
  Surveyed cross section 11
X1    3220      61     6000     6972    1750.    1200.    1560.
X3     10       0        0    4500       0        0        0        0        0
GR    4000     250     3990     2665     3966     2700     3966     3930     3964     3968
GR    3962    4103    3961.3    4190     3960     4415     3958     4740     3958     4880
GR   3958.4   5290     3958     5512     3960     5842    3961.1    6000     3957     6008
GR    3953    6013    3949.5    6015    3946.6    6029    3944.9    6062    3945.2    6097
1
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GR   3946.3   6133    3946.9    6162    3949.1    6189    3949.5    6217    3950.9    6229
GR   3957.1   6243    3956.6    6274    3955.5    6301    3957.2    6326    3957.8    6350
GR   3958.5   6403    3958.2    6450    3952.7    6464    3949.4    6467    3945.9    6476
GR   3945.2   6479    3947.3    6514    3948.1    6556    3946.6    6588    3945.6    6630
GR   3944.7   6660    3943.5    6699    3944.3    6732    3945.6    6767    3945.6    6805
GR   3946.4   6841    3946.6    6875     3947     6911    3949.1    6951    3956.8    6970
GR   3960.6   6972     3962     7030     3962     7033     3966     7040     3968     7050
GR   3968.4   7060     3968     7085     3970     7118     3980     7152     3990     7180
GR    4000    7220
```

```
 Surveyed cross section 10

X1    4040     48     7000    7800    930.    690.    820.
X3      10      0        0       0       0       0       0       0       0
GR    4000    100     3988    1680    3966    4150    3966    4620    3964    4799
GR    4000   4800     4000    5000    3962    5001    3962    5400    3960    5650
GR    3958   5655     3958    6505    3960    6510    3960    6640    3960    6835
GR    3960   6965   3960.8    7000  3949.6    7012  3944.8    7053  3943.8    7089
GR  3944.8   7125   3946.7    7179  3947.6    7213  3947.8    7241  3947.5    7276
GR  3947.5   7313   3947.4    7350  3947.4    7382    3947    7421  3945.9    7452
GR  3945.1   7480   3948.1    7490  3948.2    7526  3947.4    7553  3946.5    7593
GR  3945.6   7638     3945    7677  3943.4    7718  3941.9    7738  3949.4    7769
GR  3962.2   7800     3964    7823    3966    7832    3968    7851    3968    7898
GR    3970   7905     3980    7922    4000    7995

NC                             .1      .3
NH       9    .06    3900.      .1   4900.     .10   5730.      .1   6802.     .15
NH   7100.    .03    7569.      .1    7655     .02   7703.     .08   7800.
 Surveyed cross section 9
X1    5505     49     7100    7569   1190.   1470.   1465.
X3      10      0        0       0       0       0       0       0       0
GR    4000     15     3980     500    3968    3120    3966    3240    3964    3500
GR    3962   3760     3960    3900    3960    4100    3958    4175    3958    4490
GR    3958   4900     3958    5730    3958    6112    3958    6310    3958    6520
GR  3959.2   6670     3960    6758    3960    6802    3958    6888    3958    6900
GR    3960   7045   3961.1    7100  3954.6    7107  3952.7    7114  3949.7    7116
GR  3946.2   7145   3947.2    7181  3947.3    7224  3946.7    7257  3946.6    7293
GR    3946   7323   3945.8    7355  3944.6    7391  3942.5    7424  3940.8    7459
GR  3940.2   7494   3948.2    7517  3949.7    7536  3960.9    7569  3964.1    7578
GR    3966   7620     3968    7642    3970    7650    3972    7655    3972    7703
GR    3974   7712     3976    7730    3978    7735    4000    7800

NH       5    .06    3280.      .1   8000.     .08   8267.     .03    9060     .08
NH  10300.
 Surveyed cross section 8
X1    7920     68     7915    9068   1865.   2540.   2415.
X3      10      0        0       0       0       0       0       0       0
GR    4000     70     3960    3280    3958    3610    3958    3700    3958    5115
GR    3960   6530     3960    6700    3960    6740    3960    6990    3961    7092
GR    3962   7200     3962    7530    3962    7595    3964    7670  3964.6    7710
GR    3964   7745     3962    7825    3964    7840    3966    7852    3966    7862
GR    3964   7878     3962    7915  3959.6    8000  3951.8    8025  3952.5    8070
GR  3953.7   8110   3954.5    8154  3955.3    8190  3955.7    8225  3956.2    8267
GR  3952.3   8279   3954.8    8294  3954.6    8311  3951.8    8331  3951.7    8370
GR  3952.1   8401   3951.6    8429    3950    8451  3948.2    8489  3948.3    8526
1
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GR  3948.3   8560   3948.1    8586  3948.2    8608  3948.2    8644  3947.7    8678
GR  3948.2   8714   3945.9    8757  3945.6    8794  3945.2    8827  3945.3    8862
GR  3944.3   8895   3944.2    8924  3944.6    8952  3944.4    8981  3946.2    9006
GR  3949.9   9030   3957.5    9054  3961.1    9060    3962    9068  3969.1    9089
GR    3970   9130     3972    9140    3974    9170    3976    9190    3978   10000
GR    3980  10250     3980   10275    4000   10300

NH       5     .1    7000.     .06   7367.     .03   8201.     .15   8720.     .08
NH   9020.
 Surveyed cross section 7
X1    9830     68    7000.   8201.   1690.   1980.   1910.
X3      10
```

```
GR  4000.0    200.   3962.0   1760.   3960.0   1980.   3958.0   2150.   3960.0   2232.
GR  3964.0   2260.   3964.0   2300.   3958.0   2320.   3957.0   2850.   3957.3   3825.
GR  3958.0   4070.   3958.0   4120.   3960.0   4560.   3960.2   4920.   3960.0   5325.
GR  3959.4   5830.   3960.0   5982.   3962.0   6720.   3963.9   7000.   3955.1   7020.
GR  3956.3   7150.   3958.3   7255.   3957.3   7367.   3951.3   7376.   3946.2   7450.
GR  3946.9   7484.   3950.5   7512.   3951.2   7546.   3951.1   7581.   3950.6   7609.
GR  3949.3   7642.   3949.0   7666.   3948.4   7690.   3948.2   7715.   3948.6   7746.
GR  3947.9   7777.   3949.1   7819.   3951.1   7827.   3952.3   7830.   3952.2   7859.
GR  3951.1   7872.   3948.9   7908.   3949.3   7939.   3948.9   7974.   3947.8   8013.
GR  3947.0   8038.   3947.4   8059.   3945.9   8082.   3946.0   8112.   3945.5   8140.
GR  3951.3   8186.   3963.2   8201.   3960.0   8245.   3960.0   8338.   3960.0   8390.
GR  3958.0   8650.   3958.0   8682.   3960.0   8700.   3966.0   8720.   3968.0   8762.
GR  3970.0   8800.   3972.0   8850.   3974.0   8870.   3976.0   8875.   3977.0   8900.
GR  3976.0   8920.   3976.0   8950.   4000.0   9020.

NH     8     .1    5000.    .15    5080.     .06    5124.     .03    5472.     .15
NH   5550.    .03   6074.    .1    6618.     .05    6835.
 Surveyed cross section 6
X1   12360     87    5000.   6074.    1860.    2820.    2530.
X3     10
GR  4000.0    555.   3990.0    610.   3980.0    710.   3978.0    750.   3976.0    790.
GR  3974.0    828.   3972.0    868.   3970.0    915.   3968.0    970.   3966.0   1032.
GR  3964.0   1105.   3962.0   1188.   3960.0   1210.   3958.0   1765.   3957.5   1950.
GR  3958.0   2100.   3960.0   2590.   3961.7   3429.   3962.0   3455.   3962.5   3568.
GR  3962.0   3620.   3962.0   3755.   3960.4   3863.   3962.0   3998.   3962.0   4658.
GR  3964.0   4955.   3964.1   5000.   3961.3   5015.   3962.5   5024.   3962.8   5047.
GR  3961.8   5080.   3957.6   5105.   3957.6   5124.   3957.2   5140.   3955.2   5147.
GR  3958.1   5169.   3957.8   5197.   3957.7   5226.   3958.0   5255.   3958.0   5276.
GR  3957.9   5297.   3957.2   5326.   3954.8   5334.   3951.8   5336.   3951.6   5353.
GR  3950.3   5385.   3949.6   5407.   3949.2   5427.   3950.6   5443.   3948.9   5443.
GR  3951.0   5460.   3953.3   5462.   3957.7   5469.   3958.6   5472.   3961.3   5480.
GR  3959.2   5550.   3951.6   5555.   3947.7   5593.   3947.7   5630.   3947.5   5651.
GR  3947.4   5689.   3946.9   5722.   3946.9   5742.   3946.7   5775.   3946.8   5802.
GR  3946.9   5825.   3947.3   5857.   3947.9   5884.   3948.6   5906.   3948.9   5933.
GR  3950.0   5963.   3951.9   5987.   3952.4   6023.   3954.0   6055.   3964.0   6074.
GR  3964.0   6102.   3962.0   6142.   3960.0   6180.   3962.0   6213.   3964.0   6330.
GR  3966.0   6618.   3968.0   6670.   3970.0   6685.   3980.0   6710.   3990.0   6768.
GR  4000.0   6815.   4010.0   6835.
1
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NH     6     .1    4000.    .03    4140.     .15    4623.     .03    5036.     .15
NH   5140.    .08   8045.
 Surveyed cross section 5
X1   13775     69    4623    5036    1030.    1420.    1415.
X3     0       0      0     3790      0        0        0        0        0
GR    4000     800    3990     852    3988     870    3988     900    3980     985
GR    3976    1000    3974    1030    3972    1080    3970    1150    3968    1200
GR    3966    1250    3964    1310    3962    1380    3960    1990    3960    2070
GR    3962    2620    3962    3000    3960    3150    3962    3380    3962    3812
GR    3960    3897    3960    3922    3962    3938    3962    4000  3948.2    4053
GR  3949.7    4059    3950    4079  3950.8    4105  3951.4    4127    3960    4140
GR  3960.4    4168    3959    4175  3959.1    4200  3958.9    4215    3956    4223
GR  3955.1    4248  3955.2    4273  3955.1    4298  3954.6    4322    3954    4337
GR  3963.4    4348    3964    4510    3966    4623  3960.4    4630  3956.2    4641
GR  3951.9    4649  3950.5    4675  3948.1    4705    3947    4725    3946    4756
GR  3946.2    4781  3946.8    4796    3948    4816  3948.1    4849  3947.9    4869
GR  3944.8    4904  3946.4    4938    3950    4982  3952.1    5002  3957.6    5019
GR  3966.5    5036    3966    5080    3964    5140  3967.2    5710    3970    5935
```

```
GR   3980    6640    3980    6900     3990     7730     4000     8045

NH      5     .08    1130.      .1    3000.     .15     3237.     .03     3843      .08
NH   4815.
 Surveyed cross section 4
X1   15545      50    3000    3843      750.    2150.    1770.
X3      10       0       0    2928        0        0        0        0        0
GR   4000      820    3996     830     3994      860    3992      880    3990      900
GR   3988      910    3986     930     3986      975    3985.3   1025    3984     1052
GR   3968     1130    3968    2737     3968     2885    3970     2928    3969.3   3000
GR   3962.3   3019    3961    3101     3961.1   3149    3961.5   3190    3961.1   3222
GR   3961.1   3237    3954.4  3261     3954     3292    3955.6   3333    3950.8   3358
GR   3951.9   3394    3950.9  3407     3948.7   3421    3947.8   3472    3949.2   3512
GR   3949.5   3554    3949.3  3587     3948.8   3622    3948.2   3647    3947.9   3680
GR   3946.8   3710    3946.6  3774     3952.2   3816    3970.3   3843    3969.3   3937
GR   3970     4050    3970    4580     3972     4587    3974     4595    3975     4605
GR   3976     4615    3975    4625     3980     4650    3990     4790    4000     4815

NC      .1      .1     .03      .3       .5
X1   16905      49    500.    1307.    1600.    1240.    1360.
X3      10
GR   4000.0    90.    3986.7    98.    3985.9    177.    3984.7    255.    3983.2    334.
GR   3982.1   421.    3981.9   460.    3982.0    500.    3963.0    539.    3955.0    547.
GR   3949.5   563.    3948.0   579.    3946.2    583.    3946.6    618.    3946.9    657.
GR   3947.3   661.    3946.3   673.    3946.2    697.    3946.0    709.    3946.1    736.
GR   3946.2   776.    3947.8   815.    3949.4    823.    3951.8    827.    3953.2    854.
GR   3954.5   874.    3954.5   894.    3955.0    933.    3955.5    973.    3956.6   1012.
GR   3956.7  1051.    3956.8  1091.    3956.8   1130.    3956.9   1170.    3956.0   1209.
GR   3955.5  1244.    3955.5  1248.    3962.7   1260.    3963.0   1288.    3981.9   1307.
GR   3981.9  1319.    3981.8  1359.    3981.7   1398.    3981.8   1437.    3982.0   1477.
GR   3982.2  1516.    3982.6  1556.    3983.0   1595.    4000.0   1603.
1
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SB    0.90    1.56     2.5       0    255.1      56.    18394.     11.5
 Surveyed cross section 3.5
X1   16935                              30.      30.      30.
X2                      1    3978.8   3981.9
X3      10
BT     -49      90   4000.0   4000.0      98   3986.7   3986.7     177   3985.9   3985.9
BT             255   3984.7   3984.7     334   3983.2   3983.2     421   3982.1   3982.1
BT             460   3981.9   3981.9     500   3981.9   3977.0     539   3982.2   3977.2
BT             547   3982.2   3977.2     563   3982.3   3977.3     579   3982.3   3977.3
BT             583   3982.4   3977.4     618   3982.4   3977.4     657   3982.5   3977.5
BT             661   3982.5   3977.5     673   3982.6   3977.6     697   3982.6   3977.6
BT             709   3982.7   3977.7     736   3982.7   3977.7     776   3982.8   3977.8
BT             815   3982.8   3977.8     823   3982.8   3977.8     827   3982.8   3977.8
BT             854   3982.8   3977.8     874   3982.8   3977.8     894   3982.8   3977.8
BT             933   3982.8   3977.8     973   3982.8   3977.8    1012   3982.8   3977.8
BT            1051   3982.7   3977.7    1091   3982.6   3977.6    1130   3982.5   3977.5
BT            1170   3982.4   3977.4    1209   3982.3   3977.3    1244   3982.1   3977.1
BT            1248   3982.2   3977.2    1260   3982.1   3977.1    1288   3982.0   3977
BT            1307   3981.9   3976.9    1319   3981.9   3981.9    1359   3981.8   3981.8
BT            1398   3981.7   3981.7    1437   3981.8   3981.8    1477   3982.0   3982
BT            1516   3982.2   3982.2    1556   3982.6   3982.6    1595   3983.0   3983
BT            1603   4000.0   4000.0

NC     .05      .1     .03
 Surveyed cross section 3
```

```
X1   18275      24      500     1202     1080.     1540.     1340.
GR    4000      50     3970       52     3970        75     3969.5     500    3952.5     538
GR  3948.6     559   3949.2      586   3949.9       609     3950.6     633    3951.1     660
GR  3951.5     688   3950.6      720   3950.2       755     3949.1     789      3947     841
GR  3944.7     900   3944.3      920   3942.5       960       3943     992    3946.1    1023
GR  3952.2    1053     3964     1153   3966.6      1202       4000    1250

NC     .1       .1      .03       .1       .3
 Surveyed cross section 2
X1   20975      33    100.0     532.    2500.     2600.      2700.
GR  4000.0     50.   3971.0      52.   3971.0       75.     3970.3    100.    3952.6    114.
GR  3949.3    135.   3948.8     147.   3948.2      190.     3948.1    207.    3948.1    215.
GR  3947.9    263.   3946.6     301.   3947.8      330.     3945.9    372.    3952.6    412.
GR  3953.8    433.   3953.8     433.   3954.9      453.     3954.6    458.    3955.1    470.
GR  3955.0    482.   3956.1     492.   3955.7      507.     3957.6    532.    3957.5    549.
GR  3958.9    567.   3960.0     589.   3960.9      593.     3962.2    597.    3964.0    600.
GR  3966.5    608.   3967.9     629.   4000.0      700.
 Surveyed cross section 1

X1   23475      25     515.     965.    3000.     2450.      2500.
X3      10
GR  4000.0     90.   3998.0     100.   3962.9      225.     3959.8    305.    3964.5    361.
GR  3964.6    436.   3965.0     453.   3966.4      515.     3956.3    516.    3953.3    534.
GR  3949.5    584.   3949.0     613.   3948.5      653.     3948.7    700.    3948.9    728.
GR  3948.6    765.   3948.9     800.   3946.8      833.     3946.8    880.    3947.8    907.
GR  3952.4    928.   3952.9     944.   3956.9      954.     3967.3    965.    4000.0   1080.
1
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   SECNO    DEPTH    CWSEL    CRIWS    WSELK    EG       HV       HL     OLOSS   L-BANK ELEV
   Q        QLOB     QCH      QROB     ALOB     ACH      AROB     VOL    TWA     R-BANK ELEV
   TIME     VLOB     VCH      VROB     XNL      XNCH     XNR      WTN    ELMIN   SSTA
   SLOPE    XLOBL    XLCH     XLOBR    ITRIAL   IDC      ICONT    CORAF  TOPWID  ENDST


*PROF 1

CRITICAL DEPTH TO BE CALCULATED AT ALL CROSS SECTIONS

CCHV=     .100 CEHV=     .300
*SECNO  .000
     .000     8.17  3948.57  3945.57  3948.60  3948.63      .06      .00      .00  3960.90
   4000.0       .0   4000.0       .0       .0   2048.6       .0       .0       .0  3960.90
      .00      .00     1.95      .00     .000     .025     .000     .000  3940.40   134.09
  .000181       0.       0.       0.        0       17        3      .00   534.85   668.94


*SECNO 1145.000
 1145.000    10.34  3948.74  3943.19      .00  3948.83      .09      .19      .01  3959.20
   4000.0       .0   4000.0       .0       .0   1675.3       .0     48.9     10.8  3956.70
      .13      .00     2.39      .00     .000     .025     .000     .000  3938.40   127.94
  .000155    1145.    1145.    1145.        2       11        0      .00   286.16   414.10


1490 NH CARD USED
*SECNO 1660.000
 1660.000    10.72  3948.82  3943.95      .00  3948.91      .09      .08      .00  3960.60
   4000.0       .0   4000.0       .0       .0   1687.4       .0     68.8     14.3  3959.30
      .19      .00     2.37      .00     .000     .025     .000     .000  3938.10   225.38
  .000162     515.     515.     515.        2       11        0      .00   300.43   525.81
```

*SECNO 3220.000

3265 DIVIDED FLOW

3470 ENCROACHMENT STATIONS= 4500.0 7220.0 TYPE= 1 TARGET= -4500.000

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA= 3961.10 ELREA= 3960.60

```
 3220.000     5.66  3949.16  3946.83     .00  3949.23     .06     .32     .00  3961.10
   4000.0       .0   4000.0       .0      .0   1986.9      .0   134.6    31.5  3960.60
      .41      .00     2.01      .00    .000     .025    .000    .000 3943.50  6016.61
  .000265    1750.    1560.    1200.       3       17       0     .00  680.66  6951.17
```

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```
 SECNO   DEPTH   CWSEL   CRIWS   WSELK   EG      HV      HL      OLOSS   L-BANK ELEV
 Q       QLOB    QCH     QROB    ALOB    ACH     AROB    VOL     TWA     R-BANK ELEV
 TIME    VLOB    VCH     VROB    XNL     XNCH    XNR     WTN     ELMIN   SSTA
 SLOPE   XLOBL   XLCH    XLOBR   ITRIAL  IDC     ICONT   CORAR   TOPWID  ENDST
```

*SECNO 4040.000

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA= 3960.80 ELREA= 3962.20

```
 4040.000     7.47  3949.37  3946.63     .00  3949.41     .05     .19     .00  3960.80
   4000.0       .0   4000.0       .0      .0   2298.0      .0   174.9    44.8  3962.20
      .54      .00     1.74      .00    .000     .025    .000    .000 3941.90  7013.98
  .000195     930.     820.     690.       3       14       0     .00  754.88  7768.87
```

CCHV= .100 CEHV= .300
1490 NH CARD USED
*SECNO 5505.000

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA= 3961.10 ELREA= 3960.90

```
 5505.000     9.44  3949.64  3945.37     .00  3949.72     .08     .30     .01  3961.10
   4000.0       .0   4000.0       .0      .0   1770.9      .0   243.4    64.5  3960.90
      .72      .00     2.26      .00    .000     .025    .000    .000 3940.20  7116.50
  .000212    1190.    1465.    1470.       2       15       0     .00  418.75  7535.24
```

1490 NH CARD USED
*SECNO 7920.000

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA= 3962.00 ELREA= 3962.00

```
 7920.000     5.99  3950.19  3946.99     .00  3950.25     .06     .53     .00  3962.00
   4000.0       .0   4000.0       .0      .0   1986.4      .0   347.5    92.3  3962.00
     1.05      .00     2.01      .00    .000     .025    .000    .000 3944.20  8448.33
  .000224    1865.    2415.    2540.       3       17       0     .00  582.60  9030.93
```

1490 NH CARD USED
*SECNO 9830.000

3265 DIVIDED FLOW

3302 WARNING: CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE, KRATIO = .68


```
 SECNO    DEPTH   CWSEL   CRIWS   WSELK    EG      HV      HL     OLOSS  L-BANK ELEV
 Q        QLOB    QCH     QROB    ALOB     ACH     AROB    VOL    TWA    R-BANK ELEV
 TIME     VLOB    VCH     VROB    XNL      XNCH    XNR     WTN    ELMIN  SSTA
 SLOPE    XLOBL   XLCH    XLOBR   ITRIAL   IDC     ICONT   CORAR  TOPWID ENDST
```

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA= 3963.90 ELREA= 3963.20

```
 9830.000    5.28  3950.78  3948.91     .00  3950.86     .09     .61     .01  3963.90
  4000.0      .0   4000.0      .0       .0   1668.4      .0    427.7   119.8  3963.20
   1.27      .00     2.40     .00     .000     .025    .000     .000  3945.50  7383.68
 .000485    1690.   1910.    1980.       2       11       0      .00   672.13  8181.80
```

1490 NH CARD USED
*SECNO 12360.000

3265 DIVIDED FLOW

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA= 3964.10 ELREA= 3964.00

```
12360.000    4.98  3951.68  3949.02     .00  3951.76     .08     .89     .00  3964.10
  4000.0      .0   4000.0      .0       .0   1779.9      .0    527.8   155.1  3964.00
   1.59      .00     2.25     .00     .000     .024    .000     .000  3946.70  5346.63
 .000268    1860.   2530.    2820.       2       14       0      .00   543.17  5984.16
```

1490 NH CARD USED
*SECNO 13775.000

3265 DIVIDED FLOW

3470 ENCROACHMENT STATIONS= 3790.0 8045.0 TYPE= 1 TARGET= -3790.000

```
13775.000    7.24  3952.04  3948.82     .00  3952.13     .09     .37     .00  3966.00
  4000.0   222.5   3777.5      .0    153.9   1508.0      .0    583.0   170.7  3966.50
   1.75     1.45     2.51     .00     .025     .025    .000     .000  3944.80  4038.27
 .000257    1030.   1415.    1420.       3       15       0      .00   442.34  5001.39
```

1490 NH CARD USED
*SECNO 15545.000

3470 ENCROACHMENT STATIONS= 2928.0 4815.0 TYPE= 1 TARGET= -2928.000

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA= 3969.30 ELREA= 3970.30

```
 SECNO    DEPTH    CWSEL   CRIWS    WSELK    EG      HV      HL      OLOSS   L-BANK ELEV
 Q        QLOB     QCH     QROB     ALOB     ACH     AROB    VOL     TWA     R-BANK ELEV
 TIME     VLOB     VCH     VROB     XNL      XNCH    XNR     WTN     ELMIN   SSTA
 SLOPE    XLOBL    XLCH    XLOBR    ITRIAL   IDC     ICONT   CORAR   TOPWID  ENDST


15545.000    5.90  3952.50  3949.73     .00  3952.58     .08     .45     .00  3969.30
  4000.0       .0   4000.0       .0      .0   1735.9      .0   650.2   188.1  3970.30
    1.96      .00     2.30      .00    .000     .025    .000    .000 3946.60  3349.15
 .000262     750.    1770.    2150.       3       18       0     .00  467.30  3816.45


CCHV=     .300 CEHV=     .500
*SECNO 16905.000

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA=      3982.00 ELREA=      3981.90

16905.000    6.79  3952.79  3948.57     .00  3952.88     .09     .29     .01  3982.00
  4000.0       .0   4000.0       .0      .0   1617.2      .0   702.6   200.0  3981.90
    2.11      .00     2.47      .00    .000     .025    .000    .000 3946.00   553.45
 .000179    1600.    1360.    1240.       2       14       0     .00  292.50   845.95


SPECIAL BRIDGE

5070, VARIABLE ELCHU OR ELCHD ON SB CARD NOT SPECIFIED
SB  XK      XKOR    COFQ    RDLEN    BWC      BWP      BAREA     SS     ELCHU     ELCHD
    .90     1.56    2.50      .00   255.10    56.00  18394.00   11.50  3946.00   3946.00

*SECNO 16935.000
CLASS A LOW FLOW

3420 BRIDGE W.S.=    3952.76 BRIDGE VELOCITY=      2.14    CALCULATED CHANNEL AREA=      1872.

 EGPRS    EGLWC      H3     QWEIR     QLOW    BAREA   TRAPEZOID    ELLC     ELTRD    WEIRLN
                                      AREA
    .00  3952.89     .01       0.    4000.   18394.    18903.   3978.80  3981.90       0.


3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA=      3982.00 ELREA=      3981.90

16935.000    6.80  3952.80      .00     .00  3952.89     .09     .01     .00  3982.00
  4000.0       .0   4000.0       .0      .0   1621.9      .0   703.7   200.2  3981.90
    2.11      .00     2.47      .00    .000     .025    .000    .000 3946.00   553.40
 .000177      30.      30.      30.       0        0       0     .00  292.85   846.26


*SECNO 18275.000
1
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 SECNO    DEPTH    CWSEL   CRIWS    WSELK    EG      HV      HL      OLOSS   L-BANK ELEV
 Q        QLOB     QCH     QROB     ALOB     ACH     AROB    VOL     TWA     R-BANK ELEV
 TIME     VLOB     VCH     VROB     XNL      XNCH    XNR     WTN     ELMIN   SSTA
 SLOPE    XLOBL    XLCH    XLOBR    ITRIAL   IDC     ICONT   CORAR   TOPWID  ENDST
```

```
3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,  KRATIO =  1.53

 18275.000     10.52   3953.02   3946.83       .00   3953.06      .04      .15      .02   3969.50
   4000.0        .0   4000.0        .0        .0   2634.4        .0    769.2    212.7   3966.60
     2.36       .00     1.52       .00      .000      .025      .000     .000   3942.50   536.83
  .000076     1080.    1340.     1540.        3        14         0      .00    523.15   1059.98


CCHV=     .100 CEHV=     .300
*SECNO 20975.000

3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,  KRATIO =   .58

 20975.000      7.41   3953.31   3949.66       .00   3953.41      .11      .33      .02   3970.30
   4000.0        .0   4000.0        .0        .0   1536.0        .0    898.4    238.6   3957.60
     2.65       .00     2.60       .00      .000      .025      .000     .000   3945.90   113.44
  .000229     2500.    2700.     2600.        3        22         0      .00    310.89    424.34


*SECNO 23475.000

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA=     3966.40 ELREA=     3967.30

 23475.000      7.00   3953.80   3949.96       .00   3953.86      .06      .45      .00   3966.40
   4000.0        .0   4000.0        .0        .0   1988.6        .0    999.6    259.4   3967.30
     2.99       .00     2.01       .00      .000      .025      .000     .000   3946.80   531.03
  .000142     3000.    2500.     2450.        2        18         0      .00    415.21    946.24


1
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 TW  Weir flow from left bank between cross section 4 and 5

    ASQ     QCOMP     ERRAC     TASQ      TCQ     TABER     NITER     DSWS      USWS      DSSNO     USSNO

      .00      .00      .00      .00      .00      .00       2  3952.036  3952.500 13775.000 15545.000

1
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T1  Hydraulic analysis for Atlas Mineral Tailings Pile, Moab, Utah
T2  Mussetter Engineering, Inc. (Project 94.02)
T3      Colorado River, Moab, UT
T4  Prepared by Bob Mussetter (4/94)

J1  ICHECK    INQ     NINV    IDIR    STRT    METRIC   HVINS    Q      WSEL     FQ

      0       3       0       0   .00018                        3955.0

J2  NPROF   IPLOT   PRFVS   XSECV   XSECH    FN    ALLDC    IBW    CHNIM    ITRACE

      2       0      -1       0               1     -1

1
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```

```
SECNO    DEPTH    CWSEL    CRIWS    WSELK    EG       HV       HL       OLOSS    L-BANK ELEV
Q        QLOB     QCH      QROB     ALOB     ACH      AROB     VOL      TWA      R-BANK ELEV
TIME     VLOB     VCH      VROB     XNL      XNCH     XNR      WTN      ELMIN    SSTA
SLOPE    XLOBL    XLCH     XLOBR    ITRIAL   IDC      ICONT    CORAR    TOPWID   ENDST
```

*PROF 2

CRITICAL DEPTH TO BE CALCULATED AT ALL CROSS SECTIONS

CCHV= .100 CEHV= .300

*SECNO .000

```
     .000    15.58  3955.98  3948.19  3955.00  3956.14      .16      .00      .00  3960.90
  20000.0       .0  20000.0       .0       .0   6152.6       .0       .0       .0  3960.90
      .00      .00     3.25      .00     .000     .030     .000     .000  3940.40   109.45
  .000182       0.       0.       0.        0       11        3      .00   565.70   675.15
```

*SECNO 1145.000

3265 DIVIDED FLOW

3302 WARNING: CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE, KRATIO = .68

```
 1145.000    17.78  3956.18  3948.14      .00  3956.48      .30      .29      .04  3959.20
  20000.0       .0  19999.9       .1       .0   4565.6      1.1    140.9     13.8  3956.70
      .07      .00     4.38      .09     .000     .030     .080     .000  3938.40   113.74
  .000392    1145.    1145.    1145.        3       14        0      .00   486.10   614.61
```

1490 NH CARD USED

*SECNO 1660.000

```
 1660.000    18.36  3956.46  3948.24      .00  3956.65      .19      .17      .01  3960.60
  20000.0       .0  20000.0       .0       .0   5660.1       .0    201.3     20.8  3959.30
      .11      .00     3.53      .00     .000     .028     .000     .000  3938.10   207.23
  .000271     515.     515.     515.        2       14        0      .00   694.52   901.75
```

*SECNO 3220.000

3265 DIVIDED FLOW

3470 ENCROACHMENT STATIONS= 4500.0 7220.0 TYPE= 1 TARGET= -4500.000

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA= 3961.10 ELREA= 3960.60

```
 3220.000    13.36  3956.86  3949.20      .00  3956.97      .11      .31      .01  3961.10
  20000.0       .0  20000.0       .0       .0   7558.7       .0    438.0     47.8  3960.60
      .28      .00     2.65      .00     .000     .030     .000     .000  3943.50  6008.16
  .000149    1750.    1560.    1200.        2       17        0      .00   814.72  6970.04
```



```
SECNO    DEPTH    CWSEL    CRIWS    WSELK    EG       HV       HL       OLOSS    L-BANK ELEV
Q        QLOB     QCH      QROB     ALOB     ACH      AROB     VOL      TWA      R-BANK ELEV
TIME     VLOB     VCH      VROB     XNL      XNCH     XNR      WTN      ELMIN    SSTA
```

SLOPE XLOBL XLCH XLOBR ITRIAL IDC ICONT CORAR TOPWID ENDST

*SECNO 4040.000

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA= 3960.80 ELREA= 3962.20

```
 4040.000    15.08  3956.98  3949.05     .00  3957.07     .09     .10     .00  3960.80
  20000.0       .0  20000.0       .0      .0   8155.0      .0   585.9    62.9  3962.20
      .37      .00     2.45      .00    .000     .030    .000    .000 3941.90  7004.10
  .000109     930.     820.     690.       2       11       0     .00  783.25  7787.35
```

CCHV= .100 CEHV= .300
1490 NH CARD USED
*SECNO 5505.000

3302 WARNING: CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE, KRATIO = .64

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA= 3961.10 ELREA= 3960.90

```
 5505.000    16.91  3957.11  3949.48     .00  3957.36     .25     .24     .05  3961.10
  20000.0       .0  20000.0       .0      .0   5032.1      .0   807.7    83.7  3960.90
      .47      .00     3.97      .00    .000     .030    .000    .000 3940.20  7104.29
  .000265    1190.    1465.    1470.       2       14       0     .00  453.57  7557.86
```

1490 NH CARD USED
*SECNO 7920.000

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA= 3962.00 ELREA= 3962.00

```
 7920.000    13.77  3957.97  3950.07     .00  3958.06     .08     .68     .02  3962.00
  20000.0       .0  20000.0       .0      .0   8585.3      .0  1185.2   125.3  3962.00
      .76      .00     2.33      .00    .000     .045    .000    .000 3944.20  8005.22
  .000303    1865.    2415.    2540.       3       22       0     .00 1049.57  9054.79
```

1490 NH CARD USED
*SECNO 9830.000

3302 WARNING: CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE, KRATIO = 1.50


```
SECNO   DEPTH   CWSEL   CRIWS   WSELK   EG      HV      HL      OLOSS   L-BANK ELEV
Q       QLOB    QCH     QROB    ALOB    ACH     AROB    VOL     TWA     R-BANK ELEV
TIME    VLOB    VCH     VROB    XNL     XNCH    XNR     WTN     ELMIN   SSTA
SLOPE   XLOBL   XLCH    XLOBR   ITRIAL  IDC     ICONT   CORAR   TOPWID  ENDST
```

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA= 3963.90 ELREA= 3963.20

```
 9830.000    12.84  3958.34  3951.35     .00  3958.43     .09     .37     .00  3963.90
  20000.0       .0  20000.0       .0      .0   8301.8      .0  1555.4   174.3  3963.20
      .98      .00     2.41      .00    .000     .026    .000    .000 3945.50  7012.65
  .000134    1690.    1910.    1980.       2       18       0     .00 1182.21  8194.87
```

```
1490 NH CARD USED
*SECNO 12360.000

3265 DIVIDED FLOW


3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA=     3964.10 ELREA=     3964.00

 12360.000     12.05  3958.75  3951.88      .00  3958.90      .15      .45      .02  3964.10
   20000.0        .0  20000.0       .0       .0   6490.8       .0   1985.0    234.4  3964.00
      1.21       .00     3.08      .00     .000     .028     .000     .000  3946.70  5098.17
   .000247     1860.    2530.    2820.        3       18        0      .00   887.99  6064.02


1490 NH CARD USED
*SECNO 13775.000

3265 DIVIDED FLOW


3470 ENCROACHMENT STATIONS=     3790.0    8045.0  TYPE=     1  TARGET=    -3790.000
 13775.000     14.26  3959.06  3952.29      .00  3959.29      .23      .37      .02  3966.00
   20000.0    3202.1  16797.9       .0   1404.6   4116.7       .0   2173.9    258.5  3966.50
      1.31      2.28     4.08      .00     .038     .030     .000     .000  3944.80  4011.24
   .000295     1030.    1415.    1420.        2       14        0      .00   675.11  5021.81


1490 NH CARD USED
*SECNO 15545.000

3470 ENCROACHMENT STATIONS=     2928.0    4815.0  TYPE=     1  TARGET=    -2928.000

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA=     3969.30 ELREA=     3970.30

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   26MAY94     09:25:51                                                  PAGE   17


   SECNO     DEPTH    CWSEL    CRIWS    WSELK     EG      HV      HL     OLOSS   L-BANK ELEV
   Q       QLOB     QCH      QROB     ALOB     ACH     AROB     VOL     TWA     R-BANK ELEV
   TIME     VLOB     VCH      VROB     XNL      XNCH     XNR     WTN     ELMIN    SSTA
   SLOPE    XLOBL    XLCH     XLOBR    ITRIAL   IDC     ICONT    CORAR   TOPWID   ENDST


 15545.000     12.96  3959.56  3952.63      .00  3959.76      .20      .47      .00  3969.30
   20000.0        .0  20000.0       .0       .0   5572.6       .0   2382.8    280.7  3970.30
      1.44       .00     3.59      .00     .000     .030     .000     .000  3946.60  3242.50
   .000262      750.    1770.    2150.        2       15        0      .00   584.48  3826.98


CCHV=     .300 CEHV=     .500
*SECNO 16905.000

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA=     3982.00 ELREA=     3981.90

 16905.000     13.98  3959.98  3952.44      .00  3960.19      .21      .42      .01  3982.00
   20000.0        .0  20000.0       .0       .0   5437.5       .0   2554.7    301.0  3981.90
      1.54       .00     3.68      .00     .000     .030     .000     .000  3946.00   542.02
   .000372     1600.    1360.    1240.        2        8        0      .00   713.45  1255.47
```

SPECIAL BRIDGE

5070, VARIABLE ELCHU OR ELCHD ON SB CARD NOT SPECIFIED

SB XK	XKOR	COFQ	RDLEN	BWC	BWP	BAREA	SS	ELCHU	ELCHD
.90	1.56	2.50	.00	255.10	56.00	18394.00	11.50	3946.00	3946.00

*SECNO 16935.000
CLASS A LOW FLOW

3420 BRIDGE W.S.= 3959.92 BRIDGE VELOCITY= 4.00 CALCULATED CHANNEL AREA= 4998.

EGPRS	EGLWC	H3	QWEIR	QLOW	BAREA	TRAPEZOID AREA	ELLC	ELTRD	WEIRLN
.00	3960.21	.02	0.	20000.	18394.	18903.	3978.00	3981.90	0.

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA= 3982.00 ELREA= 3981.90

16935.000	14.00	3960.00	.00	.00	3960.21	.21	.02	.00	3982.00
20000.0	.0	20000.0	.0	.0	5455.4	.0	2558.4	301.5	3981.90
1.55	.00	3.67	.00	.000	.030	.000	.000	3946.00	542.00
.000368	30.	30.	30.	0	0	0	.00	713.51	1255.51

*SECNO 18275.000
1
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SECNO	DEPTH	CWSEL	CRIWS	WSELK	EG	HV	HL	OLOSS	L-BANK ELEV
Q	QLOB	QCH	QROB	ALOB	ACH	AROB	VOL	TWA	R-BANK ELEV
TIME	VLOB	VCH	VROB	XNL	XNCH	XNR	WTN	ELMIN	SSTA
SLOPE	XLOBL	XLCH	XLOBR	ITRIAL	IDC	ICONT	CORAR	TOPWID	ENDST

3302 WARNING: CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE, KRATIO = 1.61

18275.000	17.89	3960.39	3951.42	.00	3960.52	.14	.29	.02	3969.50
20000.0	.0	20000.0	.0	.0	6778.4	.0	2746.6	321.7	3966.60
1.67	.00	2.95	.00	.000	.030	.000	.000	3942.50	520.36
.000142	1080.	1340.	1540.	3	14	0	.00	602.04	1122.40

CCHV= .100 CEHV= .300
*SECNO 20975.000

3302 WARNING: CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE, KRATIO = .64

20975.000	14.94	3960.84	3953.39	.00	3961.15	.30	.57	.05	3970.30
20000.0	.0	19929.6	70.4	.0	4498.3	135.7	3100.2	355.4	3957.60
1.84	.00	4.43	.52	.000	.030	.100	.000	3945.90	107.48
.000349	2500.	2700.	2600.	2	18	0	.00	485.26	592.74

*SECNO 23475.000

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA= 3966.40 ELREA= 3967.30

```
 23475.000    14.80  3961.60  3953.11     .00  3961.81     .21     .66     .01  3966.40
  20000.0       .0  20000.0~      .0      .0   5389.7      .0   3387.7   382.0  3967.30
     2.03      .00     3.71      .00    .000     .030    .000     .000 3946.80   515.48
  .000206    3000.    2500.    2450.       2       18       0      .00  443.50   958.97

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 TW  Weir flow from left bank between cross section 4 and 5

    ASQ    QCOMP    ERRAC    TASQ     TCQ     TABER    NITER    DSWS     USWS     DSSNO    USSNO

     .00      .00      .00      .00      .00      .00       2  3959.063  3959.565 13775.000 15545.000

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  26MAY94    09:25:51                                                        PAGE  20


T1  Hydraulic analysis for Atlas Mineral Tailings Pile, Moab, Utah
T2  Mussetter Engineering, Inc. (Project 94.02)
T3      Colorado River, Moab, UT
T4  Prepared by Bob Mussetter (4/94)

J1  ICHECK    INQ      NINV     IDIR     STRT     METRIC    HVINS     Q       WSEL     FQ

      0        4        0        0    .00018                 3960.0

J2  NPROF    IPLOT    PRFVS    XSECV    XSECH     FN      ALLDC    IBW     CHNIM    ITRACE

      3        0       -1        0               0.9       -1

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  26MAY94    09:25:51                                                        PAGE  21


   SECNO    DEPTH    CWSEL    CRIWS    WSELK     EG       HV       HL      OLOSS   L-BANK ELEV
   Q        QLOB     QCH      QROB     ALOB     ACH      AROB     VOL      TWA     R-BANK ELEV
   TIME     VLOB     VCH      VROB     XNL      XNCH     XNR      WTN      ELMIN    SSTA
   SLOPE    XLOBL    XLCH     XLOBR    ITRIAL   IDC      ICONT    CORAR    TOPWID   ENDST

*PROF 3

CRITICAL DEPTH TO BE CALCULATED AT ALL CROSS SECTIONS

CCHV=     .100 CEHV=     .300
*SECNO  .000
     .000    22.42  3962.82  3951.09  3960.00  3963.19     .36      .00      .00  3960.90
  48900.0       .8  48891.7      7.5      3.4  10095.1    22.1       .0       .0  3960.90
      .00      .25     4.84      .34     .072     .027    .072     .000  3940.40    96.48
  .000177       0.       0.       0.        0       11       3      .00   603.74   700.22


*SECNO 1145.000
 1145.000    24.53  3962.93  3953.34      .00  3963.52     .60      .27      .07  3959.20
  48900.0     14.3  48656.4    229.2     22.3   7837.0   197.7    238.9     14.9  3956.70
      .05      .64     6.21     1.16     .072     .027    .072     .000  3938.40    97.70
  .000318    1145.    1145.    1145.        3       14       0      .00   533.10   630.80
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1490 NH CARD USED
*SECNO 1660.000
 1660.000   25.26  3963.36  3952.83    .00  3963.69    .34    .14    .03  3960.60
  48900.0     2.7  48894.2      3.1    7.4  10526.0   12.5  348.9   22.4  3959.30
      .08     .37     4.65      .24   .072     .030   .135   .000  3938.10  194.62
  .000244    515.     515.     515.      2       14      0    .00   720.56  915.18

*SECNO 3220.000

3302 WARNING: CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE, KRATIO = 1.59


3470 ENCROACHMENT STATIONS=   4500.0   7220.0  TYPE=   1  TARGET=  -4500.000
 3220.000   20.29  3963.79  3951.66    .00  3963.94    .15    .23    .02  3961.10
  48900.0  3725.2  45118.7     56.1 7651.1  14109.5  152.7  946.1   83.7  3960.60
      .23     .49     3.20      .37   .090     .027   .072   .000  3943.50 4500.00
  .000097   1750.    1560.    1200.      2       17      0    .00  2536.14 7036.14


*SECNO 4040.000
 4040.000   21.96  3963.86  3951.41    .00  3964.02    .16    .07    .00  3960.80
  48900.0  3570.1  45326.9      3.0 8370.3  13624.5   17.7 1379.5  138.4  3962.20
      .30     .43     3.33      .17   .090     .027   .072   .000  3941.90 5000.95
  .000085    930.     820.     690.      2       15      0    .00  2820.30 7821.25


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  26MAY94    09:25:51                                              PAGE  22


   SECNO   DEPTH   CWSEL   CRIWS   WSELK   EG     HV    HL    OLOSS  L-BANK ELEV
   Q       QLOB    QCH     QROB    ALOB    ACH    AROB  VOL   TWA    R-BANK ELEV
   TIME    VLOB    VCH     VROB    XNL     XNCH   XNR   WTN   ELMIN  SSTA
   SLOPE   XLOBL   XLCH    XLOBR   ITRIAL  IDC    ICONT CORAR TOPWID ENDST


CCHV=    .100 CEHV=    .300
1490 NH CARD USED
*SECNO 5505.000
 5505.000   23.76  3963.96  3952.87    .00  3964.20    .24    .16    .03  3961.10
  48900.0 11702.5  37194.1      3.4 18568.3  8211.1   13.2 2115.2  236.6  3960.90
      .41     .63     4.53      .26   .091     .027   .090   .000  3940.20 3505.30
  .000152   1190.    1465.    1470.      3       14      0    .00  4072.30 7577.60


1490 NH CARD USED
*SECNO 7920.000

3265 DIVIDED FLOW


3302 WARNING: CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE, KRATIO = 1.48

 7920.000   20.17  3964.37  3953.01    .00  3964.45    .08    .23    .02  3962.00
  48900.0  9978.5  38920.0      1.5 23639.6 15673.5    8.3 3681.5  464.4  3962.00
      .72     .42     2.48      .19   .089     .028   .072   .000  3944.20 2929.77
  .000069   1865.    2415.    2540.      2       22      0    .00  6082.85 9074.99
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1490 NH CARD USED
*SECNO 9830.000
 9830.000    19.00  3964.50  3953.60     .00  3964.57    .07    .12    .00  3963.90
  48900.0  11295.1  36944.7    660.2  27306.5  15663.7   2553.4   5415.0   727.0  3963.20
    1.00     .41     2.36     .26    .090    .027    .135    .000  3945.50  1657.17
  .000062   1690.   1910.   1980.     2      18      0     .00  7057.85  8715.02

1490 NH CARD USED
*SECNO 12360.000
 12360.000   17.96  3964.66  3954.65     .00  3964.80    .14    .20    .02  3964.10
  48900.0   7865.9  40849.1    185.0  15586.3  12373.6    569.2   7246.1  1018.8  3964.00
    1.23     .50     3.30     .33    .090    .025    .090    .000  3946.70  1081.03
  .000123   1860.   2530.   2820.     2      18      0     .00  5343.54  6424.57

1490 NH CARD USED
*SECNO 13775.000
1
  26MAY94    09:25:51                                                    PAGE  23

   SECNO    DEPTH    CWSEL    CRIWS    WSELK    EG      HV      HL     OLOSS   L-BANK ELEV
   Q        QLOB     QCH      QROB     ALOB     ACH     AROB    VOL    TWA     R-BANK ELEV
   TIME     VLOB     VCH      VROB     XNL      XNCH    XNR     WTN    ELMIN   SSTA
   SLOPE    XLOBL    XLCH     XLOBR    ITRIAL   IDC     ICONT   CORAR  TOPWID  ENDST

3265 DIVIDED FLOW

3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,  KRATIO =   .63

3470 ENCROACHMENT STATIONS=    3790.0   8045.0  TYPE=    1  TARGET=   -3790.000
 13775.000   19.88  3964.68  3955.72     .00  3965.14    .46    .25    .10  3966.00
  48854.5  10527.3  38319.2      8.0   4177.5   6353.0     48.1   7793.9  1106.1  3966.50
    1.30    2.52     6.03     .17    .043    .027    .077    .000  3944.80  3790.00
  .000315   1030.   1415.   1420.     3      14      0     .00  1307.87  5261.16

1490 NH CARD USED
*SECNO 15545.000

3470 ENCROACHMENT STATIONS=    2928.0   4815.0  TYPE=    1  TARGET=   -2928.000

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA=     3969.30 ELREA=     3970.30

 15545.000   18.65  3965.25  3955.87     .00  3965.63    .39    .48    .01  3969.30
  48900.0       .0  48900.0       .0       .0   9807.1       .0   8159.4  1141.2  3970.30
    1.39     .00     4.99     .00    .000    .025    .000    .000  3946.60  3010.99
  .000267    750.   1770.   2150.     2      14      0     .00   824.48  3835.47

CCHV=     .300 CEHV=     .500
*SECNO 16905.000

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA=     3982.00 ELREA=     3981.90

 16905.000   19.62  3965.62  3957.60     .00  3966.02    .40    .38    .01  3982.00
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```
 48900.0      .0  48900.0      .0      .0   9582.3      .0   8462.1   1165.9  3981.90
   1.47      .00     5.10     .00    .000     .027    .000     .000  3946.00   533.62
 .000296   1600.    1360.    1240.       2       11       0      .00   757.02  1290.64
```



```
 SECNO     DEPTH    CWSEL    CRIWS    WSELK     EG       HV       HL      OLOSS   L-BANK ELEV
 Q         QLOB     QCH      QROB     ALOB      ACH      AROB     VOL     TWA     R-BANK ELEV
 TIME      VLOB     VCH      VROB     XNL       XNCH     XNR      WTN     ELMIN   SSTA
 SLOPE     XLOBL    XLCH     XLOBR    ITRIAL    IDC      ICONT    CORAR   TOPWID  ENDST
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SPECIAL BRIDGE

5070, VARIABLE ELCHU OR ELCHD ON SB CARD NOT SPECIFIED
SB  XK     XKOR    COFQ    RDLEN    BWC     BWP       BAREA    SS       ELCHU    ELCHD
    .90    1.56    2.50    .00     255.10   56.00   18394.00   11.50   3946.00  3946.00

*SECNO 16935.000
CLASS A LOW FLOW

3420 BRIDGE W.S.=    3965.48 BRIDGE VELOCITY=      5.93   CALCULATED CHANNEL AREA=      8245.

 EGPRS    EGLWC     H3     QWEIR    QLOW     BAREA    TRAPEZOID    ELLC      ELTRD    WEIRLN
                                    AREA
   .00   3966.07    .04      0.    48900.   18394.    18903.     3978.80   3981.90     0.


3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA=     3982.00 ELREA=     3981.90

 16935.000    19.66  3965.66     .00      .00  3966.07     .40      .04      .00  3982.00
  48900.0        .0  48900.0      .0       .0   9615.2      .0   8468.7   1166.4  3981.90
     1.47       .00     5.09     .00     .000     .027    .000     .000  3946.00   533.53
  .000293       30.      30.     30.        0        0       0      .00   757.15  1290.68


*SECNO 18275.000
 18275.000    23.56  3966.06  3954.42     .00  3966.40     .34      .32      .02  3969.50
  48900.0        .0  48900.0      .0       .0  10384.4      .0   8776.3   1188.6  3966.60
     1.55       .00     4.71     .00     .000     .027    .000     .000  3942.50   507.70
  .000197     1080.    1340.   1540.        3       14       0      .00   684.07  1191.76


CCHV=    .100 CEHV=     .300
*SECNO 20975.000

3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,  KRATIO =   .70

 20975.000    20.61  3966.51  3957.61     .00  3967.26     .74      .74      .12  3970.30
  48900.0        .0  48232.8   667.2       .0   6922.6   522.6   9328.3   1225.4  3957.60
     1.66       .00     6.97    1.28     .000     .027    .090     .000  3945.90   102.99
  .000403     2500.    2700.   2600.        2        8       0      .00   505.35   608.34
```

```
SECNO    DEPTH    CWSEL    CRIWS    WSELK    EG      HV      HL      OLOSS   L-BANK ELEV
Q        QLOB     QCH      QROB     ALOB     ACH     AROB    VOL     TWA     R-BANK ELEV
TIME     VLOB     VCH      VROB     XNL      XNCH    XNR     WTN     ELMIN   SSTA
SLOPE    XLOBL    XLCH     XLOBR    ITRIAL   IDC     ICONT   CORAR   TOPWID  ENDST


*SECNO 23475.000
23475.000    20.74  3967.54  3956.56     .00  3968.08     .54     .81     .02  3966.40
  48900.0    906.6  47993.4       .0  1220.4   8044.2      .1  9814.5  1263.3  3967.30
     1.78      .74     5.97      .06    .090     .027    .090    .000  3946.80  208.47
  .000263    3000.    2500.    2450.       2       14       0     .00   757.37  965.84


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 26MAY94    09:25:51                                                    PAGE  26


TW  Weir flow from left bank between cross section 4 and 5

  ASQ    QCOMP    ERRAC    TASQ    TCQ    TABER    NITER    DSWS    USWS    DSSNO    USSNO

  45.48   45.84     .79   45.48   45.84     .79       8  3964.680  3965.248 13775.000 15545.000

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 26MAY94    09:25:51                                                    PAGE  27

T1  Hydraulic analysis for Atlas Mineral Tailings Pile, Moab, Utah
T2  Mussetter Engineering, Inc. (Project 94.02)
T3     Colorado River, Moab, UT
T4  Prepared by Bob Mussetter (4/94)

J1  ICHECK   INQ    NINV    IDIR    STRT    METRIC   HVINS    Q      WSEL    FQ

     0        5       0       0   .00018                     3962.0

J2  NPROF   IPLOT   PRFVS   XSECV   XSECH    FN     ALLDC    IBW    CHNIM    ITRACE

     4        0      -1       0           0.8333    -1

1
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SECNO    DEPTH    CWSEL    CRIWS    WSELK    EG      HV      HL      OLOSS   L-BANK ELEV
Q        QLOB     QCH      QROB     ALOB     ACH     AROB    VOL     TWA     R-BANK ELEV
TIME     VLOB     VCH      VROB     XNL      XNCH    XNR     WTN     ELMIN   SSTA
SLOPE    XLOBL    XLCH     XLOBR    ITRIAL   IDC     ICONT   CORAR   TOPWID  ENDST


*PROF 4

CRITICAL DEPTH TO BE CALCULATED AT ALL CROSS SECTIONS

CCHV=    .100 CEHV=    .300
*SECNO  .000
     .000    25.55  3965.95  3952.87  3962.00  3966.49     .54     .00     .00  3960.90
  70300.0     11.9  70229.1     59.1     23.4  11921.5    74.1      .0      .0  3960.90
      .00      .51     5.89      .80    .067     .025    .067    .000  3940.40   90.75
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 .000180      0.      0.      0.      0     11      4    .00   610.29   701.04


*SECNO 1145.000
 1145.000    27.59  3965.99  3955.24     .00  3966.85     .86     .27     .10  3959.20
  70300.0     64.8  69718.1    517.1    61.4   9326.2   331.6   285.7    15.2  3956.70
     .04     1.06     7.48     1.56    .067     .025    .067    .000  3938.40    92.78
  .000313    1145.    1145.    1145.      3       14       0     .00   547.22   640.00


1490 NH CARD USED
*SECNO 1660.000
 1660.000    28.47  3966.57  3954.63     .00  3967.03     .47     .14     .04  3960.60
  70300.0     23.0  70245.6     31.4    34.7  12801.4    58.9   419.4    22.9  3959.30
     .07      .66     5.49      .53    .067     .029    .088    .000  3938.10   188.36
  .000241     515.     515.     515.      2       11       0     .00   749.18   937.54


*SECNO 3220.000

3302 WARNING: CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE, KRATIO = 1.75


3470 ENCROACHMENT STATIONS=    4500.0   7220.0  TYPE=    1  TARGET=   -4500.000
 3220.000    23.59  3967.09  3953.11     .00  3967.26     .17     .20     .03  3961.10
  70300.0   8259.1  61808.7    232.2 12602.3  17317.9   375.9  1218.5    84.7  3960.60
     .20      .66     3.57      .62    .083     .025    .067    .000  3943.50  4500.00
  .000079    1750.    1560.    1200.      2       22       0     .00  2545.46  7045.46


*SECNO 4040.000

3265 DIVIDED FLOW

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  26MAY94    09:25:51                                                         PAGE  29


   SECNO    DEPTH    CWSEL    CRIWS    WSELK     EG      HV      HL     OLOSS   L-BANK ELEV
   Q        QLOB     QCH      QROB     ALOB     ACH     AROB    VOL     TWA     R-BANK ELEV
   TIME     VLOB     VCH      VROB     XNL      XNCH    XNR     WTN     ELMIN   SSTA
   SLOPE    XLOBL    XLCH     XLOBR    ITRIAL   IDC     ICONT   CORAR   TOPWID  ENDST


 4040.000    25.24  3967.14  3952.72     .00  3967.33     .19     .06     .01  3960.80
  70300.0   9114.0  61134.2     51.8 15921.7  16248.5   118.5  1842.9   148.0  3962.20
     .27      .57     3.76      .44    .083     .025    .067    .000  3941.90  4021.66
  .000073     930.     820.     690.      2       14       0     .00  3619.42  7842.86


CCHV=   .100 CEHV=   .300
1490 NH CARD USED
*SECNO 5505.000
 5505.000    27.04  3967.24  3954.93     .00  3967.47     .23     .13     .01  3961.10
  70300.0  24545.4  45702.4     52.1 31016.1   9750.8   143.2  2925.6   262.8  3960.90
     .39      .79     4.69      .36    .062     .025    .083    .000  3940.20  3165.47
  .000111    1190.    1465.    1470.      3       14       0     .00  4468.20  7633.66


1490 NH CARD USED
*SECNO 7920.000
```

```
3302 WARNING: CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE, KRATIO = 1.48

 7920.000    23.37  3967.57  3954.55     .00  3967.64     .07     .16     .02  3962.00
  70300.0  20954.4  49331.7     13.9  40001.6  19371.2    45.9  5258.7   506.6  3962.00
      .71      .52     2.55      .30    .081     .027    .067    .000  3944.20  2672.40
  .000050    1865.    2415.    2540.       2       18       0     .00  6412.07  9084.48


1490 NH CARD USED
*SECNO 9830.000
 9830.000    22.17  3967.67  3954.90     .00  3967.73     .06     .09     .00  3963.90
  70300.0  22092.0  46852.6   1355.5  44430.4  19466.7  4222.4  7845.1   779.0  3963.20
     1.00      .50     2.41      .32    .083     .026    .125    .000  3945.50  1527.17
  .000044    1690.    1910.    1980.       2       18       0     .00  7227.92  8755.10


1490 NH CARD USED
*SECNO 12360.000
12360.000    21.07  3967.77  3956.28     .00  3967.89     .13     .14     .02  3964.10
  70300.0  17427.4  51927.6    945.0  27943.6  15714.1  2171.9  10618.9  1084.9  3964.00
     1.25      .62     3.30      .44    .083     .025    .083    .000  3946.70   977.22
  .000085    1860.    2530.    2820.       2       11       0     .00  5686.72  6663.94


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 SECNO   DEPTH   CWSEL   CRIWS   WSELK   EG      HV      HL      OLOSS   L-BANK ELEV
 Q       QLOB    QCH     QROB    ALOB    ACH     AROB    VOL     TWA     R-BANK ELEV
 TIME    VLOB    VCH     VROB    XNL     XNCH    XNR     WTN     ELMIN   SSTA
 SLOPE   XLOBL   XLCH    XLOBR   ITRIAL  IDC     ICONT   CORAR   TOPWID  ENDST


1490 NH CARD USED
*SECNO 13775.000

3302 WARNING: CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE, KRATIO = .54


3470 ENCROACHMENT STATIONS=    3790.0  8045.0  TYPE=    1  TARGET=   -3790.000
13775.000    22.84  3967.64  3957.55     .00  3968.22     .58     .19     .14  3966.00
  69970.4  16864.5  52324.4    781.4  6591.7   7570.1  1388.3  11463.4  1187.6  3966.50
     1.31     2.56     6.91      .56    .045     .025    .072    .000  3944.80  3790.00
  .000287    1030.    1415.    1420.       3       14       0     .00  1955.16  5745.16


1490 NH CARD USED
*SECNO 15545.000

3470 ENCROACHMENT STATIONS=    2928.0  4815.0  TYPE=    1  TARGET=   -2928.000

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA=    3969.30 ELREA=    3970.30

15545.000    21.56  3968.16  3957.63     .00  3968.67     .51     .45     .01  3969.30
  70300.0       .0  70300.0       .0      .0  12226.7      .0  11956.6  1237.7  3970.30
     1.39      .00     5.75      .00    .000     .025    .000    .000  3946.60  3003.08
  .000260     750.    1770.    2150.       2       11       0     .00   836.73  3839.81


CCHV=    .300 CEHV=    .500
```

*SECNO 16905.000

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA= 3982.00 ELREA= 3981.90

```
 16905.000     22.50  3968.50  3958.95      .00  3969.05      .55      .36      .02  3982.00
  70300.0         .0  70300.0       .0       .0  11775.0       .0  12331.3   1262.7  3981.90
     1.46        .00     5.97      .00     .000     .025     .000     .000  3946.00   527.71
  .000269      1600.    1360.    1240.        2       14        0      .00   765.82  1293.53
```

SPECIAL BRIDGE

```
1
  26MAY94    09:25:51                                                      PAGE  31

   SECNO     DEPTH    CWSEL    CRIWS    WSELK      EG       HV       HL    OLOSS  L-BANK ELEV
   Q          QLOB     QCH      QROB     ALOB     ACH      AROB     VOL      TWA   R-BANK ELEV
   TIME       VLOB     VCH      VROB     XNL      XNCH     XNR      WTN     ELMIN   SSTA
   SLOPE      XLOBL    XLCH     XLOBR    ITRIAL   IDC      ICONT    CORAR   TOPWID  ENDST
```

5070, VARIABLE ELCHU OR ELCHD ON SB CARD NOT SPECIFIED

```
SB  XK       XKOR     COFQ     RDLEN    BWC      BWP      BAREA     SS      ELCHU    ELCHD
    .90      1.56     2.50      .00    255.10    56.00  18394.00   11.50  3946.00  3946.00
```

*SECNO 16935.000
CLASS A LOW FLOW

3420 BRIDGE W.S.= 3968.32 BRIDGE VELOCITY= 6.91 CALCULATED CHANNEL AREA= 10176.

```
  EGPRS     EGLWC      H3     QWEIR     QLOW     BAREA  TRAPEZOID    ELLC     ELTRD   WEIRLN
                                        AREA
    .00   3969.11     .06        0.   70300.    18394.    18903.   3978.80  3981.90       0.
```

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA= 3982.00 ELREA= 3981.90

```
 16935.000     22.56  3968.56      .00      .00  3969.11      .55      .06      .00  3982.00
  70300.0         .0  70300.0       .0       .0  11820.7       .0  12339.4   1263.2  3981.90
     1.46        .00     5.95      .00     .000     .025     .000     .000  3946.00   527.59
  .000266        30.      30.      30.        0        0        0      .00   766.00  1293.59
```

*SECNO 18275.000

```
 18275.000     26.43  3968.93  3956.22      .00  3969.43      .50      .31      .01  3969.50
  70300.0         .0  70299.0      1.0       .0  12386.6      3.9  12711.8   1285.8  3966.60
     1.52        .00     5.68      .24     .000     .025     .083     .000  3942.50   501.27
  .000200      1080.    1340.    1540.        3       14        0      .00   704.08  1205.35
```

CCHV= .100 CEHV= .300
*SECNO 20975.000

3301 HV CHANGED MORE THAN HVINS

3302 WARNING: CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE, KRATIO = .69

```
20975.000    23.36  3969.26  3959.69     .00  3970.37    1.11     .76     .18  3970.30
 70300.0       .0  69025.9   1274.1      .0   8102.1   776.4  13370.1  1324.0  3957.60
   1.61       .00     8.52     1.64    .000    .025     .083     .000  3945.90  100.82
 .000423    2500.    2700.    2600.       3      11        0      .00   531.20  632.02
```

```
1
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 SECNO    DEPTH    CWSEL    CRIWS    WSELK    EG      HV      HL     OLOSS   L-BANK ELEV
 Q       QLOB     QCH      QROB     ALOB     ACH     AROB    VOL     TWA     R-BANK ELEV
 TIME    VLOB     VCH      VROB     XNL      XNCH    XNR     WTN     ELMIN   SSTA
 SLOPE   XLOBL    XLCH     XLOBR    ITRIAL   IDC     ICONT   CORAR   TOPWID  ENDST


*SECNO 23475.000
23475.000    23.65  3970.45  3958.60     .00  3971.25     .79     .84     .03  3966.40
 70300.0   2327.6  67965.6      6.8  2128.2   9354.7    17.5  13966.6  1363.3  3967.30
   1.71      1.09     7.27      .39    .083    .025     .083     .000  3946.80  198.10
 .000273    3000.    2500.    2450.       2       8        0      .00   777.98  976.09
```

```
1
 26MAY94    09:25:51                                                    PAGE  33


TW  Weir flow from left bank between cross section 4 and 5

 ASQ     QCOMP    ERRAC    TASQ     TCQ     TABER    NITER   DSWS      USWS      DSSNO      USSNO

 329.63  329.68     .01   329.63   329.68     .01       6  3967.637  3968.160  13775.000  15545.000
```

```
1
 26MAY94    09:25:51                                                    PAGE  34

T1  Hydraulic analysis for Atlas Mineral Tailings Pile, Moab, Utah
T2  Mussetter Engineering, Inc. (Project 94.02)
T3     Colorado River Moab, UT
T4  Prepared by Bob Mussetter (4/94)

J1  ICHECK   INQ     NINV    IDIR    STRT     METRIC   HVINS   Q       WSEL    FQ

      0       6        0       0   .00018                     3965.0

J2  NPROF    IPLOT   PRFVS   XSECV   XSECH    FN      ALLDC   IBW     CHNIM   ITRACE

      5       0       -1       0            .8333      -1
```

```
1
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 SECNO    DEPTH    CWSEL    CRIWS    WSELK    EG      HV      HL     OLOSS   L-BANK ELEV
 Q       QLOB     QCH      QROB     ALOB     ACH     AROB    VOL     TWA     R-BANK ELEV
 TIME    VLOB     VCH      VROB     XNL      XNCH    XNR     WTN     ELMIN   SSTA
 SLOPE   XLOBL    XLCH     XLOBR    ITRIAL   IDC     ICONT   CORAR   TOPWID  ENDST
```

```
*PROF 5

CRITICAL DEPTH TO BE CALCULATED AT ALL CROSS SECTIONS

CCHV=     .100 CEHV=      .300
*SECNO  .000
     .000     33.62   3974.02   3956.45   3965.00   3974.87      .85      .00      .00   3960.90
 123500.0     152.4  123013.4     334.2     157.7   16633.9    220.2       .0       .0   3960.90
      .00       .97      7.40      1.52      .067      .025     .067     .000  3940.40     75.97
  .000182        0.        0.        0.         0        14        4      .00   627.19    703.16


*SECNO 1145.000
 1145.000     35.58   3973.98   3959.32       .00   3975.26     1.29      .26      .13   3959.20
 123500.0     379.1  121263.6    1857.3     234.3   13209.7    885.1    411.9     16.0   3956.70
      .04      1.62      9.18      2.10      .067      .025     .067     .000  3938.40     79.93
  .000297     1145.     1145.     1145.         2        14        0      .00   589.10    669.03


1490 NH CARD USED
*SECNO 1660.000

3301 HV CHANGED MORE THAN HVINS

 1660.000     36.70   3974.80   3958.26       .00   3975.46      .66      .13      .06   3960.60
 123500.0     226.3  121889.5    1384.2     196.7   18640.2    621.6    611.6     24.3   3959.30
      .06      1.15      6.54      2.23      .067      .030     .042     .000  3938.10    172.30
  .000228      515.      515.      515.         2        11        0      .00   812.50    984.80


*SECNO 3220.000

3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,  KRATIO =  2.00


3470 ENCROACHMENT STATIONS=     4500.0    7220.0  TYPE=      1  TARGET=    -4500.000
 3220.000     31.97   3975.47   3956.37       .00   3975.66      .20      .16      .05   3961.10
 123500.0   22136.9  100089.2    1274.0   25169.6   25461.5   1546.2   1940.7     88.4   3960.60
      .19       .88      3.93       .82      .083      .025     .067     .000  3943.50   4500.00
  .000057     1750.     1560.     1200.         2        18        0      .00  2636.60   7136.60


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   SECNO     DEPTH     CWSEL     CRIWS     WSELK      EG       HV       HL     OLOSS   L-BANK ELEV
   Q         QLOB      QCH       QROB      ALOB      ACH      AROB      VOL     TWA    R-BANK ELEV
   TIME      VLOB      VCH       VROB      XNL       XNCH     XNR       WTN     ELMIN    SSTA
   SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC      ICONT     CORAR   TOPWID   ENDST


*SECNO 4040.000

3265 DIVIDED FLOW

 4040.000     33.63   3975.53   3955.64       .00   3975.71      .19      .05      .00   3960.80
 123500.0   31301.3   91522.2     676.5   43132.8   22952.4    967.5   3145.5    163.0   3962.20
      .26       .73      3.99       .70      .083      .025     .067     .000  3941.90   3080.83
  .000052      930.      820.      690.         2        18        0      .00  4632.23   7914.39
```

```
CCHV=    .100 CEHV=    .300
1490 NH CARD USED
*SECNO 5505.000
 5505.000    35.45  3975.65  3959.27     .00  3975.79    .14    .08    .00  3961.10
 123500.0  63913.9  58766.3    819.9  70843.2  13693.5  1041.4  5352.4  316.8  3960.90
      .41      .90     4.29      .79     .078     .025    .060   .000  3940.20  1450.04
  .000059    1190.    1465.    1470.        2       11       0    .00  6276.80  7726.84


1490 NH CARD USED
*SECNO 7920.000

3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,  KRATIO =  1.43

 7920.000    31.63  3975.83  3961.93     .00  3975.89    .05    .09    .01  3962.00
 123500.0  53814.5  69423.1    262.4  86053.2  28897.0   623.7  9940.3  617.3  3962.00
      .78      .63     2.40      .42     .079     .028    .067   .000  3944.20  2009.40
  .000029    1865.    2415.    2540.        2       10       0    .00  7178.93  9188.33


1490 NH CARD USED
*SECNO 9830.000
 9830.000    30.39  3975.89  3958.22     .00  3975.94    .05    .05    .00  3963.90
 123500.0  52463.3  67385.0   3851.6  90788.2  29335.7  9399.6  14875.3  814.2  3963.20
     1.11      .58     2.30      .39     .083     .027    .119   .000  3945.50  1189.83
  .000026    1690.    1910.    1980.        2       18       0    .00  7684.89  8874.72


1490 NH CARD USED
*SECNO 12360.000
12360.000    29.24  3975.94  3959.91     .00  3976.02    .09    .08    .01  3964.10
 123500.0  44947.6  73811.8   4740.6  61630.2  24487.6  7188.0  20229.3  1236.3  3964.00
     1.42      .73     3.01      .66     .083     .026    .078   .000  3946.70   791.22
  .000045    1860.    2530.    2820.        2       18       0    .00  5908.62  6699.84


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  26MAY94    09:25:51                                                    PAGE   37


    SECNO    DEPTH    CWSEL    CRIWS    WSELK     EG      HV     HL    OLOSS  L-BANK ELEV
    Q        QLOB     QCH      QROB     ALOB      ACH     AROB   VOL   TWA    R-BANK ELEV
    TIME     VLOB     VCH      VROB     XNL       XNCH    XNR    WTN   ELMIN  SSTA
    SLOPE    XLOBL    XLCH     XLOBR    ITRIAL    IDC     ICONT  CORAR TOPWID ENDST


1490 NH CARD USED
*SECNO 13775.000

3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,  KRATIO =   .49


3470 ENCROACHMENT STATIONS=    3790.0    8045.0  TYPE=    1  TARGET=   -3790.000
13775.000    31.04  3975.84  3959.82     .00  3976.18    .34    .08    .08  3966.00
  98881.6  26371.8  62989.3   9520.5  13429.2  10960.1  9747.9  21968.5  1351.6  3966.50
     1.50     1.96     5.75      .98     .055     .025    .071   .000  3944.80  3790.00
  .000121    1030.    1415.    1420.        2       11       0    .00  2557.12  6347.12


1490 NH CARD USED
*SECNO 15545.000
```

```
3265 DIVIDED FLOW


3470 ENCROACHMENT STATIONS=     2928.0    4815.0  TYPE=      1  TARGET=    -2928.000
 15545.000      29.34   3975.94   3962.06       .00   3976.53       .59       .27       .07   3969.30
  123500.0      381.8  118275.0    4843.2     453.0   18777.7    4520.6   23044.3    1436.6   3970.30
      1.58        .84      6.30      1.07      .083      .027      .067      .000   3946.60   2928.00
   .000214       750.     1770.     2150.         2         8         0       .00   1700.53   4629.71


CCHV=      .300 CEHV=      .500
*SECNO 16905.000

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA=     3982.00 ELREA=     3981.90

 16905.000      30.15   3976.15   3962.03       .00   3976.91       .75       .30       .08   3982.00
  123500.0         .0  123500.0        .0        .0   17724.5        .0   23686.8    1474.6   3981.90
      1.63        .00      6.97       .00      .000      .025      .000      .000   3946.00    512.00
   .000223      1600.     1360.     1240.         2        11         0       .00    789.22   1301.22


SPECIAL BRIDGE

1
   26MAY94    09:25:51                                                                PAGE  38


   SECNO     DEPTH     CWSEL     CRIWS     WSELK       EG        HV        HL     OLOSS  L-BANK ELEV
   Q         QLOB       QCH      QROB      ALOB       ACH      AROB       VOL       TWA  R-BANK ELEV
   TIME      VLOB       VCH      VROB       XNL      XNCH       XNR       WTN     ELMIN      SSTA
   SLOPE    XLOBL      XLCH     XLOBR    ITRIAL       IDC     ICONT     CORAR    TOPWID     ENDST


5070, VARIABLE ELCHU OR ELCHD ON SB CARD NOT SPECIFIED
SB  XK        XKOR      COFQ     RDLEN       BWC       BWP     BAREA        SS     ELCHU     ELCHD
      .90      1.56      2.50       .00    255.10     56.00  18394.00     11.50   3946.00   3946.00

*SECNO 16935.000
CLASS A LOW FLOW

3420 BRIDGE W.S.=     3975.99 BRIDGE VELOCITY=       7.57    CALCULATED CHANNEL AREA=      16310.

  EGPRS     EGLWC        H3     QWEIR      QLOW     BAREA  TRAPEZOID      ELLC     ELTRD    WEIRLN
                                                     AREA
      .00   3976.97       .07        0.   123500.    18394.    18903.   3978.80   3981.90        0.


3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA=     3982.00 ELREA=     3981.90

 16935.000      30.22   3976.22       .00       .00   3976.97       .75       .07       .00   3982.00
  123500.0         .0  123500.0        .0        .0   17779.6        .0   23699.0    1475.2   3981.90
      1.63        .00      6.95       .00      .000      .025      .000      .000   3946.00    511.86
   .000221        30.       30.       30.         0         0         0       .00    789.43   1301.29


*SECNO 18275.000
 18275.000      34.09   3976.59   3960.05       .00   3977.26       .66       .26       .03   3969.50
  123500.0     5098.0  118359.2      42.9    3061.3   17764.6      71.8   24285.0    1503.9   3966.60
      1.69       1.67      6.66       .60      .042      .025      .083      .000   3942.50     51.56
```

```
 .000171    1080.   1340.   1540.      3     11      0     .00  1164.80  1216.36


CCHV=    .100 CEHV=    .300
*SECNO 20975.000

3301 HV CHANGED MORE THAN HVINS


3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,  KRATIO =   .63

 20975.000     30.66  3976.56  3964.01      .00  3978.26     1.70      .69      .31  3970.30
  123500.0     305.7 119665.5   3528.8    276.5  11251.3   1564.4  25328.8   1557.2  3957.60
      1.76      1.11    10.64     2.26     .083     .025     .083     .000  3945.90    51.62
   .000427     2500.    2700.    2600.        3       11        0      .00   596.53   648.15


1
  26MAY94    09:25:51                                                         PAGE  39


   SECNO     DEPTH    CWSEL    CRIWS    WSELK      EG       HV       HL      OLOSS   L-BANK ELEV
   Q         QLOB      QCH      QROB     ALOB      ACH     AROB      VOL      TWA    R-BANK ELEV
   TIME      VLOB      VCH      VROB      XNL     XNCH      XNR      WTN    ELMIN     SSTA
   SLOPE    XLOBL     XLCH     XLOBR   ITRIAL      IDC    ICONT    CORAR   TOPWID    ENDST


*SECNO 23475.000

3301 HV CHANGED MORE THAN HVINS

 23475.000     31.18  3977.98  3962.79      .00  3979.17     1.19      .86      .05  3966.40
  123500.0    7992.6 115328.9    178.4   4615.1  12742.9    200.6  26235.5   1600.3  3967.30
      1.84      1.73     9.05      .89     .083     .025     .083     .000  3946.80   171.29
   .000281     3000.    2500.    2450.        2       11        0      .00   831.28  1002.57


1
  26MAY94    09:25:51                                                         PAGE  40


 TW  Weir flow from left bank between cross section 4 and 5

   ASQ     QCOMP    ERRAC     TASQ      TCQ    TABER    NITER     DSWS      USWS     DSSNO     USSNO

 24618.39 24814.67      .79 24618.39 24814.67      .79        8 3975.841  3975.938 13775.000 15545.000

1
  26MAY94    09:25:51                                                         PAGE  41

T1  Hydraulic analysis for Atlas Mineral Tailings Pile, Moab, Utah
T2  Mussetter Engineering, Inc. (Project 94.02)
T3      Colorado River, Moab, UT
T4  Prepared by Bob Mussetter (4/94)

J1  ICHECK    INQ     NINV    IDIR    STRT    METRIC   HVINS    Q      WSEL    FQ

      0        7       0       0    .00018                    3970.0
```

```
J2  NPROF    IPLOT    PRFVS    XSECV    XSECH    FN     ALLDC    IBW     CHNIM     ITRACE

    6      0      -1      0           .8333      -1

1
  26MAY94     09:25:51                                               PAGE  42

   SECNO    DEPTH    CWSEL    CRIWS    WSELK    EG      HV      HL      OLOSS    L-BANK ELEV
   Q        QLOB     QCH      QROB     ALOB     ACH     AROB    VOL     TWA      R-BANK ELEV
   TIME     VLOB     VCH      VROB     XNL      XNCH    XNR     WTN     ELMIN    SSTA
   SLOPE    XLOBL    XLCH     XLOBR    ITRIAL   IDC     ICONT   CORAR   TOPWID   ENDST

*PROF 6

CRITICAL DEPTH TO BE CALCULATED AT ALL CROSS SECTIONS

CCHV=     .100 CEHV=     .300
*SECNO  .000
    .000     40.54   3980.94   3959.61   3970.00   3982.07     1.13      .00      .00   3960.90
 178000.0    471.7  176824.0     704.3     367.9   20676.9    359.1       .0       .0   3960.90
     .00      1.28      8.55      1.96      .067      .025     .067     .000   3940.40     63.29
  .000182       0.        0.        0.         0        14        4      .00    641.70    704.99

*SECNO 1145.000

3301 HV CHANGED MORE THAN HVINS

 1145.000    42.43   3980.83   3962.79       .00   3982.49     1.67      .26      .16   3959.20
 178000.0    912.8  173406.8    3680.4     464.3   16538.5   1426.9    523.5     16.4   3956.70
     .03      1.97     10.49      2.58      .067      .025     .067     .000   3938.40     68.92
  .000287    1145.     1145.     1145.         2        14        0      .00    608.26    677.18

1490 NH CARD USED
*SECNO 1660.000

3301 HV CHANGED MORE THAN HVINS

 1660.000    43.79   3981.89   3960.88       .00   3982.71      .82      .13      .08   3960.60
 178000.0    650.9  173607.6    3741.5     441.9   23663.7   1183.8    782.0     25.0   3959.30
     .05      1.47      7.34      3.16      .067      .031     .041     .000   3938.10    158.49
  .000218     515.      515.      515.         2        11        0      .00    833.40    991.89

*SECNO 3220.000

3301 HV CHANGED MORE THAN HVINS


3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,  KRATIO =  2.12


3470 ENCROACHMENT STATIONS=     4500.0    7220.0  TYPE=      1  TARGET=    -4500.000
 3220.000    39.18   3982.68   3959.31       .00   3982.91      .22      .14      .06   3961.10
 178000.0  36877.4  138260.0    2862.5   35994.4   32475.9   2820.4   2574.3     89.7   3960.60
     .17      1.02      4.26      1.01      .083      .025     .067     .000   3943.50   4500.00
  .000049    1750.     1560.     1200.         2        18        0      .00   2659.52   7159.52
```

```
SECNO   DEPTH   CWSEL   CRIWS   WSELK   EG      HV      HL      OLOSS   L-BANK ELEV
Q       QLOB    QCH     QROB    ALOB    ACH     AROB    VOL     TWA     R-BANK ELEV
TIME    VLOB    VCH     VROB    XNL     XNCH    XNR     WTN     ELMIN   SSTA
SLOPE   XLOBL   XLCH    XLOBR   ITRIAL  IDC     ICONT   CORAR   TOPWID  ENDST
```

```
*SECNO 4040.000

3265 DIVIDED FLOW

 4040.000    40.87  3982.77  3958.22      .00  3982.95      .18      .04      .00  3960.80
 178000.0  58201.4 118166.9   1631.7  73036.0  28751.8   1848.9   4351.4    173.3  3962.20
      .25      .80     4.11      .88     .083     .025     .067     .000  3941.90  2266.94
  .000041     930.     820.     690.        2       14        0      .00  5464.25  7932.12


CCHV=    .100 CEHV=    .300
1490 NH CARD USED
*SECNO 5505.000
 5505.000    42.71  3982.91  3963.27      .00  3983.01      .10      .05      .01  3961.10
 178000.0 107810.6  67587.1   2602.3 116804.7  17099.1   2275.1   7785.1    353.0  3960.90
      .43      .92     3.95     1.14     .073     .025     .046     .000  3940.20   429.43
  .000037    1190.    1465.    1470.        2       14        0      .00  7320.08  7749.51


1490 NH CARD USED
*SECNO 7920.000
 7920.000    38.83  3983.03  3962.07      .00  3983.07      .05      .06      .01  3962.00
 178000.0  87881.7  87373.2   2745.1 130610.5  37190.9   7470.4  14870.7    720.1  3962.00
      .83      .67     2.35      .37     .078     .029     .067     .000  3944.20  1432.13
  .000021    1865.    2415.    2540.        2       14        0      .00  8846.65 10278.78


1490 NH CARD USED
*SECNO 9830.000
 9830.000    37.56  3983.06  3960.12      .00  3983.11      .04      .04      .00  3963.90
 178000.0  83673.2  87814.4   6512.4 133530.2  37952.3  14815.2  22148.6   1060.9  3963.20
     1.17      .63     2.31      .44     .083     .028     .113     .000  3945.50   895.30
  .000019    1690.    1910.    1980.        2       19        0      .00  8075.30  8970.60


1490 NH CARD USED
*SECNO 12360.000
12360.000    36.39  3983.09  3964.60      .00  3983.17      .08      .05      .01  3964.10
 178000.0  73005.4  95914.2   9080.4  92219.5  32174.9  11747.4  29864.6   1395.6  3964.00
     1.49      .79     2.98      .77     .083     .027     .077     .000  3946.70   679.06
  .000032    1860.    2530.    2820.        2       15        0      .00  6048.88  6727.94
```



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SECNO   DEPTH   CWSEL   CRIWS   WSELK   EG      HV      HL      OLOSS   L-BANK ELEV
Q       QLOB    QCH     QROB    ALOB    ACH     AROB    VOL     TWA     R-BANK ELEV
TIME    VLOB    VCH     VROB    XNL     XNCH    XNR     WTN     ELMIN   SSTA
SLOPE   XLOBL   XLCH    XLOBR   ITRIAL  IDC     ICONT   CORAR   TOPWID  ENDST
```

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1490 NH CARD USED
*SECNO 13775.000

3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,  KRATIO =   .48


3470 ENCROACHMENT STATIONS=     3790.0    8045.0  TYPE=      1  TARGET=    -3790.000
 13775.000      38.26   3983.06   3960.89       .00   3983.26       .20       .05       .04   3966.00
  114553.4   30451.6   64327.9   19773.9   19440.6   13940.5   21900.2   32482.2    1525.9   3966.50
     1.60      1.57      4.61       .90      .059      .025      .070      .000   3944.80   3790.00
   .000057     1030.     1415.     1420.        2        14         0       .00   3364.17   7154.17


1490 NH CARD USED
*SECNO 15545.000

3470 ENCROACHMENT STATIONS=     2928.0    4815.0  TYPE=      1  TARGET=    -2928.000
 15545.000      36.35   3982.95   3964.55       .00   3983.55       .60       .17       .12   3969.30
  178000.0    1127.3  160663.2   16209.5     958.2   24692.7   10203.0   34235.0    1632.4   3970.30
     1.68      1.18      6.51      1.59      .083      .028      .067      .000   3946.60   2928.00
   .000172      750.     1770.     2150.        2        14         0       .00   1763.41   4691.41


CCHV=     .300 CEHV=     .500
*SECNO 16905.000
 16905.000      37.05   3983.05   3964.81       .00   3983.96       .91       .25       .16   3982.00
  178000.0      27.4  177898.6      74.1     120.0   23235.7     280.9   35152.2    1678.5   3981.90
     1.73       .23      7.66       .26      .083      .025      .083      .000   3946.00    346.17
   .000194     1600.     1360.     1240.        2        11         0       .00   1248.86   1595.02



SPECIAL BRIDGE

5070, VARIABLE ELCHU OR ELCHD ON SB CARD NOT SPECIFIED
SB  XK       XKOR      COFQ      RDLEN     BWC       BWP       BAREA     SS        ELCHU     ELCHD
      .90      1.56      2.50       .00    255.10     56.00  18394.00     11.50   3946.00   3946.00

*SECNO 16935.000
PRESSURE AND WEIR FLOW,  Weir Submergence Based on TRAPEZOIDAL Shape

1
   26MAY94      09:25:51                                                        PAGE   45


     SECNO     DEPTH     CWSEL     CRIWS     WSELK      EG        HV        HL       OLOSS    L-BANK ELEV
     Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA      R-BANK ELEV
     TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN     SSTA
     SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID    ENDST


 EGPRS     EGLWC       H3      QWEIR       QPR      BAREA   TRAPEZOID     ELLC      ELTRD     WEIRLN
                                                            AREA
   3985.31   3984.03      .07    13539.   165301.    18394.    18903.   3978.80   3981.90     1361.


 16935.000      38.16   3984.16       .00       .00   3985.00       .84      1.05       .00   3982.00
  178000.0     111.8  177654.8     233.4     329.0   24137.3     603.0   35169.0    1679.4   3981.90
     1.73       .34      7.36       .39      .083      .025      .083      .000   3946.00    283.26
```

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 .000171      30.      30.      30.        2        0        2      .00   1312.29   1595.55


*SECNO 18275.000
 18275.000     42.06   3984.56   3963.13       .00   3985.24       .69       .20       .05   3969.50
  178000.0   15923.4  161899.3     177.4    6634.9   23355.5     231.7   36000.5    1716.4   3966.60
     1.79      2.40      6.93       .77      .042      .025      .083      .000   3942.50     51.03
  .000128     1080.     1340.     1540.        3       11        0       .00   1176.78   1227.81


CCHV=     .100 CEHV=     .300
*SECNO 20975.000

3301 HV CHANGED MORE THAN HVINS


3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,  KRATIO =   .59

 20975.000     38.25   3984.15   3967.76       .00   3986.20      2.05       .55       .41   3970.30
  178000.0    1083.5  170367.6    6548.8     646.0   14532.6    2510.4   37465.5    1770.6   3957.60
     1.85      1.68     11.72      2.61      .083      .025      .083      .000   3945.90     51.09
  .000369     2500.     2700.     2600.        3       11        0       .00    613.85    664.94


*SECNO 23475.000

3301 HV CHANGED MORE THAN HVINS

 23475.000     38.80   3985.60   3966.88       .00   3987.02      1.42       .76       .06   3966.40
  178000.0   15564.7  161728.3     707.0    7337.4   16171.6     589.0   38708.7    1815.9   3967.30
     1.93      2.12     10.00      1.20      .083      .025      .083      .000   3946.80    144.15
  .000249     3000.     2500.     2450.        2       11        0       .00    585.21   1029.36


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 TW  Weir flow from left bank between cross section 4 and 5

   ASQ      QCOMP     ERRAC     TASQ       TCQ     TABER    NITER     DSWS      USWS      DSSNO     USSNO

 63446.64  63953.33      .80  63446.64  63953.33      .80       8  3983.060  3982.954  13775.000  15545.000

1
  26MAY94     09:25:51                                                    PAGE   47

T1  Hydraulic analysis for Atlas Mineral Tailings Pile, Moab, Utah
T2  Mussetter Engineering, Inc. (Project 94.02)
T3      Colorado River, Moab, UT
T4  Prepared by Bob Mussetter (4/94)

J1  ICHECK   INQ     NINV    IDIR    STRT    METRIC   HVINS    Q       WSEL     FQ

      0       8        0       0   .00018                      3972.0

J2  NPROF   IPLOT   PRFVS   XSECV   XSECH    FN    ALLDC   IBW    CHNIM   ITRACE

      7       0      -1       0           .8333    -1
```

```
 SECNO    DEPTH    CWSEL    CRIWS    WSELK     EG      HV      HL     OLOSS   L-BANK ELEV
 Q        QLOB     QCH      QROB     ALOB      ACH     AROB    VOL    TWA     R-BANK ELEV
 TIME     VLOB     VCH      VROB     XNL       XNCH    XNR     WTN    ELMIN   SSTA
 SLOPE    XLOBL    XLCH     XLOBR    ITRIAL    IDC     ICONT   CORAR  TOPWID  ENDST

*PROF 7

CRITICAL DEPTH TO BE CALCULATED AT ALL CROSS SECTIONS

CCHV=    .100 CEHV=    .300
*SECNO  .000
    .000    53.54   3993.94   3965.62   3972.00   3995.62     1.68      .00      .00  3960.90
300000.0   2054.1  296261.5    1684.4    1125.8   28263.8    854.0       .0       .0  3960.90
     .00     1.82     10.48      2.58      .067      .025     .067     .000  3940.40    15.42
 .000180       0.        0.        0.         0        15        5      .00   692.99   708.40

*SECNO 1145.000

3301 HV CHANGED MORE THAN HVINS

1145.000    55.29   3993.69   3969.48       .00   3996.09     2.40      .25      .21  3959.20
300000.0   2791.7  288611.8    8596.5    1122.8   22786.6   2594.7    743.2     17.9  3956.70
     .03     2.49     12.67      3.31      .067      .025     .067     .000  3938.40    25.59
 .000273    1145.     1145.     1145.         2        14        0      .00   666.90   692.49

1490 NH CARD USED
*SECNO 1660.000

3301 HV CHANGED MORE THAN HVINS

1660.000    57.11   3995.21   3966.16       .00   3996.34     1.13      .12      .13  3960.60
300000.0   2297.8  287263.8   10438.4    1167.7   33107.2   2390.1   1116.6     27.0  3959.30
     .04     1.97      8.68      4.37      .067      .031     .042     .000  3938.10   132.52
 .000203     515.      515.      515.         2        11        0      .00   877.90  1010.42

*SECNO 3220.000

3301 HV CHANGED MORE THAN HVINS

3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,  KRATIO =  2.25

3470 ENCROACHMENT STATIONS=    4500.0    7220.0  TYPE=    1  TARGET=   -4500.000
3220.000    52.76   3996.26   3963.78       .00   3996.54      .28      .12      .09  3961.10
300000.0  70496.8  222166.8    7336.4   56362.7   45674.6   5648.5   3793.7     93.2  3960.60
     .15     1.25      4.86      1.30      .083      .025     .067     .000  3943.50  4500.00
 .000040    1750.     1560.     1200.         2        22        0      .00  2705.06  7205.06
```

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SECNO   DEPTH   CWSEL   CRIWS   WSELK   EG      HV      HL      OLOSS   L-BANK ELEV
Q       QLOB    QCH     QROB    ALOB    ACH     AROB    VOL     TWA     R-BANK ELEV
TIME    VLOB    VCH     VROB    XNL     XNCH    XNR     WTN     ELMIN   SSTA
SLOPE   XLOBL   XLCH    XLOBR   ITRIAL  IDC     ICONT   CORAR   TOPWID  ENDST


*SECNO 4040.000

3265 DIVIDED FLOW

 4040.000    54.52  3996.42  3963.97      .00  3996.58      .16      .03      .01  3960.80
 300000.0 128114.2 167785.7   4100.1 146052.8  39671.9   3992.4   6834.1    195.7  3962.20
      .24      .88     4.23     1.03     .083     .025     .067     .000  3941.90   571.06
  .000028     930.     820.     690.        2       18        0      .00  7210.69  7981.94


CCHV=     .100 CEHV=     .300
1490 NH CARD USED
*SECNO 5505.000
 5505.000    56.35  3996.55  3967.14      .00  3996.62      ^7      .03      .01  3961.10
 300000.0 208404.8  84771.3   6823.9 210078.8  23498./   5013.1  12912.8    404.5  3960.90
      .45      .99     3.61     1.36     .069     .025     .042     .000  3940.20    98.55
  .000020    1190.    1465.    1470.        2        9        0      .00  7691.27  7789.82


1490 NH CARD USED
*SECNO 7920.000
 7920.000    52.42  3996.62  3963.53      .00  3996.66      .04      .03      .00  3962.00
 300000.0 163931.4 121870.1  14198.6 226159.1  52865.6  24046.2  25215.6    803.7  3962.00
      .87      .72     2.31      .59     .075     .030     .067     .000  3944.20   341.16
  .000013    1865.    2415.    2540.        2       22        0      .00  9954.62 10295.78


1490 NH CARD USED
*SECNO 9830.000
 9830.000    51.14  3996.64  3963.94      .00  3996.68      .04      .02      .00  3963.90
 300000.0 154428.3 131991.1  13580.6 220200.1  54258.8  25533.2  37349.6   1177.8  3963.20
     1.22      .70     2.43      .53     .083     .028     .107     .000  3945.50   337.91
  .000014    1690.    1910.    1980.        2       23        0      .00  8672.29  9010.20


1490 NH CARD USED
*SECNO 12360.000
12360.000    49.95  3996.65  3965.85      .00  3996.73      .08      .04      .01  3964.10
 300000.0 135816.4 144521.6  19662.0 151635.7  46739.5  21124.5  49731.6   1530.3  3964.00
     1.53      .90     3.09      .93     .083     .028     .074     .000  3946.70   573.40
  .000022    1860.    2530.    2820.        2       22        0      .00  6225.88  6799.28


1
  26MAY94    09:25:51                                                      PAGE  50

SECNO   DEPTH   CWSEL   CRIWS   WSELK   EG      HV      HL      OLOSS   L-BANK ELEV
Q       QLOB    QCH     QROB    ALOB    ACH     AROB    VOL     TWA     R-BANK ELEV
TIME    VLOB    VCH     VROB    XNL     XNCH    XNR     WTN     ELMIN   SSTA
SLOPE   XLOBL   XLCH    XLOBR   ITRIAL  IDC     ICONT   CORAR   TOPWID  ENDST


1490 NH CARD USED
*SECNO 13775.000
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3302 WARNING: CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE, KRATIO =  .52


3470 ENCROACHMENT STATIONS=    3790.0   8045.0  TYPE=     1  TARGET=   -3790.000
 13775.000    51.88  3996.68  3962.35      .00  3996.76      .08      .03      .00  3966.00
 135122.3   32918.9  61358.8  40844.5  30785.9  19565.5  57297.9  54243.5   1675.8  3966.50
   1.72     1.07     3.14      .71     .062     .025     .069     .000  3944.80  3790.00
 .000017    1030.    1415.    1420.      .2       22        0      .00  4150.49  7940.49


1490 NH CARD USED
*SECNO 15545.000

3301 HV CHANGED MORE THAN HVINS


3470 ENCROACHMENT STATIONS=    2928.0   4815.0  TYPE=     1  TARGET=   -2928.000
 15545.000    49.79  3996.39  3969.29      .00  3997.02      .63      .09      .16  3969.30
 300000.0    2814.0 248725.6  48460.3   1925.4  36017.8  22629.2  57626.8   1804.5  3970.30
   1.80     1.46     6.91     2.14     .083     .029     .067     .000  3946.60  2928.00
 .000127     750.    1770.    2150.       2       14        0      .00  1877.98  4805.98


CCHV=     .300 CEHV=     .500
*SECNO 16905.000
 16905.000    50.34  3996.34  3969.87      .00  3997.43     1.08      .18      .23  3982.00
 300000.0    5743.8 289050.2   5206.0   4988.3  33966.5   4152.4  59227.5   1857.0  3981.90
   1.84     1.15     8.51     1.25     .083     .025     .083     .000  3946.00    92.20
 .000145    1600.    1360.    1240.       2       14        0      .00  1509.08  1601.28



SPECIAL BRIDGE

5070, VARIABLE ELCHU OR ELCHD ON SB CARD NOT SPECIFIED
SB  XK       XKOR     COFQ     RDLEN     BWC      BWP     BAREA     SS       ELCHU     ELCHD
     .90     1.56     2.50      .00    255.10    56.00  18394.00   11.50  3946.00  3946.00

*SECNO 16935.000
1
  26MAY94    09:25:51                                                      PAGE  51


   SECNO     DEPTH    CWSEL    CRIWS    WSELK     EG       HV       HL      OLOSS   L-BANK ELEV
   Q         QLOB     QCH      QROB     ALOB      ACH      AROB     VOL     TWA     R-BANK ELEV
   TIME      VLOB     VCH      VROB     XNL       XNCH     XNR      WTN     ELMIN   SSTA
   SLOPE     XLOBL    XLCH     XLOBR    ITRIAL    IDC      ICONT    CORAR   TOPWID  ENDST


6870 D.S. ENERGY OF  3997.43 IS HIGHER THAN COMPUTED ENERGY OF  3997.40
PRESSURE AND WEIR FLOW,  Weir Submergence Based on TRAPEZOIDAL Shape


EGPRS     EGLWC      H3      QWEIR     QPR      BAREA   TRAPEZOID    ELLC     ELTRD    WEIRLN
                                       AREA
 4002.79   3997.50     .07   178850.  121274.   18394.   18903.   3978.80  3981.90    1510.


16935.000    50.34  3996.34      .00      .00  3997.43     1.08      .00      .00  3982.00
 300000.0   5744.8 289048.4   5206.8   4989.1  33968.1   4152.9  59257.2   1858.0  3981.90
   1.85     1.15     8.51     1.25     .083     .025     .083     .000  3946.00    92.20
```

```
 .000145     30.     30.     30.      2      0      6     .00  1509.08  1601.28


*SECNO 18275.000
 18275.000    54.25  3996.75  3968.79     .00  3997.65     .90     .17     .05  3969.50
  300000.0  40878.7 258451.1    670.1  12114.9  31916.1   653.3  60567.6  1897.8  3966.60
     1.89     3.37     8.10     1.03    .042     .025    .083    .000 [illegible]42.50   50.22
  .000116    1080.    1340.    1540.      3     11      0     .00  1195.12  1245.33


CCHV=    .100 CEHV=    .300
*SECNO 20975.000

3301 HV CHANGED MORE THAN HVINS


3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,  KRATIO =   .55

 20975.000    49.84  3995.74  3974.88     .00  3998.82    3.09     .52     .66  3970.30
  300000.0   2906.6 283183.9  13909.4   1217.2  19537.4  4199.0  62689.6  1953.3  3957.60
     1.95     2.39    14.49     3.31    .083     .025    .083    .000  3945.90   50.29
  .000380    2500.    2700.    2600.      3     11      0     .00   640.28   690.57


*SECNO 23475.000

3301 HV CHANGED MORE THAN HVINS

 23475.000    50.86  3997.66  3973.59     .00  3999.70    2.05     .78     .10  3966.40
  300000.0  33621.4 263634.7   2743.9  12067.8  21597.6  1620.7  64491.1  2002.1  3967.30
     2.01     2.79    12.21     1.69    .083     .025    .083    .000  3946.80  101.21
  .000253    3000.    2500.    2450.      2     11      0     .00   970.55  1071.77


1
  26MAY94     09:25:51                                                      PAGE   52


 TW  Weir flow from left bank between cross section 4 and 5

    ASQ      QCOMP     ERRAC     TASQ      TCQ      TABER    NITER    DSWS      USWS      DSSNO      USSNO

 164877.70 166193.90      .80 164877.70 166193.90      .80       8  3996.682  3996.369 13775.000 15545.000
1
  26MAY94     09:25:51                                                      PAGE   53



                                          THIS RUN EXECUTED 26MAY94    09:27:34
 **************************************
 HEC-2 WATER SURFACE PROFILES

 Version   4.5.1;  September 1990
 **************************************


 NOTE- ASTERISK (*) AT LEFT OF CROSS-SECTION NUMBER INDICATES MESSAGE IN SUMMARY OF ERRORS
LIST
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Colorado River, Moab, U

SUMMARY PRINTOUT TABLE 150

SECNO	XLCH	ELTRD	ELLC	ELMIN	Q	CWSEL	CRIWS	EG	10*KS	VCH	AREA	.01K
.000	.00	.00	.00	3940.40	4000.00	3948.57	3945.57	3948.63	1.81	1.95	2048.56	2973.59
.000	.00	.00	.00	3940.40	20000.00	3955.98	3948.19	3956.14	1.82	3.25	6152.63	14841.00
.000	.00	.00	.00	3940.40	48900.00	3962.82	3951.09	3963.19	1.77	4.84	10120.55	36724.58
.000	.00	.00	.00	3940.40	70300.00	3965.95	3952.87	3966.49	1.80	5.89	12018.96	52376.22
.000	.00	.00	.00	3940.40	123500.00	3974.02	3956.45	3974.87	1.82	7.40	17011.66	91520.41
.000	.00	.00	.00	3940.40	178000.00	3980.94	3959.61	3982.07	1.82	8.55	21403.99	131878.60
.000	.00	.00	.00	3940.40	300000.00	3993.94	3965.62	3995.62	1.80	10.48	30043.56	223350.50
1145.000	1145.00	.00	.00	3938.40	4000.00	3948.74	3943.19	3948.83	1.55	2.39	1675.28	3215.13
* 1145.000	1145.00	.00	.00	3938.40	20000.00	3956.18	3948.14	3956.48	3.92	4.38	4566.67	10097.35
1145.000	1145.00	.00	.00	3938.40	48900.00	3962.93	3953.34	3963.52	3.18	6.21	8056.95	27434.56
1145.000	1145.00	.00	.00	3938.40	70300.00	3965.99	3955.24	3966.85	3.13	7.48	97[illegible]9.17	39729.08
1145.000	1145.00	.00	.00	3938.40	123500.00	3973.98	3959.32	3975.26	2.97	9.18	14329.11	71683.66
1145.000	1145.00	.00	.00	3938.40	178000.00	3980.83	3962.79	3982.49	2.87	10.49	18429.69	105078.20
1145.000	1145.00	.00	.00	3938.40	300000.00	3993.69	3969.48	3996.09	2.73	12.67	26504.12	181528.00
1660.000	515.00	.00	.00	3938.10	4000.00	3948.82	3943.95	3948.91	1.62	2.37	1687.40	3147.32
1660.000	515.00	.00	.00	3938.10	20000.00	3956.46	3948.24	3956.65	2.71	3.53	5660.13	12146.83
1660.000	515.00	.00	.00	3938.10	48900.00	3963.36	3952.83	3963.69	2.44	4.65	10546.00	31296.29
1660.000	515.00	.00	.00	3938.10	70300.00	3966.57	3954.63	3967.03	2.41	5.49	12894.98	45285.80
1660.000	515.00	.00	.00	3938.10	123500.00	3974.80	3958.26	3975.46	2.28	6.54	19458.51	81777.07
1660.000	515.00	.00	.00	3938.10	178000.00	3981.89	3960.88	3982.71	2.18	7.34	25289.28	120586.10
1660.000	515.00	.00	.00	3938.10	300000.00	3995.21	3966.16	3996.34	2.03	8.68	36665.05	210352.10
3220.000	1560.00	.00	.00	3943.50	4000.00	3949.16	3946.83	3949.23	2.65	2.01	1986.92	2457.49
3220.000	1560.00	.00	.00	3943.50	20000.00	3956.86	3949.20	3956.97	1.49	2.65	7558.66	16397.82
* 3220.000	1560.00	.00	.00	3943.50	48900.00	3963.79	3951.66	3963.94	.97	3.20	21913.34	49622.91
* 3220.000	1560.00	.00	.00	3943.50	70300.00	3967.09	3953.11	3967.26	.79	3.57	30296.04	

79137.78

	SECNO	XLCH	ELTRD	ELLC	ELMIN	Q	CWSEL	CRIWS	EG	10*KS	VCH	AREA	.01K
*	3220.000	1560.00	.00	.00	3943.50	123500.00	3975.47	3956.37	3975.66	.57	3.93	52177.21163209.40	
*	3220.000	1560.00	.00	.00	3943.50	178000.00	3982.68	3959.31	3982.91	.49	4.26	71290.74255460.00	
*	3220.000	1560.00	.00	.00	3943.50	300000.00	3996.26	3963.78	3996.54	.40	4.86	107685.70473043.80	

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	SECNO	XLCH	ELTRD	ELLC	ELMIN	Q	CWSEL	CRIWS	EG	10*KS	VCH	AREA	.01K
	4040.000	820.00	.00	.00	3941.90	4000.00	3949.37	3946.63	3949.41	1.95	1.74	2298.00	2864.67
	4040.000	820.00	.00	.00	3941.90	20000.00	3956.98	3949.05	3957.07	1.09	2.45	8155.03	19160.40
	4040.000	820.00	.00	.00	3941.90	48900.00	3963.86	3951.41	3964.02	.85	3.33	22012.41	53164.46
	4040.000	820.00	.00	.00	3941.90	70300.00	3967.14	3952.72	3967.33	.73	3.76	32288.66	82086.69
	4040.000	820.00	.00	.00	3941.90	123500.00	3975.53	3955.64	3975.71	.52	3.99	67052.79171305.70	
	4040.000	820.00	.00	.00	3941.90	178000.00	3982.77	3958.22	3982.95	.41	4.11	103636.70278368.90	
	4040.000	820.00	.00	.00	3941.90	300000.00	3996.42	3963.97	3996.58	.28	4.23	189717.20565063.80	
	5505.000	1465.00	.00	.00	3940.20	4000.00	3949.64	3945.37	3949.72	2.12	2.26	1770.94	2745.36
*	5505.000	1465.00	.00	.00	3940.20	20000.00	3957.11	3949.48	3957.36	2.65	3.97	5032.05	12294.22
	5505.000	1465.00	.00	.00	3940.20	48900.00	3963.96	3952.87	3964.20	1.52	4.53	26792.57	39612.48
	5505.000	1465.00	.00	.00	3940.20	70300.00	3967.24	3954.93	3967.47	1.11	4.69	40910.16	66658.47
	5505.000	1465.00	.00	.00	3940.20	123500.00	3975.65	3959.27	3975.79	.59	4.29	85578.07160387.20	
	5505.000	1465.00	.00	.00	3940.20	178000.00	3982.91	3963.27	3983.01	.37	3.95	136178.90291042.70	
	5505.000	1465.00	.00	.00	3940.20	300000.00	3996.55	3967.14	3996.62	.20	3.61	238590.30664332.10	
	7920.000	2415.00	.00	.00	3944.20	4000.00	3950.19	3946.99	3950.25	2.24	2.01	1986.43	2673.36
	7920.000	2415.00	.00	.00	3944.20	20000.00	3957.97	3950.07	3958.06	3.03	2.33	8585.31	11483.76
*	7920.000	2415.00	.00	.00	3944.20	48900.00	3964.37	3953.01	3964.45	.69	2.48	39321.39	58814.82
*	7920.000	2415.00	.00	.00	3944.20	70300.00	3967.57	3954.55	3967.64	.50	2.55	59418.66	98945.63
*	7920.000	2415.00	.00	.00	3944.20	123500.00	3975.83	3961.93	3975.89	.29	2.40	115573.80229115.50	
	7920.000	2415.00	.00	.00	3944.20	178000.00	3983.03	3962.07	3983.07	.21	2.35	175271.90391020.20	
	7920.000	2415.00	.00	.00	3944.20	300000.00	3996.62	3963.53	3996.66	.13	2.31	303070.90830648.40	
*	9830.000	1910.00	.00	.00	3945.50	4000.00	3950.78	3948.91	3950.86	4.85	2.40	1668.41	

```
1816.17
 * 9830.000  1910.00    .00    .00  3945.50  20000.00  3958.34  3951.35  3958.43   1.34   2.41  8301.76
17248.16
   9830.000  1910.00    .00    .00  3945.50  48900.00  3964.50  3953.60  3964.57    .62   2.36 45523.62
61910.66
   9830.000  1910.00    .00    .00  3945.50  70300.00  3967.67  3954.90  3967.73    .44   2.41
68119.52105403.90
   9830.000  1910.00    .00    .00  3945.50 123500.00  3975.89  3958.22  3975.94    .26   2.30
129523.50244354.40
   9830.000  1910.00    .00    .00  3945.50 178000.00  3983.06  3960.12  3983.11    .19   2.31
186297.70407652.40
   9830.000  1910.00    .00    .00  3945.50 300000.00  3996.64  3963.94  3996.68    .14   2.43
299992.10814625.50

  12360.000  2530.00    .00    .00  3946.70   4000.00  3951.68  3949.02  3951.76   2.68   2.25  1779.87
2445.09
  12360.000  2530.00    .00    .00  3946.70  20000.00  3958.75  3951.88  3958.90   2.47   3.08  6490.83
12722.90
  12360.000  2530.00    .00    .00  3946.70  48900.00  3964.66  3954.65  3964.80   1.23   3.30 28529.07
44006.36
  12360.000  2530.00    .00    .00  3946.70  70300.00  3967.77  3956.28  3967.89    .85   3.30 45829.65
76117.11
  12360.000  2530.00    .00    .00  3946.70 123500.00  3975.94  3959.91  3976.02    .45   3.01
93305.70184923.50
  12360.000  2530.00    .00    .00  3946.70 178000.00  3983.09  3964.60  3983.17    .32   2.98
136141.80315078.00
  12360.000  2530.00    .00    .00  3946.70 300000.00  3996.65  3965.85  3996.73    .22   3.09
219499.70640691.80

  13775.000  1415.00    .00    .00  3944.80   4000.00  3952.04  3948.82  3952.13   2.57   2.51  1661.93
2497.51
  13775.000  1415.00    .00    .00  3944.80  20000.00  3959.06  3952.29  3959.29   2.95   4.08  5521.29
11647.16
 * 13775.000  1415.00    .00    .00  3944.80  48854.52  3964.68  3955.72  3965.14   3.15   6.03 10578.61
27507.97
 * 13775.000  1415.00    .00    .00  3944.80  69970.37  3967.64  3957.55  3968.22   2.87   6.91 15550.12
41334.20
 * 13775.000  1415.00    .00    .00  3944.80  98881.61  3975.84  3959.82  3976.18   1.21   5.75 34137.13
89910.43
 * 13775.000  1415.00    .00    .00  3944.80 114553.40  3983.06  3960.89  3983.26    .57   4.61
55281.30152293.70
 * 13775.000  1415.00    .00    .00  3944.80 135122.30  3996.68  3962.35  3996.76    .17   3.14
107649.40331346.80

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  26MAY94     09:25:51                                                   PAGE  55


     SECNO     XLCH    ELTRD    ELLC    ELMIN       Q     CWSEL    CRIWS      EG   10*KS     VCH
AREA    .01K

  15545.000  1770.00    .00    .00  3946.60   4000.00  3952.50  3949.73  3952.58   2.62   2.30  1735.94
2471.96
  15545.000  1770.00    .00    .00  3946.60  20000.00  3959.56  3952.63  3959.76   2.62   3.59  5572.55
12354.19
  15545.000  1770.00    .00    .00  3946.60  48900.00  3965.25  3955.87  3965.63   2.67   4.99  9807.13
29920.12
  15545.000  1770.00    .00    .00  3946.60  70300.00  3968.16  3957.63  3968.67   2.60   5.75 12226.75
4[illegible].47
  15545.000  1770.00    .00    .00  3946.60 123500.00  3975.94  3962.06  3976.53   2.14   6.30
23751.23 84457.24
```

15545.000	1770.00	.00	.00	3946.60	178000.00	3982.95	3964.55	3983.55	1.72	6.51	35853.84	135686.00
15545.000	1770.00	.00	.00	3946.60	300000.00	3996.39	3969.29	3997.02	1.27	6.91	60572.47	265835.30
16905.000	1360.00	.00	.00	3946.00	4000.00	3952.79	3948.57	3952.88	1.79	2.47	1617.22	2992.65
16905.000	1360.00	.00	.00	3946.00	20000.00	3959.98	3952.44	3960.19	3.72	3.68	5437.46	10376.14
16905.000	1360.00	.00	.00	3946.00	48900.00	3965.62	3957.60	3966.02	2.96	5.10	9582.25	28411.31
16905.000	1360.00	.00	.00	3946.00	70300.00	3968.50	3958.95	3969.05	2.69	5.97	11775.05	42864.21
16905.000	1360.00	.00	.00	3946.00	123500.00	3976.15	3962.03	3976.91	2.23	6.97	17724.53	82747.69
16905.000	1360.00	.00	.00	3946.00	178000.00	3983.05	3964.81	3983.96	1.94	7.66	23636.67	127746.60
16905.000	1360.00	.00	.00	3946.00	300000.00	3996.34	3969.87	3997.43	1.45	8.51	43107.13	249505.00
16935.000	30.00	3981.90	3978.80	3946.00	4000.00	3952.80	.00	3952.89	1.77	2.47	1621.86	3004.57
16935.000	30.00	3981.90	3978.80	3946.00	20000.00	3960.00	.00	3960.21	3.68	3.67	5455.40	10432.45
16935.000	30.00	3981.90	3978.80	3946.00	48900.00	3965.66	.00	3966.07	2.93	5.09	9615.15	28570.09
16935.000	30.00	3981.90	3978.80	3946.00	70300.00	3968.56	.00	3969.11	2.66	5.95	11820.67	43133.24
16935.000	30.00	3981.90	3978.80	3946.00	123500.00	3976.22	.00	3976.97	2.21	6.95	17779.64	83159.19
16935.000	30.00	3981.90	3978.80	3946.00	178000.00	3984.16	.00	3985.00	1.71	7.36	25069.27	136301.10
16935.000	30.00	3981.90	3978.80	3946.00	300000.00	3996.34	.00	3997.43	1.45	8.51	43110.08	249525.90
* 18275.000	1340.00	.00	.00	3942.50	4000.00	3953.02	3946.83	3953.06	.76	1.52	2634.39	4592.10
* 18275.000	1340.00	.00	.00	3942.50	20000.00	3960.39	3951.42	3960.52	1.42	2.95	6778.43	16803.07
18275.000	1340.00	.00	.00	3942.50	48900.00	3966.06	3954.42	3966.40	1.97	4.71	10384.40	34873.91
18275.000	1340.00	.00	.00	3942.50	70300.00	3968.93	3956.22	3969.43	2.00	5.68	12390.55	49704.32
18275.000	1340.00	.00	.00	3942.50	123500.00	3976.59	3960.05	3977.26	1.71	6.66	20897.58	94469.15
18275.000	1340.00	.00	.00	3942.50	178000.00	3984.56	3963.13	3985.24	1.28	6.93	30222.15	157059.00
18275.000	1340.00	.00	.00	3942.50	300000.00	3996.75	3968.79	3997.65	1.16	8.10	44684.27	279041.80
* 20975.000	2700.00	.00	.00	3945.90	4000.00	3953.31	3949.66	3953.41	2.29	2.60	153[illegible].01	2641.46
* 20975.000	2700.00	.00	.00	3945.90	20000.00	3960.84	3953.39	3961.15	3.49	4.43	4634.03	10702.15
* 20975.000	2700.00	.00	.00	3945.90	48900.00	3966.51	3957.61	3967.26	4.03	6.97	7445.20	24370.44
* 20975.000	2700.00	.00	.00	3945.90	70300.00	3969.26	3959.69	3970.37	4.23	8.52	8878.56	34186.70
* 20975.000	2700.00	.00	.00	3945.90	123500.00	3976.56	3964.01	3978.26	4.27	10.64	13092.23	59761.77
* 20975.000	2700.00	.00	.00	3945.90	178000.00	3984.15	3967.76	3986.20	3.69	11.72		

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17688.93 92681.40
 * 20975.000  2700.00    .00    .00  3945.90 300000.00  3995.74  3974.88  3998.82   3.80   14.49
24953.59153894.50

   23475.000  2500.00    .00    .00  3946.80   4000.00  3953.80  3949.96  3953.86   1.42    2.01  198[illegible].56
3353.58
   23475.000  2500.00    .00    .00  3946.80  20000.00  3961.60  3953.11  3961.81   2.06    3.71  5339.[illegible]
13936.97
   23475.000  2500.00    .00    .00  3946.80  48900.00  3967.54  3956.56  3968.08   2.63    5.97  9264.65
30173.85
   23475.000  2500.00    .00    .00  3946.80  70300.00  3970.45  3958.60  3971.25   2.73    7.27 11500.40
42546.31
   23475.000  2500.00    .00    .00  3946.80 123500.00  3977.98  3962.79  3979.17   2.81    9.05
17558.71 73732.38
   23475.000  2500.00    .00    .00  3946.80 178000.00  3985.60  3966.88  3987.02   2.49   10.00
24097.98112730.70
   23475.000  2500.00    .00    .00  3946.80 300000.00  3997.66  3973.59  3999.70   2.53   12.21
35286.00188777.00
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Colorado River, Moab, U

SUMMARY PRINTOUT TABLE 150

SECNO	Q	CWSEL	DIFWSP	DIFWSX	DIFKWS	TOPWID	XLCH
.000	4000.00	3948.57	.00	.00	-.03	534.35	.00
.000	20000.00	3955.98	7.41	.00	.98	565.70	.00
.000	48900.00	3962.82	6.85	.00	2.82	603.74	.00
.000	70300.00	3965.95	3.13	.00	3.95	610.29	.00
.000	123500.00	3974.02	8.07	.00	9.02	627.19	.00
.000	178000.00	3980.94	6.92	.00	10.94	641.70	.00
.000	300000.00	3993.94	12.99	.00	21.94	692.99	.00
1145.000	4000.00	3948.74	.00	.17	.00	286.16	1145.00
* 1145.000	20000.00	3956.18	7.44	.20	.00	486.10	1145.00
1145.000	48900.00	3962.93	6.75	.10	.00	533.10	1145.00
1145.000	70300.00	3965.99	3.06	.04	.00	547.22	1145.00
1145.000	123500.00	3973.98	7.98	-.05	.00	589.10	1145.00
1145.000	178000.00	3980.83	6.85	-.12	.00	608.26	1145.00
1145.000	300000.00	3993.69	12.86	-.25	.00	666.90	1145.00
1660.000	4000.00	3948.82	.00	.08	.00	300.43	515.00
1660.000	20000.00	3956.46	7.64	.28	.00	694.52	515.00
1660.000	48900.00	3963.36	6.90	.43	.00	720.56	515.00
1660.000	70300.00	3966.57	3.21	.57	.00	749.18	515.00
1660.000	123500.00	3974.80	8.23	.83	.00	812.50	515.00
1660.000	178000.00	3981.89	7.09	1.06	.00	833.40	515.00
1660.000	300000.00	3995.21	13.32	1.52	.00	877.90	515.00
3220.000	4000.00	3949.16	.00	.34	.00	660.66	1560.00
3220.000	20000.00	3956.86	7.70	.40	.00	814.72	1560.00
* 3220.000	48900.00	3963.79	6.93	.44	.00	2536.14	1560.00
* 3220.000	70300.00	3967.09	3.29	.52	.00	2545.46	1560.00
* 3220.000	123500.00	3975.47	8.38	.67	.00	2636.60	1560.00
* 3220.000	178000.00	3982.68	7.22	.80	.00	2659.52	1560.00
* 3220.000	300000.00	3996.26	13.58	1.06	.00	2705.06	1560.00

	4040.000	4000.00	3949.37	.00	.20	.00	754.88	820.00
	4040.000	20000.00	3956.98	7.61	.12	.00	783.25	820.00
	4040.000	48900.00	3963.86	6.88	.07	.00	2620.30	820.00
	4040.000	70300.00	3967.14	3.28	.05	.00	3619.42	820.00
	4040.000	123500.00	3975.53	8.39	.06	.00	4632.23	820.00
	4040.000	178000.00	3982.77	7.25	.09	.00	5464.25	820.00
	4040.000	300000.00	3996.42	13.65	.16	.00	7210.69	820.00
	5505.000	4000.00	3949.64	.00	.28	.00	418.75	1465.00
*	5505.000	20000.00	3957.11	7.47	.13	.00	453.57	1465.00
	5505.000	48900.00	3963.96	6.85	.10	.00	4072.30	1465.00
	5505.000	70300.00	3967.24	3.28	.10	.00	4468.20	1465.00
	5505.000	123500.00	3975.65	8.41	.12	.00	6276.80	1465.00
	5505.000	178000.00	3982.91	7.26	.14	.00	7320.08	1465.00
	5[illegible].000	300000.00	3996.55	13.65	.13	.00	7691.27	1465.00

	SECNO	Q	CWSEL	DIFWSP	DIFWSX	DIFKWS	TOPWID	XLCH
	7920.000	4000.00	3950.19	.00	.54	.00	582.60	2415.00
	7920.000	20000.00	3957.97	7.78	.86	.00	1049.57	2415.00
*	7920.000	48900.00	3964.37	6.40	.41	.00	6082.85	2415.00
*	7920.000	70300.00	3967.57	3.20	.33	.00	6412.07	2415.00
*	7920.000	123500.00	3975.83	8.26	.19	.00	7178.93	2415.00
	7920.000	178000.00	3983.03	7.19	.12	.00	8846.65	2415.00
	7920.000	300000.00	3996.62	13.60	.07	.00	9954.62	2415.00
*	9830.000	4000.00	3950.78	.00	.59	.00	672.13	1910.00
*	9830.000	20000.00	3958.34	7.56	.37	.00	1182.21	1910.00
	9830.000	48900.00	3964.50	6.17	.13	.00	7057.85	1910.00
	9830.000	70300.00	3967.67	3.17	.10	.00	7227.92	1910.00
	9830.000	123500.00	3975.89	8.22	.06	.00	7684.89	1910.00
	9830.000	178000.00	3983.06	7.17	.04	.00	8075.30	1910.00
	9830.000	300000.00	3996.64	13.58	.02	.00	8672.29	1910.00
	12360.000	4000.00	3951.68	.00	.90	.00	543.17	2530.00
	12360.000	20000.00	3958.75	7.07	.41	.00	887.99	2530.00
	12360.000	48900.00	3964.66	5.91	.15	.00	5343.54	2530.00
	12360.000	70300.00	3967.77	3.11	.09	.00	5686.72	2530.00
	12360.000	123500.00	3975.94	8.17	.05	.00	5908.62	2530.00
	12360.000	178000.00	3983.09	7.16	.03	.00	6048.88	2530.00
	12360.000	300000.00	3996.65	13.56	.01	.00	6225.88	2530.00
	13775.000	4000.00	3952.04	.00	.36	.00	442.34	1415.00
	13775.000	20000.00	3959.06	7.03	.32	.00	675.11	1415.00
*	13775.000	48854.52	3964.68	5.62	.03	.00	1307.87	1415.00
*	13775.000	69970.37	3967.64	2.96	-.13	.00	1955.16	1415.00
*	13775.000	98881.61	3975.84	8.20	-.09	.00	2557.12	1415.00
*	13775.000	114553.40	3983.06	7.22	-.03	.00	3364.17	1415.00
*	13775.000	135122.30	3996.68	13.62	.03	.00	4150.49	1415.00
	15545.000	4000.00	3952.50	.00	.46	.00	467.30	1770.00
	15545.000	20000.00	3959.56	7.07	.50	.00	584.48	1770.00
	15545.000	48900.00	3965.25	5.68	.57	.00	824.48	1770.00
	15545.000	70300.00	3968.16	2.91	.52	.00	836.73	1770.00
	15545.000	123500.00	3975.94	7.78	.10	.00	1700.53	1770.00
	15545.000	178000.00	3982.95	7.02	-.11	.00	1763.41	1770.00

15545.000	300000.00	3996.39	13.44	-.29	.00	1877.98	1770.00
16905.000	4000.00	3952.79	.00	.29	.00	292.50	1360.00
16905.000	20000.00	3959.98	7.20	.42	.00	713.45	1360.00
16905.000	48900.00	3965.62	5.64	.37	.00	757.02	1360.00
16905.000	70300.00	3968.50	2.88	.34	.00	765.82	1360.00
16905.000	123500.00	3976.15	7.65	.21	.00	789.22	1360.00
16905.000	178000.00	3983.05	6.89	.09	.00	1248.86	1360.00
16905.000	300000.00	3996.34	13.30	-.05	.00	1509.08	1360.00

SECNO	Q	CWSEL	DIFWSP	DIFWSX	DIFKWS	TOPWID	XLCH
16935.000	4000.00	3952.80	.00	.01	.00	292.85	30.00
16935.000	20000.00	3960.00	7.21	.02	.00	713.51	30.00
16935.000	48900.00	3965.66	5.66	.04	.00	757.15	30.00
16935.000	70300.00	3968.56	2.90	.06	.00	766.00	30.00
16935.000	123500.00	3976.22	7.66	.07	.00	789.43	30.00
16935.000	178000.00	3984.16	7.94	1.12	.00	1312.29	30.00
16935.000	300000.00	3996.34	12.18	.00	.00	1509.08	30.00
* 18275.000	4000.00	3953.02	.00	.22	.00	523.15	1340.00
* 18275.000	20000.00	3960.39	7.37	.38	.00	602.04	1340.00
18275.000	48900.00	3966.06	5.67	.39	.00	684.07	1340.00
18275.000	70300.00	3968.93	2.87	.37	.00	704.08	1340.00
18275.000	123500.00	3976.59	7.66	.37	.00	1164.80	1340.00
18275.000	178000.00	3984.56	7.96	.39	.00	1176.78	1340.00
18275.000	300000.00	3996.75	12.19	.41	.00	1195.12	1340.00
* 20975.000	4000.00	3953.31	.00	.28	.00	310.89	2700.00
* 20975.000	20000.00	3960.84	7.54	.45	.00	485.26	2700.00
* 20975.000	48900.00	3966.51	5.67	.46	.00	505.35	2700.00
* 20975.000	70300.00	3969.26	2.75	.33	.00	531.20	2700.00
* 20975.000	123500.00	3976.56	7.29	-.04	.00	596.53	2700.00
* 20975.000	178000.00	3984.15	7.60	-.41	.00	613.85	2700.00
* 20975.000	300000.00	3995.74	11.58	-1.02	.00	640.28	2700.00
23475.000	4000.00	3953.80	.00	.49	.00	415.21	2500.00
23475.000	20000.00	3961.60	7.80	.76	.00	443.50	2500.00
23475.000	48900.00	3967.54	5.94	1.03	.00	757.37	2500.00
23475.000	70300.00	3970.45	2.91	1.19	.00	777.98	2500.00
23475.000	123500.00	3977.98	7.53	1.43	.00	831.28	2500.00
23475.000	178000.00	3985.60	7.62	1.45	.00	885.21	2500.00
23475.000	300000.00	3997.66	12.06	1.92	.00	970.55	2500.00

SUMMARY OF ERRORS AND SPECIAL NOTES

WARNING SECNO= 1145.000 PROFILE= 2 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

WARNING SECNO= 3220.000 PROFILE= 3 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 3220.000 PROFILE= 4 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

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WARNING SECNO=  3220.000  PROFILE= 5  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=  3220.000  PROFILE= 6  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=  3220.000  PROFILE= 7  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

WARNING SECNO=  5505.000  PROFILE= 2  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

WARNING SECNO=  7920.000  PROFILE= 3  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=  7920.000  PROFILE= 4  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=  7920.000  PROFILE= 5  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

WARNING SECNO=  9830.000  PROFILE= 1  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=  9830.000  PROFILE= 2  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

WARNING SECNO= 13775.000  PROFILE= 3  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 13775.000  PROFILE= 4  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 13775.000  PROFILE= 5  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 13775.000  PROFILE= 6  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 13775.000  PROFILE= 7  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

WARNING SECNO= 18275.000  PROFILE= 1  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 18275.000  PROFILE= 2  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

WARNING SECNO= 20975.000  PROFILE= 1  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 20975.000  PROFILE= 2  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 20975.000  PROFILE= 3  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 20975.000  PROFILE= 4  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 20975.000  PROFILE= 5  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 20975.000  PROFILE= 6  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 20975.000  PROFILE= 7  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
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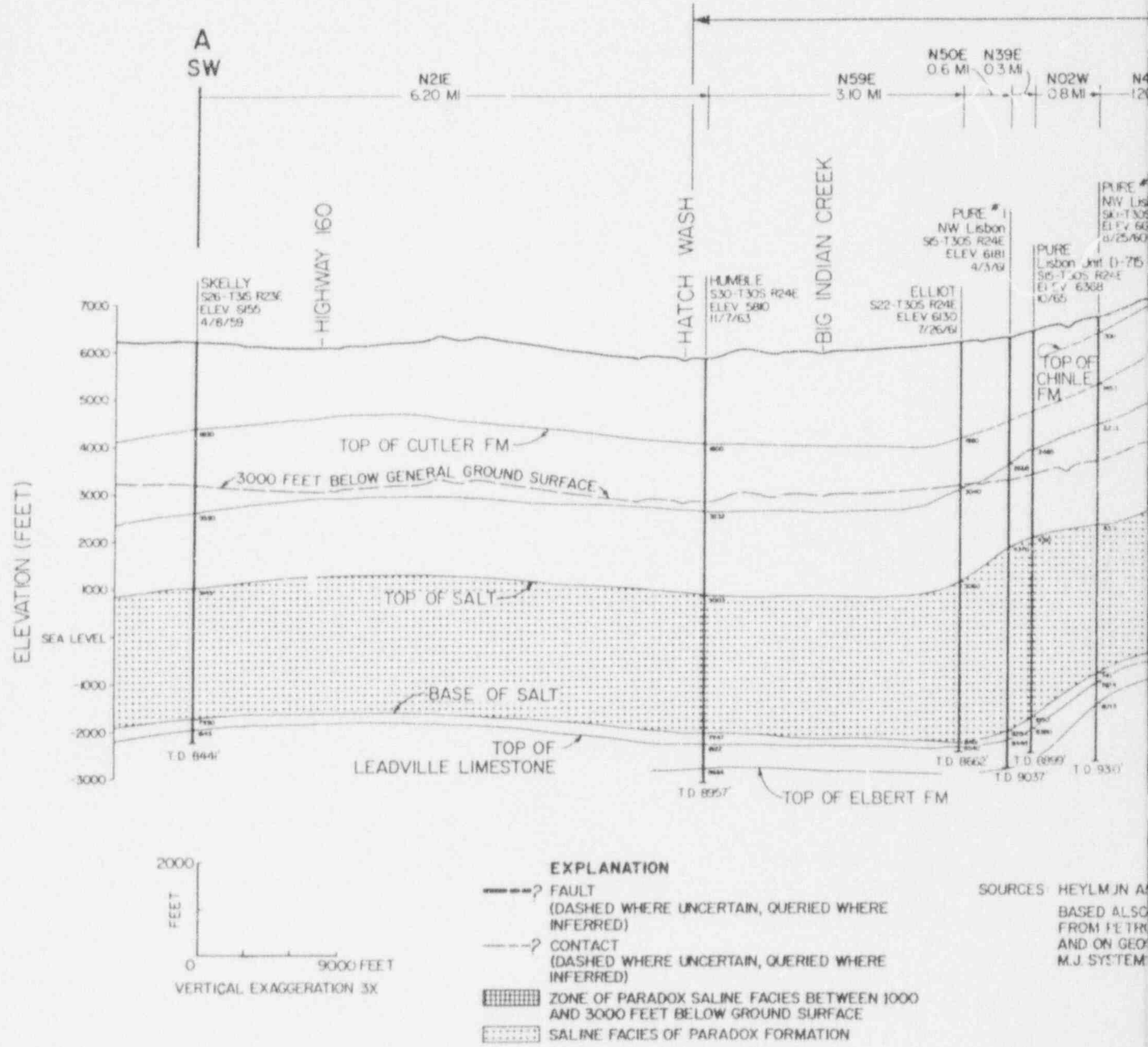

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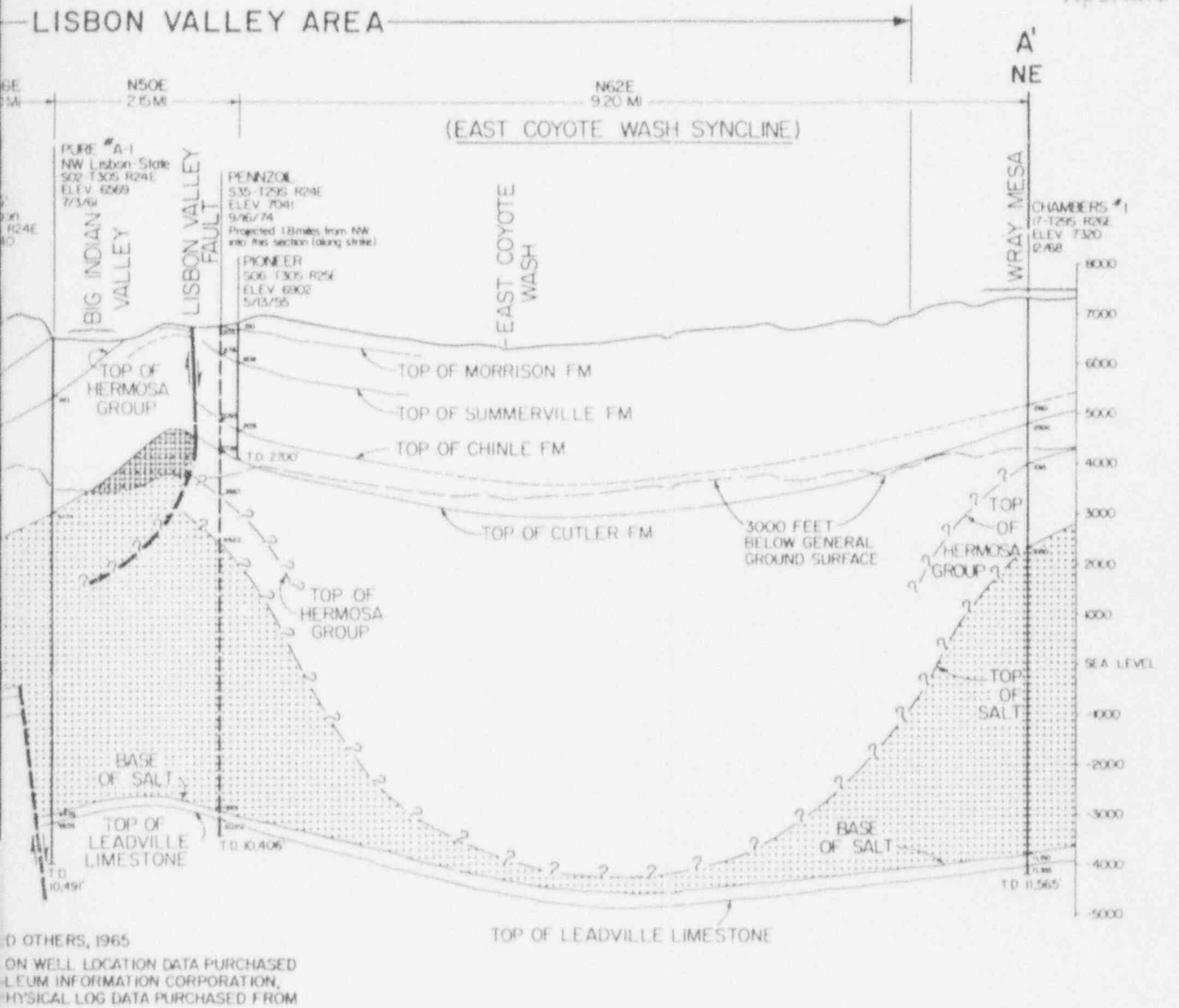
ANSTEC
APERTURE
CARD

Also Available on
Aperture Card



Source: Woodward-Clyde Consultants, 1982

Project No. SK9407	Moab Uranium Mill Tailings Site	GEOLOGIC CROSS SECTION THROUGH THE LISBON VALLEY FAULT	Figure 3
Woodward-Clyde Federal Services			

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