US Army Corps of Engineers
Los Angeles District

Santa Cruz River, Paseo de las Iglesias
Pima County, Arizona

Final Feasibility Report
and
Environmental Impact Statement

APPENDIX B

HYDRAULIC INVESTIGATION

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I INTRODUCTION

The Paseo de Las Iglesias Study Area is traversed by several watercourses including the Santa Cruz River (SCR) and the West Branch of the Santa Cruz River (WBSCR). The study area is located between the Los Reales Road alignment and Congress Street within Township 14, Range 13, Sections 14, 22-24, 25-27, 34 and 35, as well as Township 15, Range 13, Sections 2-3, 10-11, 14, and 15 (Figure 1). Five separate studies contain hydraulic data for the watercourses traversing and immediately adjacent to this reach. This report summarizes the available hydraulic information, including HEC-2 analyses, work maps, and hydraulic information for bridges and culverts within and adjacent to the study area. Much of the information sited is available within the attached appendices.

II DESCRIPTION OF CURRENT HYDRAULIC STUDIES

1.1 The most recent SCR **Flood Insurance Study** (FIS) that includes the Paseo de Las Iglesias study area was performed on March 26th, 1990, by CMG Drainage Engineering Inc. The CMG Drainage Engineering study area covers the reach of the SCR downstream of the I-19 bridge (south of the study area) north past Congress Street through Tucson (Figure 1). The FIS was issued by the Federal Emergency Management Agency (FEMA) on February 8, 1999. The peak discharges of the SCR at both Drexel Road and Congress Street are reported to be 16800, 41000, 60000, and 93000 cfs for the 10-, 50-, 100-, and 500-year flood events, respectively. The drainage areas at Drexel Road and Congress Street are 2101 and 2222 square miles, respectively. The cross section elevations were determined using the 1984, 1”=200’ aerial topography maps with a 2’ contour interval based on the North American Vertical Datum (NAVD) 1929. The complete set of mylars of these orthophoto-topographic maps with floodplain delineations is available through the Pima County Department of Transportation, Mapping and Records Division. The FIS document is available through the FEMA Publication Center. Although no formal written report was prepared, CMG Drainage Engineering Inc. provided the input files for the HEC-2 analyses. A diskette containing the HEC-2 model input files for the 10-, 50-, 100-, and 500-year floodplain (PC25uf5.DAT) and the floodway (PC25ux5.DAT) for the Santa Cruz River from the I-19 bridge to Camino Del Cerro are available in Appendix 1.

1.2 **Master Drainage Study, Tohono O’odham Nation-San Xavier District Phase 1- Panhandle Area Existing Conditions** was prepared by McGovern, MacVittie, Lodge, and Associates, Inc. (MMLA) on July 31, 2001. The area studied is immediately adjacent to the south and west of the Paseo de Las Iglesias study area (Figure 1). Hydraulic information contained in this report includes details regarding four culvert crossings on Valencia Road, the Los Reales Improvement District collector and conveyance channels, and floodplain analysis utilizing HEC-RAS.

The culvert under Valencia Road at Valencia Wash (west of the Master Drainage Study area) is a seven-cell, 10’ x 6’ RCBC, with a design capacity (Q_{Design}) of 5257 cfs, which will fully contain 100-year flood discharge (Q_{100}) of 3680 cfs. A single-cell 10' x 4' RCBC culvert at the southwest corner of Mission Road and Valencia Road conveys flows under Valencia Road into a concrete lined channel that conveys flows into the WBSCR. The Q_{Design} of 360 cfs is sufficient to pass the Q_{100} of 251 cfs, assuming all flow will concentrate at the headwall of the culvert. A three-cell, 71" x 47" CMPA is located in the historic alignment of the WBCSR at Valencia and Mission Road, 900' west of the WBSCR channel realignment. The Q_{Design} of 512 cfs conveys low flows under Valencia Road. The final culvert documented in this MMLA report conveys the flows from the relocated WBSCR under Valencia Road, east of Mission Road. It is a ten-cell 12' x 8' RCBC with upstream channel improvements. The Q_{Design} of 8000 cfs could pass the Q_{100} of 6900 cfs, as determined in this MMLA Master Drainage Study, under Valencia road without breakout, except earthen berms near the relocated WBSCR prevent some runoff from entering the channel, contributing to a wide floodplain in the area. This relocated WBSCR culvert design was also analyzed in the Midvale Park Master Drainage Report, which is presented in Section 1.4 (below).

Collector and conveyance channels information described in the MMLA Master Drainage Study are based on information more completely documented in the Arroyo Engineering Inc. report described in section 1.3 (below). HEC-RAS analyses of the floodplains in the Panhandle Study Area were performed based on discharges obtained from Manning Equation calculations. Topographic mapping based on aerial topography taken November 15, 1992 was completed by Kucera International Inc., with a horizontal scale of 1"=200' and a vertical contour interval of 2', based on NAVD 1929. A summing of hydrographs was done to obtain the 100-year discharge of 6809 cfs for Mission Wash upstream of Valencia Road. The HEC-RAS output files, as well as maps showing cross section locations are included in Appendix 2.

1.3 The **Request for a Letter of Map Revision for the Los Reales Improvement District Located in Pima County, Arizona, and the City of Tucson, Arizona** report was completed by Arroyo Engineering Inc. in December of 1994. This Letter of Map Revision (LOMR) was approved by FEMA prior to the issuance of the February 8, 1999 FIS, so the information contained in the current FIS reflects this LOMR. The Los Reales Improvement District (LRID) is located south of Valencia Road, entirely within Section 15 of Township 15 South, Range 13 East (Figure 1). The report contains detailed hydraulic analysis based on existing conditions including a new floodwall and associated drainage channels. The ground-profile data for the eastern portion of the report was based on 1984 Cooper Aerial Survey Co. aerial topographic maps, and the western portion was based on the 1986, McLain Aerial Surveys aerial topography maps. Both map sets have a horizontal scale of 1"=200' and a 2' contour interval based on NAVD 1929. Two HEC-2 models were assembled. The first detailed the depth of ponding against the floodwall, determined flood depths south of Valencia Road along the WBSCR, and performed split flow analysis to differentiate water flowing into the South Channel or westward into the SCR. The second HEC-2 model and split flow analysis was used to predict water surface elevations in the South Channel, and quantify the amount of floodwater that will either flow northward along Indian Agency Road, or eastward in the South Channel.

Ground profile data used to represent the improved portions of the South Channel were taken from field survey data and approved constructions plans. In evaluating breakout flows, a value of 2.6 was assigned to the weir-loss coefficient "C" to represent the flow over the roadways and channel levees. Areas of ineffective flow downstream of channel expansions were assigned specific cross sections, and an expansion ratio of 4:1 was used to delineate these areas. A 100-year peak discharge of 7638 cfs (determined by Buck Lewis and Associates, Inc., 1982) was used to establish flood heights for the WBSCR.

Based on the split flow calculations, output data predicted that 3131 cfs will flow northward in the "West Branch Channel" (WBSCR) during a 100-year flood, 3308 cfs will flow northward from the Reservation into the South Channel, and 1199 cfs will flow directly eastward into the SCR. A split flow calculation performed on the 3131 cfs flowing northward in the WBSCR predicted that approximately 219 cfs and 123 cfs will breakout at two locations and sheet flow to the east. This 342 cfs of break-out flow will concentrate south of Valencia Road, then be conveyed under the road by a 2-cell, 10'x 4' RCBC, into a 30' wide flood control channel that trends northwesterly and feeds back into the WBSCR. A separate split flow calculation predicted that the 3308 cfs that flows in the South Channel during the 100-year flood would be entirely contained within the South Channel. Full printouts of the input and output files, the plotted hydraulic cross sections, and river profiles for the HEC-2 model of the SCR are contained in Appendix 3. Printouts contain a summary of the split flow calculations.

1.4 The **Midvale Park Master Drainage Report** was completed in July of 1983 by Dooley-Jones & Associates, Inc. This study covers an irregular area south of Irvington Road and west of the SCR, within Township 15 South, Range 13 East, Sections 3, 10, and 15 (Figure 1). The report described the general design of numerous hydraulic structures. Tables and graphs for roadway capacities were provided, but were not tied to specific locations. Numerous generalized typical, as well as some alternative, cross sections and plans are provided for roadways, drainage channels, detentions basins, spillways, etc., but no specific location information was provided for this hydraulic information. The typical cross sections for the West Branch Channel are included in Appendix 4.

1.5 The **Old West Branch of the Santa Cruz River Letter of Map Revision Study** was completed in 1994 by McGovern, MacVittie, Lodge, and Associates, Inc. No project report document was prepared. The Letter of Map Revision was approved by FEMA on July 24, 2000. The area studied includes the historic WBSCR north of Irvington Road to its confluence with the SCR (Figure 1). The cross section elevations were based on 1983, 1"=200' Cooper Aerial Survey Co. aerial topography maps with a 2' contour interval based on the NAVD 1929. The discharges used in the models were based on the Tucson Stormwater Management Study. Copies of the applicable work maps, and a diskette with the WBSCR HEC-2 input files are located in Appendix 1.

III. HYDRAULIC INVESTIGATION OF WITH PROJECT CONDITIONS

1.1 INTRODUCTION

1.1.1 PURPOSE

The purpose of this section is to document the hydraulic analysis completed in support of the Alternative Formulation Briefing (AFB) milestone for the Santa Cruz River, Paseo de las Iglesias Feasibility Study. This hydraulic analysis has been conducted to determine the "With Project" hydraulic conditions on the Santa Cruz River for the final array of alternatives. With Project hydraulic analysis was not performed on the Old West Branch and Los Reales tributaries, because no flood damage reduction or ecosystem restoration measures are being proposed for these reaches.

1.1.2 STUDY AREA DESCRIPTION

The Santa Cruz River has its headwaters in the San Rafael Valley in southeastern Arizona. From there, the river flows south into Mexico. After a 35-mile loop through Mexico, it turns to flow northward and reenters Arizona about six miles east of Nogales. The river continues northward to Tucson then northwest to its confluence with the Gila River 12 miles southwest of Phoenix. The river runs approximately 43 miles north of the US-Mexico border before entering the study area. Throughout this reach, flow occurs only because of effluent discharges or following major storms.

The Paseo de las Iglesias study area (see Figure 2) encompasses approximately 5005 acres and consists of a 7.5 river mile reach of the Santa Cruz River and its tributary washes. Beginning where Congress Street crosses the river in downtown Tucson the study area extends upstream to the south along the river to the boundary of the San Xavier District of the Tohono O'Odham Nation. The eastern study boundary is represented by Interstates 10 and 19. The western study area boundary is represented by Mission Road and the San Xavier District of the Tohono O'Odham Nation. Soil cement bank protection exists on both channel banks between Irvington Road and Ajo Way; near Valencia Road; and on both banks of the river between Silver Lake Road (29th Street) and Congress Street. All other portions of the river are unprotected with near vertical eroded banks. Bridges in the study area include Valencia Road, Irvington Road, Ajo Way, Silverlake Road, 22nd Street, and Congress Street.

The main channel of the Santa Cruz River flows in a relatively straight northerly direction from the southern to the northern borders of the study area. The West Branch tributary of the Santa Cruz River currently extends from the southern border of the study area to the north approximately 3.5 river miles to where it joins the mainstem of the Santa Cruz River, just north of Irvington Road. The portion of this channel just north of Irvington Road, the New West Branch, has been re-routed. The former channel (before it was re-routed) extends from just north of Irvington to just south of 22nd Street where it joins the mainstem of the Santa Cruz River.

The reach investigated for this hydraulic analysis includes approximately seven and one-half (7.5) river miles of stream channel and historic floodplain areas and is characterized by an incised, partially bank protected river with a narrow 100-year floodplain. Between Ajo Way and Irvington Road, the New West Branch tributary joins the Santa Cruz River at a confluence marked by a large concrete drop structure and energy dissipater.

1.1.2.1 Major Tributaries

Old West Branch: The Old West Branch of the Santa Cruz River is an entrenched natural channel that extends from Irvington Road to 22nd Street where it joins the river. The average base width is 20 ft and the average bank height is 10 ft. There is a significant amount of vegetation (e.g., mesquite) growing along the banks and some vegetation growing in the channel bed. There is a large concrete drop structure at the confluence of the New West Branch and the Santa Cruz River. Vehicular bridges exist at the Silverlake Road and Ajo Way crossings.

Los Reales Improvement District: The Pima County Department of Transportation and Flood Control District (FCD) formed the Los Reales Improvement District in 1987 in order to construct a flood-control levee and associated drainage ways. The District is located at the upstream end of the New West Branch, between Los Reales and Valencia Roads. The purpose of this project was to divert flows around the development and dispose of these flood flows either into the Santa Cruz River or into the New West Branch channel. Along the south boundary of this Improvement District, there is a 4 ft high, 1400 ft long floodwall, which extends between the Tohono O'odham Indian Reservation Boundary and Indian Agency Road. On the west end of this floodwall, a partially lined concrete channel diverts a portion of the flood flows northward into the New West Branch channel. A partially lined concrete channel exists along the south edge of the development and diverts all remainder flood flows into the Santa Cruz River approximately opposite Hughes Wash.

New West Branch: The New West Branch diversion is an entrenched partially bank protected trapezoidal channel that extends 3.5 miles from Los Reales road to Irvington Road where it joins the river. The channel has a natural bottom with 3 on 1 concrete lined sideslopes. The base width varies from 100 to 120 ft. The average bank height is 8 ft. There is a large concrete drop structure at the confluence of the New West Branch and the Santa Cruz River. Vehicular bridges exist at Irvington and Valencia Roads and one (1) a pedestrian bridge exists south of Drexel Road.

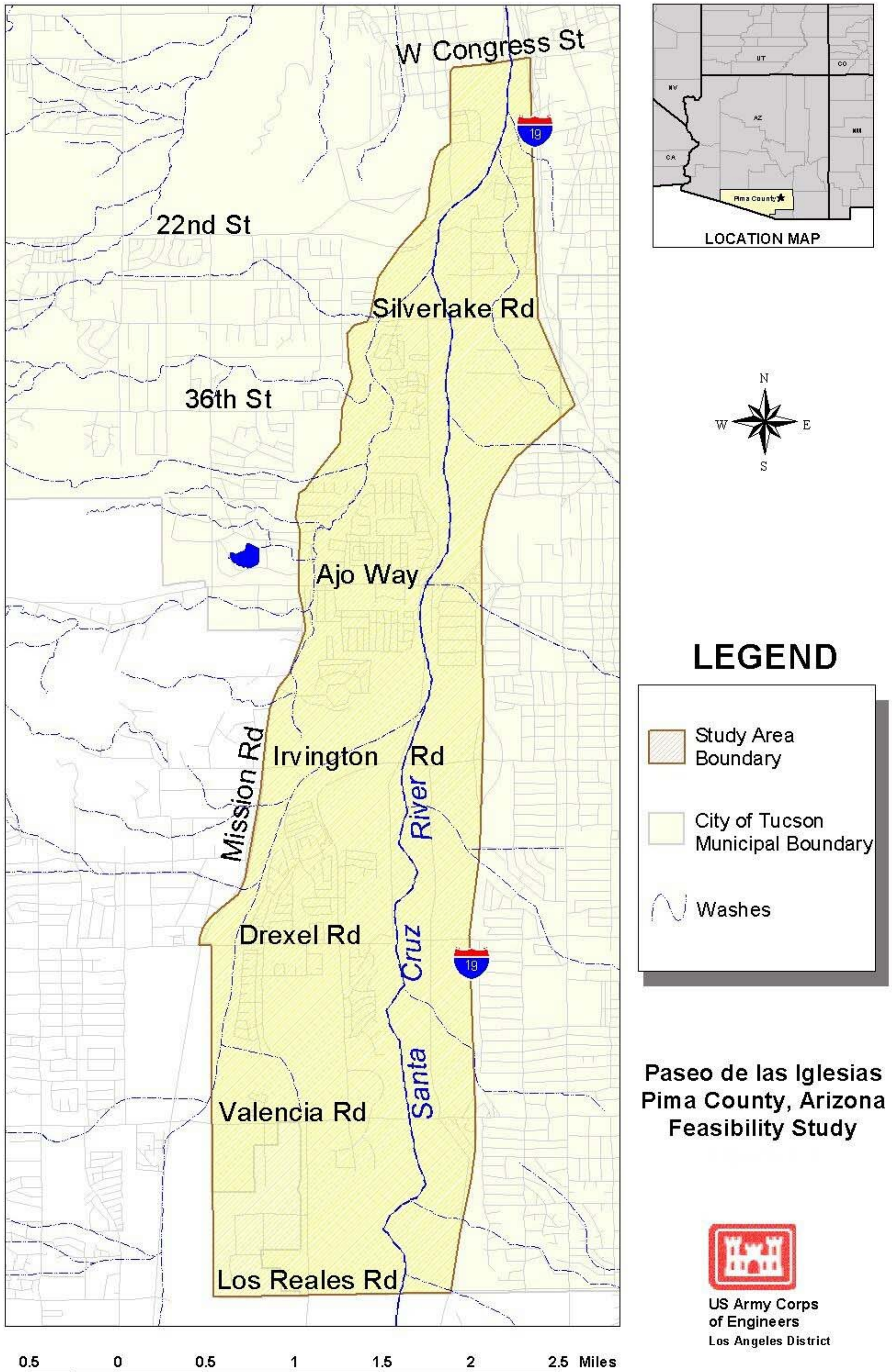


Figure 2: Paseo de las Iglesias Study Area

1.2 METHODOLOGY

1.2.1 GUIDANCE

The hydraulic analysis was prepared in accordance with EM 1110-2-1601, "Hydraulic Design of Flood Control Channels", USACE 1994. EM 1110-2-1418, "Channel Stability Assessment for Flood Control Projects" (USACE, 1994), and EM 1110-2-1619, "Risk-Based Analysis for Flood Damage Reduction Studies" (USACE, 1996) provided additional guidance.

1.2.2 ANALYSIS TOOLS

HEC-RAS (USACE 2001) was used for the Santa Cruz River with project conditions model(s). The ArcView (ESRI 1999) extension HEC-GeoRAS (HEC 2000) was used as a pre and post processor for HEC-RAS.

1.2.3 HYDROLOGY AND DESIGN DISCHARGES

Table 1 below summarizes the peak discharges that were used for the with project hydraulic analysis. Hydrologic methodologies and assumptions were used to develop the respective discharges are documented in Appendix A, Hydrology.

Table 1: Santa Cruz River (Drainage Area = 2,222 Sq. mi.)
Discharge – Frequency Relationships

Frequency (Year)	Discharge (cfs)
2	4,900
5	9,500
10	14,000
20	20,000
50	35,000
100	55,000
200	75,000
500	120,000

1.2.4 TOPOGRAPHIC MAPPING AND VERTICAL DATUM

The information used for this study is based on two vertical datums. The original Flood Insurance Study (FIS) models and workmaps that were based on the National Geodetic Vertical Datum of 1929 (NGVD 1929). The datum used for the current topography is the North American Vertical Datum of 1988 (NAVD 1988). The difference between these datums varies as a function of location.

However, within the study reach, a constant difference was determined to be appropriate and reasonable. The following equations were used to convert between the datums:

Elev(NAVD) = Elev(NGVD) + ♠Elev
Elev(NGVD) = Elev(NAVD) - ♠Elev

where: Elev(NAVD) = elevation in NAVD 1988 datum;
Elev(NGVD) = elevation in NGVD 1929 datum.
♠Elev = 2.2 ft.

The Pima County Flood Control District provided digital orthophotos (1998), digital terrain model (DTM) breakline data, DTM mass points, ArcInfo coverage of the existing mapped floodplains, and digital GIS layers for the County. Additional field survey data was provided by Pima County for the New West Branch diversion. Triangulated Irregular Networks (TIN) were then developed to obtain cross section data for the models. All topography provided by Pima County was based on NAVD 1988 datum.

1.2.4.1 New West Branch Survey Information

Field survey information for the New West Branch channel was provided by Pima County on 18 June 2003. The survey information consisted of a spreadsheet containing northing, easting, elevation data and an AutoCAD image of the points and breaklines. The data is on the same coordinate system as the topography that was used in the original hydraulic model. Pima County also provided some field drawing showing structure locations (e.g., bike paths, concrete channel locations, pipes).

1.3. HYDRAULIC ANALYSES

1.3.1 PREVIOUS MODELS AND DATA

The Pima County Department of Transportation and Flood Control District assembled a continuous HEC-2 water surface profile model for the Santa Cruz River that extended through Pima County, from the Santa Cruz County line to the Pinal County line. The original model was adapted from previously coded HEC-2 flood insurance study and County engineering study models.

In September 1998, the Corps of Engineers (USACE) converted the original Pima County HEC-2 model into a HEC-RAS model for the Gila River, Santa Cruz River Watershed, Pima County, Arizona, Final Feasibility Study, dated August 2001. Within Pima County, the Santa Cruz River was modeled under six contiguous reaches, which provided the modelers an efficient method to characterize the hydraulic differences along the river. The geometric data contained in the USACE model was updated at several locations along the Santa Cruz River from cross-section data provided by Pima County that was generated from detailed topography provided to the County by the U.S. Bureau of Reclamation.

The Paseo de las Iglesias study area is contained in the Tucson Urban reach, known as Reach 4 in the USACE Santa Cruz River Watershed Feasibility Study. The original cross-section geometric data within the stream valley in Reach 4 was not updated from the Bureau of Reclamation topography; however, some of the overbank areas (also known as the Historic Floodplain) have been updated using the GEO-RAS software program. The distinction for the age of the geometric data indicates that the station versus elevation data used to define the in-channel cross-sections (low flow area) is older than the historic floodplain (upland areas that receive flow only during major flood events) data, which was more recently updated with accurate topography. In short, the model's accuracy for predicting floodwater surface elevations is somewhat diminished "inside" the channel, whereas flood elevations "outside" the channel are more accurate.

Starting Water Surface Elevations

The starting water surface elevations were determined for each model based on stage-discharge curves from the FIS model at the downstream end of the Santa Cruz River model.

Bridge Modeling

All bridges on the Santa Cruz River were modeled using detailed bridge geometry developed for the Santa Cruz River Watershed Study (USACE 2001) HEC-RAS model. Contraction and expansion loss coefficients were set at 0.30 and 0.50, respectively in the cross sections upstream and downstream of bridges. Standard bridge pier loading was used.

Manning's Roughness Coefficients

Manning's roughness coefficients contained in the Pima County FIS model were used initially. These roughness coefficients were subsequently field checked and found to be reasonable. In general, roughness coefficients assigned to the channel, overbanks, and ineffective flow areas were 0.025 – 0.035, 0.035 – 0.070, and 1.00 respectively.

For with project conditions, the roughness coefficients will be increased to reflect the proposed establishment of vegetation along the channel where it does not currently exist.

1.3.1.1 Revised New West Branch Model

At the request of the non-federal sponsor, additional hydraulic analysis was performed subsequent to the Without Project investigation. Based on suspicions that the New West Branch Channel actually has a higher conveyance capacity, field survey data described in Section 2.4.1 was provided by the non-federal sponsor. The Without Project HEC-RAS model was then updated using this new survey information. However, there were two limitations with the new data: 1) the survey locations did not correspond with the original HEC-RAS cross-sections, and were subsequently incorporated into the original model as additional cross-sections; and 2) the new survey only included channel geometric information, i.e. there was no overbank information. Once the original HEC-RAS model was updated with new geometric information, another channel capacity-split flow analysis was performed to determine the amount of water overtopping the left bank. Finally, the left overbank was modeled separately using the flows determined from the split flow analysis to compute the more representative water surface elevations.

1.3.1.1.1 *Revised New West Branch Model Results*

1. The 2-, 5-, 10-, 25-, 50-, 100-, 200-, and 500-year flood events were simulated for the New West Branch channel reach. There are no breakouts for the 50-year flood event. The New West Branch was determined to have a flood conveyance capacity of between a 50- and 100-year flood event within the channel system. The 100-, 200-, and 500-year flood events would overtop the channel banks, primarily the left overbank looking downstream.
2. For the 100-year flood event, approximately 1,120 cfs overtops the left bank. The breakout over the weir (left levee) extends approximately 760 ft with a depth of 1-2 ft. The overbank breakout flow then quickly spreads out onto the overbank where flood depths of approximately one foot are experienced.
3. The 200- and 500-year flood events would overtop the channel similar to the original HEC-RAS model results.
4. Plate 15 in the Without Project Hydraulics Appendix was updated to reflect the changes described above. Specifically, the 50-year floodplain was removed from the left overbank. The 100-year floodplain was redrawn, while the 200- and 500-year floodplains remained the same.
5. Conclusions: The revised without-project overflow analysis for the New West Branch of the Santa Cruz River indicated that the existing channel capacity and

amount of overflow is different from the original hydraulic model results. Applicable hydraulic data tables, overflow maps, and equivalent annual damage estimates were updated based on the results of this analysis.

1.3.2 SANTA CRUZ RIVER WITH PROJECT CONDITIONS ANALYSIS

As part of the project, ecosystem restoration measures are being proposed within the active channel, on the channel banks and the historic overbank floodplain. The predominant method for ecosystem restoration is the establishment of native vegetation species in areas that do not receive high frequency flows. These areas exist within the main channel but are located on terraces that are above low flow channel or 2-year recurrent event water surface elevation.

Stream banks along the Santa Cruz River are highly unstable and nearly vertical cliffs composed of weakly cemented sands, which are highly susceptible to instability from shear stresses during flood events, desiccation and wind erosion from the lack of vegetative cover that would normally provide stability from these erosive forces. Modifications to the present channel geometry important to the ability to construct, re-vegetate and sustain a restored riparian ecosystem include lowering the gradient of the steep channel banks, reducing instability from water and wind erosion. By altering the station versus elevation data on specific River Station cross-sections, the available flow area within the channel can be increased which would result in a lower water surface elevation.

The hydraulic investigation of the potential impacts of the proposed actions for the project can be analyzed by modeling the proposed conditions and comparing the results to the existing conditions. The two major changes to the existing model, adding vegetation for an increased Manning's roughness coefficient and decreasing the steepness of the channel banks through the alteration of station versus elevation data, will allow for the comparison of existing and proposed conditions.

1.3.3 SANTA CRUZ RIVER MODEL ALTERATION

The existing USACE Santa Cruz River Watershed Study HEC-RAS model was used to determine the hydraulic effects of proposed channel alterations on portions of the study area. The limits of the HEC-RAS model for the Santa Cruz River study are located upstream at River Station 40.11 (Los Reales Road) and downstream at River Station 32.62 (Congress Street bridge). River Stations within the model are defined and measured as river miles starting at zero at the mouth of the Santa Cruz and increasing in an upstream direction. There are 73 HEC-RAS River Station (RS) cross-sections and five bridge crossings within the study area model. Areas along the project reach that lacked soil cement bank protection and had sufficient width of adjacent vacant land were identified for the establishment of vegetation and laying back the over steep banks. Areas along the channel that are currently protected by soil cement or areas where development exists in close proximity to the historic floodplain were not altered in the model. Based on these parameters, two main reaches of the model were identified for channel alterations as shown in Table 2:

Table 2: Reach Alteration River Station Limits

Reach	Upstream RS in Reach	Downstream RS in Reach	No. of RS Altered
Upstream	RS 39.16 (Valencia Rd)	RS 36.93 (Irvington Rd)	23
Downstream	RS 35.66 (Ajo Way)	RS 34.34 (Silverlake Rd)	15

The cross-section geometric data for each River Station in these two reaches was examined to determine the existing slopes of the channel banks and the location and value of the Manning's roughness coefficient. Within the station versus elevation data that define the cross-sectional shape of the channel at that River Station, the channel banks that were steeper than a five-on-one vertical to horizontal (5:1 V:H) slope where altered to achieve a 5:1 slope. The station versus elevation data pairs that defined the steep slopes within the cross-section were replaced by proposed station versus elevation data pairs that were set on a 5:1 slope.

Alteration to the existing station versus elevation data pairs was limited to only those data pairs that define the channel geometry at elevations above the 2-year recurrent storm water surface elevation. By preserving geometric data pairs near the invert of the channel, the channel-forming discharge (also known as the bankfull discharge) was left in tact to prevent further instability within the low flow boundaries of the channel.

The location and value of the Manning's roughness coefficient was reviewed and altered for each of the River Stations identified in Table 2. The roughness coefficient is applied to each cross-section by indicating the location and value in the model. The overbank areas, either left overbank or right overbank, usually have higher roughness values than in the channel, which is attributed to the fact that larger vegetation and/or development (resulting in higher roughness values) is more readily able to grow in less flooded areas on the overbanks. Likewise, the channel roughness values are lower because frequent discharges presumably reduce the ability for vegetation to persist.

Manning's roughness values for floodplain (or overbank) areas in the project were set at 0.05, corresponding to the existing scattered brush and trees in the project area. The roughness values for channel areas in the project were set at 0.025; the appropriate value for the existing clean, straight, full stage channel, with no rifts or deep pools. The roughness values (0.05 in the floodplain and 0.025 in the channel) set for the project were unchanged in value, however, the location of where the roughness values were applied was changed in each of the 38 altered River Stations. The left overbank and right overbank areas (roughness set at 0.05) were expanded toward the centerline of the channel to account for the proposed establishment of vegetation on the banks and in the terraces. Likewise, the channel roughness value (set at 0.025) was applied to the reduced lateral extent of the 2-year recurrent storm water surface elevation, where dense vegetation typically does not exist, due to the higher frequency of flow.

1.3.4 SANTA CRUZ RIVER MODEL RESULTS

There was an increase in the 100-year recurrent floodwater surface elevation in 19 of the 38 altered cross-sections due to the change in roughness values within the channel (decreasing horizontal range of 0.025 to only include 2-year event discharges). A rise is defined in this investigation as any increase exceeding 0.1 feet in vertical elevation. The largest rise was 1.53 feet at River Station 37.4, which is located on a meander bend approximately halfway between Irvington Road bridge crossing and Drexel Road. The proposed 100-year recurrent flood event water surface elevation at this, and all other locations showing increases remains within the Santa Cruz River valley banks and would not induce flooding conditions in the historic floodplain.

Thirteen (13) altered cross-section River Stations showed a reduction in the 100-year recurrent flood water surface elevation due primarily to added available flow area from laying back the steep banks to a uniform 5:1 slope. A reduction is defined in this investigation as any decrease in water surface elevation greater than 0.09-feet. River Station 35.66, located immediately downstream from the Ajo Way bridge crossing, exhibited the largest reduction in water surface flood elevation at a minus 2.03 feet. The remaining six cross-section River Stations either exhibited no change in water surface elevation, exhibited an increase between 0 and 0.1 feet, or exhibited a reduction in water surface elevation between 0 and 0.1 feet.

These results are expected and would typically be observed in this type of project where both the roughness and channel geometry are altered for the purpose of ecosystem restoration and bank stability efforts. Table 3 provides a comparison of With and Without Project model results. River stations are measured from the confluence of the Santa Cruz River and Gila River, 35 miles downstream of the study area. Overflow maps are provided in Figures 2a and 2b following Table 3.

Table 3: Santa Cruz River Comparison – With Project

River Station	Profile	Q Total (cfs)	Without Project Water Surface Elevation (ft)	With Project Water Surface Elevation (ft)	Change in Water Surface Elevation (Pro - Ex)ft
40.11	2YR	4900	2469.23	2469.23	0
40.11	100YR	55000	2475.79	2475.79	0
40.01	2YR	4900	2468.45	2468.45	0
40.01	100YR	55000	2472.89	2472.89	0
39.92	2YR	4900	2466.88	2466.88	0
39.92	100YR	55000	2470.83	2470.86	0.03
39.82	2YR	4900	2461.68	2461.68	0
39.82	100YR	55000	2470.64	2470.67	0.03
39.73	2YR	4900	2461.48	2461.48	0
39.73	100YR	55000	2469.91	2469.95	0.04

River Station	Profile	Q Total (cfs)	Without Project Water Surface Elevation (ft)	With Project Water Surface Elevation (ft)	Change in Water Surface Elevation (Pro - Ex)ft
39.63	2YR	4900	2459.64	2459.65	0.01
39.63	100YR	55000	2466.77	2466.5	-0.27
39.54	2YR	4900	2452.28	2452.28	0
39.54	100YR	55000	2468.56	2468.44	-0.12
39.44	2YR	4900	2452.26	2452.25	-0.01
39.44	100YR	55000	2468.32	2468.19	-0.13
39.35	2YR	4900	2452.24	2452.24	0
39.35	100YR	55000	2468.33	2468.2	-0.13
39.25	2YR	4900	2452.24	2452.24	0
39.25	100YR	55000	2468.31	2468.18	-0.13
39.16	2YR	4900	2451.19	2451.19	0
39.16	100YR	55000	2461.3	2461.34	0.04
39.06	2YR	4900	2448.34	2448.36	0.02
39.06	100YR	55000	2460.92	2459.64	-1.28
38.97	2YR	4900	2445.32	2445.32	0
38.97	100YR	55000	2462.12	2461.85	-0.27
38.965	Bridge at Valencia Road				
38.96	2YR	4900	2444.58	2444.58	0
38.96	100YR	55000	2461.85	2461.56	-0.29
38.82	2YR	4900	2444.11	2444.11	0
38.82	100YR	55000	2461.97	2461.64	-0.33
38.73	2YR	4900	2443.98	2443.98	0
38.73	100YR	55000	2461.84	2461.42	-0.42
38.63	2YR	4900	2443.68	2443.68	0
38.63	100YR	55000	2461.52	2460.85	-0.67
38.54	2YR	4900	2441.46	2441.46	0
38.54	100YR	55000	2454.84	2454.7	-0.14
38.44	2YR	4900	2437.64	2437.64	0
38.44	100YR	55000	2448.7	2448.88	0.18
38.35	2YR	4900	2435.89	2435.89	0
38.35	100YR	55000	2449.1	2449.69	0.59

River Station	Profile	Q Total (cfs)	Without Project Water Surface Elevation (ft)	With Project Water Surface Elevation (ft)	Change in Water Surface Elevation (Pro - Ex)ft
38.25	2YR	4900	2435.22	2435.23	0.01
38.25	100YR	55000	2449.04	2449.59	0.55
38.16	2YR	4900	2433.42	2433.42	0
38.16	100YR	55000	2443.53	2443.84	0.31
38.06	2YR	4900	2430.62	2430.61	-0.01
38.06	100YR	55000	2438.59	2439.12	0.53
37.97	2YR	4900	2429.4	2429.29	-0.11
37.97	100YR	55000	2438.19	2438.63	0.44
37.87	2YR	4900	2428.44	2428.34	-0.1
37.87	100YR	55000	2437.85	2438.17	0.32
37.78	2YR	4900	2427.53	2427.54	0.01
37.78	100YR	55000	2435.48	2436.56	1.08
37.69	2YR	4900	2425.24	2425.22	-0.02
37.69	100YR	55000	2432.52	2433.24	0.72
37.59	2YR	4900	2422.32	2422.43	0.11
37.59	100YR	55000	2431.07	2431.52	0.45
37.5	2YR	4900	2420.07	2420.06	-0.01
37.5	100YR	55000	2430.66	2430.6	-0.06
37.4	2YR	4900	2418.3	2418.25	-0.05
37.4	100YR	55000	2428.37	2429.9	1.53
37.31	2YR	4900	2416.32	2416.44	0.12
37.31	100YR	55000	2427.15	2426.74	-0.41
37.21	2YR	4900	2414.97	2415	0.03
37.21	100YR	55000	2426.71	2426.68	-0.03
37.12	2YR	4900	2413.64	2413.62	-0.02
37.12	100YR	55000	2426.35	2426.66	0.31
37.02	2YR	4900	2412.55	2412.53	-0.02
37.02	100YR	55000	2426.06	2426.58	0.52
36.93	2YR	4900	2409.84	2409.85	0.01
36.93	100YR	55000	2425.66	2424.93	-0.73

River Station	Profile	Q Total (cfs)	Without Project Water Surface Elevation (ft)	With Project Water Surface Elevation (ft)	Change in Water Surface Elevation (Pro - Ex)ft
36.83	2YR	4900	2406.66	2406.66	0
36.83	100YR	55000	2425.72	2425.72	0
36.825	Bridge at Irvington				
36.82	2YR	4900	2405.23	2405.23	0
36.82	100YR	55000	2415.19	2415.19	0
36.72	2YR	4900	2403.34	2403.34	0
36.72	100YR	55000	2412.15	2412.15	0
36.63	2YR	4900	2400.53	2400.53	0
36.63	100YR	55000	2412.33	2412.33	0
36.54	2YR	4900	2399.42	2399.42	0
36.54	100YR	55000	2413.18	2413.18	0
36.44	2YR	4900	2398.23	2398.23	0
36.44	100YR	55000	2409.92	2409.92	0
36.35	2YR	4900	2396.84	2396.84	0
36.35	100YR	55000	2408.79	2408.79	0
36.25	2YR	4900	2395.84	2395.84	0
36.25	100YR	55000	2408.43	2408.43	0
36.16	2YR	4900	2394.47	2394.47	0
36.16	100YR	55000	2407.2	2407.2	0
36.06	2YR	4900	2392.93	2392.93	0
36.06	100YR	55000	2405.5	2405.5	0
35.97	2YR	4900	2390.12	2390.12	0
35.97	100YR	55000	2403.03	2403.04	0.01
35.87	2YR	4900	2389.79	2389.79	0
35.87	100YR	55000	2403.1	2403.11	0.01
35.78	2YR	4900	2388.67	2388.67	0
35.78	100YR	55000	2401.88	2401.88	0
35.775	Bridge at Ajo Way				
35.77	2YR	4900	2387.62	2387.62	0
35.77	100YR	55000	2398.6	2398.6	0

River Station	Profile	Q Total (cfs)	Without Project Water Surface Elevation (ft)	With Project Water Surface Elevation (ft)	Change in Water Surface Elevation (Pro - Ex)ft
35.66	2YR	4900	2383.58	2383.58	0
35.66	100YR	55000	2395.78	2393.75	-2.03
35.57	2YR	4900	2382.74	2382.72	-0.02
35.57	100YR	55000	2391.2	2391.22	0.02
35.47	2YR	4900	2381.1	2381.09	-0.01
35.47	100YR	55000	2389.48	2389.98	0.5
35.38	2YR	4900	2379.67	2379.67	0
35.38	100YR	55000	2388.91	2389.75	0.84
35.29	2YR	4900	2377.91	2377.91	0
35.29	100YR	55000	2385.5	2385.78	0.28
35.19	2YR	4900	2376.5	2376.5	0
35.19	100YR	55000	2386.02	2386.06	0.04
35.1	2YR	4900	2375.33	2375.35	0.02
35.1	100YR	55000	2384.83	2384.02	-0.81
35	2YR	4900	2374.06	2373.85	-0.21
35	100YR	55000	2381.4	2381.41	0.01
34.91	2YR	4900	2372.47	2372.56	0.09
34.91	100YR	55000	2382.4	2382.9	0.5
34.81	2YR	4900	2369.62	2369.61	-0.01
34.81	100YR	55000	2379.88	2379.06	-0.82
34.72	2YR	4900	2367.01	2367.05	0.04
34.72	100YR	55000	2379.7	2378.3	-1.4
34.62	2YR	4900	2366.41	2366.45	0.04
34.62	100YR	55000	2377.82	2377.95	0.13
34.53	2YR	4900	2365.24	2365.24	0
34.53	100YR	55000	2378.49	2378.34	-0.15
34.43	2YR	4900	2362.4	2362.4	0
34.43	100YR	55000	2378.3	2377.98	-0.32
34.34	2YR	4900	2359.3	2359.31	0.01
34.34	100YR	55000	2377.32	2376.87	-0.45
34.25	2YR	4900	2357.34	2357.34	0

River Station	Profile	Q Total (cfs)	Without Project Water Surface Elevation (ft)	With Project Water Surface Elevation (ft)	Change in Water Surface Elevation (Pro - Ex)ft
34.25	100YR	55000	2376.17	2376.17	0
34.245	Bridge at Silverlake				
34.24	2YR	4900	2356.23	2356.23	0
34.24	100YR	55000	2367.77	2367.77	0
34.14	2YR	4900	2352.86	2352.86	0
34.14	100YR	55000	2365.45	2365.45	0
34.05	2YR	4900	2350.55	2350.55	0
34.05	100YR	55000	2363.73	2363.73	0
33.95	2YR	4900	2350.35	2350.35	0
33.95	100YR	55000	2365.62	2365.62	0
33.86	2YR	4900	2349.38	2349.38	0
33.86	100YR	55000	2362.38	2362.38	0
33.76	2YR	4900	2348.08	2348.08	0
33.76	100YR	55000	2361.08	2361.08	0
33.755	Bridge at 22nd Street				
33.75	2YR	4900	2346.96	2346.96	0
33.75	100YR	55000	2359.02	2359.02	0
33.66	2YR	4900	2343.92	2343.92	0
33.66	100YR	55000	2359.21	2359.21	0
33.57	2YR	4900	2343	2343	0
33.57	100YR	55000	2359.18	2359.18	0
33.47	2YR	4900	2342.02	2342.02	0
33.47	100YR	55000	2356.6	2356.6	0
33.38	2YR	4900	2340.92	2340.92	0
33.38	100YR	55000	2354.7	2354.7	0
33.28	2YR	4900	2339.79	2339.79	0
33.28	100YR	55000	2352.68	2352.68	0
33.19	2YR	4900	2338.64	2338.64	0
33.19	100YR	55000	2350.77	2350.77	0
33.09	2YR	4900	2338.19	2338.19	0

River Station	Profile	Q Total (cfs)	Without Project Water Surface Elevation (ft)	With Project Water Surface Elevation (ft)	Change in Water Surface Elevation (Pro - Ex)ft
33.09	100YR	55000	2352.45	2352.45	0
33	2YR	4900	2337.02	2337.02	0
33	100YR	55000	2351.65	2351.65	0
32.9	2YR	4900	2334.77	2334.77	0
32.9	100YR	55000	2350.15	2350.15	0
32.81	2YR	4900	2333.55	2333.55	0
32.81	100YR	55000	2350.13	2350.13	0
32.72	2YR	4900	2332.9	2332.9	0
32.72	100YR	55000	2350.07	2350.07	0
32.62	2YR	4900	2331.85	2331.85	0
32.62	100YR	55000	2347.46	2347.46	0
32.615	Bridge at Congress Street				
32.61	2YR	4900	2331.48	2331.48	0
32.61	100YR	55000	2343.46	2343.46	0
32.53	2YR	4900	2330.8	2330.8	0
32.53	100YR	55000	2343.5	2343.5	0
32.44	2YR	4900	2328.25	2328.25	0
32.44	100YR	55000	2340.82	2340.82	0
32.34	2YR	4900	2325.37	2325.37	0
32.34	100YR	55000	2341.27	2341.27	0
32.25	2YR	4900	2323	2323	0
32.25	100YR	55000	2340.48	2340.48	0
32.15	2YR	4900	2321.94	2321.94	0
32.15	100YR	55000	2341.06	2341.06	0
32.06	2YR	4900	2320.98	2320.98	0
32.06	100YR	55000	2340.87	2340.87	0
31.96	2YR	4900	2319.87	2319.87	0
31.96	100YR	55000	2339.73	2339.73	0
31.955	Bridge at St. Marys				
31.95	2YR	4900	2318.71	2318.71	0

River Station	Profile	Q Total (cfs)	Without Project Water Surface Elevation (ft)	With Project Water Surface Elevation (ft)	Change in Water Surface Elevation (Pro - Ex)ft
31.95	100YR	55000	2332.88	2332.88	0
31.82	2YR	4900	2315.83	2315.83	0
31.82	100YR	55000	2328.3	2328.3	0
31.73	2YR	4900	2314.02	2314.02	0
31.73	100YR	55000	2328.03	2328.03	0
31.63	2YR	4900	2311.68	2311.68	0
31.63	100YR	55000	2327.63	2327.63	0
31.54	2YR	4900	2310.72	2310.72	0
31.54	100YR	55000	2328.56	2328.56	0
31.53		Bridge at Speedway			
31.52	2YR	4900	2310.13	2310.13	0
31.52	100YR	55000	2323.43	2323.43	0

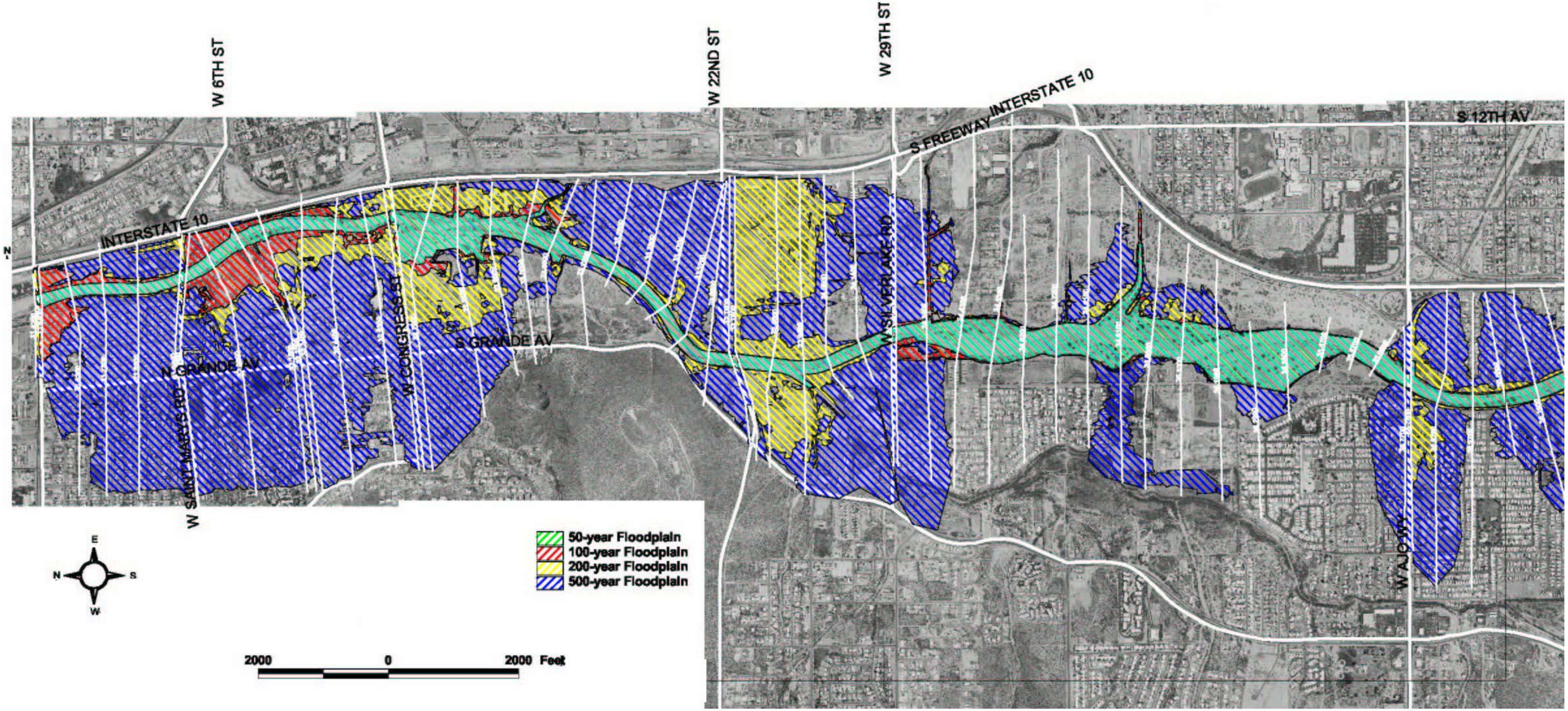


Figure 3 Santa Cruz River With Project Floodplain
Northern Portion of Study Area

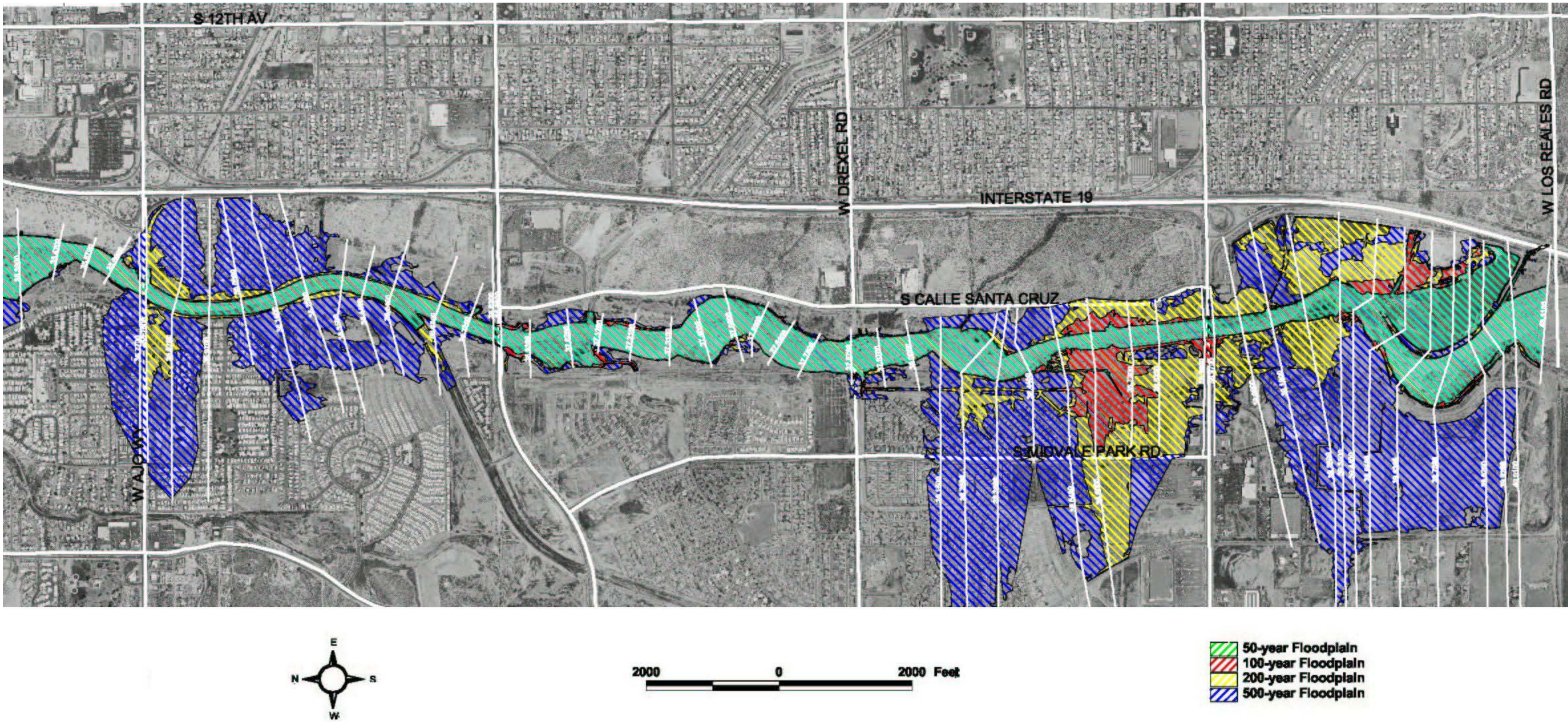


Figure 4 Santa Cruz River With Project Floodplain
Southern Portion of Study Area

1.3.5 SEDIMENT BUDGET ANALYSIS

To date, a sediment budget level of analysis was undertaken for the Without Project Condition only. The computer program SAM (WES, 1997) was used for the sediment budget analysis. More detailed analysis (e.g., HEC-6, HEC, 1993) program model approach will be utilized once a recommend plan is identified for design purposes.

In general, the previous analysis results indicate that there would be significant to moderate degradation at both the extreme upstream and downstream reaches and to a lesser extent within the middle reaches. In other words, almost all of the entire study reach was found to be subject to some overall degradation. However, a full comprehension of the results especially at the upstream and downstream limit of the study reach needs to be expanded upon. In the case of the upstream reach, the deep scour phenomenon may be the result of the equilibrium conditions that were assumed for this reach. Whereas, for the downstream reach, the obvious effects of the existing grade control structure downstream of Congress Street could not be incorporated in the sediment budget model. Hence, the application of a sediment budget analysis inherently suffers several notable shortcomings as a penalty for the simple and expedient nature of the calculations. Specifically, the analysis does not properly restrict the deposition of the wash load from the supply reach; it does not revise the hydraulic characteristics of the stream to reflect the changes in bed slope caused by scour and deposition; it does not account for the effect of changes in the bed material composition on the computed sediment transport capacities; and it does not account for armoring of the streambed that would limit degradation. Because of these simplifications, a sediment budget analysis typically overestimates aggradation and degradation. This overestimation is evident in the results for the upstream reach of the Santa Cruz River. In addition, a sediment budget analysis is extremely sensitive to the selection of subreaches and representative cross sections. Relatively minor differences in average hydraulic characteristics, particularly velocity, can translate into large differences in computed average bed changes. For these reasons, firm conclusions as to the stability of the study reach could not be drawn from the limited sedimentation computations. However, the reach did appear to exhibit a progression toward quasi-equilibrium by a lessening in the erosion rate.

Because of the inadequacies of the sediment budget analysis, the historical behavior of the existing stream was reviewed to add additional clarity in assessing the stability of this reach of the Santa Cruz River. The following excerpt was extracted from the Santa Cruz River Management Study (SLA, 1986):

"*USGS data suggest that there may have been vertical stability during the early to mid 19th century, but that this reach has been degrading since the 1950's. There have been multiple references to degradation along specific reaches of the Santa Cruz River during the late 1950's to the mid 1960's. Ajo Way to Grant Road experienced 10 to 15 feet of degradation, while 6 to 8 feet of degradation occurred between Speedway Boulevard and Valencia Road. This change may be partially due to the extensive use of materials from the Santa Cruz River streambed during the construction of the I-10 highway during the late 1950's/early 1960's. While subsequent bed profiles show a slight recovery, the overall profile of the streambed has still degraded by one to four feet through the Tucson Urban Reach since*

1947. Historic lateral changes are not easily identified through this reach of the river due to extensive fill and channelization. There is general agreement that this reach is well defined and incised; however, any documentation of the lateral changes may suffer due to the intensive channel work performed in the metropolitan area.

The floods of 1983 were a significant test of lateral and channel stability. During this event, the unstabilized embankments along two reach locations—one reach located just upstream of and within the southern end (i.e., between I-19 and Ajo Way), and the other reach located at the northern end of the Tucson Urban Reach (i.e., just downstream of Grant Road to the Silverbell Golf Course)—experienced significant erosion/lateral migration (i.e., from 200 feet to 500 feet)."

1.3.6 BANK EROSION

1.3.6.1 Background

The bank erosion study was limited to the Santa Cruz River. The New West Branch was not studied since its banks are lined with concrete/soil cement. This was the same case for the Los Reales Improvement District area. The Old West Branch was not studied due to plan formulation constrains that preclude structural channel modifications.

1.3.6.2 Geomorphic Relationships

Since there is no official guidance on determining bank erosion, several widely acceptable technical approaches within the hydraulic community were used in the study. The processes and methodologies were found in the following references:

a. EM 1110-2-1418, "Channel Stability Assessment for Flood Control Channels" (US Army Corps of Engineers, 1994). The section titled "Channel Evolution and Geomorphic Thresholds" has guidance on distinguishing braided from non-braided channels. The channel slope of the study area is approximately 0.003. In natural streams the channel-forming discharge can often be taken as equivalent to the bank-full discharge. In terms of flood frequency, a return period of around 2 years appears to be common in the eastern half of the United States. However, in the western United States area, a return period between 5 and 10 years is more appropriate (the latter for urban and channelized streams). The channel forming discharge is between 4900 cfs (2-year flood event) and 14000 cfs (10-year flood event). This range of data was plotted on Figure 2-24. The Leopold & Wolman 1957 braided vs. meandering separation line was used to distinguish between braided and meandering channels. According to this figure, this reach of the Santa Cruz River is of the braided type.

b. Rosgen Classification System (Rosgen, 1996). This reach of the Santa Cruz River has a slope of 0.003, sinuosity less than 1.2, has multiple channels, and consists of sands and gravels. According to the Rosgen Classification System, it can be classified as a D4 or D5 channel. Rosgen describes a D5 channel as follows: "The D5 stream types are multiple channel systems described as braided streams... The braided channel system is characterized by high bank erosion rates, excessive deposition occurring as both longitudinal and transverse bars, and annual shifts of the bed location. A combination of adverse conditions are responsible for channel braiding, including high sediment supply, high bank erodibility, moderately steep gradients, and very flashy runoff conditions which can vary rapidly from a base flow to an over-bank flow on a frequent basis (Rosgen, 1996)."

c. Restoring Streams in Cities (Riley, 1998). According to the book: "A braided stream channel is typically wide and shallow and contains a number of separated channels that flow in and around mid-channel sediment bars and islands. Braided channels usually indicate that a stream is supplied with more sediment than it can carry. Other conditions that can lead to braiding are steep slopes, coarse materials with low erosion resistance, sediments deposited at grade changes, and aggradation that allows the channel to shift course…A braided stream is unstable, changes its alignment rapidly, carries large amounts of sediment, is wide and shallow even at flood flows, and is in general unpredictable." This reach of the Santa Cruz River certainly fits this description.

d. USGS Water Supply Paper 2429, Channel Change on the Santa Cruz River, Pima County, Arizona, 1936-86 (USGS, 1995). This paper contained some historical and geomorphic information.

1.3.6.3 Existing Bank Protection

In response to historical flooding and lateral bank erosion, Pima Count and the City of Tucson initiated a program of bank stabilization. Many areas in the study reach were channelized and the banks lined with soil cement revetments. Soil cement grade control structures were also installed to prevent scour at selected bridges. Currently, the following areas of the Santa Cruz River are completely bank protected with soil cement and were excluded from this analysis:

- Upstream and downstream of the Valencia Road Bridge,
- Irvington Road to Ajo Way, and
- Silverlake Road to Congress Street.

There are three (3) remaining gaps that are currently unprotected:

- Los Reales Road to south of Valencia Road,
- North of Valencia Road to Irvington Road, and
- Ajo Way to Silverlake Road.

1.3.6.4 Historical Bank Erosion Information

The following excerpts from USGS Water Supply Paper 2429 (1995) pertain to this study reach:

"*The Tucson reach has shown the least lateral instability during the period. Either much of the apparent stability is artificial—because of bank armoring, which has prevented channel change, or of artificial filling, which has obscured the record of change occurring between 1936 and 1986. Parts of the reach underwent about 15 ft of degradation between the 1950's and 1976*."

"*Arroyo change along other reaches of the Santa Cruz River is difficult to evaluate because the Tucson and Sahuarita reaches have been subject to extensive human alteration and much of the apparent lateral stability of the reaches is artificial. For example, according to bridge specifications prepared in 1916, the channel at Congress Street in the Tucson reach widened to 375 ft during the floods of 1914-15, but subsequent artificial filling reduced width at that location to less than 200 ft. Two motels now stand on landfill above the site of the migrating meander that destroyed the Congress Street bridge in 1915. In contrast to the San Xavier reach, most arroyo widening of the upper Tucson reach took place in the 1950's, and little widening occurred thereafter except locally as a result of the flood of 1983. Some of the arroyo widening that took place between Silverlake Road and Congress Street in the 1950's may have been associated with construction activity that is visible in aerial photographs of 1960…The most pronounced arroyo widening occurred from Silverlake Road to Grant Road during 1953-60 before degradation had begun at most locations in the Tucson reach. Between Silverlake Road and Congress Street, the rate of arroyo widening was constant from 1953 to 1971. From Congress Street to Grant Road, however, no significant arroyo widening occurred between 1960 and 1978 even though this was a period of maximum incision and subsequent vertical fluctuation. After the flood of 1983, only the part of the Tucson reach from Congress Street to Speedway Boulevard showed a significant increase in mean arroyo width*."

"Between 1915 and 1929, extensive arroyo widening occurred during 1914-15 floods throughout the reach and the Congress Street bridge was destroyed. Between 1930 and 1959, extensive widening occurred between Speedway Boulevard and Grant Road and channel degradation begins during the later years. Between 1960 and 1986, the arroyo widths were generally stable. There was apparent narrowing at some locations caused by channelization and landfill operations. As much as 15 ft of arroyo incision occurred. There was substantial arroyo wall retreat along unprotected segments of the reach as a result of 1983 flood."

Table 4 summarizes the amount of bank movement between 1941 and 2002. Within the study reach, there was major arroyo widening throughout the study period. There was considerable degradation in the 1950's and 1960's. Artificial changes include extensive channelization and armoring; and landfill operations. There was sand-gravel mining at Valencia Road. There were some armoring, highway fill, and landfill at other locations.

At some locations, the banks generally did not move. This is expected in geologically confined reaches and reaches with bank protection. At other locations, the banks moved as much as 900 ft within the past 60 years. In addition, the migration rate per year for each bank was determined by dividing the migration amount by the number of years between the photographs, i.e. the migration rate was linearized from the historical data.

Table 4: Bank Erosion Between 1941-2002

Year	Bank Width	Lt. Bank Erosion	Rt. Bank Erosion	Lt. Bank Erosion Rate Per Year	Rt Bank Erosion Rate Per Year
Station 34.43					
1941	180				
1960	130	40	60	2	3
2002	650	350	170	8	4
Station 35.66					
1941	220				
1960	250	420	380	22	20
2002	330	380	460	9	11
Station 37.50					
1941	610				
1960	360	340	680	18	36
2002	890	380	850	9	20

1.3.6.5 Erosion Hazard Boundary Mapping

Erosion hazard boundary maps from the Santa Cruz River Management Study (SLA, 1986) were also considered in this study. The subject report developed a map identifying potential erosion-hazard areas based on lateral-migration measurements and a time-sequence series of historical photographs. They present the “worst-case” estimates of the potential bank erosion limits of the Santa Cruz River. The erosion limits within the study area were manually digitized and is illustrated in Plate 19.

The Pima County Flood Control District provided digitized historical aerial photographs of the Santa Cruz River study reach dated 1941 and 1969. The digitized photographs were not georeferenced or orthorectified. Using an ArcView extension, the photographs were georeferenced only. They were not orthorectified since this is a more involved process. The left and right banks were then digitized. Given the original conditions of the photographs, the historical bank locations are not exact but were determined to be adequate for this level of study.

Recent geologic banks were determined from reviewing the historical aerial photographs and viewing the shape of the topographic lines along the Santa Cruz River study reach. The boundaries were initially set to include all areas where abandoned meander features were found as well as extending to the areas where the contour lines changed direction from following the regional slopes to being perpendicular to the river channel. This coverage should be fairly close to the maximum historical meander belt for the river in this reach. It varies from approximately 0.5 mile in width at 22nd Street to approximately 1.5 miles in width at Valencia Road. Lateral migration would not be expected to exceed these limits.

1.3.6.6 Conclusions

The purpose of this erosion investigation was to determine the maximum bank erosion as well as the average annual bank erosion along the study reach of the Santa Cruz River. The references cited in this section contained numerous historical material for the Santa Cruz River and geomorphic relationships for natural streams. However, there was no information or guidance to calculate average annual bank erosion for braided type streams. To complicate matters, there were several artificial features that affected the bank stability of the study reach, i.e. bridge abutment fill, bank armoring, gravel mining, etc.

For the reasons stated above, it was determined that a simplified methodology would be used to determine the maximum bank erosion; it would be inappropriate at this time to determine an average annual erosion rate given all the uncertainties. Using a combination of all the methods and historical information described above, a maximum bank erosion set of limits was developed and is illustrated on Plate 19.

It is anticipated that the With Project Conditions bank erosion analysis will not significantly change from the Without Project analysis. The flattening of unprotected banks and introduction of vegetative habitat may prevent bank erosion and lateral head cutting during frequent storm events, however these measures are unlikely to provide sufficient bank stability infrequent (e.g., 50 to 500-year) storm events.

1.4 NEW WEST BRANCH WITH PROJECT CONDITIONS

1.4.1 ALTERNATIVES ANALYSES

The revised without project conditions HEC-RAS model for the New West Branch was modified to determine the impacts of two proposed alternatives. These alternatives are NWB-1 (Channel Invert Excavation), NWB-2 (raise Existing Levees), and NWB-3 (Floodwalls).

1.4.1.1 Alternative NWB-1 (Channel Dredging)

The without project hydraulic model was modified to determine the impacts of channel dredging. The following impacts or concerns were identified:

a) Excavation can increase the conveyance of the New West Branch up to the 100-yr flood event only. Up to two (2) ft of excavation is necessary.
b) Excavation alone would not contain the 200- and 500-yr flood events.
c) The existing grade control structure at Station 6.0 would need to be modified (i.e., lowered or reconstructed) as well as the key-in to the existing bank protection.
d) The existing footbridge upstream of Drexel Road would need to be removed or replaced.

e) Excavation may result in undermining of the existing soil cement bank protection. The toe down depth(s) of the existing soil cement bank protection is unknown and cannot be verified. Additional field exploration will be required to determine structural integrity, toe-down depths, and subsurface conditions behind and under the soil cement.

The results of this evaluation are presented in Figures 5 and 6 and Table 5.

1.4.1.2 Alternative NWB-2 and NWB-3

Low levees currently exist along both channel banks, however they do not contain the 100, 200, and 500-year flows. An alternative analysis was performed to determine effects of raising the existing levees to protect for the 100 through 500-year flood events. As built drawings for the existing levees and bank protection are not available therefore, for engineering design and cost estimating purposes, the existing levees were assumed to be structurally inadequate, therefore new engineered levees are assumed. Due to the high velocities and possibility of run-up at the curve, rigid armoring (i.e., soil cement) is recommended for the inside slopes of the levees.

The results of the evaluation and required levee heights for each respective design storm are presented in Table 6.

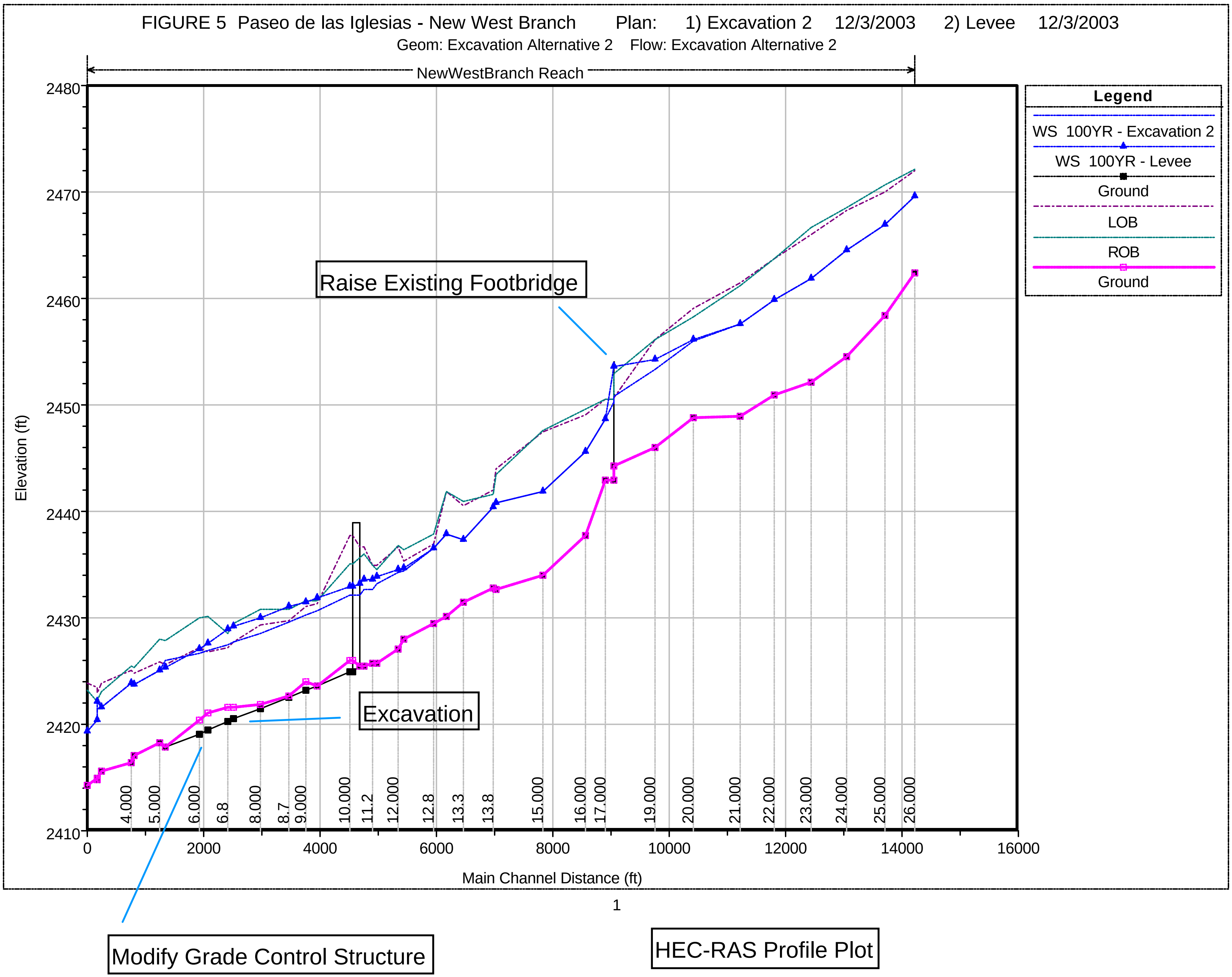
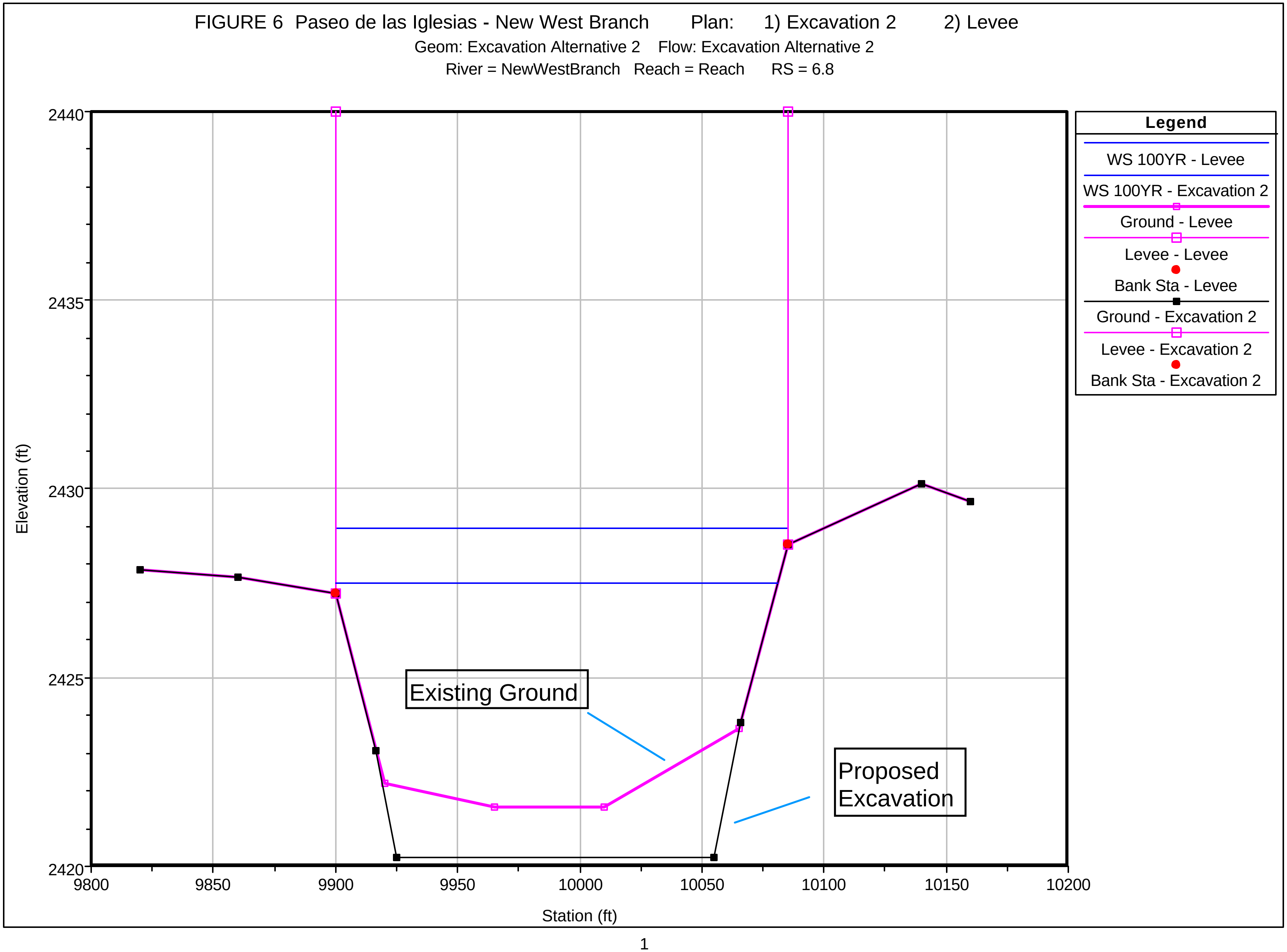


FIGURE 5 Paseo de las Iglesias - New West Branch Plan: 1) Excavation 2 12/3/2003 2) Levee 12/3/2003
Geom: Excavation Alternative 2 Flow: Excavation Alternative 2
NewWestBranch Reach
Legend
WS 100YR - Excavation 2
WS 100YR - Levee
Ground
LOB
ROB
Ground
Raise Existing Footbridge
Excavation
Modify Grade Control Structure
HEC-RAS Profile Plot
Elevation (ft)
Main Channel Distance (ft)
2480
2470
2460
2450
2440
2430
2420
2410
0
2000
4000
6000
8000
10000
12000
14000
16000
4.000
5.000
6.000
6.8
8.000
8.7
9.000
10.000
11.2
12.000
12.8
13.3
13.8
15.000
16.000
17.000
19.000
20.000
21.000
22.000
23.000
24.000
25.000
26.000
1



Typical Cross-Section

TABLE 5 HEC-RAS Plan: Excavation 2 River: NewWestBranch Reach: Reach Profile: 100YR

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach	1.000	100YR	9908.00	2414.25	2419.37	2419.37	2421.76	0.005646	12.42	797.89	165.90	1.00
Reach	1.9	100YR	9908.00	2415.00	2420.44	2420.44	2422.76	0.005491	12.24	809.58	173.32	1.00
Reach	2.000	100YR	9908.00	2414.78	2422.13	2420.63	2422.99	0.002886	7.43	1334.23	375.13	0.69
Reach	3.000	100YR	9908.00	2415.55	2421.54	2421.22	2423.58	0.004423	11.47	863.44	172.99	0.91
Reach	4.000	100YR	9908.00	2416.43	2423.87	2422.19	2425.14	0.002102	9.05	1095.26	179.15	0.64
Reach	4.2	100YR	9908.00	2417.00	2423.76	2422.80	2425.37	0.003119	10.19	972.70	179.52	0.77
Reach	5.000	100YR	9908.00	2418.25	2425.11	2423.96	2426.65	0.002776	9.96	994.70	173.40	0.73
Reach	5.2	100YR	9908.00	2417.80	2425.95	2423.17	2426.89	0.001285	7.80	1270.47	178.32	0.51
Reach	6.000	100YR	9908.00	2419.13	2426.71	2424.46	2427.77	0.001579	8.25	1201.48	181.41	0.56
Reach	6.3	100YR	9908.00	2419.46	2426.87	2424.86	2428.06	0.001803	8.73	1134.46	173.47	0.60
Reach	6.8	100YR	9908.00	2420.25	2427.51	2425.70	2428.73	0.001984	8.85	1119.35	180.83	0.63
Reach	7.000	100YR	9908.00	2420.47	2427.74	2425.87	2428.93	0.001920	8.75	1132.23	181.65	0.62
Reach	8.000	100YR	9908.00	2421.47	2428.57	2426.87	2429.84	0.002103	9.07	1092.72	177.93	0.64
Reach	8.7	100YR	9908.00	2422.59	2429.62	2428.01	2430.92	0.002189	9.14	1083.69	179.72	0.66
Reach	9.000	100YR	9908.00	2423.25	2430.28	2428.63	2431.57	0.002176	9.09	1089.89	181.53	0.65
Reach	9.2	100YR	9908.00	2423.57	2430.70	2429.14	2432.03	0.002275	9.23	1073.62	182.32	0.67
Reach	10.000	100YR	9908.00	2424.94	2432.07	2430.19	2433.17	0.001826	8.40	1178.98	193.51	0.60
Reach	10.5		Bridge									
Reach	11.000	100YR	9908.00	2425.48	2432.71	2430.83	2433.93	0.001926	8.86	1118.66	176.34	0.62
Reach	11.2	100YR	9908.00	2425.77	2432.63	2432.01	2434.52	0.003689	11.03	898.16	166.47	0.84
Reach	11.3	100YR	9908.00	2425.70	2433.16	2432.15	2434.78	0.003038	10.23	968.72	174.06	0.76
Reach	12.000	100YR	9908.00	2427.04	2434.22	2433.27	2435.94	0.003105	10.51	942.36	164.96	0.78
Reach	12.2	100YR	9908.00	2428.00	2434.39	2433.89	2436.37	0.004013	11.30	877.01	167.11	0.87
Reach	12.8	100YR	9908.00	2429.50	2436.56	2435.19	2437.98	0.002463	9.56	1036.35	175.69	0.69
Reach	13.000	100YR	9908.00	2430.08	2437.84	2435.69	2438.45	0.001304	6.24	1588.68	318.09	0.49
Reach	13.3	100YR	9908.00	2431.52	2437.35	2437.35	2439.86	0.005442	12.69	780.73	156.75	1.00
Reach	13.8	100YR	9908.00	2432.76	2440.45	2438.31	2441.27	0.001420	7.27	1362.91	229.94	0.53
Reach	14.000	100YR	9908.00	2432.60	2440.80	2437.68	2441.36	0.000842	6.04	1639.74	246.62	0.41
Reach	15.000	100YR	9908.00	2434.04	2441.82	2441.82	2444.26	0.005392	12.53	790.67	160.29	0.99
Reach	16.000	100YR	9908.00	2437.70	2445.60	2445.18	2447.75	0.004193	11.76	842.55	155.97	0.89
Reach	17.000	100YR	9908.00	2442.96	2448.67	2448.67	2451.07	0.005484	12.43	797.12	164.41	0.99
Reach	17.5		Bridge									
Reach	18.000	100YR	9908.00	2444.29	2450.86	2450.06	2452.71	0.003608	10.93	906.18	165.90	0.82
Reach	19.000	100YR	9908.00	2446.01	2453.32	2452.51	2455.22	0.003423	11.06	895.89	156.02	0.81
Reach	20.000	100YR	9908.00	2448.79	2456.03	2454.62	2457.06	0.002229	8.16	1213.53	242.86	0.64
Reach	21.000	100YR	9908.00	2448.97	2457.62	2456.96	2459.62	0.003657	11.34	874.07	154.39	0.84
Reach	22.000	100YR	9908.00	2450.92	2459.81	2458.95	2461.68	0.003281	10.97	903.34	154.56	0.80
Reach	23.000	100YR	9908.00	2452.07	2461.86	2461.64	2464.28	0.004654	12.48	793.62	144.70	0.94
Reach	24.000	100YR	9908.00	2454.54	2464.56	2463.77	2466.74	0.003502	11.84	837.13	133.33	0.83
Reach	25.000	100YR	9908.00	2458.40	2466.90	2466.65	2469.54	0.004559	13.04	759.86	127.70	0.94
Reach	26.000	100YR	9908.00	2462.46	2469.55	2469.48	2471.98	0.005118	12.53	790.64	154.60	0.98

HEC-RAS Standard Output Table for Proposed Excavation Alternative

Table 6. New West Branch of the Santa Cruz River Required Levee Elevations

Station[1]	WSEL[2] (ft)			Existing Top of Levee (ft)		Minimum Top of Levee[3] (ft)			Minimum Required Levee Raising[4] (ft)					
									100-yr		200-yr		500-yr	
	100-yr	200-yr	500-yr	Left Levee	Right Levee	100-yr	200-yr	500-yr	Left Levee	Right Levee	Left Levee	Right Levee	Left Levee	Right Levee
1	2419.4	2420.0	2420.6	2423.8	2423.2	2421.4	2422.0	2422.6	-2.5	-1.8	-1.8	-1.2	-1.2	-0.6
1.9	2420.4	2421.1	2421.7	2423.5	2422.1	2422.4	2423.1	2423.7	-1.0	0.3	-0.3	1.0	0.3	1.6
2	2422.1	2423.3	2424.2	2423.0	2422.2	2424.1	2425.3	2426.2	1.2	1.9	2.3	3.1	3.2	4.0
3	2421.5	2422.4	2423.2	2423.9	2423.1	2423.5	2424.4	2425.2	-0.4	0.5	0.5	1.3	1.3	2.1
4	2423.9	2424.6	2425.3	2425.1	2425.4	2425.9	2426.6	2427.3	0.8	0.4	1.5	1.2	2.3	1.9
4.2	2423.8	2424.5	2425.2	2424.8	2425.3	2425.8	2426.5	2427.2	1.0	0.5	1.7	1.2	2.4	2.0
5	2425.1	2425.8	2426.5	2425.9	2428.1	2427.1	2427.8	2428.5	1.2	-0.9	1.9	-0.2	2.5	0.4
5.2	2425.3	2426.1	2426.7	2425.6	2427.9	2427.3	2428.1	2428.7	1.8	-0.6	2.5	0.2	3.1	0.8
6	2427.1	2427.9	2428.5	2427.3	2430.0	2429.1	2429.9	2430.5	1.9	-0.9	2.6	-0.1	3.3	0.5
6.3	2427.6	2428.3	2429.0	2426.8	2430.1	2429.6	2430.3	2431.0	2.8	-0.5	3.5	0.2	4.1	0.8
6.8	2429.0	2429.8	2430.5	2427.2	2428.5	2431.0	2431.8	2432.5	3.8	2.4	4.5	3.2	5.2	3.9
7	2429.3	2430.1	2430.8	2427.7	2429.5	2431.3	2432.1	2432.8	3.5	1.7	4.4	2.6	5.1	3.3
8	2430.0	2430.8	2431.5	2429.4	2430.8	2432.0	2432.8	2433.5	2.6	1.2	3.5	2.1	4.2	2.8
8.7	2431.1	2432.0	2432.7	2429.8	2430.8	2433.1	2434.0	2434.7	3.3	2.3	4.2	3.2	4.9	3.9
9	2431.5	2432.4	2433.1	2431.0	2431.6	2433.5	2434.4	2435.1	2.5	1.8	3.3	2.7	4.1	3.4
9.2	2431.9	2432.7	2433.4	2431.3	2431.7	2433.9	2434.7	2435.4	2.6	2.3	3.4	3.1	4.1	3.8
10	2432.9	2433.7	2434.5	2437.7	2435.0	2434.9	2435.7	2436.5	-2.8	-0.1	-2.0	0.7	-1.2	1.5
11	2433.6	2434.4	2435.3	2436.7	2436.0	2435.6	2436.4	2437.3	-1.1	-0.5	-0.2	0.4	0.6	1.3
11.2	2433.6	2434.5	2435.3	2435.0	2435.0	2435.6	2436.5	2437.3	0.6	0.6	1.4	1.4	2.3	2.3
11.3	2433.8	2434.7	2435.5	2435.0	2434.6	2435.8	2436.7	2437.5	0.8	1.2	1.7	2.1	2.5	2.9
12	2434.5	2435.3	2436.1	2436.7	2436.8	2436.5	2437.3	2438.1	-0.2	-0.3	0.6	0.6	1.4	1.3
12.2	2434.7	2435.5	2436.2	2435.3	2436.4	2436.7	2437.5	2438.2	1.3	0.3	2.1	1.1	2.9	1.9
12.8	2436.5	2437.3	2437.9	2436.9	2437.9	2438.5	2439.3	2439.9	1.6	0.6	2.4	1.3	3.1	2.0
13	2437.8	2438.8	2439.6	2441.9	2441.9	2439.8	2440.8	2441.6	-2.1	-2.1	-1.2	-1.2	-0.3	-0.3
13.3	2437.4	2438.1	2438.7	2440.6	2440.9	2439.4	2440.1	2440.7	-1.2	-1.6	-0.5	-0.8	0.1	-0.2
13.8	2440.5	2441.3	2442.1	2442.0	2441.7	2442.5	2443.3	2444.1	0.4	0.8	1.3	1.7	2.1	2.5
14	2440.8	2441.7	2442.5	2444.0	2443.5	2442.8	2443.7	2444.5	-1.2	-0.7	-0.4	0.2	0.4	1.0
15	2441.8	2442.5	2443.1	2447.5	2447.6	2443.8	2444.5	2445.1	-3.6	-3.8	-2.9	-3.1	-2.3	-2.5
16	2445.6	2446.3	2446.8	2449.1	2449.6	2447.6	2448.3	2448.8	-1.5	-2.0	-0.8	-1.3	-0.2	-0.8
17	2448.7	2449.4	2450.0	2450.5	2450.5	2450.7	2451.4	2452.0	0.2	0.2	0.9	0.8	1.5	1.5
18	2453.7	2453.9	2454.1	2450.7	2453.0	2455.7	2455.9	2456.1	4.9	2.7	5.2	3.0	5.4	3.2
19	2454.3	2454.8	2454.9	2456.1	2456.1	2456.3	2456.8	2456.9	0.2	0.2	0.7	0.6	0.8	0.8
20	2456.1	2456.9	2457.7	2459.1	2458.3	2458.1	2458.9	2459.7	-1.0	-0.2	-0.1	0.7	0.7	1.5
21	2457.6	2458.2	2458.7	2461.4	2461.2	2459.6	2460.2	2460.7	-1.8	-1.6	-1.2	-1.0	-0.7	-0.5
22	2459.8	2460.7	2461.4	2463.8	2463.7	2461.8	2462.7	2463.4	-2.0	-1.9	-1.1	-1.0	-0.4	-0.3
23	2461.9	2462.6	2463.2	2466.1	2466.6	2463.9	2464.6	2465.2	-2.2	-2.8	-1.5	-2.0	-0.8	-1.4
24	2464.6	2465.3	2466.0	2468.3	2468.5	2466.6	2467.3	2468.0	-1.7	-1.9	-0.9	-1.1	-0.3	-0.5
25	2466.9	2467.7	2468.5	2470.0	2470.7	2468.9	2469.7	2470.5	-1.1	-1.8	-0.3	-1.0	0.4	-0.2
26	2469.6	2470.5	2471.3	2472.1	2472.2	2471.6	2472.5	2473.3	-0.5	-0.6	0.4	0.3	1.2	1.1

Notes:

1. Station numbers with decimals are from additional Pima County survey data.
2. HEC-RAS computed water surface elevations.
3. 95% confidence levee elevation (computed water surface elevation + 2.0 ft).
4. Negative numbers indicate locations where levee raising is not necessary.

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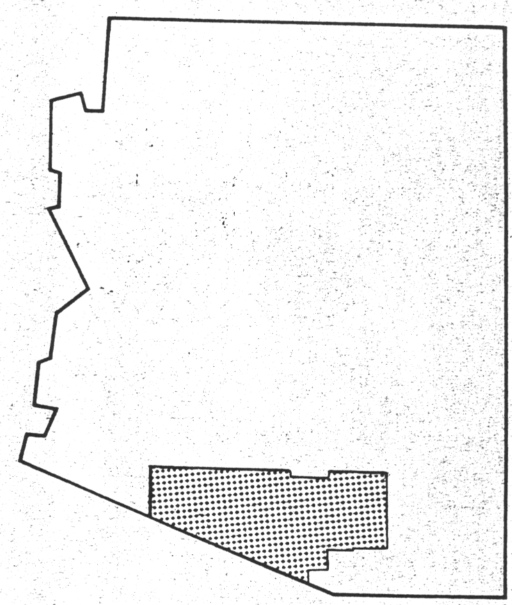
FLOOD INSURANCE STUDY

PIMA COUNTY, ARIZONA

AND INCORPORATED AREAS

VOLUME 1 OF 3



COMMUNITY NAME	COMMUNITY NUMBER
MARANA, TOWN OF	040118
ORO VALLEY, TOWN OF	040109
PIMA COUNTY, UNINCORPORATED AREAS	040073
SAHUARITA, TOWN OF	040137
SOUTH TUCSON, TOWN OF	040075
TUCSON, CITY OF	040076

REVISED: FEBRUARY 8, 1999

FEDERAL EMERGENCY MANAGEMENT AGENCY

Federal Emergency Management Agency

Table 2. Summary of Discharges (Cont'd)

Flooding Source and Location	Drainage Area (Square Miles)	Peak Discharges (cfs) 10-Year	50-Year	100-Year	500-Year
Ruelas Canyon					
Downstream of confluence with Unnamed Canyon	56.6	--[1]	--[1]	6,562	--[1]
At Apex	3.58	1,800	4,460	5,990	10,470
Sabino Creek					
Above confluence with Tanque Verde Creek	66.4	4,900	12,000	18,000	36,000
Above confluence with Bear Creek	36.8	3,750	8,500	12,500	25,000
Sahuara Wash					
At Pima Street	0.4	--[1]	--[1]	622	--[1]
San Juan Wash					
At confluence with West Branch Santa Cruz River	1.2	--[1]	--[1]	2,165	--[1]
1,300 feet upstream of Mission Road	1.1	--[1]	--[1]	2,420	--[1]
At Greasewood Road	0.4	--[1]	--[1]	1,125	--[1]
Santa Clara Wash					
At Interstate Highway 19	0.3	--[1]	--[1]	705	--[1]
Santa Cruz River					
At Cortaro Road	3,503	21,800	48,000	70,000	107,400
Above confluence with Canada del Oro Wash	3,232	21,800	48,000	70,000	107,400
At Cortaro Farms Road	3,053	21,800	48,000	70,000	107,400
Above confluence with Rillito Creek	2,282	16,800	41,000	60,000	93,000
At Congress Street	2,222	16,800	41,000	60,000	93,000
At Drexel Road	2,101	16,800	41,000	60,000	93,000
At Continental Road	1,662	--[1]	--[1]	45,000	--[1]

See LOMR 7-24-00

[1]Data not computed

```
T1       EMW-94-C-4542 (MMLA Job No. 92145-03)
T2       City of Tucson FIS (FEMA '94)
T3       West Branch SCR 100-yr Floodplain
J1      0       2       0       0   0.011       0     0.0  6621.0
J2     -1       1     0.0     0.0     0.0     0.0     0.0     0.0     0.0
J6      1       0     0.0
NC 0.045    0.045   0.035     0.1     0.3
X1    0.5       9    67.5   117.5     0.0     0.0     0.0     1.0     0.0
GR2366.0      0.0  2366.0    50.0  2365.5    60.0  2365.0    67.5  2347.5    84.0
GR2347.5    101.0  2365.0   117.5  2365.5   125.0  2370.0   130.0
NC 0.055    0.055   0.035     0.1     0.3
X1      1       9   140.0   180.0   505.0   505.0   505.0     1.0     0.0
GR2370.0      0.0  2370.0   125.0  2360.0   140.0  2353.0   155.0  2353.0   165.0
GR2360.0    180.0  2370.0   190.0  2372.0   240.0  2374.0   300.0
NC 0.055    0.055   0.035     0.1     0.3
X1      2      10   168.0   200.0   520.0   520.0   520.0     1.0     0.0
GR2372.0      0.0  2370.0   130.0  2360.0   168.0  2356.0   180.0  2356.0   190.0
GR2360.0    200.0  2370.0   220.0  2372.0   225.0  2374.0   270.0  2376.0   315.0
NC 0.055    0.055   0.035     0.1     0.3
X1      3      10   245.0   330.0   400.0   400.0   400.0     1.0     0.0
GR2373.0      0.0  2372.0   190.0  2370.0   245.0  2360.0   275.0  2358.0   285.0
GR2358.0    300.0  2360.0   305.0  2370.0   330.0  2374.0   335.0  2376.0   660.0
NC 0.055    0.055   0.035     0.3     0.5
QT      1  6220.0
X1      4       7   220.0   273.0   345.0   345.0   345.0     1.0     0.0
X3      0     0.0     0.0   220.0  2376.0   273.0  2376.0     0.0     0.0
GR2376.0      0.0  2374.0   150.0  2372.8   220.0  2360.4   221.0  2360.4   272.0
GR2372.8    273.0  2376.0   550.0
NC 0.055    0.055   0.035     0.3     0.5
SC 4.012      0.4     3.0   100.0    12.0    12.0    90.0    10.1  2360.8  2360.4
X1    4.1       7   220.0   273.0   100.0   100.0   100.0     1.0     0.0
X2    0.0     0.0       2     0.0  2373.3     0.0       0     0.0     0.0
X3      0     0.0     0.0   220.0  2376.0   273.0  2376.0     0.0     0.0
GR2376.0      0.0  2374.0   150.0  2372.8   220.0  2360.8   221.0  2360.8   272.0
GR2372.8    273.0  2376.0   550.0
NC 0.055    0.065   0.035     0.1     0.3
X1      5      15   620.0   685.0   440.0   620.0   510.0     1.0     0.0
GR2380.0      0.0  2378.0    50.0  2376.0   620.0  2370.0   640.0  2364.0   645.0
GR2364.0    655.0  2370.0   665.0  2376.0   685.0  2377.0   705.0  2377.0  1030.0
GR2376.0   1031.0  2376.0  1055.0  2377.0  1060.0  2377.0  1560.0  2378.5  1580.0
NC 0.055    0.065   0.035     0.1     0.3
X1      6      12   455.0   495.0   670.0   370.0   590.0     1.0     0.0
GR2380.0      0.0  2378.0   330.0  2376.0   440.0  2372.0   455.0  2366.0   470.0
GR2366.0    482.0  2372.0   495.0  2378.0   512.0  2380.0   600.0  2378.0   750.0
GR2378.0   1600.0  2379.5  1660.0
NC 0.055     0.06   0.035     0.1     0.3
QT      1  5722.0
X1      7       8   185.0   240.0   580.0   460.0   560.0     1.0     0.0
GR2382.0      0.0  2380.0    80.0  2380.0   185.0  2369.0   205.0  2369.0   225.0
GR2380.0    240.0  2380.0  1160.0  2381.5  1210.0
NC 0.055    0.065   0.035     0.1     0.3
X1      8      11   747.0   770.0   550.0   650.0   680.0     1.0     0.0
GR2384.0      0.0  2382.0   120.0  2380.0   220.0  2380.0   747.0  2372.0   750.0
GR2372.0    760.0  2380.0   770.0  2382.0   780.0  2382.0  1230.0  2383.2  1620.0
GR2383.5   1955.0
NC 0.055    0.065   0.035     0.1     0.3
X1      9      12  1035.0  1080.0   400.0   500.0   470.0     1.0     0.0
```

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GR2384.0      0.0  2383.5   130.0  2382.0   660.0  2382.0  1035.0  2380.0  1045.0
GR2373.5   1050.0  2373.5  1070.0  2380.0  1080.0  2382.0  1100.0  2382.0  1155.0
GR2383.0   1390.0  2384.0  1760.0
NC 0.055     0.06   0.035     0.1     0.3
X1    10        9  1090.0  1130.0   470.0   470.0   480.0     1.0     0.0
GR2386.0      0.0  2384.0   400.0  2383.5   805.0  2382.0  1090.0  2378.0  1110.0
GR2378.0   1120.0  2382.0  1130.0  2384.0  1220.0  2386.0  1700.0
NC 0.055     0.06   0.035     0.1     0.3
NH     3     0.05   410.0   0.035   455.0    0.05  1080.0
X1    11       10   410.0   455.0   600.0   650.0   800.0     1.0     0.0
GR2388.0      0.0  2386.0   370.0  2384.0   410.0  2380.0   425.0  2380.0   450.0
GR2384.0    455.0  2386.0   475.0  2385.5   700.0  2386.0   950.0  2388.0  1080.0
NC  0.05     0.05   0.035     0.1     0.3
X1    12       13   410.0   470.0   520.0   620.0   695.0     1.0     0.0
GR2392.0      0.0  2390.0   165.0  2390.0   360.0  2388.0   410.0  2384.0   440.0
GR2384.0    460.0  2390.0   470.0  2390.0   560.0  2388.0   710.0  2387.5   800.0
GR2388.0    890.0  2390.0   900.0  2391.0   950.0
NC 0.055    0.055   0.035     0.1     0.3
QT     1   3614.0
X1    13       10   300.0   350.0   475.0   475.0   475.0     1.0     0.0
GR2392.5      0.0  2391.0   190.0  2390.0   300.0  2385.5   320.0  2385.5   335.0
GR2390.0    350.0  2391.5   355.0  2390.0   600.0  2390.0   770.0  2393.0   800.0
NC 0.055    0.055   0.035     0.1     0.3
X1  13.5       11   280.0   335.0   270.0   360.0   310.0     1.0     0.0
GR2394.0      0.0  2392.0   220.0  2390.0   280.0  2387.0   290.0  2387.0   330.0
GR2390.0    335.0  2392.0   340.0  2392.0   550.0  2391.5   600.0  2392.0   670.0
GR2394.0    680.0
NC 0.055    0.055   0.035     0.1     0.3
NH     4    0.055   160.0   0.035   220.0   0.045   310.0    0.06   910.0
X1    14        9   170.0   210.0   450.0   560.0   480.0     1.0     0.0
GR2396.0      0.0  2394.0   130.0  2392.0   160.0  2389.0   170.0  2389.0   210.0
GR2394.0    220.0  2394.0   310.0  2394.0   460.0  2395.5   910.0
NC   0.0      0.0     0.0     0.1     0.3
NH     4    0.055   110.0   0.035   160.0    0.04   230.0    0.07   620.0
X1  14.5       10   110.0   140.0   390.0   390.0   390.0     1.0     0.0
X3     0      0.0     0.0     0.0     0.0   280.0  2396.5     0.0     0.0
GR2398.0      0.0  2396.0    63.0  2392.0    85.0  2390.0   110.0  2390.0   140.0
GR2396.0    160.0  2396.0   230.0  2396.5   280.0  2396.0   340.0  2398.0   620.0
NC 0.055    0.055   0.035     0.1     0.3
X1    15        9   130.0   180.0   360.0   405.0   380.0     1.0     0.0
GR2400.0      0.0  2398.0    60.0  2396.0   100.0  2394.0   130.0  2390.7   135.0
GR2390.7    162.0  2396.0   180.0  2398.0   235.0  2400.0   350.0
NC 0.055    0.055   0.035     0.1     0.3
NH     3     0.05    65.0   0.035   135.0   0.055   300.0
X1  15.5        8    65.0   135.0   375.0   375.0   375.0     1.0     0.0
GR2402.0      0.0  2400.0    40.0  2398.0    65.0  2391.5    75.0  2391.5    90.0
GR2398.0    135.0  2400.0   215.0  2401.0   300.0
NC 0.055     0.05   0.035     0.1     0.3
X1    16        7    70.0   120.0   580.0   580.0   580.0     1.0     0.0
X3     0      0.0     0.0     0.0     0.0   190.0     0.0     0.0     0.0
GR2404.0      0.0  2402.0    70.0  2394.5    80.0  2394.5   110.0  2402.0   120.0
GR2403.0    190.0  2404.0   240.0
NC 0.055    0.055   0.035     0.1     0.3
X1    17       11    57.0   100.0   445.0   445.0   445.0     1.0     0.0
X3     0      0.0     0.0     0.0     0.0   190.0  2405.5     0.0     0.0
GR2406.0      0.0  2404.0    30.0  2402.0    40.0  2400.0    55.0  2398.0    57.0
GR2395.0     70.0  2395.0    95.0  2398.0   100.0  2400.0   115.0  2404.0   130.0
```

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GR2405.5   435.0
NC  0.04   0.065   0.035     0.1     0.3
X1  17.5       8    30.0   140.0   570.0   570.0   570.0     1.0     0.0
GR2410.0     0.0  2410.0    30.0  2396.5    75.0  2396.5   100.0  2400.0   110.0
GR2402.0   122.0  2408.0   140.0  2408.5   200.0
NC 0.055   0.055   0.035     0.3     0.5
X1    18       8   370.0   430.0   415.0   415.0   415.0     1.0     0.0
X3     0     0.0     0.0   370.0  2415.0   430.0  2415.0     0.0     0.0
GR2418.0     0.0  2414.0   190.0  2412.0   230.0  2411.0   370.0  2399.0   381.0
GR2399.0   419.0  2410.5   430.0  2411.0  1200.0
NC 0.055   0.055   0.035     0.3     0.5
SC 3.012     0.4     3.0    90.0    10.0    12.0    77.0     8.1  2399.2  2399.0
X1  18.1       8   370.0   430.0    80.0    80.0    80.0     1.0     0.0
X2   0.0     0.0       2     0.0  2411.0     0.0       0     0.0     0.0
X3     0     0.0     0.0   370.0  2415.0   430.0  2415.0     0.0     0.0
GR2418.0     0.0  2414.0   190.0  2412.0   230.0  2411.0   370.0  2399.2   381.0
GR2399.2   419.0  2410.5   430.0  2411.0  1200.0
NC 0.040   0.060   0.035     0.1     0.3
X1  18.5      12   420.0   465.0   265.0   265.0   265.0     1.0     0.0
GR2418.0     0.0  2416.0    95.0  2414.0   145.0  2414.0   245.0  2412.0   340.0
GR2410.0   417.0  2408.0   420.0  2400.0   430.0  2400.0   460.0  2408.0   465.0
GR2410.0   473.0  2412.0   520.0
NC 0.050   0.075   0.035     0.1     0.3
X1    19       8   390.0   425.0   280.0   305.0   315.0     1.0     0.0
GR2414.0     0.0  2412.0   280.0  2410.0   390.0  2400.5   405.0  2400.5   420.0
GR2410.0   425.0  2412.0   525.0  2413.5   570.0
NC 0.045    0.06   0.035     0.1     0.3
QT     1  1657.0
X1  19.5       9   310.0   335.0   185.0   230.0   210.0     1.0     0.0
GR2416.0     0.0  2414.0   170.0  2412.0   295.0  2410.0   310.0  2401.0   315.0
GR2401.0   325.0  2410.0   335.0  2412.0   360.0  2414.0   430.0
NC  0.05    0.05   0.035     0.1     0.3
X1    20      10   280.0   310.0   395.0   380.0   395.0     1.0     0.0
GR2416.0     0.0  2414.0   220.0  2412.0   270.0  2410.0   280.0  2401.7   290.0
GR2401.7   300.0  2410.0   310.0  2412.0   327.0  2414.0   330.0  2414.5   390.0
NC  0.04   0.045   0.035     0.1     0.3
X1  20.5       9   275.0   315.0   330.0   390.0   390.0     1.0     0.0
GR2416.0     0.0  2414.0   250.0  2412.0   254.0  2410.0   275.0  2402.5   287.0
GR2402.5   297.0  2410.0   315.0  2414.5   327.0  2416.0   427.0
NC 0.055   0.055   0.035     0.1     0.3
X1    21      10   200.0   228.0   330.0   330.0   330.0     1.0     0.0
GR2416.0     0.0  2414.0   190.0  2408.0   200.0  2404.0   210.0  2404.0   220.0
GR2408.0   228.0  2410.0   240.0  2414.0   250.0  2416.0   265.0  2417.5   400.0
NC 0.055   0.055   0.035     0.1     0.3
X1  21.5      10    75.0   100.0   380.0   510.0   510.0     1.0     0.0
GR2418.0     0.0  2416.0    55.0  2410.0    75.0  2406.0    78.0  2406.0    95.0
GR2410.0   100.0  2412.0   110.0  2414.0   127.0  2416.0   133.0  2418.0   250.0
NC 0.055   0.055   0.035     0.1     0.3
X1    22      13    89.0   105.0   370.0   370.0   370.0     1.0     0.0
GR2420.0     0.0  2418.0    50.0  2414.0    60.0  2412.0    75.0  2410.0    89.0
GR2408.0    90.0  2408.0   100.0  2410.0   105.0  2412.0   110.0  2414.0   137.0
GR2416.0   160.0  2416.0   190.0  2417.0   400.0
NC 0.055   0.055   0.035     0.1     0.3
X1    23      11    70.0    95.0   580.0   580.0   580.0     1.0     0.0
GR2420.0     0.0  2418.0    60.0  2416.0    65.0  2414.0    70.0  2410.5    75.0
GR2410.5    95.0  2414.0    98.0  2416.0   104.0  2418.0   140.0  2419.0   250.0
GR2420.0   380.0
```

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NC 0.055    0.055    0.035      0.3      0.5
X1     24       6    150.0    220.0    215.0    215.0    215.0      1.0      0.0
X3      0     0.0      0.0    150.0   2422.0    220.0   2422.0      0.0      0.0
GR2422.0      0.0   2421.5    150.0   2411.7    184.0   2411.7    216.0   2421.5    220.0
GR2422.0    500.0
NC 0.055    0.055    0.035      0.3      0.5
SC 3.012      0.4      3.0     50.0      7.0     10.0     50.0     10.1   2412.0 2411.75
X1   24.1       6    170.0    240.0     75.0     75.0     75.0      1.0      0.0
X2    0.0     0.0        2      0.0   2421.5      0.0        0      0.0      0.0
X3      0     0.0      0.0    170.0   2422.0    240.0   2422.0      0.0      0.0
GR2422.0      0.0   2421.5    170.0   2412.0    184.0   2412.0    216.0   2421.5    240.0
GR2422.0    500.0
NC 0.055    0.055    0.035      0.1      0.3
QT      1   768.0
X1     25      10    157.0    181.0    325.0    325.0    325.0      1.0      0.0
GR2421.0      0.0   2420.0    145.0   2414.0    157.0   2412.5    160.0   2412.5    170.0
GR2414.0    181.0   2416.0    183.0   2418.0    200.0   2420.0    290.0   2421.0    350.0
NC 0.055    0.055    0.035      0.1      0.3
X1     26       9     40.0     57.0    490.0    500.0    490.0      1.0      0.0
GR2422.0      0.0   2420.0     27.0   2416.0     37.0   2415.0     40.0   2415.0     53.0
GR2416.0     57.0   2418.0    110.0   2420.0    120.0   2422.0    150.0
NC 0.055    0.055    0.035      0.1      0.3
X1     27      10     65.0     95.0    500.0    500.0    500.0      1.0      0.0
GR2424.0      0.0   2422.0     45.0   2420.0     50.0   2418.0     65.0   2416.0     70.0
GR2416.0     85.0   2418.0     95.0   2420.0    120.0   2422.0    150.0   2424.0    185.0
NC 0.055    0.055    0.035      0.1      0.3
X1     28       9     40.0     65.0    425.0    475.0    435.0      1.0      0.0
GR2424.0      0.0   2422.0     29.0   2420.0     40.0   2418.0     50.0   2418.0     65.0
GR2420.0     65.0   2421.0    145.0   2422.0    220.0   2424.0    240.0
NC 0.055    0.055    0.035      0.1      0.3
X1     29      10     90.0    140.0      350      350      350      1.0      0.0
GR2426.0      0.0   2424.0     85.0   2421.5    100.0   2421.5    120.0   2424.0    125.0
GR2426.0    150.0   2426.0    210.0   2425.0    240.0   2425.0    420.0   2426.0    480.0

EJ


ER
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Appendix 2

Master Drainage Study, Tohono O'Odham Nation-San Xavier District Phase 1- Pan-handle Area Existing Conditions: study boundaries, hydraulic analysis, HEC-RAS output printout, and maps (2) of HEC-RAS cross section locations

MASTER DRAINAGE STUDY
TOHONO O'ODHAM NATION - SAN XAVIER DISTRICT
PHASE I – PANHANDLE AREA
EXISTING CONDITIONS

Location:
The study area is located in portions of
Section 9, 16, 21&22, Township 15 South, Range 13 East

Prepared for:
Pima County Flood Control District
201 N. Stone Avenue
Tucson, Arizona 85701

July 31, 2001

Prepared by:

MMLA Inc.
800 E. Wetmore Road, Suite 110
Tucson, AZ 85719

MMLA 99024-04-45

REGISTERED PROFESSIONAL ENGINEER (CIVIL)
CERTIFICATE NO.
33984
MICHAEL E.
DALY
DATE SIGNED 9/12/01
ARIZONA U.S.A.

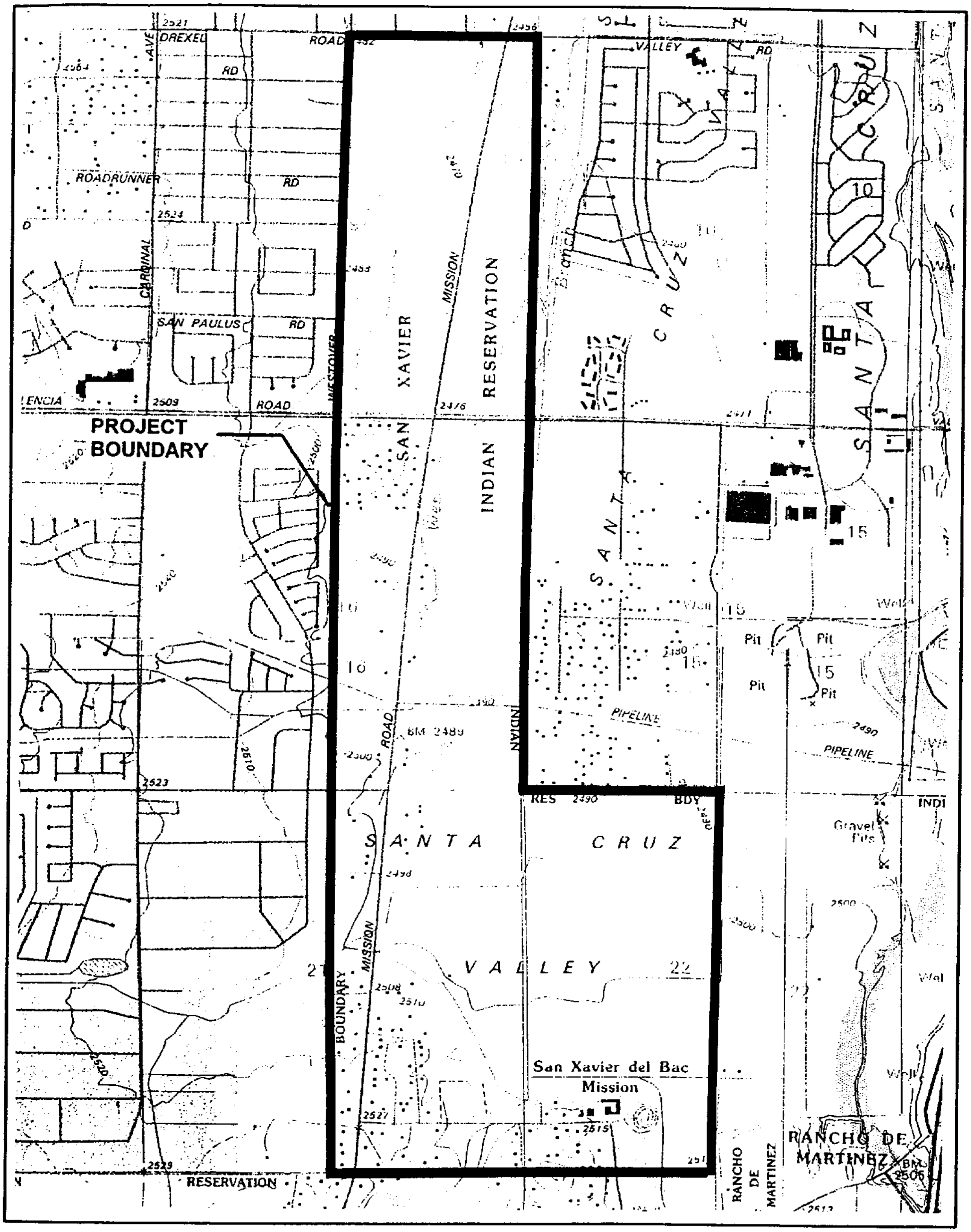

FIGURE 1
STUDY BOUNDARY MAP
Township 15S, Range 13E,
Portions of Sections 9,16, 21 & 22

MMLA
McGovern MacVittie Lodge & Associates, Inc.
MMLA Job No. 98013-05-45

3.3.3 Split Flow Analysis

In order to better quantify the peak discharges in Cemetery Wash at San Xavier Mission Road, a split flow analysis was completed on Black Mountain Wash (Watershed 21) using the HEC-2 split flow option. The analysis utilized the HEC-1 peak discharge calculated at Concentration Point (C.P.) 21, and it was assumed that breakout over Mission Road behaves as weir flow. The results of the split flow analysis were entered back into the HEC-1 model as a flow diversion.

Under existing conditions, conveyance in Black Mountain Wash is limited to approximately 1630 cfs upstream of Go:k Ka:wulk Wo:g. Excess flow breaks over Mission Road and enters Watershed 17. Downstream of Go:k Ka:wulk Wo:g, most of the remaining flow crosses Mission Road and enters the Cemetery Wash watershed. Flow that does not cross Mission Road, enters the Mission Wash watershed and causes problematic flooding along Su:dagi Wo:g, a local dirt road. A detailed analysis of this second flow split was not completed due to the lack of adequate topography, and all of the runoff downstream of Go:k Ka:wulk Wo:g was assumed to contribute to Cemetery Wash. A copy of the split flow output and a cross-section location map are provided in Appendix 8.8.

4.0 HYDRAULIC ANALYSIS

4.1 EXISTING DRAINAGE IMPROVEMENTS

4.1.1 CULVERT CROSSINGS

There are currently four culvert crossings that affect the study area, all of which are located along Valencia Road. The details and design capacities of the culverts were determined from as-built drawings obtained from Pima County Mapping and Records. The first crossing consists of a 7 cell, 10' x 6' RCBC which conveys flow in Valencia Wash under Valencia Road. The upstream channel and culvert have a design capacity of 5257 cfs, which will pass the calculated 100-year peak discharge without breakout over Valencia Road. The second crossing is located at the southwest corner of Mission Road and Valencia Road and consists of a single 10' x 4' RCBC. The crossing conveys flow at C.P. 5 (Figure 4a) under Valencia Road and into a concrete lined channel which conveys flow to WBCSR. The design capacity of the culvert is 360 cfs, which will pass the 100-year discharge if all flow can concentrate at the headwall of the culvert. The third crossing consists of a 3 cell, 71" x 47" CMPA which is located in the historic alignment of the WBSCR, approximately 900 feet west of the channel realignment. The design capacity of the crossing is 512 cfs and conveys low flows in the historic channel under Valencia Road. The final crossing consists of a 10 cell, 12' x 8' RCBC and upstream channel improvements that convey flow from the relocated WBSCR under Valencia Road. The upstream channel and culvert crossing have a design capacity of 8000 cfs, which assuming all flow is contained in the channel, could pass the calculated 100-year discharge without breakout over Valencia Road. However, the earthen berms near the improved WBSCR prevent runoff from entering the channel, contributing to the wide floodplain across the panhandle area and Co-op Farm. Table 2 provides a summary of culvert crossing details.

TABLE 2
SUMMARY OF CULVERT CROSSING DETAILS

LOCATION	TYPE	Q_{design} (cfs)	Q_{100}* (cfs)
Valencia Wash @ Valencia Road	10-12' x 8 RCBC	5257	3680
Mission Road @ Valencia Road	1-10' x 4' RCBC	360	251
900 ft. west of WBSCR	3-71" x 47" CMPA	512	N/A
WBSCR @ Valencia Road	7-10' x 6' RCBC	8000	6900

*As determined by this study

4.1.2 LOS REALES IMPROVEMENT DISTRICT

In order to mitigate flooding caused from Mission Wash, Cemetery Wash and the unnamed drainage located just east of San Xavier Mission, the residents of the Los Reales subdivision formed an improvement district with Pima County in 1986. The formation of the Los Reales Improvement District (LRID) resulted in the construction of collector and conveyance channels on the west and south boundaries of the subdivision. The channel on the west boundary ties into an existing channel improvement which was associated with the construction of the 10-12'x 8' RCBC under Valencia Road. The extent of the west LRID channel is shown on Figure 5 (Sheet 2). Along the southern boundary, a floodwall was constructed which diverts flow to the head of the southern conveyance channel. The floodwall extends approximately 1500' feet east from the southwest corner of the subdivision, and has a height of four feet. The southern channel conveys flow directly to the Santa Cruz River as shown on Figure 5 (Sheet 4).

Record drawings for the LRID were obtained from Pima County to estimate the conveyance capacity of the channels. The western channel consists of two distinct channel reaches. The first reach is fully lined with concrete and extends north from Los Reales Road for a distance of approximately 1100 feet. It has 1:1 side slopes, a depth that varies from 4.5 to 6 feet, and a bottom width of 34 feet with a slope of 0.32%. The channel then transitions into Reach 2 geometry, which extends north for a distance of approximately 1500 feet. The channel has a 26' bottom width with a slope of 0.35%. The sides are concrete lined with a 1:1 slope, and the channel depth ranges from 5.5 to 7.5 feet.

The southern channel consists of three distinct reaches, the first of which begins at the end of the flood wall. This reach extends approximately 2100' east and has a 30' to 40' bottom width, 1:1 concrete lined side slopes, and a depth ranging from 6 to 9 feet. The slope of the earthen bottom is 0.25%. The channel then transitions into Reach 2 geometry which extends approximately 2000 feet to the east. Reach 2 has an unlined bottom with a width of 15' to 30' feet and slope of 0.25%. The northern side of the channel is earthen with a 3:1 slope. The southern side of the channel is concrete lined with a 1:1 slope. The last segment of the channel (Reach 3) extends approximately 630 east where it discharges to the Santa Cruz River. The channel is completely unlined with 3:1 side slopes, a depth of 15 to 19 feet, and a 15' bottom width with a 1.2% slope.

A minimum and maximum capacity for each reach of the west and south channels was calculated using Manning's equation. A field inspection of channel integrity and more detailed backwater analysis may be completed on both channels as part of the Phase II study. Hydraulic calculation sheets and typical cross-sections for the channels taken from the record drawings are provided in Appendix 8.8. The approximate beginning and end for each channel reach is shown on Figure 5 (Sheets 2 & 4). The minimum full flow discharge for each segment is summarized in Table 3 below. The variances in full flow capacity are the results of both varying channel depth and bottom slope. As shown in the table, it does not appear the LRID channels were designed to convey the 100-year discharge. The capacity values calculated as part of this study correlate well with those presented in the *Letter of Map Revision for the Los Reales Improvement District*, completed by Arroyo Engineering in December 1994. The analysis presented in that document is the basis for the current FEMA floodplain mapping in the area of the collector channels.

TABLE 3
SUMMARY OF MANNING'S CALCULATIONS
LOS REALES IMPROVEMENT DISTRICT CONVEYANCE CHANNELS

CHANNEL	SEGMENT	ESTIMATED CAPACITY (cfs)		INFLOW (cfs)		
		Min.	Max.	Q_2	Q_{10}	Q_{100}
West	1	1938	2858	2241	4215	6901
West	2	1578	2389	2241	4215	6901
South	1	2723	2829	1056	2355	5128
South	2	3559	4498	1056	2355	5128
South	3	17010	18500	1056	2355	5128

Based on field observations and available topographic mapping, the channels are not effectively receiving the flows they were intended to convey. The presence of earthen berms, as shown on Figure 5 (Sheets 2 & 4), is severely impeding conveyance into both the western and southern channels. Consequently, the channels are not providing any appreciable level of flood control or mitigation for the Nation. The presence of the berms is shown on the record drawings. However, it is unknown whether they were present prior to construction, or placed as part of construction.

4.2 FLOODPLAIN ANALYSIS

The purpose of the floodplain analysis was to delineate the 100-year floodplains impacting the study area, and determine the 100-year water surface elevations for planning of future improvements. Floodplain delineation was completed using Manning's equation, the HEC-RAS computer program, as well as the results of aerial photograph analysis and field reconnaissance in areas where computational methods were considered inappropriate due to topography and limited conveyance. Floodplain mapping was completed on 1"= 200', 2' contour interval aerial topography dated November 15, 1994 (Figure 5). The topography was supplied to Pima County Flood Control District by the Natural Resource Conservation Service (NRCS), Phoenix office, and is based on the North American Vertical Datum of 1929. An attempt was made in a memorandum dated April 16, 1999, to obtain the more recent topography (April 1998) which is to be distributed by Pima Association of Governments. However, it was determined that this topography was not readily available at the time of this report, and that it did not extend far enough into the study area. Manning's calculation sheets and HEC-RAS output files are provided in Appendix 8.10.

The 100-year discharge of 6809 cfs used upstream of Valencia Road represents the hydrograph summation of the Mission Wash and Cemetery Wash watersheds. An additional 2440 cfs is contributed from the smaller watersheds to the west. However, this discharge was not added to the 6809 cfs due to the large difference in the time to peak discharge between the those smaller watersheds to the west, and the Cemetery Wash and Mission Wash watersheds which contribute the largest amount of flow. Mission Wash was modeled assuming an approximate 4:1 expansion from the point where flow crosses Mission Road. This approach was taken to ensure that water surface elevations on the west side of the floodplain were not underestimated as a result of the expansion of flows into the agricultural area east of Mission Road (see Figure 5, Sheet 3). The results of the floodplain analysis yielded the following conclusions:

- The agricultural area south of Valencia Road is **completely inundated** during the 100-year event because of flat topography and poor conveyance into the existing Los Reales Improvement District southern channel. Most existing residences in the panhandle area south of Valencia Road are not in the 100-year floodplain.

- Flow from Watershed 17 which enters the study area east of San Xavier Mission is conveyed east to the Santa Cruz River, either directly, or by way of the Los Reales Improvement District southern conveyance channel. This assumption is based on existing topography and the presence of a berm on both sides of Cemetery Wash that tends to promote conveyance to the east.

- For the purposes of future development, the entire panhandle area north of Valencia Road is considered as **completely inundated** during the 100-year event. This assumption is based on the results of the hydrologic analysis, and review of the existing topography which indicates flows in the various poorly defined drainages converge prior to reaching Mission Road creating large ponded areas. In addition, the actual location of discharge points across Westover Avenue is unpredictable due to poorly defined dip sections and periodic grading of the shoulder. Any "islands" which do exist in the panhandle area during the 100-year event would be inaccessible due to flooding in the surrounding areas.

- The 100-year discharge in the Santa Cruz River is contained within the existing channel banks as per FIRM Panel C2830K, dated February 8, 1999.

HEC-RAS September 1998 Version 2.2
U.S. Army Corp of Engineers
Hydrologic Engineering Center
609 Second Street, Suite D
Davis, California 95616-4687
(916) 756-1104

```
X     X  XXXXXX   XXXX        XXXX      XX      XXXX
X     X  X       X    X       X   X    X  X    X
X     X  X       X            X   X   X    X   X
XXXXXXX  XXXX    X      XXX   XXXX    XXXXXX    XXXX
X     X  X       X            X  X    X    X        X
X     X  X       X    X       X   X   X    X        X
X     X  XXXXXX   XXXX        X    X  X    X   XXXXX
```

PROJECT DATA
Project Title: San Xavier District Master Drainage Study
Project File : FSPNIR.prj
Run Date and Time: 11/22/99 2:21:08 PM

Project in English units

Project Description:
100-year Floodplain Mission Wash, Mission Road to Valencia Road

PLAN DATA

Plan Title: Plan 06
Plan File : e:\mike\98013-05\FSPNIR.p06

Geometry Title: Mission Wash - South of Valencia
Geometry File : e:\mike\98013-05\FSPNIR.g02

Flow Title : Mission Wash
Flow File : e:\mike\98013-05\FSPNIR.f04

Plan Summary Information:

Number of:	Cross Sections =	11	Mulitple Openings =	0
	Culverts =	0	Inline Weirs =	0
	Bridges =	0		

Computational Information
- Water surface calculation tolerance = 0.01
- Critical depth calculaton tolerance = 0.01
- Maximum number of interations = 20
- Maximum difference tolerance = 0.3
- Flow tolerance factor = 0.001

Computation Options
- Critical depth computed only where necessary
- Conveyance Calculation Method: At breaks in n values only
- Friction Slope Method: Average Conveyance
- Computational Flow Regime: Subcritical Flow

FLOW DATA

Flow Title: Mission Wash
Flow File : e:\mike\98013-05\FSPNIR.f04

Flow Data (cfs)

River	Reach	RS	PF#1
Mission Wash	1	11	6901

Boundary Conditions

River	Reach	Profile	Upstream	Downstream
Mission Wash	1	PF#1		Normal S = .003

GEOMETRY DATA

Geometry Title: Mission Wash - South of Valencia
Geometry File : e:\mike\98013-05\FSPNIR.g02

CROSS SECTION RIVER: Mission Wash

```
REACH: 1                  RS: 11

INPUT
Description:
Station Elevation Data     num=      9
     Sta     Elev      Sta     Elev      Sta     Elev      Sta     Elev      Sta     Elev
       0   2504.9      240     2502      490     2500      590     2498      620     2498
     720     2500      990     2502     1050     2504     1150     2505

Manning's n Values         num=      3
     Sta    n Val      Sta    n Val      Sta    n Val
       0     .035        0     .035     1150     .035

Bank Sta: Left    Right     Lengths: Left Channel    Right      Coeff Contr.     Expan.
             0     1150               720      720      720                 .1         .3

CROSS SECTION            RIVER: Mission Wash
REACH: 1                  RS: 10

INPUT
Description:
Station Elevation Data     num=     18
     Sta     Elev      Sta     Elev      Sta     Elev      Sta     Elev      Sta     Elev
       0     2502      220     2500      420     2498      530     2498      640   2498.2
     660   2496.3      770   2496.3      790     2498      830     2498      840     2496
    1070   2495.5     1690   2494.5     1870   2494.2     2380     2496     2540     2496
    2640     2495     2720     2496     2730     2498

Manning's n Values         num=      3
     Sta    n Val      Sta    n Val      Sta    n Val
       0     .035        0     .035     2730     .035

Bank Sta: Left    Right     Lengths: Left Channel    Right      Coeff Contr.     Expan.
             0     2730               640      640      640                 .1         .3
Ineffective Flow      num=        1
   Sta L    Sta R     Elev
     820     2730     2502

CROSS SECTION            RIVER: Mission Wash
REACH: 1                  RS: 9

INPUT
Description:
Station Elevation Data     num=     23
     Sta     Elev      Sta     Elev      Sta     Elev      Sta     Elev      Sta     Elev
       0     2500      320     2498      370   2497.8      490     2497      590   2496.2
     650     2496      750     2495      810     2494      820     2495      850     2495
     900     2494      970     2493     1000   2492.4     1025   2491.9     1160     2492
    1270   2491.9     1470   2491.3     1800     2492     1835     2492     1960   2491.8
    1970   2491.7     2120     2492     2440     2494

Manning's n Values         num=      3
     Sta    n Val      Sta    n Val      Sta    n Val
       0     .035        0     .035     2440     .035

Bank Sta: Left    Right     Lengths: Left Channel    Right      Coeff Contr.     Expan.
             0     2440               600      600      600                 .1         .3
Ineffective Flow      num=        1
   Sta L    Sta R     Elev
     950     2440     2498

CROSS SECTION            RIVER: Mission Wash
REACH: 1                  RS: 8

INPUT
Description: 0
Station Elevation Data     num=     15
     Sta     Elev      Sta     Elev      Sta     Elev      Sta     Elev      Sta     Elev
       0     2496      150     2495      370     2494      470     2493      550     2492
     600   2492.5      610     2492      800   2491.1      900     2490     1200   2490.3
    1500   2490.5     1600   2490.4     1700   2490.5     1800   2490.7     2000   2492.3

Manning's n Values         num=      3
     Sta    n Val      Sta    n Val      Sta    n Val
       0     .035        0     .035     2000     .035

Bank Sta: Left    Right     Lengths: Left Channel    Right      Coeff Contr.     Expan.
             0     2000               460      460      460                 .1         .3
Ineffective Flow      num=        1
   Sta L    Sta R     Elev
    1050     2000     2498

CROSS SECTION            RIVER: Mission Wash
REACH: 1                  RS: 7

INPUT
Description:
Station Elevation Data     num=     16
     Sta     Elev      Sta     Elev      Sta     Elev      Sta     Elev      Sta     Elev
       0     2494      150     2492      207   2490.9      360   2490.5      500     2490
     510     2492      517     2492      650   2490.6      840     2490     1040   2489.6
    1110   2489.4     1300   2489.2     1570   2488.9     1740   2489.9     1800     2490
    1850     2491

Manning's n Values         num=      3
```

Sta	n Val	Sta	n Val	Sta	n Val
0	.035	0	.035	1850	.035

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
0	1850	500	500	500	.1	.3

CROSS SECTION RIVER: Mission Wash
REACH: 1 RS: 6

INPUT
Description:
Station Elevation Data num= 14

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	2492	25	2492	165	2490	400	2488	585	2488.3
1340	2488	1760	2486	1772	2484	1800	2486	1810	2488
1815	2490.5	1825	2481.2	1855	2481.2	1865	2491		

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
0	.035	0	.035	1815	.025

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
0	1815	800	800	800	.1	.3

Ineffective Flow num= 1

Sta L	Sta R	Elev
1815	1865	2490.5

CROSS SECTION RIVER: Mission Wash
REACH: 1 RS: 5

INPUT
Description:
Station Elevation Data num= 18

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	2488	60	2488	180	2487	220	2486	260	2486
620	2485.3	1045	2485.4	1255	2485.3	1625	2484	1720	2482
1740	2481	1750	2482	1760	2484	1765	2486	1770	2488
1780	2479.5	1810	2479.5	1820	2489				

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
0	.035	0	.035	1770	.025

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
0	1770	800	800	800	.1	.3

Ineffective Flow num= 1

Sta L	Sta R	Elev
1770	1820	2488

CROSS SECTION RIVER: Mission Wash
REACH: 1 RS: 4

INPUT
Description:
Station Elevation Data num= 18

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	2486	35	2486	100	2484	260	2482	750	2481
1050	2480.2	1404	2481.4	1535	2480	1650	2478	1660	2476
1670	2474	1680	2478	1690	2480	1700	2478	1710	2483
1720	2475	1750	2475	1760	2484				

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
0	.035	0	.035	1710	.035

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
0	1710	800	800	800	.1	.3

Ineffective Flow num= 1

Sta L	Sta R	Elev
1710	1760	2484

CROSS SECTION RIVER: Mission Wash
REACH: 1 RS: 3

INPUT
Description:
Station Elevation Data num= 19

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	2486	20	2485	40	2486	75	2484	120	2482
179	2482	300	2483	370	2482	410	2480	900	2479.5
1250	2479.7	1560	2478	1575	2477	1590	2478	1615	2480
1630	2480	1645	2472	1665	2472	1675	2481		

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
0	.035	0	.035	1675	.035

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
0	1675	780	780	780	.1	.3

Ineffective Flow num= 1

Sta L	Sta R	Elev
1630	1675	2482

CROSS SECTION RIVER: Mission Wash
REACH: 1 RS: 2

INPUT
Description:
Station Elevation Data num= 12

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	2481	20	2480	150	2478	430	2477.6	700	2478
1220	2478	1330	2477.6	1490	2478	1580	2480	1615	2467.5
1635	2467.5	1645	2481						

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
0	.035	0	.035	1645	.035

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
0	1645	800	800	800	.1	.3

Ineffective Flow num= 1

Sta L	Sta R	Elev
1580	1645	2480

CROSS SECTION RIVER: Mission Wash
REACH: 1 RS: 1

INPUT
Description:
Station Elevation Data num= 27

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	2479	50	2478.5	70	2478	130	2476	145	2476
160	2476	320	2474	505	2472	560	2472	650	2474
1150	2474	1312	2474	1370	2474	1440	2472	1460	2474
1471	2476	1485	2478	1500	2478	1508	2476	1512	2474
1520	2470	1530	2468	1550	2466	1580	2464	1590	2463
1600	2464	1630	2470						

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
0	.035	0	.035	1630	.035

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
0	1630	800	800	800	.1	.3

Ineffective Flow num= 1

Sta L	Sta R	Elev
1485	1630	2478

SUMMARY OF REACH LENGTHS

River: Mission Wash

Reach	River Sta.	Left	Channel	Right
1	11	720	720	720
1	10	640	640	640
1	9	600	600	600
1	8	460	460	460
1	7	500	500	500
1	6	800	800	800
1	5	800	800	800
1	4	800	800	800
1	3	780	780	780
1	2	800	800	800
1	1	800	800	800

Profile Output Table - Standard Table 1

Reach Froude # Chl	River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)
1 0.45	11	6901.00	2498.00	2502.75		2502.97	0.002764	3.77	1830.75	834.10
1 0.43	10	6901.00	2494.20	2500.85	2499.53	2501.09	0.002462	3.92	1761.19	2604.05
1 0.84	9	6901.00	2491.30	2497.54	2497.26	2498.22	0.010125	6.62	1043.21	2031.29
1 0.61	8	6901.00	2490.00	2493.52	2492.81	2493.92	0.005165	5.08	1357.99	1581.78
1 0.62	7	6901.00	2488.90	2490.97		2491.20	0.006484	3.81	1809.73	1536.06
1 0.34	6	6901.00	2484.00	2489.53	2488.58	2489.63	0.001777	2.55	2708.14	1640.44
1 0.99	5	6901.00	2481.00	2485.87	2485.87	2486.31	0.018049	5.33	1295.82	1479.79
1 0.31	4	6901.00	2474.00	2482.68	2481.44	2482.77	0.001369	2.41	2863.17	1551.81
1 0.32	3	6901.00	2472.00	2481.52	2480.40	2481.63	0.001474	2.65	2599.29	1295.44
1 0.70	2	6901.00	2467.50	2479.05	2478.80	2479.33	0.008439	4.22	1636.64	1516.79
1 0.45	1	6901.00	2463.00	2475.36	2474.63	2475.53	0.003002	3.28	2103.99	1376.97

Profile Output Table - Standard Table 2

Reach	River Sta	E.G. Elev (ft)	W.S. Elev (ft)	Vel Head (ft)	Frctn Loss (ft)	C & E Loss (ft)	Q Left (cfs)	Q Channel (cfs)	Q Right (cfs)	Top Width (ft)
1	11	2502.97	2502.75	0.22	1.87	0.00		6901.00		834.10
1	10	2501.09	2500.85	0.24	2.83	0.04		6901.00		2604.05
1	9	2498.22	2497.54	0.68	4.22	0.08		6901.00		2031.29
1	8	2493.92	2493.52	0.40	2.67	0.05		6901.00		1581.78
1	7	2491.20	2490.97	0.23	1.53	0.04		6901.00		1536.06
1	6	2489.63	2489.53	0.10	3.29	0.03		6901.00		1640.44
1	5	2486.31	2485.87	0.44	2.69	0.11		6901.00		1479.79
1	4	2482.77	2482.68	0.09	1.14	0.00		6901.00		1551.81
1	3	2481.63	2481.52	0.11	2.29	0.02		6901.00		1295.44
1	2	2479.33	2479.05	0.28	3.77	0.03		6901.00		1516.79
1	1	2475.53	2475.36	0.17				6901.00		1376.97

Appendix 3

Request for a Letter of Map Revision for the Los Reales Improvement District Located in Pima County, Arizona, and the City of Tucson, Arizona: study boundaries, HEC-2 input and output printout for the West Branch of the Santa Cruz River from Valencia Road to the Reservation Boundary, HEC-2 input and output printout for the South Channel

REQUEST FOR A
LETTER OF MAP REVISION FOR THE
LOS REALES IMPROVEMENT DISTRICT
LOCATED IN PIMA COUNTY, ARIZONA,
AND IN THE CITY OF TUCSON, ARIZONA

Submitted to:
PIMA COUNTY DEPARTMENT OF TRANSPORTATION
AND FLOOD CONTROL DISTRICT
Floodplain Planning Section
Fourth Floor, Public Works Building
201 North Stone Avenue
Tucson, Arizona 85701-1207
(602) 740-6350

and to:
CITY OF TUCSON DEPARTMENT OF TRANSPORTATION
Engineering Division, Floodplain Section
P.O. Box 27210
Tucson, Arizona 85726-7210
(602) 791-4914

Prepared By:
ARROYO ENGINEERING, INC.
P.O.Box 2668
Tucson, Arizona 85702
(602) 882-0206

Registered Professional Engineer (Civil)
CERTIFICATE NO.
18683
ROBERT J.
SMOLINSKY
DATE SIGNED 1-10-95
ARIZONA, U.S.A.

December, 1994

ARROYO
ENGINEERING, INC.

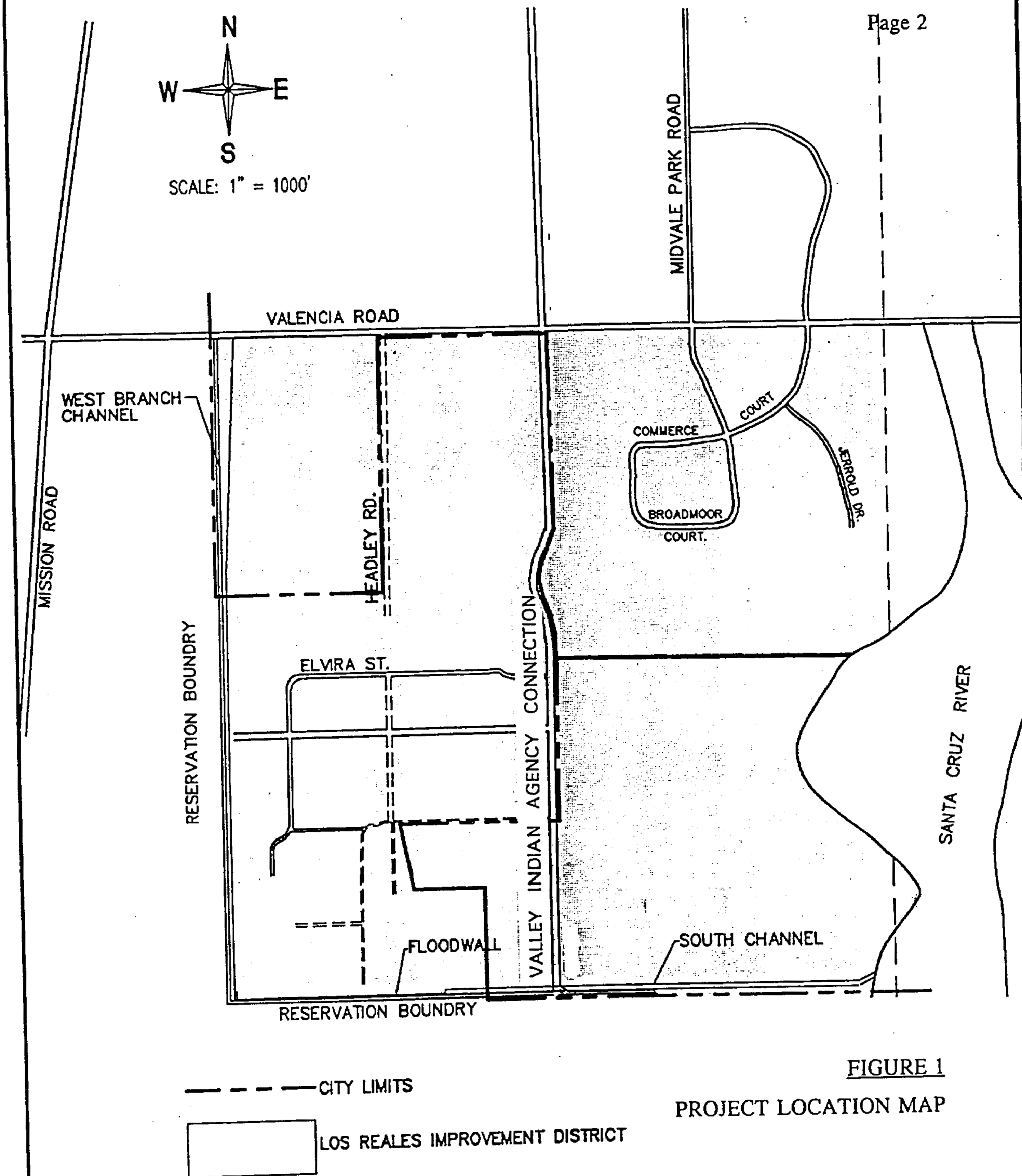

FIGURE 1

PROJECT LOCATION MAP

Appendix C

HEC-2 Input and Output Files for the West Branch of the Santa Cruz River from Valencia Rd to the Reservation Boundary

ARROYO ENGINEERING, INC.

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SF  Splitflow Analysis of the Los Reales Floodwall and Diversion Channels
JC  Splitflow Analysis
JP     0       0     100       0       0
TN  Normal depth split flow  - Sections 11 to 12
NS     2      11      12      -1    0.06   0.004
NG     0  2477.2     200  2478.0
TN  Normal depth split flow - Sections 12 to 13
NS     2      12      13      -1    0.06   0.004
NG     0  2478.0     200  2478.5
TN  Normal depth split flow - Section 13 to 14
NS     2      13      14      -1    0.06   0.004
NG     0  2478.5     112  2478.6
TN  Normal depth split flow - Sections 14 to 15
NS     2      14      15      -1    0.06   0.004
NG     0  2478.6     100  2479.5
TN  Normal depth split flow - Sections 21 to 22
NS     2      21      22      -1    0.06   0.003
NG     0  2484.3      44  2484.4
TN  Normal depth split flow - Sections 22 to 23
NS     2      22      23      -1    0.06   0.003
NG     0  2484.4     231  2484.5
TC  Rating curve outflow data set for Splitflow into South Diversion Channel
CS     3      28    28.1      -1
CR  3250 2489.90    3300 2489.93    3350 2489.97
TW  Splitflow #28 to #28.1 (Splitflow goes directly into the Santa Cruz River)
WS     9      28    28.1      -1     2.6
WC6750.0  2491.3  6760.0  2488.3  6950.0  2489.1  7150.0  2489.2  7350.0  2490.0
WC7550.0  2491.6  7750.0  2491.8  7850.0  2492.5  7950.0  2494.1
EE
T1      Los Reales Improvement District, Letter of Map Revision
T2      Arroyo Job #PDOT01.1, HEC2 File: WEST.H2I
T3      West Branch Santa Cruz  River
T4      West Branch Santa Cruz River, from Valencia Rd. to Los Reales Rd.

J1     0       2       0       0       0       0       0       0  2466.7
J2     1       0      -1       0       0       0       0       0       0
J3    38      43      13      14      15       1       2       3       8      53
J3     4      54      61             150
NC  .030    .030   .0275     0.1     0.3
QT     1    7638

X1     1      15    1390    2002       0       0       0
*  X-Sec  1: Same as Sta 448+00 on West Branch Bank Protection Plan 4BVALE
GR  2474    1300    2474    1390    2472    1520    2470    1695    2468    1780
GR  2466    1810    2465    1836  2463.7  1861.5    2463    1864    2463    1995
GR  2470    2002  2470.3    2022    2470    2172    2472    2860    2472    3020

X1     2      23    1800    2002     100     100     100
*  X-Sec  2: Same as Sta 447+00 on West Branch Bank Protection Plan 4BVALE
GR  2475    1250    2474    1430    2472    1560    2470    1710    2470    1778
GR  2472    1785    2472    1794    2474    1800    2472    1805    2470    1810
GR  2468    1825    2466  1835.5  2464.9    1841  2465.2    1852    2464    1864
GR2463.5  1865.5  2463.5    1995  2470.5    2002  2470.8    2022  2471.4    2024
GR2471.7    2074    2472    2164    2472    3050

X1     3      18    1820    2002     200     200     200
*  X-Sec  3: Same as Sta 445+00 on West Branch Bank Protection Plan 4BVALE
GR2475.5    1200    2474    1470    2472    1565    2470    1650    2472    1680
GR  2472    1750    2472    1790    2476    1805    2476    1820  2471.5  1836.5
GR2465.8    1858  2464.5    1878  2464.3  1879.5  2464.4    1995  2471.2    2002
GR2471.5    2022  2471.8    2023    2473    3050

X1     4      16    1838    2002     200     200     200
*  X-Sec  4: Same as Sta 443+00 on West Branch Bank Protection Plan 4BVALE
GR  2476    1260    2474    1515    2472    1600    2472    1660    2474    1820
GR  2476    1830    2479    1838    2474    1848  2466.8    1873  2464.7    1939
GR  2465  1945.5    2465    1995    2472    2002  2472.3    2022  2472.5    2023
GR2473.5    3100

X1     5      15    1841    2002     200     200     200
*  X-Sec  5: Same as Sta 441+00 on West Branch Bank Protection Plan 4BVALE
X3     0       0       0       0       0    3090
GR2476.0    1250    2476    1530    2474    1790    2474    1820    2476    1830
GR2479.5    1841  2465.5    1901  2464.8    1918  2465.6  1925.5  2465.6    1995
GR2472.6    2002    2473    2022  2473.8    2023    2472    2720  2472.5    3100

X1     6      15    1868    2002     200     200     200
*  X-Sec  6: Same as Sta 439+00 on West Branch Bank Protection Plan 4BVALE
X3     0       0       0       0       0    3040
GR  2476    1300    2476    1840    2480    1850    2480    1868    2474    1879
GR  2467    1913    2465    1913  2466.5  1965.5  2466.5    1995  2473.5    2002
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GR2473.7  2026.5    2474    2028    2472    2100    2473    2800  2474.0    3100

X1     7      14    1886    2002     200     200     200
*  X-Sec  7: Same as Sta 437+00 on West Branch Bank Protection Plan 4BVALE
X3     0       0       0       0       0    3000
GR  2477    1300    2476    1870    2478    1875    2480    1880    2481    1886
GR2475.3    1894  2469.5    1922  2466.7    1930  2467.1  1982.5  2467.1    1995
GR  2474    2002  2474.4    2022  2472.5    2400    2474    3000

X1     8      12    1880    2000     200     200     200
*  X-Sec  8: Same as Sta 435+00 on West Branch Bank Protection Plan 4BVALE
X3     0       0       0       0       0    2970
GR  2477    1300    2478    1880    2480    1890  2480.0    1895  2476.5    1905
GR  2470    1930    2467    1948    2468    1992  2474.8    2000    2475    2020
GR  2474    2400  2475.5    3150

X1     9      17    1920    1998     164     164     164
*  X-Sec  9: Same as Sta 433+36 on West Branch Bank Protection Plan 4BVALE
X3     0       0       0       0       0    2930
GR  2478    1500    2478    1900    2480    1905    2480    1920  2476.8    1934
GR2467.7    1953  2467.5    1978    2469  1982.6    2469  1991.3  2475.5    1998
GR2475.6    2018    2476    2019    2476  2043.5  2474.5  2230.0  2475.0    2550
GR2476.0    2900    2476    3150

NC  .030    .030    .029     0.1     0.3
X1    10      18    1946  2004.5     136     136     136
*  X-Sec 10: Same as Sta 432+00 on West Branch Bank Protection Plan 4BVALE
X3     0       0       0       0       0    2920
GR  2482     400    2480     420    2478     540    2478     780    2478    1730
GR  2477    1850  2478.0    1920    2480    1940  2482.8    1946  2477.5    1955
GR2469.5    1977    2469    1980    2469    1998  2475.9  2004.5  2476.1    2064
GR  2475    2300  2476.0    2700  2476.5    3200
NC  .030    .060    .029     0.1     0.3

X1    11      18    1960    2003     200     200     200
*  X-Sec 11: Same as Sta 430+00 on West Branch Bank Protection Plan 4BVALE
X3     0       0       0       0       0    2860
GR  2480     580    2478     660    2478    1840  2477.0    1880    2480    1935
GR  2480    1960  2478.4    1965  2477.4    1972  2472.8    1972  2469.8    1978
GR2469.6  1979.5  2469.6    1996  2476.6    2003  2476.8    2015  2476.0    2040
GR2475.8    2200  2476.0    2520  2477.2    3350

X1    12      17    1955    2003     200     200     200
*  X-Sec 12: Same as Sta 428+00 on West Branch Bank Protection Plan 4BVALE
X3     0       0       0       0       0    2810
GR  2482     680    2480     720  2478.4    1600    2478    1875  2477.5    1900
GR  2478    1925    2480    1950  2483.1    1955    2477    1965  2470.8    1979
GR2470.3  1982.8  2470.3    1995  2478.4    2003  2478.7    2015    2476    2300
GR2477.5  2850.0  2478.0    3320

X1    13      19    1955    2003     200     200     200
*  X-Sec 13: Same as Sta 426+00 on West Branch Bank Protection Plan 4BVALE
X3     0       0       0       0       0    2765
GR  2482     680    2480     770  2479.1    1300    2478    1870  2477.7    1885
GR  2478    1920    2480    1932    2480    1945    2484    1955    2479    1965
GR  2478    1971    2473    1971    2471  1976.5    2471  1995.5  2478.5    2003
GR2478.5    2015  2477.5    2280    2478    2700  2478.5    3450

NC  .030    .060    .020     0.1     0.3
X1    14      16    1960    2000     112     112     112       0
*  X-Sec 14: Same as Sta 52+66 on Los Reales Improvement District Plan ID-101
*               and Sta 424+88 on West Branch Bank Protection Plan 4BVALE
X3     0       0       0       0       0    2740
GR  2482     720    2480     800    2479    1200    2479    1800    2478    1870
GR2477.8    1900    2478    1920    2480    1950  2480.0    1960  2476.3    1966
GR2471.9    1970  2471.9    1996  2479.2    2000  2477.5    2400  2478.0    2650
GR2478.6    3500

NC  .030    .060   .0235     0.1     0.3
X1    15      16    2000    2040     100     100     100       0
*  X-Sec 15: Same as Sta 51+66 on Los Reales Improvement District Plan ID-101
X3     0       0       0       0       0    2765
GR  2482     760    2480     820    2480    1180  2479.5    1820  2478.0    1895
GR  2476    1908    2474    1930    2474    1990  2478.8    2000  2472.2    2007
GR2472.2    2033  2479.7    2040    2478    2420    2478    2420    2479    2900
GR2479.5    3500

X1    16      20    1993    2040     250     250     250       0
*  X-Sec 16: Same as Sta 49+16 on Los Reales Improvement District Plan ID-101
X3     0       0       0       0       0    2680
GR  2484     510    2482     890    2480    1310  2479.8    1750    2480    1870
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GR 2480     1920    2478    1927    2476    1932    2476    1940    2478    1948
GR 2480     1960    2482    1967    2482    1993  2480.3    2000 2473.11    2007
GR2473.1    2033  2480.5    2040  2478.5    2160  2480.0    2590  2481.5    3350

X1   17       14    1995    2040     250     250     250       0
* X-Sec 17: Same as Sta 46+66 on Los Reales Improvement District Plan ID-101
X3    0        0       0       0       0    2620
GR 2484      490    2482    1190    2480    1740    2481    1900    2480    1940
GR 2482     1970    2482    1995  2480.7    2000 2474.02    2007 2474.02    2033
GR2481.1    2040  2480.5    2250  2481.0    2900  2481.8    3300

X1   18       18    1990    2040     250     250     250       0    2000
* X-Sec 18: Same as Sta 44+16 on Los Reales Improvement District Plan ID-101
X3    0        0       0       0       0    2550
GR  486      450     484     580     482    1300   481.6    1530     482    1740
GR 482.2    1830     482    1910     480    1950     477    1970     480    1980
GR  483     1990   481.1    2000  474.92    2007  474.92    2033   481.7    2040
GR 481.5    2480     482    3300   482.2    3450

X1   19       17    1995    2040     250     250     250       0    2000
* X-Sec 19: Same as Sta 41+66 on Los Reales Improvement District Plan ID-101
X3    0        0       0       0       0    2480
GR  488      500     486     520     484     830   482.2    1500     482    1940
GR  480     1960     479    1980     480    1990     487    1995   481.6    2000
GR475.80    2007  475.80    2033   482.3    2040   481.8    2250     482    2500
GR  482     3000     483    3680

X1   20       18    1995    2040     250     250     250       0    2000
* X-Sec 20: Same as Sta 39+16 on Los Reales Improvement District Plan ID-101
X3    0        0       0       0       0    2420
GR  488      445     486     695     484     810   482.9    1065   482.2    1860
GR  478     1950     480    1960     482    1970     484    1980     486    1990
GR  487     1995   482.3    2000  476.67    2007  476.67    2033   483.0    2040
GR 482.2    2280     483    2930     484    3310

NC  .030    .060    .020
X1   21       16    1990    2048     197     197     197       0    2000
* X-Sec 21: Same as Sta 37+19 on Los Reales Improvement District Plan ID-101
X3    0        0       0       0       0    2375
GR  488      410     486     670     484    1060     484    1930     482    1949
GR  482     1962     484    1972     486    1980     487    1990   483.0    2000
GR477.37    2015  477.37    2041   484.0    2048   483.3    2300     484    2595
GR 484.3    3330

X1   22       19    1990    2046      44      44      44       0    2000
* X-Sec 22: Same as Sta 36+75 on Los Reales Improvement District Plan ID-101
X3    0        0       0       0       0    2365
GR  488      390     488     650     486     720     484     780     484    1600
GR  482     1660     482    1910     482    1965     484    1975     486    1982
GR  487     1990   483.2    2000  478.87    2006  478.87    2040   484.2    2046
GR  484     2080   483.4    2300     484    2640   484.4    3335

X1   23       15    1980    2046     231     231     231       0    2000
* X-Sec 23: Same as Sta 34+44 on Los Reales Improvement District Plan ID-101
X3    0        0       0       0       0    2310
GR  490      450     488     470     486    1230   484.3    1800     484    1910
GR  482     1935   481.5    1940     487    1980   484.2    2000   479.6    2006
GR 479.6    2040   485.2    2046   484.1    2140   484.5    3000   484.5    3400

X1   24       13    1985    2046     231     231     231       0    2000
* X-Sec 24: Same as Sta 32+13 on Los Reales Improvement District Plan ID-101
X3    0        0       0       0       0    2250
GR  488      370   487.4     820     486    1380     484    1950   482.2    1960
GR  488     1985     486    1995   485.8    2000   480.4    2006   480.4    2040
GR 485.4    2046   485.5    2400     486    3150

X1   25       15    2000    2046     300     300     300       0    2000
* X-Sec 25: Same as Sta 29+13 on Los Reales Improvement District Plan ID-101
X3    0        0       0       0       0    2170
GR  488      410     486    1850     484    1950   483.5    1955     484    1970
GR  486     1982     488    1995   488.3    2000   481.3    2006   481.3    2040
GR 488.3    2046   486.5    2430     487    3040   486.2    3450   487.5    4100

X1   26       13    2000    2046     235     235     235       0    2000
* X-Sec 26: Same as Sta 26+78 on Los Reales Improvement District Plan ID-101
X3    0        0       0       0       0    2100
GR  490      420     488     650     487    1200     486    1940     485    1950
GR  486     1975     488    1990   488.5    2000   482.1    2006   482.1    2040
GR 488.5    2046     487    2500     488    3400

X1   27       16    2000    2046     234     234     234       0
```

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*  X-Sec 2444  Located at u/s end of channel
GR2494.0      50  2492.0     200  2490.0     490  2488.0    1900  2487.4  1931.5
GR2485.6  1957.5  2488.5  1961.5  2488.8  1967.5  2488.2  1975.5  2489.1  1984.5
GR2488.8  1998.9  2488.8    2000  2482.8    2006  2482.8    2040  2488.8  2045.5
GR2493.4  2046.0

NC 0.030   0.060   0.022      .1      .3
X1    28      44    2000    3340      52      52      52       0
*  X-Sec 2392  Located at u/s end of channel and 31 ft u/s from Floodwall
*  Ground-profile data along upstream side of floodwall were determined by
*  field survey (NGVD-1929 datum).
GR2494.0       0  2492.0     150  2491.0     400  2489.5     650  2489.5     800
GR2490.0    1000  2490.0    1200  2490.0    1400  2490.0    1600  2490.0  1746.5
GR2490.3    1800  2490.2  1846.5  2490.0  1889.5  2488.6    1903  2488.6  1912.5
GR2487.4  1931.5  2485.6  1957.5  2488.5  1961.5  2488.8  1967.5  2488.2  1975.5
GR2489.1  1984.5  2488.8  1998.9  2488.7  2000.0  2488.9  2042.3  2489.4  2046.4
GR2488.7  2046.5  2489.3  2260.0  2489.2  2520.0  2489.0  2770.0  2489.2  3020.0
GR2489.3  3340.0  2488.9    3470  2488.9  3546.5  2488.2  4046.5  2488.7  4346.5
GR2487.9  4546.5  2489.5  4633.5  2489.5    4650  2489.5    5200  2488.7    5500
GR2488.6  5800.5  2488.7    6100  2488.3    6400  2491.3    6750

NC 0.030   0.060   0.022      .1      .3
X1  28.1      52    2000    3340       2       2       2       0
*  X-Sec 2390  Located at u/s end of channel and 33 ft u/s from Floodwall
*  Ground-profile data along upstream side of floodwall were determined by
*  field survey (NGVD-1929 datum).
GR2494.0       0  2492.0     150  2491.0     400  2489.5     650  2489.5     800
GR2490.0    1000  2490.0    1200  2490.0    1400  2490.0    1600  2490.0  1746.5
GR2490.3    1800  2490.2  1846.5  2490.0  1889.5  2488.6    1903  2488.6  1912.5
GR2487.4  1931.5  2485.6  1957.5  2488.5  1961.5  2488.8  1967.5  2488.2  1975.5
GR2489.1  1984.5  2488.8  1998.9  2488.7  2000.0  2488.9  2042.3  2489.4  2046.4
GR2488.7  2046.5  2489.3  2260.0  2489.2  2520.0  2489.0  2770.0  2489.2  3020.0
GR2489.3  3340.0  2488.9    3470  2488.9  3546.5  2488.2  4046.5  2488.7  4346.5
GR2487.9  4546.5  2489.5  4633.5  2489.5    4650  2489.5    5200  2488.7    5500
GR2488.6  5800.5  2488.7    6100  2488.3    6400  2491.3    6750  2488.3    6760
GR2489.1    6950  2489.2    7150    2490    7350  2491.6    7550  2491.8    7750
GR2492.5    7850  2494.1    7950
EJ
ER
```

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*********************************************
* HEC-2 WATER SURFACE PROFILES              *
*                                           *
* Version    4.6.2;  May 1991               *
*                                           *
* RUN DATE    30NOV94    TIME    11:37:31   *
*********************************************
```



```
**************************************
* U.S. ARMY CORPS OF ENGINEERS       *
* HYDROLOGIC ENGINEERING CENTER      *
* 609 SECOND STREET, SUITE D         *
* DAVIS, CALIFORNIA 95616-4687       *
*          (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
```

WEST BRANCH SANTA CRUZ RIVER

EXISTING CONDITIONS

REVISED 12-1-94

INCLUDES SPLIT FLOWS TO EAST

THIS RUN EXECUTED 30NOV94 11:37:31

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**************************************
HEC-2 WATER SURFACE PROFILES

Version   4.6.2;  May 1991
**************************************


SPLIT FLOW BEING PERFORMED

SF  Splitflow Analysis of the Los Reales Floodwall and Diversion Channels

JC  Splitflow Analysis
JP     0       0     100       0       0

TN  Normal depth split flow  - Sections 11 to 12
NS     2      11      12      -1    0.06   0.004
NG     0  2477.2     200  2478.0

TN  Normal depth split flow - Sections 12 to 13
NS     2      12      13      -1    0.06   0.004
NG     0  2478.0     200  2478.5

TN  Normal depth split flow - Section 13 to 14
NS     2      13      14      -1    0.06   0.004
NG     0  2478.5     112  2478.6

TN  Normal depth split flow - Sections 14 to 15
NS     2      14      15      -1    0.06   0.004
NG     0  2478.6     100  2479.5

TN  Normal depth split flow - Sections 21 to 22
NS     2      21      22      -1    0.06   0.003
NG     0  2484.3      44  2484.4

TN  Normal depth split flow - Sections 22 to 23
NS     2      22      23      -1    0.06   0.003
NG     0  2484.4     231  2484.5

TC  Rating curve outflow data set for Splitflow into South Diversion Channel
CS     3      28    28.1      -1
CR  3250 2489.90    3300 2489.93    3350 2489.97

TW  Splitflow #28 to #28.1 (Splitflow goes directly into the Santa Cruz River)
WS     9      28    28.1      -1     2.6
WC6750.0  2491.3  6760.0  2488.3  6950.0  2489.1  7150.0  2489.2  7350.0  2490.0
WC7550.0  2491.6  7750.0  2491.8  7850.0  2492.5  7950.0  2494.1
```

```
T1      Los Reales Improvement District, Letter of Map Revision
T2      Arroyo Job #PDOT01.1, HEC2 File: WEST.H2I
T3      West Branch Santa Cruz  River
T4      West Branch Santa Cruz River, from Valencia Rd. to Los Reales Rd.

J1  ICHECK     INQ       NINV      IDIR      STRT      METRIC    HVINS     Q         WSEL      FQ

      0          2         0         0         0         0         0         0      2466.7

J2  NPROF     IPLOT     PRFVS     XSECV     XSECH     FN        ALLDC     IBW       CHNIM     ITRACE

      1          0        -1         0         0         0         0         0         0

J3  VARIABLE CODES FOR SUMMARY PRINTOUT

     38         43        13        14        15         1         2         3         8        53
      4         54        61                  150

NC    .030      .030      .0275      0.1       0.3
QT      1       7638

X1      1         15      1390      2002         0         0         0
  X-Sec  1: Same as Sta 448+00 on West Branch Bank Protection Plan 4BVALE
GR   2474       1300      2474      1390      2472      1520      2470      1695      2468      1780
GR   2466       1810      2465      1836    2463.7    1861.5      2463      1864      2463      1995
GR   2470       2002    2470.3      2022      2470      2172      2472      2860      2472      3020

X1      2         23      1800      2002       100       100       100
  X-Sec  2: Same as Sta 447+00 on West Branch Bank Protection Plan 4BVALE
GR   2475       1250      2474      1430      2472      1560      2470      1710      2470      1778
GR   2472       1785      2472      1794      2474      1800      2472      1805      2470      1810
GR   2468       1825      2466    1835.5    2464.9      1841    2465.2      1852      2464      1864
GR 2463.5     1865.5    2463.5      1995    2470.5      2002    2470.8      2022    2471.4      2024
GR 2471.7       2074      2472      2164      2472      3050

X1      3         18      1820      2002       200       200       200
  X-Sec  3: Same as Sta 445+00 on West Branch Bank Protection Plan 4BVALE
GR 2475.5       1200      2474      1470      2472      1565      2470      1650      2472      1680
GR   2472       1750      2472      1790      2476      1805      2476      1820    2471.5    1836.5
GR 2465.8       1858    2464.5      1878    2464.3    1879.5    2464.4      1995    2471.2      2002
GR 2471.5       2022    2471.8      2023      2473      3050

X1      4         16      1838      2002       200       200       200
  X-Sec  4: Same as Sta 443+00 on West Branch Bank Protection Plan 4BVALE
GR   2476       1260      2474      1515      2472      1600      2472      1660      2474      1820
GR   2476       1830      2479      1838      2474      1848    2466.8      1873    2464.7      1939
GR   2465     1945.5      2465      1995      2472      2002    2472.3      2022    2472.5      2023
GR 2473.5       3100
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X1        5        15      1841      2002       200       200       200
   X-Sec  5: Same as Sta 441+00 on West Branch Bank Protection Plan 4BVALE
X3        0         0         0         0         0      3090
GR   2476.0      1250      2476      1530      2474      1790      2474      1820      2476      1830
GR   2479.5      1841    2465.5      1901    2464.8      1918    2465.6    1925.5    2465.6      1995
GR   2472.6      2002      2473      2022    2473.8      2023      2472      2720    2472.5      3100

X1        6        15      1868      2002       200       200       200
   X-Sec  6: Same as Sta 439+00 on West Branch Bank Protection Plan 4BVALE
X3        0         0         0         0         0      3040
GR     2476      1300      2476      1840      2480      1850      2480      1868      2474      1879
GR     2467      1913      2465      1913    2466.5    1965.5    2466.5      1995    2473.5      2002
GR   2473.7    2026.5      2474      2028      2472      2100      2473      2800    2474.0      3100

X1        7        14      1886      2002       200       200       200
   X-Sec  7: Same as Sta 437+00 on West Branch Bank Protection Plan 4BVALE
X3        0         0         0         0         0      3000
GR     2477      1300      2476      1870      2478      1875      2480      1880      2481      1886
GR   2475.3      1894    2469.5      1922    2466.7      1930    2467.1    1982.5    2467.1      1995
GR     2474      2002    2474.4      2022    2472.5      2400      2474      3000

X1        8        12      1880      2000       200       200       200
   X-Sec  8: Same as Sta 435+00 on West Branch Bank Protection Plan 4BVALE
X3        0         0         0         0         0      2970
GR     2477      1300      2478      1880      2480      1890    2480.0      1895    2476.5      1905
GR     2470      1930      2467      1948      2468      1992    2474.8      2000      2475      2020
GR     2474      2400    2475.5      3150

X1        9        17      1920      1998       164       164       164
   X-Sec  9: Same as Sta 433+36 on West Branch Bank Protection Plan 4BVALE
X3        0         0         0         0         0      2930
GR     2478      1500      2478      1900      2480      1905      2480      1920    2476.8      1934
GR   2467.7      1953    2467.5      1978      2469    1982.6      2469    1991.3    2475.5      1998
GR   2475.6      2018      2476      2019      2476    2043.5    2474.5    2230.0    2475.0      2550
GR   2476.0      2900      2476      3150

NC     .030      .030      .029       0.1       0.3
X1       10        18      1946    2004.5       136       136       136
   X-Sec 10: Same as Sta 432+00 on West Branch Bank Protection Plan 4BVALE
X3        0         0         0         0         0      2920
GR     2482       400      2480       420      2478       540      2478       780      2478      1730
GR     2477      1850    2478.0      1920      2480      1940    2482.8      1946    2477.5      1955
GR   2469.5      1977      2469      1980      2469      1998    2475.9    2004.5    2476.1      2064
GR     2475      2300    2476.0      2700    2476.5      3200
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NC     .030      .060      .029      0.1       0.3

X1       11        18      1960      2003       200       200       200
  X-Sec 11: Same as Sta 430+00 on West Branch Bank Protection Plan 4BVALE
X3        0         0         0         0         0      2860
GR     2480       580      2478       660      2478      1840    2477.0      1880      2480      1935
GR     2480      1960    2478.4      1965    2477.4      1972    2472.8      1972    2469.8      1978
GR   2469.6    1979.5    2469.6      1996    2476.6      2003    2476.8      2015    2476.0      2040
GR   2475.8      2200    2476.0      2520    2477.2      3350

X1       12        17      1955      2003       200       200       200
  X-Sec 12: Same as Sta 428+00 on West Branch Bank Protection Plan 4BVALE
X3        0         0         0         0         0      2810
GR     2482       680      2480       720    2478.4      1600      2478      1875    2477.5      1900
GR     2478      1925      2480      1950    2483.1      1955      2477      1965    2470.8      1979
GR   2470.3    1982.8    2470.3      1995    2478.4      2003    2478.7      2015      2476      2300
GR   2477.5    2850.0    2478.0      3320

X1       13        19      1955      2003       200       200       200
  X-Sec 13: Same as Sta 426+00 on West Branch Bank Protection Plan 4BVALE
X3        0         0         0         0         0      2765
GR     2482       680      2480       770    2479.1      1300      2478      1870    2477.7      1885
GR     2478      1920      2480      1932      2480      1945      2484      1955      2479      1965
GR     2478      1971      2473      1971      2471    1976.5      2471    1995.5    2478.5      2003
GR   2478.5      2015    2477.5      2280      2478      2700    2478.5      3450

NC     .030      .060      .020       0.1       0.3
X1       14        16      1960      2000       112       112       112         0
  X-Sec 14: Same as Sta 52+66 on Los Reales Improvement District Plan ID-101
            and Sta 424+88 on West Branch Bank Protection Plan 4BVALE
X3        0         0         0         0         0      2740
GR     2482       720      2480       800      2479      1200      2479      1800      2478      1870
GR   2477.8      1900      2478      1920      2480      1950    2480.0      1960    2476.3      1966
GR   2471.9      1970    2471.9      1996    2479.2      2000    2477.5      2400    2478.0      2650
GR   2478.6      3500

NC     .030      .060     .0235       0.1       0.3
X1       15        16      2000      2040       100       100       100         0
  X-Sec 15: Same as Sta 51+66 on Los Reales Improvement District Plan ID-101
X3        0         0         0         0         0      2765
GR     2482       760      2480       820      2480      1180    2479.5      1820    2478.0      1895
GR     2476      1908      2474      1930      2474      1990    2478.8      2000    2472.2      2007
GR   2472.2      2033    2479.7      2040      2478      2420      2478      2420      2479      2900
GR   2479.5      3500
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X1       16        20      1993      2040       250       250       250         0
  X-Sec 16: Same as Sta 49+16 on Los Reales Improvement District Plan ID-101
X3        0         0         0         0         0      2680
GR     2484       510      2482       890      2480      1310    2479.8      1750      2480      1870
GR     2480      1920      2478      1927      2476      1932      2476      1940      2478      1948
GR     2480      1960      2482      1967      2482      1993    2480.3      2000   2473.11      2007
GR   2473.1      2033    2480.5      2040    2478.5      2160    2480.0      2590    2481.5      3350

X1       17        14      1995      2040       250       250       250         0
  X-Sec 17: Same as Sta 46+66 on Los Reales Improvement District Plan ID-101
X3        0         0         0         0         0      2620
GR     2484       490      2482      1190      2480      1740      2481      1900      2480      1940
GR     2482      1970      2482      1995    2480.7      2000   2474.02      2007   2474.02      2033
GR   2481.1      2040    2480.5      2250    2481.0      2900    2481.8      3300

X1       18        18      1990      2040       250       250       250         0      2000
  X-Sec 18: Same as Sta 44+16 on Los Reales Improvement District Plan ID-101
X3        0         0         0         0         0      2550
GR      486       450       484       580       482      1300     481.6      1530       482      1740
GR    482.2      1830       482      1910       480      1950       477      1970       480      1980
GR      483      1990     481.1      2000    474.92      2007    474.92      2033     481.7      2040
GR    481.5      2480       482      3300     482.2      3450

X1       19        17      1995      2040       250       250       250         0      2000
  X-Sec 19: Same as Sta 41+66 on Los Reales Improvement District Plan ID-101
X3        0         0         0         0         0      2480
GR      488       500       486       520       484       830     482.2      1500       482      1940
GR      480      1960       479      1980       480      1990       487      1995     481.6      2000
GR   475.80      2007    475.80      2033     482.3      2040     481.8      2250       482      2500
GR      482      3000       483      3680

X1       20        18      1995      2040       250       250       250         0      2000
  X-Sec 20: Same as Sta 39+16 on Los Reales Improvement District Plan ID-101
X3        0         0         0         0         0      2420
GR      488       445       486       695       484       810     482.9      1065     482.2      1860
GR      478      1950       480      1960       482      1970       484      1980       486      1990
GR      487      1995     482.3      2000    476.67      2007    476.67      2033     483.0      2040
GR    482.2      2280       483      2930       484      3310

NC     .030      .060      .020
X1       21        16      1990      2048       197       197       197         0      2000
  X-Sec 21: Same as Sta 37+19 on Los Reales Improvement District Plan ID-101
X3        0         0         0         0         0      2375
GR      488       410       486       670       484      1060       484      1930       482      1949
GR      482      1962       484      1972       486      1980       487      1990     483.0      2000
GR   477.37      2015    477.37      2041     484.0      2048     483.3      2300       484      2595
GR    484.3      3330
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X1       22        19      1990      2046        44        44        44         0      2000
   X-Sec 22: Same as Sta 36+75 on Los Reales Improvement District Plan ID-101
X3        0         0         0         0         0      2365
GR      488       390       488       650       486       720       484       780       484      1600
GR      482      1660       482      1910       482      1965       484      1975       486      1982
GR      487      1990     483.2      2000    478.87      2006    478.87      2040     484.2      2046
GR      484      2080     483.4      2300       484      2640     484.4      3335

X1       23        15      1980      2046       231       231       231         0      2000
   X-Sec 23: Same as Sta 34+44 on Los Reales Improvement District Plan ID-101
X3        0         0         0         0         0      2310
GR      490       450       488       470       486      1230     484.3      1800       484      1910
GR      482      1935     481.5      1940       487      1980     484.2      2000     479.6      2006
GR    479.6      2040     485.2      2046     484.1      2140     484.5      3000     484.5      3400

X1       24        13      1985      2046       231       231       231         0      2000
   X-Sec 24: Same as Sta 32+13 on Los Reales Improvement District Plan ID-101
X3        0         0         0         0         0      2250
GR      488       370     487.4       820       486      1380       484      1950     482.2      1960
GR      488      1985       486      1995     485.8      2000     480.4      2006     480.4      2040
GR    485.4      2046     485.5      2400       486      3150

X1       25        15      2000      2046       300       300       300         0      2000
   X-Sec 25: Same as Sta 29+13 on Los Reales Improvement District Plan ID-101
X3        0         0         0         0         0      2170
GR      488       410       486      1850       484      1950     483.5      1955       484      1970
GR      486      1982       488      1995     488.3      2000     481.3      2006     481.3      2040
GR    488.3      2046     486.5      2430       487      3040     486.2      3450     487.5      4100

X1       26        13      2000      2046       235       235       235         0      2000
   X-Sec 26: Same as Sta 26+78 on Los Reales Improvement District Plan ID-101
X3        0         0         0         0         0      2100
GR      490       420       488       650       487      1200       486      1940       485      1950
GR      486      1975       488      1990     488.5      2000     482.1      2006     482.1      2040
GR    488.5      2046       487      2500       488      3400

X1       27        16      2000      2046       234       234       234         0
   X-Sec 2444  Located at u/s end of channel
GR   2494.0        50    2492.0       200    2490.0       490    2488.0      1900    2487.4    1931.5
GR   2485.6    1957.5    2488.5    1961.5    2488.8    1967.5    2488.2    1975.5    2489.1    1984.5
GR   2488.8    1998.9    2488.8      2000    2482.8      2006    2482.8      2040    2488.8    2045.5
GR   2493.4    2046.0
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NC    0.030     0.060     0.022        .1        .3
X1       28        44      2000      3340        52        52        52         0
  X-Sec 2392  Located at u/s end of channel and 31 ft u/s from Floodwall
  Ground-profile data along upstream side of floodwall were determined by
  field survey (NGVD-1929 datum).
GR   2494.0         0    2492.0       150    2491.0       400    2489.5       650    2489.5       800
GR   2490.0      1000    2490.0      1200    2490.0      1400    2490.0      1600    2490.0    1746.5
GR   2490.3      1800    2490.2    1846.5    2490.0    1889.5    2488.6      1903    2488.6    1912.5
GR   2487.4    1931.5    2485.6    1957.5    2488.5    1961.5    2488.8    1967.5    2488.2    1975.5
GR   2489.1    1984.5    2488.8    1998.9    2488.7    2000.0    2488.9    2042.3    2489.4    2046.4
GR   2488.7    2046.5    2489.3    2260.0    2489.2    2520.0    2489.0    2770.0    2489.2    3020.0
GR   2489.3    3340.0    2488.9      3470    2488.9    3546.5    2488.2    4046.5    2488.7    4346.5
GR   2487.9    4546.5    2489.5    4633.5    2489.5      4650    2489.5      5200    2488.7      5500
GR   2488.6    5800.5    2488.7      6100    2488.3      6400    2491.3      6750

NC    0.030     0.060     0.022        .1        .3
X1     28.1        52      2000      3340         2         2         2         0
  X-Sec 2390  Located at u/s end of channel and 33 ft u/s from Floodwall
  Ground-profile data along upstream side of floodwall were determined by
  field survey (NGVD-1929 datum).
GR   2494.0         0    2492.0       150    2491.0       400    2489.5       650    2489.5       800
GR   2490.0      1000    2490.0      1200    2490.0      1400    2490.0      1600    2490.0    1746.5
GR   2490.3      1800    2490.2    1846.5    2490.0    1889.5    2488.6      1903    2488.6    1912.5
GR   2487.4    1931.5    2485.6    1957.5    2488.5    1961.5    2488.8    1967.5    2488.2    1975.5
GR   2489.1    1984.5    2488.8    1998.9    2488.7    2000.0    2488.9    2042.3    2489.4    2046.4
GR   2488.7    2046.5    2489.3    2260.0    2489.2    2520.0    2489.0    2770.0    2489.2    3020.0
GR   2489.3    3340.0    2488.9      3470    2488.9    3546.5    2488.2    4046.5    2488.7    4346.5
GR   2487.9    4546.5    2489.5    4633.5    2489.5      4650    2489.5      5200    2488.7      5500
GR   2488.6    5800.5    2488.7      6100    2488.3      6400    2491.3      6750    2488.3      6760
GR   2489.1      6950    2489.2      7150      2490      7350    2491.6      7550    2491.8      7750
GR   2492.5      7850    2494.1      7950
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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 1
0

 CCHV=     .100 CEHV=     .300
 *SECNO 1.000
     1.000     3.70  2466.70      .00  2466.70  2467.04      .34      .00      .00  2474.00
    2786.7       .0   2786.7       .0       .0    594.7       .0       .0       .0  2470.00
       .00      .00     4.69      .00     .000     .027     .000     .000  2463.00  1799.50
   .001769       0.       0.       0.        0        0        0      .00   199.20  1998.70

 *SECNO 2.000
     2.000     3.31  2466.81      .00      .00  2467.30      .49      .21      .05  2474.00
    2786.7       .0   2786.7       .0       .0    494.0       .0      1.2       .4  2470.50
       .00      .00     5.64      .00     .000     .027     .000     .000  2463.50  1831.24
   .002603     100.     100.     100.        2        0        0      .00   167.07  1998.31

 *SECNO 3.000
     3.000     2.99  2467.29      .00      .00  2468.06      .77      .68      .08  2476.00
    2786.7       .0   2786.7       .0       .0    395.3       .0      3.3      1.1  2471.20
       .01      .00     7.05      .00     .000     .027     .000     .000  2464.30  1852.38
   .004552     200.     200.     200.        2        0        0      .00   145.60  1997.98

 *SECNO 4.000
     4.000     3.47  2468.17      .00      .00  2469.18     1.00     1.05      .07  2479.00
    2786.7       .0   2786.7       .0       .0    346.4       .0      5.0      1.8  2472.00
       .02      .00     8.04      .00     .000     .027     .000     .000  2464.70  1868.25
   .006089     200.     200.     200.        3        0        0      .00   129.92  1998.17

 *SECNO 5.000

 3470 ENCROACHMENT STATIONS=         .0   3090.0  TYPE=      1  TARGET=      3089.999
     5.000     4.51  2469.31      .00      .00  2470.07      .77      .87      .02  2479.50
    2786.7       .0   2786.7       .0       .0    397.0       .0      6.7      2.3  2472.60
       .03      .00     7.02      .00     .000     .027     .000     .000  2464.80  1884.69
   .003274     200.     200.     200.        3        0        0      .00   114.02  1998.71

 *SECNO 6.000
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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


3470 ENCROACHMENT STATIONS=          .0    3040.0  TYPE=      1  TARGET=     3039.999
   6.000      4.89   2469.89       .00       .00   2470.91      1.02       .77       .08   2480.00
  2786.7        .0    2786.7        .0        .0     343.5        .0       8.4       2.8   2473.50
     .03       .00      8.11       .00      .000      .027      .000      .000   2465.00   1898.96
 .004534      200.      200.      200.         3         0         0       .00     99.43   1998.39

*SECNO 7.000

3301 HV CHANGED MORE THAN HVINS

7185 MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED

3470 ENCROACHMENT STATIONS=          .0    3000.0  TYPE=      1  TARGET=     2999.999
   7.000      3.92   2470.62   2470.62       .00   2472.29      1.66      1.17       .19   2481.00
  2786.7        .0    2786.7        .0        .0     269.1        .0       9.8       3.2   2474.00
     .04       .00     10.35       .00      .000      .027      .000      .000   2466.70   1916.57
 .007778      200.      200.      200.         3        15         0       .00     82.00   1998.58

*SECNO 8.000

3470 ENCROACHMENT STATIONS=          .0    2970.0  TYPE=      1  TARGET=     2969.999
   8.000      5.17   2472.17       .00       .00   2473.59      1.42      1.28       .02   2478.00
  2786.7        .0    2786.7        .0        .0     291.6        .0      11.1       3.6   2474.80
     .05       .00      9.56       .00      .000      .027      .000      .000   2467.00   1921.61
 .005332      200.      200.      200.         3         0         0       .00     75.31   1996.92

*SECNO 9.000

3301 HV CHANGED MORE THAN HVINS

3685 20 TRIALS ATTEMPTED WSEL,CWSEL
3693 PROBABLE MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED

3470 ENCROACHMENT STATIONS=          .0    2930.0  TYPE=      1  TARGET=     2929.999
   9.000      5.59   2473.09   2473.09       .00   2475.29      2.21      1.02       .24   2480.00
  2786.7        .0    2786.7        .0        .0     233.8        .0      12.1       3.8   2475.50
     .05       .00     11.92       .00      .000      .027      .000      .000   2467.50   1941.75
 .007384      164.      164.      164.        20         8         0       .00     53.76   1995.51
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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

CCHV= .100 CEHV= .300
*SECNO 10.000

3301 HV CHANGED MORE THAN HVINS

3685 20 TRIALS ATTEMPTED WSEL.CWSEL
3693 PROBABLE MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED

3470 ENCROACHMENT STATIONS= .0 2920.0 TYPE= 1 TARGET= 2919.999

10.000	7.35	2476.35	2476.35	.00	2476.79	.44	.49	.18	2482.80
2786.7	.0	1647.8	1138.9	.0	243.4	600.5	13.8	5.4	2475.90
.06	.00	6.77	1.90	.000	.029	.030	.000	2469.00	1958.17
.002148	136.	136.	136.	20	12	0	.00	961.83	2920.00

CCHV= .100 CEHV= .300
*SECNO 11.000

3265 DIVIDED FLOW

3685 20 TRIALS ATTEMPTED WSEL.CWSEL
3693 PROBABLE MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED

3470 ENCROACHMENT STATIONS= .0 2860.0 TYPE= 1 TARGET= 2859.999

11.000	7.53	2477.13	2477.13	.00	2477.67	.54	.48	.03	2480.00
2786.7	.2	1549.3	1237.3	.5	198.6	914.3	18.3	9.7	2476.60
.07	.41	7.80	1.35	.030	.029	.060	.000	2469.60	1874.80
.002642	200.	200.	200.	20	9	0	.00	895.58	2860.00

*SECNO 12.000

3265 DIVIDED FLOW

3685 20 TRIALS ATTEMPTED WSEL.CWSEL
3693 PROBABLE MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED

3470 ENCROACHMENT STATIONS= .0 2810.0 TYPE= 1 TARGET= 2809.999

12.000	7.54	2477.84	2477.84	.00	2478.46	.61	.58	.02	2483.10
2786.7	5.1	1647.0	1134.6	5.9	203.6	764.9	23.1	13.5	2478.40
.08	.86	8.09	1.48	.030	.029	.060	.000	2470.30	1882.82
.003187	200.	200.	200.	20	5	0	.00	777.78	2810.00

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 13.000

3265 DIVIDED FLOW

3280 CROSS SECTION 13.00 EXTENDED .35 FEET

3685 20 TRIALS ATTEMPTED WSEL,CWSEL
3693 PROBABLE MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED

3470 ENCROACHMENT STATIONS= .0 2765.0 TYPE= 1 TARGET= 2764.999

13.000	7.85	2478.85	2478.85	.00	2479.28	.43	.54	.02	2484.00
2798.7	374.6	1538.9	885.3	240.4	219.8	746.9	28.1	18.3	2478.50
.09	1.56	7.00	1.19	.030	.029	.060	.000	2471.00	1428.52
.002295	200.	200.	200.	20	9	0	.00	1295.70	2765.00

CCHV= .100 CEHV= .300
*SECNO 14.000

3265 DIVIDED FLOW

3280 CROSS SECTION 14.00 EXTENDED .74 FEET

3685 20 TRIALS ATTEMPTED WSEL,CWSEL
3693 PROBABLE MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED

3470 ENCROACHMENT STATIONS= .0 2740.0 TYPE= 1 TARGET= 2739.999

14.000	7.44	2479.34	2479.34	.00	2479.77	.43	.16	.00	2480.00
2863.0	403.1	1631.8	828.1	372.5	237.1	912.2	31.6	22.1	2479.20
.10	1.08	6.88	.91	.030	.020	.060	.000	2471.90	1063.48
.000965	112.	112.	112.	20	9	0	.00	1655.57	2740.00

CCHV= .100 CEHV= .300
*SECNO 15.000
3280 CROSS SECTION 15.00 EXTENDED .23 FEET

3302 WARNING: CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE. KRATIO = 1.64

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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


3470 ENCROACHMENT STATIONS=        .0    2765.0  TYPE=      1  TARGET=      2764.999
   15.000      7.53   2479.73       .00       .00   2479.85       .12       .06       .03   2478.80
   2910.1    1534.3     952.3     423.5     624.2     251.9     807.6      35.2      25.4   2479.70
      .11      2.46      3.78       .52      .030      .023      .060      .000   2472.20   1525.00
  .000369      100.      100.      100.         2         0         0       .00   1240.00   2765.00

*SECNO 16.000

3265 DIVIDED FLOW

3685 20 TRIALS ATTEMPTED WSEL,CWSEL
3693 PROBABLE MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED

3470 ENCROACHMENT STATIONS=        .0    2680.0  TYPE=      1  TARGET=      2679.999
   16.000      7.19   2480.29   2480.29       .00   2480.80       .51       .17       .12   2482.00
   2910.1     648.1    1728.1     534.0     344.7     236.4     562.5      43.4      32.9   2480.50
      .12      1.88      7.31       .95      .030      .023      .060      .000   2473.10   1248.73
  .001503      250.      250.      250.        20         9         0       .00   1379.59   2680.00

*SECNO 17.000

3265 DIVIDED FLOW

3685 20 TRIALS ATTEMPTED WSEL,CWSEL
3693 PROBABLE MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED

3470 ENCROACHMENT STATIONS=        .0    2620.0  TYPE=      1  TARGET=      2619.999
   17.000      7.44   2481.46   2481.46       .00   2481.94       .48       .36       .00   2482.00
   2910.1     804.7    1766.3     339.1     498.5     250.4     438.7      50.1      40.5   2481.10
      .14      1.61      7.05       .77      .030      .023      .060      .000   2474.02   1339.65
  .001400      250.      250.      250.        20         9         0       .00   1245.09   2620.00

*SECNO 18.000

3265 DIVIDED FLOW

7185 MINIMUM SPECIFIC ENERGY
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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

3720 CRITICAL DEPTH ASSUMED

3470 ENCROACHMENT STATIONS=       .0    2550.0  TYPE=     1  TARGET=     2549.999
   18.000     7.36  2482.28  2482.28      .00  2482.75      .46      .35      .00  2483.00
   2910.1    907.9   1743.4    258.9    431.5    252.8    353.8     56.4     47.9  2481.70
      .15     2.10     6.90      .73     .030     .023     .060     .000  2474.92  1198.13
  .001422     250.     250.     250.        3        6        0      .00  1345.70  2550.00

*SECNO 19.000

3265 DIVIDED FLOW

3685 20 TRIALS ATTEMPTED WSEL,CWSEL
3693 PROBABLE MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED

3470 ENCROACHMENT STATIONS=       .0    2480.0  TYPE=     1  TARGET=     2479.999
   19.000     6.92  2482.72  2482.72      .00  2483.23      .50      .37      .01  2487.00
   2910.1    934.1   1707.9    268.1    459.4    234.5    332.8     62.4     55.1  2482.30
      .17     2.03     7.28      .81     .030     .023     .060     .000  2475.80  1304.99
  .001520     250.     250.     250.       20        9        0      .00  1168.00  2480.00

*SECNO 20.000

3265 DIVIDED FLOW

3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE.  KRATIO =  1.57

3470 ENCROACHMENT STATIONS=       .0    2420.0  TYPE=     1  TARGET=     2419.999
   20.000     6.69  2483.36      .00      .00  2483.50      .14      .23      .04  2487.00
   2910.1   1691.2   1028.6    190.4   1035.4    226.4    333.3     69.9     62.6  2483.00
      .19     1.63     4.54      .57     .030     .023     .060     .000  2476.67   957.99
  .000616     250.     250.     250.        2        0        0      .00  1439.95  2420.00

*SECNO 21.000

3265 DIVIDED FLOW
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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

3685 20 TRIALS ATTEMPTED WSEL,CWSEL
3693 PROBABLE MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED

3470 ENCROACHMENT STATIONS= .0 2375.0 TYPE= 1 TARGET= 2374.999

21.000	7.21	2484.58	2484.58	.00	2485.05	.47	.15	.10	2487.00
2910.1	747.2	1917.0	245.9	617.0	283.7	323.5	76.3	69.0	2484.00
.20	1.21	6.76	.76	.030	.020	.060	.000	2477.37	946.98
.000948	197.	197.	197.	20	9	0	.00	1406.29	2375.00

*SECNO 22.000

3265 DIVIDED FLOW

3302 WARNING: CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE. KRATIO = 2.39

3470 ENCROACHMENT STATIONS= .0 2365.0 TYPE= 1 TARGET= 2364.999

22.000	6.20	2485.07	.00	.00	2485.11	.04	.01	.04	2487.00
2927.5	2036.2	713.8	177.5	1990.5	261.3	442.5	78.2	70.5	2484.20
.21	1.02	2.73	.40	.030	.020	.060	.000	2478.87	747.59
.000168	44.	44.	44.	2	0	0	.00	1601.14	2365.00

*SECNO 23.000

3265 DIVIDED FLOW

3301 HV CHANGED MORE THAN HVINS

3685 20 TRIALS ATTEMPTED WSEL,CWSEL
3693 PROBABLE MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED

3470 ENCROACHMENT STATIONS= .0 2310.0 TYPE= 1 TARGET= 2309.999

23.000	5.76	2485.36	2485.36	.00	2485.92	.56	.09	.16	2487.00
3129.9	1007.9	1833.4	288.7	454.4	239.3	275.1	88.0	77.0	2485.20
.22	2.22	7.66	1.05	.030	.020	.060	.000	2479.60	1443.49
.001612	231.	231.	231.	20	10	0	.00	842.91	2310.00

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 24.000

3265 DIVIDED FLOW

3685 20 TRIALS ATTEMPTED WSEL,CWSEL
3693 PROBABLE MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED

3470 ENCROACHMENT STATIONS= .0 2250.0 TYPE= 1 TARGET= 2249.999

24.000	5.65	2486.05	2486.05	.00	2486.52	.48	.35	.01	2488.00
3129.9	1364.6	1679.4	86.0	657.9	229.3	125.9	93.2	81.6	2485.40
.24	2.07	7.33	.68	.030	.020	.060	.000	2480.40	1361.64
.001453	231.	231.	231.	20	6	0	.00	870.17	2250.00

*SECNO 25.000

3265 DIVIDED FLOW

3685 20 TRIALS ATTEMPTED WSEL,CWSEL
3693 PROBABLE MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED

3470 ENCROACHMENT STATIONS= .0 2170.0 TYPE= 1 TARGET= 2169.999

25.000	5.67	2486.97	2486.97	.00	2487.56	.59	.45	.03	2488.30
3129.9	1366.4	1763.5	.0	627.6	220.4	.0	99.6	87.6	2488.30
.25	2.18	8.00	.00	.030	.020	.000	.000	2481.30	1150.92
.001560	300.	300.	300.	20	5	0	.00	881.11	2044.86

*SECNO 26.000

3265 DIVIDED FLOW

3470 ENCROACHMENT STATIONS= .0 2100.0 TYPE= 1 TARGET= 2099.999

26.000	5.42	2487.52	.00	.00	2487.91	.40	.33	.02	2488.50
3129.9	1631.4	1498.6	.0	912.5	212.0	.0	104.9	93.0	2488.50
.27	1.79	7.07	.00	.030	.020	.000	.000	2482.10	911.98
.001280	235.	235.	235.	3	0	0	.00	1118.62	2045.08

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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 27.000
3685 20 TRIALS ATTEMPTED WSEL,CWSEL
3693 PROBABLE MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED
   27.000      6.45   2489.25   2489.25       .00   2489.87       .62       .30       .07   2488.80
   3129.9    1111.0    2019.0        .0     695.7     258.8        .0     110.5      98.7   2493.40
      .28      1.60      7.80       .00      .030      .020      .000      .000   2482.80   1021.68
  .001267      234.      234.      234.        20        12         0       .00   1023.87   2045.55

CCHV=     .100 CEHV=      .300
*SECNO 28.000

3265 DIVIDED FLOW

3301 HV CHANGED MORE THAN HVINS

3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,  KRATIO =  2.15

   28.000      4.35   2489.95       .00       .00   2489.96       .01       .03       .06   2488.70
   3129.9     343.6    1052.1    1734.3     331.3    1084.8    3660.8     114.1     102.4   2489.30
      .30      1.04       .97       .47      .030      .022      .060      .000   2485.60    575.13
  .000273       52.       52.       52.         3         0         0       .00   5106.97   6592.40

CCHV=     .100 CEHV=      .300
*SECNO 28.100

3265 DIVIDED FLOW

   28.100      4.32   2489.92       .00       .00   2489.97       .05       .00       .01   2488.70
   7638.0     798.0    2394.2    4445.8     318.5    1051.1    4036.4     114.4     102.7   2489.30
      .30      2.51      2.28      1.10      .030      .022      .060      .000   2485.60    579.32
  .001573        2.        2.        2.         2         0         0       .00   5665.98   7331.02
```

TN Normal depth split flow - Sections 11 to 12

TOTAL AREA	AVG VELOCITY	MAX DEPTH	AVG DEPTH	TOF WIDTH	TOP WIDTH
.0	.00	.00	.00	200.0	.0

ASQ	QCOMP	ERRAC	TASQ	TCQ	TABER	NITER	DSWS	USWS	DSSNO	USSNO
.00	.00	.00	.00	.00	.00	10	2477.130	2477.844	11.000	12.000

TN Normal depth split flow - Sections 12 to 13

TOTAL AREA	AVG VELOCITY	MAX DEPTH	AVG DEPTH	TOF WIDTH	TOP WIDTH
24.4	.49	.35	.18	200.0	138.5

ASQ	QCOMP	ERRAC	TASQ	TCQ	TABER	NITER	DSWS	USWS	DSSNO	USSNO
12.00	11.99	.10	12.00	11.99	.10	10	2477.844	2478.852	12.000	13.000

TN Normal depth split flow - Section 13 to 14

TOTAL AREA	AVG VELOCITY	MAX DEPTH	AVG DEPTH	TOF WIDTH	TOP WIDTH
61.2	1.05	.74	.55	112.0	112.0

ASQ	QCOMP	ERRAC	TASQ	TCQ	TABER	NITER	DSWS	USWS	DSSNO	USSNO
64.27	64.11	.25	76.27	76.10	.22	10	2478.852	2479.341	13.000	14.000

TN Normal depth split flow - Sections 14 to 15

TOTAL AREA	AVG VELOCITY	MAX DEPTH	AVG DEPTH	TOF WIDTH	TOP WIDTH
48.6	.97	.74	.49	100.0	100.0

ASQ	QCOMP	ERRAC	TASQ	TCQ	TABER	NITER	DSWS	USWS	DSSNO	USSNO
47.12	47.03	.19	123.39	123.13	.21	10	2479.341	2479.730	14.000	15.000

TN Normal depth split flow - Sections 21 to 22

TOTAL AREA	AVG VELOCITY	MAX DEPTH	AVG DEPTH	TOF WIDTH	TOP WIDTH
20.9	.83	.67	.48	44.0	44.0

ASQ	QCOMP	ERRAC	TASQ	TCQ	TABER	NITER	DSWS	USWS	DSSNO	USSNO
17.34	17.29	.32	140.73	140.42	.22	10	2484.580	2485.071	21.000	22.000

TN Normal depth split flow - Sections 22 to 23

TOTAL AREA	AVG VELOCITY	MAX DEPTH	AVG DEPTH	TOF WIDTH	TOP WIDTH
177.3	1.14	.86	.77	231.0	231.0

ASQ	QCOMP	ERRAC	TASQ	TCQ	TABER	NITER	DSWS	USWS	DSSNO	USSNO
202.49	201.53	.48	343.23	341.95	.37	10	2485.071	2485.363	22.000	23.000

TC Rating curve outflow data set for Splitflow into South Diversion Channel

ASQ	QCOMP	ERRAC	TASQ	TCQ	TABER	NITER	DSWS	USWS	DSSNO	USSNO
3308.07	3308.22	.00	3651.30	3650.17	.03	10	2489.949	2489.924	28.000	28.100

TW Splitflow #28 to #28.1 (Splitflow goes directly into the Santa Cruz River)

ASQ	QCOMP	ERRAC	TASQ	TCQ	TABER	NITER	DSWS	USWS	DSSNO	USSNO
1199.98	1197.65	.19	4851.28	4847.82	.07	10	2489.949	2489.924	28.000	28.100

THIS RUN EXECUTED 30NOV94 11:41:02

****
HEC-2 WATER SURFACE PROFILES

Version 4.6.2; May 1991
****

NOTE- ASTERISK (*) AT LEFT OF CROSS-SECTION NUMBER INDICATES MESSAGE IN SUMMARY OF ERRORS LIST

West Branch Santa Cruz

SUMMARY PRINTOUT

	SECNO	Q	QLOB	QCH	QROB	CWSEL	CRIWS	EG	DEPTH	SSTA	TOPWID	ENDST	DIFEG
	1.000	2786.72	.00	2786.72	.00	2466.70	.00	2467.04	3.70	1799.50	199.20	1998.70	.00
	2.000	2786.72	.00	2786.72	.00	2466.81	.00	2467.30	3.31	1831.24	167.07	1998.31	.00
	3.000	2786.72	.00	2786.72	.00	2467.29	.00	2468.06	2.99	1852.38	145.60	1997.98	.00
	4.000	2786.72	.00	2786.72	.00	2468.17	.00	2469.18	3.47	1868.25	129.92	1998.17	.00
	5.000	2786.72	.00	2786.72	.00	2469.31	.00	2470.07	4.51	1884.69	114.02	1998.71	.00
	6.000	2786.72	.00	2786.72	.00	2469.89	.00	2470.91	4.89	1898.96	99.43	1998.39	.00
*	7.000	2786.72	.00	2786.72	.00	2470.62	2470.62	2472.29	3.92	1916.57	82.00	1998.58	.00
	8.000	2786.72	.00	2786.72	.00	2472.17	.00	2473.59	5.17	1921.61	75.31	1996.92	.00
*	9.000	2786.72	.00	2786.72	.00	2473.09	2473.09	2475.29	5.59	1941.75	53.76	1995.51	.00
*	10.000	2786.72	.00	1647.79	1138.94	2476.35	2476.35	2476.79	7.35	1958.17	961.83	2920.00	.00
*	11.000	2786.72	.20	1549.26	1237.26	2477.13	2477.13	2477.67	7.53	1874.80	895.58	2860.00	.00
*	12.000	2786.72	5.10	1646.98	1134.64	2477.84	2477.84	2478.46	7.54	1882.82	777.78	2810.00	.00
*	13.000	2798.72	374.61	1538.86	885.25	2478.85	2478.85	2479.28	7.85	1428.52	1295.70	2765.00	.00
*	14.000	2862.99	403.09	1631.77	828.13	2479.34	2479.34	2479.77	7.44	1063.48	1655.57	2740.00	.00
*	15.000	2910.11	1534.34	952.28	423.49	2479.73	.00	2479.85	7.53	1525.00	1240.00	2765.00	.00
*	16.000	2910.11	648.07	1728.09	533.95	2480.29	2480.29	2480.80	7.19	1248.73	1379.59	2680.00	.00
*	17.000	2910.11	804.66	1766.34	339.11	2481.46	2481.46	2481.94	7.44	1339.65	1245.09	2620.00	.00

	SECNO	Q	QLOB	QCH	QROB	CWSEL	CRIWS	EG	DEPTH	SSTA	TOPWID	ENDST	DIFEG
*	18.000	2910.11	907.86	1743.38	258.88	2482.28	2482.28	2482.75	7.36	1198.13	1345.70	2550.00	.00
*	19.000	2910.11	934.13	1707.91	268.07	2482.72	2482.72	2483.23	6.92	1304.99	1168.00	2480.00	.00
*	20.000	2910.11	1691.17	1028.56	190.38	2483.36	.00	2483.50	6.69	957.99	1439.95	2420.00	.00
*	21.000	2910.11	747.23	1916.99	245.89	2484.58	2484.58	2485.05	7.21	946.98	1406.29	2375.00	.00
*	22.000	2927.46	2036.17	713.84	177.45	2485.07	.00	2485.11	6.20	747.59	1601.14	2365.00	.00
*	23.000	3129.95	1007.85	1833.37	288.72	2485.36	2485.36	2485.92	5.76	1443.49	842.91	2310.00	.00
*	24.000	3129.95	1364.55	1679.39	86.00	2486.05	2486.05	2486.52	5.65	1361.64	870.17	2250.00	.00
*	25.000	3129.95	1366.44	1763.51	.00	2486.97	2486.97	2487.56	5.67	1150.92	881.11	2044.86	.00
	26.000	3129.95	1631.36	1498.59	.00	2487.52	.00	2487.91	5.42	911.98	1118.62	2045.08	.00
*	27.000	3129.95	1110.97	2018.97	.00	2489.25	2489.25	2489.87	6.45	1021.68	1023.87	2045.55	.00
*	28.000	3129.95	343.55	1052.07	1734.33	2489.95	.00	2489.96	4.35	575.13	5106.97	6592.40	.00
	28.100	7638.00	797.98	2394.20	4445.82	2489.92	.00	2489.97	4.32	579.32	5665.98	7331.02	.00

West Branch Santa Cruz

SUMMARY PRINTOUT TABLE 150

	SECNO	XLCH	ELTRD	ELLC	ELMIN	Q	CWSEL	CRIWS	EG	10*KS	VCH	AREA	.01K
	1.000	.00	.00	.00	2463.00	2786.72	2466.70	.00	2467.04	17.69	4.69	594.71	662.55
	2.000	100.00	.00	.00	2463.50	2786.72	2466.81	.00	2467.30	26.03	5.64	493.97	546.18
	3.000	200.00	.00	.00	2464.30	2786.72	2467.29	.00	2468.06	45.52	7.05	395.31	413.05
	4.000	200.00	.00	.00	2464.70	2786.72	2468.17	.00	2469.18	60.89	8.04	346.42	357.13
	5.000	200.00	.00	.00	2464.80	2786.72	2469.31	.00	2470.07	32.74	7.02	396.99	487.04
	6.000	200.00	.00	.00	2465.00	2786.72	2469.89	.00	2470.91	45.34	8.11	343.47	413.87
*	7.000	200.00	.00	.00	2466.70	2786.72	2470.62	2470.62	2472.29	77.78	10.35	269.14	315.99
	8.000	200.00	.00	.00	2467.00	2786.72	2472.17	.00	2473.59	53.32	9.56	291.63	381.65
*	9.000	164.00	.00	.00	2467.50	2786.72	2473.09	2473.09	2475.29	73.84	11.92	233.84	324.31
*	10.000	136.00	.00	.00	2469.00	2786.72	2476.35	2476.35	2476.79	21.48	6.77	843.87	601.30
*	11.000	200.00	.00	.00	2469.60	2786.72	2477.13	2477.13	2477.67	26.42	7.80	1113.41	542.18
*	12.000	200.00	.00	.00	2470.30	2786.72	2477.84	2477.84	2478.46	31.87	8.09	974.42	493.60
*	13.000	200.00	.00	.00	2471.00	2798.72	2478.85	2478.85	2479.28	22.95	7.00	1207.04	584.25
*	14.000	112.00	.00	.00	2471.90	2862.99	2479.34	2479.34	2479.77	9.65	6.88	1521.86	921.51
*	15.000	100.00	.00	.00	2472.20	2910.11	2479.73	.00	2479.85	3.69	3.78	1683.71	1514.73
*	16.000	250.00	.00	.00	2473.10	2910.11	2480.29	2480.29	2480.80	15.03	7.31	1143.65	750.67
*	17.000	250.00	.00	.00	2474.02	2910.11	2481.46	2481.46	2481.94	14.00	7.05	1187.54	777.70
*	18.000	250.00	.00	.00	2474.92	2910.11	2482.28	2482.28	2482.75	14.22	6.90	1038.16	771.77
*	19.000	250.00	.00	.00	2475.80	2910.11	2482.72	2482.72	2483.23	15.20	7.28	1026.78	746.48
*	20.000	250.00	.00	.00	2476.67	2910.11	2483.36	.00	2483.50	6.16	4.54	1595.12	1172.58
*	21.000	197.00	.00	.00	2477.37	2910.11	2484.58	2484.58	2485.05	9.48	6.76	1224.30	945.13
*	22.000	44.00	.00	.00	2478.87	2927.46	2485.07	.00	2485.11	1.68	2.73	2694.39	2258.57
*	23.000	231.00	.00	.00	2479.60	3129.95	2485.36	2485.36	2485.92	16.12	7.66	968.81	779.68
*	24.000	231.00	.00	.00	2480.40	3129.95	2486.05	2486.05	2486.52	14.53	7.33	1013.08	821.05

	SECNO	XLCH	ELTRD	ELLC	ELMIN	Q	CWSEL	CRIWS	EG	10*KS	VCH	AREA	.01K
*	25.000	300.00	.00	.00	2481.30	3129.95	2486.97	2486.97	2487.56	15.60	8.00	847.99	792.52
	26.000	235.00	.00	.00	2482.10	3129.95	2487.52	.00	2487.91	12.80	7.07	1124.46	874.98
*	27.000	234.00	.00	.00	2482.80	3129.95	2489.25	2489.25	2489.87	12.67	7.80	954.45	879.46
*	28.000	52.00	.00	.00	2485.60	3129.95	2489.95	.00	2489.96	2.73	.97	5076.90	1892.93
	28.100	2.00	.00	.00	2485.60	7638.00	2489.92	.00	2489.97	15.73	2.28	5406.00	1925.84

West Branch Santa Cruz

SUMMARY PRINTOUT TABLE 150

	SECNO	Q	CWSEL	DIFWSP	DIFWSX	DIFKWS	TOPWID	XLCH
	1.000	2786.72	2466.70	.00	.00	.00	199.20	.00
	2.000	2786.72	2466.81	.00	.11	.00	167.07	100.00
	3.000	2786.72	2467.29	.00	.48	.00	145.60	200.00
	4.000	2786.72	2468.17	.00	.88	.00	129.92	200.00
	5.000	2786.72	2469.31	.00	1.14	.00	114.02	200.00
	6.000	2786.72	2469.89	.00	.59	.00	99.43	200.00
*	7.000	2786.72	2470.62	.00	.73	.00	82.00	200.00
	8.000	2786.72	2472.17	.00	1.55	.00	75.31	200.00
*	9.000	2786.72	2473.09	.00	.91	.00	53.76	164.00
*	10.000	2786.72	2476.35	.00	3.26	.00	961.83	136.00
*	11.000	2786.72	2477.13	.00	.78	.00	895.58	200.00
*	12.000	2786.72	2477.84	.00	.71	.00	777.78	200.00
*	13.000	2798.72	2478.85	.00	1.01	.00	1295.70	200.00
*	14.000	2862.99	2479.34	.00	.49	.00	1655.57	112.00
*	15.000	2910.11	2479.73	.00	.39	.00	1240.00	100.00
*	16.000	2910.11	2480.29	.00	.56	.00	1379.59	250.00
*	17.000	2910.11	2481.46	.00	1.16	.00	1245.09	250.00
*	18.000	2910.11	2482.28	.00	.83	.00	1345.70	250.00
*	19.000	2910.11	2482.72	.00	.44	.00	1168.00	250.00
*	20.000	2910.11	2483.36	.00	.63	.00	1439.95	250.00
*	21.000	2910.11	2484.58	.00	1.22	.00	1406.29	197.00
*	22.000	2927.46	2485.07	.00	.49	.00	1601.14	44.00
*	23.000	3129.95	2485.36	.00	.29	.00	842.91	231.00
*	24.000	3129.95	2486.05	.00	.68	.00	870.17	231.00

	SECNO	Q	CWSEL	DIFWSP	DIFWSX	DIFKWS	TOPWID	XLCH
*	25.000	3129.95	2486.97	.00	.93	.00	881.11	300.00
	26.000	3129.95	2487.52	.00	.55	.00	1118.62	235.00
*	27.000	3129.95	2489.25	.00	1.73	.00	1023.87	234.00
*	28.000	3129.95	2489.95	.00	.70	.00	5106.97	52.00
	28.100	7638.00	2489.92	.00	-.02	.00	5665.98	2.00

SUMMARY OF ERRORS AND SPECIAL NOTES

CAUTION	SECNO=	7.000	PROFILE=	1	CRITICAL DEPTH ASSUMED
CAUTION	SECNO=	7.000	PROFILE=	1	MINIMUM SPECIFIC ENERGY
CAUTION	SECNO=	9.000	PROFILE=	1	CRITICAL DEPTH ASSUMED
CAUTION	SECNO=	9.000	PROFILE=	1	PROBABLE MINIMUM SPECIFIC ENERGY
CAUTION	SECNO=	9.000	PROFILE=	1	20 TRIALS ATTEMPTED TO BALANCE WSEL
CAUTION	SECNO=	10.000	PROFILE=	1	CRITICAL DEPTH ASSUMED
CAUTION	SECNO=	10.000	PROFILE=	1	PROBABLE MINIMUM SPECIFIC ENERGY
CAUTION	SECNO=	10.000	PROFILE=	1	20 TRIALS ATTEMPTED TO BALANCE WSEL
CAUTION	SECNO=	11.000	PROFILE=	1	CRITICAL DEPTH ASSUMED
CAUTION	SECNO=	11.000	PROFILE=	1	PROBABLE MINIMUM SPECIFIC ENERGY
CAUTION	SECNO=	11.000	PROFILE=	1	20 TRIALS ATTEMPTED TO BALANCE WSEL
CAUTION	SECNO=	12.000	PROFILE=	1	CRITICAL DEPTH ASSUMED
CAUTION	SECNO=	12.000	PROFILE=	1	PROBABLE MINIMUM SPECIFIC ENERGY
CAUTION	SECNO=	12.000	PROFILE=	1	20 TRIALS ATTEMPTED TO BALANCE WSEL
CAUTION	SECNO=	13.000	PROFILE=	1	CRITICAL DEPTH ASSUMED
CAUTION	SECNO=	13.000	PROFILE=	1	PROBABLE MINIMUM SPECIFIC ENERGY
CAUTION	SECNO=	13.000	PROFILE=	1	20 TRIALS ATTEMPTED TO BALANCE WSEL
CAUTION	SECNO=	14.000	PROFILE=	1	CRITICAL DEPTH ASSUMED
CAUTION	SECNO=	14.000	PROFILE=	1	PROBABLE MINIMUM SPECIFIC ENERGY
CAUTION	SECNO=	14.000	PROFILE=	1	20 TRIALS ATTEMPTED TO BALANCE WSEL
WARNING	SECNO=	15.000	PROFILE=	1	CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
CAUTION	SECNO=	16.000	PROFILE=	1	CRITICAL DEPTH ASSUMED
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CAUTION	SECNO=	16.000	PROFILE=	1	20 TRIALS ATTEMPTED TO BALANCE WSEL
CAUTION	SECNO=	17.000	PROFILE=	1	CRITICAL DEPTH ASSUMED
CAUTION	SECNO=	17.000	PROFILE=	1	PROBABLE MINIMUM SPECIFIC ENERGY
CAUTION	SECNO=	17.000	PROFILE=	1	20 TRIALS ATTEMPTED TO BALANCE WSEL
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CAUTION	SECNO=	18.000	PROFILE=	1	MINIMUM SPECIFIC ENERGY
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CAUTION	SECNO=	19.000	PROFILE=	1	PROBABLE MINIMUM SPECIFIC ENERGY
CAUTION	SECNO=	19.000	PROFILE=	1	20 TRIALS ATTEMPTED TO BALANCE WSEL
WARNING	SECNO=	20.000	PROFILE=	1	CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
CAUTION	SECNO=	21.000	PROFILE=	1	CRITICAL DEPTH ASSUMED
CAUTION	SECNO=	21.000	PROFILE=	1	PROBABLE MINIMUM SPECIFIC ENERGY
CAUTION	SECNO=	21.000	PROFILE=	1	20 TRIALS ATTEMPTED TO BALANCE WSEL
WARNING	SECNO=	22.000	PROFILE=	1	CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

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CAUTION SECNO=     23.000  PROFILE=  1  PROBABLE MINIMUM SPECIFIC ENERGY
CAUTION SECNO=     23.000  PROFILE=  1  20 TRIALS ATTEMPTED TO BALANCE WSEL

CAUTION SECNO=     24.000  PROFILE=  1  CRITICAL DEPTH ASSUMED
CAUTION SECNO=     24.000  PROFILE=  1  PROBABLE MINIMUM SPECIFIC ENERGY
CAUTION SECNO=     24.000  PROFILE=  1  20 TRIALS ATTEMPTED TO BALANCE WSEL

CAUTION SECNO=     25.000  PROFILE=  1  CRITICAL DEPTH ASSUMED
CAUTION SECNO=     25.000  PROFILE=  1  PROBABLE MINIMUM SPECIFIC ENERGY
CAUTION SECNO=     25.000  PROFILE=  1  20 TRIALS ATTEMPTED TO BALANCE WSEL

CAUTION SECNO=     27.000  PROFILE=  1  CRITICAL DEPTH ASSUMED
CAUTION SECNO=     27.000  PROFILE=  1  PROBABLE MINIMUM SPECIFIC ENERGY
CAUTION SECNO=     27.000  PROFILE=  1  20 TRIALS ATTEMPTED TO BALANCE WSEL

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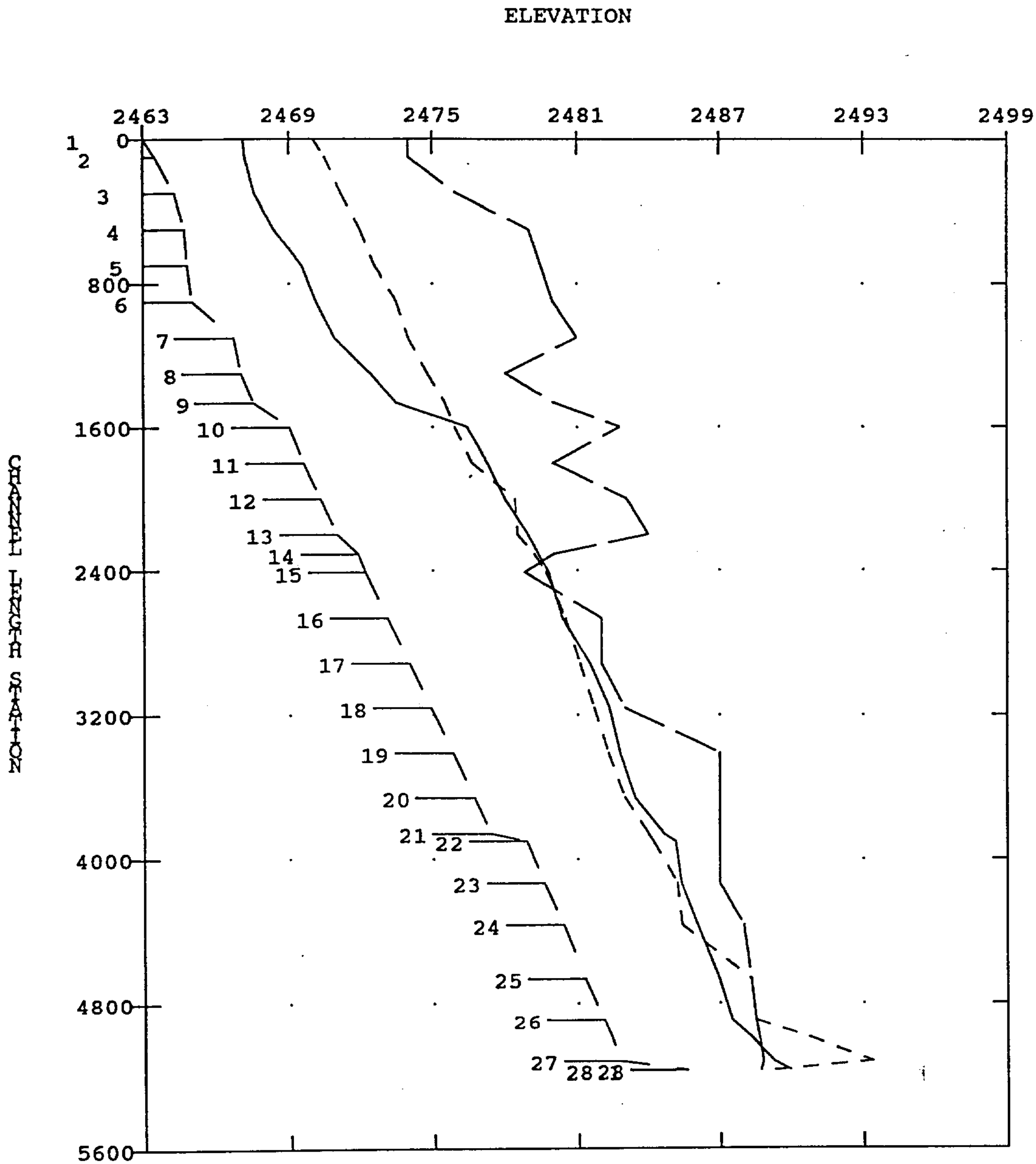
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2400
3200
4000
4800
5600
CHANNEL LENGTH STATION
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2
3
4
5
6
7
8
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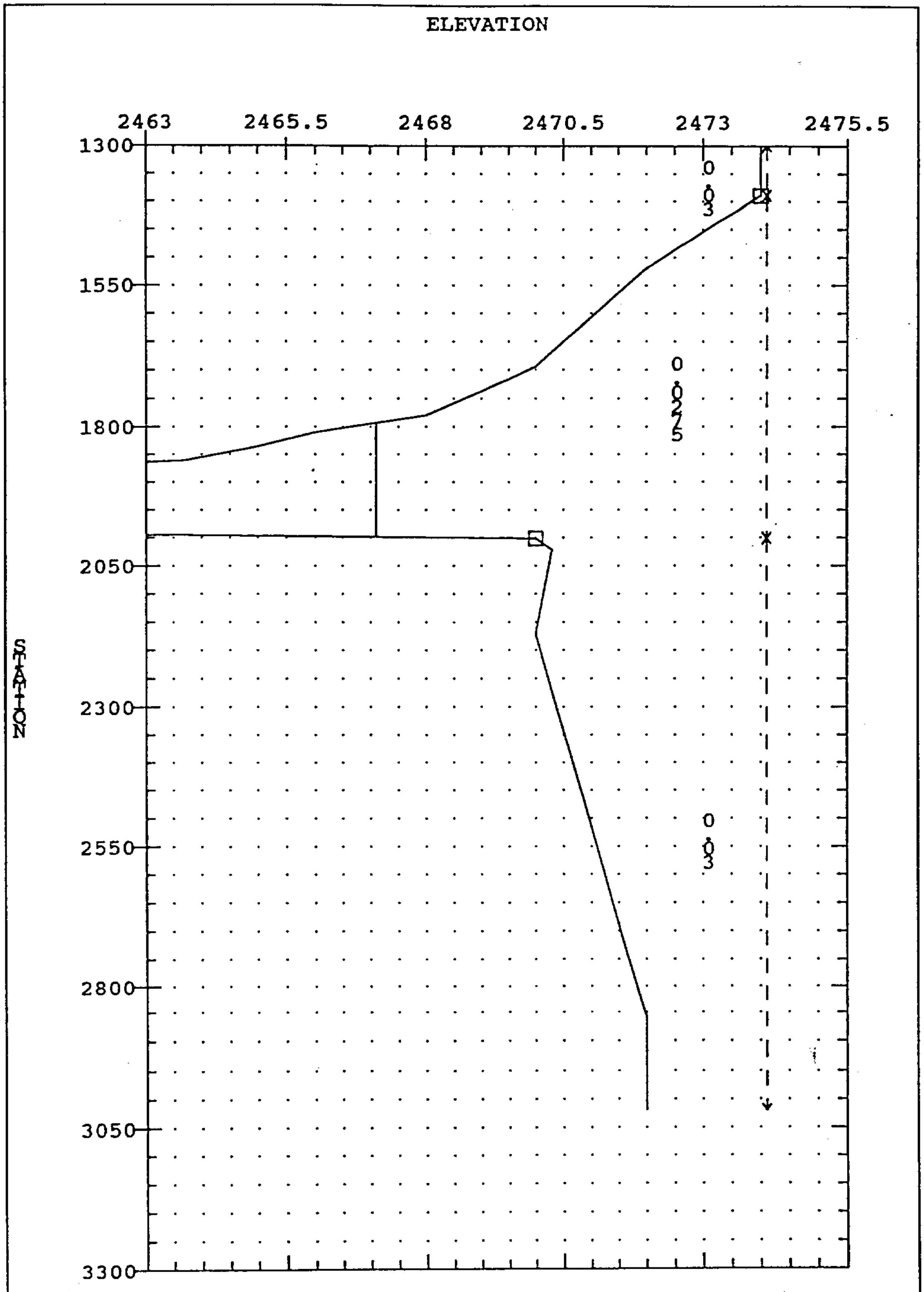
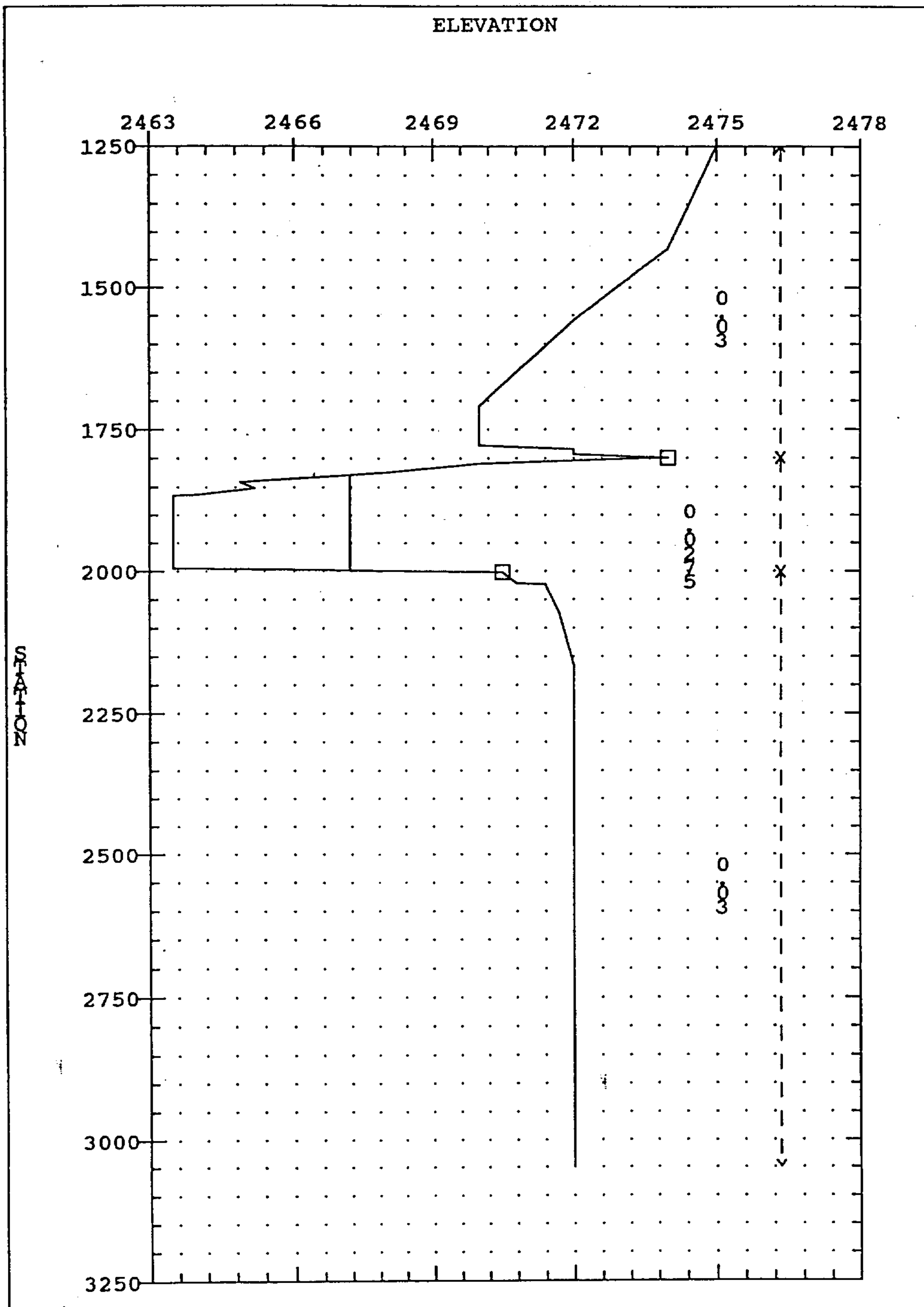


SECTION : 1

West Branch Santa Cruz River



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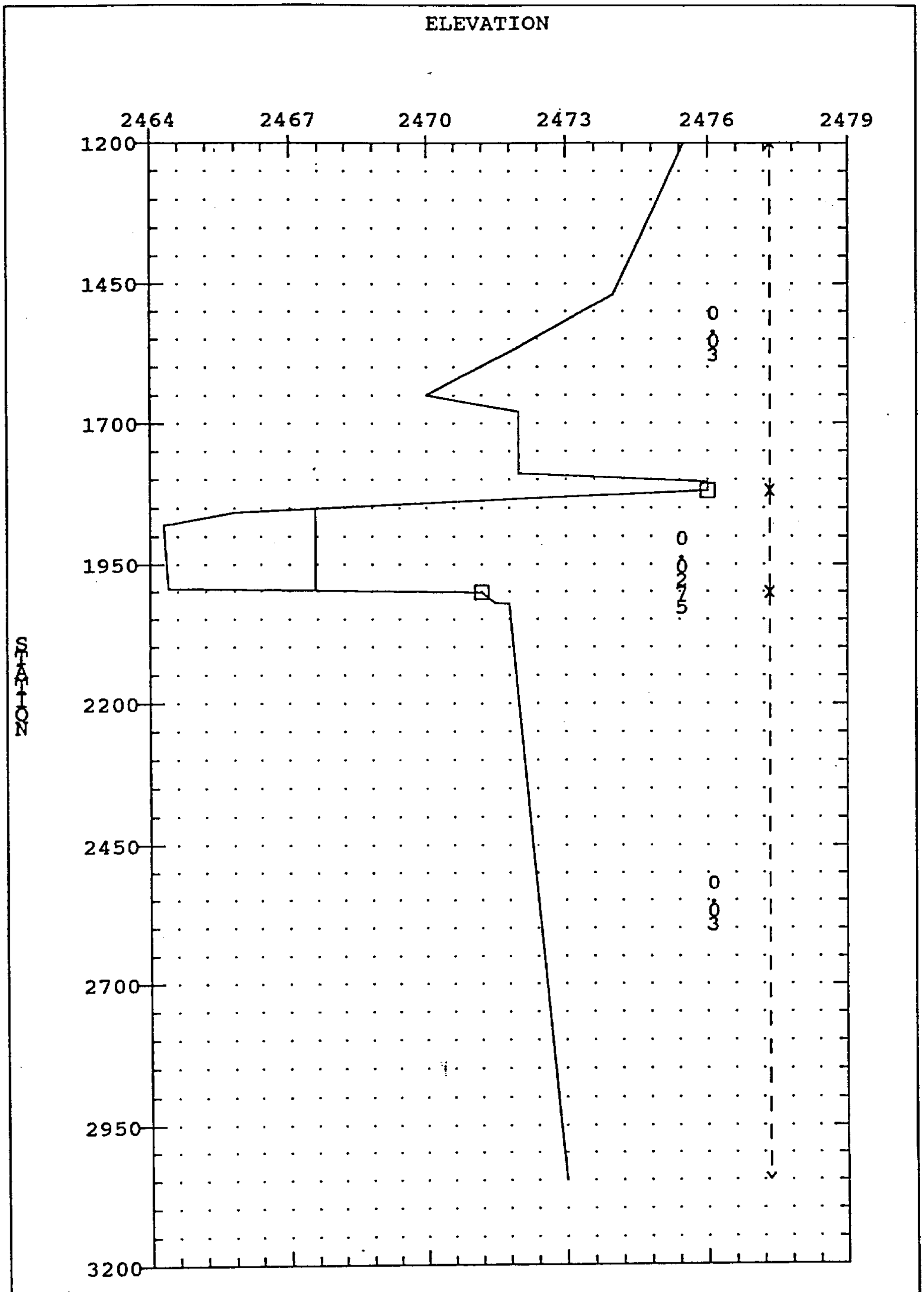
West Branch Santa Cruz River



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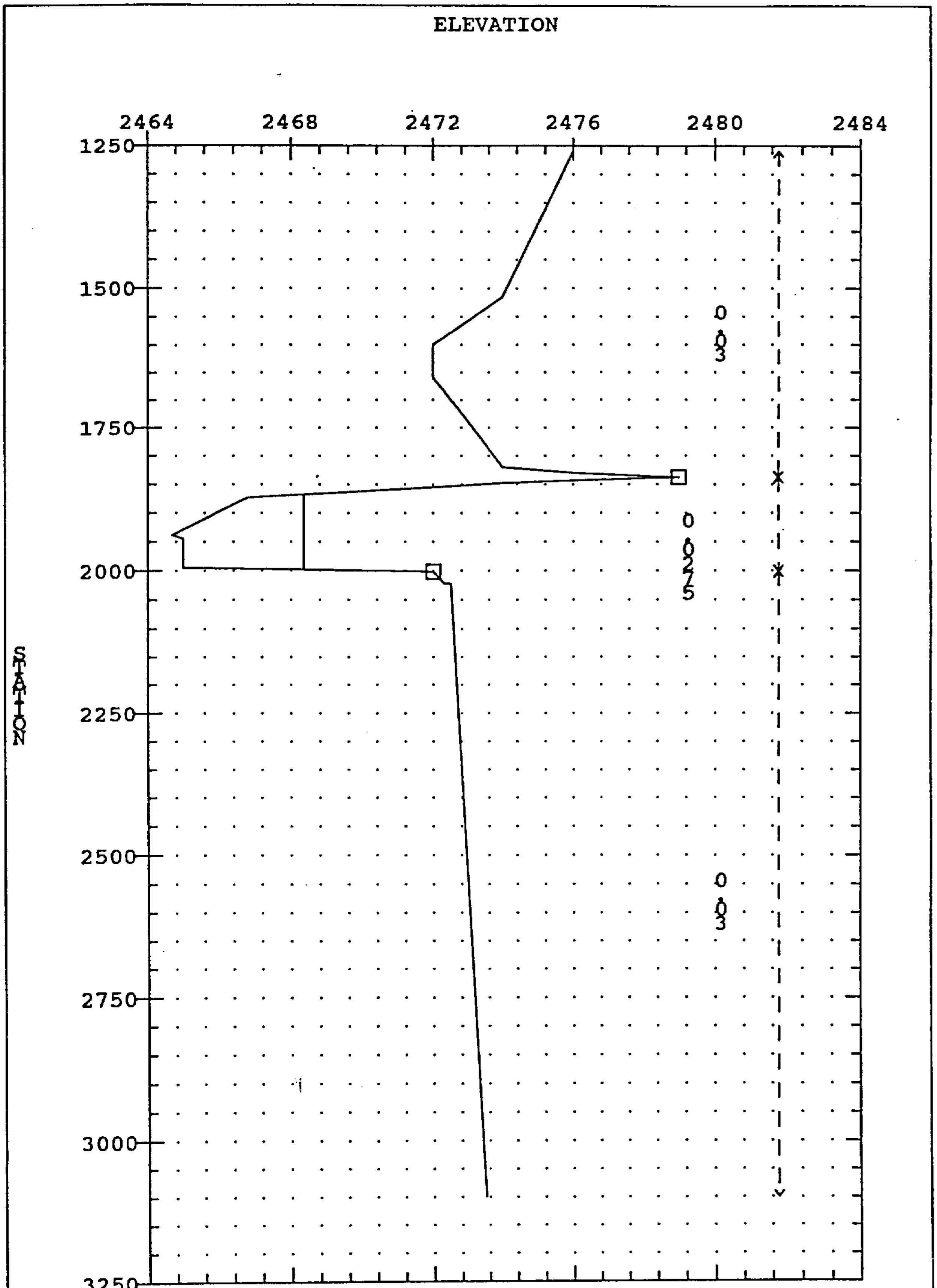
West Branch Santa Cruz River



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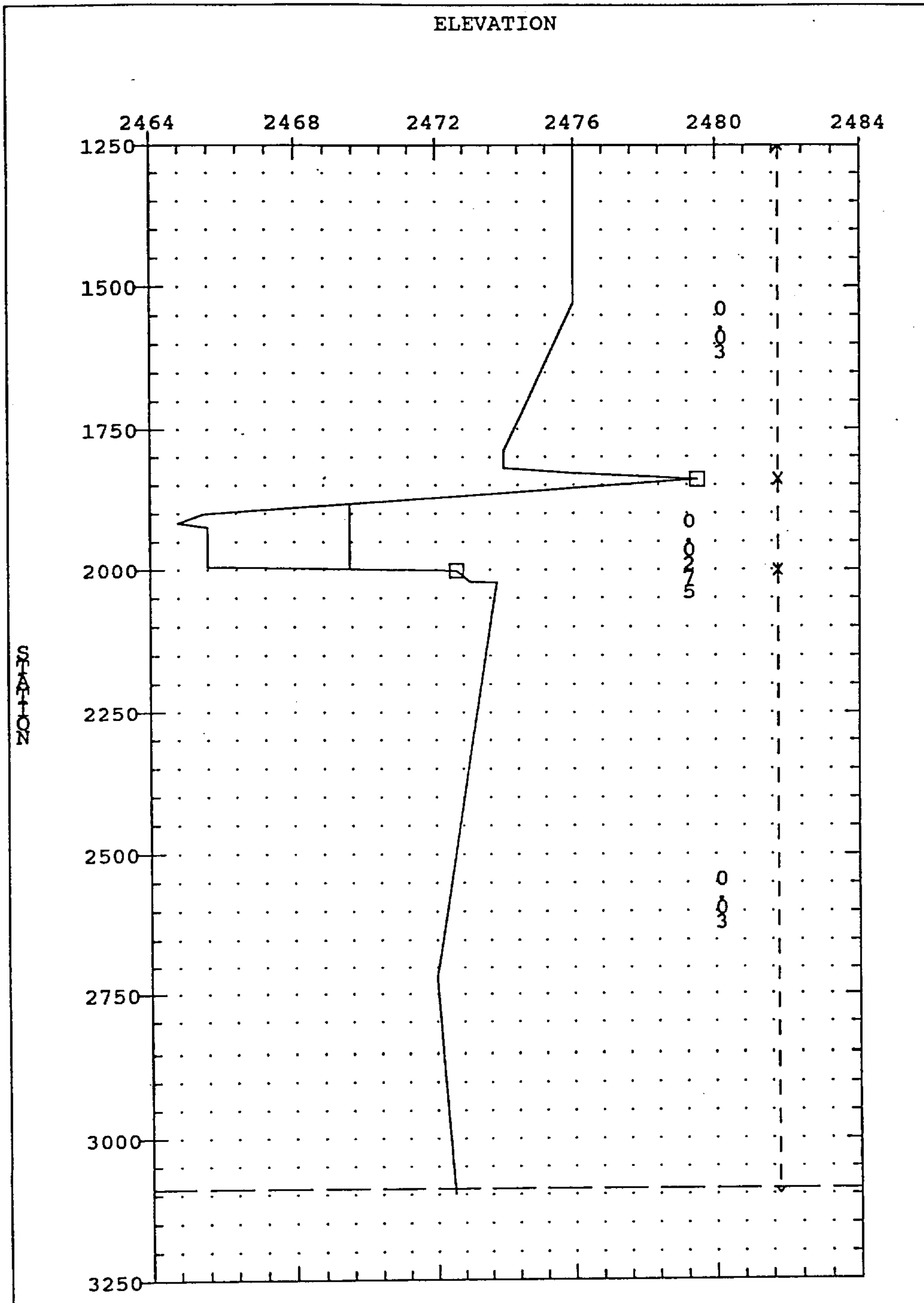
West Branch Santa Cruz River



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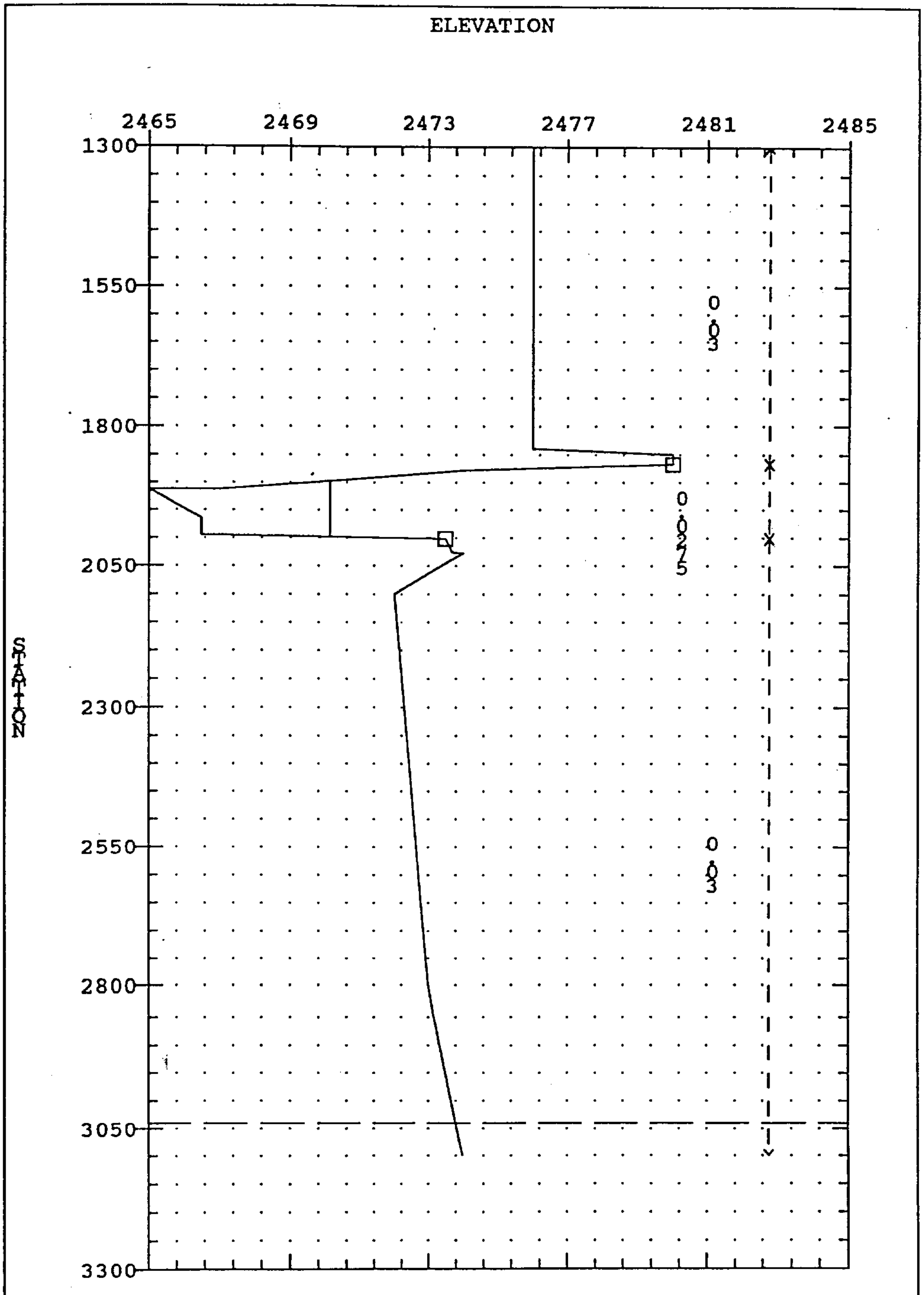
West Branch Santa Cruz River



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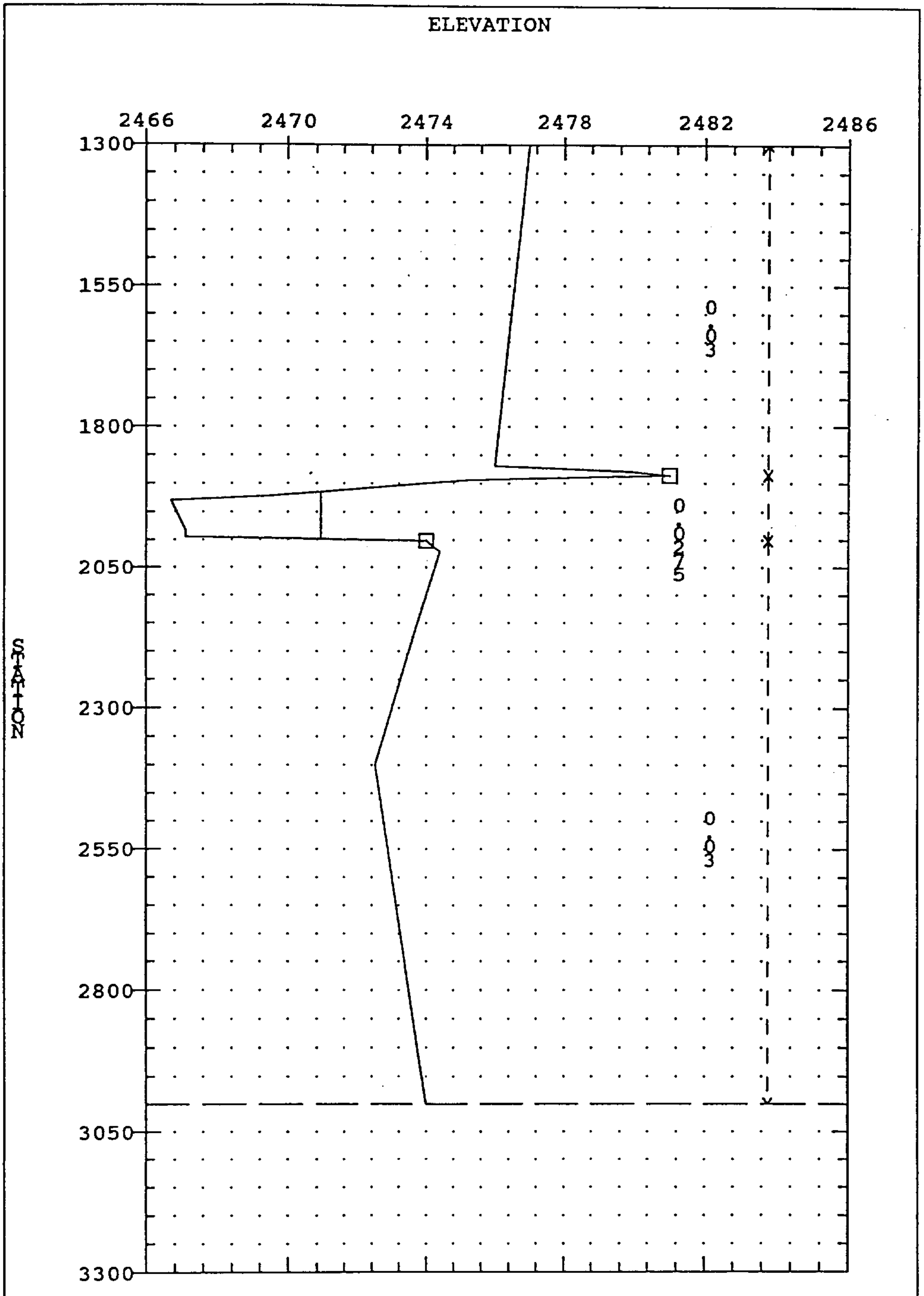
West Branch Santa Cruz River



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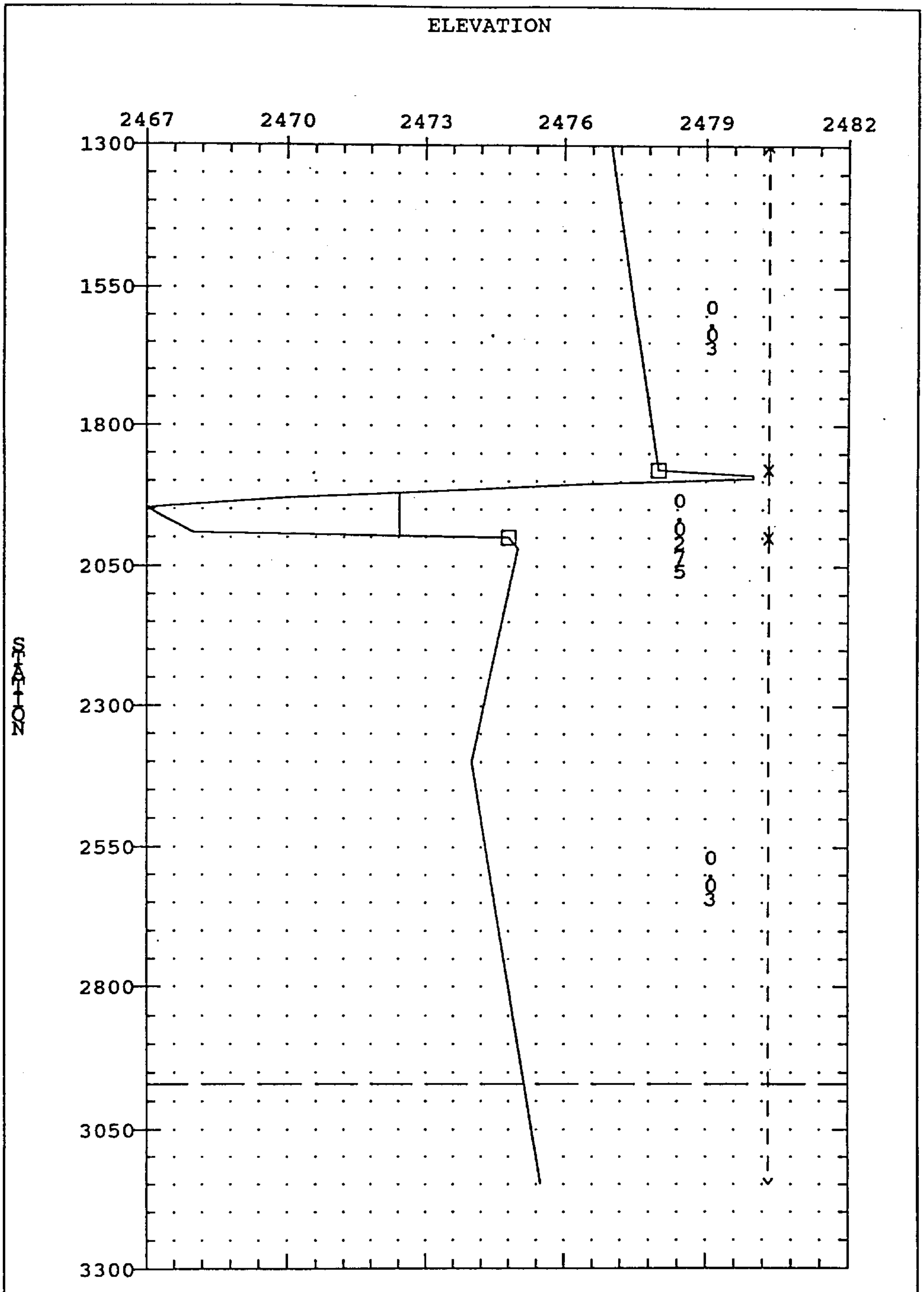
West Branch Santa Cruz River



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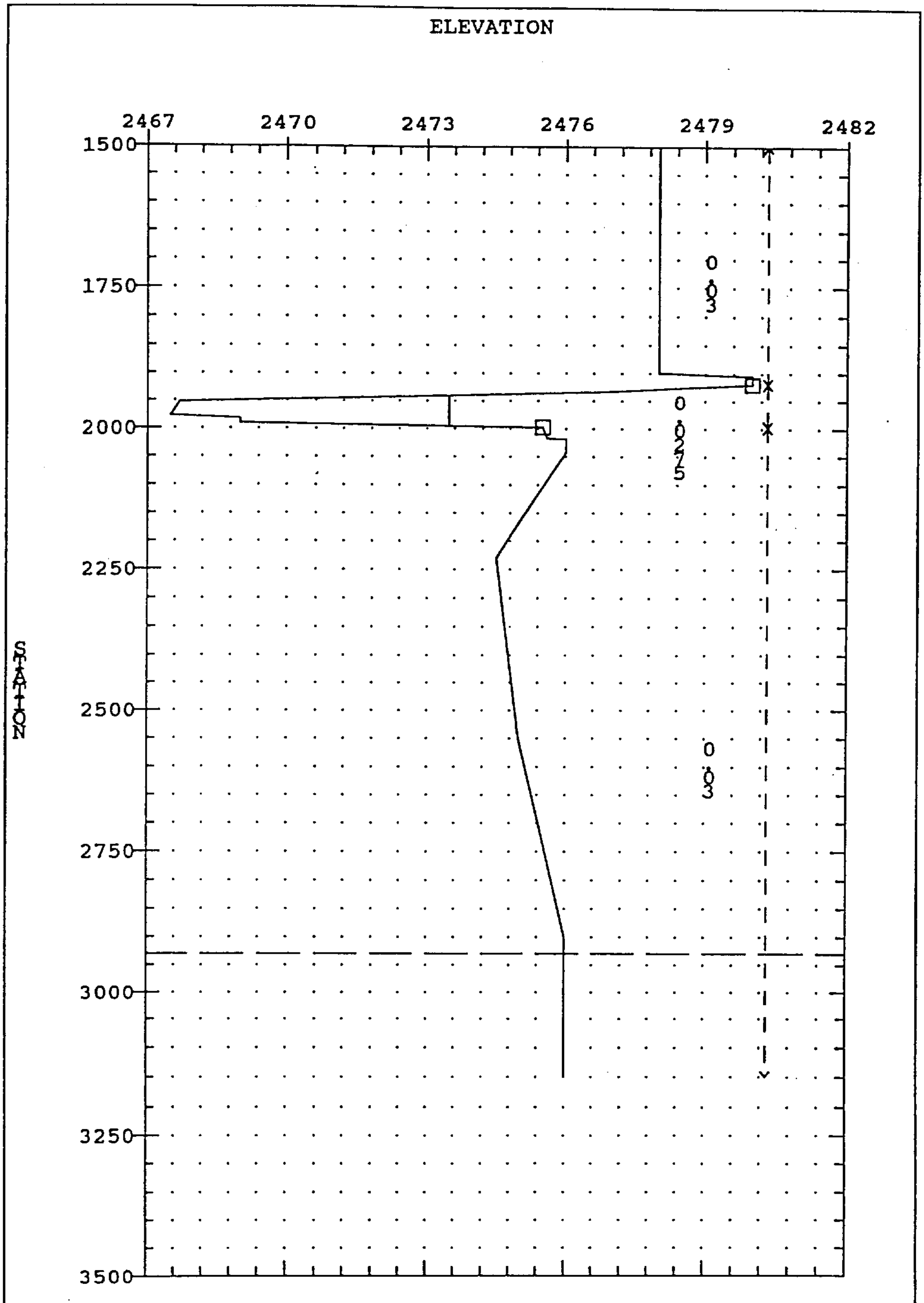
West Branch Santa Cruz River



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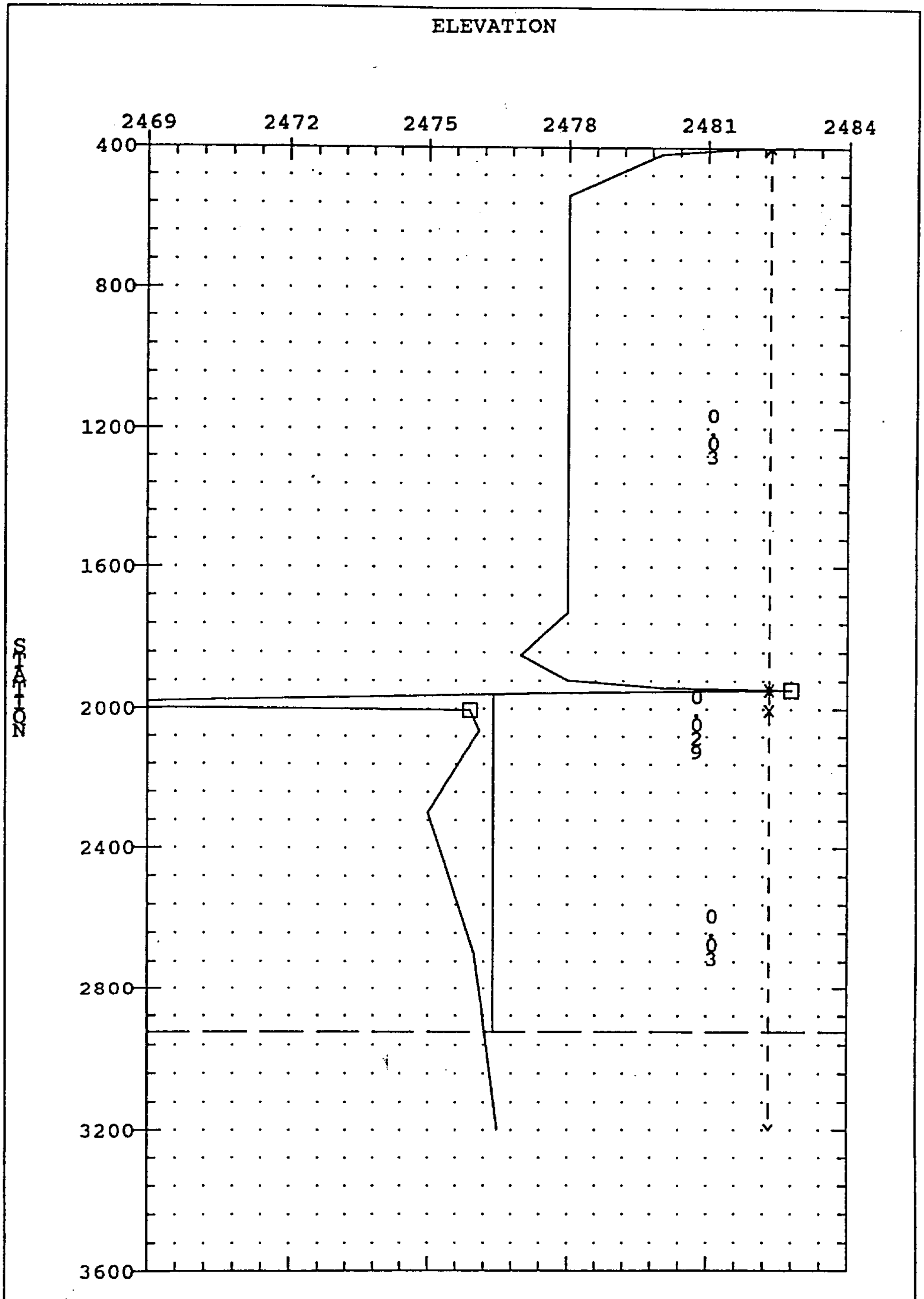
West Branch Santa Cruz River



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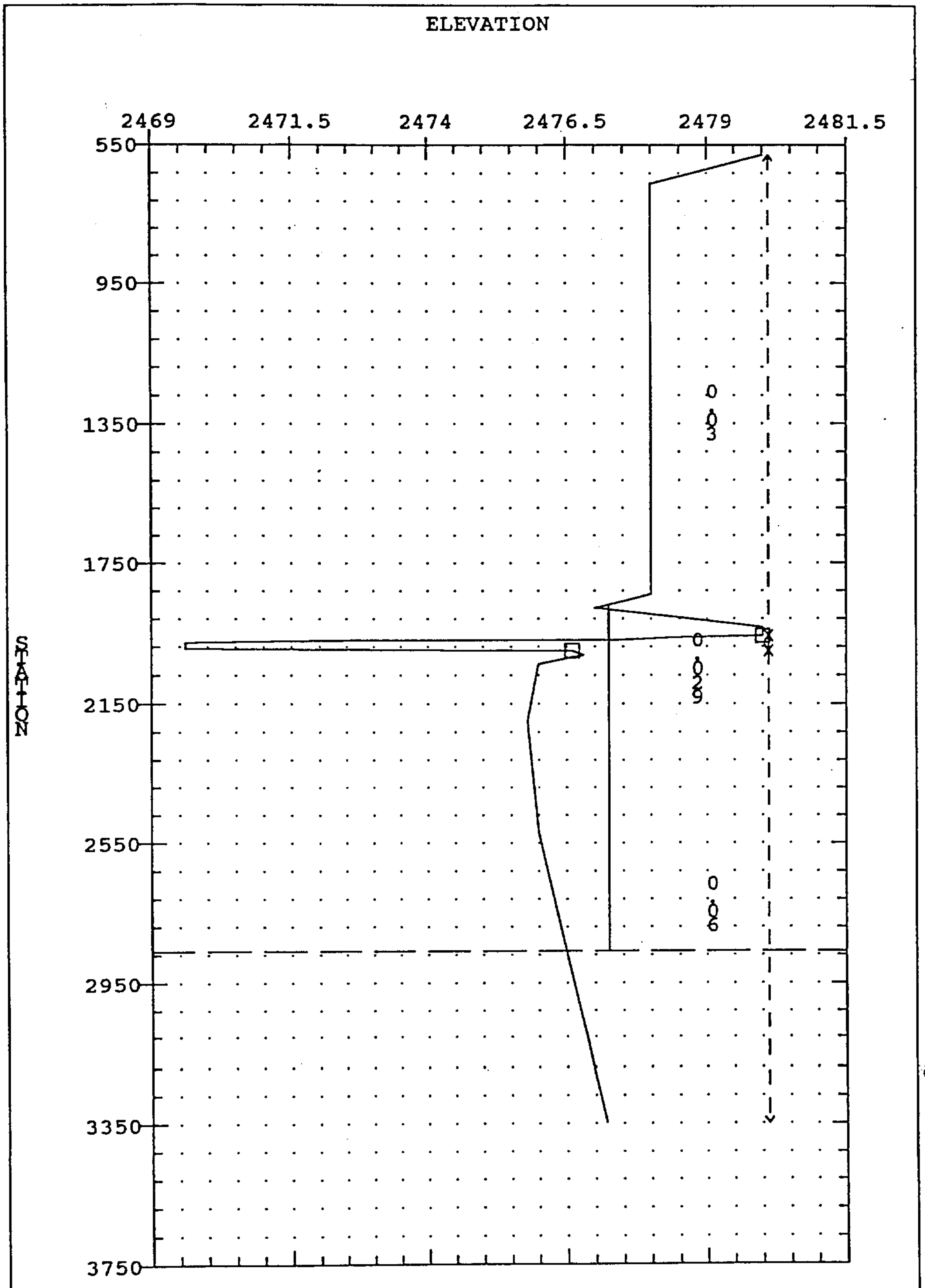
West Branch Santa Cruz River



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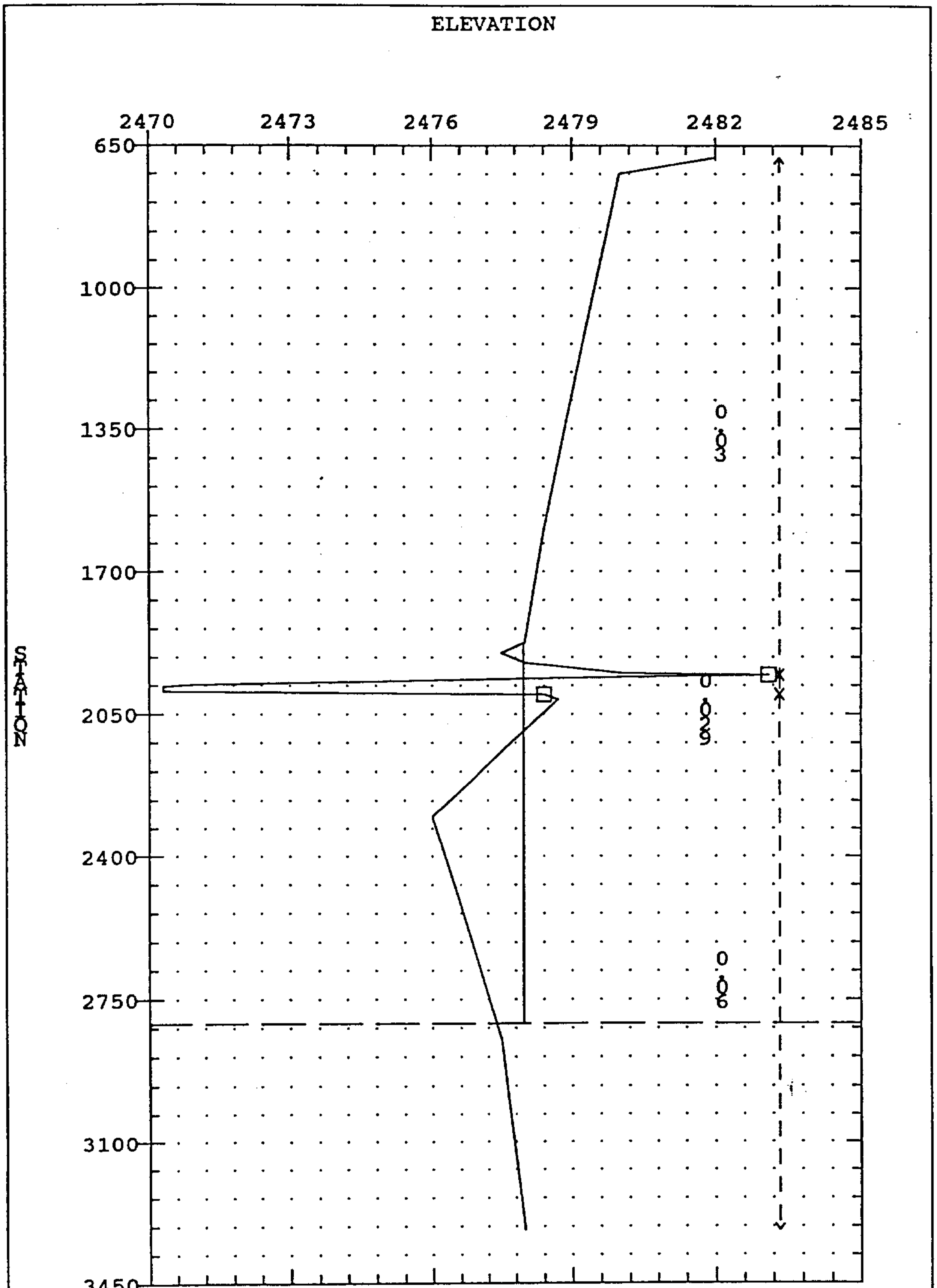
West Branch Santa Cruz River



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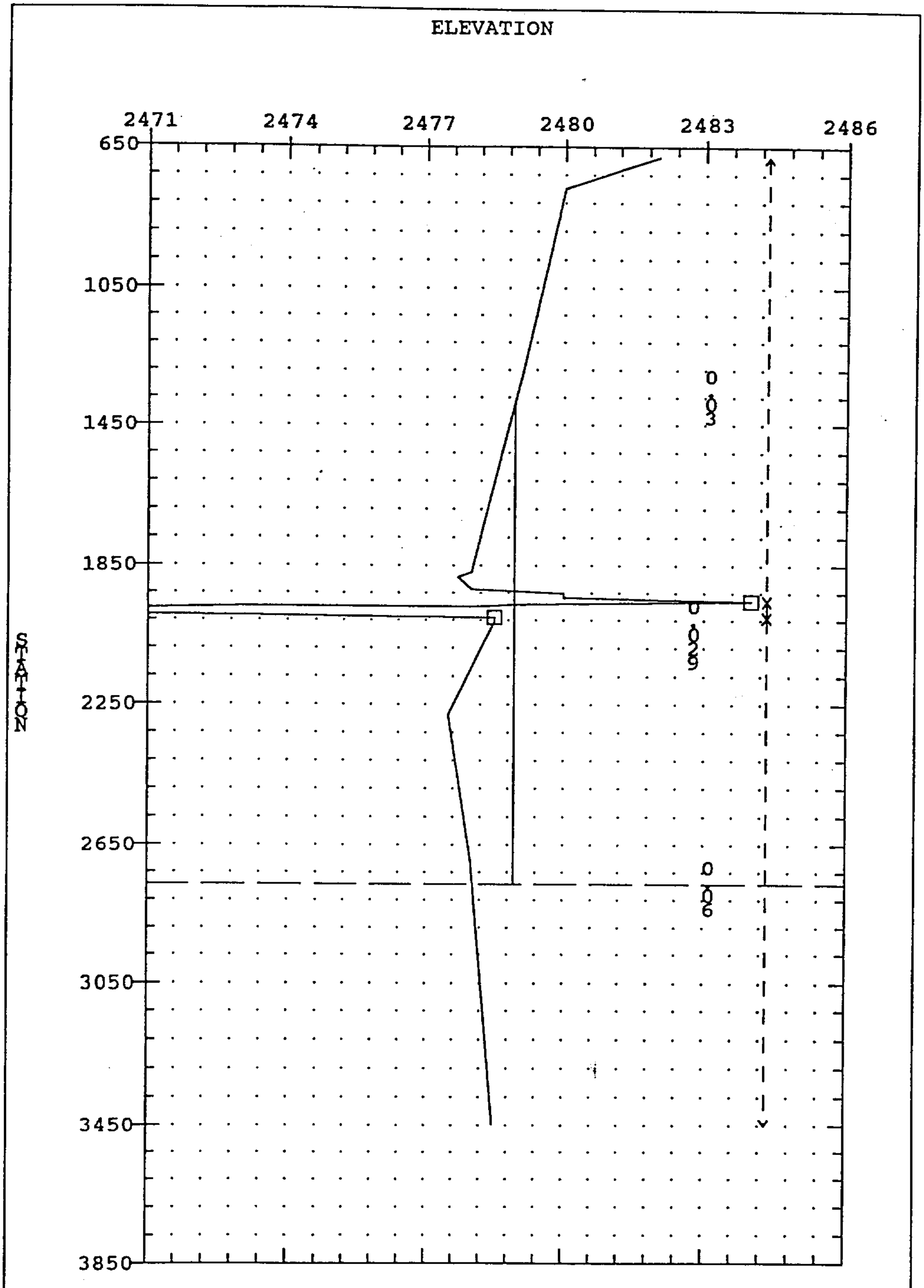
West Branch Santa Cruz River



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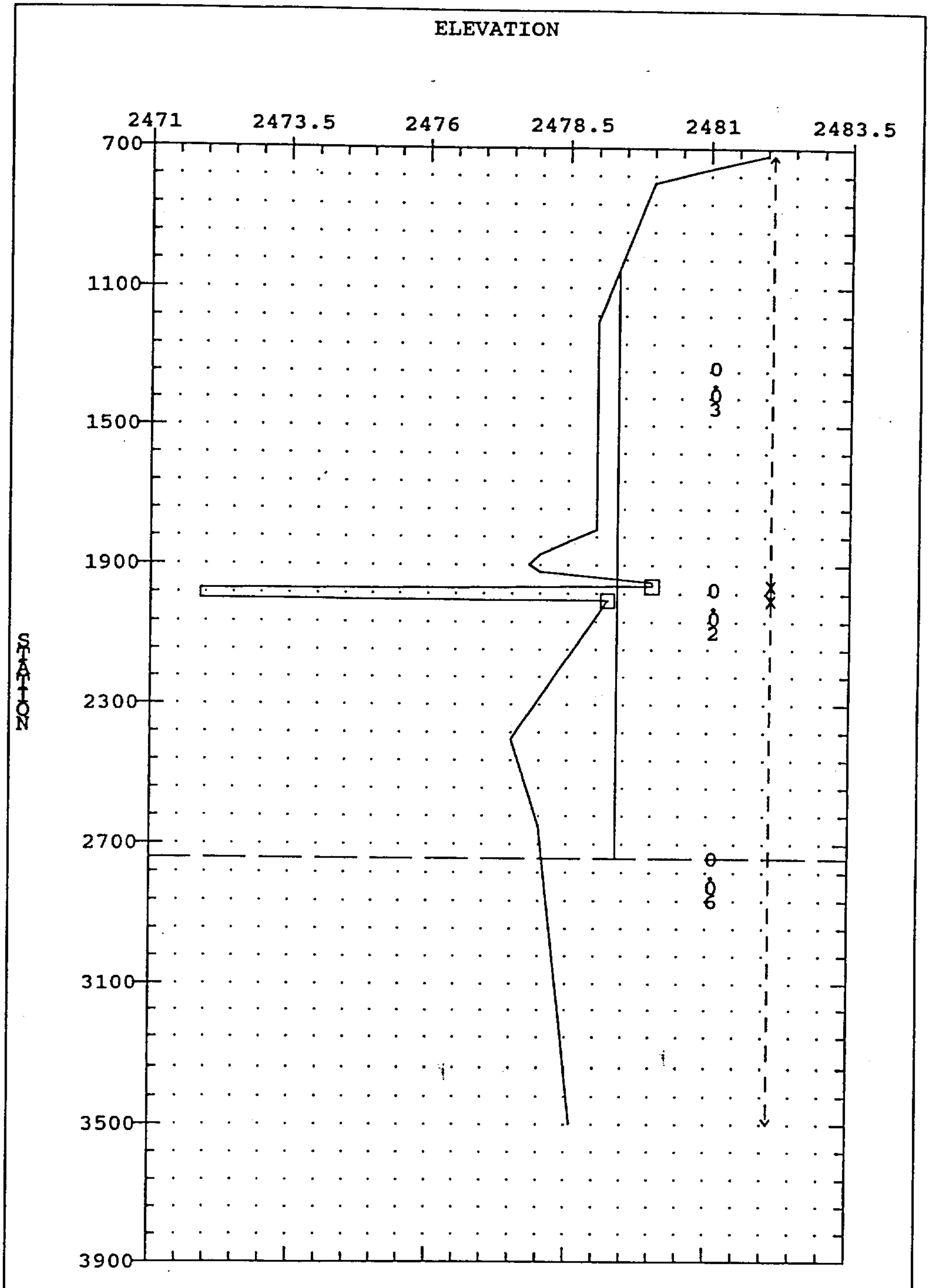
West Branch Santa Cruz River



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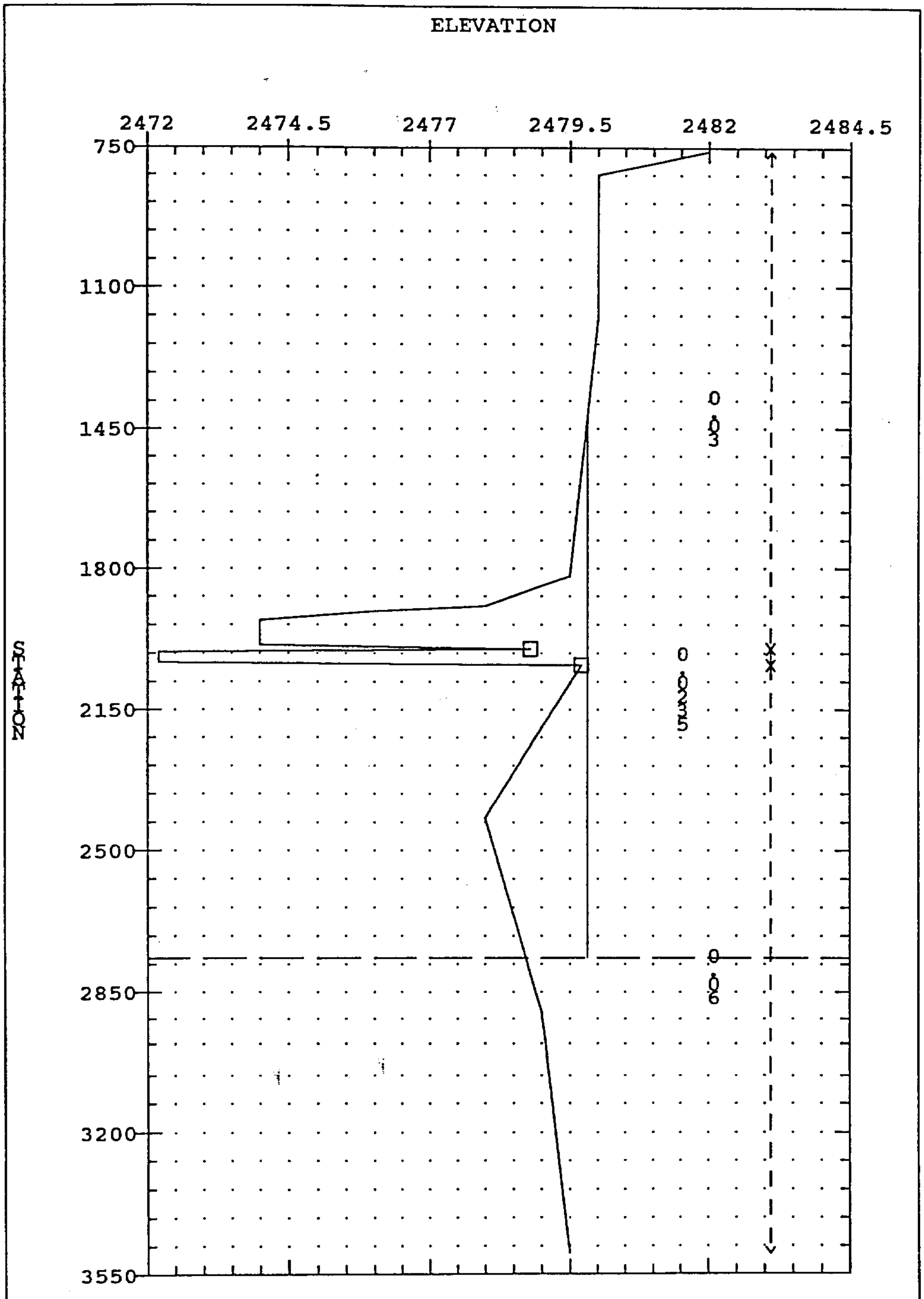
West Branch Santa Cruz River



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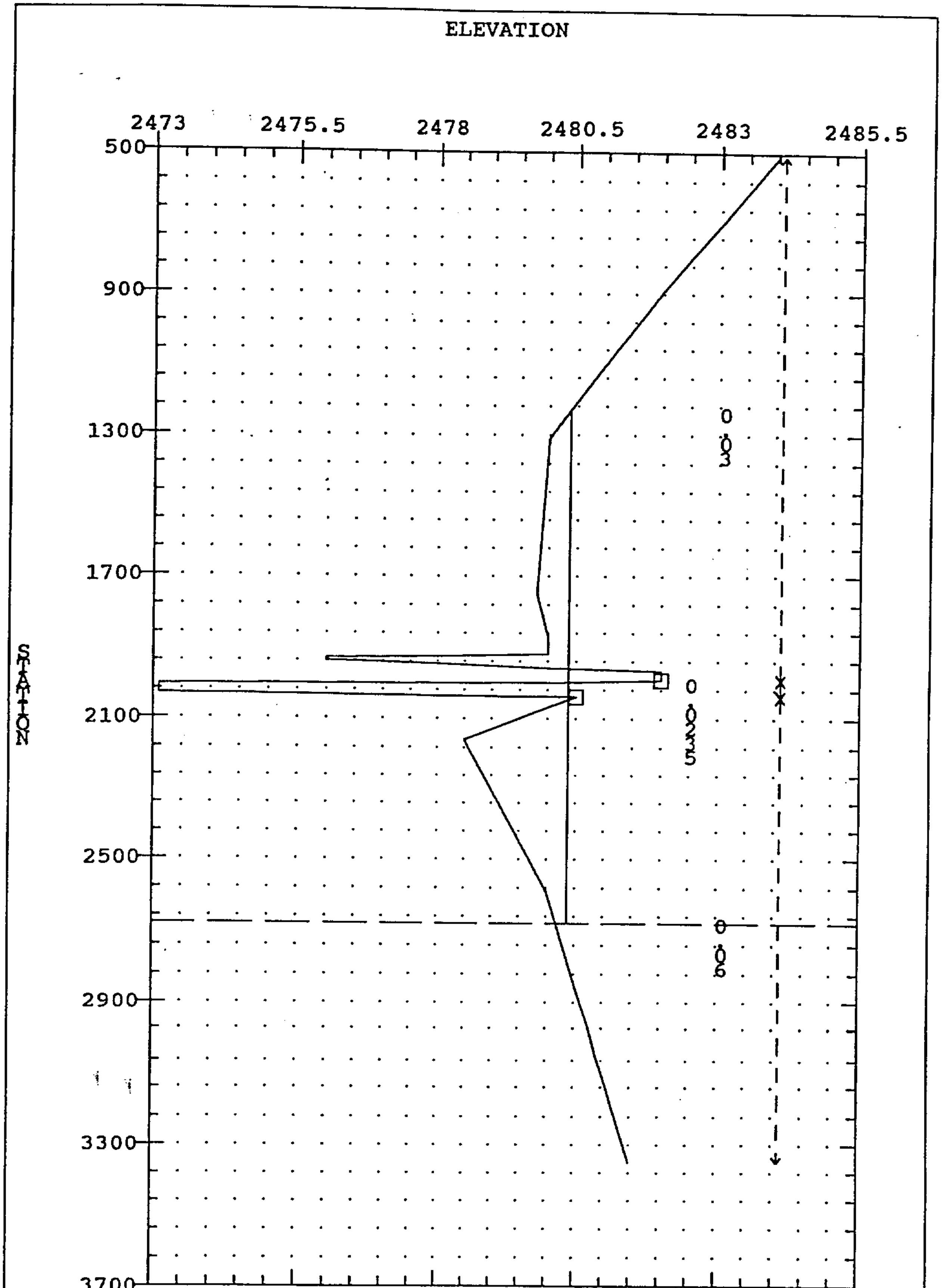
West Branch Santa Cruz River



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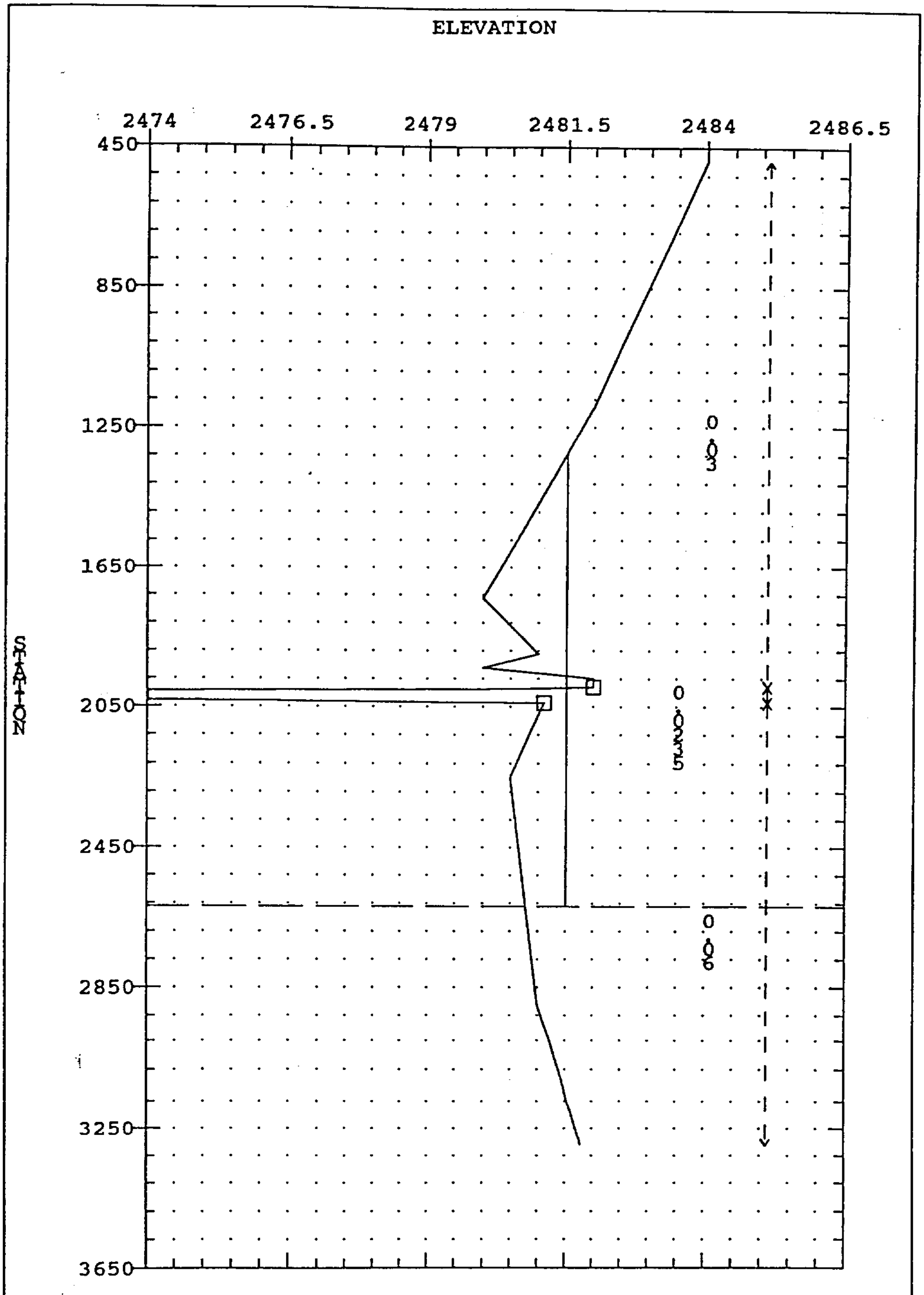
West Branch Santa Cruz River



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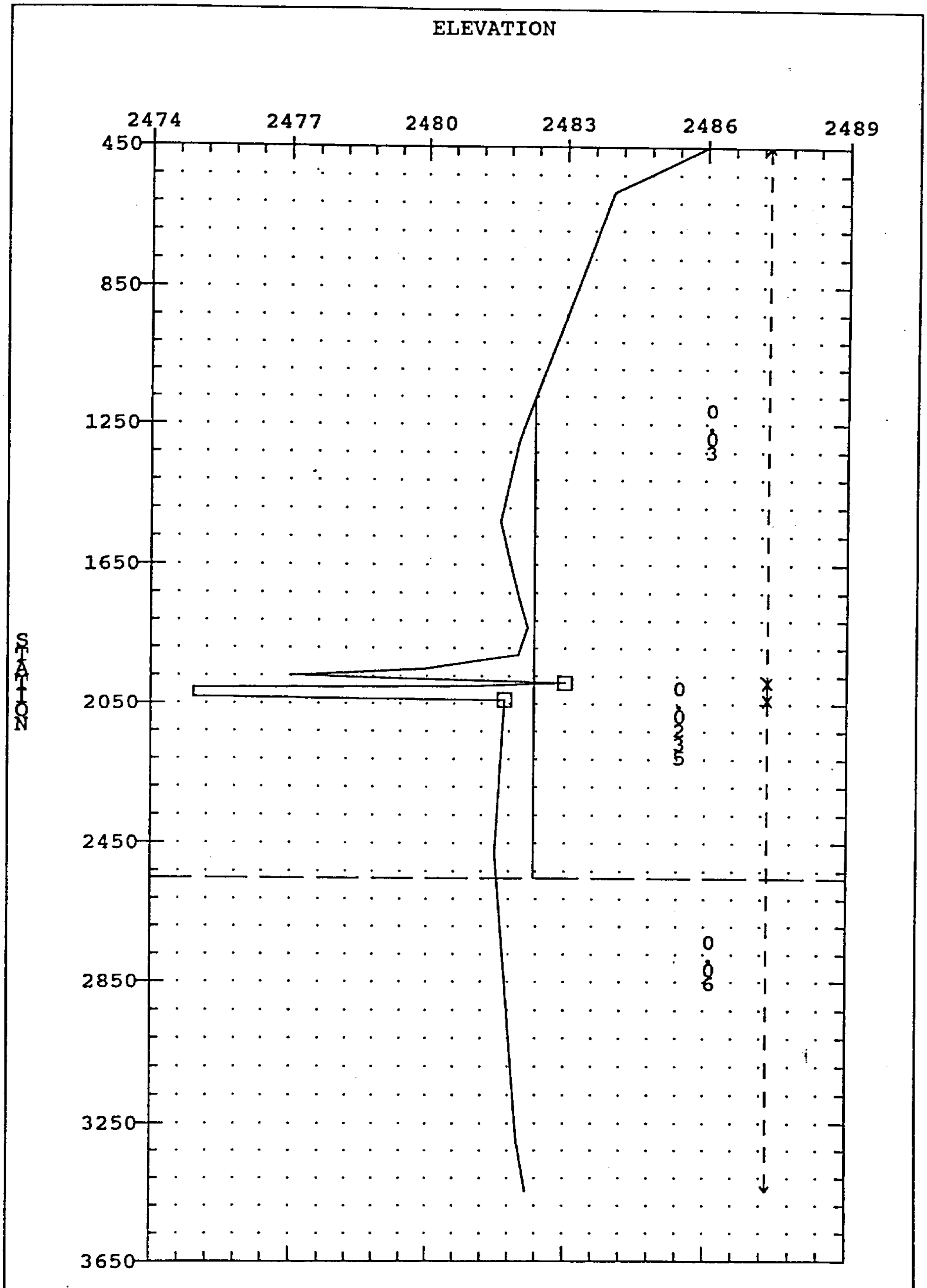
West Branch Santa Cruz River



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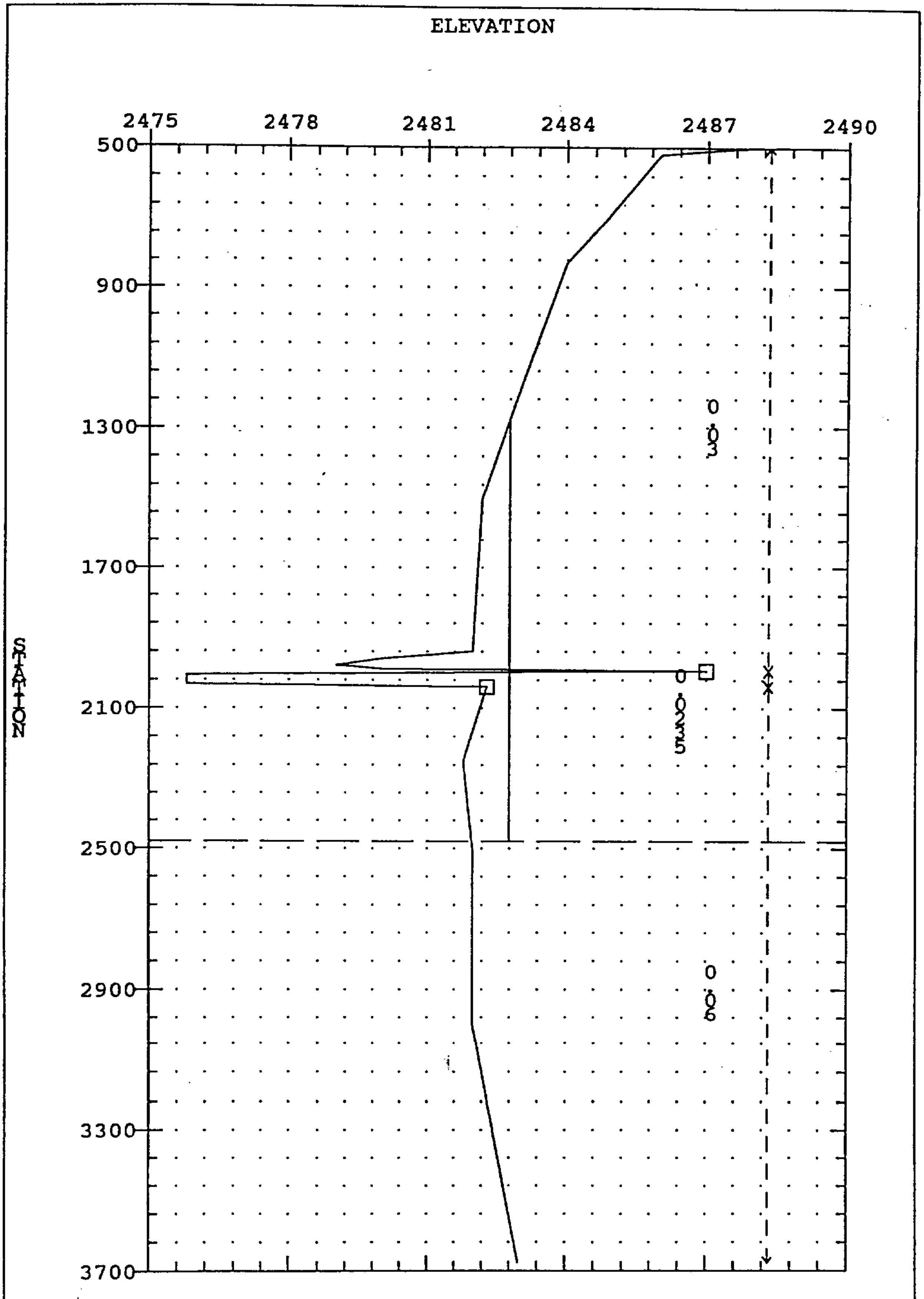
West Branch Santa Cruz River



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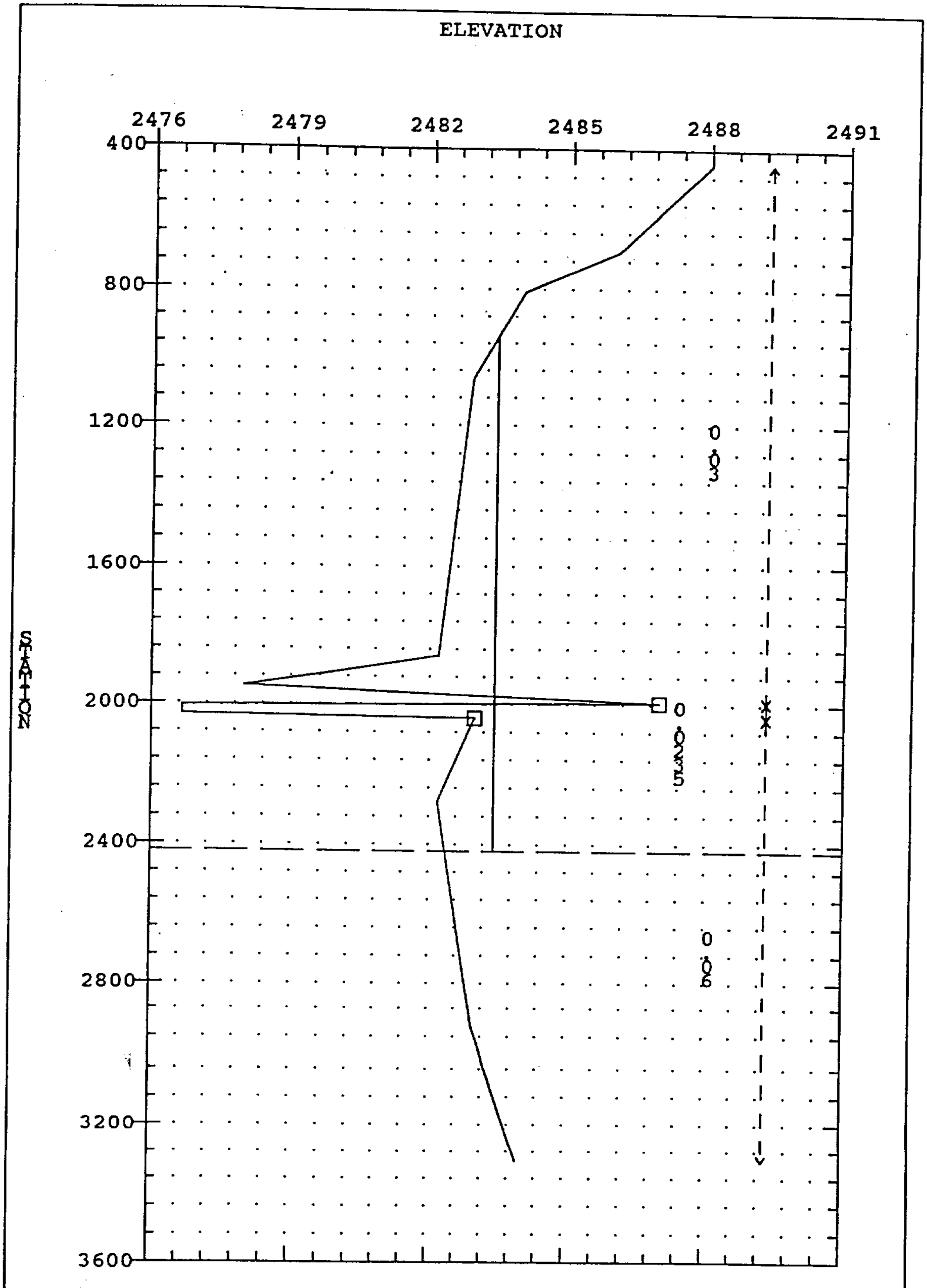
West Branch Santa Cruz River



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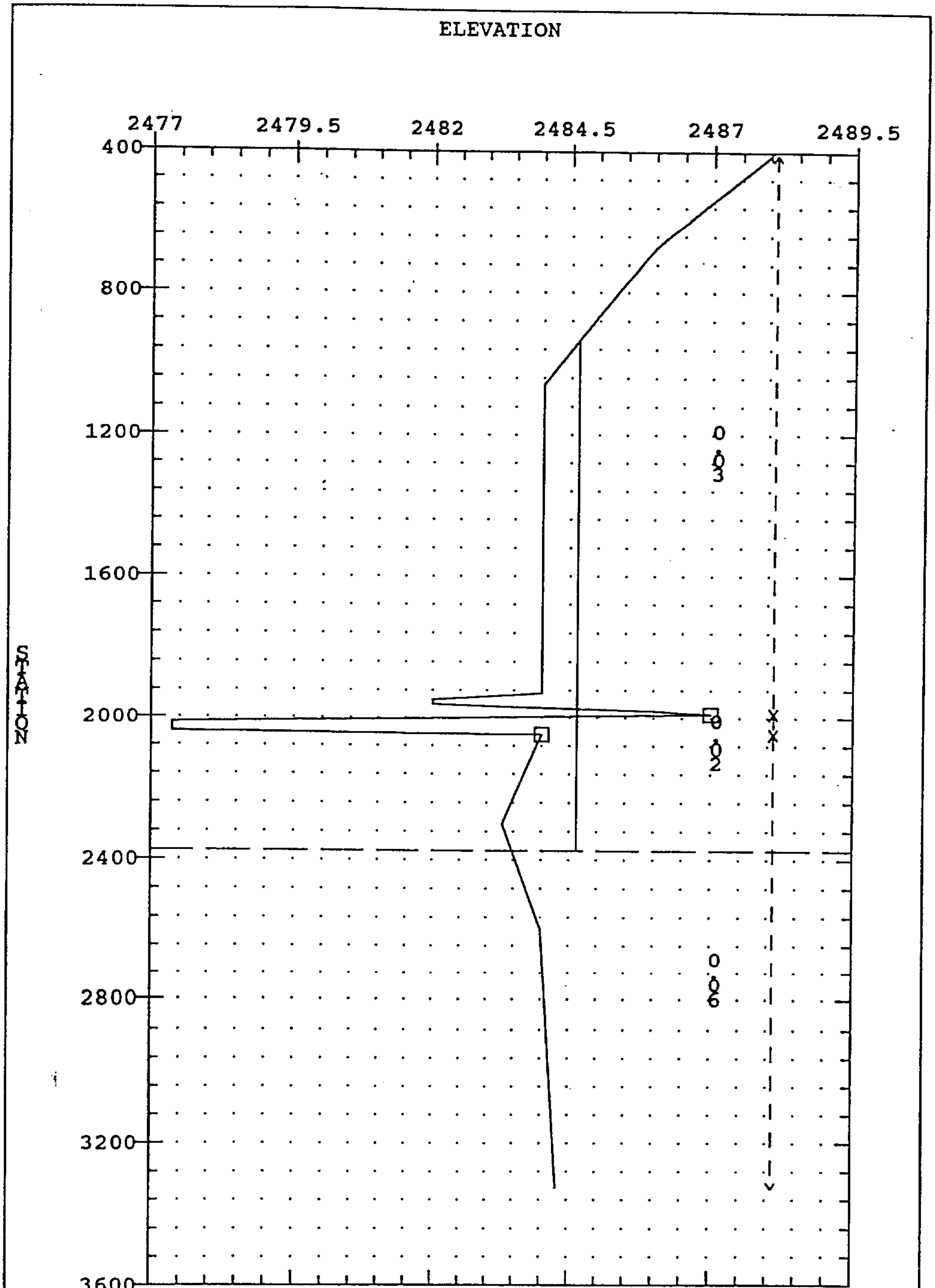
West Branch Santa Cruz River



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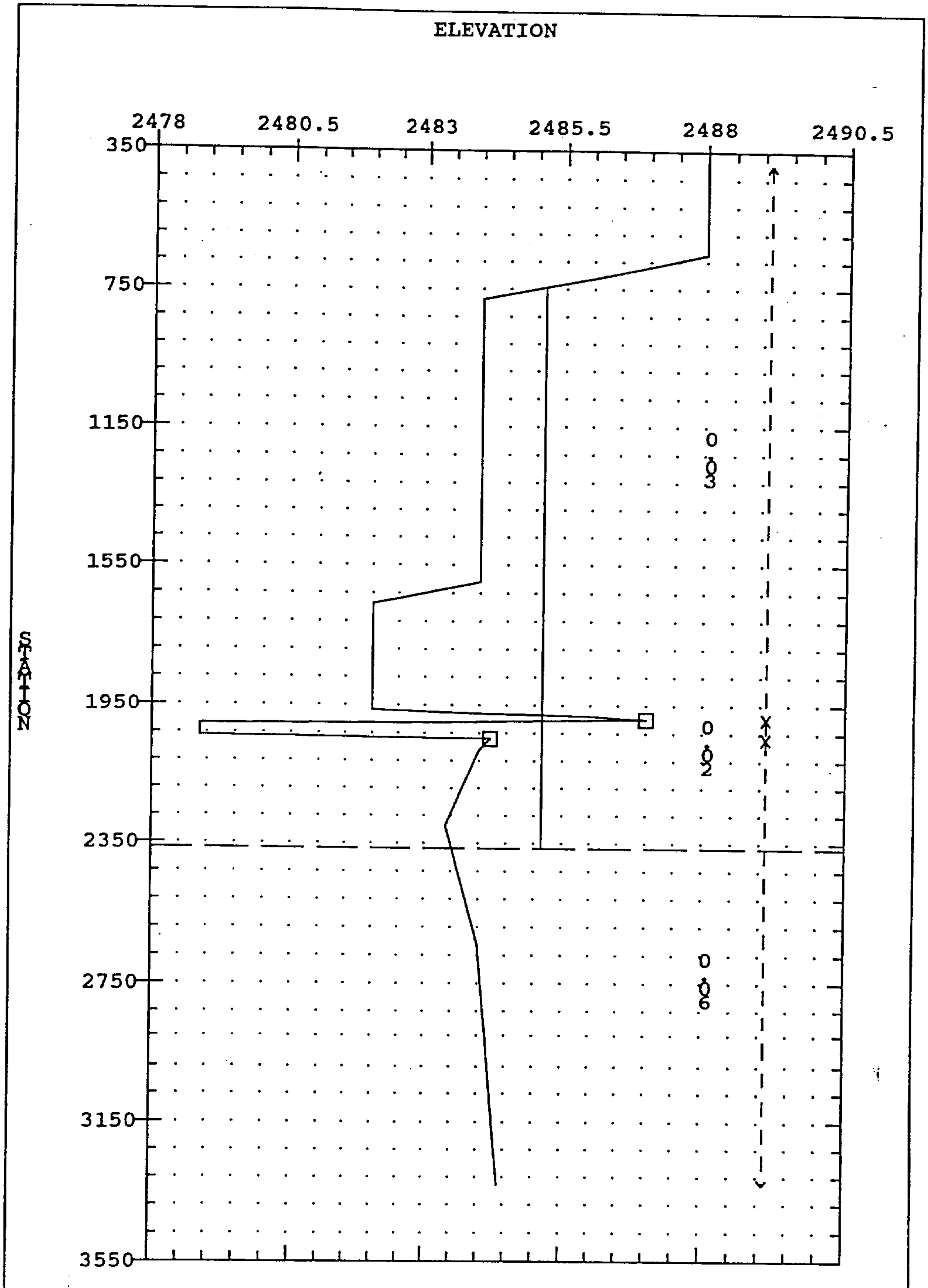

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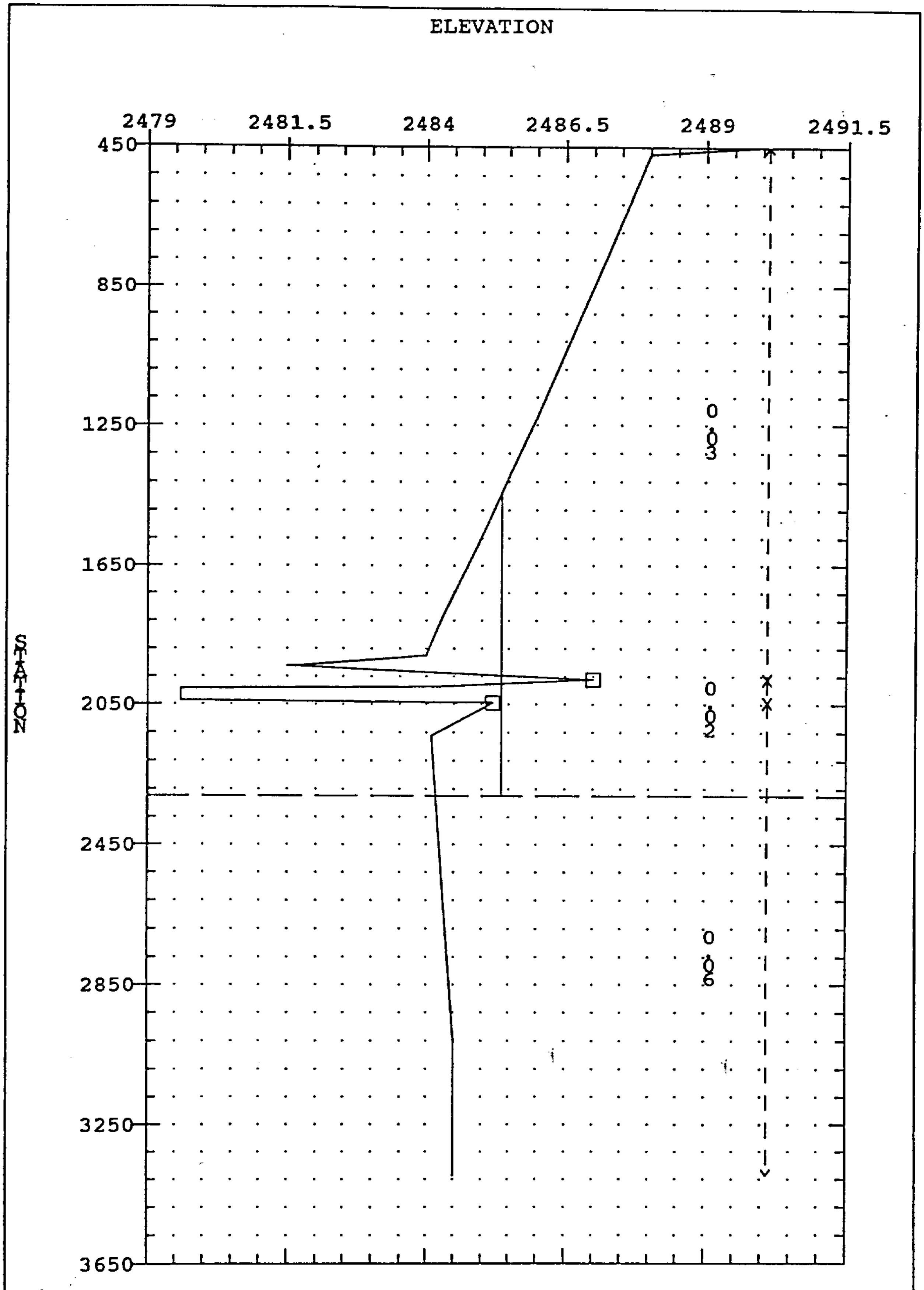
West Branch Santa Cruz River



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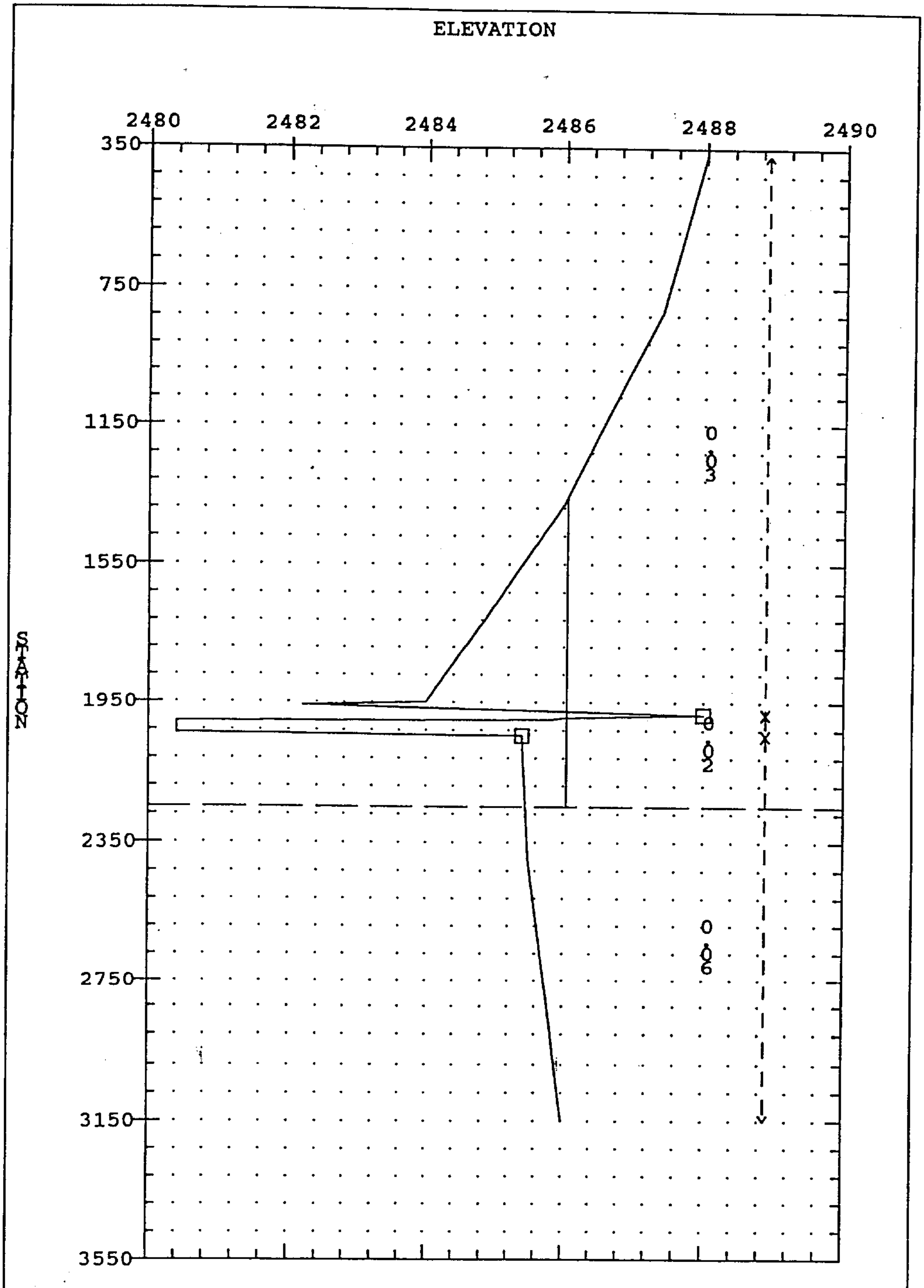
West Branch Santa Cruz River



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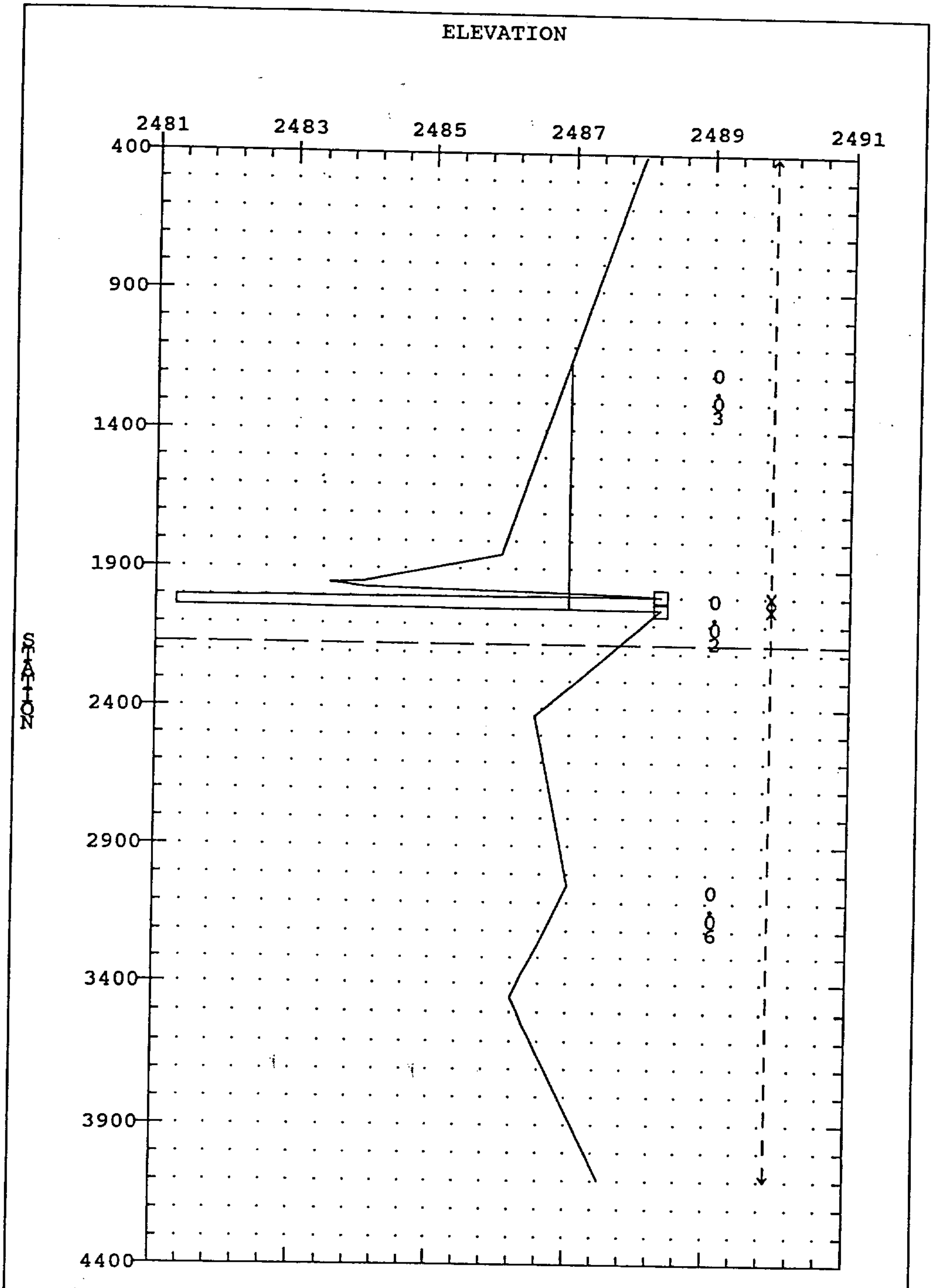
West Branch Santa Cruz River



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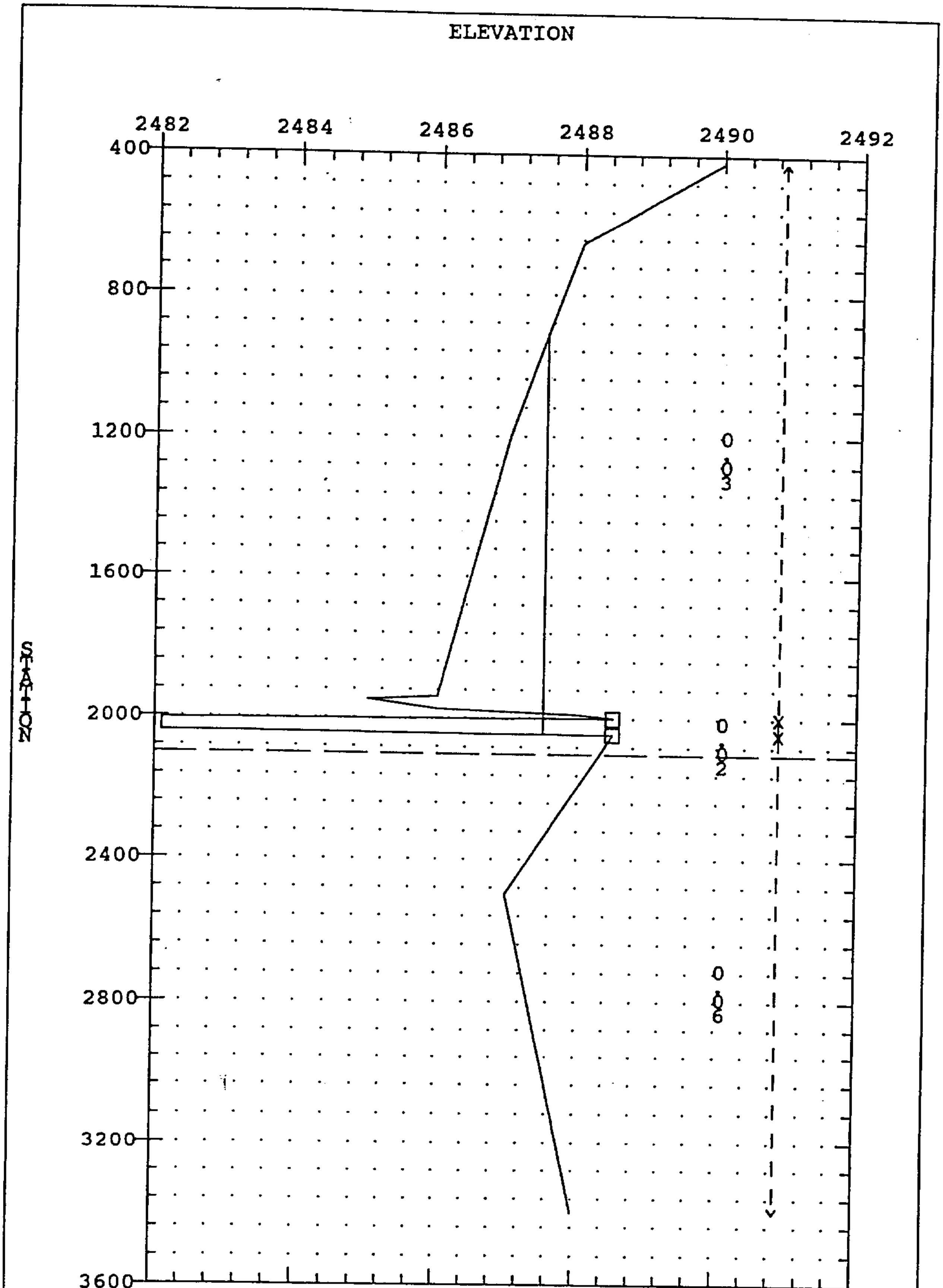
West Branch Santa Cruz River



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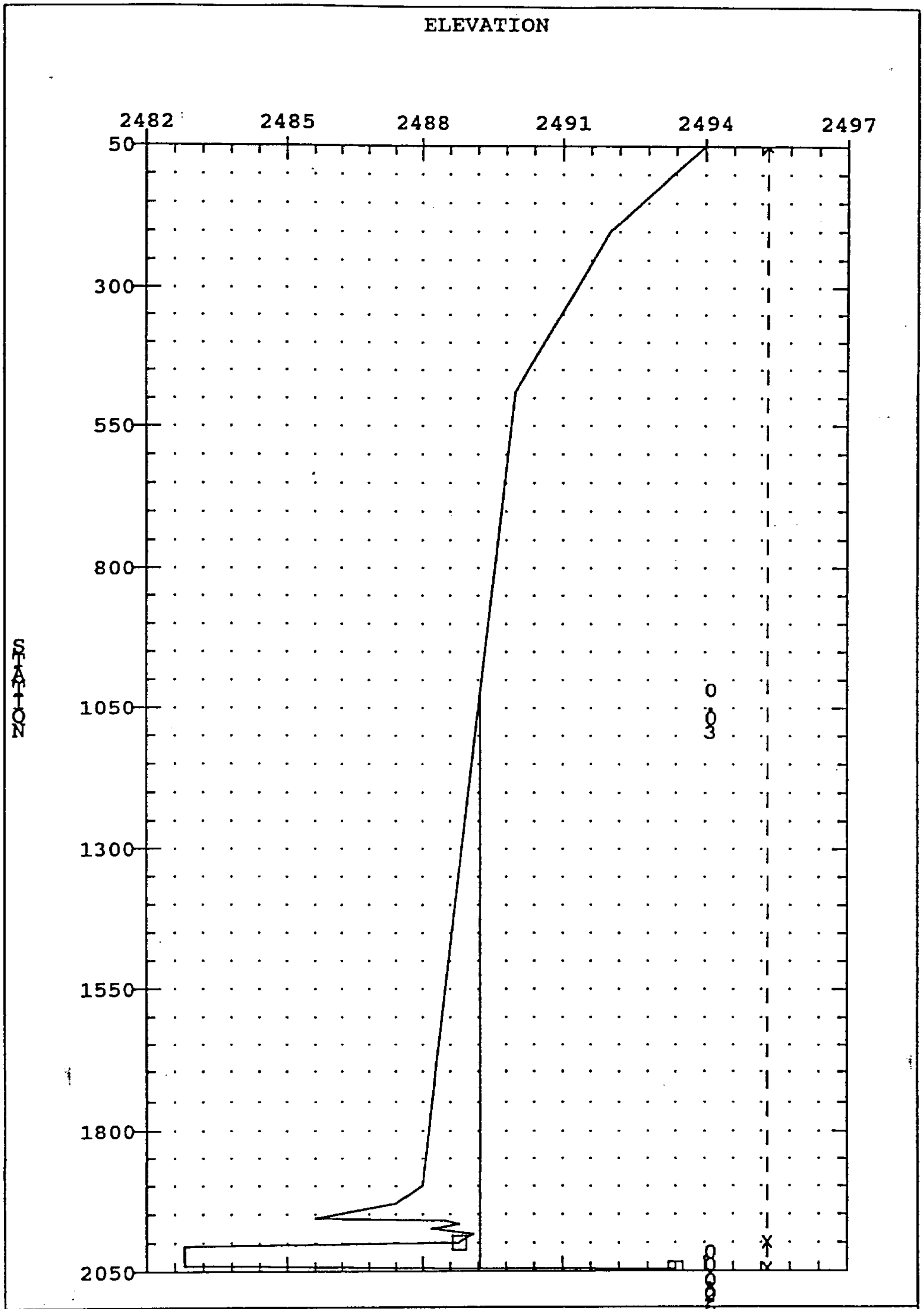
West Branch Santa Cruz River



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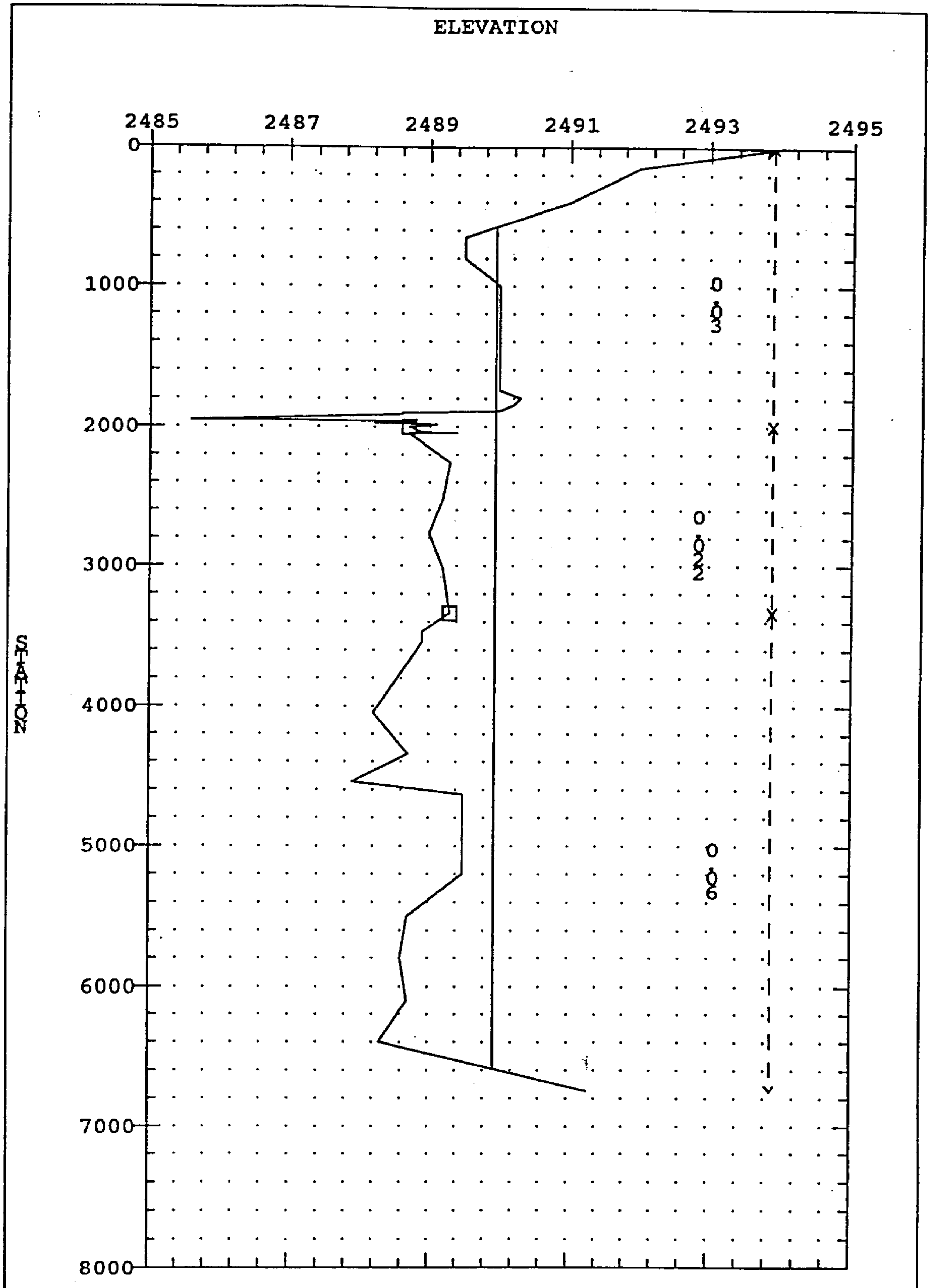
West Branch Santa Cruz River



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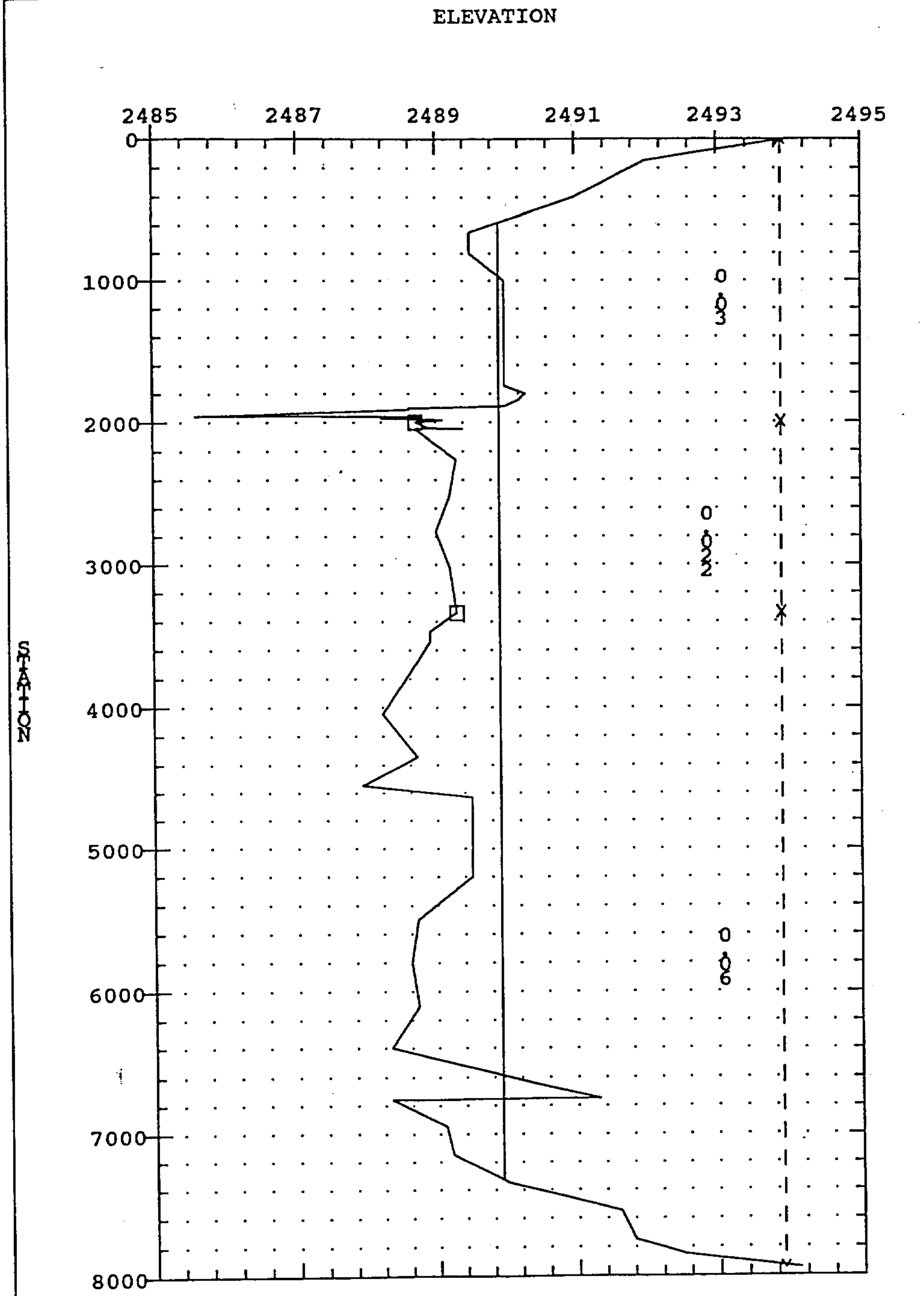
West Branch Santa Cruz River



SECTION : 28.1

West Branch Santa Cruz River

Appendix D

HEC-2 Input And Output Files For The
South Channel Of The Los Reales Improvement District

ARROYO ENGINEERING, INC.

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SF Splitflow Analysis of the South Channel
TW Splitflow #9 to #10, Weir flow across Los Reales Rd. on No.Side of So.Channel
WS     7       9      10      -1     2.6
WC     0  2493.1       1  2489.8     530  2489.4     730  2489.7    1080  2492.5
WC  1280  2492.5    1450  2492.5
EE
T1      Los Reales Improvement District, Letter of Map Revision
T2      Arroyo Job #PDOT01.1, HEC2 File: South.H2I
T3      South Channel
J1     0       2       0       0      -1       0       0       0    2472
J2     1       0      -1       0       0       0       0       0       0
J3    38      43      13      14      15       1       2       3       8      53
J3     4      54      61              150
NC  .025    .025    .025     0.1     0.3
QT     3    3250    3300    3350

*  Note that 3 flood discharges were used in this multi-profile run.  These
*  discharges were used to develop the stage-discharge curve for use in the
*  HEC-2 model of the West Branch (see TC cards in HEC-2 file WEST.H2I), as well
*  as to predict water-surface elevations within and along the South Channel.
*  In addition, the water-surface elevation given in field J1.9 is equal to the
*  10-year water-surface elevation within the Santa Cruz River at the channel outlet.

*  Cross Section #62+50 from Sheet 12 of 15 of Los Reales Improvement District
*  Job No. 85-074
X1     1       4       0     128       0       0       0
GR2486.6       0  2468.9      57  2468.9      73  2486.4     128

*  Cross Section #60+00 from Sheet 12 of 15 of Los Reales Improvement District
*  Job No. 85-074
X1     2       4       0     112     250     250     250
GR2487.4       0  2471.8      48  2471.8      64  2487.6     112

*  Cross Section #57+00 from Sheet 11 of 15 of Los Reales Improvement District
*  Job No. 85-074
NC  .024    .024    .024     0.1     0.3
X1     3       6       0    86.9     300     300     300       0    2400
GR 87.78       0   75.20    27.1   75.20    56.0   88.19    66.5   91.31    75.9
GR 91.31    86.9

*  Cross Section #54+00 from Sheet 11 of 15 of Los Reales Improvement District
*  Job No. 85-074
X1     4       6       0    86.9     300     300     300       0    2400
GR 87.95       0   75.67    27.1   75.67    56.0   88.15    66.5   91.51    75.9
GR 91.51    86.9

*  Cross Section #51+00 from Sheet 11 of 15 of Los Reales Improvement District
*  Job No. 85-074
X1     5       6       0    86.9     300     300     300       0    2400
GR 88.11       0   76.64    27.1   76.64    56.0   88.35    66.5   91.59    75.9
GR 91.59    86.9

*  Cross Section #48+00 from Sheet 10 of 15 of Los Reales Improvement District
*  Job No. 85-074
X1     6       6       0    86.9     300     300     300       0    2400
GR 87.47       0   77.44    27.1   77.44    56.0   88.30    66.5    92.2    75.9
GR  92.2    86.9

*  Cross Section #45+00 from Sheet 10 of 15 of Los Reales Improvement District
*  Job No. 85-074
```

```
X1     7        6        0     86.9     300     300     300      0    2400
GR 87.99        0    78.16     27.1   78.16    56.0   88.50   66.5   92.03    75.9
GR 92.03     86.9

*  Cross Section #42+00 from sheet 10 of 15 of Los Reales Improvement District
*  Job No. 85-074
X1     8        6        0     86.9     300     300     300      0    2400
GR 88.28        0    78.70     27.1   78.70    56.0   88.71   66.5   92.55    75.9
GR 92.55     86.9

*  Cross Section #39+20 from sheet  9 of 15 of Los Reales Improvement District
*  Job No. 85-074
NC  .022     .022     .022      0.1     0.3
X1     9        4        0       67     280     280     280      0    2400
GR  88.0        0     79.4       28    79.4      57    89.0     67

*  Cross Section runs along south top of bank protection between sta.
*  #24+70 and #39+20 from sheets 8 & 9 of 15 of Los Reales Improvement District
*  Job No. 85-074

X1    10        7        0      730    1450     720    1085      0    2400
GR  93.1        0     89.8        1    88.6     530    88.9    730    88.0    1130
GR  89.3     1310     92.5     1450

EJ

T1        Los Reales Improvement District, Letter of Map Revision
T2        Arroyo Job #PDOT01.1, HEC2 File: South.H2I
T3        South Channel
J1     0        3        0        0      -1       0       0      0    2472
J2     2        0       -1        0       0       0       0      0       0

T1        Los Reales Improvement District, Letter of Map Revision
T2        Arroyo Job #PDOT01.1, HEC2 File: South.H2I
T3        South Channel
J1     0        4        0        0      -1       0       0      0    2472
J2     3        0       -1        0       0       0       0      0       0

ER
```

```
**********************************************
* HEC-2 WATER SURFACE PROFILES               *
*                                            *
* Version  4.6.2;  May 1991                  *
*                                            *
* RUN DATE    03OCT94    TIME    15:32:21    *
**********************************************
```

```
**************************************
* U.S. ARMY CORPS OF ENGINEERS       *
* HYDROLOGIC ENGINEERING CENTER      *
* 609 SECOND STREET, SUITE D         *
* DAVIS, CALIFORNIA 95616-4687       *
*         (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
```

THIS RUN EXECUTED 03OCT94 15:32:21

```
****************************************
 HEC-2 WATER SURFACE PROFILES

 Version  4.6.2;  May 1991
****************************************
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SPLIT FLOW BEING PERFORMED

SF Splitflow Analysis of the South Channel

```
TW Splitflow #9 to #10, Weir flow across Los Reales Rd. on No.Side of So.Channel
WS     7       9      10      -1     2.6
WC     0  2493.1       1  2489.8     530  2489.4     730  2489.7    1080  2492.5
WC  1280  2492.5    1450  2492.5
```

T1 Los Reales Improvement District, Letter of Map Revision
T2 Arroyo Job #PDOT01.1, HEC2 File: South.H2I
T3 South Channel

J1	ICHECK	INQ	NINV	IDIR	STRT	METRIC	HVINS	Q	WSEL	FQ
	0	2	0	0	-1	0	0	0	2472	

J2	NPROF	IPLOT	PRFVS	XSECV	XSECH	FN	ALLDC	IBW	CHNIM	ITRACE
	1	0	-1	0	0	0	0	0	0	

J3 VARIABLE CODES FOR SUMMARY PRINTOUT

38	43	13	14	15	1	2	3	8	53
4	54	61		150					

NC	.025	.025	.025	0.1	0.3
QT	3	3250	3300	3350	

Note that 3 flood discharges were used in this multi-profile run. These discharges were used to develop the stage-discharge curve for use in the HEC-2 model of the West Branch (see TC cards in HEC-2 file WEST.H2I), as well as to predict water-surface elevations within and along the South Channel. In addition, the water-surface elevation given in field J1.9 is equal to the 10-year water-surface elevation within the Santa Cruz River at the channel ou

Cross Section #62+50 from Sheet 12 of 15 of Los Reales Improvement District
Job No. 85-074

X1	1	4	0	128	0	0	0	
GR	2486.6	0	2468.9	57	2468.9	73	2486.4	128

Cross Section #60+00 from Sheet 12 of 15 of Los Reales Improvement District
Job No. 85-074

X1	2	4	0	112	250	250	250	
GR	2487.4	0	2471.8	48	2471.8	64	2487.6	112

Cross Section #57+00 from Sheet 11 of 15 of Los Reales Improvement District
Job No. 85-074

NC	.024	.024	.024	0.1	0.3					
X1	3	6	0	86.9	300	300	300	0	2400	
GR	87.78	0	75.20	27.1	75.20	56.0	88.19	66.5	91.31	75.9
GR	91.31	86.9								

Cross Section #54+00 from Sheet 11 of 15 of Los Reales Improvement District
Job No. 85-074

X1	4	6	0	86.9	300	300	300	0	2400	
GR	87.95	0	75.67	27.1	75.67	56.0	88.15	66.5	91.51	75.9
GR	91.51	86.9								

Cross Section #51+00 from Sheet 11 of 15 of Los Reales Improvement District
Job No. 85-074

X1	5	6	0	86.9	300	300	300	0	2400	
GR	88.11	0	76.64	27.1	76.64	56.0	88.35	66.5	91.59	75.9
GR	91.59	86.9								

Cross Section #48+00 from Sheet 10 of 15 of Los Reales Improvement District
Job No. 85-074

X1	6	6	0	86.9	300	300	300	0	2400	
GR	87.47	0	77.44	27.1	77.44	56.0	88.30	66.5	92.2	75.9
GR	92.2	86.9								

Cross Section #45+00 from Sheet 10 of 15 of Los Reales Improvement District
Job No. 85-074

X1	7	6	0	86.9	300	300	300	0	2400	
GR	87.99	0	78.16	27.1	78.16	56.0	88.50	66.5	92.03	75.9
GR	92.03	86.9								

Cross Section #42+00 from sheet 10 of 15 of Los Reales Improvement District
Job No. 85-074

X1	8	6	0	86.9	300	300	300	0	2400	
GR	88.28	0	78.70	27.1	78.70	56.0	88.71	66.5	92.55	75.9
GR	92.55	86.9								

Cross Section #39+20 from sheet 9 of 15 of Los Reales Improvement District
Job No. 85-074

NC	.022	.022	.022	0.1	0.3				
X1	9	4	0	67	280	280	280	0	2400
GR	88.0	0	79.4	28	79.4	57	89.0	67	

Cross Section runs along south top of bank protection between sta.
#24+70 and #39+20 from sheets 8 & 9 of 15 of Los Reales Improvement District
Job No. 85-074

X1	10	7	0	730	1450	720	1085	0	2400	
GR	93.1	0	89.8	1	88.6	530	88.9	730	88.0	1130
GR	89.3	1310	92.5	1450						

```
 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 1



CCHV=     .100 CEHV=     .300
*SECNO 1.000
3720 CRITICAL DEPTH ASSUMED
     1.000      7.03   2475.93   2475.93   2472.00   2478.18      2.26       .00       .00   2486.60
    3250.0        .0    3250.0        .0        .0     269.7        .0        .0        .0   2486.40
       .00       .00     12.05       .00      .000      .025      .000      .000   2468.90     34.36
   .005899        0.        0.        0.         0        16         0       .00     60.73     95.09


*SECNO 2.000
3685 20 TRIALS ATTEMPTED WSEL,CWSEL
3693 PROBABLE MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED
     2.000      7.12   2478.92   2478.92       .00   2481.19      2.27      1.46       .00   2487.40
    3250.0        .0    3250.0        .0        .0     269.0        .0       1.5        .3   2487.60
       .01       .00     12.08       .00      .000      .025      .000      .000   2471.80     26.09
   .005818      250.      250.      250.        20         5         0       .00     59.54     85.63


CCHV=     .100 CEHV=     .300
*SECNO 3.000
3685 20 TRIALS ATTEMPTED WSEL,CWSEL
3693 PROBABLE MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED
     3.000      6.48   2481.68   2481.68       .00   2484.32      2.63      1.70       .11   2487.78
    3250.0        .0    3250.0        .0        .0     249.7        .0       3.3        .7   2491.31
       .01       .00     13.02       .00      .000      .024      .000      .000   2475.20     13.13
   .005544      300.      300.      300.        20        11         0       .00     48.11     61.24


*SECNO 4.000

 3301 HV CHANGED MORE THAN HVINS


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

     4.000      8.42   2484.09       .00       .00   2485.42      1.33       .97       .13   2487.95
    3250.0        .0    3250.0        .0        .0     351.3        .0       5.4       1.1   2491.51
       .02       .00      9.25       .00      .000      .024      .000      .000   2475.67      8.52
   .002130      300.      300.      300.         4         0         0       .00     54.56     63.08
```

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 5.000

5.000	8.06	2484.70	.00	.00	2486.13	1.43	.68	.03	2488.11
3250.0	.0	3250.0	.0	.0	338.7	.0	7.8	1.4	2491.59
.03	.00	9.59	.00	.000	.024	.000	.000	2476.64	8.06
.002410	300.	300.	300.	3	0	0	.00	55.17	63.23

*SECNO 6.000

6.000	8.08	2485.52	.00	.00	2486.84	1.31	.70	.01	2487.47
3250.0	.0	3250.0	.0	.0	353.3	.0	10.2	1.8	2492.20
.04	.00	9.20	.00	.000	.024	.000	.000	2477.44	5.27
.002234	300.	300.	300.	2	0	0	.00	58.55	63.81

*SECNO 7.000

7.000	8.04	2486.20	.00	.00	2487.51	1.31	.67	.00	2487.99
3250.0	.0	3250.0	.0	.0	354.4	.0	12.6	2.2	2492.03
.05	.00	9.17	.00	.000	.024	.000	.000	2478.16	4.93
.002237	300.	300.	300.	2	0	0	.00	59.24	64.17

*SECNO 8.000

8.000	8.26	2486.96	.00	.00	2488.15	1.19	.63	.01	2488.28
3250.0	.0	3250.0	.0	.0	371.2	.0	15.1	2.7	2492.55
.06	.00	8.76	.00	.000	.024	.000	.000	2478.70	3.73
.001986	300.	300.	300.	2	0	0	.00	60.94	64.67

CCHV= .100 CEHV= .300

*SECNO 9.000

9.000	8.11	2487.51	.00	.00	2488.66	1.16	.51	.00	2488.00
3250.0	.0	3250.0	.0	.0	376.4	.0	17.5	3.1	2489.00
.07	.00	8.63	.00	.000	.022	.000	.000	2479.40	1.60
.001679	280.	280.	280.	2	0	0	.00	63.85	65.45

*SECNO 10.000

3301 HV CHANGED MORE THAN HVINS

10.000	1.90	2489.90	.00	.00	2489.99	.09	1.22	.11	2493.10
3250.0	.0	1116.4	2133.6	.0	600.2	812.8	36.4	17.9	2488.90
.18	.00	1.86	2.62	.000	.022	.022	.000	2488.00	.97
.000983	1450.	1085.	720.	6	0	0	.00	1335.27	1336.24

TW Splitflow #9 to #10, Weir flow across Los Reales Rd. on No.Side of So.Channel

ASQ	QCOMP	ERRAC	TASQ	TCQ	TABER	NITER	DSWS	USWS	DSSNO	USSNO
.00	.00	.00	.00	.00	.00	2	2487.507	2489.900	9.000	10.000

T1 Los Reales Improvement District, Letter of Map Revision
T2 Arroyo Job #PDOT01.1, HEC2 File: South.H2I
T3 South Channel

J1	ICHECK	INQ	NINV	IDIR	STRT	METRIC	HVINS	Q	WSEL	FQ
	0	3	0	0	-1	0	0	0	2472	

J2	NPROF	IPLOT	PRFVS	XSECV	XSECH	FN	ALLDC	IBW	CHNIM	ITRACE
	2	0	-1	0	0	0	0	0	0	

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

CCHV= .100 CEHV= .300
*SECNO 1.000
3720 CRITICAL DEPTH ASSUMED

1.000	7.09	2475.99	2475.99	2472.00	2478.25	2.27	.00	.00	2486.60
3300.0	.0	3300.0	.0	.0	273.2	.0	.0	.0	2486.40
.00	.00	12.08	.00	.000	.025	.000	.000	2468.90	34.18
.005873	0.	0.	0.	0	16	0	.00	61.10	95.27

*SECNO 2.000
3685 20 TRIALS ATTEMPTED WSEL,CWSEL
3693 PROBABLE MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED

2.000	7.17	2478.97	2478.97	.00	2481.26	2.28	1.46	.01	2487.40
3300.0	.0	3300.0	.0	.0	272.1	.0	1.6	.3	2487.60
.01	.00	12.13	.00	.000	.025	.000	.000	2471.80	25.93
.005811	250.	250.	250.	20	5	0	.00	59.87	85.79

CCHV= .100 CEHV= .300
*SECNO 3.000
3685 20 TRIALS ATTEMPTED WSEL,CWSEL
3693 PROBABLE MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED

3.000	6.54	2481.74	2481.74	.00	2484.40	2.65	1.70	.11	2487.78
3300.0	.0	3300.0	.0	.0	252.6	.0	3.4	.7	2491.31
.01	.00	13.07	.00	.000	.024	.000	.000	2475.20	13.00
.005532	300.	300.	300.	20	11	0	.00	48.29	61.29

*SECNO 4.000

3301 HV CHANGED MORE THAN HVINS

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

4.000	8.49	2484.16	.00	.00	2485.50	1.34	.97	.13	2487.95
3300.0	.0	3300.0	.0	.0	355.0	.0	5.5	1.1	2491.51
.02	.00	9.30	.00	.000	.024	.000	.000	2475.67	8.37
.002132	300.	300.	300.	4	0	0	.00	54.76	63.14

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 5.000									
5.000	8.13	2484.77	.00	.00	2486.21	1.44	.68	.03	2488.11
3300.0	.0	3300.0	.0	.0	342.5	.0	7.9	1.5	2491.59
.03	.00	9.63	.00	.000	.024	.000	.000	2476.64	7.90
.002408	300.	300.	300.	3	0	0	.00	55.39	63.29
*SECNO 6.000									
6.000	8.15	2485.59	.00	.00	2486.92	1.32	.69	.01	2487.47
3300.0	.0	3300.0	.0	.0	357.5	.0	10.3	1.8	2492.20
.04	.00	9.23	.00	.000	.024	.000	.000	2477.44	5.07
.002230	300.	300.	300.	2	0	0	.00	58.81	63.88
*SECNO 7.000									
7.000	8.11	2486.27	.00	.00	2487.59	1.32	.67	.00	2487.99
3300.0	.0	3300.0	.0	.0	358.5	.0	12.7	2.3	2492.03
.05	.00	9.21	.00	.000	.024	.000	.000	2478.16	4.74
.002233	300.	300.	300.	2	0	0	.00	59.50	64.24
*SECNO 8.000									
8.000	8.33	2487.03	.00	.00	2488.23	1.20	.63	.01	2488.28
3300.0	.0	3300.0	.0	.0	375.4	.0	15.3	2.7	2492.55
.06	.00	8.79	.00	.000	.024	.000	.000	2478.70	3.53
.001984	300.	300.	300.	2	0	0	.00	61.21	64.74
CCHV= .100 CEHV= .300									
*SECNO 9.000									
9.000	8.18	2487.58	.00	.00	2488.74	1.17	.51	.00	2488.00
3300.0	.0	3300.0	.0	.0	380.7	.0	17.7	3.1	2489.00
.07	.00	8.67	.00	.000	.022	.000	.000	2479.40	1.38
.001677	280.	280.	280.	2	0	0	.00	64.13	65.52
*SECNO 10.000									
3301 HV CHANGED MORE THAN HVINS									
10.000	1.93	2489.93	.00	.00	2490.02	.09	1.17	.11	2493.10
3300.0	.0	1153.9	2146.1	.0	625.5	833.9	37.1	18.0	2488.90
.18	.00	1.84	2.57	.000	.022	.022	.000	2488.00	.96
.000915	1450.	1085.	720.	6	0	0	.00	1336.80	1337.76

TW Splitflow #9 to #10, Weir flow across Los Reales Rd. on No.Side of So.Channel

ASQ	QCOMP	ERRAC	TASQ	TCQ	TABER	NITER	DSWS	USWS	DSSNO	USSNO
.00	.00	.00	.00	.00	.00	2	2487.575	2489.935	9.000	10.000

T1 Los Reales Improvement District, Letter of Map Revision
T2 Arroyo Job #PDOT01.1, HEC2 File: South.H2I
T3 South Channel

J1	ICHECK	INQ	NINV	IDIR	STRT	METRIC	HVINS	Q	WSEL	FQ
	0	4	0	0	-1	0	0	0	2472	

J2	NPROF	IPLOT	PRFVS	XSECV	XSECH	FN	ALLDC	IBW	CHNIM	ITRACE
	3	0	-1	0	0	0	0	0	0	

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

CCHV= .100 CEHV= .300
*SECNO 1.000
3720 CRITICAL DEPTH ASSUMED

1.000	7.14	2476.04	2476.04	2472.00	2478.32	2.28	.00	.00	2486.60
3350.0	.0	3350.0	.0	.0	276.6	.0	.0	.0	2486.40
.00	.00	12.11	.00	.000	.025	.000	.000	2468.90	34.00
.005855	0.	0.	0.	0	16	0	.00	61.45	95.45

*SECNO 2.000
3685 20 TRIALS ATTEMPTED WSEL,CWSEL
3693 PROBABLE MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED

2.000	7.23	2479.03	2479.03	.00	2481.33	2.30	1.46	.01	2487.40
3350.0	.0	3350.0	.0	.0	275.3	.0	1.6	.3	2487.60
.01	.00	12.17	.00	.000	.025	.000	.000	2471.80	25.76
.005802	250.	250.	250.	20	5	0	.00	60.19	85.96

CCHV= .100 CEHV= .300
*SECNO 3.000
3685 20 TRIALS ATTEMPTED WSEL,CWSEL
3693 PROBABLE MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED

3.000	6.60	2481.80	2481.80	.00	2484.47	2.67	1.70	.11	2487.78
3350.0	.0	3350.0	.0	.0	255.3	.0	3.4	.7	2491.31
.01	.00	13.12	.00	.000	.024	.000	.000	2475.20	12.88
.005528	300.	300.	300.	20	11	0	.00	48.46	61.34

*SECNO 4.000

3301 HV CHANGED MORE THAN HVINS

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

4.000	8.56	2484.23	.00	.00	2485.58	1.35	.97	.13	2487.95
3350.0	.0	3350.0	.0	.0	358.7	.0	5.5	1.1	2491.51
.02	.00	9.34	.00	.000	.024	.000	.000	2475.67	8.22
.002134	300.	300.	300.	4	0	0	.00	54.97	63.20

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 5.000

5.000	8.20	2484.84	.00	.00	2486.29	1.45	.68	.03	2488.11
3350.0	.0	3350.0	.0	.0	346.3	.0	8.0	1.5	2491.59
.03	.00	9.67	.00	.000	.024	.000	.000	2476.64	7.74
.002406	300.	300.	300.	3	0	0	.00	55.61	63.35

*SECNO 6.000

6.000	8.22	2485.66	.00	.00	2487.00	1.33	.69	.01	2487.47
3350.0	.0	3350.0	.0	.0	361.6	.0	10.4	1.9	2492.20
.04	.00	9.26	.00	.000	.024	.000	.000	2477.44	4.88
.002225	300.	300.	300.	2	0	0	.00	59.06	63.95

*SECNO 7.000

7.000	8.18	2486.34	.00	.00	2487.66	1.33	.67	.00	2487.99
3350.0	.0	3350.0	.0	.0	362.5	.0	12.9	2.3	2492.03
.05	.00	9.24	.00	.000	.024	.000	.000	2478.16	4.55
.002231	300.	300.	300.	2	0	0	.00	59.75	64.30

*SECNO 8.000

8.000	8.40	2487.10	.00	.00	2488.31	1.21	.63	.01	2488.28
3350.0	.0	3350.0	.0	.0	379.5	.0	15.4	2.7	2492.55
.06	.00	8.83	.00	.000	.024	.000	.000	2478.70	3.34
.001984	300.	300.	300.	2	0	0	.00	61.47	64.81

CCHV= .100 CEHV= .300

*SECNO 9.000

9.000	8.25	2487.65	.00	.00	2488.82	1.17	.51	.00	2488.00
3350.0	.0	3350.0	.0	.0	385.3	.0	17.9	3.1	2489.00
.07	.00	8.70	.00	.000	.022	.000	.000	2479.40	1.15
.001673	280.	280.	280.	2	0	0	.00	64.44	65.59

*SECNO 10.000

3301 HV CHANGED MORE THAN HVINS

3302 WARNING: CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE, KRATIO = 1.40

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
10.000	1.97	2489.97	.00	.00	2490.05	.08	1.12	.11	2493.10
3350.0	.0	1191.2	2158.8	.0	651.1	855.3	37.9	18.0	2488.90
.18	.00	1.83	2.52	.000	.022	.022	.000	2488.00	.95
.000853	1450.	1085.	720.	6	0	0	.00	1338.35	1339.30

TW Splitflow #9 to #10, Weir flow across Los Reales Rd. on No.Side of So.Channel

ASQ	QCOMP	ERRAC	TASQ	TCQ	TABER	NITER	DSWS	USWS	DSSNO	USSNO
.00	.00	.00	.00	.00	.00	2	2487.645	2489.970	9.000	10.000

THIS RUN EXECUTED 03OCT94 15:34:10

****

HEC-2 WATER SURFACE PROFILES

Version 4.6.2; May 1991

****

NOTE- ASTERISK (*) AT LEFT OF CROSS-SECTION NUMBER INDICATES MESSAGE IN SUMMARY OF ERRORS LIST

South Channel

SUMMARY PRINTOUT

	SECNO	Q	QLOB	QCH	QROB	CWSEL	CRIWS	EG	DEPTH	SSTA	TOPWID	ENDST	DIFEG
*	1.000	3250.00	.00	3250.00	.00	2475.93	2475.93	2478.18	7.03	34.36	60.73	95.09	.00
*	1.000	3300.00	.00	3300.00	.00	2475.99	2475.99	2478.25	7.09	34.18	61.10	95.27	.07
*	1.000	3350.00	.00	3350.00	.00	2476.04	2476.04	2478.32	7.14	34.00	61.45	95.45	.14
*	2.000	3250.00	.00	3250.00	.00	2478.92	2478.92	2481.19	7.12	26.09	59.54	85.63	.00
*	2.000	3300.00	.00	3300.00	.00	2478.97	2478.97	2481.26	7.17	25.93	59.87	85.79	.07
*	2.000	3350.00	.00	3350.00	.00	2479.03	2479.03	2481.33	7.23	25.76	60.19	85.96	.14
*	3.000	3250.00	.00	3250.00	.00	2481.68	2481.68	2484.32	6.48	13.13	48.11	61.24	.00
*	3.000	3300.00	.00	3300.00	.00	2481.74	2481.74	2484.40	6.54	13.00	48.29	61.29	.08
*	3.000	3350.00	.00	3350.00	.00	2481.80	2481.80	2484.47	6.60	12.88	48.46	61.34	.16
*	4.000	3250.00	.00	3250.00	.00	2484.09	.00	2485.42	8.42	8.52	54.56	63.08	.00
*	4.000	3300.00	.00	3300.00	.00	2484.16	.00	2485.50	8.49	8.37	54.76	63.14	.08
*	4.000	3350.00	.00	3350.00	.00	2484.23	.00	2485.58	8.56	8.22	54.97	63.20	.16
	5.000	3250.00	.00	3250.00	.00	2484.70	.00	2486.13	8.06	8.06	55.17	63.23	.00
	5.000	3300.00	.00	3300.00	.00	2484.77	.00	2486.21	8.13	7.90	55.39	63.29	.08
	5.000	3350.00	.00	3350.00	.00	2484.84	.00	2486.29	8.20	7.74	55.61	63.35	.16
	6.000	3250.00	.00	3250.00	.00	2485.52	.00	2486.84	8.08	5.27	58.55	63.81	.00
	6.000	3300.00	.00	3300.00	.00	2485.59	.00	2486.92	8.15	5.07	58.81	63.88	.08
	6.000	3350.00	.00	3350.00	.00	2485.66	.00	2487.00	8.22	4.88	59.06	63.95	.16
	7.000	3250.00	.00	3250.00	.00	2486.20	.00	2487.51	8.04	4.93	59.24	64.17	.00
	7.000	3300.00	.00	3300.00	.00	2486.27	.00	2487.59	8.11	4.74	59.50	64.24	.08
	7.000	3350.00	.00	3350.00	.00	2486.34	.00	2487.66	8.18	4.55	59.75	64.30	.16
	8.000	3250.00	.00	3250.00	.00	2486.96	.00	2488.15	8.26	3.73	60.94	64.67	.00
	8.000	3300.00	.00	3300.00	.00	2487.03	.00	2488.23	8.33	3.53	61.21	64.74	.08
	8.000	3350.00	.00	3350.00	.00	2487.10	.00	2488.31	8.40	3.34	61.47	64.81	.16

	SECNO	Q	QLOB	QCH	QROB	CWSEL	CRIWS	EG	DEPTH	SSTA	TOPWID	ENDST	DIFEG
	9.000	3250.00	.00	3250.00	.00	2487.51	.00	2488.66	8.11	1.60	63.85	65.45	.00
	9.000	3300.00	.00	3300.00	.00	2487.58	.00	2488.74	8.18	1.38	64.13	65.52	.08
	9.000	3350.00	.00	3350.00	.00	2487.65	.00	2488.82	8.25	1.15	64.44	65.59	.15
	10.000	3250.00	.00	1116.35	2133.65	2489.90	.00	2489.99	1.90	.97	1335.27	1336.24	.00
	10.000	3300.00	.00	1153.94	2146.06	2489.93	.00	2490.02	1.93	.96	1336.80	1337.76	.03
*	10.000	3350.00	.00	1191.23	2158.77	2489.97	.00	2490.05	1.97	.95	1338.35	1339.30	.06

South Channel

SUMMARY PRINTOUT TABLE 150

	SECNO	XLCH	ELTRD	ELLC	ELMIN	Q	CWSEL	CRIWS	EG	10*KS	VCH	AREA	.01K
*	1.000	.00	.00	.00	2468.90	3250.00	2475.93	2475.93	2478.18	58.99	12.05	269.69	423.15
*	1.000	.00	.00	.00	2468.90	3300.00	2475.99	2475.99	2478.25	58.73	12.08	273.20	430.61
*	1.000	.00	.00	.00	2468.90	3350.00	2476.04	2476.04	2478.32	58.55	12.11	276.56	437.80
*	2.000	250.00	.00	.00	2471.80	3250.00	2478.92	2478.92	2481.19	58.18	12.08	268.95	426.10
*	2.000	250.00	.00	.00	2471.80	3300.00	2478.97	2478.97	2481.26	58.11	12.13	272.12	432.89
*	2.000	250.00	.00	.00	2471.80	3350.00	2479.03	2479.03	2481.33	58.02	12.17	275.32	439.82
*	3.000	300.00	.00	.00	2475.20	3250.00	2481.68	2481.68	2484.32	55.44	13.02	249.69	436.48
*	3.000	300.00	.00	.00	2475.20	3300.00	2481.74	2481.74	2484.40	55.32	13.07	252.58	443.69
*	3.000	300.00	.00	.00	2475.20	3350.00	2481.80	2481.80	2484.47	55.28	13.12	255.33	450.59
*	4.000	300.00	.00	.00	2475.67	3250.00	2484.09	.00	2485.42	21.30	9.25	351.27	704.21
*	4.000	300.00	.00	.00	2475.67	3300.00	2484.16	.00	2485.50	21.32	9.30	354.96	714.62
*	4.000	300.00	.00	.00	2475.67	3350.00	2484.23	.00	2485.58	21.34	9.34	358.69	725.14
	5.000	300.00	.00	.00	2476.64	3250.00	2484.70	.00	2486.13	24.10	9.59	338.72	662.05
	5.000	300.00	.00	.00	2476.64	3300.00	2484.77	.00	2486.21	24.08	9.63	342.52	672.46
	5.000	300.00	.00	.00	2476.64	3350.00	2484.84	.00	2486.29	24.06	9.67	346.34	682.99
	6.000	300.00	.00	.00	2477.44	3250.00	2485.52	.00	2486.84	22.34	9.20	353.35	687.60
	6.000	300.00	.00	.00	2477.44	3300.00	2485.59	.00	2486.92	22.30	9.23	357.49	698.87
	6.000	300.00	.00	.00	2477.44	3350.00	2485.66	.00	2487.00	22.25	9.26	361.63	710.19
	7.000	300.00	.00	.00	2478.16	3250.00	2486.20	.00	2487.51	22.37	9.17	354.37	687.17
	7.000	300.00	.00	.00	2478.16	3300.00	2486.27	.00	2487.59	22.33	9.21	358.50	698.36
	7.000	300.00	.00	.00	2478.16	3350.00	2486.34	.00	2487.66	22.31	9.24	362.49	709.22
	8.000	300.00	.00	.00	2478.70	3250.00	2486.96	.00	2488.15	19.86	8.76	371.16	729.26
	8.000	300.00	.00	.00	2478.70	3300.00	2487.03	.00	2488.23	19.84	8.79	375.38	740.82
	8.000	300.00	.00	.00	2478.70	3350.00	2487.10	.00	2488.31	19.84	8.83	379.49	752.10
	9.000	280.00	.00	.00	2479.40	3250.00	2487.51	.00	2488.66	16.79	8.63	376.43	793.18
	9.000	280.00	.00	.00	2479.40	3300.00	2487.58	.00	2488.74	16.77	8.67	380.73	805.76
	9.000	280.00	.00	.00	2479.40	3350.00	2487.65	.00	2488.82	16.73	8.70	385.26	819.11
	10.000	1085.00	.00	.00	2488.00	3250.00	2489.90	.00	2489.99	9.83	1.86	1413.02	1036.65
	10.000	1085.00	.00	.00	2488.00	3300.00	2489.93	.00	2490.02	9.15	1.84	1459.34	1090.75
*	10.000	1085.00	.00	.00	2488.00	3350.00	2489.97	.00	2490.05	8.53	1.83	1506.36	1146.82

South Channel

SUMMARY PRINTOUT TABLE 150

	SECNO	Q	CWSEL	DIFWSP	DIFWSX	DIFKWS	TOPWID	XLCH
*	1.000	3250.00	2475.93	.00	.00	3.93	60.73	.00
*	1.000	3300.00	2475.99	.06	.00	3.99	61.10	.00
*	1.000	3350.00	2476.04	.05	.00	4.04	61.45	.00
*	2.000	3250.00	2478.92	.00	2.99	.00	59.54	250.00
*	2.000	3300.00	2478.97	.05	2.99	.00	59.87	250.00
*	2.000	3350.00	2479.03	.05	2.99	.00	60.19	250.00
*	3.000	3250.00	2481.68	.00	2.76	.00	48.11	300.00
*	3.000	3300.00	2481.74	.06	2.77	.00	48.29	300.00
*	3.000	3350.00	2481.80	.06	2.77	.00	48.46	300.00
*	4.000	3250.00	2484.09	.00	2.41	.00	54.56	300.00
*	4.000	3300.00	2484.16	.07	2.41	.00	54.76	300.00
*	4.000	3350.00	2484.23	.07	2.42	.00	54.97	300.00
	5.000	3250.00	2484.70	.00	.61	.00	55.17	300.00
	5.000	3300.00	2484.77	.07	.61	.00	55.39	300.00
	5.000	3350.00	2484.84	.07	.61	.00	55.61	300.00
	6.000	3250.00	2485.52	.00	.82	.00	58.55	300.00
	6.000	3300.00	2485.59	.07	.82	.00	58.81	300.00
	6.000	3350.00	2485.66	.07	.83	.00	59.06	300.00
	7.000	3250.00	2486.20	.00	.68	.00	59.24	300.00
	7.000	3300.00	2486.27	.07	.68	.00	59.50	300.00
	7.000	3350.00	2486.34	.07	.68	.00	59.75	300.00
	8.000	3250.00	2486.96	.00	.76	.00	60.94	300.00
	8.000	3300.00	2487.03	.07	.76	.00	61.21	300.00
	8.000	3350.00	2487.10	.07	.76	.00	61.47	300.00
	9.000	3250.00	2487.51	.00	.55	.00	63.85	280.00
	9.000	3300.00	2487.58	.07	.55	.00	64.13	280.00
	9.000	3350.00	2487.65	.07	.55	.00	64.44	280.00
	10.000	3250.00	2489.90	.00	2.39	.00	1335.27	1085.00
	10.000	3300.00	2489.93	.03	2.36	.00	1336.80	1085.00
*	10.000	3350.00	2489.97	.04	2.32	.00	1338.35	1085.00

SUMMARY OF ERRORS AND SPECIAL NOTES

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CAUTION SECNO=      1.000  PROFILE=  1  CRITICAL DEPTH ASSUMED
CAUTION SECNO=      1.000  PROFILE=  2  CRITICAL DEPTH ASSUMED
CAUTION SECNO=      1.000  PROFILE=  3  CRITICAL DEPTH ASSUMED

CAUTION SECNO=      2.000  PROFILE=  1  CRITICAL DEPTH ASSUMED
CAUTION SECNO=      2.000  PROFILE=  1  PROBABLE MINIMUM SPECIFIC ENERGY
CAUTION SECNO=      2.000  PROFILE=  1  20 TRIALS ATTEMPTED TO BALANCE WSEL
CAUTION SECNO=      2.000  PROFILE=  2  CRITICAL DEPTH ASSUMED
CAUTION SECNO=      2.000  PROFILE=  2  PROBABLE MINIMUM SPECIFIC ENERGY
CAUTION SECNO=      2.000  PROFILE=  2  20 TRIALS ATTEMPTED TO BALANCE WSEL
CAUTION SECNO=      2.000  PROFILE=  3  CRITICAL DEPTH ASSUMED
CAUTION SECNO=      2.000  PROFILE=  3  PROBABLE MINIMUM SPECIFIC ENERGY
CAUTION SECNO=      2.000  PROFILE=  3  20 TRIALS ATTEMPTED TO BALANCE WSEL

CAUTION SECNO=      3.000  PROFILE=  1  CRITICAL DEPTH ASSUMED
CAUTION SECNO=      3.000  PROFILE=  1  PROBABLE MINIMUM SPECIFIC ENERGY
CAUTION SECNO=      3.000  PROFILE=  1  20 TRIALS ATTEMPTED TO BALANCE WSEL
CAUTION SECNO=      3.000  PROFILE=  2  CRITICAL DEPTH ASSUMED
CAUTION SECNO=      3.000  PROFILE=  2  PROBABLE MINIMUM SPECIFIC ENERGY
CAUTION SECNO=      3.000  PROFILE=  2  20 TRIALS ATTEMPTED TO BALANCE WSEL
CAUTION SECNO=      3.000  PROFILE=  3  CRITICAL DEPTH ASSUMED
CAUTION SECNO=      3.000  PROFILE=  3  PROBABLE MINIMUM SPECIFIC ENERGY
CAUTION SECNO=      3.000  PROFILE=  3  20 TRIALS ATTEMPTED TO BALANCE WSEL

WARNING SECNO=      4.000  PROFILE=  1  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=      4.000  PROFILE=  2  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=      4.000  PROFILE=  3  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

WARNING SECNO=     10.000  PROFILE=  3  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
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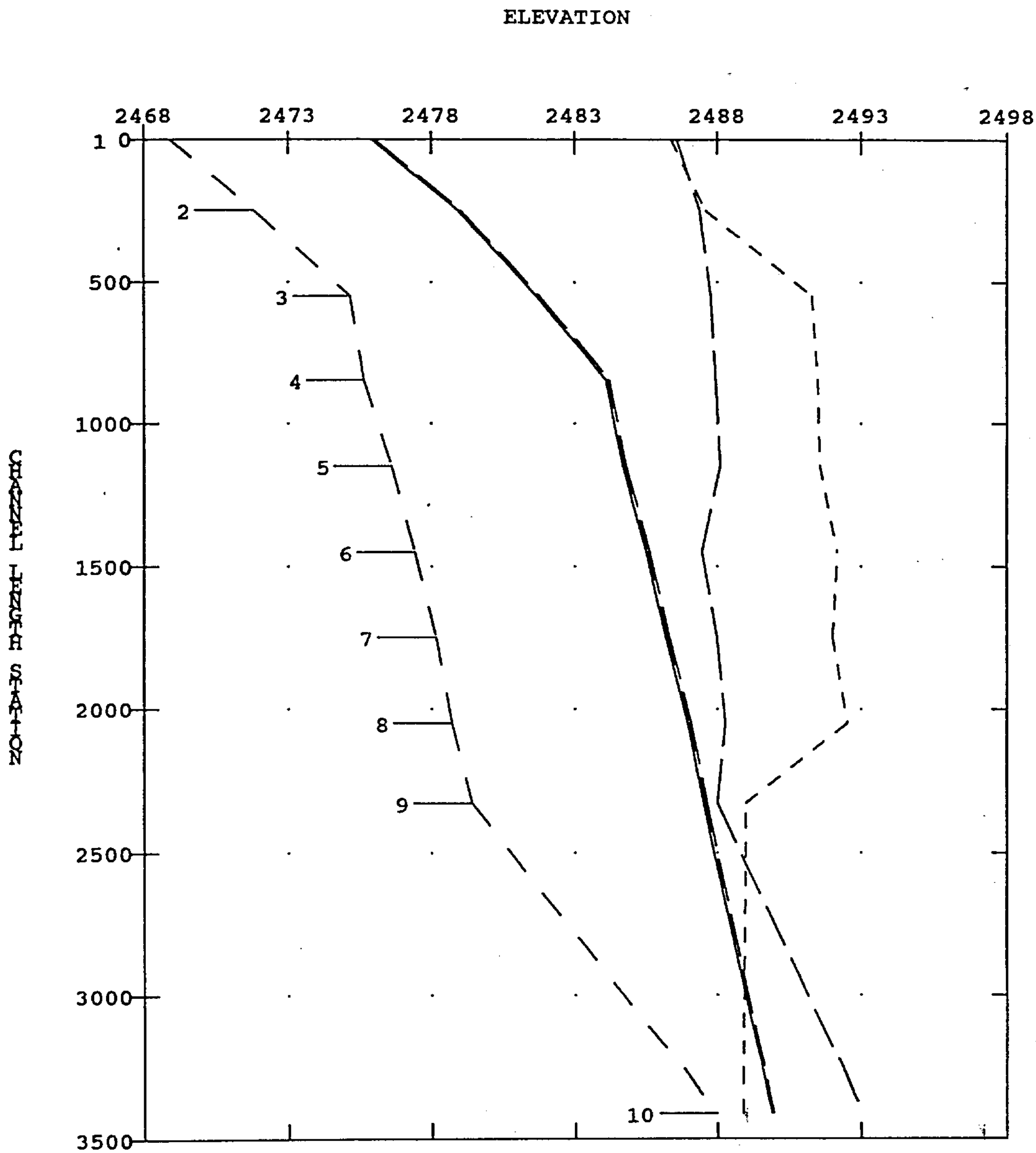
ELEVATION
2468
2473
2478
2483
2488
2493
2498
CHANNEL LENGTH STATION
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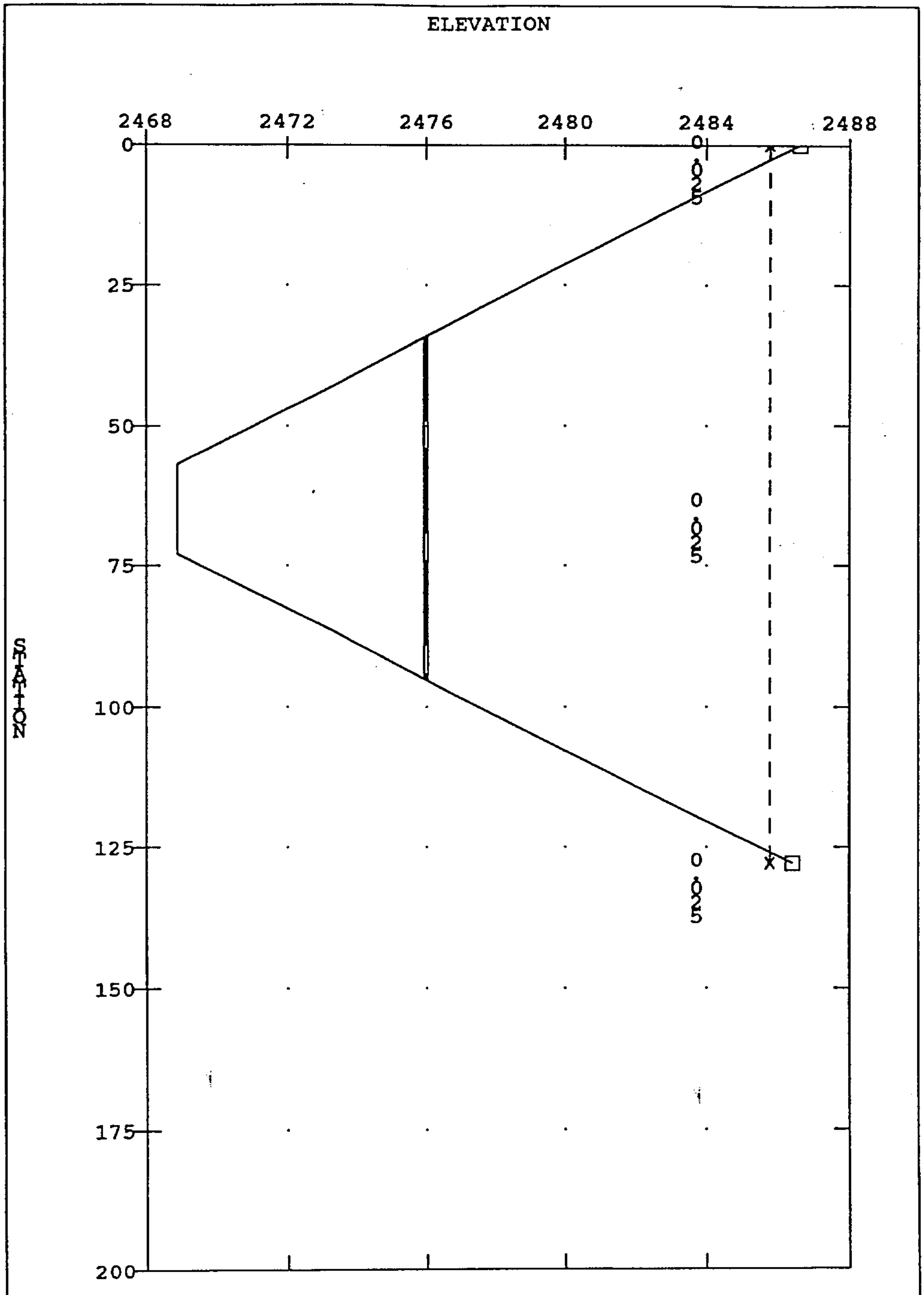
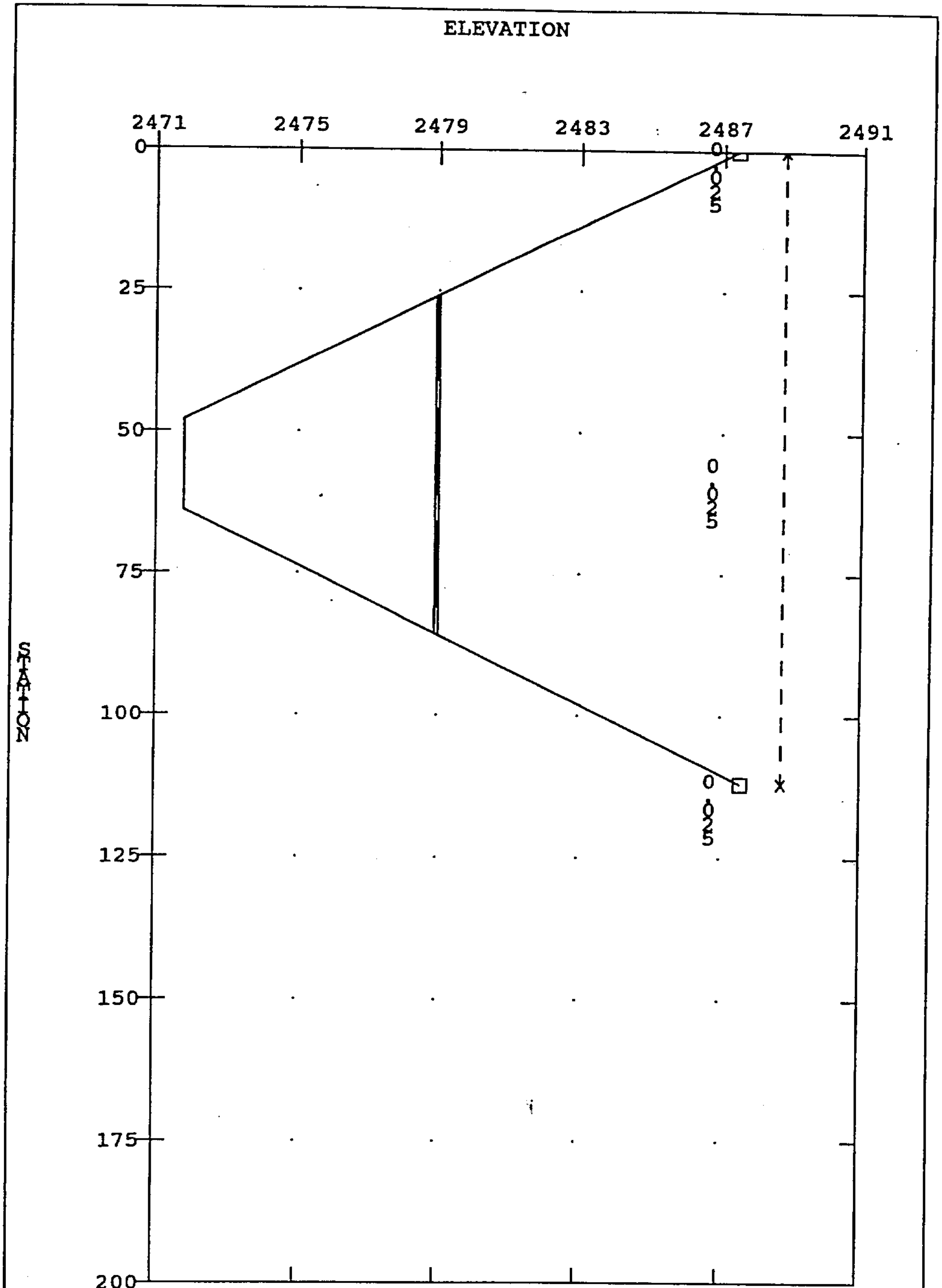
10



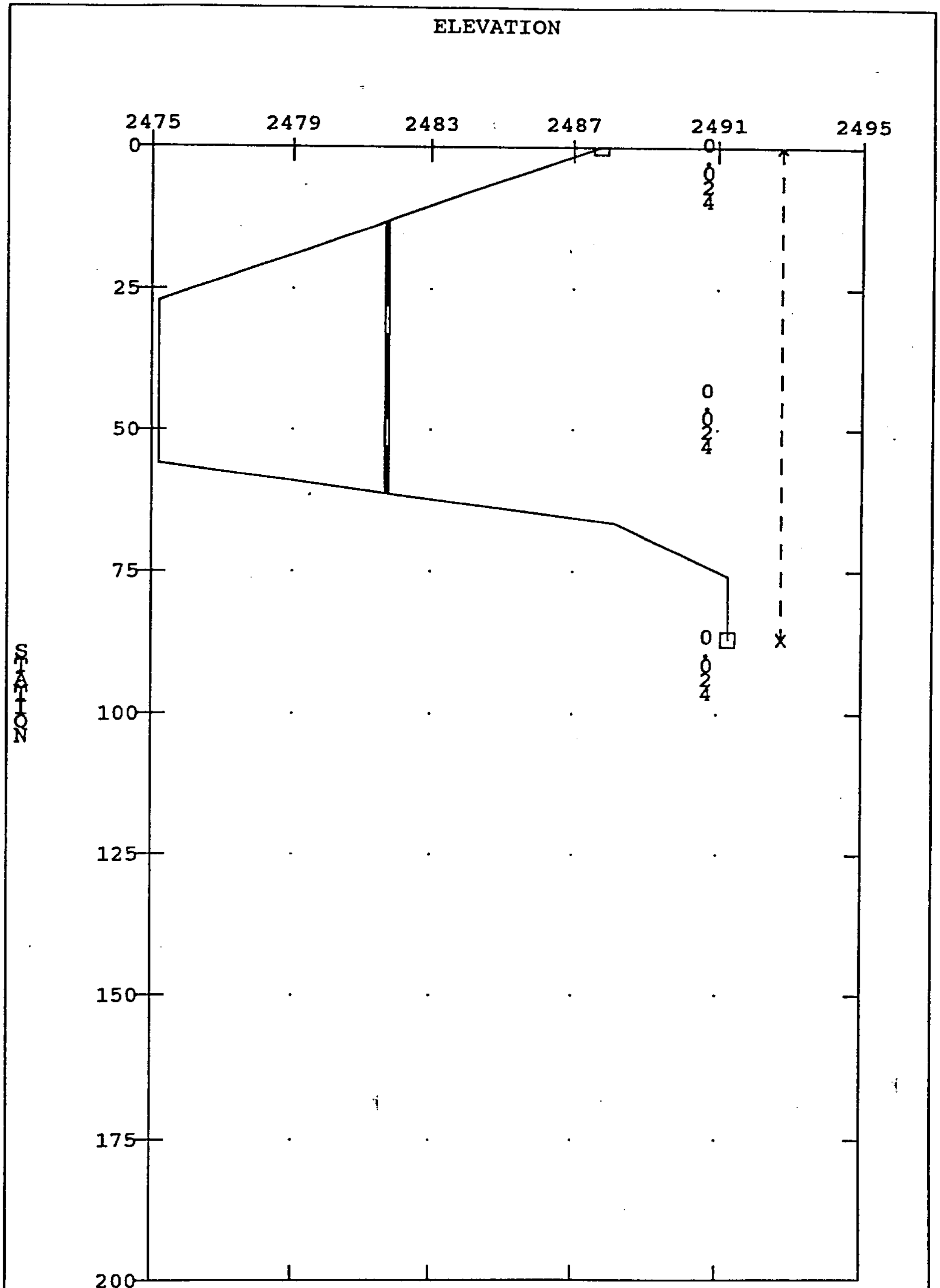
SECTION : 1

South Channel



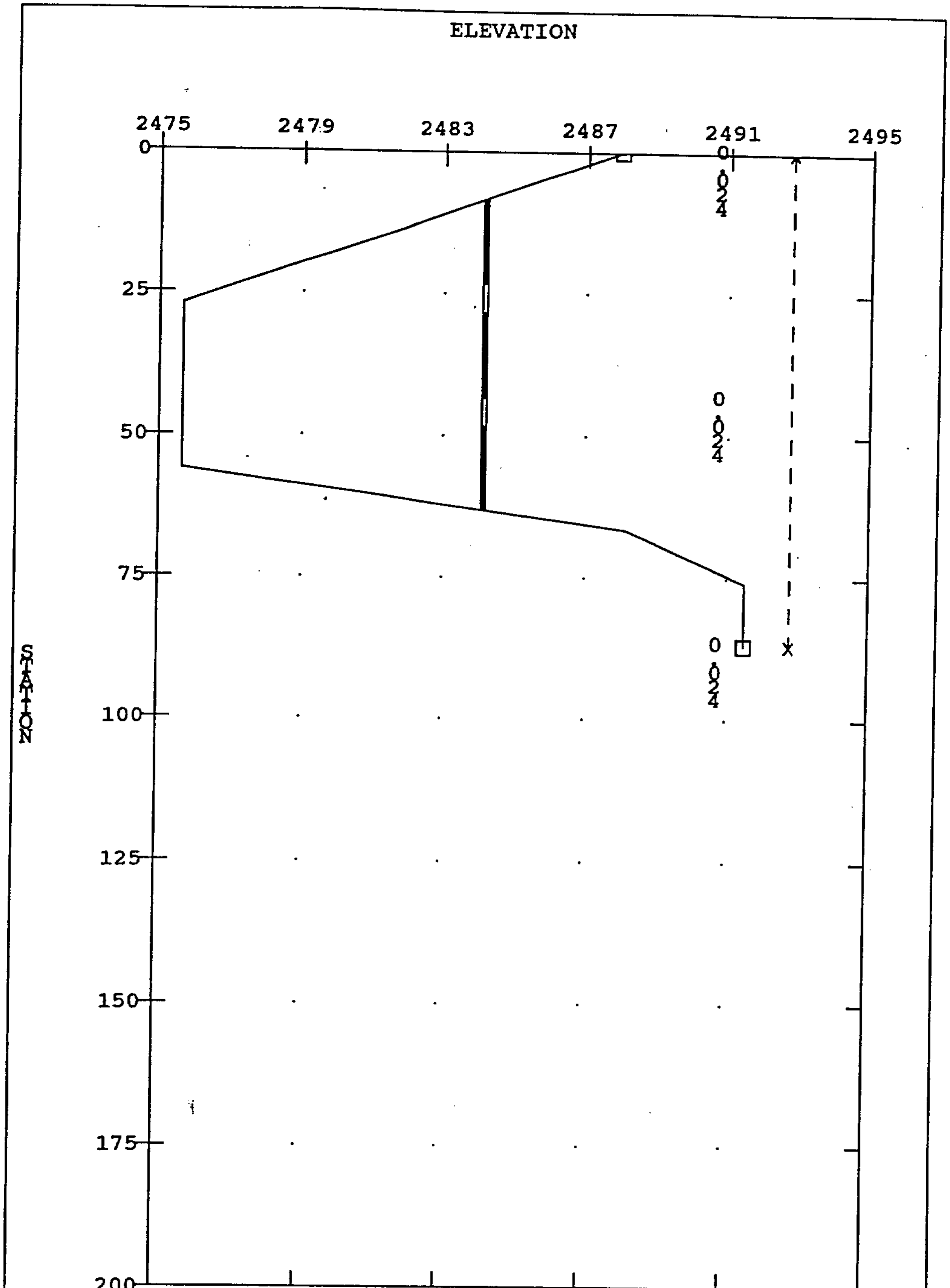
SECTION : 2

South Channel



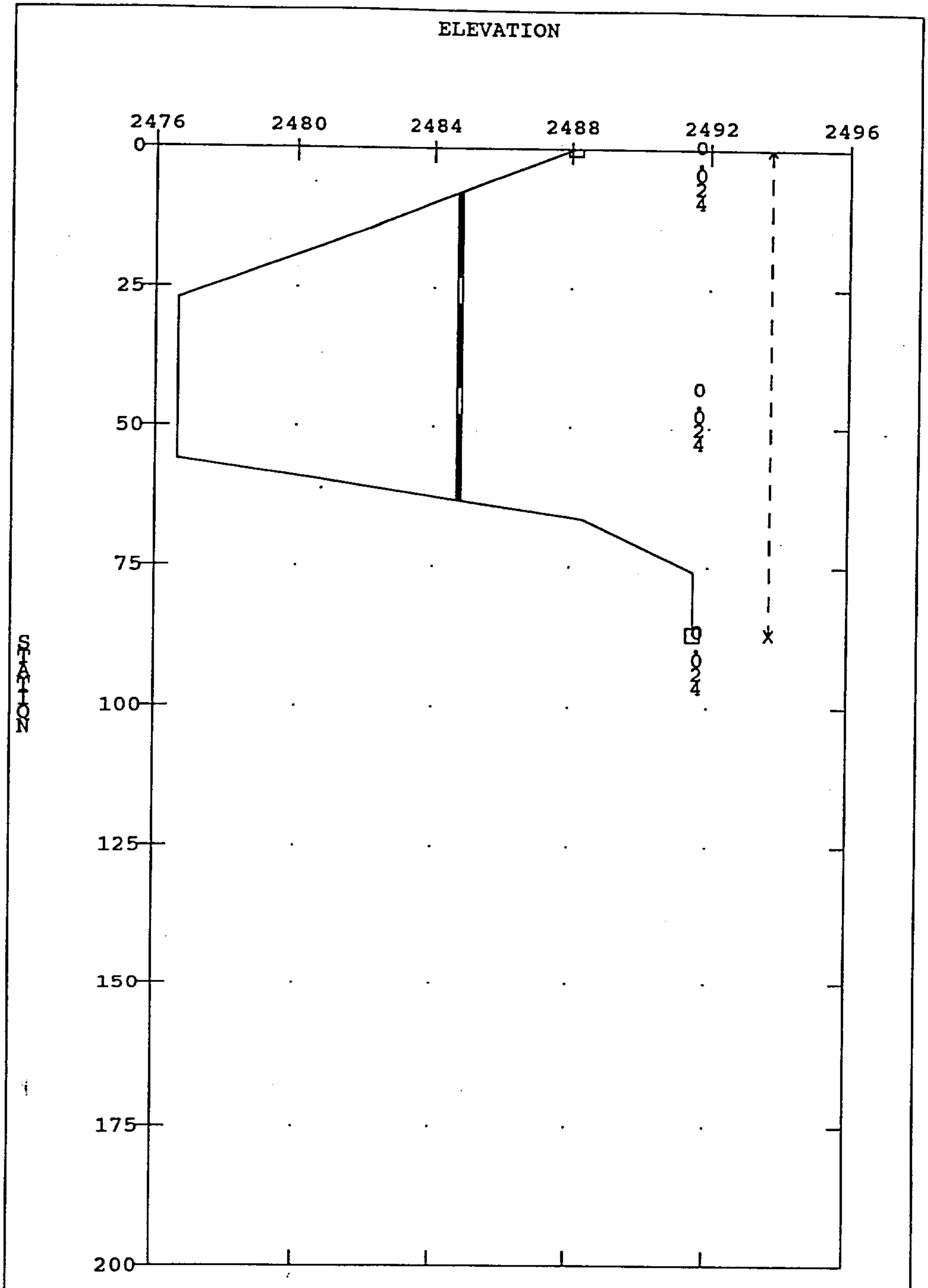
SECTION : 3

South Channel



SECTION : 4

South Channel



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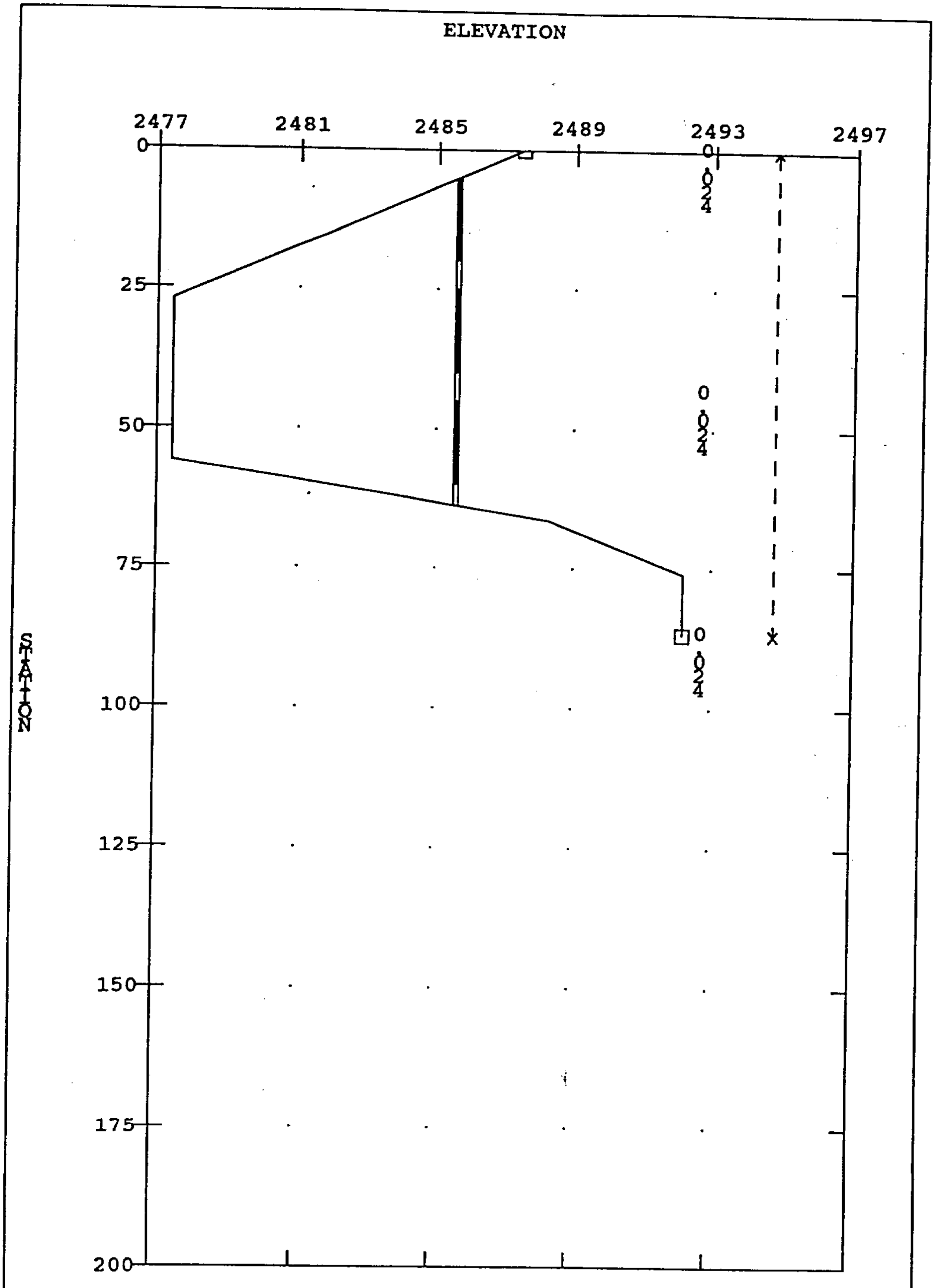
South Channel



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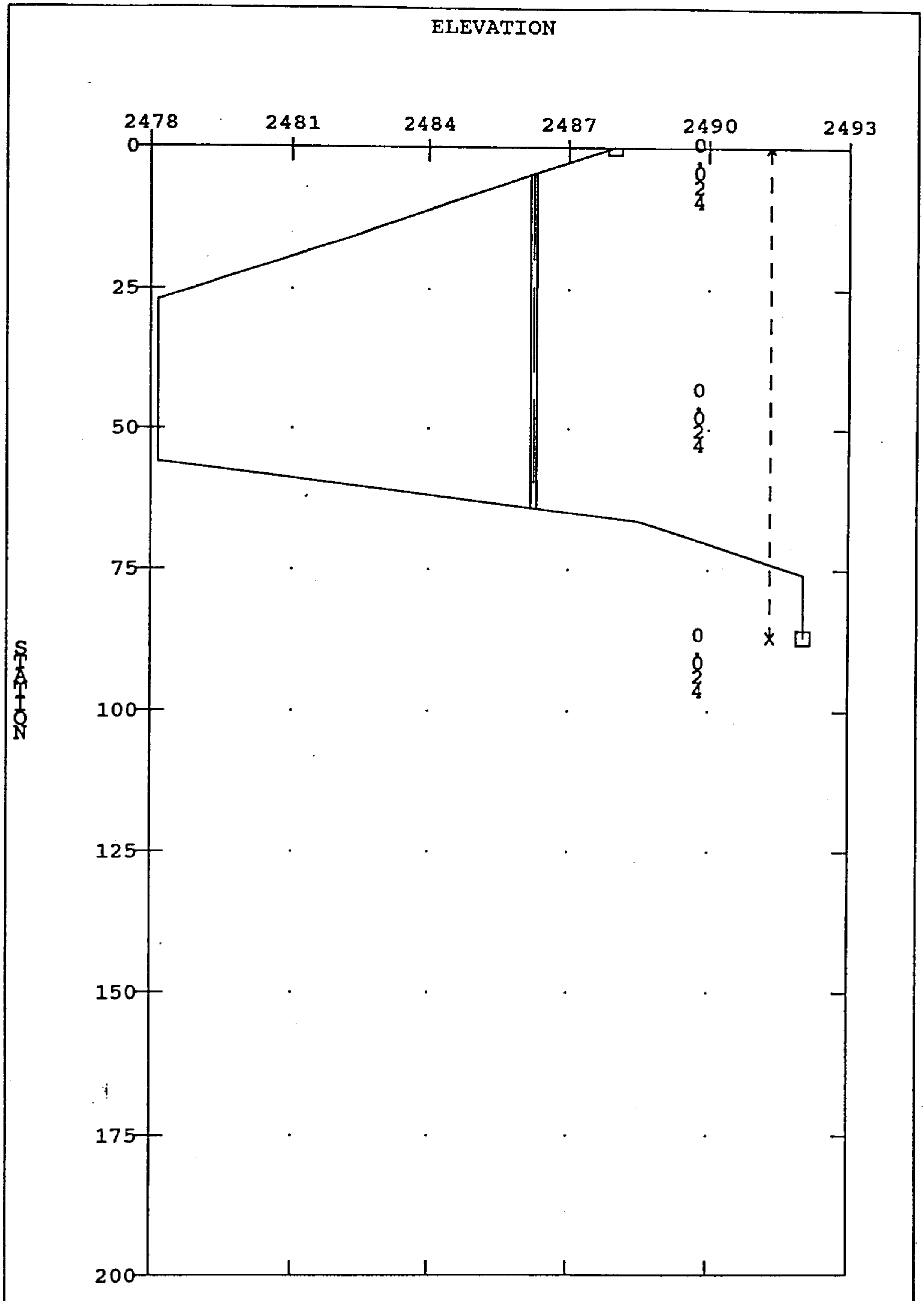
South Channel



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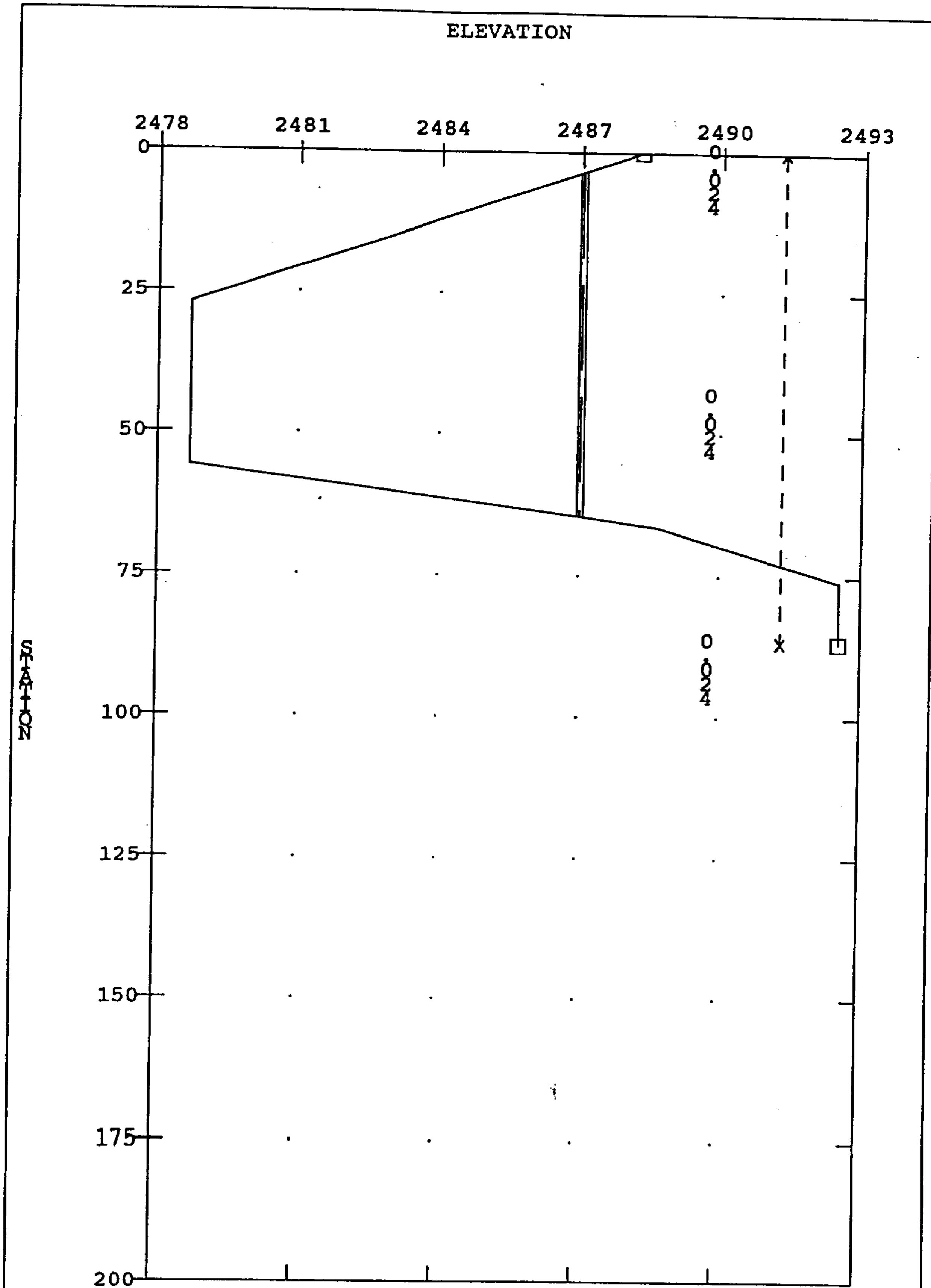

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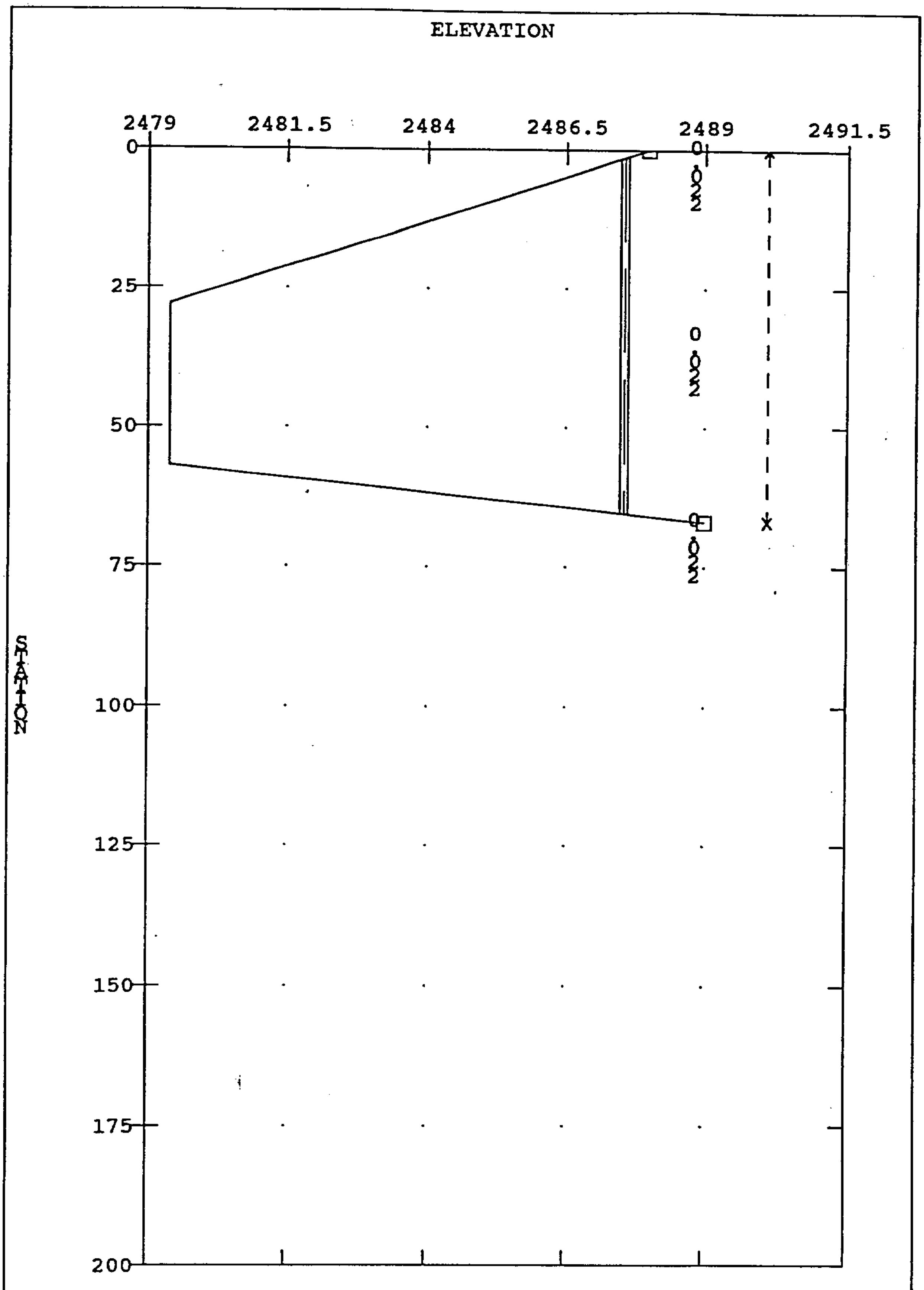
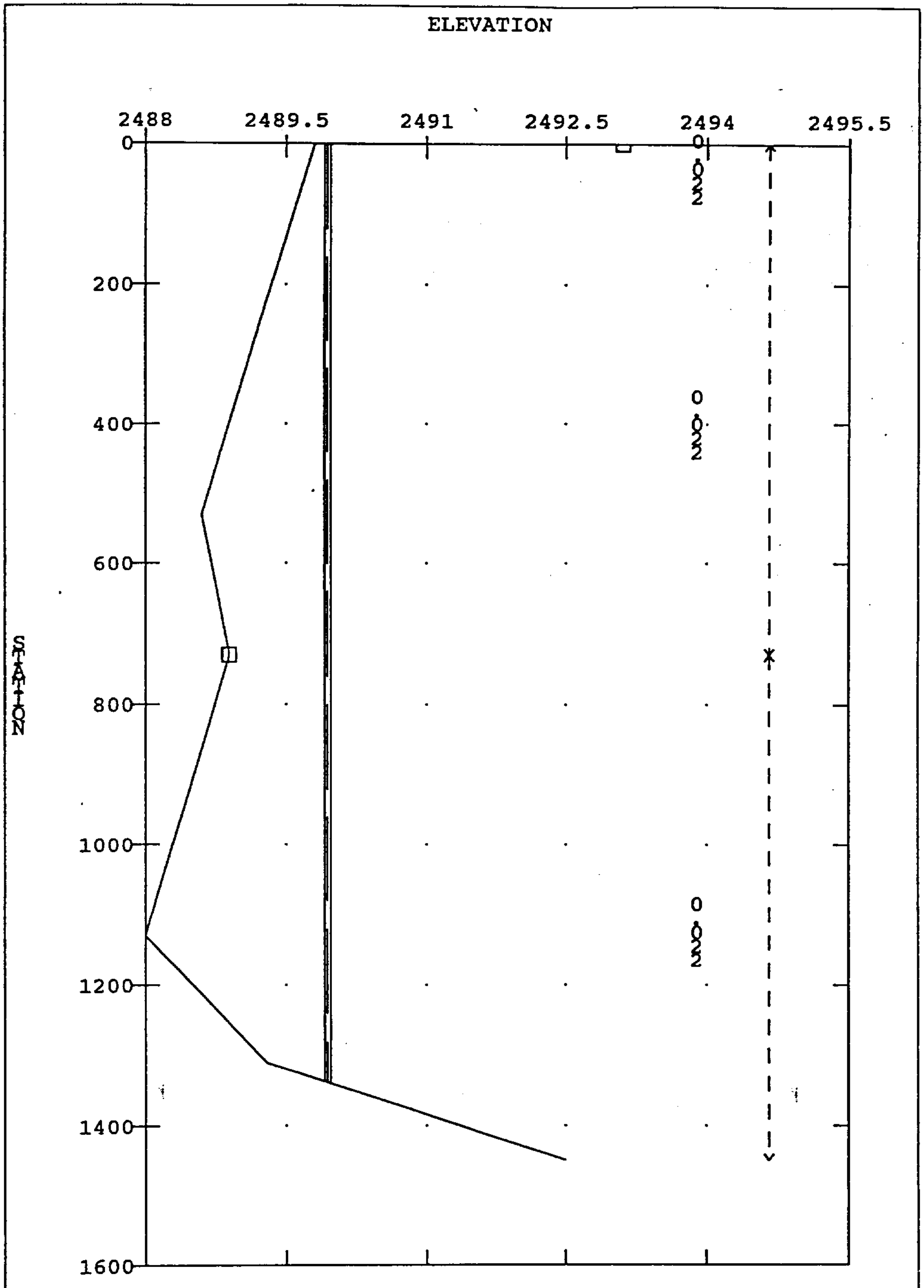
South Channel



SECTION : 9

South Channel



SECTION : 10

South Channel

Appendix 4

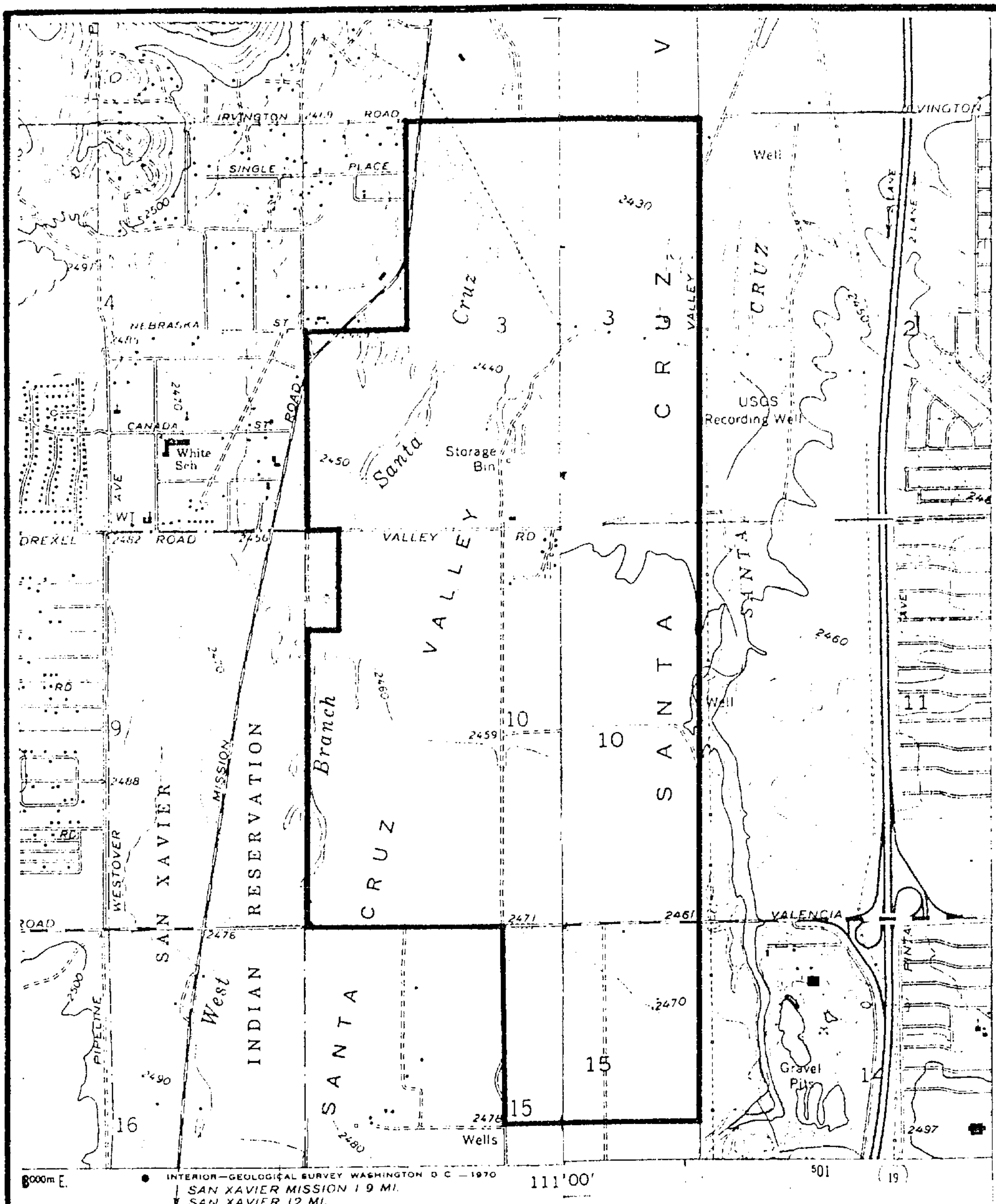
Midvale Park Master Drainage Report: study boundaries, West Branch Channel typical cross sections

Dooley-Jones & Associates, Inc.

CONSULTING ENGINEERS / PLANNERS

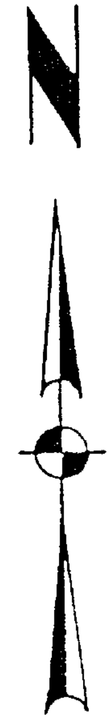
MIDVALE PARK
MASTER DRAINAGE REPORT

... EAST TOOLE AVENUE • P.O. BOX 1830, TUCSON, ARIZONA 85702 • (602) 624-2391



MIDVALE PARK

SCALE: 1" - 2000'



LOCATION PLAN

FIGURE 1