BRIDGE HYDRAULICS REPORT

116TH AVENUE BRIDGE

AT THE GILA RIVER

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BRIDGE HYDRAULICS REPORT

116TH AVENUE BRIDGE

AT THE GILA RIVER

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DEPARTMENT OF TRANSPORTATION

Submitted to:

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I. INTRODUCTION

1.1 Authorization

This 116th Avenue Bridge Hydraulics Report was authorized by Hoffman-Miller Engineers, Inc., for use in conjunction with their design of a proposed roadway and bridge structure that will span the Gila River. The proposed structure crosses the Gila River at approximately 116th Avenue just downstream of the confluence of the Gila and Salt Rivers.

Simons, Li & Associates, Inc., as a subconsultant to Hoffman-Miller Engineers, Inc., conducted the hydraulic analysis for the bridge waterway opening design; and the sediment-transport analyses required as part of the bridge foundation design. This report is a revision of the original report submitted in October, 1994.

1.2 Purpose

The primary purposes of this 116th Avenue Bridge Hydraulics Report are to: 1) present the results of the hydraulic and sediment-transport analyses undertaken as part of the bridge design; 2) recommend an appropriate bridge length and low-chord elevation; 3) quantify the scour depths that are expected to occur in the vicinity of the proposed bridge during the design flood; and 4) recommend measures to protect the bridge along the bank alignment.

1.3 Hydraulic Design Criteria

The hydraulic design of the proposed 116th Avenue Bridge is based upon the following considerations: 1) the bridge is to convey the 100-year design flood with less than 0.305 meters increase in water surface elevation; 2) the bridge piers, abutments and associated hydraulic structures are to be designed to withstand the effects of scour for the worst conditions resulting from floods equal to or less than the 100-year flood; and 3) the bridge is to be designed utilizing the International System of Measurement (SI).

1.4 Project Location

The proposed 116th Avenue Bridge over the Gila River will be located in the southern portion of Avondale, Arizona, as identified on the site location map contained on Figure 1.1. This new bridge will replace an existing low water crossing that presently exists on the 115th Avenue alignment. This location is based on the preferred alternative from the "Gila River Crossing Study, Design Concept Report", (1).

The proposed 116th Avenue bridge is located just downstream of the confluence of the Gila and Salt Rivers, and 5.5 kilometers upstream from the Gila River confluence with the Agua Fria River.

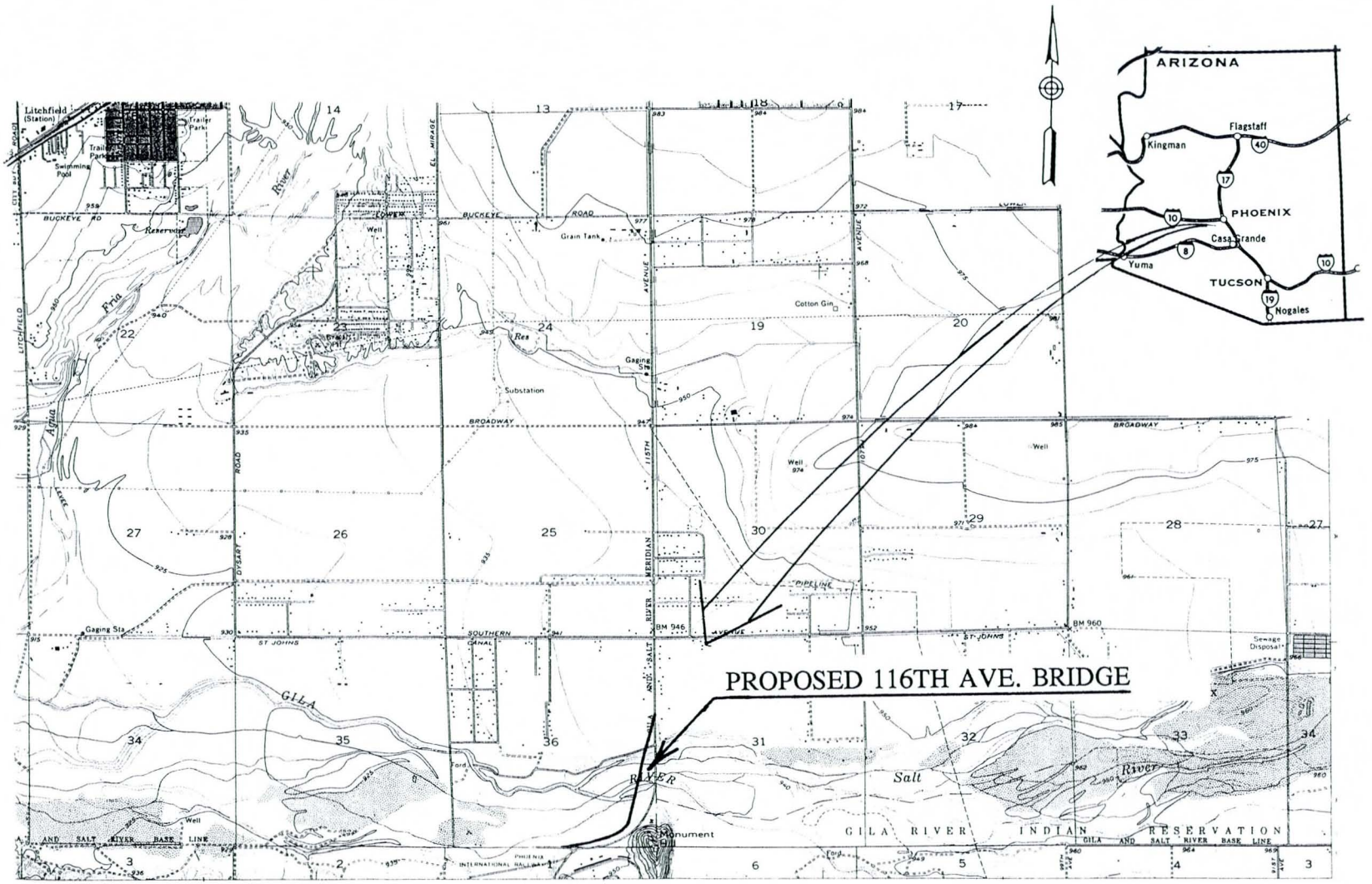

FIGURE 1.1 Location Map

II. HYDROLOGIC CONDITIONS

2.1 Existing Water Resources Facilities

Six upstream water-supply and hydropower dams, owned and operated by the Salt River Project (SRP) generally control the flows in the Salt River above the confluence with the Gila River. Horseshoe and Bartlett Dams are located on the Verde River. Roosevelt, Horse Mesa, Mormon Flat, and Stewart Mountain Dams are located on the Salt River. Currently, there is no flood control storage allocated in these upstream reservoirs (2). Just below the confluence of the Verde and Salt Rivers is Granite Reef Dam, a diversion structure which channels water into an extensive network of SRP irrigation and water supply canals. Additionally two other dams on the Gila River system help regulate flows. Coolidge Dam, primarily a water-supply dam, is located on the Gila River upstream of the confluence of the San Pedro River and the Gila River. Tat Momolikot Dam is a flood control dam located on Santa Rosa Wash above the confluence of the Santa Cruz River with the Gila River.

Roosevelt Dam, the most upstream dam on the Salt River, is undergoing major modifications to increase the dam height and outlet capacity. The increased height of the dam is intended to provide flood control storage for runoff from the Upper Salt River Basin. Operating procedures for the modified Roosevelt Dam have not been finalized. Therefore, the modified Roosevelt Dam's impact on downstream discharge-frequency relationships can only be estimated.

2.2 Floods of Record

The largest floods of record in the vicinity of the proposed 116th Avenue Bridge on the Gila and Salt Rivers include: 1) 9,954 cms on the Salt River in March of 1893 prior to the construction of the dams within the watershed; 2) 6,004 cms in February 1980, the largest discharge since the completion of the dams within the Salt River watershed; 3) 991 cms on the Gila River upstream from the confluence with the Salt River and Santa Cruz River at Laveen in October 1983, (a peak discharge of 935 cms estimated on the Santa Cruz River in October 1983); and 4) an estimated 7,079 cms at Gillespie Dam in 1891 (prior to the completion of the dams within the Gila River Watershed).

2.3 Gila River Hydrology

In 1982, the Los Angeles District of the U.S. Army Corps of Engineers (COE) finalized a hydrologic study for the Gila River and tributaries, which includes the Salt River, as part of the Central Arizona Water Control Study (CAWCS) (3). That study presented discharge-frequency relationships at various points along the Gila River and tributaries for existing conditions. To develop the discharge-frequency relationships, the recorded streamflow for the Gila and Salt Rivers had to be converted to a sequence of "standardized" discharges. Standardization,

converting all streamflow data to the same base conditions, was required because the recorded data was published for a non-homogeneous period of record. To standardize flow in the Salt River, SRP reservoirs were modeled using the HEC-5 computer program to simulate SRP operation under existing conditions. The HEC-5 model was calibrated using the December 1965 through January 1966 and March 1978 floods. The resulting annual maximum values for the peak and various flow duration discharges were ordered and plotted on log-probability frequency paper.

Table 2.1 presents the results of the COE hydrologic analyses for the Salt River above the confluence with the Gila River. Table 2.2 presents the results of the COE hydrologic analyses for the Gila River just below the confluence with the Salt River. The discharges presented in Tables 2.1 and 2.2 were used to quantify the impact of the Salt River on the Gila River flood events.

A second study was performed in 1988 by the COE (2) which quantified the impact of the modified Roosevelt Dam on the discharge-frequency relationships at selected sites within the Gila River Basin. The COE studies cited provide the best current estimate of existing and future hydrologic conditions (i.e., pre-and post-Roosevelt modifications) at the proposed 116th Avenue bridge site.

The 100-year flood and superflood hydrographs for this study were developed from the COE balanced flood hydrograph for the regulated flow routed through the existing SRP reservoir system. The design hydrographs are based on the most recent COE hydrologic analyses (2). The hydrographs presented in Figure 2.1 were utilized within the QUASED analysis presented in Section 3.

2.4 Regulatory Floodplain/Floodway Hydrology

In 1983-84, the COE performed a Flood Insurance Study (FIS) (4) encompassing 45 kilometers of the Salt River from the confluence with the Gila River to Country Club Drive and 5.5 kilometers of the Gila River from the confluence with the Agua Fria River to its confluence with the Salt River. The COE FIS was adopted by the Federal Emergency Management Agency (FEMA) and the mapping published as the regulatory floodplain and floodway. The existing FIS used the peak flood discharges developed by CAWCS (3). These discharges are presented as current conditions in Tables 2.1 and 2.2. The converging flows of the Gila and Salt Rivers occurs east of 115th Avenue over a distance of approximately 1.6 kilometers (5). The FIS gradually changes the discharge over this distance to reflect the combining flows.

2.5 Design Discharges for the 116th Avenue Bridge

Discharges for the 116th Avenue Bridge analysis were compiled from several sources including the CAWCS (3), and the 1994 Gila River Crossing Study, Design Concept Report (1). The discharges presented in Table 2.3 were utilized in the HEC-2 hydraulic analysis of the 116th Avenue Bridge for both current (baseline) and design (with bridge) conditions. The 100-year discharge for post-Roosevelt modification is provided for information only.

Table 2.1. Salt River Discharge above Gila River Confluence.

Return Period (years)	Current Conditions (cms)	Post-Roosevelt (cms)
5	1,019	1,133
10	2,407	2,124
20	3,540	2,832
50	4,106	3,540
100	5,239	4,247
200	7,079	5,239
500	8,778	6,796

Table 2.2. Gila River Discharge below Salt River Confluence.

Return Period (years)	Current Conditions (cms)	Post-Roosevelt (cms)
5	1,133	1,133
10	2,690	2,407
20	3,823	3,115
50	5,663	5,097
100	7,079	6,088
200	8,354	6,513
500	10,194	8,212

Table 2.3. Discharges for the 116th Avenue Bridge Over the Gila River.

Return Period (years)	Discharge (cms)
10	2,690
100	7,079
500	10,194
(Future) 100*	6,088*

* For comparison only

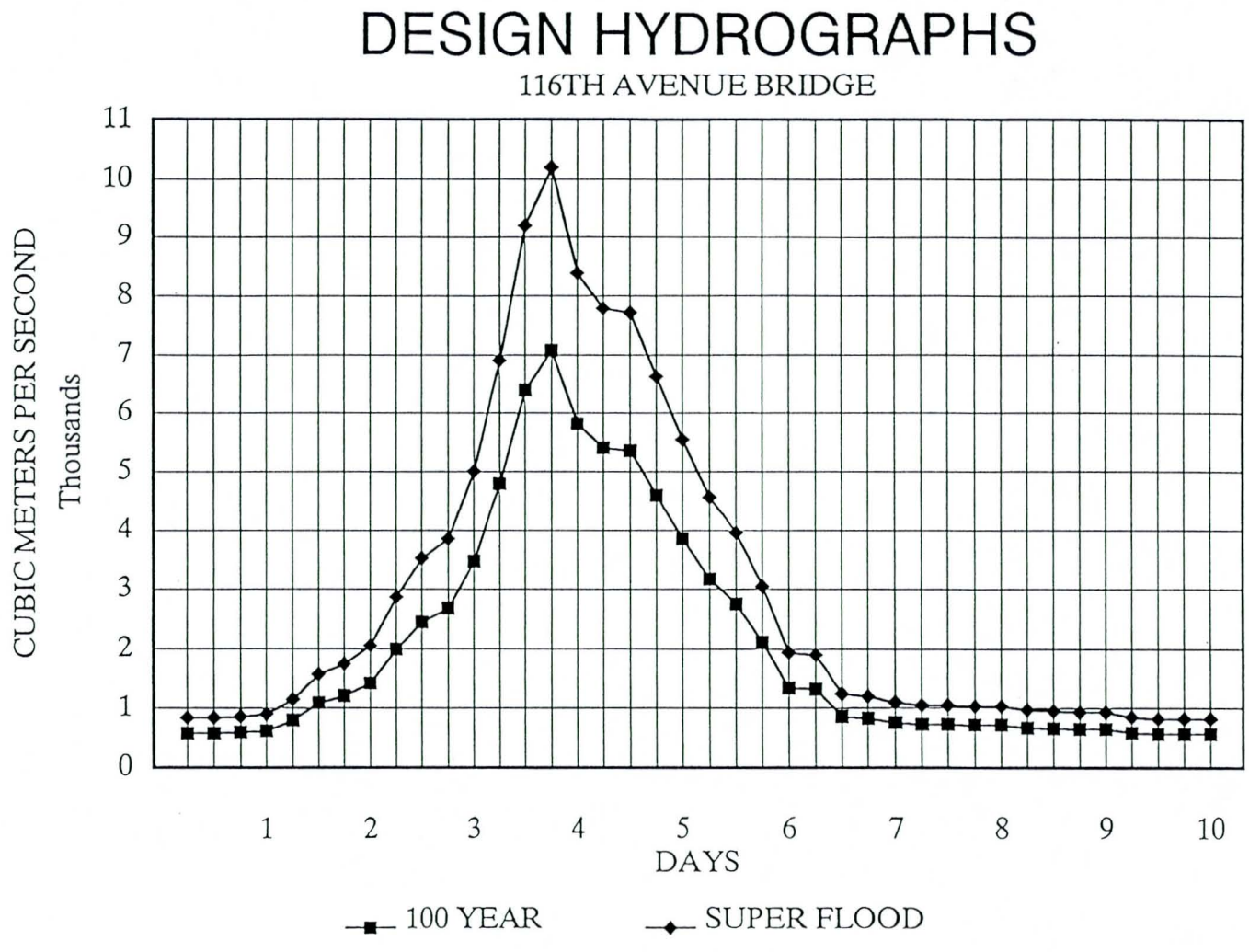

FIGURE 2.1 Hydrographs for QUASED

III. GEOMORPHOLOGY OF THE GILA AND SALT RIVERS

The Gila and Salt Rivers stability and sediment transport analyses were conducted using a three level approach. The first level was a qualitative geomorphic assessment of the existing Gila and Salt River conditions (Level I). The second level utilized an engineering geomorphic approach (Level II). The Level II analysis quantifies many of the responses that were assessed in Level I. The third level of analyses employed a physical-process mathematical model to predict the general response of the Gila and Salt Rivers to both a 100-year flood and a "Superflood" event (Level III). A discussion of the results of these analyses follows.

3.1 Qualitative Geomorphic Analyses (Level I)

3.1.a Sinuosity

Leopold, Wolman, and Miller (7) utilized the sinuosity ratio, which is defined as the thalweg length divided by the valley length, as a criterion which could be used to classify river patterns. Through the observation of several natural river systems, they concluded that systems with a sinuosity ratio equal to or greater than 1.5 would be classified as meandering while those less than 1.5 would be braided or straight.

The "Concept Report, Flood Mitigation Study At The 91st Avenue Wastewater Treatment Plant" (8) included an analysis of the Salt River and the confluence area with the Gila River from 91st Avenue to 115th Avenue. The report indicated that an average sinuosity ratio of 1.2 exists between 91st Avenue and 115th Avenue. A sinuosity ratio of 1.5 presently exists in the study reach from 107th Avenue to 123rd Avenue.

3.1.b Existing Information and Historical Aerial Photographs

Five sets of historical photos were collected for the study reach of the Gila and Salt Rivers. These photos were taken in 1941, 1957, 1983, 1989, and 1993. Examination of these photos indicates a braided channel pattern has existed over the last half century. A summary of the changes in land use, lateral migration, shifting low-flow channels, vegetation, and sediment deposition is provided below.

Land Use Changes

The land use adjacent to the Gila and Salt Rivers has generally remained constant over the photographic period of record. The land adjacent to both sides of the Salt River is generally utilized for agriculture with some single family homes. Single family homes in a low density residential setting appeared south of Southern Avenue along 115th Avenue and along 123rd Avenue (El Mirage Road) sometime between 1957 and 1983. Sand and gravel mining has occurred within the study reach. One pit remnant is located between 115th Avenue and 123rd

Avenue (10). This area will be purchased by MCDOT.

Lateral Migration

The presence of Monument Hill defines the southern most lateral migration of the Gila River at 115th Avenue. In 1903 the confluence of the Gila and Salt Rivers was more sinuous (11) and took place just southeast of Monument Hill.

The north channel bank of the Gila River from about the 113th Avenue alignment to 123rd Avenue is bank protected against erosion and designed to contain 3,823 cms (10). The channel bank protection on the north bank of the Gila River effectively reduces the possibility of northward lateral migration at 115th Avenue. Figure 3.1 depicts the approximate channel bank location from 1903 to 1994 in the vicinity of 115th Avenue.

Shifting of Low-Flow Channels

The historical sequence of aerial photographs and topographic surveys indicates extensive shifting in the Gila and Salt River's multiple low-flow channels. The study reach of the Gila and Salt Rivers can be characterized as braided with multiple, interlacing channels. Multiple islands and bars separate the low-flow channels. At flood stage, the islands and bars are not visible.

The Gila River near the confluence with the Salt River appears to have a relatively stable thalweg. The location of the Gila River thalweg upstream of the confluence with the Salt River did not change over the photographic period of record. The Gila River upstream of the Salt River confluence appears to be a less dynamic and more stable watercourse. The floodplain is heavily vegetated contributing to the channel stability. In the vicinity of the confluence with the Salt River, the Gila River thalweg appears sinuous with random variation in width and does not appear to have migration tendencies. Topographic evidence from 1903 indicates that the thalweg of the Gila River impinged on the southeastern side of Monument Hill.

Vegetation Changes

The Salt and Gila Rivers were perennial streams prior to construction of upstream water supply dams. Historical records indicate the Salt River was a wide braided channel supporting considerable vegetation. However, the Salt River experienced annual flood events prior to upstream dam construction, which would have washed out major vegetation growth within the main channel. Upon completion of the six upstream water supply dams on the Salt and Verde Rivers, considerable amounts of time passed without any flow events in the Salt River at the project site. Prior to April 1965, the Salt River was virtually dry for more than twenty years (12).

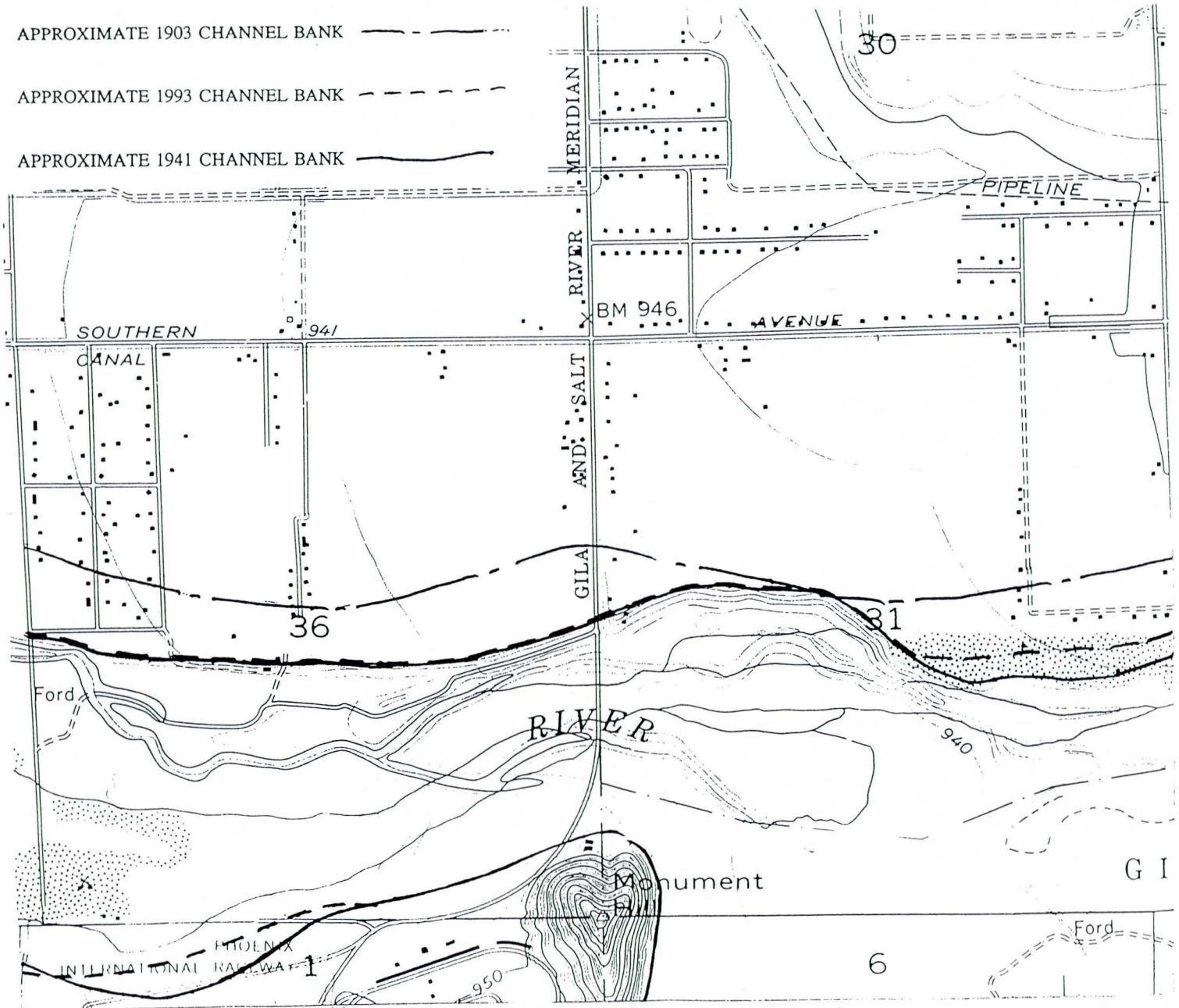

FIGURE 3.1 Approximate Historic Channel Bank Location

Construction of the 91st Avenue Wastewater Treatment Plant (WWTP) resulted in significant volumes of water released into the Salt River just above the confluence with the Gila River. The 91st Avenue WWTP currently discharges a greater volume of water into the Salt River than the estimated base flow of the Gila River (12). As a result of Salt River streamflow losses, a reduction in groundwater pumpage due to an abundance of surface water, and the 91st Avenue WWTP discharge; groundwater levels have risen dramatically (12). Consequently, vegetation has increased within the Salt and Gila Rivers.

The Flood Control District (FCD) of Maricopa County obtained right-of-way and/or flowage easements approximately 305 meters wide within the Salt and Gila River channels from 91st Avenue to Gillespie Dam. The FCD has cleared the vegetation within the 305 meter-wide channel for more than ten years. The channel clearing project was intended to increase conveyance within the Salt and Gila Rivers and reduce potential flood damage. In addition to clearing the 305 meter wide channel, the FCD has maintained a pilot channel along a majority of the project length. Should the FCD clearing not be maintained, increasing ground water and the constant surface water supply from the 91st Avenue WWTP could significantly increase vegetation density in the vicinity of the proposed 116th Avenue bridge.

Bed Material

The design gradation for the Gila River was determined based on previous studies conducted on the Lower Salt River. Previous studies by SLA have determined the sediment gradation characteristics for the study reach just upstream of the bridge site. Table 3.1 presents the design gradation with a D_{50} of 12.5 mm and a D_{90} of 125 mm. Appendix H contains additional information regarding bed material determination.

Mining Impacts

Over the photographic period of record, evidence exists that significant mining has occurred within the Gila and Salt Rivers. Typically, mining/borrow pits have been filled by sediment from flood events. The most obvious examples of mining are adjacent to the 91st Avenue Wastewater Treatment Plant where borrow/mining operations occurred in the 50's and 60's.

Excessive sand and gravel removal from a river channel (removal greater than supply in a given reach) can endanger the stability of the river system by inducing general scour, headcutting, and lateral migration. However, in-stream mining near the proposed 116th Avenue bridge does not appear to have adversely impacted the watercourse and is not expected to affect the bride.

Table 3.1 Design Gradation

Gradation	Size (mm)
D_{100}	185
D_{90}	125
D_{80}	90
D_{70}	50
D_{60}	28
D_{50}	12.5
D_{40}	6
D_{30}	1.5
D_{20}	0.5
D_{10}	0.2

3.1.c Site Investigation

A field visit was made to the proposed 116th Avenue bridge site in order to assess existing geomorphic factors and to identify any geologic formations that might control either horizontal or vertical channel movement. The visit also provided an opportunity for a ground level inspection of the natural channel geometry, channel pattern, and bed material composition.

The primary channel of the Gila River from its confluence with the Salt River downstream to 123rd Avenue is a wide, locally braided, river. The continuous presence of effluent water has encouraged the growth of dense vegetation along the low flow channels. The valley setting is generally low, with the primary channel in alluvium located north of the rock outcrops associated with the foothills of Sierra Estralles. The many low flow channels of the Gila River form a braided pattern of alluvial islands.

The overbank areas to the north of the primary channel are flat with no apparent natural levees and are typical of rural farming areas with agricultural fields, fences, irrigation ditches, and some homes. Primary channel depth ranges from 2 to 3 meters. At the confluence of the Gila and Salt Rivers, a major rock outcrop defining the south bank could potentially control both the horizontal and vertical movement of the Gila River.

3.1.d Channel Characteristics

All aspects of the Level I analysis confirm the existence of a braided channel pattern. Braided channels are generally wide and consist of two or more channels which cross one another giving

the river bed a braided appearance at low-flow. Braiding results from random deposition of materials (sediment) transported during high flows in quantities or sizes too great for continued transport during low-flows. Accordingly, as the stream discharge is reduced, larger sediment particles begin to drop to the bed as the stream "sorts" or leaves behind those sizes of the load which it is unable to transport. The accumulation of these particles on the channel bed initiates the formation of a bar which serves to trap even more sediment particles. Growth of the bars will eventually reach a size that will significantly alter the channel conveyance capacity, at which time the channel will seek a new equilibrium condition.

Historical aerial photos indicate that the channel banks of the Gila and Salt Rivers have remained relatively stable along the study area. The confluence area of the Gila and Salt Rivers in the vicinity of rock outcroppings associated with Monument Hill may cause some reflective erosive forces to act upon the north channel bank of the Gila River.

3.2 Quantitative Geomorphic Analyses (Level II)

3.2.a Hydraulic Analysis

The U.S. Army Corps of Engineers computer program "HEC-2 Water Surface Profiles" was used to calculate the current hydraulic conditions for the Gila River along the study reach. Since no significant structures are located within the study reach, no bridge routines have been included in the existing conditions hydraulic analyses. In addition, since the existing north bank protection was designed for the 20-year event, it has been assumed to be ineffective in preventing discharge from breaking out onto the north over-bank during the 100-year flood. HEC-2 cross-section location maps are provided in Appendix A. The existing conditions (baseline) HEC-2 output is provided in Appendix B.

Topographic Dataset

SLA developed the HEC-2 cross-section data from digitized areal topography supplied by Urban Engineering and Kenny Aerial Mapping. The topographic information was imported into AutoCAD, and with the assistance of a digital terrain model interface (BOSS HEC-2) HEC-2 input files were compiled. HEC-2 cross-sections were oriented perpendicular to the direction of flow. Aerial photos of the January 1993 flood were used to assist in aligning the cross-sections. The cross-sections were spaced at 100 meter intervals with the GR card horizontal station of approximately 10,831 meters representing the hydraulic baseline. Those stations that can be readily compared with previous or ongoing studies are presented in Table 3.2.

Table 3.2. Cross Section Locations.

Location	1984 FIS (miles)	1994 FCD (miles)	116TH AVE. (meters)
123rd Avenue	192.49	198.2	11,400
115th Avenue	193.5	199.3	13,000
107th Avenue	1.4*	200.3	14,600

* distance in miles above the Salt River confluence with the Gila River

Downstream Boundary Conditions

The starting water-surface elevation for the rigid boundary analyses was based on the effective Flood Insurance Study 100-year water surface elevation as depicted on the Flood Insurance Rate Maps.

Energy-Loss Coefficients

The roughness coefficients (Manning's "n" values) used in the HEC-2 analysis range from 0.15 for densely vegetated overbank areas to 0.032 for sparsely vegetated primary channel areas. Roughness coefficients of 0.100 for dense vegetation along the primary channel; and 0.045 for agricultural areas with associated irrigation facilities, fences, and structures were used. The Manning's "n" values selected were compared with other on-going studies within the area and with the 1983-84 FIS values. Additionally, the Manning's "n" values selected are consistent with those presented in the "Estimated Manning's Roughness Coefficients for Stream Channel and Flood Plains in Maricopa County, Arizona" (19). As part of the FCD's maintenance program, a 305 meter wide channel has been cleared of vegetation between Gillespie Dam and 91st Avenue on a yearly basis.

Aerial photos of the January 1993 flood event combined with topographic vegetation limits were used to assist in defining the horizontal variation in channel roughness.

For existing conditions, expansion and contraction coefficients were set at 0.3 and 0.1, respectively. Since no structures or abrupt flow transitions occurred within the study reach, the expansion and contraction coefficients were not modified throughout the existing conditions HEC-2 analysis.

Ineffective Flow

Encroachment stations were inserted into the HEC-2 data set through the Gila and Salt River confluence to conform with the program's one-dimensional flow limitations. These stations were defined using the 4 to 1 expansion, and 1 to 1 contraction rates recommended in the HEC-2 Users Manual (13).

All cross-sections were reviewed and encroachment stations inserted to comply with HEC-2's limitations and maintain reasonable section-to-section conveyance continuity. The ineffective flow encroachments were determined for the 100-year flood event, and were not modified for other flood events.

3.2.b Low-Flow Channel Profile Analysis

Four sets of topographic data were collected for the study reach. The topographic data covers a time period of approximately 90 years from 1903 to 1993. The first set of data was from the USBR/SRP 1903 topographic and irrigation supply survey. The second set of data was based on USGS 7.5-minute series quad maps from 1957. The third set of topographic mapping was developed for the 1983-84 FIS with four-foot contour intervals. The fourth set is the 1993 topographic mapping developed for the FCD update of the Salt River FIS using four-foot contour intervals. The profile analysis indicated aggradation has occurred in the area of the proposed 116th Avenue bridge over the Gila River. However, considering the topographic accuracy of the maps and the shifting nature of the multiple low-flow channels, no definite amount can be quantified. Figure 3.2 presents the approximate profile invert elevations over the last 90 years.

3.2.c Armoring Potential

Armoring in river channels refers to the process of developing a surface layer of non-moving coarser particles. Eventually, enough coarser particles accumulate to shield, or "armor," the entire bed surface. An armor layer sufficient to protect the bed against moderate discharges can be disrupted during high flow but may be restored as flows diminish.

For the Salt River from 91st Avenue to 115th Avenue the average armoring size has been previously determined (8) to be approximately 76 mm and the computed depth to armoring was calculated to be approximately 0.7 meters for the dominant discharge. Due primarily to a wider channel section and a flatter slope, these values become 47 mm and 0.3 m for the study reach. Appendix F contains the armor computations for the hydraulic variables found through the study reach.

3.3 Physical-Process Modeling (Level III)

An approximation of the amount of scour or deposition that could potentially occur within a given reach throughout the passage of a flood event may be determined through the application of the sediment transport continuity concept. The change (scour or deposition) that may occur within a given reach will depend on the difference between its sediment transport capacity and the amount of sediment supplied by the upstream reach. Excessive supply in relation to the transport capacity will result in deposition, whereas insufficient supply will result in scour. The scour or deposition volume, spread over the length and width of the reach of concern, gives an indication of the potential scour or deposition depth. Depositional tendencies at the Gila/Salt confluence have been previously demonstrated (8) for the condition of a flood event on the Salt River with the Gila River not flowing.

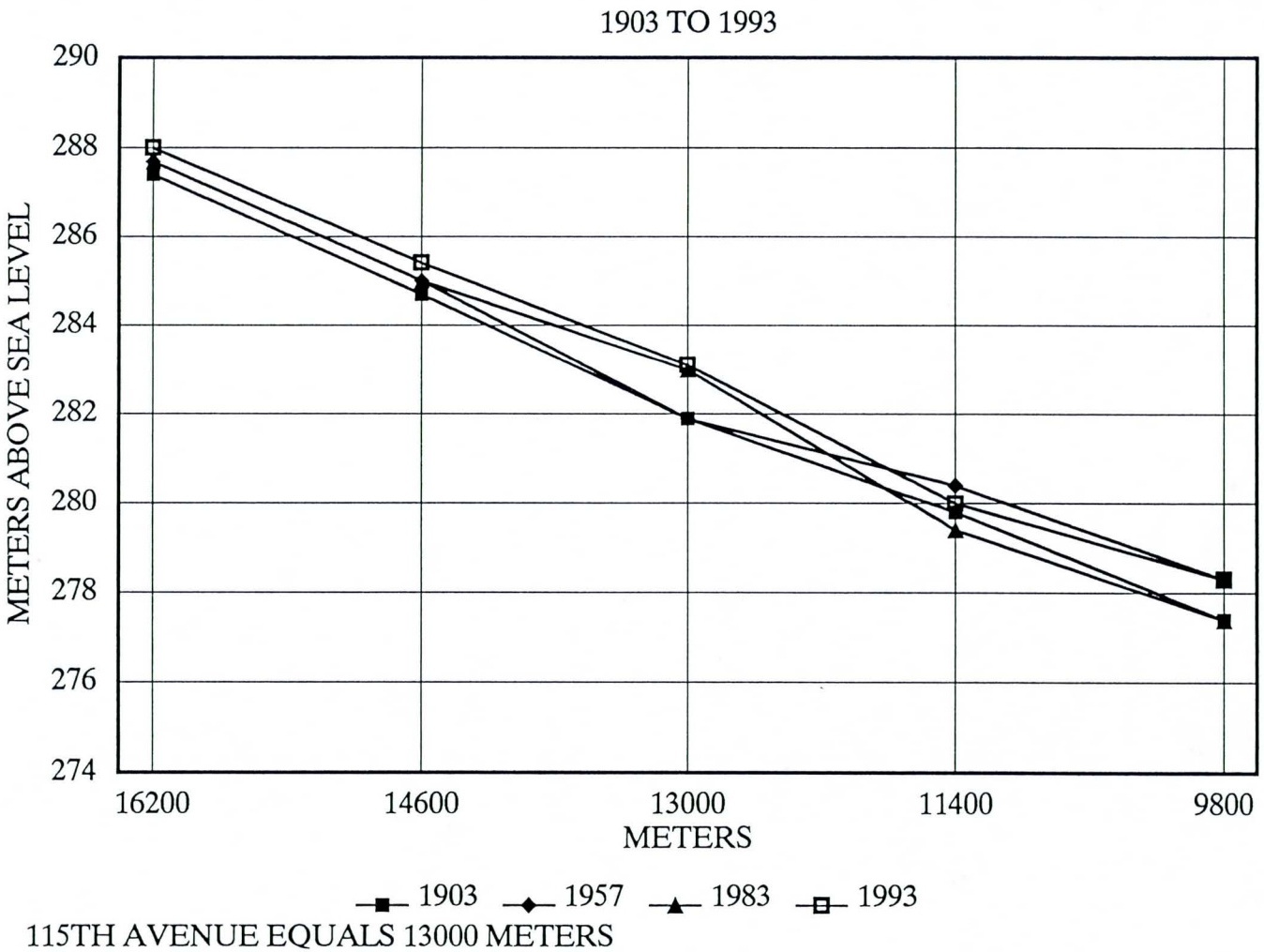

FIGURE 3.2 Gila River Invert Profile

The QUASED hydraulic and sediment routing computer program was utilized to provide a more refined estimate of the extent of scour and deposition likely during a 100-year flood, and "Superflood" event. QUASED is a quasi-dynamic sediment routing procedure developed by SLA for the purposes of determining scour or deposition within a river system. QUASED uses HEC-2 as its hydraulic computational platform in conjunction with established sediment transport equations of Meyer-Peter, Muller and Einstein's integration of suspended sediment.

Within QUASED the channel geometry, hydraulics, and bed material is updated after each time step of the hydrograph. A six-hour time step was used for this analysis. This required 40 time steps to model the entire 100-year, 10-day hydrograph. For the purposes of this report and due to the hydraulically short study reach, a QUASED model developed for the Gila and Salt Rivers from 67th Avenue to 115th Avenue (8) was augmented with additional downstream cross sections. The additional cross sections from 115th Avenue to the confluence of the Agua Fria River were compiled from the effective FIS.

IV. HYDRAULIC AND SCOUR ANALYSES

The U.S. Army Corps of Engineers computer program "HEC-2 Water Surface Profiles" (13) was used to establish the hydraulic conditions of the Gila River at the project site as discussed in the previous section. The HEC-2 analyses were performed from 2,200 meters downstream of the proposed 116th Avenue bridge to 2,000 meters upstream of the site. The starting water-surface elevations for the HEC-2 analyses were based on the COE Gila River Flood Insurance Study (4).

4.1 Regulatory Floodplain/Floodway Mapping

The project study reach lies within a Special Flood Hazard Area (SFHA), Zone A8. Zone A8 was determined using detailed hydraulic analysis methods which indicate special flood hazard areas inundated by the 100-year flood. The zone designation is assigned according to flood hazard factors. The flood hazard factor is a function of the average difference in water-surface elevations between the 10-year and 100-year flood profiles. Zone A8 indicated an average difference of 1.2 meters between the 1-year and 100-year flood profiles.

The flood insurance rate maps provide 100-year base flood elevations (BFE) along the study reach. The BFE's range from an elevation of 285 meters near 123rd Avenue to 288 meters near 107th Avenue. The regulatory floodway varies in width from a maximum of 3,200 meters to a minimum of 2,286 meters. The regulatory floodway extends from Monument Hill northward approximately 1,417 meters to Southern Avenue.

The FCD is conducting a Flood Insurance Re-Study for the Gila and Salt Rivers. The study begins at Gillespie Dam on the Gila River and proceeds up the Salt River to the Granite Reef Diversion Dam. Preliminary 1992 topographic mapping for the FIS study has been completed and the detailed hydraulic analysis is currently being conducted. However, the January 1993 floods have changed the channel geometry at a number of locations along the Salt and Gila Rivers. The FCD has remapped several portions of the Gila and Salt Rivers and revised the 1992 mapping to reflect the 1993 current conditions.

The existing conditions model utilized for this project showed good correlation with the effective FIS and with other ongoing studies. Table 4.1 presents the existing conditions model's results compared with the effective FIS.

Table 4.1 Comparison of Existing Conditions Water Surface Elevations With the Effective Flood Insurance Study

Cross Section	Effective FIRM (msl) NGVD 29	Existing Conditions Model NGVD 29
11500 (Near 123rd Avenue)	285.56	285.60
12500	287.16	287.04
12600	287.31	287.22
12700	287.44	287.36
12777 (D.S. Side of Bridge)	287.53	287.44
12800 (u.S. Side of Bridge)	287.56	287.48
12900	287.66	287.55
13000 (115th Avenue)	287.74	287.66
13100	287.81	287.83
13200	287.88	288.05
13300	287.95	288.18
13400 (U.S. End of Bank Protection)	288.02	288.29

4.2 Bridge Alternatives Analysis

The originally proposed 685 meter bridge opening would create a maximum surcharge in water surface of 0.29 meters for a 100-year discharge of 7,079 cms at Section 12800. Although the 685 meter opening would surcharge the water surface less than the allowable 0.305 meters, it would adversely impact the floodway both physically and from a regulatory standpoint. Therefore, bridge openings with two additional spans and three additional spans were also analyzed resulting in the following three alternatives: 1) the originally proposed 685 meter bridge; 2) a 771 meter bridge; and 3) a 814 meter bridge. Table 4.2 presents a comparison of water surface elevations for the existing conditions model and those presented by the alternatives.

From Table 4.2 it can be seen that significant reductions in water surface surcharges were found to result from the additional spans, primarily due to the added conveyance found in the south abutment area (left bank). the 771 meter bridge was determined to be the preferred alternative due to: 1) the diminishing benefit realized with three additional spans; and 2) the existing primary channel at 115th Avenue is 760 meters wide.

Table 4.2 Comparison of Bridge Hydraulics for Three Alternatives

Cross Section	Existing Conditions Model (msl) NGVD 29	685 Bridge Opening (msl) NGVD 29	771m Bridge Opening (msl) NGVD 29	813m Bridge Opening (msl) NGVD 29
11500 (123rd Avenue)	285.60	285.60	285.60	285.60
12500	287.04	287.12	287.10	287.07
12600	287.22	287.37	287.31	287.28
12700	287.36	287.53	287.47	287.43
12777 (D.S. Side of Bridge)	287.44	287.73	287.63	287.56
12800 (U.S. Side of Bridge)	287.48	287.77	287.64	287.57
12900	287.55	287.83	287.70	287.62
13000 (115th Avenue)	287.66	287.90	287.80	287.73
13100	287.83	288.03	287.95	287.90
13200	388.05	288.19	288.13	288.09
13300	288.15	288.30	288.25	288.21
13400 (U.S. End of Bank Protection)	288.29	288.39	288.34	288.31

4.3 Detailed Hydraulic Analysis

As a result of the alternative analysis, it is recommended the 116th Avenue bridge be approximately 771 meters long. The general plan for the proposed 116th Avenue bridge over the Gila River is provided in Appendix C. To account for debris accumulation, 0.74 meter of debris was assumed to build-up on each side of the 1.52 meter diameter columns; resulting in an effective pier width of 3 meters. Debris accumulation was assumed to extend from the water-surface to the bed of the channel. Adjustments for bridge skew were included within the normal bridge and special bridge methods in accordance with the above referenced computer program manual.

Four separate HEC-2 models were developed to determine the possible impacts of the proposed 116th Avenue bridge on flow conditions. The models developed were for the following conditions: (1) existing conditions (baseline conditions); (2) proposed design conditions; (3) future conditions; and (4) encroached future conditions. These four conditions are described in more detail in the following paragraphs.

The existing conditions are those conditions without the proposed 116th Avenue bridge in place. The existing conditions were used to develop the baseline conditions described in Section 3.2.a of this report. The HEC-2 computer program output can be found in Appendix B.

The design conditions are the proposed conditions upon completion of the 116th Avenue bridge project. The design conditions assume minor grading of the channel during construction, installation of spur dikes and guide banks locally at the bridge site, and the existing north channel bank protection in place. However, the design conditions also assume the 100-year event is conveyed freely between the proposed 116th Avenue bridge and the north overbank. No upstream channel improvements are included as part of the 116th Avenue project to prevent the Salt/Gila River flows from breaking out onto the north overbank during the 30-year or larger events, as it currently does.

For the design conditions, the expansion and contraction coefficients for normal valley sections were set at 0.3 and 0.1, respectively. The expansion and contraction coefficients used through the proposed 116th Avenue bridge were 0.5 and 0.3, respectively for the "normal" bridge analysis. Expansion downstream of the proposed bridge was approximated by encroachment stations. Encroachments approximate observed flow conditions (i.e., flow of January 1993). The design conditions also assume continued channel clearing by the FCD, and channel roughness coefficients as stated in Section 3.2.b. Design conditions HEC-2 computer program output can be found in Appendix D.

The "Superflood" (Q_{500} = 10,194 cms) hydraulic parameters for both design and future conditions are also provided for information purposes. Table 4.3 provides the hydraulic parameters and water surface elevation at cross section 12,900, which is approximately 100 meters upstream of the proposed 116th Avenue bridge, for the design conditions.

Table 4.3 Design Conditions Hydraulic Parameters.
(assuming overbank flow)

	100-Year Event	Superflood Event
Channel Velocity (mps)	2.26	2.58
Channel Froude Number	0.37	0.40
Channel Depth (m)	4.70	5.21
Water Surface Elevation (m)	287.70	288.21

0.51 m increase

The future conditions are those conditions that may occur following construction of the 116th Avenue bridge. The future conditions assume the entire 100-year flow is conveyed through the 116th Avenue bridge (i.e., no north overbank flow). This assumption implies that channel improvements have been made upstream of the 116th Avenue bridge to prevent the Salt/Gila Rivers from breaking out onto the north overbank area. For future conditions, the "special" bridge routine was used with expansion and contraction coefficients through the proposed 116th

Avenue bridge being 0.5 and 0.3, respectively. Flow upstream of the proposed 116th Avenue bridge was forced to be fully contracted prior to impacting the site due to the rock outcroppings on the south bank and assumed 100-year levee on the north bank. Expansion downstream of the proposed bridge was approximated by encroachment stations. The future conditions also assume continued channel clearing by the FCD, and channel roughness coefficients as stated in Section 3.2.a. Future conditions HEC-2 computer program output can be found in Appendix E. Table 4.4 provides the hydraulic parameters and water surface elevation at cross section 12,900 for the future conditions.

Table 4.4 Future Conditions Hydraulic Parameters. (assuming no overbank flow)

	100-Year Event	Superflood Event
Channel Velocity (mps)	2.29	2.33
Channel Froude Number	0.36	0.33
Channel Depth (m)	4.93	5.89
Water Surface Elevation (m)	287.93	288.89

The encroached future conditions are those that would occur if the floodplain was encroached upon, assuming equal conveyance from both sides, up to the existing banks; thereby, reducing the 100-year overbank flows to zero. The encroached future conditions are a worst case scenario provided for informational purposes only. Appendix J contains the encroached future conditions HEC-2 computer program output and a tabular summary is presented in Table 4.5.

The results of the hydraulic analysis are presented in the following paragraphs. Superelevated flow was not considered during the hydraulic analysis due to the general straight alignment of the Salt River upstream of the site.

Table 4.2 summarizes and compares the water surface elevations for the 100-year flood event for the existing and design conditions. For design conditions, the proposed 116th Avenue structure will increase the existing water-surface elevation a maximum of 0.19 meter. This increase occurs at the downstream side of the bridge during a 100-year flood. The design condition 100-year water-surface profile equals that of the existing (baseline) conditions approximately 1,600 meters upstream of the proposed bridge. The possibility of flows breaking out of the primary channel of the Gila River to the north will not be reduced by the construction of the bridge. Under existing conditions (i.e., no bridge) approximately 462 cubic meters per second of flow would be in the north overbank area at 115th Avenue during a 100-year flood. Should a 100-year flood occur on the Gila River after the completion of the 116th Avenue bridge and prior to the completion of the Roosevelt Dam reconstruction (i.e., a 100-year flood flow of 7,079 cms), the north overbank area would experience a flow of approximately 512 cms at this location.

Avenue bridge being 0.5 and 0.3, respectively. Flow upstream of the proposed 116th Avenue bridge was forced to be fully contracted prior to impacting the site due to the rock outcroppings on the south bank and assumed 100-year levee on the north bank. Expansion downstream of the proposed bridge was approximated by encroachment stations. The future conditions also assume continued channel clearing by the FCD, and channel roughness coefficients as stated in Section 3.2.a. Future conditions HEC-2 computer program output can be found in Appendix E. Table 4.4 provides the hydraulic parameters and water surface elevation at cross section 12,900 for the future conditions.

Table 4.4 Future Conditions Hydraulic Parameters.
(assuming no overbank flow)

	100-Year Event	Superflood Event
Channel Velocity (mps)	2.29	2.33
Channel Froude Number	0.36	0.33
Channel Depth (m)	4.93	5.89
Water Surface Elevation (m)	287.93	288.89

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4.5

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585

Table 4.5 Encroached Future Conditions*

Cross Section	Existing Water Surface Elevations	Encroached Water Surface Elevations
11500	285.60	285.91
12500	287.04	287.35
12600	287.22	287.59
12700	287.36	287.82
12777	287.44	287.95
12800	287.48	287.95
12900	287.55	288.01
13000	287.66	288.11
13100	287.83	288.28
13200	288.05	288.53
13300	288.18	288.68
13400	288.28	288.79

*For Informational Purposes Only

4.4 Bridge Scour Analysis

This section presents the procedures, methodology, assumptions, and results of the scour analyses for the proposed 116th Avenue bridge crossing of the Gila River. Several scour components were considered in determining the total scour potential at the proposed bridge site during the design floods. The total scour at 116th Avenue was determined by adding the general scour, local scour, bed-form scour, and long-term scour components. A 30% safety factor was applied to the general scour, local scour, and bed-form scour components to account for non-uniform flow distributions that are typical of alluvial channels.

Scour depths were predicted for the 100-year design flood and "Superflood". The detailed calculations supporting the scour conditions described below are provided in Appendix F. Hydraulic Engineering Circular No. 18, "Evaluating Scour at Bridges" (14) was utilized for computing contraction scour and local scour.

4.4.a. Long Term Scour

Long term scour is due to natural or man-induced causes that affect the reach of river on which the bridge is located. It involves the lowering of the bed due to a deficit sediment supply or excess transport capacity during the dominate discharge.

Previous studies conducted on the Gila and Salt Rivers have indicated a relative stable channel bed profile (8). Stable slope analysis indicates that the existing slope of the Gila River in the study reach is greater than the computed stable slope for the dominate discharge (Q10). However, due to the gradation of the bed material, armoring will limit long term degradation to 0.3 meters. The methods and computations are presented in Appendix F.

4.4.b. General Scour

General scour refers to the vertical lowering of the channel bed over relatively short time periods (e.g., the scour in a given reach after passage of a single flood event). General scour and deposition for the proposed 116th Avenue bridge were computed from the QUASED analyses described in Section 3.3. This QUASED analyses predicted the site would experience slight aggradation (0.5 m) during both the 100-year and "Superflood" events. The input and output for this analysis are presented in Appendix G.

Contraction scour is a special case of general scour that occurs when the flow area becomes smaller causing the average velocity and bed shear stress to increase. Calculations for the contraction scour at the proposed 116th Avenue bridge is included in Appendix F. Contraction scour for the 100-year and "Superflood" events at the site are estimated to be 1.6 meters and 2.5 meters, respectively.

4.4.c. Local Scour

Local scour at the bridge piers was analyzed for both the 100-year design and "Superflood" hydraulic conditions. The pier scour calculations were performed using the C.S.U. Method described in the publication, "Evaluating Scour at Bridges" (14). Debris accumulation at the piers was accounted for by adding 1.48 meter to the 1.52 meter diameter columns. The piers were assumed to be oriented parallel to the direction of flow. The results of the pier scour analyses predicts pier scour of 4.6 meters for the 100-year flood, and 4.8 meters for the "Superflood".

Local scour at abutments is the result of a change in local flow direction/velocity and increased flow turbulence caused either by: (1) the abutment projecting into the flow of a watercourse; (2) overbank flow being intercepted and forced back into the channel by the abutment embankment; or (3) a combination of these conditions. The abutments were analyzed based on a worst case scenario of assuming all bank protection fails and flow impinges directly on the abutment.

The north and south abutment scour estimates for the 100-year and "Superflood" events are less than the respective pier scour estimates. Therefore, it is recommended that the pier scour estimates also be used for the abutment foundation design as the worst case scenario. The pier and abutment scour computations are included in Appendix F.

4.4.d. Bed-Form Scour

During the 100-year and "Superflood", flow in the vicinity of the proposed bridge is subcritical in nature. The flow is predicted to be in the lower regime and dunes are expected to form. Water surface undulations will be out of phase with the bed surface with separation zone downstream from the crest of each dune. The bed-form scour component was estimated by calculating the dune height using relationships developed by Yalin and Allen (15). The bed-form scour depths were estimated to be 0.3 meters and 0.4 meters for the 100-year and "Superflood" events, respectively (See Appendix F).

4.4.e. Low-Flow Incisement

Finally, an adjustment was included for low-flow channel incisement. During the passage of small magnitude flows, a large river channel will develop a small, low-flow channel that provides for a hydraulically more efficient conveyance of the low-flow discharges. The hydraulic conditions of the low-flow channel are entirely different than those associated with the original channel geometry. The small channel is "incised" in the original bed and should be accounted for in determining total scour. Based on field inspection, a value of 1.0 meter was included to account for low-flow channel incisement.

4.4.f. Total Pier Scour

The total scour at the proposed 116th Avenue bridge piers was determined by calculating all the individual scour components and applying a factor of safety to the appropriate components. The factor of safety equals 30% of the sum of the general scour, local scour, and bed-form scour components. This safety factor is included to account for the non-uniform flow distribution that is typical of alluvial channels. A summary of these values and the pier scour elevations is provided in Tables 4.6 and 4.7.

Table 4.6 Estimate Pier Scour Depths

Design Event	Long-Term Degradation (m)	General Scour (m)	Local Scour (m)	Bed-Form Scour (m)	Low-Flow Incis. (m)	Factor of Safety (m)	Total Pier Scour (m)
100-Year	0.3	1.6	4.6	0.3	1.0	2.0	9.8
Superflood	0.3	2.5	4.8	0.4	1.0	2.3	11.3

Table 4.7 Bridge Pier Scour Elevations

Design Event	Design Invert Elevation (m)	Total Pier Scour (m)	Pier Scour Elevation (m)
100-Year	283.0	9.8	273.2
Superflood	283.0	11.3	271.7

4.5 Determination of Low Chord Elevation

The low-chord elevation requirement is the calculated water-surface elevation for the 100-year design flood, plus the sum of the increases in water-surface elevation due to wave heights, general deposition, superelevation, and debris accumulation, should these be present. Because our study reach is relatively straight, superelevation was not analyzed.

4.5.a. Wave Heights

During the 100-year flood local flow in the vicinity of the proposed bridge is subcritical in nature. The flow is predicted to be in the lower regime of flow, with dunes as the bed form. Water surface undulations are out of phase with the bed surface, and therefore wave heights would not need to be considered in establishing the low-chord elevation.

4.5.b. General Deposition

Based upon the results of our QUASED sediment-transport model, described in the previous section of this report, it is quantitatively predicted that general deposition can occur in the vicinity of the bridge during a 100-year design flood. Results of the QUASED model predict 0.5 meter of deposition during a 100-year event (see Appendix G).

4.5.c. Debris Accumulation

Debris accumulation at a bridge crossing can significantly reduce conveyance by partially blocking the available flow area beneath the bridge. Additionally, since debris floats, it is usually the upper portion of flow that is restricted by debris, thereby resulting in higher flow velocities and scour depths near the channel bed. Quantification of the increase in water-surface elevation is largely subjective, and is normally based on engineering experience. Debris consisting of tree trunks approximately one meter in diameter might be possible. Assuming one half of the trunk is beneath the water, 0.5 meter would be required to account for debris.

4.5.d. Low Chord Elevation

The low-chord elevation requirement is the calculated water-surface elevation for the 100-year design flood, plus the sum of the increases in water-surface elevation due to general deposition and debris accumulation. Tables 4.8 provides the total freeboard requirement based on the estimated deposition and debris accumulation at the proposed bridge site.

Table 4.8 Total Freeboard.

General Deposition (m)	Debris (m)	Total Freeboard (m)
0.5	0.5	1.0

4.6 Abutment/Bank Protection Measures

A configuration of the upstream and downstream abutment and bank protection was presented in the "Gila River Crossing Study, Design Concept Report". This configuration included: 1) a north abutment and spur dike arrangement at the approximate location of the existing channel bank protection; and 2) a spur dike/bank protection arrangement at the south abutment intended to tie into Monument Hill to the east and the existing roadway to the west.

The recommended concept is a modification of the original design concept in that no spur dike is proposed for the north abutment (See Figure 5.1). The north overbank area will continue to convey a portion of the design flood which will overtop 115th Avenue.

The toe-down depth for the proposed 100-year bank protection and spur dike was computed by adding the standard components of general and bed-form scour (to which a 30% safety factor is added), long-term degradation, and low-flow incisement. This yields a minimum standard toe-down depth of 3.8 meters to protect against the anticipated abutment scour at both the north and south abutments. This depth must be increased to 6.0 meters immediately under the bridge at the north abutment due to the influence of local pier scour. (See computations and figure in Appendix F).

V. RECOMMENDATIONS

A hydraulic analysis was performed to determine the effects of the proposed 116th Avenue bridge on the 100-year water-surface profile and the hydraulic parameters within the Gila River. A scour analysis quantified the total scour that can be expected to impact the bridge substructure during the 100-year flood and "Superflood" events. In addition, freeboard was calculated for the 100-year flood conditions to determine the low chord elevation of the proposed bridge. Additional analyses evaluated the impact of the proposed structure on the existing Gila River bank protection along the north bank. Based on the results of these analyses, design recommendations have been made with respect to the total scour at the bridge piers and abutments along with recommended abutment and bank protection measures.

This section presents: 1) bridge design parameter recommendations; 2) spur dike and guide bank concept design recommendations; and 3) overbank low-flow structure recommendations.

5.1 Bridge Design Parameters

Table 5.1 presents the recommended low chord elevation, 100-year flood pier scour elevation, "Superflood" pier scour elevation, 100-year abutment scour elevation, and "Superflood" abutment scour elevation. The design criteria for this project requires a minimum of 1.07 meters of freeboard above the 100-year water surface elevation. Therefore, 1.07 meter has been used to determine the low-chord elevation for the proposed bridge site.

Table 5.1 Recommended Design Parameters

Parameter	Elevation (meters)
Low Chord	288.7
100-Year Pier Scour	273.2
Superflood Pier Scour	271.7
100-Year North & South Abutment Scour	273.2
Superflood North & South Abutment Scour	271.7

5.2 Spur Dike/Guide Bank Design

As mentioned in the previous section, a combination of guide banks and spur dikes are recommended to guide the primary channel flow through the bridge section, and protect the

proposed bridge abutments with minimum energy losses. Figure 5.1 presents the spur dike/guide bank concept design, and Table 5.2 provides the recommended 100-year toe-down elevations.

Table 5.2 Spur Dike/Guide Bank Design Parameters at Bridge

Parameter	Elevation
Guide Bank/Spur Dike Toe-down	288.5
Guide Bank/Spur Dike Standard Toe-Down	279.2
Guide Bank Toe-Down within Pier Scour Zone of Influence, North Bank Only	277.0

It is recommended that all bank protection and spur dikes constructed to protect the proposed bridge be constructed of cement stabilized alluvium (CSA) with 1½:1 slopes and provide 0.92 m of freeboard.

5.2.a North Abutment

Under existing conditions, approximately the 30-year flood is contained by the north bank protection when freeboard is included. This discharge is captured approximately 360 meters upstream of 115th Avenue. During larger floods, the bank protection is out-flanked or overtopped allowing over-bank flow. The north abutment will be isolated by the flow in the primary channel under the bridge and the overbank flow on the north floodplain. It is recommended the existing bank protection be raised and strengthened at the bridge in order to safely and efficiently handle the 100-year event. This would allow the bank protection to act as a guide bank, dividing the flow, as well as protecting the north abutment. Once the length required for the 100-year protection is achieved, the guide banks can transition down to the elevation of the existing bank. The recommended length of protection downstream of the abutment is 100 meters. The upstream protection should close the present opening for 115th Avenue and continue upstream until it meets the top of the existing bank protection before tapering down.

5.2.b. South Abutment

Near the south abutment, flows are naturally contained within the main channel due to the presence of Monument Hill just upstream. An upstream guide bank is proposed to provide protection against the 100-year flood. It is recommended the guide bank extend upstream on a smooth transition and key into Monument Hill. This will minimize contraction losses and local scour, and enhance stability by ensuring the bank is not out-flanked to the south.

It is also recommended that the downstream side of the south abutment be protected by CSA. A minimum length of 100 meters from the downstream side of the abutment is recommended.

The configuration shown in Figure 5.1 will allow the bank protection to be extended along Indian Springs Road in the future.

5.3 Overbank Low Flow Structures

Overbank low flows north of the main channel must be accommodated through the proposed bank protection. The existing bank protection along the north bank has several cross drainage structures to allow flow under the channel bank protection. The addition of one such structure just downstream of 115th Avenue with an outlet above the 20-year level of protection or an outlet backflow device is recommended. A cross drainage structure for local ditch drainage along 115th Avenue and any ponded water behind the bank protection on the east side of 115th Avenue will also be required.

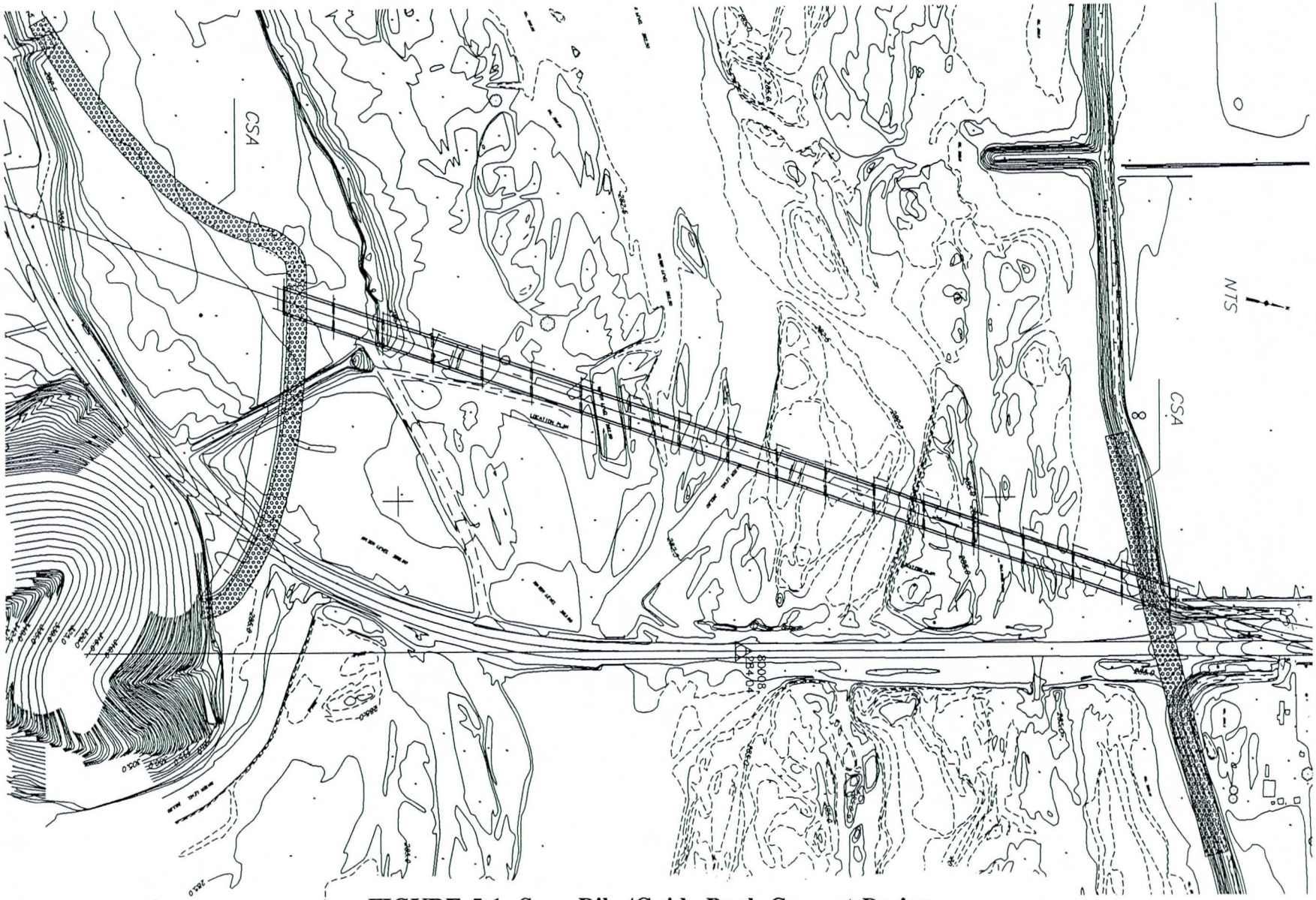

FIGURE 5.1 Spur Dike/Guide Bank Concept Design

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14. Federal Highway Administration, "Evaluating Scour at Bridges, Second Edition" Hydraulic Engineering Circular No. 18, Publication No. FHWA-IP-90-017, Revised April, 1993.

15. Simons, D.B. and F. Senturk, Sediment Transport Technology, Water Resources Publications, Fort Collins, Colorado, 1977.

Other References:

American Society for Testing and Materials, "Standard Practice for Use of the International System of Units (SI)", ASTM E-380-93.

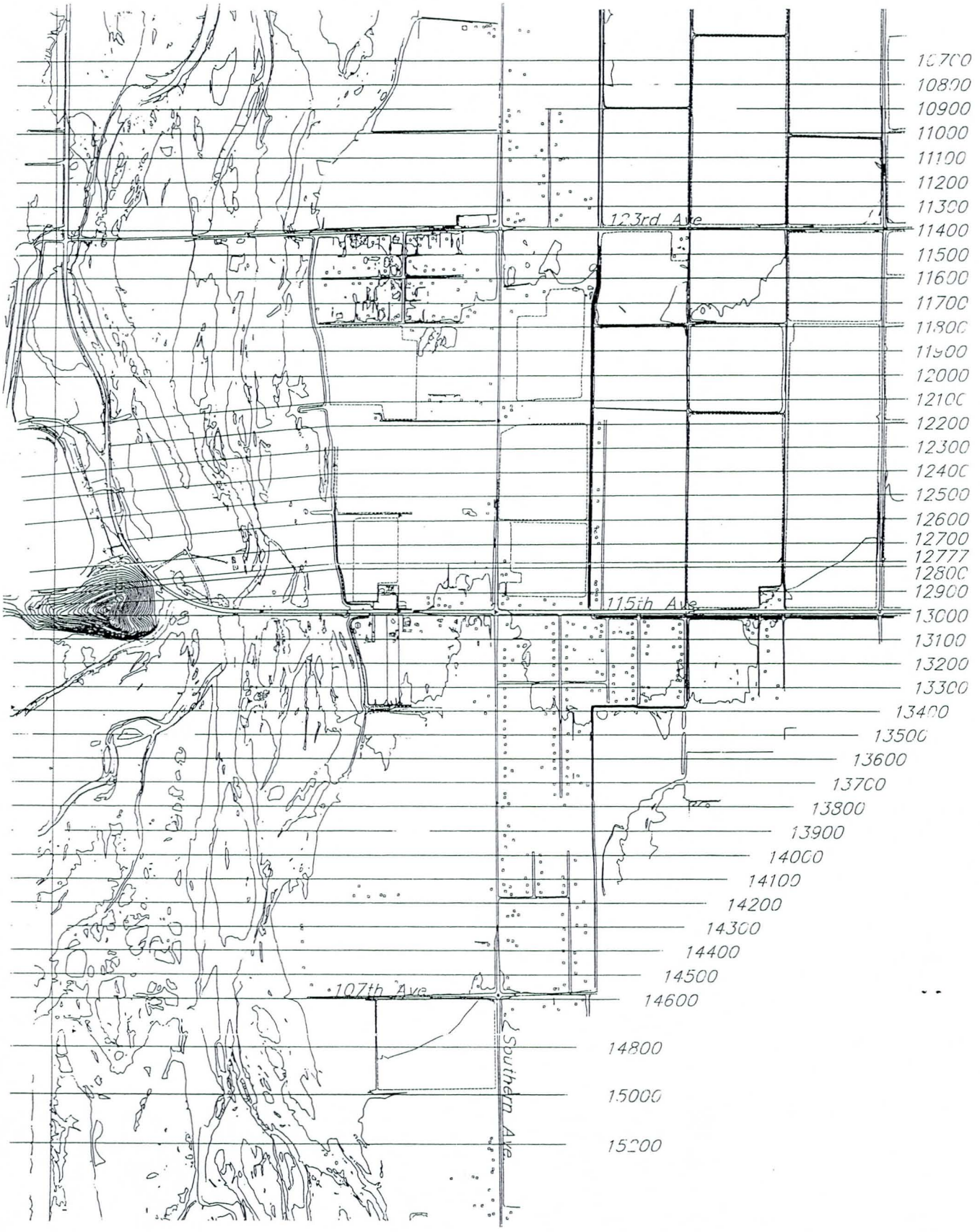
Simons, Li & Associates, Inc., "Concept Hydraulic Design, Salt River Channelization, East Papago Freeway," Submitted to Daniel, Mann, Johnson, & Mendenhall, May 1988, Revised February, 1989.

Thomsen, B.W., H.W. Hjalmerson, "Estimated Manning's Roughness Coefficients for Stream Channels and Flood Plains in Maricopa County, Arizona", U.S.G.S., 1991, prepared for the Flood Control District of Maricopa County.

Pemberton, E.L., L.M. Joseph, "Computing Degradation and Local Scour", Denver, Colorado, 1984, USBR Technical Guideline.

APPENDIX A

CROSS SECTION LOCATIONS


123rd Ave
115th Ave
107th Ave
Southern Ave
10700
10800
10900
11000
11100
11200
11300
11400
11500
11600
11700
11800
11900
12000
12100
12200
12300
12400
12500
12600
12700
12777
12800
12900
13000
13100
13200
13300
13400
13500
13600
13700
13800
13900
14000
14100
14200
14300
14400
14500
14600
14800
15000
15200

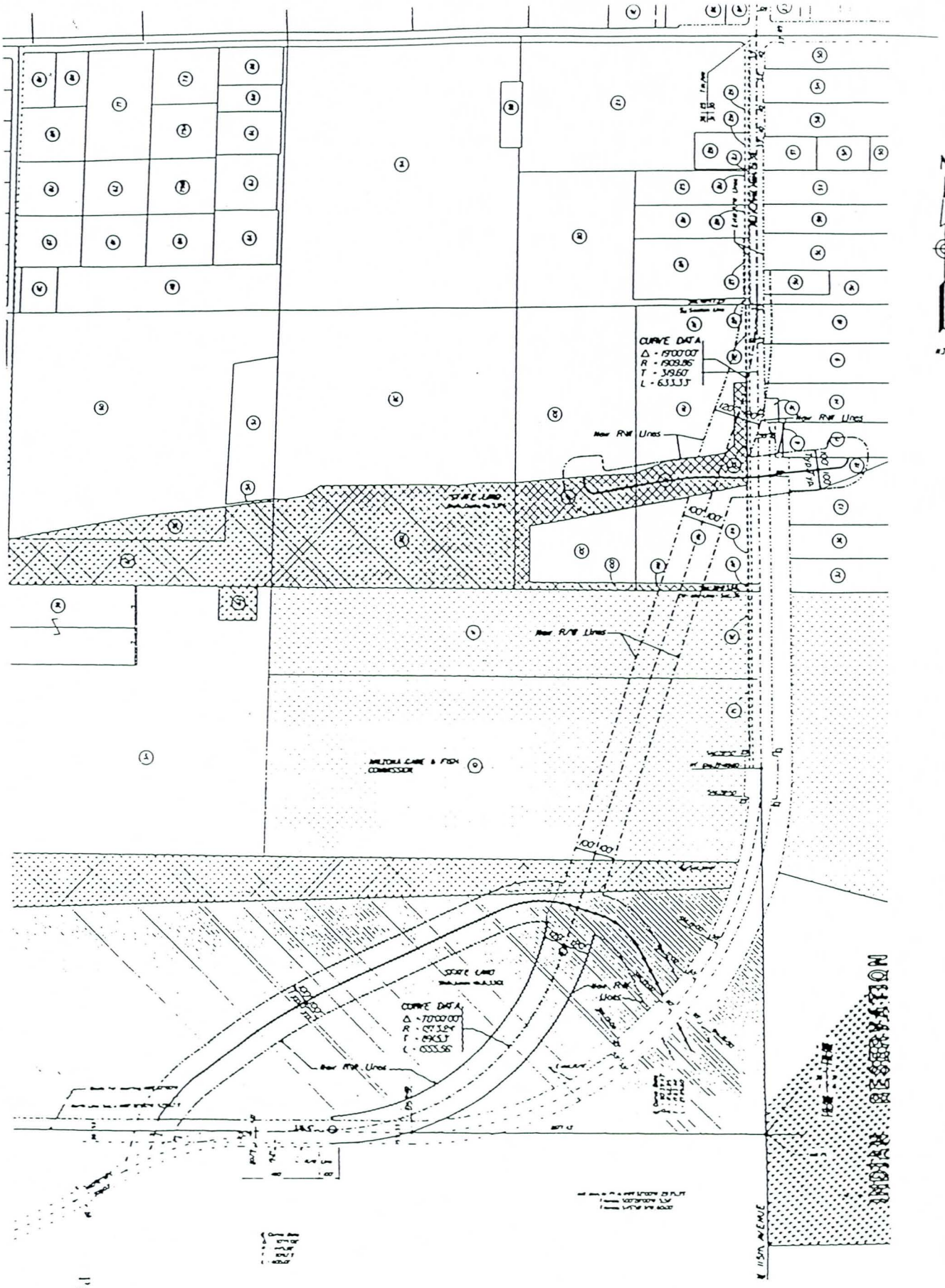
APPENDIX B

EXISTING (BASELINE) HYDRAULIC CONDITIONS
HEC-2 OUTPUT

(SEPARATELY BOUND)

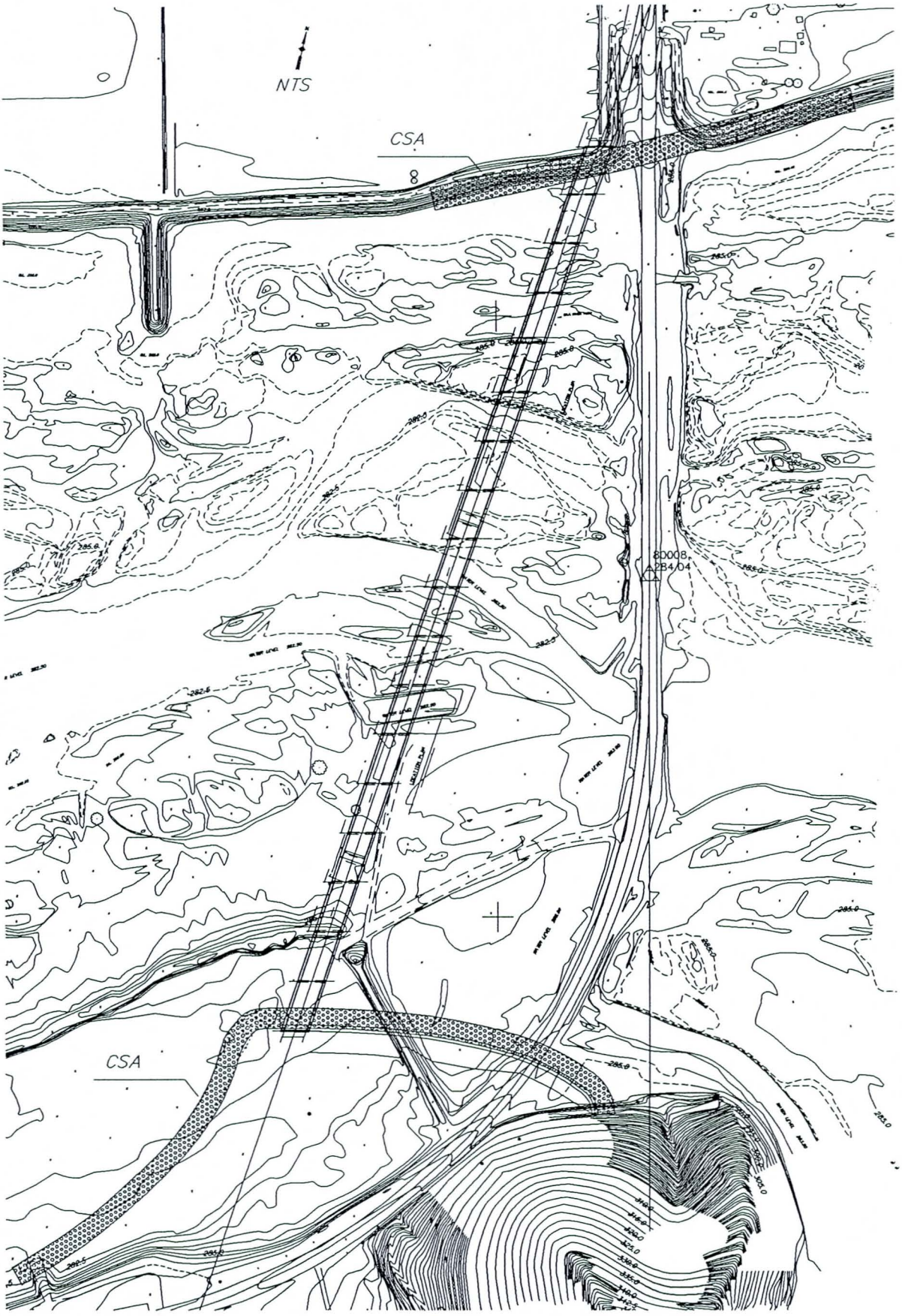
APPENDIX C

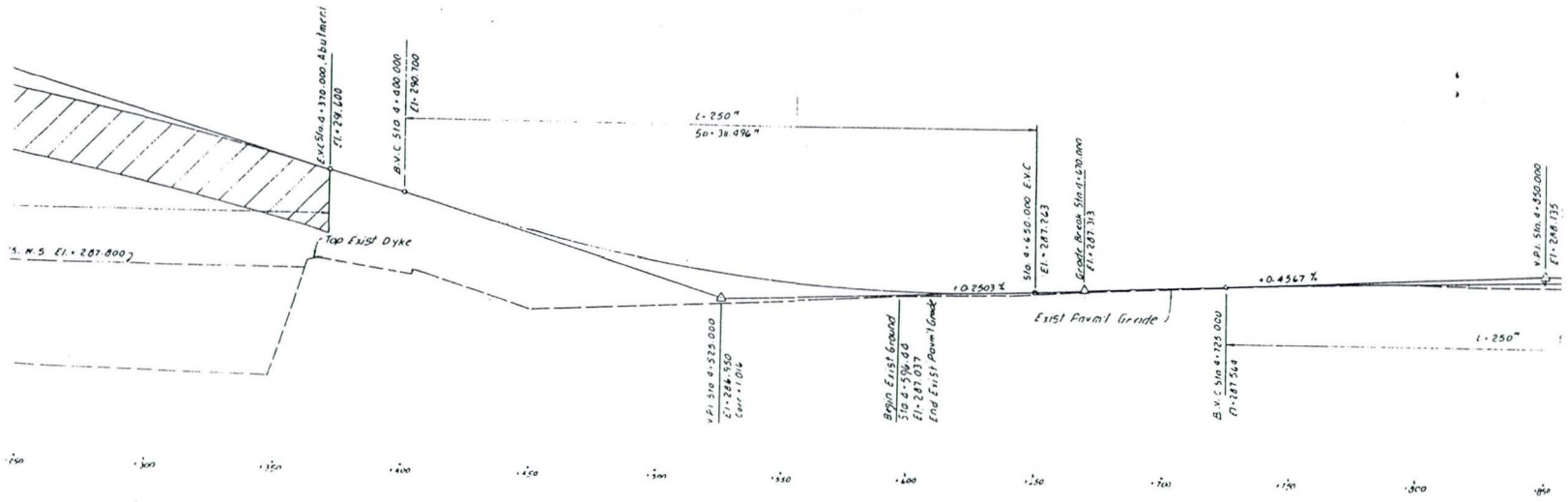
116TH AVE. BRIDGE GENERAL PLAN

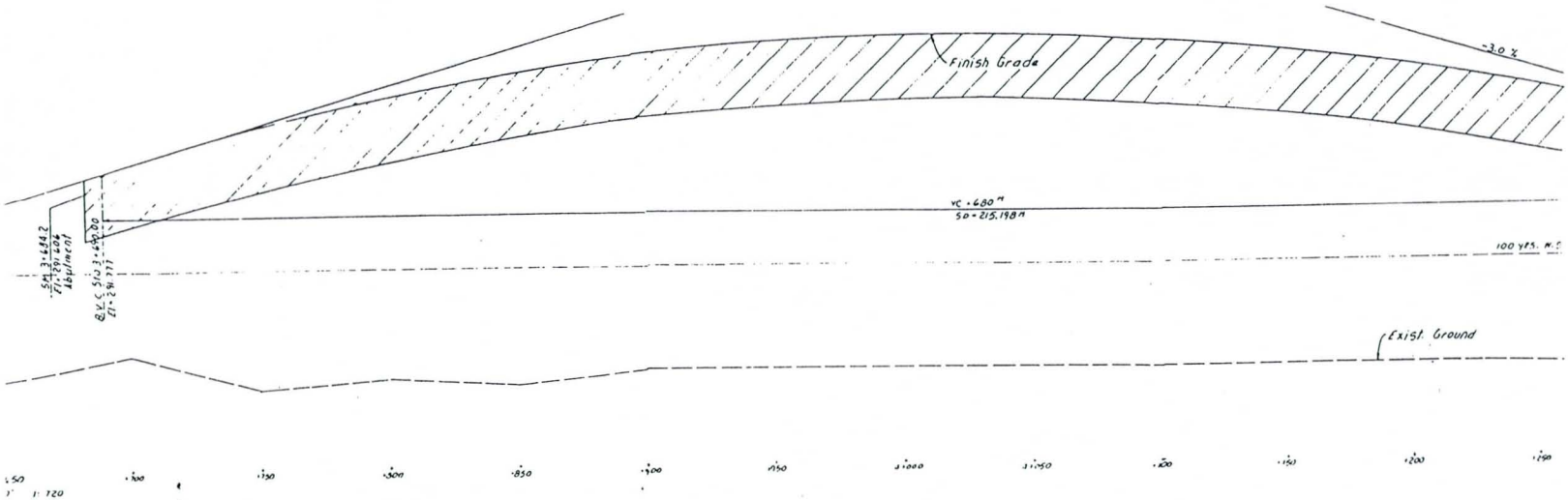


PHOENIX INTERNATIONAL RACEWAY

Figure 5.1
Preferred Alternative
Alignment Map

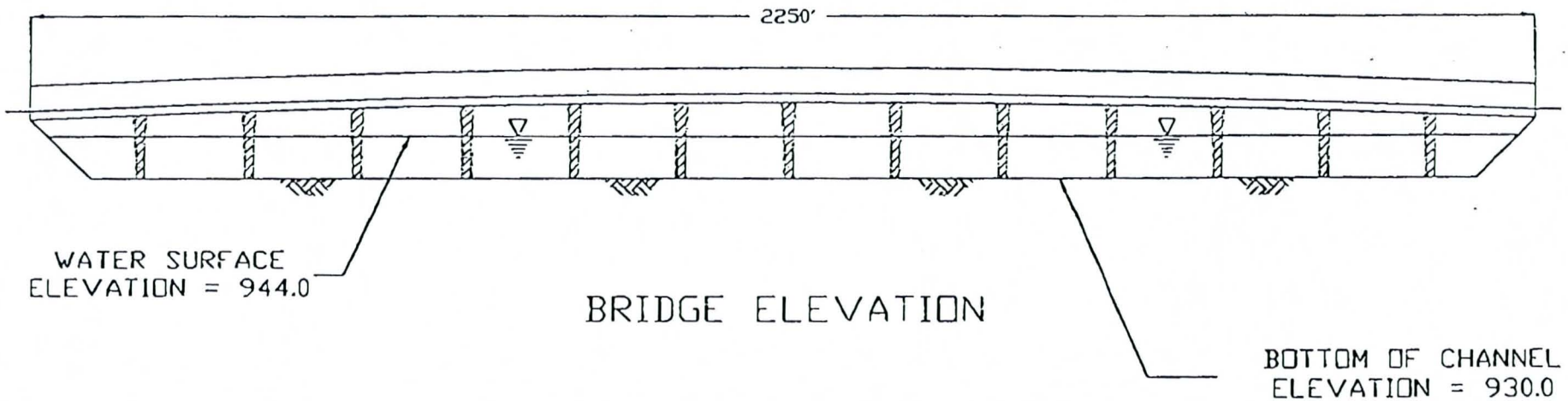

NTS
CSA
8
8D008,
2B4,04
CSA



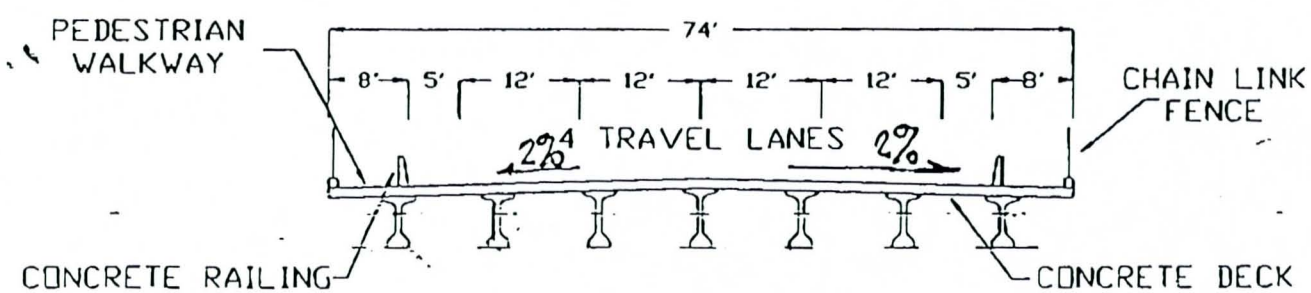


1" = 1:720
1:72

OF 2



BRIDGE ELEVATION



BRIDGE DECK SECTION

NOT TO SCALE

6'-9" ± Top of deck to Bottom of girder

MARICOPA COUNTY DEPT. OF TRANSPORTATION
PROJECT: GILA RIVER CROSSING - BRIDGE SECTION

FIGURE 5.2

APPENDIX D

PROPOSED HYDRAULIC DESIGN CONDITIONS ASSUMING OVERBANK FLOWS

(SEPARATELY BOUND)

APPENDIX E

FUTURE HYDRAULIC CONDITIONS ASSUMING NO OVERBANK FLOWS

(SEPARATELY BOUND)

APPENDIX F

SCOUR CALCULATIONS

sla
SIMONS, li & ASSOCIATES, INC.

CLIENT MCDOT JOB NO. PA23HMEQ01 PAGE 1/16
PROJECT 116th Ave. Bridge DATE CHECKED DATE 2/10/95
DETAIL Bridge Scour CHECKED BY B COMPUTED BY TMM

Long Term Scour

Armor Size - Per USBR "Computing Degradation and local Scour" 1984

$D_{50} = 12.5$ mm

$D_{90} = 125$ mm

hydraulics based on existing conditions HEC-2 Run w/ $Q_{10} = 2690$ cms

Slope = (average energy slope from 123rd Ave. to 107th Ave.)

$$S = \frac{288.48 - 284.42}{3100} = 0.001287$$

hydraulic parameters @ x-sec 12900 @ $Q_{10} = 2690$ cms ~~2609~~ from existing conditions Run

$V = 1.63$ (Average V per HEC-2) mps
$n_s = 0.037$ (per HEC-2)

d = (based on channel hydraulic Depth) = 2.15 m use 2.2 m

Meyer - Peter, Muller

$$D_c = \frac{dS}{K\left(\frac{n_s}{D_{90}^{1/6}}\right)^{3/2}} = \frac{2.2\ (0.001287)}{0.058\left(\frac{0.037}{125^{1/6}}\right)^{3/2}} = 23 \text{ mm}$$

Long Term Scour

Armor Size - Per USBR "Computing Degradation and local Scour" 1984

$D_{50} = 12.5$ mm

$D_{90} = 125$ mm

hydraulics based on existing conditions
HEC-2 Run w/ $Q_{10} = 2690$ cms

Slope = (average energy slope from 123rd Ave. to 107th Ave.)

$$S = \frac{288.48 - 284.42}{3100} = 0.001287$$

2690 cms (see TABLE 2.3).

hydraulic parameters @ x-sec 12900
@ $Q_{10} = 2609$ From existing conditions Run

$V = 1.63$ (Average V per HEC-2) mps
$n_s = 0.037$ (per HEC-2)

d = (based on channel hydraulic Depth) = 2.15 m use 2.2 m

Meyer - Peter, Muller

$$D_c = \frac{ds}{K\left(\frac{n_s}{D_{90}^{1/6}}\right)^{3/2}} = \frac{2.2\ (0.001287)}{0.058\left(\frac{0.037}{125^{1/6}}\right)^{3/2}} = 23 \text{ mm}$$

Competent Bottom Velocity

$$D_c = 20.2\,V^2 = 20.2\,(1.63)^2 = 53.67 \text{ mm}$$

Lane's Tractive Force

$$T_c = 10^6 \text{ g/m}^3\,(2.2)(0.001287) = 2831 \text{ g/m}^2$$

From Figure 4 USBR 1984

$$D_c = 40 \text{ mm}$$

Shields Diagram

$$T_* = \frac{T_c}{(\gamma_s - \gamma_w)\,D_c} = 0.06$$

$$D_c = \frac{1.0\,(2.2)(0.001287)}{0.06\,(1.65)} = 0.0286 \text{ m}$$

use 29 mm

Yang incipient Motion

$$D_c = 0.0216\,V_{cr}^2 = 0.0216\,(1.63)^2 = 0.0574 \text{ m}$$

use 57.4 mm

Average Armor Size for Q_{10}

$$D_i = \frac{23 + 53.67 + 40 + 29 + 57.4}{5} = 40.6$$

use **41 mm**

Depth to Armor

$$y_d = y_a\left(\frac{1}{\Delta P} - 1\right)$$

* Assume 3 layers of Material

$41\,mm \cong D_{67}$ $\quad \Delta P = 0.33$

$$y_d = (3)(0.041)\left(\frac{1}{0.33} - 1\right) = 0.25$$

use **0.3 m**

General Scour

Contraction Scour
Per HEC-No. 18 FHWA-IP-90-017

$$\frac{Y_2}{Y_1} = \left(\frac{Q_2}{Q_1}\right)^{6/7}\left(\frac{W_1}{W_2}\right)^{K_1}$$

$$Y_s = Y_2 - Y_1$$

$$\frac{V_*}{\omega} = \frac{(g Y_1 S)^{1/2}}{\omega}$$

* 17 PIERS @ 3.0 m of obstruction w/ DEBRIS ACCUMULATION.

Use HEC-2 Run for Special Bridge w/ all flow under the bridge

100-year Parameters

$g = 9.8\ m/s^2$ ($32.2\ ft/s^2$)

ω = (fall velocity for $D_{50} = 12.5mm$) $\cong 1\ m/s$

S = (Energy Slope from 13400 to 12900)

X-Sec 12900, 13400

$$S = \frac{288.72 - 288.19}{500} = 0.00106\ m/m$$

Y_1 = Hydraulic Depth = 3.74 m = $\frac{3680}{850}$ (Q_{main} / W_{main})

$Q_1 = 6504$ cms

$Q_2 = 7079$ (all flow under bridge)

$W_1 = 1083$ m

$W_2 = 678$ m (bridge opening adjusted for skew & pier + debris)

proposed.

bridge length, Pier + debris

* 771 − 42 − 51 = 678m

skew adjust

Referenced?

$$\frac{V_*}{\omega} = \frac{[9.81\ m/s^2\ 3.74m\ (0.00106\ m/m)]^{1/2}}{1\ mps}$$

$$\frac{V_*}{\omega} = 0.197 < 0.50 \therefore K_1 = 0.59$$

Contraction Scour Cont.

100 - Year

$$Y_2 = 3.74 \left(\frac{7079}{6504}\right)^{6/7} \left(\frac{1083}{678}\right)^{0.59} = 5.3 \text{ m}$$

$$Y_s = 5.3 - 3.74 = 1.56 \text{ m}$$

use **1.6 m**

"Super Flood"

Y_1 = Hydraulic Depth = 4.63 m (X-sec 13,400)

Q_1 = 8579 cms

Q_2 = 10194 all flow under bridge

W_1 = 1083 m

W_2 = 678 m

$$Y_2 = 4.63 \left(\frac{10194}{8579}\right)^{6/7} \left(\frac{1083}{678}\right)^{0.59} = 7.08 \text{ m}$$

$$Y_s = 7.08 - 4.63 = \underline{2.45 \text{ m}}$$

use **2.5 m**

local Scour

By CSU eq. HEC-18 pp 39

$$\frac{Y_s}{Y_1} = 2.0\, K_1 K_2 K_3 \left(\frac{a}{Y_1}\right)^{0.65} F^{0.43}$$

Worst Case
Hydraulic Parameters @ x-Sec 12900

100-Year

Y_1 = Max Depth = 4.93m

F = 0.36

"Super Flood"

Y_1 = 5.89

F = 0.33

CSU Eq.

K_1 = 1.0 (debris considered seperately)

K_2 = 1.0 (L/a = 7.7 Per Skew $\alpha = 0°$)

K_3 = 1.0 (Dunes, bed forms considered seperately)

a = 3.0 m (including debris)

100-Year local Scour

$$Y_s = 2.0(1)(1)(1)\left(\frac{3}{4.93}\right)^{0.65}(0.36)^{0.43}\,4.93$$

$$= \underline{\underline{4.6\ m}}$$

local Scour Cont.

"Superflood"

$$Y_s = 2.0(1)(1)(1)\left(\frac{3}{5.89}\right)^{0.65}(0.33)^{0.43}\,5.89$$

$$Y_s = 4.72\,m$$

use $\underline{\underline{4.8\,m}}$

Bed form Scour

*Check Regime & Bed form

100-year (x-sec 12900)

$Fr = 0.36$

$D_{50} = 12.5\,mm$

R = use Hydraulic Depth $= 3.50$

$$R/D_{50} = \frac{3.50}{0.0125} = 280$$

"Superflood"

$F_r = 0.33$ $R = 4.3$

$D_{50} = 12.5$

$$R/D_{50} = \frac{4.3}{0.0125} = 344$$

Bed Form Scour Cont.

Fig 5.23 Simons & Senturk (1977)

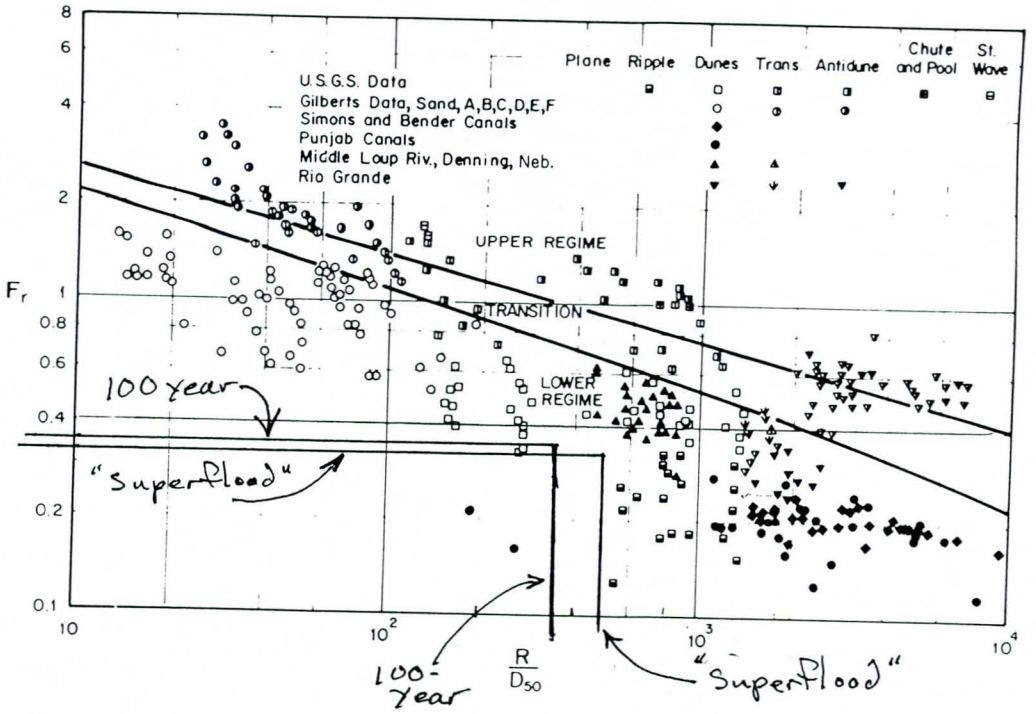


Fig. 5.23 Bed form prediction as a function of F_r and R/D_{50}.

Dune Formation

Allen (Simons & Senturk)

$A = 0.0839\, d^{1.209}$ (metric)

Yalin (Simons & Senturk)

$A = 1/6\, d$

Bed Form Scour Cont.

Dune Scour

Lower Regime of Flow

100-year

(Allen, 1963) or Yalin

$A = 0.0839\,(3.5)^{1.209} = 0.382\ m$

or

$A = \frac{1}{6} d = \frac{1}{6}(3.5) = \underline{0.583}$

$Y_s = \frac{1}{2} A = \frac{1}{2}(0.583) = 0.292$

use $\underline{\underline{0.3\ m}}$

"Superflood"

$A = 0.0839\,(4.3)^{1.209} = 0.489$

or

$A = \frac{1}{6} d = \frac{1}{6}(4.3) = \underline{0.717}$

$Y_s = \frac{1}{2} A = \frac{1}{2}(0.717) = 0.3585$

use $\underline{\underline{0.4\ m}}$

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SIMONS, LI & ASSOCIATES, INC.

CLIENT _____ JOB NO. _____ PAGE 10/16
PROJECT _____ DATE CHECKED _____ DATE 6/26/95
DETAIL Pier Scour _____ CHECKED BY _____ COMPUTED BY TDM
Revised from 2/10/95

Pier Scour Total

	100-year	"Superflood"
General	1.6	2.5
local	4.6	4.8
Bed Form	0.3	0.4
Subtotal	6.5	7.7
low flow incisement	1.0	1.0
long Term	0.3	0.3
Safety Factor	1.95	2.31
Total	9.75	11.31
use	9.8 m	11.3 m

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SIMONS, LI & ASSOCIATES, INC.

CLIENT _____ JOB NO. _____ PAGE 10/16
PROJECT _____ DATE CHECKED _____ DATE 2/10/95
DETAIL Pier Scour CHECKED BY B COMPUTED BY TMM

Pier Scour Total

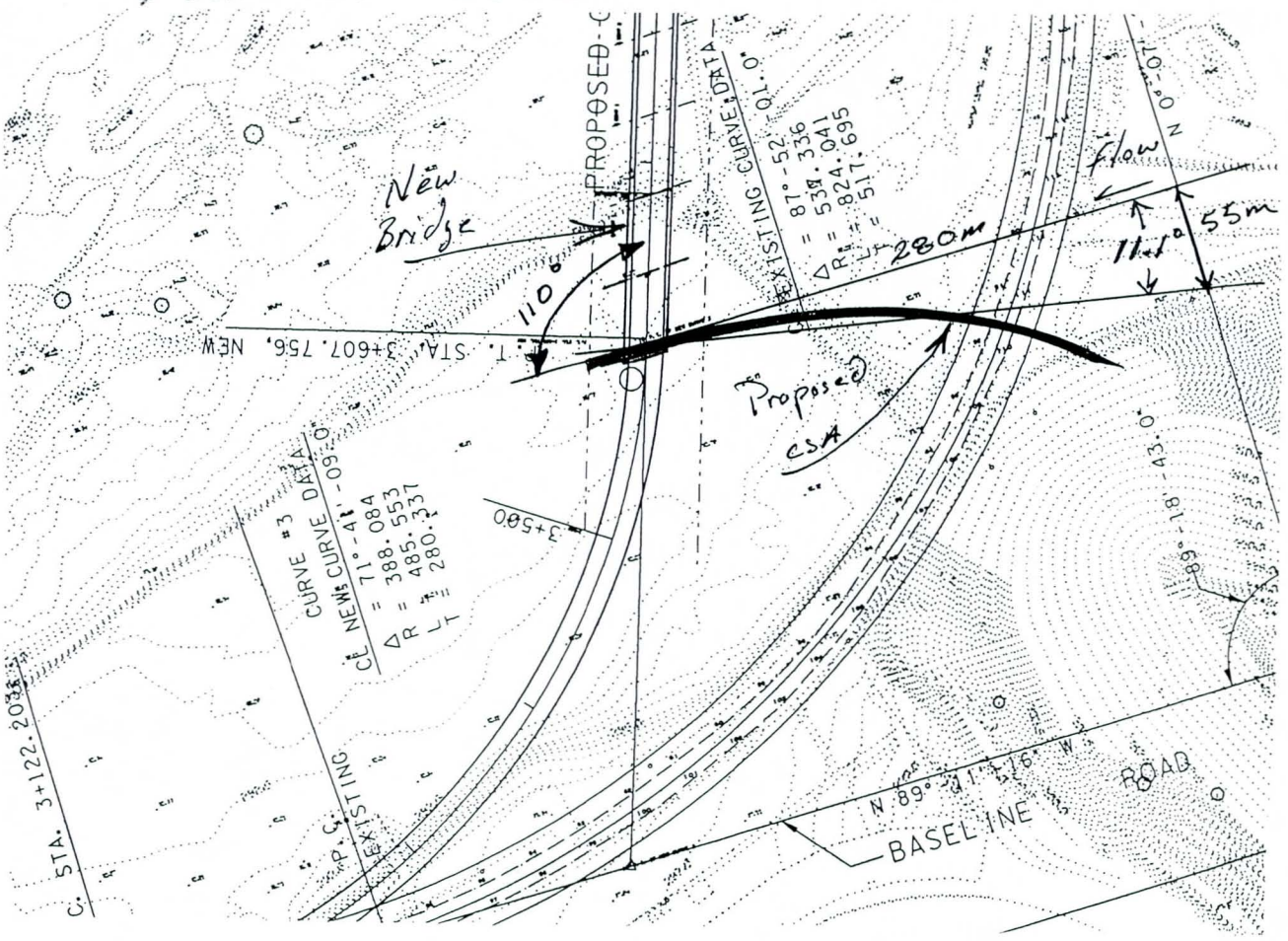
	100-Year	"Superflood"
General	1.6	2.5
local	4.6	4.8
Bed form	0.3	0.4
Subtotal	6.5	7.7
low flow incisement	1.0	1.0
long Term	0.3	0.3
Safety factor }	2.0 *	2.3 *
Total	9.8 m	11.3 m

30% of

30% of

* SAFETY FACTOR = 30% OF TOTAL SCOUR.
= 0.3 x TOTAL SCOUR

South Abutment Scour



use Froehlich's equation per HEC No. 18 pp 49

$$\frac{Y_s}{Y_a} = 2.27 K_1 K_2 \left(\frac{a'}{Y_a}\right)^{0.43} F_r^{0.61} + 1$$

$K_1 = 0.55$ (ie, spill through due to the CSA)

$K_2 = \left(\frac{100}{90}\right)^{0.13} = 1.03$ { Foundation depth design ... assume no guidebank }

$a' = 55m$

Y_a = Hydraulic Depth in a' F_r = Froude Number

Y_s = Scour depth

South Abutment Scour Cont.

100-year

$Y_a = 2.74\,m$

{from Flow Dist. @ Cross-Section 12900}

$$F_r = \frac{1.5}{\sqrt{9.8(2.74)}} = 0.2895 \cong 0.29$$

$$Y_s = 2.74\left[(2.27)\,0.55\,(1.03)\left(\frac{55}{2.75}\right)^{0.43}(0.29)^{0.61} + 1\right]$$

$$Y_s = 2.74\left[2.19 + 1\right] = 8.74\,m$$

use 8.7 m

8.7 m < 9.8 use 9.8m

abutment scour — Pier Scour

"Superflood"

$Y_a = 3.47\,m$

$$F_r = \frac{1.58}{\sqrt{9.8(3.47)}} = 0.2709 \cong 0.271$$

$$Y_s = 3.47\left[(2.27)\,0.55\,(1.03)\left(\frac{55}{3.47}\right)^{0.43}(0.271)^{0.61} + 1\right]$$

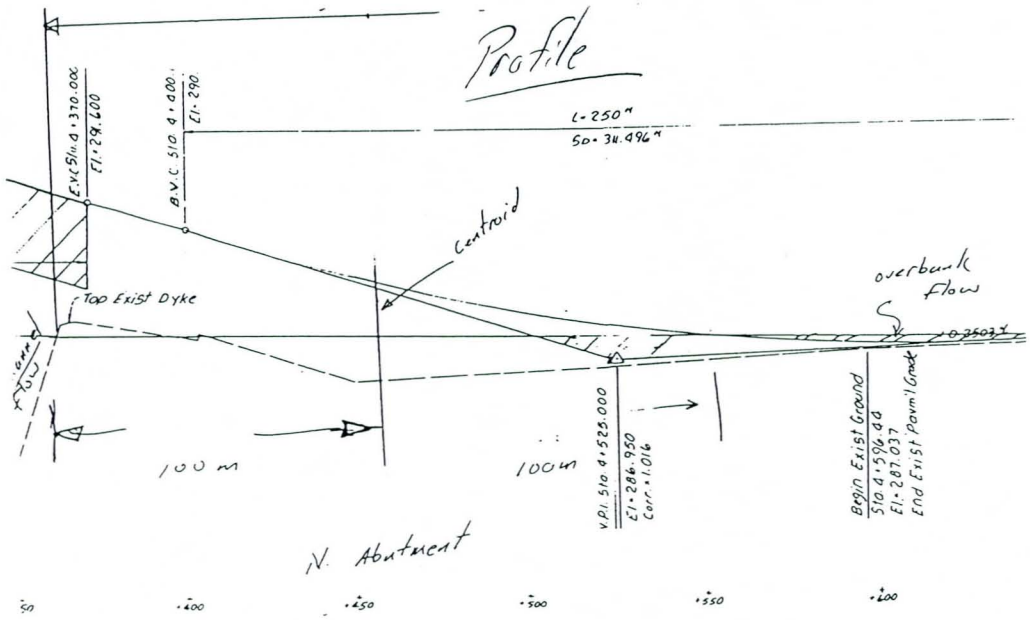
$Y_s = 3.47(1.90 + 1) = 10.06\,m$ use 10.1

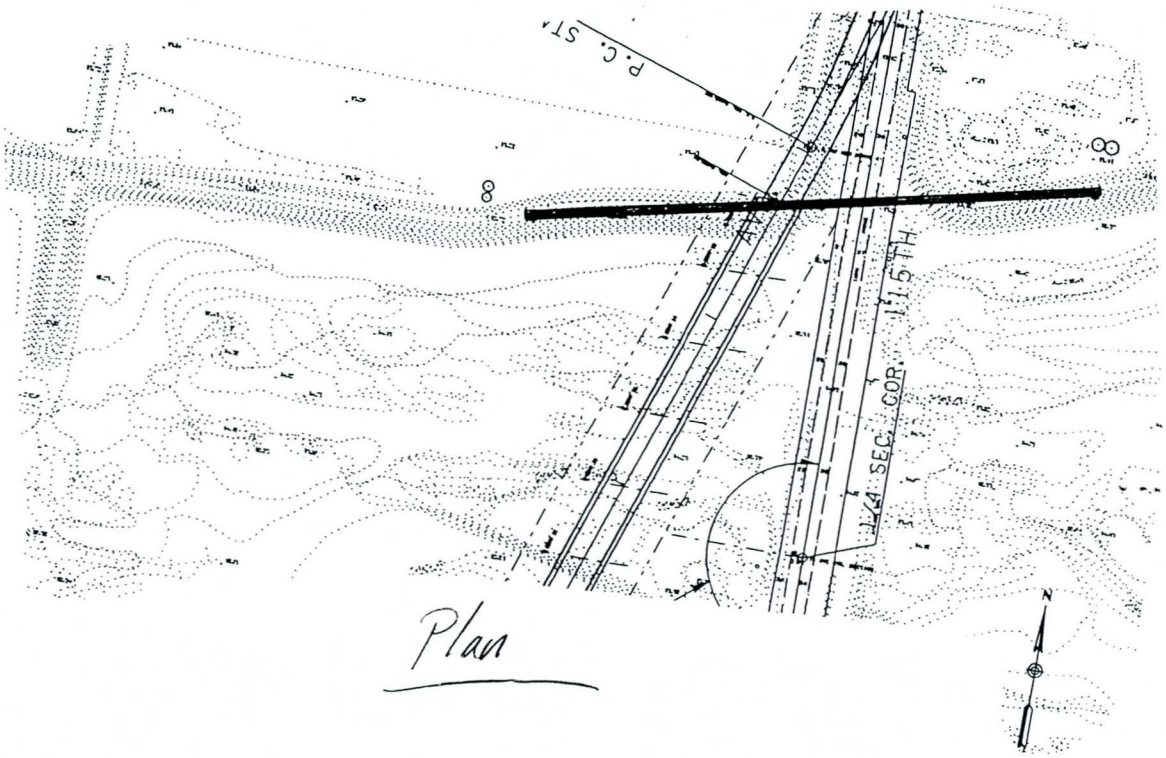
10.1 m < 11.3 m use 11.3m

abutment scour — pier scour

North Abutment Scour

North abutment will set behind CSA in a location where the bank alignment is uniform.





Plan

North Abutment Scour Cont.

Assume flow in overbank must flow around abutment w/ Stagnation point @ Centroid of approach

a' is based on flow around approach in "Normal Bridge Run"

Y_1 is based on average depth of flow in the overbank area affected.

100-year (cross Section 12900)

$a' = 100m$ $Y_1 = 0.54m$ $V_1 = 0.62mps$

$$\frac{a'}{Y_1} = \frac{100}{0.54} = 185 > 25$$

use $\frac{Y_s}{Y_1} = 4 F_{r_1}^{0.33}$ $F_r = \frac{0.54}{\sqrt{9.8(0.62)}} = 0.22$

$$Y_s = (0.54)\,4\,(0.22)^{0.33} = \underline{1.31\ m}$$

1.31 m < 9.8m use **9.8m**

Abutment Scour — Pier Scour

"Superflood"

$a' = 100m$ $Y_1 = 1.08m$ $V_1 = 0.86mps$

$$F_r = \frac{0.86}{\sqrt{9.8(1.08)}} = 0.264$$

$$Y_s = 1.08(4)(0.264)^{0.33} = 2.77\ m$$

2.77m < 11.3 m use **11.3 m**

abutment — Pier scour

Bank Protection / CSA Toe Down

General Scour	1.6	m
Bed Form Scour	0.3	
Factor of Safety (1.9)(30%) = 0.57	0.6	
long Term Degradation	0.3	
low flow incisement	1.0	
Total	3.8 m	

Bank Protection Near Bridge use 3.8 m

Bank Protection @ Bridge - Check for local pier scour "Zone of Influence"

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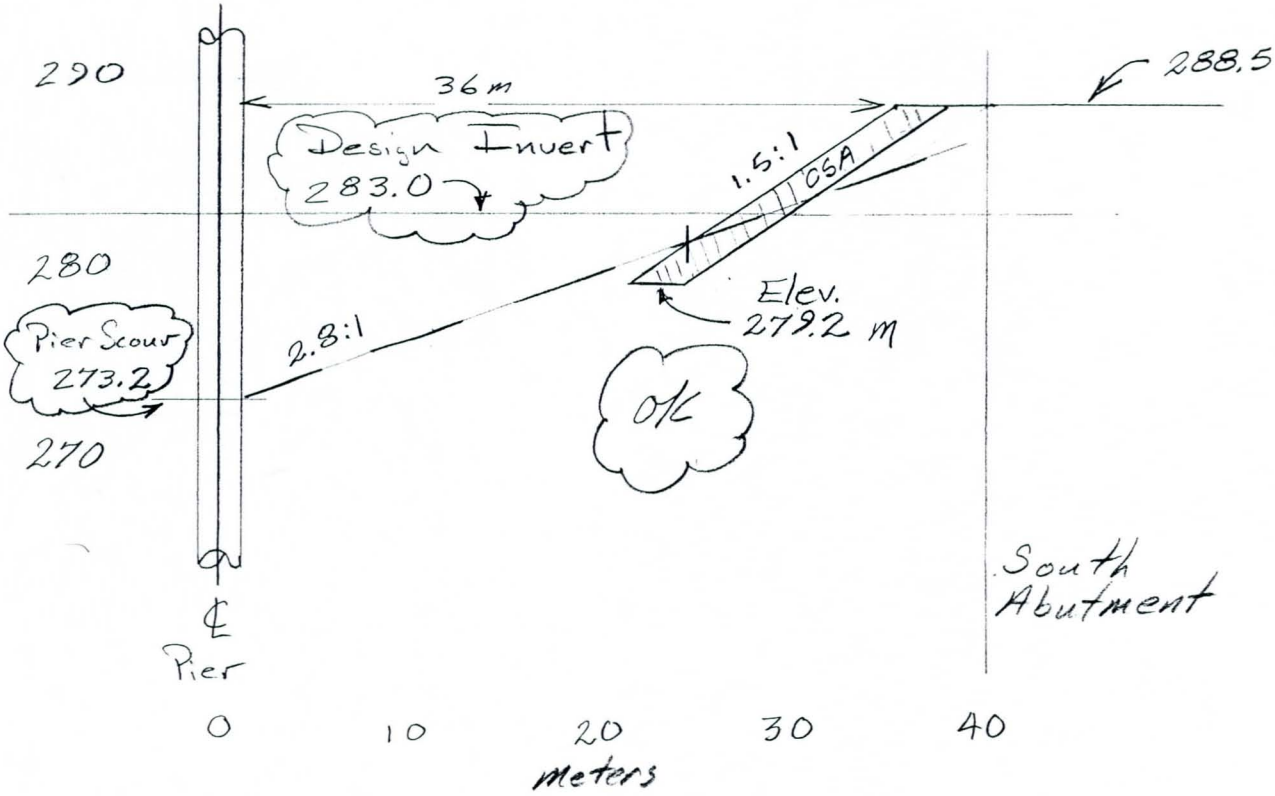
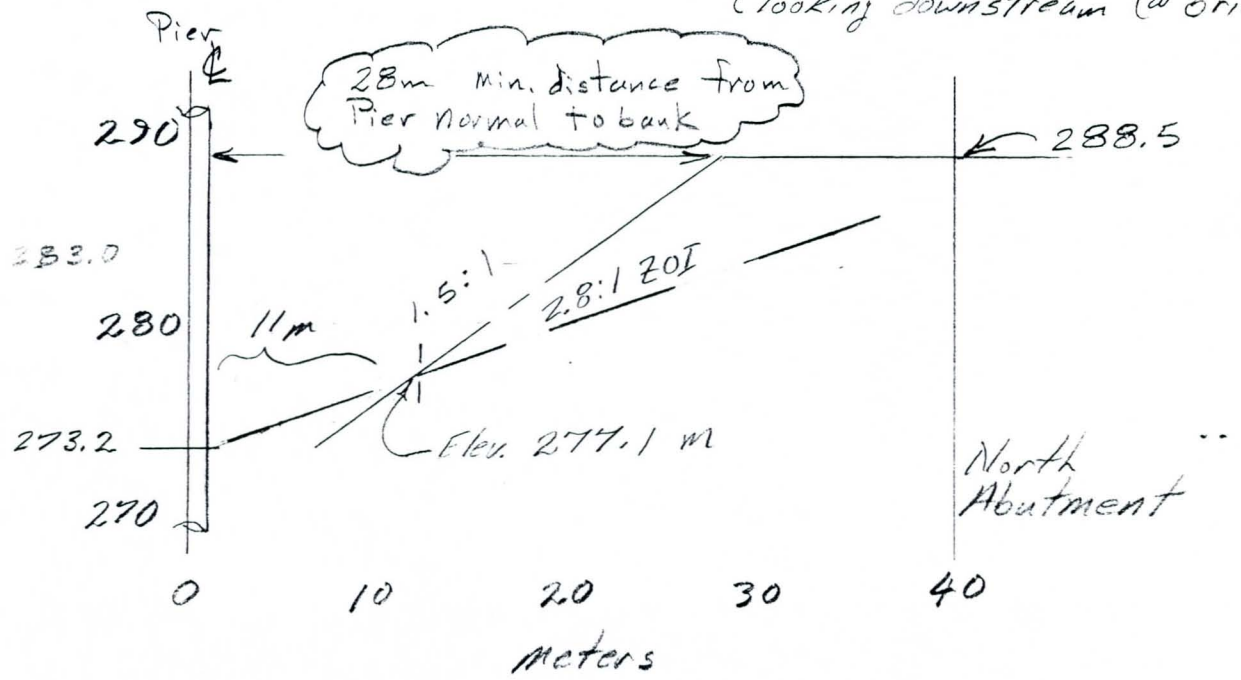
SIMONS, LI & ASSOCIATES, INC.

CLIENT _____ JOB NO. _____ PAGE 16/16
PROJECT 116th Ave. Bridge DATE CHECKED _____ DATE 2/13/95
DETAIL GSA - Zone of Influence CHECKED BY _____ COMPUTED BY MM

100-year Zone of Influence
South Abutment (looking upstream @ bridge)



North Abutment Zone of Influence
(looking downstream @ bridge)



APPENDIX G

QUASED AND SEDIMENT TRANSPORT COMPUTATIONS

MODIFICATION OF 91ST AVE. DATA TO INCLUDE
REACHES FROM 115th AVE. TO THE AGUA FRIA

FIS or 91 STA.	BEFORE (QUASED) 100 YR	AFTER (QUASED) 100 YR	DELTA (QUASED) 100 YR	91st AVE. FILE NG (QUASED) 100 YR	91st AVE. STEADY 100 YR	91st AVE STA.	AFTER SUPER FLOOD	SUPER FLOOD DELTA	
190.05	899.6	901.4	1.8			-3.45882	901.7	2.1	AGUA FRIA CONF.
190.25	899.6	901	1.4			-3.25825	901.4	1.8	
190.54	903.6	904.1	0.5			-2.9698	904.5	0.9	
190.75	906.4	907	0.6			-2.76128	907.3	0.9	
190.95	906.3	906.7	0.4			-2.55939	907.3	1	
191.14	906.4	906.8	0.4			-2.36147	907.4	1	
191.35	908.8	909	0.2			-2.15655	909.5	0.7	
191.54	910	910	0			-1.9698	910	0	
191.68	915.1	915.1	0			-1.82359	915.2	0.1	
191.84	914	913.4	-0.6			-1.6717	913.4	-0.6	
192.01	915	914.2	-0.8			-1.49026	914.3	-0.7	
192.18	916.2	916.6	0.4			-1.32511	916.1	-0.1	
192.34	916.6	917.4	0.8			-1.16923	917.5	0.9	
192.49	915.9	915.5	-0.4			-1.01431	915.5	-0.4	123rd AVE
192.62	917	916.5	-0.5			-0.88988	916.6	-0.4	
192.74	918.8	918.2	-0.6			-0.77056	918.1	-0.7	
192.9	919.4	918.7	-0.7			-0.60768	918.5	-0.9	
193.08	921.4	921.4	0			-0.43155	922.2	0.8	
193.25	923.1	923.1	0			-0.25352	923.5	0.4	
193.4	926.1	927.4	1.3			-0.10389	927.7	1.6	
193.5	928.5	930	1.5	1.3	4	0.000273	930	1.5	
0.102	930.6	932	1.4	0		0.102545	932	1.4	115th AVE.
0.197	932	932	0	0		0.197242	932	0	
0.292	932	932	0	0		0.291939	932	0	
0.386	932	931.9	-0.1	0.1	3	0.386636	932	0	
0.481	932	932	0	0		0.481333	932	0	
0.576	932	932.3	0.3	-0.3		0.57603	933.2	1.2	
0.67	932	932	0	0		0.670727	932	0	
0.765	932	932.5	0.5	0.5		0.765424	933.1	1.1	
0.86	932	934.9	2.9	0.1	-9	0.860121	936	4	
0.955	932	935.7	3.7	0.1		0.954818	938.1	6.1	107th AVE.
1.049	932	930.9	-1.1	0.8		1.049515	931.1	-0.9	
1.144	936	934.7	-1.3	1.2		1.144212	935.3	-0.7	
1.239	936	936.1	0.1	0.3		1.238909	937	1	
1.333	936	936.4	0.4	0.6	7	1.333606	936.8	0.8	
1.428	936	936.1	0.1	2.4		1.428303	936.7	0.7	
1.523	936	938.1	2.1	0.2		1.523	939.1	3.1	
1.618	940	941.5	1.5	0.4		1.618644	942.5	2.5	
1.712	940	941.6	1.6	-0.3		1.712394	942.1	2.1	
1.807	940	939.8	-0.2	0.2		1.807091	940.4	0.4	
1.902	944	944.1	0.1	0.1	-4	1.901788	944.8	0.8	
2.015	944	944	0	-1.1		2.015424	944.8	0.8	99th AVE.
2.11	944	943	-1	-0.5		2.110121	943.5	-0.5	
2.205	944	942.7	-1.3	0.6		2.205765	943.3	-0.7	
2.299	944	942.7	-1.3	1		2.299515	943	-1	
2.394	948	946.9	-1.1	-1		2.394212	946.9	-1.1	
2.489	948	946.9	-1.1	-0.8		2.488909	946.9	-1.1	
2.586	948	949.7	1.7	0.1	-4	2.586447	950.1	2.1	
2.679	948	949.4	1.4	0.2		2.67925	949.9	1.9	
2.775	952	950.9	-1.1	-1		2.774894	951.1	-0.9	
2.869	952	951	-1	-0.1		2.869591	951.2	-0.8	
2.964	952	951.9	-0.1	-0.2		2.964288	951.7	-0.3	
3.059	952	952.1	0.1	-0.2		3.058985	952	0	
3.153	956	955.1	-0.9	-0.5	6	3.153682	955.1	-0.9	
3.248	956	956.4	0.4	-0.5		3.248379	956.5	0.5	
3.343	956	956.3	0.3	-0.4		3.343076	956.5	0.5	
3.438	956	956.4	0.4	0.7		3.437773	956.7	0.7	
3.532	956	956.8	0.8	0.5		3.53247	956.9	0.9	
3.627	960	960.9	0.9	0.1		3.627167	960.7	0.7	
3.721	960	959	-1	0.9	-9	3.720917	960.6	0.6	
3.813	960	959.8	-0.2	-0.1		3.81372	960.2	0.2	
3.908	960	960	0	0		3.908417	960.2	0.2	
4.001	960	960.2	0.2	-0.2		4.00122	960.4	0.4	
4.095	960	960.2	0.2	0.1		4.09497	960.4	0.4	
4.189	961.5	962.1	0.6	-0.4	26	4.189667	962	0.5	
4.284	964	965	1	-0.9		4.284364	964.9	0.9	
4.379	964	965.2	1.2	-0.6		4.379061	965.4	1.4	
4.473	964	966.2	2.2	0.4		4.473758	965.9	1.9	
4.568	964	966.4	2.4	0.4		4.568455	966.1	2.1	
4.663	964	962.4	-1.6	-0.8	-24	4.663152	963.2	-0.8	

4.758	968	966.3	-1.7	-1.1		4.757848	967.5	-0.5
4.852	972	971.9	-0.1	0		4.852545	971.3	-0.7
4.947	968	967.4	-0.6	0.3		4.947242	967	-1
5.042	972	969.1	-2.9	-0.7		5.041939	968.1	-3.9
5.136	972	969	-3	-1.2		5.136636	967.9	-4.1
5.231	976	971.1	-4.9	0.5	-6	5.231333	969.7	-6.3
5.326	976	971.1	-4.9	1.6		5.32603	969.6	-6.4
5.42	976	973.7	-2.3	-2		5.420727	972.5	-3.5
5.515	976	973.9	-2.1	0.2		5.515424	973.1	-2.9
5.61	976	974.8	-1.2	-0.2		5.610121	974.6	-1.4
5.705	976	974.4	-1.6	-0.1		5.704818	973.7	-2.3
5.799	976	973.6	-2.4	0.5		5.799515	972.9	-3.1
5.894	976	973.1	-2.9	-0.2		5.894212	972.6	-3.4
5.989	976	974.7	-1.3	-0.5		5.988909	974.3	-1.7
6.083	976	974.4	-1.6	1.6		6.083606	974.2	-1.8
6.178	976	976	0	0		6.178303	976	0
6.273	976	976	0	0		6.273	976	0

Simons, Li & Associates, Inc.

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AC
AC      HEC-2 DATA MOFIFIED FOR QUASI-DYNAMIC SEDIMENT ROUTING MODEL (QUASED)
AC
AC      THE IMPACT OF THE GILA RIVER IS CONSIDERED IN THIS ANALYSIS.
AC      DISCHARGE CHANGES OCCUR AT SECTIONS 0.567 & 0.955 IN REACHES 3 & 5.
AC
AC      MANNING'S "n" VALUES ARE CONSISTENT WITH THE HEC2 ANALYSES TO ALLOW
AC      COMPARISON OF RATING CURVES BETWEEN THE RIGID AND MOVABLE BED ANALYSES.
AC
AC      INEFFECTIVE FLOW AREAS WITHIN A CROSS-SECTION WERE REMOVED TO FACILITATE
AC      THE QUASED CALCULATIONS AND LIMIT THE HYDRAULIC CALCULATIONS TO THE
AC      EFFECTIVE AREAS OF THE CHANNEL.
AC
AC      190.05   CONFLUENCE WITH AGUA FRIA RIVER
AC      193.4   SAME CROSS SECTION AS MILE 0.0 ON SALT RIVER
AC      193.5   115TH AVE  WITH 1984 ROAD IMPROVEMENTS BY ADOT
AC
T1      SIMONS, LI & ASSOCIATES, INC. -- TEMPE, AZ
T2      GILA RIVER ANALYSIS (A.F. CONF. TO 67th)
T3      QUASED HEC-2  H2QS116.DAT
J1            2                  0.001                  20588     910
J2     1            -1
J3    38      39      42       1       2       3      43       5       8       4
J3    25       0      38      55      56      26      13      15      14      53
J3    54      33
J6     0       1
QT     1   20588
NC 0.045   0.045   0.045     0.1     0.3
X1190.05     100   19412   22382     540     720     693
GR1070.5   19220  1036.4   19288   982.4   19386   944.1   19412   901.0   19469
GR 900.2   19562   902.8   19595   899.7   19624   899.6   19767   902.9   19827
GR 900.8   19844   902.5   19901   903.0   19966   904.2   20000   904.4   20069
GR 905.6   20104   903.6   20148   903.6   20227   904.9   20252   902.5   20363
GR 902.5   20425   913.6   20458   913.8   20479   907.3   20493   907.3   20627
GR 909.2   20634   908.1   20773   907.2   20850   907.2   20948   911.7   20964
GR 912.1   21101   911.8   21201   917.7   21225   913.8   21324   908.4   21345
GR 908.8   21429   909.3   21521   910.5   21580   910.5   21663   910.5   21741
GR 910.5   21800   909.8   21925   910.1   22197   916.4   22382   920.8   22489
GR 924.6   22536   924.2   22598   922.2   22631   920.9   22683   926.2   22730
GR 924.9   22816   919.2   22901   917.0   22986   917.4   23099   914.0   23223
GR 914.0   23347   919.6   23366   917.2   23424   918.8   23637   918.1   23770
GR 919.3   23965   917.4   24026   916.4   24072   916.4   24366   916.6   24569
GR 917.0   24728   918.2   24839   922.4   24867   922.4   25045   922.1   25179
GR 922.6   25370   923.4   25526   923.7   25680   923.6   25700   924.2   25763
GR 924.4   25871   924.4   25936   924.2   26010   924.0   26123   924.6   26164
GR 922.7   26198   923.2   26396   925.4   26490   925.5   26590   926.3   26667
GR 928.2   26738   931.4   26805   930.2   26838   928.0   26912   928.0   26990
GR 926.3   27107   926.3   27209   927.0   27326   931.6   27372   931.5   27419
GR 927.5   27438   928.8   27582   933.4   27657   934.3   27692   931.9   27735
X1190.25     100   17974   21762    1100     650    1059
GR 929.2   17370   923.7   17395   929.8   17461   928.9   17550   923.3   17599
GR 922.1   17660   920.6   17747   914.8   17797   914.9   17898   914.0   17974
GR 899.6   18011   902.2   18036   903.6   18119   901.4   18230   901.8   18269
GR 906.5   18291   907.3   18356   906.2   18481   904.4   18608   905.2   18717
GR 901.2   18765   902.9   18778   901.6   18823   900.9   18909   901.2   18955
GR 904.0   18995   904.0   19069   905.3   19093   905.3   19160   910.4   19186
GR 912.0   19247   911.3   19295   912.4   19332   910.0   19365   911.2   19409
GR 908.4   19455   912.6   19491   912.1   19586   906.9   19611   902.0   19665
GR 901.2   19697   911.3   19746   912.0   19771   907.3   19796   908.0   20000
GR 908.0   20164   909.6   20209   909.3   20258   908.2   20276   910.9   20325
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GR 907.8	20365	908.2	20383	912.8	20414	913.3	20471	914.1	20551
GR 914.6	20605	912.8	20661	914.0	20710	915.8	20786	915.7	20849
GR 915.7	20877	912.4	20900	914.4	20973	915.4	21049	913.4	21120
GR 909.1	21154	910.6	21368	911.2	21460	914.3	21548	914.0	21762
GR 913.2	21911	913.9	22040	915.5	22234	916.3	22477	917.1	22708
GR 917.8	22960	917.4	23220	917.9	23462	918.2	23685	917.4	23788
GR 918.6	23988	919.0	24000	920.0	24064	921.5	24457	921.1	24915
GR 921.6	25271	921.8	25549	920.7	25606	919.5	25639	920.4	25823
GR 920.4	25988	923.0	26222	924.4	26341	925.1	26556	925.2	26727
GR 924.7	26928	924.2	27058	923.5	27232	924.7	27500	925.9	27704
X1190.54	100	17695	21824	1500	1250	1523			
GR 931.4	17143	936.2	17200	935.6	17228	924.7	17300	924.6	17395
GR 924.2	17453	915.1	17484	915.9	17537	917.2	17572	917.1	17695
GR 905.6	17722	906.4	17781	906.4	17815	911.5	17838	913.5	17966
GR 911.1	18146	904.8	18274	903.6	18362	905.8	18429	907.0	18510
GR 910.7	18554	909.1	18608	906.8	18621	906.3	18679	905.9	18756
GR 907.4	18820	907.4	18894	912.2	18931	911.2	19040	912.6	19108
GR 911.8	19158	905.5	19213	905.5	19299	907.5	19351	903.6	19399
GR 903.6	19503	907.2	19588	908.8	19690	908.8	19798	906.3	19849
GR 906.3	20000	906.3	20108	913.8	20138	914.3	20241	912.7	20303
GR 914.3	20340	911.6	20348	916.0	20386	914.4	20430	914.7	20488
GR 913.2	20546	911.8	20573	909.4	20616	911.1	20644	910.4	20659
GR 914.7	20706	913.5	20795	914.2	20881	914.3	20940	914.6	21000
GR 910.3	21168	915.5	21225	917.4	21377	916.7	21581	917.0	21824
GR 910.7	21883	910.8	21937	917.0	21995	917.1	22080	915.9	22129
GR 916.6	22263	916.6	22440	916.8	22609	917.8	22751	918.6	22834
GR 918.6	22873	912.7	22900	912.7	22936	918.6	22979	919.4	23052
GR 914.0	23066	914.0	23084	920.4	23098	920.0	23110	916.8	23121
GR 918.3	23243	918.7	23383	917.4	23425	919.5	23460	919.6	23648
GR 919.6	23842	918.3	24032	919.2	24154	920.0	24266	921.2	24388
GR 921.9	24510	921.8	24639	922.0	24700	924.4	24920	924.3	25011
X1190.75	100	17734	22014	1600	710	1101			
GR 935.6	17011	941.8	17164	944.3	17261	936.3	17318	923.4	17396
GR 922.0	17475	922.2	17617	921.9	17734	923.1	17852	922.8	17948
GR 918.7	17979	919.4	18000	921.4	18028	918.7	18068	918.4	18251
GR 907.9	18287	907.9	18314	908.7	18436	910.8	18477	908.6	18584
GR 909.5	18770	912.0	18798	912.8	18990	913.2	19078	917.6	19127
GR 919.6	19184	915.2	19317	913.2	19434	913.2	19490	914.3	19532
GR 910.6	19612	911.2	19670	911.0	19745	909.8	19801	907.2	19819
GR 906.4	19913	907.2	20000	907.2	20266	915.6	20284	915.1	20404
GR 915.0	20513	915.0	20615	914.2	20649	911.5	20683	916.0	20739
GR 915.1	20840	915.2	20885	918.6	20917	914.4	20962	918.2	21027
GR 917.1	21091	918.3	21216	916.0	21300	916.3	21300	915.4	21397
GR 915.5	21479	917.8	21530	917.1	21573	912.3	21604	920.4	21615
GR 918.3	21714	918.0	21816	918.6	21879	914.3	21902	916.7	21933
GR 917.6	22014	918.4	22524	919.4	22992	919.4	23200	921.5	23212
GR 921.5	23243	919.2	23249	919.2	23264	921.8	23273	921.8	23288
GR 918.6	23303	920.3	23599	920.8	24236	921.4	24615	922.3	24800
GR 924.4	25116	924.8	25523	925.8	25903	927.4	25938	926.4	25965
GR 923.8	25982	925.0	26001	925.8	26025	925.9	26211	927.8	26371
GR 929.1	26521	929.8	26640	929.9	26770	930.0	26905	927.8	26931
GR 930.0	26941	929.5	26966	924.8	27033	923.5	27096	927.2	27205
X1190.95	100	18176	21968	1250	770	1066			
GR 933.6	17386	933.1	17444	931.1	17553	931.1	17707	929.1	17777
GR 928.4	17841	923.5	17900	922.0	17997	924.3	18089	924.4	18176
GR 921.0	18207	922.2	18245	920.7	18313	913.8	18338	916.8	18420
GR 917.6	18612	915.4	18674	909.4	18728	910.8	18844	912.2	18959
GR 913.5	19009	910.7	19171	914.6	19200	909.9	19215	909.6	19263
GR 907.1	19283	907.1	19383	913.1	19401	912.3	19527	912.2	19648
GR 910.8	19758	909.2	19802	906.3	19831	906.8	20000	906.8	20078

GR 909.8	20107	909.1	20175	910.2	20231	910.6	20355	906.7	20376
GR 906.7	20438	913.2	20462	919.4	20503	919.4	20544	918.0	20622
GR 917.5	20687	920.3	20719	919.2	20805	917.8	20881	916.7	21005
GR 918.4	21096	917.9	21152	913.0	21189	915.8	21229	915.4	21297
GR 914.7	21356	919.0	21373	919.0	21407	914.8	21422	916.8	21531
GR 916.7	21563	918.6	21581	916.7	21600	919.1	21656	918.0	21696
GR 919.0	21856	920.0	21968	919.1	22101	919.0	22200	918.6	22578
GR 920.0	22997	920.2	23432	920.4	23545	921.8	23598	918.2	23606
GR 918.2	23616	922.0	23626	921.4	23647	919.8	23681	921.2	24245
GR 922.0	24709	921.9	24885	923.9	25000	924.3	25133	926.0	25889
GR 926.0	26185	927.4	26214	928.2	26229	924.8	26242	928.0	26252
GR 930.2	26277	931.1	26424	931.9	26636	931.9	26924	931.9	27035
GR 929.2	27056	929.9	27071	929.9	27247	930.3	27299	927.6	27358
X1191.14	100	18575	21973	1000	1000	1045			
GR 944.5	17500	942.7	17673	941.5	17784	938.8	17928	937.8	17983
GR 923.4	18068	923.4	18218	922.3	18407	922.8	18549	921.5	18567
GR 923.1	18575	922.3	18636	916.8	18667	915.8	18734	917.8	18882
GR 922.3	18902	920.8	19023	907.2	19043	907.5	19349	913.1	19399
GR 917.1	19498	917.6	19566	916.0	19673	913.2	19738	912.3	19841
GR 912.2	19899	909.5	19931	911.6	19972	912.0	20001	913.4	20103
GR 907.0	20138	907.0	20259	909.1	20308	912.0	20368	909.6	20449
GR 906.4	20474	906.4	20507	910.6	20535	917.6	20567	917.6	20591
GR 921.8	20630	920.7	20752	919.5	20850	919.4	20915	918.6	21010
GR 918.2	21105	919.6	21207	919.2	21246	917.9	21287	919.9	21316
GR 916.6	21348	915.6	21386	921.0	21414	920.4	21469	918.7	21552
GR 919.9	21690	919.1	21825	919.0	21869	912.2	21884	912.3	21928
GR 913.6	21957	921.1	21973	918.4	22016	920.6	22039	920.0	22081
GR 920.8	22564	921.6	23382	921.8	23767	923.1	23781	922.2	23814
GR 922.7	23913	921.1	24357	921.1	24468	923.9	24481	923.9	24509
GR 917.4	24526	917.4	24541	924.4	24551	924.4	24579	921.6	24591
GR 921.6	24687	922.6	24838	922.6	24969	922.6	25092	923.4	25136
GR 922.7	25177	924.2	25300	925.1	25609	926.3	26136	926.4	26240
GR 927.1	26252	925.6	26279	927.1	26404	929.1	26416	929.1	26438
GR 926.6	26445	928.0	26455	930.0	26742	930.7	27121	931.5	27513
X1191.35	100	18606	22442	1080	1120	1082			
GR 946.0	17500	942.8	17731	941.8	17897	926.8	17952	926.4	18143
GR 925.1	18330	924.0	18480	925.2	18606	921.9	18659	922.0	18727
GR 917.4	18779	918.7	18814	916.7	18877	918.0	18965	915.9	19031
GR 909.1	19072	910.3	19624	914.3	19652	915.4	19738	915.9	19851
GR 916.7	19964	917.4	20000	916.0	20073	909.8	20097	912.7	20161
GR 913.5	20256	917.2	20282	916.3	20347	914.7	20393	915.8	20483
GR 912.0	20548	911.4	20597	914.7	20629	910.6	20672	910.6	20690
GR 908.8	20702	908.8	20737	911.8	20764	912.8	20841	922.3	20880
GR 920.7	20979	919.1	21117	918.4	21168	921.2	21286	919.8	21446
GR 915.1	21527	912.0	21606	915.1	21683	914.0	21770	917.8	21807
GR 918.8	21933	922.7	21986	923.5	22000	922.7	22068	922.0	22267
GR 919.8	22311	921.5	22365	924.4	22442	924.4	22522	921.9	22566
GR 921.9	22604	919.4	22636	922.7	22672	923.9	22760	921.0	22798
GR 922.8	23288	923.4	23857	925.9	23879	925.6	23903	926.2	23952
GR 925.5	24243	924.6	24492	923.8	24686	923.5	24905	923.5	25069
GR 923.5	25149	925.4	25162	917.9	25183	917.9	25194	924.2	25206
GR 924.6	25262	924.6	25400	925.8	25735	925.9	26134	925.6	26380
GR 928.2	26388	928.2	26451	929.1	26465	929.1	26487	931.6	26500
GR 932.6	26630	933.2	27006	933.2	27633	933.2	27787	931.1	27807
GR 931.6	27827	930.6	27888	931.4	28300	931.5	28666	931.6	29012
X1191.54	100	18611	22387	1020	960	986			
GR 967.5	16605	965.9	16683	959.6	16754	952.4	16841	947.7	16909
GR 953.6	17007	942.8	17075	940.1	17165	938.0	17191	941.7	17234
GR 939.2	17323	942.7	17441	942.7	17540	944.3	17616	943.3	17786
GR 940.7	17970	933.1	18034	925.4	18084	927.0	18194	927.6	18276

GR	927.2	18368	926.7	18438	925.9	18530	926.3	18611	926.3	18646
GR	925.2	18673	926.2	18711	927.1	18769	928.9	18836	927.9	18904
GR	925.6	18937	917.6	18975	920.3	19033	922.8	19063	914.3	19115
GR	914.6	19243	916.0	19356	915.6	19454	912.6	19476	914.4	19510
GR	918.8	19537	918.4	19628	920.3	19688	921.8	19767	921.5	19864
GR	915.2	19927	915.2	20000	915.4	20095	915.5	20141	915.5	20237
GR	917.9	20265	918.7	20359	918.8	20444	917.4	20527	917.4	20558
GR	911.0	20601	910.0	20640	915.8	20666	915.4	20718	918.0	20731
GR	918.6	20789	922.0	20807	920.0	20871	920.0	21016	923.4	21134
GR	924.0	21221	925.2	21333	925.0	21464	924.6	21535	923.9	21637
GR	925.1	21704	925.1	21817	915.8	21853	916.0	21941	915.4	22000
GR	917.5	22139	918.8	22180	923.1	22212	924.2	22300	926.3	22387
GR	922.6	22464	924.6	22525	926.6	22661	928.0	22761	923.5	22811
GR	924.0	22864	924.7	22916	925.2	23274	925.2	23633	925.8	23901
GR	929.3	23917	928.8	23972	927.6	24090	927.1	24101	928.0	24339
GR	926.2	24710	925.4	24859	925.2	25185	925.8	25266	922.2	25277
X1191.68		100	18599	22797	750	780	772			
GR	956.5	16418	954.3	16431	956.8	16467	955.7	16582	956.9	16665
GR	956.4	16693	949.7	16718	951.5	16762	952.1	16815	950.9	17008
GR	952.1	17057	952.5	17195	952.0	17314	948.1	17435	942.5	17516
GR	941.2	17574	940.8	17681	941.1	17717	939.2	17769	938.5	17860
GR	936.0	17994	932.1	18056	932.3	18177	929.9	18358	929.1	18496
GR	928.7	18599	927.1	18698	922.2	18729	921.8	18858	922.3	18953
GR	920.7	19002	923.0	19123	925.6	19228	916.0	19284	915.8	19344
GR	915.8	19491	917.6	19622	918.3	19704	919.8	19819	919.8	19944
GR	915.6	19963	915.6	20005	915.1	20294	916.3	20322	917.0	20409
GR	920.6	20446	920.7	20518	923.1	20600	925.4	20648	927.3	20732
GR	919.9	20839	920.8	20871	923.1	20892	919.6	20953	920.6	21027
GR	921.6	21082	926.4	21115	924.3	21225	924.7	21318	926.6	21385
GR	928.4	21532	927.5	21590	925.6	21614	927.1	21717	926.4	21754
GR	923.8	21794	923.2	21849	925.6	21903	926.3	22010	925.2	22106
GR	927.9	22214	922.8	22286	921.1	22389	917.2	22426	917.2	22478
GR	920.2	22520	916.8	22576	918.2	22648	917.4	22754	926.7	22797
GR	926.8	22968	926.8	23437	927.6	23931	931.6	23945	930.1	23964
GR	931.1	23981	929.7	24037	928.4	24110	928.0	24374	926.4	24671
GR	926.6	24867	925.5	25168	927.3	25297	923.2	25312	928.3	25329
GR	928.8	25364	926.2	25372	927.5	25402	928.4	25904	928.4	26431
X1191.84		100	18461	22916	800	800	802			
GR	972.3	16068	969.9	16216	967.5	16365	963.2	16549	959.5	16584
GR	958.8	16698	962.7	16729	959.5	16860	956.9	16966	955.6	17045
GR	952.5	17063	952.4	17149	951.3	17279	952.3	17344	948.3	17580
GR	949.3	17653	948.4	17770	944.8	17959	942.7	18037	938.9	18110
GR	933.1	18169	930.1	18237	929.5	18358	928.3	18461	926.8	18531
GR	923.4	18595	922.7	18667	924.0	18736	923.0	18798	927.2	18838
GR	926.8	18894	924.0	18912	926.4	18933	925.9	19017	917.2	19053
GR	915.6	19093	917.6	19192	919.1	19258	919.4	19337	919.6	19416
GR	921.1	19527	922.4	19625	921.5	19771	919.4	19895	915.5	20001
GR	915.8	20040	916.0	20086	915.0	20099	915.0	20267	916.4	20285
GR	914.0	20332	916.0	20445	918.4	20553	919.5	20601	923.6	20651
GR	926.3	20691	920.3	20737	924.0	20803	926.7	20880	925.9	20978
GR	921.4	21050	921.5	21134	922.7	21233	927.7	21250	926.8	21326
GR	923.9	21372	920.2	21399	927.0	21459	927.2	21558	927.5	21654
GR	926.0	21663	925.8	21723	928.5	21765	927.7	21826	925.2	21870
GR	925.5	21970	927.5	22022	926.6	22159	925.6	22295	925.1	22486
GR	921.2	22501	920.2	22586	919.4	22644	920.0	22689	918.2	22828
GR	928.1	22916	928.5	23204	927.7	23857	928.1	23963	932.1	23972
GR	932.3	24012	928.5	24048	928.4	24102	927.2	24638	927.6	24853
GR	928.0	25156	928.7	25322	924.0	25342	928.5	25354	927.5	25406
X1192.01		100	18593	22673	958	958	958			
GR	971.3	16599	969.2	16716	967.6	16754	955.7	16862	952.5	16897

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GR 952.7	16927	953.6	16962	951.5	17002	952.5	17047	951.6	17135
GR 952.1	17193	951.2	17329	950.7	17447	949.1	17563	946.9	17656
GR 945.2	17738	946.0	17806	944.1	17862	931.7	17920	929.7	17955
GR 931.2	18058	930.7	18171	929.7	18227	931.7	18309	930.0	18349
GR 932.3	18399	930.7	18426	931.2	18485	932.1	18563	933.9	18593
GR 932.3	18639	932.3	18665	923.4	18710	927.0	18766	928.0	18795
GR 926.6	18836	925.1	18892	926.7	18930	928.0	18964	929.2	19037
GR 927.1	19083	928.4	19106	927.3	19127	929.2	19152	930.1	19213
GR 918.8	19267	919.1	19323	918.8	19430	918.6	19551	917.9	19699
GR 917.2	19769	917.2	19820	915.0	19830	915.0	19994	917.0	20006
GR 919.4	20060	920.6	20137	921.8	20239	923.8	20258	922.7	20307
GR 924.7	20367	924.2	20405	922.3	20438	924.8	20488	929.6	20525
GR 927.3	20562	927.0	20616	924.8	20686	927.7	20701	927.9	20801
GR 924.2	20898	925.6	20991	926.7	21119	924.0	21202	921.9	21268
GR 921.1	21344	919.4	21383	922.3	21445	918.6	21496	918.6	21544
GR 923.0	21579	923.0	21625	932.3	21669	930.5	21765	928.1	21886
GR 929.3	21967	923.8	22019	926.6	22106	925.0	22307	924.0	22409
GR 921.8	22476	918.4	22488	918.4	22514	920.6	22527	919.1	22636
GR 929.7	22673	930.4	22834	930.0	23498	930.7	23995	931.7	24031
X1192.18	100	18797	22165	870	870	872			
GR 973.2	16131	972.8	16209	971.2	16294	962.8	16364	965.3	16428
GR 966.1	16460	952.5	16549	957.9	16617	960.7	16700	950.9	16783
GR 946.9	16830	945.5	16919	944.9	17013	942.8	17126	942.8	17172
GR 940.9	17256	940.3	17375	938.4	17449	938.9	17519	937.7	17615
GR 935.6	17642	935.2	17741	934.8	17796	937.9	17835	936.9	17886
GR 933.5	17960	932.5	18060	932.5	18138	931.7	18244	932.4	18297
GR 932.5	18386	933.6	18423	933.1	18473	932.7	18513	933.6	18570
GR 930.9	18664	930.1	18728	930.8	18748	930.0	18771	932.3	18797
GR 927.1	18816	926.3	18887	917.4	18932	917.4	19115	919.8	19156
GR 918.4	19275	918.4	19322	916.2	19337	916.2	19384	920.0	19424
GR 919.9	19480	922.4	19520	918.2	19535	926.3	19588	926.7	19615
GR 926.2	19658	926.2	19744	926.3	19800	924.7	19826	927.5	19875
GR 927.5	19929	928.8	19999	928.9	20002	924.7	20022	924.3	20080
GR 926.8	20123	927.3	20205	926.2	20274	923.0	20304	923.9	20334
GR 923.0	20365	922.7	20409	919.2	20472	928.3	20497	927.3	20574
GR 925.4	20594	929.5	20622	928.5	20649	923.4	20669	924.6	20690
GR 927.1	20700	929.7	20732	928.4	20773	924.6	20801	926.3	20840
GR 927.3	20895	927.1	21031	928.5	21098	929.6	21183	931.2	21299
GR 930.4	21403	925.1	21468	921.0	21518	921.0	21644	920.8	21759
GR 923.5	21803	924.4	21910	923.0	22009	920.6	22076	922.4	22165
X1192.34	100	18496	21728	823	823	823			
GR 950.8	16000	948.7	16027	949.7	16066	950.8	16091	950.3	16138
GR 947.9	16362	945.2	16482	944.3	16572	943.8	16608	945.3	16626
GR 945.5	16923	944.5	17065	943.2	17175	942.3	17353	941.5	17499
GR 938.8	17718	936.8	17957	933.8	18212	932.6	18320	933.1	18385
GR 933.2	18496	916.6	18543	916.6	18720	919.2	18771	919.9	18954
GR 920.8	19115	923.6	19136	925.4	19209	926.3	19244	926.2	19280
GR 927.8	19436	928.8	19558	923.8	19594	927.8	19621	927.0	19761
GR 927.2	19864	927.5	19989	926.2	20029	927.9	20094	922.0	20169
GR 923.5	20220	927.1	20239	925.6	20366	926.6	20472	926.0	20576
GR 924.6	20600	925.0	20691	923.9	20713	925.8	20748	927.8	20813
GR 931.5	20916	926.7	20946	929.9	21023	930.7	21081	928.3	21154
GR 931.5	21179	929.0	21293	920.2	21329	920.2	21414	920.4	21552
GR 919.5	21669	929.9	21728	925.5	21743	928.6	21894	929.6	22077
GR 930.3	22278	930.8	22573	931.0	22872	930.8	23171	930.3	23449
GR 930.4	23873	931.2	24034	935.3	24055	932.7	24072	932.7	24097
GR 930.3	24112	930.7	24276	930.2	24499	930.7	24681	930.4	24743
GR 929.6	24917	929.6	25149	929.6	25344	930.0	25381	924.3	25402
GR 924.3	25414	930.3	25427	931.9	25468	932.2	25556	932.7	25924
GR 933.1	26473	933.4	26636	931.4	26645	931.4	26666	930.0	26682

GR 931.0	27028	931.1	27669	931.2	27700	932.8	27942	933.1	27984
X1192.49	100	18302	21548	800	850	818			
GR 961.2	16000	962.4	16043	961.7	16119	958.7	16144	962.1	16172
GR 962.3	16213	960.0	16252	961.7	16290	959.2	16315	960.7	16338
GR 959.3	16434	956.9	16624	952.1	16946	946.8	17285	944.1	17489
GR 942.0	17617	940.6	17759	939.8	17867	937.4	18031	935.4	18209
GR 933.2	18302	915.9	18341	916.7	18460	918.6	18487	920.0	18595
GR 921.4	18756	925.1	18786	927.5	18861	930.2	18954	932.2	18994
GR 926.8	19027	931.9	19038	931.4	19111	933.6	19160	929.5	19228
GR 929.5	19272	927.9	19315	933.8	19347	930.6	19386	933.4	19424
GR 928.4	19514	931.9	19534	931.4	19698	932.3	19829	930.4	19900
GR 928.3	19956	923.1	19978	923.8	20000	924.2	20037	928.4	20057
GR 927.2	20115	928.8	20163	928.2	20228	929.1	20258	929.1	20320
GR 927.6	20375	925.4	20406	930.0	20455	930.0	20506	929.2	20586
GR 930.0	20600	931.0	20655	931.2	20701	932.2	20848	929.9	21108
GR 921.2	21128	921.2	21209	922.3	21230	923.1	21285	921.8	21309
GR 923.5	21518	934.9	21548	932.7	21574	931.6	21692	934.1	21992
GR 935.0	22529	935.4	22885	935.0	23223	935.0	23560	934.5	23761
GR 935.0	23951	935.1	24028	936.1	24041	934.3	24076	932.7	24104
GR 932.3	24143	931.0	24503	930.6	24700	929.9	24954	929.5	25196
GR 931.4	25352	932.2	25417	932.7	25441	930.8	25517	933.0	25931
GR 933.1	26319	933.0	26446	933.9	26649	934.1	26962	933.9	27376
X1192.62	100	18141	21438	600	650	657			
GR 980.9	16000	977.1	16151	968.0	16283	968.5	16355	971.7	16436
GR 964.9	16530	959.1	16666	958.8	16729	957.6	16765	960.4	16820
GR 962.0	16885	958.0	16978	954.1	17122	950.1	17245	947.1	17389
GR 947.1	17458	947.9	17472	946.8	17557	944.8	17689	943.0	17830
GR 932.3	17868	929.2	17918	929.9	18022	929.6	18112	932.4	18128
GR 929.9	18141	931.8	18182	924.4	18252	917.0	18265	917.0	18334
GR 921.6	18382	920.4	18418	918.6	18454	918.6	18503	921.2	18541
GR 922.3	18673	923.5	18731	921.5	18784	925.4	18803	926.0	18836
GR 932.0	18857	933.0	18956	932.6	19067	932.4	19190	934.6	19282
GR 934.0	19387	933.8	19542	933.8	19706	933.8	19767	932.6	19808
GR 924.3	19821	926.2	19933	933.0	19949	932.7	19989	932.8	20000
GR 931.6	20045	931.4	20156	932.8	20234	931.9	20320	933.6	20369
GR 932.3	20410	932.6	20504	933.4	20551	933.0	20600	931.8	20640
GR 933.1	20716	929.4	20837	929.6	20883	934.0	20900	932.6	21095
GR 920.2	21111	921.1	21149	921.6	21277	922.0	21351	923.1	21409
GR 930.6	21438	932.6	21607	934.0	21902	934.5	22302	935.0	22595
GR 934.1	22888	934.0	23059	933.5	23186	933.6	23431	933.5	23704
GR 932.8	23933	933.0	24011	937.5	24020	935.5	24041	935.6	24061
GR 933.5	24097	933.4	24100	933.2	24247	934.3	24577	933.2	24874
GR 933.0	25145	933.0	25309	934.7	25361	927.1	25383	933.9	25400
X1192.74	100	18275	21502	650	630	630			
GR 984.0	16000	980.7	16136	974.1	16392	968.3	16578	968.7	16618
GR 967.2	16643	967.5	16706	975.3	16798	982.1	16852	977.3	16927
GR 962.4	17049	960.5	17092	954.9	17124	951.3	17224	952.7	17249
GR 960.5	17292	960.5	17313	950.1	17349	947.6	17382	947.3	17465
GR 949.3	17492	948.1	17531	935.0	17578	932.8	17622	932.7	17742
GR 931.9	17833	931.1	17933	931.1	18045	931.9	18144	932.7	18275
GR 925.5	18328	925.2	18441	918.8	18489	918.8	18618	921.8	18746
GR 922.3	18835	923.4	18919	927.6	18985	926.3	19029	925.9	19097
GR 925.8	19157	932.3	19200	932.2	19237	933.9	19279	932.0	19388
GR 932.6	19473	933.9	19543	933.9	19632	922.3	19668	922.3	19684
GR 931.5	19721	926.3	19761	926.3	19801	932.0	19831	931.1	19883
GR 933.5	19989	932.7	20000	931.6	20031	933.5	20256	933.6	20330
GR 933.6	20429	933.0	20492	932.2	20546	930.3	20581	932.3	20600
GR 934.3	20649	934.0	20724	935.2	20808	934.3	20979	929.1	21036
GR 926.6	21084	927.8	21113	925.9	21129	927.1	21182	921.6	21233
GR 921.6	21296	922.2	21384	920.4	21408	920.4	21454	933.4	21502

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GR 935.5	21547	935.5	21643	935.9	21831	935.5	22077	935.7	22378
GR 935.9	22441	935.9	22608	936.5	22694	936.1	22793	936.4	22895
GR 935.5	22925	935.6	22958	935.0	23090	934.7	23265	934.9	23375
GR 934.8	23501	935.2	23715	936.1	23818	936.2	23972	938.7	23993
X1192.90	100	18639	21672	950	860	860			
GR 973.7	16000	971.5	16071	966.8	16104	972.4	16132	969.5	16230
GR 967.7	16287	967.7	16446	965.1	16569	966.1	16597	964.3	16624
GR 964.0	16673	960.0	16853	957.9	16987	956.9	17163	956.3	17204
GR 949.3	17256	948.7	17328	954.1	17363	951.7	17506	947.5	17826
GR 944.7	18065	943.6	18108	945.9	18149	945.9	18186	942.3	18236
GR 940.7	18386	936.4	18568	934.6	18639	933.0	18674	929.0	18716
GR 927.8	18757	923.0	18806	923.0	18850	919.4	18869	921.0	18982
GR 923.2	19000	924.0	19105	927.8	19156	927.9	19208	927.0	19255
GR 929.1	19302	927.4	19364	927.6	19426	926.3	19483	925.4	19582
GR 924.6	19645	925.9	19688	924.2	19708	934.0	19744	934.0	19841
GR 932.7	19947	934.4	20000	934.4	20143	934.0	20215	933.2	20314
GR 931.9	20392	934.8	20417	934.5	20477	935.7	20553	935.3	20663
GR 937.3	20760	937.2	20858	925.9	20908	928.3	20958	926.7	21011
GR 931.6	21063	929.1	21137	925.2	21180	927.1	21227	930.6	21247
GR 930.4	21293	925.8	21361	922.4	21397	922.4	21456	925.5	21497
GR 922.0	21532	924.2	21611	937.9	21642	937.2	21672	936.8	22068
GR 936.5	22618	936.5	22876	935.7	22974	935.9	23213	936.1	23458
GR 937.0	23697	937.5	23805	937.5	23895	939.7	24000	937.7	24038
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X1193.08	100	18514	21504	780	730	930			
GR 986.3	15800	980.9	15911	974.0	16060	969.3	16130	968.1	16187
GR 963.2	16230	968.0	16249	964.8	16313	962.3	16336	962.7	16370
GR 962.0	16391	963.9	16442	962.1	16494	962.7	16576	961.7	16633
GR 960.1	16650	961.3	16693	959.9	16754	956.8	16822	958.1	16879
GR 955.7	16944	962.1	16960	952.1	17036	950.4	17105	950.3	17227
GR 950.0	17387	949.6	17508	949.6	17643	951.2	17724	953.2	17775
GR 958.3	17841	962.0	17873	946.4	17944	945.1	18071	940.7	18279
GR 938.4	18417	935.9	18514	928.4	18608	931.6	18691	926.7	18729
GR 928.8	18750	929.9	18823	928.2	18905	924.6	18930	928.6	18996
GR 927.8	19078	922.3	19153	922.3	19192	924.8	19242	921.4	19274
GR 921.4	19359	924.7	19415	927.5	19513	927.4	19590	925.8	19645
GR 925.2	19691	927.9	19743	930.0	19832	936.8	19859	936.0	19896
GR 936.0	19944	936.8	20000	936.2	20083	934.2	20100	935.5	20304
GR 937.5	20412	936.7	20480	937.9	20555	934.9	20603	934.8	20644
GR 928.8	20674	930.7	20750	929.8	20823	931.5	20846	931.5	20933
GR 931.0	21057	925.2	21132	926.8	21216	923.2	21234	923.2	21309
GR 929.2	21341	925.5	21401	927.0	21446	937.2	21476	938.7	21504
GR 937.1	21531	937.9	21998	938.1	22501	939.6	23087	939.6	23599
GR 940.0	23695	941.6	23722	941.7	23747	939.9	23765	939.6	23800
GR 938.7	24005	938.3	24945	939.7	25000	930.0	25015	939.2	25040
X1193.25	100	18203	21160	940	840	940			
GR 987.5	16171	978.8	16233	980.1	16261	974.9	16325	970.4	16423
GR 968.1	16492	964.0	16537	957.7	16626	955.9	16755	954.9	16835
GR 953.9	16891	951.9	17021	950.1	17117	950.0	17228	948.9	17319
GR 949.2	17351	947.5	17413	948.4	17470	950.8	17523	950.8	17624
GR 950.7	17695	953.6	17764	961.6	17830	960.8	17859	944.7	17912
GR 943.4	17949	943.1	18051	942.0	18158	941.5	18203	940.8	18294
GR 938.7	18328	931.4	18377	928.8	18404	933.8	18478	931.8	18536
GR 930.7	18593	931.0	18676	930.8	18754	932.4	18868	934.0	18958
GR 934.8	19046	929.9	19070	927.1	19121	929.0	19201	923.9	19221
GR 923.9	19243	936.8	19272	937.1	19323	938.3	19380	932.0	19430
GR 925.9	19452	925.9	19522	930.6	19547	930.6	19617	928.7	19649
GR 930.2	19697	930.0	19752	925.2	19778	925.2	19943	930.0	19984
GR 930.8	20000	927.4	20036	930.4	20053	928.3	20145	929.6	20318

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GR 931.2   20467   930.8   20530   933.0   20629   930.0   20700   929.6   20748
GR 928.2   20840   923.1   20859   924.4   20929   929.6   21001   929.6   21115
GR 938.5   21160   939.5   21485   940.4   22005   941.5   22615   941.7   22825
GR 941.9   23091   941.6   23320   943.2   23383   942.9   23415   941.1   23442
GR 941.3   23500   939.1   23860   938.8   24392   938.8   24640   940.1   24658
GR 930.2   24678   940.3   24702   938.7   24745   938.7   24846   937.7   24939
GR 938.9   25779   940.4   25986   941.2   26008   939.2   26036   940.4   26557
X1 193.4      90   19071   22421     770     790     790
GR 973.5   18410   953.1   18509   939.0   18531   937.2   18590   934.6   18619
GR 928.2   18670   929.4   18723   929.3   18833   930.0   18860   932.8   18893
GR 931.8   18958   932.2   19071   927.3   19087   927.3   19150   927.7   19262
GR 930.0   19363   930.5   19415   931.4   19456   936.5   19496   936.6   19500
GR 937.4   19549   934.2   19598   926.1   19625   927.0   19669   927.3   19717
GR 926.9   19805   927.4   19956   931.2   19974   932.5   20064   932.0   20164
GR 927.3   20197   926.9   20252   928.6   20354   927.4   20394   927.4   20422
GR 929.4   20438   930.9   20499   926.8   20508   926.8   20633   933.3   20657
GR 930.9   20749   928.8   20803   930.1   20823   928.6   20907   927.0   20965
GR 926.8   21015   928.4   21024   928.5   21084   928.8   21160   933.3   21202
GR 934.4   21237   937.4   21253   937.4   21614   938.4   21926   939.2   22228
GR 940.5   22421   940.9   22690   941.4   22970   941.6   23000   942.5   23195
GR 943.0   23296   942.0   23351   941.0   23601   940.4   24095   939.0   24544
GR 940.5   24573   941.4   24593   931.6   24608   940.6   24631   939.0   24688
GR 939.0   24749   939.4   24939   939.7   25366   938.5   25784   940.2   25927
GR 939.7   26000   940.5   26088   941.6   26717   942.0   27171   942.0   27270
GR 945.8   28722   945.2   29193   944.8   29631   945.4   29797   948.4   29817
GR 951.3   29855   951.3   29891   954.5   29923   952.6   29941   954.2   30000
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GR 932.9   18634     930   18765   928.5   18959   928.5   21059   929.4   21189
GR 932.1   21266   938.1   21394   940.2   21609   940.5   21907     942   22272
GR 943.2   22586     944   22872   942.9   23000   944.2   23181   944.1   23336
GR 942.5   23522   941.7   23911   941.7   24246     941   24585   940.8   24877
GR   941   25198   940.5   25488   941.6   25719   941.1   25965   941.7   26000
GR 942.6   26091     944   26377   944.1   26708   944.6   27080   945.2   27388
GR 945.8   27802   946.1   28150     946   28473   946.8   28585     947   28962
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*
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GR 940.0  8720.0  936.00  8750.0  932.00  8815.0  932.00  9150.0  932.00  9270.0
GR 930.8 10030.0  930.60 10830.0  932.00 11135.0  936.00 11310.0  940.00 11480.0
GR 940.6 11630.0  942.60 12425.0  943.60 13230.0  940.40 14010.0  940.30 14800.0
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X1  .197      12  9600.0 11410.0   500.0   500.0   500.0
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GR938.57  7970.0  938.50  8135.0  932.00  9220.0   932.0  9280.0  936.00  9380.0
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GR948.00 11550.0  944.00 11560.0  940.80 12170.0   944.0  12600.  944.00  13360.
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GR 940.0 11430.0  944.00 11440.0  944.00 13420.0  944.00 13700.0  944.00 14840.0
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QT     1  18447.
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GR936.00 10150.0  940.00 10210.0  944.00 10350.0  944.00 10530.0   940.0  10630.
GR936.00 10680.0  936.00 11205.0  940.00 11215.0  944.00 11230.0   944.0  12470.
GR948.00 13360.0
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GR956.00 15230.0
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GR 952.0 10750.0  956.00 10760.0  956.00 10770.0  952.00 10800.0  952.00 11745.0
GR 950.5 11830.0  952.00 12730.0  952.00 13455.0  950.50 13690.0  952.00 14600.0
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GR940.00  9230.0  940.00  9570.0   944.0  9650.0  948.00  9760.0  948.00  9900.0
GR944.00  9940.0  948.00  9970.0   952.0 10000.  952.00 10115.  948.00 10250.
GR944.00 10390.0  940.00 10435.0   940.0 10740.  944.00 10830.  948.00 10940.
GR948.00 10990.0  944.00 11360.0   940.0 11670.  944.00 11720.  948.00 11740.
GR952.00 11750.0  952.50 12410.0   953.2 12920.  956.00 13360.
X1 1.712      32  8745.0 11855.0   550.0   410.0   495.0
GR956.00  7920.0  952.00  7960.0  948.00  8090.0  948.00  8745.0   944.0  8800.0
GR940.00  8820.0  940.00  8900.0  944.00  9280.0  944.00  9530.0   948.0  9760.0
GR952.00  9880.0  952.00 10180.0  948.00 10210.0  944.00 10230.0   944.0 10520.
GR940.00 10540.0  940.00 10770.0  944.00 10830.0  948.00 11160.0   948.0 11430.
GR944.00 11570.0  944.00 11640.0  940.00 11770.0  940.00 11799.0   944.0 11820.
GR948.00 11840.0  952.00 11855.0  954.00 11960.0  953.40 12360.0   952.8 12670.
GR954.50 12935.0  956.00 14600.0
X1 1.807      28  8600.0 11900.0   610.0   360.0   500.0
GR 956.0  4690.0  956.00  7925.0  952.00  7935.0  948.00  8385.0  944.00  8600.0
GR 944.0  8890.0  948.00  9020.0  944.00  9250.0  944.00  9400.0  948.00  9435.0
GR 948.0  9785.0  952.00  9940.0  952.00 10200.0  948.00 10250.0  948.00 10630.0
GR 944.0 10645.0  944.00 10840.0  948.00 11070.0  948.00 11460.0  944.00 11700.0
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GR 940.0 11800.0  944.00 11860.0  948.00 11880.0  952.00 11900.0  954.30 12050.0
GR 953.3 12480.0  954.30 12950.0  956.00 14570.0
X1 1.902      26  8730.0 11765.0   460.0   555.0   500.0
GR 956.0  4900.0  956.00  7050.0  960.00  7985.0  956.00  8020.0  952.00  8030.0
GR 948.0  8240.0  948.00  8730.0  944.00  8750.0  948.00  8980.0  948.00  9275.0
GR 944.0  9350.0  948.00  9495.0  948.00  9755.0  952.00  9950.0  952.00 10030.0
GR 948.0 10265.0  948.00 10780.0  944.00 10830.0  944.00 10990.0  948.00 11190.0
GR 948.0 11415.0  944.00 11540.0  944.00 11720.0  948.00 11755.0  952.00 11765.0
GR 956.0 12790.0
X1 2.015      28  9100.0 11600.0   585.0   650.0   600.0
GR 956.0  6685.0  956.00  7180.0  960.00  7825.0  960.00  8040.0  956.00  8065.0
GR 954.0  8700.0  952.00  8760.0  952.00  8860.0  948.00  8930.0  948.00  9100.0
GR 948.0  9435.0  948.00  9610.0  952.00 10000.0  956.00 10075.0  956.00 10225.0
GR 952.0 10290.0  948.00 10730.0  948.00 10760.0  952.00 10850.0  952.00 10940.0
GR 944.0 10980.0  944.00 11135.0  944.00 11240.0  944.00 11450.0  948.00 11550.0
GR 956.0 11600.0  956.00 12130.0  960.00 13355.0
X1 2.110      31  9300.0 11400.0   420.0   560.0   500.0
GR 960.0  7790.0  960.00  7890.0  956.00  8025.0  954.00  8550.0  954.00  8880.0
GR 952.0  8910.0  952.00  9030.0  948.00  9040.0  948.00  9110.0  952.00  9210.0
GR 952.0  9300.0  952.00  9500.0  948.00  9510.0  948.00  9655.0  952.00  9705.0
GR 951.0  9770.0  952.00 10330.0  948.00 10455.0  948.00 10570.0  949.70 10670.0
GR 952.0 10780.0  952.00 10950.0  948.00 11000.0  944.00 11040.0  944.00 11250.0
GR 948.0 11310.0  952.00 11340.0  956.00 11400.0  956.40 11750.0  957.10 12125.0
GR 960.0 12355.0
X1 2.205      20  9350.0 11200.0   515.0   500.0   505.0
GR 960.0  7710.0  960.00  7950.0  956.00  7980.0  954.00  8100.0  954.00  8650.0
GR 956.0  8740.0  956.00  9025.0  954.00  9090.0  952.00  9130.0  952.00  9350.0
GR 952.0  9760.0  952.00 10310.0  948.00 10630.0  948.00 10845.0  944.00 10875.0
GR 944.0 11030.0  948.00 11140.0  952.00 11160.0  956.00 11200.0  960.00 12240.0
X1 2.299      21  9425.0 11090.0   495.0   500.0   495.0
GR 960.0  7930.0  956.00  7960.0  954.00  8090.0  954.00  8680.0  956.00  8750.0
GR 956.0  8970.0  956.00  9110.0  954.00  9160.0  952.00  9425.0  952.00  9720.0
GR 956.0  9755.0  956.00  9865.0  952.00 10120.0  948.00 10355.0  948.00 10700.0
GR 944.0 10755.0  944.00 10855.0  948.00 11050.0  952.00 11080.0  956.00 11090.0
GR 960.0 12080.0
X1 2.394      15  9290.0 11215.0   490.0   500.0   500.0
GR 964.0  8105.0  960.00  8110.0  956.00  8120.0  954.00  8580.0  954.00  8705.0
GR 952.0  9290.0  952.00  9820.0  952.00 10090.0  952.00 10730.0  948.00 10750.0
GR 948.0 10975.0  952.00 11010.0  952.00 11120.0  956.00 11215.0  960.00 11770.0
X1 2.489      28  9310.0 11270.0   475.0   515.0   500.0
GR 964.0  7695.0  964.00  7980.0  960.00  8000.0  956.00  8030.0  956.00  8185.0
GR 960.0  8295.0  960.00  8355.0  956.00  8540.0  954.00  8600.0  954.00  8875.0
GR 952.0  9310.0  952.00  9355.0  956.00  9405.0  956.00  9535.0  952.00  9580.0
GR 956.0  9820.0  956.00 10060.0  952.00 10160.0  952.00 10320.0  952.00 10775.0
GR 948.0 10830.0  948.00 10970.0  952.00 11005.0  952.00 11235.0  956.00 11270.0
GR 960.0 11320.0  960.00 11770.0  964.00 11980.0
X1 2.586      24  9315.0 11290.0   535.0   485.0   515.0
GR 964.0  7460.0  964.00  7840.0  960.00  7955.0  960.00  8250.0  960.00  8700.0
GR 956.0  8845.0  954.00  8920.0  954.00  8980.0  954.00  9315.0  952.00  9420.0
GR 952.0  9870.0  952.00 10180.0  956.00 10220.0  956.00 10305.0  952.00 10580.0
GR 948.0 10650.0  952.00 10700.0  952.00 10765.0  948.00 10920.0  948.00 11050.0
GR 952.0 11250.0  956.00 11290.0  960.00 11670.0  964.00 11905.0
X1 2.679      36  9280.0 11675.0   570.0   425.0   490.0
GR 964.0  6600.0  964.00  7885.0  960.00  7975.0  960.00  8290.0  960.00  8640.0
GR 956.0  8740.0  954.00  8760.0  956.00  8860.0  956.00  9150.0  960.00  9200.0
GR 960.0  9280.0  956.00  9345.0  952.00  9390.0  956.00  9620.0  956.00  9665.0
GR 952.0  9740.0  952.00 10080.0  956.00 10155.0  956.00 10265.0  948.00 10300.0
GR 948.0 10675.0  948.00 10760.0  960.00 10800.0  972.00 10825.0  972.00 10870.0
GR 960.0 10885.0  948.00 10960.0  948.00 11050.0  952.00 11245.0  952.00 11340.0
GR 948.0 11370.0  948.00 11590.0  952.00 11650.0  960.00 11675.0  964.00 11690.0
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GR 964.0 11835.0
X1 2.775      30  8855.0 11735.0   525.0   485.0   505.0
GR 964.3  7470.0 1014.30  7470.0  964.30  7470.0  964.00  7760.0  960.00  8305.0
GR 960.0  8360.0  956.00  8725.0  954.00  8750.0  956.00  8855.0  956.00  9280.0
GR 956.0  9720.0  952.00  9770.0  952.00  9840.0  952.00 10010.0  956.00 10150.0
GR 960.0 10200.0  960.00 10310.0  964.00 10370.0  960.00 10425.0  956.00 10515.0
GR 956.0 10570.0  960.00 10630.0  960.00 11130.0  970.40 11180.0  960.00 11210.0
GR 952.0 11440.0  952.00 11620.0  956.00 11680.0  960.00 11700.0  964.00 11735.0
X1 2.869      29  8530.0 11770.0   495.0   500.0   500.0
GR968.00  7430.0  964.00  7640.0  964.00  8175.0  960.00  8215.0   960.0  8300.0
GR964.00  8505.0  964.00  8530.0  960.00  8565.0  956.00  8645.0   956.0  8730.0
GR960.00  9100.0  960.00  9145.0  956.00  9200.0  956.00  9220.0   960.0  9260.0
GR960.00  9410.0  956.00  9680.0  952.00  9845.0  952.00 10045.0   956.0  10130.
GR960.00 10390.0  964.00 10600.0  964.00 11050.0  960.00 11380.0   956.0  11445.
GR952.00 11640.0  952.00 11710.0  960.00 11750.0  964.00 11770.0
X1 2.964      26  8555.0 11815.0   455.0   520.0   500.0
GR968.00  7420.0  964.00  7610.0  964.00  8080.0  960.00  8195.0   960.0  8280.0
GR964.00  8390.0  964.00  8555.0  960.00  8605.0  956.00  8650.0   956.0  8740.0
GR960.00  9010.0  960.00  9340.0  956.00  9480.0  956.00  9600.0   952.0  9725.0
GR952.00  9985.0  956.00 10025.0  960.00 10060.0  964.00 10390.0   964.0  10570.
GR960.00 11005.0  956.00 11370.0  956.00 11630.0  952.00 11700.0   952.0  11780.
GR976.00 11815.0
X1 3.059      24  8700.0 11810.0   500.0   500.0   500.0
GR969.20  7260.0  968.00  7290.0  964.00  7900.0  960.00  8170.0   960.0  8700.0
GR956.00  8885.0  956.00  9140.0  952.00  9410.0  952.00  9470.0   956.0  10045.
GR960.00 10295.0  960.00 10720.0  960.00 11295.0  956.00 11405.0   952.0  11560.
GR952.00 11625.0  956.00 11675.0  960.00 11755.0  976.00 11810.0   980.0  11920.
GR980.00 12000.0  972.00 12050.0  968.00 12280.0  968.00 12545.0
X1 3.153      22  8545.0 11370.0   420.0   560.0   500.0
GR970.00  7200.0  968.00  7370.0  964.00  7670.0  964.00  7980.0   960.0  8010.0
GR960.00  8150.0  964.00  8295.0  968.00  8425.0  968.00  8545.0   964.0  8570.0
GR960.00  8620.0  960.00  8710.0  956.00  8760.0  956.00  9075.0   960.0  9300.0
GR960.00  9700.0  960.00 10370.0  960.00 11135.0  956.00 11150.0   956.0  11330.
GR964.00 11350.0  968.00 11370.0
X1 3.248      30  8560.0 11240.0   480.0   520.0   500.0
GR971.20  7125.0  968.00  7450.0  964.00  7675.0  964.00  7900.0   960.0  7940.0
GR960.00  8035.0  964.00  8085.0  964.00  8270.0  968.00  8460.0   968.0  8560.0
GR964.00  8600.0  960.00  8640.0  960.00  8740.0  956.00  8790.0   956.0  9020.0
GR960.00  9190.0  960.00  9330.0  960.00  9755.0  960.00  9865.0   956.0  10180.
GR956.00 10540.0  960.00 10560.0  964.00 10610.0  964.00 10665.0   960.0  11010.
GR956.00 11025.0  956.00 11185.0  960.00 11220.0  964.00 11230.0   968.0  11240.
X1 3.343      20  8620.0 11190.0   530.0   522.0   500.0
GR964.00  7300.0  964.00  7770.0   968.0  7800.0  964.00  7820.0  964.00  8080.0
GR968.00  8320.0  968.00  8620.0   964.0  8655.0  960.00  8765.0  956.00  8800.0
GR956.00  8960.0  960.00  9195.0   964.0  9330.0  960.00  9370.0  960.00  9860.0
GR960.00 10380.0  956.00 10560.0   956.0  11110.  968.00  11150.  968.40  11190.
X1 3.438      22  8580.0 11055.0   520.0   490.0   500.0
GR964.00  7400.0  964.00  7790.0   968.0  7820.0  964.00  7875.0  964.00  8000.0
GR968.00  8270.0  968.00  8580.0   960.0  8615.0  960.00  8730.0  956.00  8730.0
GR956.00  8830.0  960.00  9190.0   964.0  9290.0  964.00  9340.0  960.00  10060.
GR960.00 10710.0  956.00 10760.0   956.0  11000.  960.00  11015.  972.00  11055.
GR972.00 11160.0  976.00 11210.0
X1 3.532      18  8410.0 11020.0   465.0   495.0   500.0
GR966.48  7460.0  964.00  7730.0  968.00  7790.0  964.00  7880.0   964.0  8410.0
GR960.00  8430.0  956.00  8490.0  960.00  8690.0  960.00  8770.0   960.0  9330.0
GR964.00  9830.0  964.00  9870.0  960.00 10520.0  956.00 10620.0   960.0  10950.
GR984.00 11020.0  984.00 11065.0  980.00 11080.0
X1 3.627      19  7720.0 11005.0   510.0   460.0   500.0
GR968.00  7550.0  968.00  7720.0   964.0  7860.0  964.00  8340.0  960.00  8370.0
GR960.00  8570.0  964.00  8820.0   964.0  8930.0  960.00  9040.0  960.00  9350.0
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GR960.00  9940.0  960.00 10420.0   960.0  10600.  960.00  10825.  968.00  10870.
GR972.00 10955.0  976.00 11005.0   975.5  11170.  975.40  11700.
X1 3.721      22  7730.0 10900.0   530.0   450.0   495.0
GR974.20  6470.0  972.00  6500.0  972.00  7625.0  968.00  7730.0   968.0  8110.0
GR964.00  8200.0  968.00  8390.0  968.00  8540.0  964.00  8590.0   960.0  8630.0
GR960.00  8690.0  964.00  9000.0  964.00  9200.0  960.00  9350.0   960.0  10080.
GR964.00 10150.0  964.00 10465.0  960.00 10650.0  960.00 10750.0   968.0  10885.
GR972.00 10900.0  972.00 11770.0
X1 3.813      22  7660.0 10870.0   570.0   445.0   490.0
GR974.50  6320.0  972.00  7660.0  968.00  7745.0   968.0  8570.0  964.00  8590.0
GR964.00  8795.0  968.00  8820.0  968.00  8940.0   964.0  9100.0  960.00  9300.0
GR960.00  9620.0  964.00  9925.0  964.00 10475.0   960.0  10525.  960.00  10605.
GR964.00 10650.0  960.00 10770.0  960.00 10800.0   964.0  10830.  968.00  10840.
GR972.00 10870.0  972.00 10945.0
X1 3.908      20  7620.0 10935.0   530.0   460.0   500.0
GR972.24  7520.0  972.00  7620.0   968.0  7700.0  968.00  8470.0  964.00  8550.0
GR964.00  8680.0  968.00  8700.0   968.0  9150.0  964.00  9200.0  960.00  9215.0
GR960.00  9340.0  964.00  9760.0   964.0  10000.  962.00  10355.  962.00  10400.
GR964.00 10440.0  964.00 10535.0   968.0  10870.  976.00  10935.  976.00  11385.
X1 4.001      22    7650 11060.0   540.0   420.0   490.0
GR969.08  7650.0  968.00  7720.0   968.0  8370.0  972.00  8410.0  968.00  8430.0
GR964.00  8470.0  964.00  8560.0   968.0  8625.0  972.00  8640.0  972.00  8790.0
GR968.00  9220.0  960.00  9260.0   960.0  9390.0  964.00  9830.0  964.00  10230.
GR962.00 10340.0  962.00 10470.0   964.0  10495.  968.00  10580.  968.00  10980.
GR976.00 11060.0  976.00 11215.0
X1 4.095      17    7780 11030.0   600.0    45.0   495.0
GR970.31  7780.0  968.00  8140.0  964.00  8195.0   964.0  8230.0  968.00  8300.0
GR968.00  8490.0  972.00  8510.0  972.00  8880.0   968.0  9150.0  964.00  9290.0
GR960.00  9300.0  960.00  9380.0  964.00  9650.0   964.0  10450.  968.00  10690.
GR972.00 10960.0  976.00 11030.0
X1 4.189      21    7920 10800.0   575.0   495.0   500.0
GR972.00  7920.0   972.0  8270.0  968.00  8310.0  964.00  8350.0  964.00  8400.0
GR968.00  8430.0   972.0  8700.0  972.00  8815.0  968.00  8910.0  968.00  8990.0
GR972.00  9110.0   968.0  9310.0  964.00  9360.0  961.50  9420.0  963.00  9750.0
GR964.00  9840.0   964.0  10540.  968.00  10660.  972.00  10750.  976.00  10800.
GR980.00 10950.0
X1 4.284      12    8050 10665.0   580.0   480.0   500.0
GR972.56  8050.0   972.0  8310.0  968.00  8490.0  968.00  8570.0  968.00  9280.0
GR964.00  9610.0   964.0  10615.  976.00  10665.  980.00  10740.  982.00  10785.
GR977.00 10845.0   978.0  11965.
X1 4.379       7    8190 10665.0   585.0   420.0   500.0
GR974.00  8190.0  972.00  8340.0   968.0  8740.0  968.00  9270.0  964.00  9285.0
GR964.00 10620.0  980.00 10665.0
X1 4.473      13  8310.0 10750.0   480.0   420.0   500.0
GR972.57  8310.0   972.0  8340.0  968.00  8670.0  968.00  8720.0  972.00  8780.0
GR976.00  9010.0   980.0  9030.0  964.00  9070.0  964.00  10260.  968.00  10630.
GR972.00 10680.0   980.0  10750.  980.00  11650.
X1 4.568      14  8440.0 10695.0   520.0   490.0   500.0
GR 983.0  6500.0  980.00  7410.0  980.00  8440.0  972.00  8485.0  970.00  8510.0
GR 970.0  8820.0  972.00  8870.0  964.00  8910.0  964.00 10110.0  968.00 10250.0
GR 968.0 10570.0  972.00 10670.0  980.00 10695.0  980.00 11495.0
X1 4.663      19  8460.0 10770.0   490.0   460.0   500.0
GR 984.0  7000.0  980.00  7100.0  980.00  8460.0  976.00  8660.0  972.00  8680.0
GR 971.0  8820.0  972.00  8940.0  972.00  9190.0  976.00  9250.0  976.00  9600.0
GR 968.0  9630.0  968.00 10280.0  964.00 10320.0  964.00 10520.0  968.00 10680.0
GR 996.0 10770.0  992.00 10900.0  984.00 10930.0  980.00 11360.0
X1 4.758      14  8860.0 11030.0   450.0   390.0   500.0
GR984.00  8860.0   980.0  8920.0  972.00  8950.0  970.00  9010.0  972.00  9040.0
GR972.00  9530.0   968.0  9565.0  968.00  9670.0  972.00  9790.0  972.00  10390.
GR968.00 10580.0   968.0  10940.  972.00  10980.  980.00  11030.
```

Simons, Li & Associates, Inc.

```
X1 4.852      14  8960.0 11050.0   410.0   525.0   500.0
GR 984.0  6530.0  984.40  6880.0  984.00  6920.0  983.00  7000.0  982.10  7200.0
GR 982.0  8000.0  984.00  8270.0  984.00  8460.0  985.00  8720.0  984.00  8960.0
GR 972.0  9020.0  974.00 10000.0  972.00 11010.0  984.00 11050.0
X1 4.947      17  9690.0 10940.0   520.0   470.0   500.0
GR 984.0  6600.0  984.00  8780.0  980.00  9050.0  980.00  9190.0  980.00  9215.0
GR 980.0  9240.0  980.00  9500.0  976.00  9690.0  972.00  9710.0  968.00  9740.0
GR 968.0 10370.0  972.00 10900.0  988.00 10940.0  988.00 11020.0  984.00 11030.0
GR 984.0 11890.0  988.00 12500.0
X1 5.042      16  9680.0 10840.0   460.0   510.0   500.0
GR 985.5  6100.0  985.70  6450.0  984.00  7850.0  986.00  8130.0  984.00  8680.0
GR 980.0  8980.0  980.00  8995.0  980.00  9030.0  980.00  9680.0  972.00  9820.0
GR 972.0 10790.0  988.00 10840.0  988.00 10900.0  984.00 10920.0  984.00 11680.0
GR 988.0 12270.0
X1 5.136       8  9690.0 10700.0   420.0   530.0   500.0
GR984.00  8550.0  984.00  8810.0  980.00  9530.0  976.00  9690.0   972.0  9720.0
GR972.00 10440.0  976.00 10670.0  988.00 10700.0
X1 5.231       7  9390.0 10480.0   450.0   530.0   500.0
GR984.00  8650.0   980.0  9390.0  976.00  9420.0  976.00  10460.  984.00  10480.
GR988.00 12050.0   990.0  12380.
X1 5.326       7  9420.0 10480.0   450.0   470.0   500.0
GR984.00  8520.0  980.00  9420.0   976.0  9440.0  976.00  10450.  988.00  10480.
GR988.00 11280.0  992.00 11910.0
X1 5.420       7  9425.0 10500.0   500.0   460.0   500.0
GR984.00  8500.0  980.00  9425.0  976.00  9430.0   976.0  10470.  988.00  10500.
GR988.00 10830.0  992.00 11970.0
X1 5.515       9  9610.0 10770.0   360.0   500.0   500.0
GR984.00  8400.0  984.00  8800.0  980.00  8910.0   980.0  9210.0  976.00  9610.0
GR976.00 10730.0  992.00 10770.0  992.00 11770.0   995.0  12340.
X1 5.610       9  9600.0 10950.0   330.0   560.0   500.0
GR984.00  8350.0  984.00  9250.0  980.00  9340.0   980.0  9450.0  976.00  9600.0
GR976.00 10920.0  992.00 10950.0  992.00 11310.0   995.0  12050.
X1 5.705      10 10040.0 10960.0   330.0   560.0   500.0
GR 994.0  8290.0  988.00  8580.0  984.00  9110.0  980.00  9140.0  980.00 10040.0
GR 976.0 10540.0  976.00 10930.0  988.00 10960.0  992.00 11150.0  996.00 11850.0
X1 5.799      17  9820.0 10910.0   460.0   510.0   500.0
GR994.00  8200.0  988.00  8240.0   988.0  8570.0  988.00  8960.0  984.00  9250.0
GR980.00  9380.0  980.00  9520.0   984.0  9580.0  984.00  9820.0  980.00  9900.0
GR976.00 10000.0  980.00 10070.0   976.0  10160.  976.00  10850.  988.00  10910.
GR992.00 10980.0  996.00 11510.0
X1 5.894      13  9780.0 10760.0   550.0   480.0   500.0
GR993.50  8120.0  988.00  8450.0   988.0  9300.0  984.00  9780.0  976.00  9800.0
GR976.00  9940.0  984.00 10010.0   980.0  10170.  976.00  10280.  976.00  10670.
GR988.00 10760.0  992.00 11080.0   996.0  11240.
X1 5.989      13  9380.0 10800.0   360.0   530.0   500.0
GR993.00  8030.0  990.00  8330.0   988.0  9380.0  984.00  9400.0  984.00  9810.0
GR980.00  9890.0  976.00 10060.0   976.0  10450.  980.00  10740.  988.00  10800.
GR992.00 11250.0  992.00 11480.0   996.0  11750.
X1 6.083      14  9130.0 10350.0   390.0   480.0   500.0
GR994.60  7890.0  989.00  7950.0  988.00  9040.0   984.0  9130.0  984.00  9400.0
GR980.00  9420.0  976.00  9650.0  976.00 10110.0   980.0  10170.  980.00  10320.
GR984.00 10350.0  988.00 10850.0  992.00 11600.0   996.0  12140.
X1 6.178      11  9020.0 10170.0   510.0   460.0   500.0
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GR976.00 10000.0  980.00 10060.0   984.0  10170.  988.00  10630.  992.00  11150.
GR996.00 12090.0
X1 6.273      13  8750.0 10190.0   470.0   480.0   500.0
GR 996.0  5590.0  996.00  7270.0  997.00  7600.0  992.00  7680.0  988.00  8750.0
GR 976.0  8790.0  976.00  9010.0  980.00  9170.0  980.00 10130.0  984.00 10190.0
GR 988.0 10700.0  992.00 11090.0  996.00 12170.0
```

Simons, Li & Associates, Inc.

EJ
ER

File QUA16.DAT

Simons, Li & Associates, Inc.

40	40	1	0.4	
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0	2	47811.	46331.	0
0	2	46331.	44211.	0
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0	2	4290.	3290.	0
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600.	600.	600.	600.	600.	600.	600.	600.	600.	600.
600.	600.	600.	600.	600.	600.	600.	600.	600.	600.
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12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5
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0.260	0.060	0.060	0.070	0.060	0.100	0.095	0.160	0.100	0.035
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0.260	0.060	0.060	0.070	0.060	0.100	0.095	0.160	0.100	0.035

0.260	0.060	0.060	0.070	0.060	0.100	0.095	0.160	0.100	0.035
0.260	0.060	0.060	0.070	0.060	0.100	0.095	0.160	0.100	0.035
0.260	0.060	0.060	0.070	0.060	0.100	0.095	0.160	0.100	0.035
0.260	0.060	0.060	0.070	0.060	0.100	0.095	0.160	0.100	0.035
0.260	0.060	0.060	0.070	0.060	0.100	0.095	0.160	0.100	0.035
0.260	0.060	0.060	0.070	0.060	0.100	0.095	0.160	0.100	0.035
0.260	0.060	0.060	0.070	0.060	0.100	0.095	0.160	0.100	0.035
0.260	0.060	0.060	0.070	0.060	0.100	0.095	0.160	0.100	0.035
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0.260	0.060	0.060	0.070	0.060	0.100	0.095	0.160	0.100	0.035
0.260	0.060	0.060	0.070	0.060	0.100	0.095	0.160	0.100	0.035
0.260	0.060	0.060	0.070	0.060	0.100	0.095	0.160	0.100	0.035
0.260	0.060	0.060	0.070	0.060	0.100	0.095	0.160	0.100	0.035
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0.260	0.060	0.060	0.070	0.060	0.100	0.095	0.160	0.100	0.035
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69967	90845	125415	167019	185000	152236	141289	140010	120148	100813
82870	71811	55410	35209	34532	22608	21931	19975	19147	19147
18846	18846	17605	17379	16965	16965	15573	14896	14896	14896
									1
0.0	0.0								
0.000000000		0.00							
0.000000000		0.00	0.000						
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4917	6384	8813	11737	13000	10697	9929	9839	8443	7085
5823	5046	3893	2475	2427	1588	1541	1403	1345	1345
1324	1324	1237	1221	1192	1192	1095	1047	1047	1047
									1
0.0	0.0								
0.000000000		0.00							
0.000000000		0.00	0.000						
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9833	12767	17626	23473	26000	21396	19856	19677	16886	14168
11647	10092	7788	4948	4853	3178	3082	2807	2691	2691
2649	2649	2474	2443	2385	2385	2188	2094	2094	2094
									1
0.0	0.0								
0.000000000		0.00							
0.000000000		0.00	0.000						
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9834	12767	17625	23473	26000	21395	19857	19677	16886	14168
11647	10092	7787	4948	4853	3177	3082	2808	2691	2691
2649	2649	2474	2442	2384	2384	2189	2093	2093	2093
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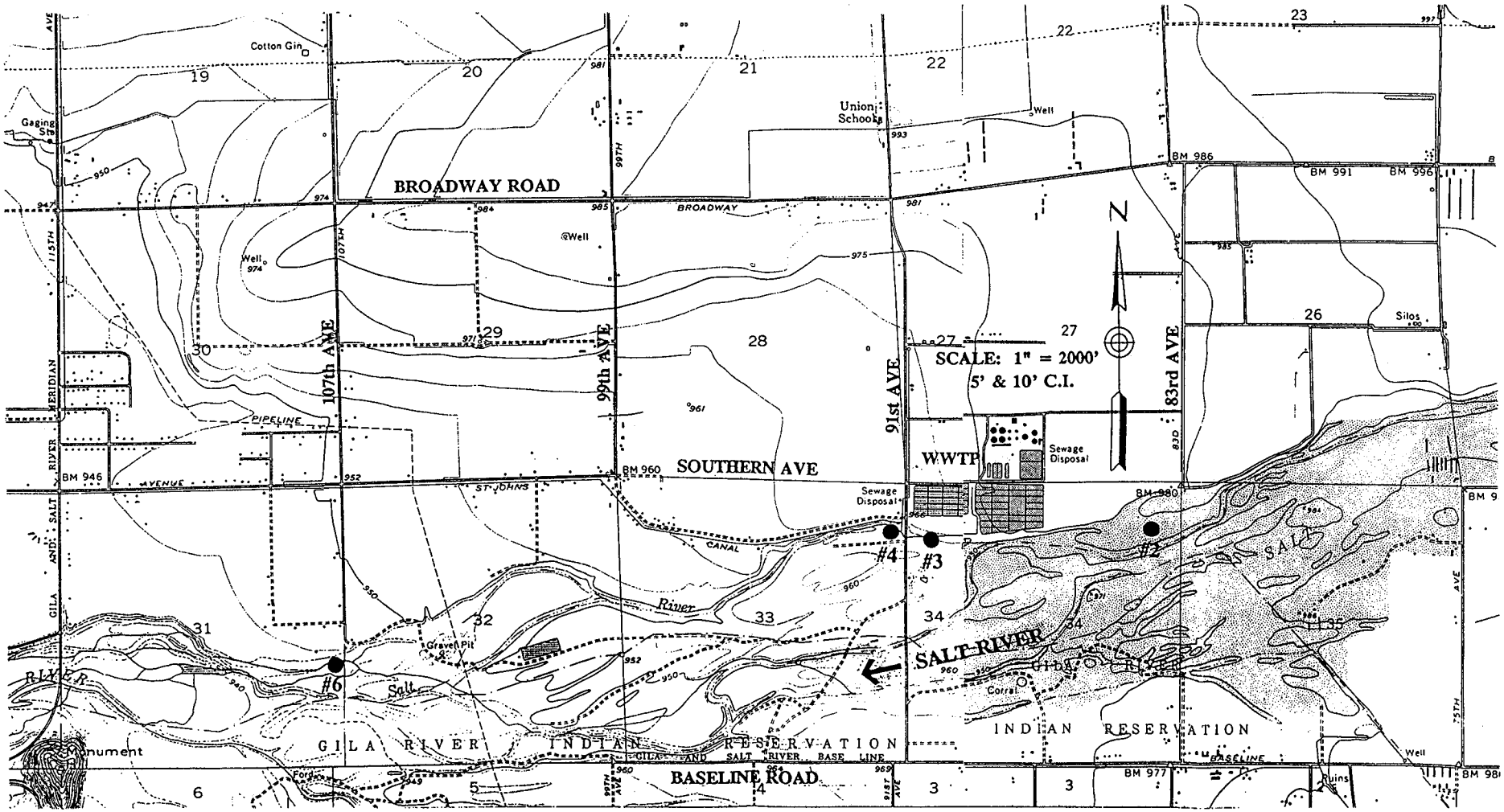
0.000000000		0.00							
0.000000000		0.00	0.000						

APPENDIX H

BED MATERIAL GRADATION



● APPROXIMATE SAMPLE LOCATION.

BASE MAPS FROM TOLLESON AND FOWLER, AZ 7.5' SERIES U.S.G.S. QUADS.

Appendix G
from 91st Ave. WTP
May, 1994

sla SIMONS, LI & ASSOCIATES, INC.

SAMPLE LOCATIONS
SITE MAP

SHB AGRA, INC.
Engineering & Environmental Services
(FORMERLY SERGENT, HAUSKINS & BECKWITH)

3232 West Virginia Avenue
Phoenix, Arizona 85009
Phone: 602-272-6848
Fax: 602-272-7239

RECEIVED JUN 0 7 1993

AZ-CPH-03

TRANSMITTAL

TO: Simons, Li & Associates, Inc.
4600 South Mill Avenue STE 200
Tempe, Arizona 85282

ATTN: Jeffrey R. Minch, P.E.

Date: 6-4-93
Project: Materials Testing
Job/Proposal #: SHB Job LT93-3022
Transmittal #: 1
Reference:

We are:	For your:	The following:
[X] transmitting	[ ] review & comment	[ ] boring logs
[ ] returning	[X] information/files	[ ] calculations
[ ] separately	[ ] approval	[ ] design charts
	[ ] signature	[ ] progress reports
	[ ] as requested	[X] laboratory results
		[ ] plans
		[ ] specifications
		[ ] other:

Copies	Date	Description

Delivery by:

[ ] Hand Delivery
[X] First Class Mail
[ ] Registered Mail
[ ] Express Mail
[ ] Courier Service
[ ] Other:
[ ] Return Receipt Requested

Remarks:

Copy to: Addressee (1)
File

By: Jon L. Sparks
Lab Supervisor

Simons, Li & Associates, Inc.

AGRA

SHB AGRA INC.
ENGINEERING & ENVIRONMENTAL SERVICES

PROJECT	MATERIALS TESTING - SIMONS & LI	PROJECT	LT93-3022
LOCATION	#2 BED MAT'L W. OF 83rd AVE	W.O. NO	1
		LAB NO	1
		DATE	6/1/93

MECHANICAL SIEVE ANALYSIS (ASTM C136)

SIEVE SIZE	% PASSING
2 IN	100
1 1/2 IN	94
1 IN	78
3/4 IN	66
1/2 IN	52
3/8 IN	46
1/4 IN	39
#4	36
#8	31
#10	30
#16	26
#30	18
#40	14
#50	11
#100	5
#200	2.6

SHB AGRA INC.
ENGINEERING & ENVIRONMENTAL SERVICES

PROJECT	MATERIALS TESTING - SIMONS & LI	PROJECT	LT93-3022
LOCATION	LOCATION #3 @ 91st AVE 100' EAST	W.O. NO	1
		LAB NO	2
		DATE	6/1/93

MECHANICAL SIEVE ANALYSIS (ASTM C136)

SIEVE SIZE	% PASSING
2 IN	100
1 1/2 IN	100
1 IN	94
3/4 IN	93
1/2 IN	88
3/8 IN	85
1/4 IN	78
#4	74
#8	74
#10	74
#16	72
#30	69
#40	68
#50	67
#100	64
#200	57.1

SHB AGRA INC.
ENGINEERING & ENVIRONMENTAL SERVICES

PROJECT	MATERIALS TESTING - SIMONS & LI	PROJECT	LT93-3022
LOCATION	LOCATION #6 @ 107th AVE N. CHANNEL	W.O. NO	1
		LAB NO	3
		DATE	6/1/93

MECHANICAL SIEVE ANALYSIS (ASTM C136)

SIEVE SIZE	% PASSING
2 IN	100
1 1/2 IN	92
1 IN	77
3/4 IN	68
1/2 IN	58
3/8 IN	53
1/4 IN	46
#4	43
#8	38
#10	37
#16	34
#30	28
#40	22
#50	16
#100	6
#200	2.9

SHB AGRA INC.
ENGINEERING & ENVIRONMENTAL SERVICES

PROJECT	MATERIALS TESTING - SIMONS & LI	PROJECT	LT93-3022
LOCATION	LOCATION #4 - 150' W. OF 91st AVE	W.O. NO	1
		LAB NO	4
		DATE	6/1/93

MECHANICAL SIEVE ANALYSIS (ASTM C136)

SIEVE SIZE	% PASSING
3 IN	100
2 IN	96
1 1/2 IN	87
1 IN	74
3/4 IN	67
1/2 IN	56
3/8 IN	53
1/4 IN	47
#4	45
#8	42
#10	41
#16	37
#30	25
#40	17
#50	10
#100	3
#200	1.6

BED MATERIAL SAMPLE NO. 2

TOTAL SAMPLE AREA = 371612
SIEVE ANALYSIS CORR. = 10.2%
ARMOR GRADATION CORR. = 89.8%

Sieve Designation (In,#)	(mm)	Area Within Size Fraction	Size Fraction Percent	Corrected Size Fraction Percent	Armor Layer Percent Passing	Sieve Analysis Percent Passing	Sieve Size Fraction Percent	Corrected Sieve Analysis Percent	Combined Size Fraction Percent	Combined Percent Finer	Combined Percent Retained
14¼	362.0										
10	254.0										
7 1/8	181.0				100.0%					100.0%	0.0%
5	125.0	50962	15.3%	13.7%	86.3%				13.7%	86.3%	13.7%
3½	90.0	69622	20.9%	18.7%	67.6%				18.7%	67.6%	32.4%
2	50.0	111499	33.4%	30.0%	37.5%	100			30.0%	37.5%	62.5%
1½	37.5	60268	18.1%	16.2%	21.3%	94	6.0%	0.6%	16.8%	20.7%	79.3%
1	25.0	41259	12.4%	11.1%	10.2%	78	16.0%	1.6%	12.7%	8.0%	92.0%
3/4	19.0					66	12.0%	1.2%	1.2%	6.7%	93.3%
1/2	12.5					52	14.0%	1.4%	1.4%	5.3%	94.7%
3/8	9.50					46	6.0%	0.6%	0.6%	4.7%	95.3%
1/4	6.30					39	7.0%	0.7%	0.7%	4.0%	96.0%
#4	4.76					36	3.0%	0.3%	0.3%	3.7%	96.3%
#8	2.36					31	5.0%	0.5%	0.5%	3.2%	96.8%
#10	2.00					30	1.0%	0.1%	0.1%	3.1%	96.9%
#16	1.00					26	4.0%	0.4%	0.4%	2.7%	97.3%
#30	0.60					18	8.0%	0.8%	0.8%	1.8%	98.2%
#40	0.425					14	4.0%	0.4%	0.4%	1.4%	98.6%
#50	0.300					11	3.0%	0.3%	0.3%	1.1%	98.9%
#100	0.150					5	6.0%	0.6%	0.6%	0.5%	99.5%
#200	0.075					2.6	2.4%	0.2%	0.2%	0.3%	99.7%
TOTALS		333609	100.0%	89.8%			97.4%	10.0%	99.7%		

SAMPLE NO. 2 (SLIDE NO. 4)

FRAME DIMENSIONS: (inches)

HL =	24.10
HR =	23.60
T =	25.05
B =	28.90

SAMPLE AREA:

Ag =	643.4 sq. in.
Ag =	415066.1 sq. mm.

AVG. FRAME DIM. =	25.4 in
TRUE FRAME DIM. =	24 in
CORR. FACTOR =	0.94
AREA OF PARTICLES >1" =	333609 sq. mm.
NO. OF PARTICLES >1" =	105

	PARTICLE AXIS (in) MAJOR	MINOR	CORR. MINOR (mm)	PARTICLE AREA	PARTICLES IN INTERVAL	INTERVAL AREA sq. mm.
1	8.00	7.25	173.9	30246		
2	7.25	6.00	143.9	20716	2	50962
3	7.50	4.80	115.1	13258		
4	5.50	4.30	103.1	10640		
5	5.75	4.25	101.9	10394		
6	5.80	4.25	101.9	10394	7	69622
7	4.40	3.90	93.6	8752		
8	4.75	3.75	90.0	8092		
9	4.50	3.75	90.0	8092		
10	4.25	3.50	84.0	7049		
11	4.20	3.40	81.6	6652		
12	5.30	3.40	81.6	6652		
13	4.00	3.25	78.0	6078		
14	4.75	3.25	78.0	6078		
15	3.50	3.00	72.0	5179		
16	5.75	3.00	72.0	5179		
17	6.00	3.00	72.0	5179		
18	3.50	3.00	72.0	5179		
19	4.75	2.80	67.2	4511		
20	3.50	2.75	66.0	4352	26	111499
21	4.00	2.75	66.0	4352		
22	4.50	2.75	66.0	4352		
23	5.50	2.75	66.0	4352		
24	4.25	2.50	60.0	3596		
25	3.00	2.50	60.0	3596		
26	3.10	2.40	57.6	3314		
27	3.70	2.30	55.2	3044		
28	3.00	2.30	55.2	3044		
29	3.30	2.25	54.0	2913		
30	2.75	2.25	54.0	2913		

31	3.25	2.25	54.0	2913		
32	3.75	2.25	54.0	2913		
33	2.40	2.20	52.8	2785		
34	2.70	2.20	52.8	2785		
35	2.90	2.10	50.4	2538		
36	2.50	2.00	48.0	2302		
37	2.50	2.00	48.0	2302		
38	2.50	2.00	48.0	2302		
39	2.50	2.00	48.0	2302		
40	3.25	2.00	48.0	2302		
41	2.25	2.00	48.0	2302		
42	2.75	2.00	48.0	2302		
43	3.30	2.00	48.0	2302	31	60268
44	3.50	2.00	48.0	2302		
45	3.50	2.00	48.0	2302		
46	2.40	2.00	48.0	2302		
47	2.40	1.90	45.6	2077		
48	2.10	1.90	45.6	2077		
49	3.25	1.90	45.6	2077		
50	3.00	1.80	43.2	1864		
51	2.40	1.80	43.2	1864		
52	1.80	1.80	43.2	1864		
53	1.80	1.80	43.2	1864		
54	3.00	1.80	43.2	1864		
55	3.25	1.75	42.0	1762		
56	2.50	1.75	42.0	1762		
57	2.20	1.70	40.8	1663		
58	2.30	1.70	40.8	1663		
59	2.00	1.70	40.8	1663		
60	2.20	1.70	40.8	1663		
61	2.00	1.70	40.8	1663		
62	2.30	1.70	40.8	1663		
63	2.00	1.60	38.4	1473		
64	3.00	1.60	38.4	1473		
65	1.90	1.60	38.4	1473		
66	2.20	1.60	38.4	1473		
67	2.00	1.50	36.0	1295		
68	1.75	1.50	36.0	1295		
69	1.90	1.50	36.0	1295		
70	2.00	1.50	36.0	1295		
71	2.20	1.50	36.0	1295		
72	1.75	1.50	36.0	1295		
73	1.50	1.50	36.0	1295		
74	2.50	1.50	36.0	1295		
75	3.50	1.50	36.0	1295		

76	3.00	1.50	36.0	1295		
77	2.30	1.50	36.0	1295		
78	2.25	1.50	36.0	1295		
79	2.50	1.50	36.0	1295		
80	2.50	1.50	36.0	1295		
81	2.80	1.40	33.6	1128		
82	1.70	1.40	33.6	1128		
83	2.10	1.40	33.6	1128		
84	3.20	1.40	33.6	1128		
85	2.00	1.40	33.6	1128	39	41259
86	1.60	1.40	33.6	1128		
87	1.80	1.40	33.6	1128		
88	1.50	1.30	31.2	972		
89	3.25	1.30	31.2	972		
90	1.50	1.25	30.0	899		
91	1.50	1.25	30.0	899		
92	2.75	1.25	30.0	899		
93	1.90	1.25	30.0	899		
94	1.75	1.25	30.0	899		
95	1.90	1.25	30.0	899		
96	2.60	1.25	30.0	899		
97	1.50	1.25	30.0	899		
98	1.40	1.20	28.8	829		
99	1.40	1.20	28.8	829		
100	1.80	1.20	28.8	829		
101	2.40	1.20	28.8	829		
102	1.30	1.10	26.4	696		
103	1.80	1.10	26.4	696		
104	1.40	1.10	26.4	696		
105	1.50	1.10	26.4	696		

BED MATERIAL SAMPLE NO. 4

TOTAL SAMPLE AREA = 371612
SIEVE ANALYSIS CORR. = 26.4%
ARMOR GRADATION CORR. = 73.6%

Sieve Designation (in,#)	(mm)	Area Within Size Fraction	Size Fraction Percent	Corrected Size Fraction Percent	Armor Layer Percent Passing	Sieve Analysis Percent Passing	Sieve Size Fraction Percent	Corrected Sieve Analysis Percent	Combined Size Fraction Percent	Combined Percent Finer	Combined Percent Retained
14¼	362.0										
10	254.0				100.0%					100.0%	
7 1/8	181.0	33977	12.4%	9.1%	90.9%				9.1%	90.9%	9.1%
5	125.0	22529	8.2%	6.1%	84.8%				6.1%	84.8%	15.2%
3½	90.0	88347	32.3%	23.8%	61.0%				23.8%	61.0%	39.0%
2	50.0	59446	21.7%	16.0%	45.0%	100			16.0%	45.0%	55.0%
1½	37.5	33223	12.2%	8.9%	36.1%	94	6.0%	1.6%	10.5%	34.5%	65.5%
1	25.0	35808	13.1%	9.6%	26.4%	78	16.0%	4.2%	13.9%	20.6%	79.4%
3/4	19.0					66	12.0%	3.2%	3.2%	17.5%	82.5%
1/2	12.5					52	14.0%	3.7%	3.7%	13.8%	86.2%
3/8	9.50					46	6.0%	1.6%	1.6%	12.2%	87.8%
1/4	6.30					39	7.0%	1.9%	1.9%	10.3%	89.7%
#4	4.76					36	3.0%	0.8%	0.8%	9.5%	90.5%
#8	2.36					31	5.0%	1.3%	1.3%	8.2%	91.8%
#10	2.00					30	1.0%	0.3%	0.3%	7.9%	92.1%
#16	1.00					26	4.0%	1.1%	1.1%	6.9%	93.1%
#30	0.60					18	8.0%	2.1%	2.1%	4.8%	95.2%
#40	0.425					14	4.0%	1.1%	1.1%	3.7%	96.3%
#50	0.300					11	3.0%	0.8%	0.8%	2.9%	97.1%
#100	0.150					5	6.0%	1.6%	1.6%	1.3%	98.7%
#200	0.075					2.6	2.4%	0.6%	0.6%	0.7%	99.3%
TOTALS		273329	100.0%	73.6%			97.4%	25.8%	99.3%		

SAMPLE NO. 4 (SLIDE NO. 11)

FRAME DIMENSIONS: (inches)

HL =	22.85
HR =	22.45
T =	22.50
B =	24.80

SAMPLE AREA:

Ag =	535.7 sq. in.
Ag =	345594.5 sq. mm.

AVG. FRAME DIM. =	23.2 in
TRUE FRAME DIM. =	24 in
CORR. FACTOR =	1.04
AREA OF PARTICLES >1" =	273329 sq. mm.
NO. OF PARTICLES >1" =	80

	PARTICLE AXIS (in) MAJOR	MINOR	CORR. MINOR (mm)	PARTICLE AREA	PARTICLES IN INTERVAL	INTERVAL AREA sq. mm.
1	10.5	7.0	184.3	33977	1	33977
2	6.0	5.7	150.1	22529	1	22529
3	5.2	4.2	110.6	12232		
4	6.2	4.2	110.6	12232		
5	7.8	4.1	108.0	11656		
6	5.5	4.0	105.3	11095	8	88347
7	5.4	4.0	105.3	11095		
8	5.7	3.8	100.1	10013		
9	6.5	3.8	100.1	10013		
10	6.9	3.8	100.1	10013		
11	3.8	3.3	86.9	7551		
12	5.2	3.2	84.3	7100		
13	4.4	3.1	81.6	6664		
14	4.4	2.8	73.7	5436		
15	2.9	2.6	68.5	4687		
16	3.6	2.5	65.8	4334		
17	6.4	2.5	65.8	4334	13	59446
18	3.0	2.5	65.8	4334		
19	2.8	2.1	55.3	3058		
20	2.2	2.1	55.3	3058		
21	3.5	2.1	55.3	3058		
22	3.1	2.1	55.3	3058		
23	3.3	2.0	52.7	2774		
24	3.1	1.9	50.0	2503		
25	2.2	1.9	50.0	2503		
26	2.5	1.8	47.4	2247		
27	4.0	1.8	47.4	2247		
28	4.3	1.8	46.1	2124		
29	3.0	1.7	44.8	2004		
30	2.5	1.7	44.8	2004		

31	2.8	1.6	42.1	1775		
32	2.5	1.6	42.1	1775	18	33223
33	1.8	1.5	39.5	1560		
34	2.1	1.5	39.5	1560		
35	1.7	1.5	39.5	1560		
36	2.3	1.5	39.5	1560		
37	1.8	1.5	39.5	1560		
38	1.7	1.5	39.5	1560		
39	2.6	1.5	39.5	1560		
40	2.7	1.5	39.5	1560		
41	3.1	1.5	39.5	1560		
42	2.1	1.4	36.9	1359		
43	2.1	1.4	36.9	1359		
44	2.0	1.3	34.2	1172		
45	2.0	1.3	34.2	1172		
46	1.7	1.3	34.2	1172		
47	2.4	1.3	34.2	1172		
48	2.5	1.3	34.2	1172		
49	2.5	1.3	34.2	1172		
50	2.1	1.3	34.2	1172		
51	2.1	1.3	32.9	1083		
52	1.7	1.3	32.9	1083		
53	2.1	1.3	32.9	1083		
54	1.2	1.2	31.6	999		
55	1.6	1.2	31.6	999		
56	1.3	1.2	31.6	999		
57	2.0	1.2	31.6	999		
58	1.5	1.2	31.6	999		
59	1.4	1.2	30.3	917		
60	1.4	1.1	29.0	839		
61	1.6	1.1	29.0	839		
62	1.3	1.1	29.0	839		
63	1.6	1.1	29.0	839	39	35808
64	1.4	1.1	29.0	839		
65	2.4	1.1	29.0	839		
66	2.3	1.1	29.0	839		
67	1.4	1.1	29.0	839		
68	1.4	1.0	26.3	693		
69	1.5	1.0	26.3	693		
70	1.3	1.0	26.3	693		
71	1.2	1.0	26.3	693		
72	1.5	1.0	26.3	693		
73	1.5	1.0	26.3	693		
74	1.7	1.0	26.3	693		
75	2.0	1.0	26.3	693		

76	1.8	1.0	26.3	693
77	1.8	1.0	26.3	693
78	1.6	1.0	26.3	693
79	1.6	1.0	26.3	693
80	1.7	1.0	26.3	693

BED MATERIAL SAMPLE NO. 6

TOTAL SAMPLE AREA = 371612
SIEVE ANALYSIS CORR. = 23.8%
ARMOR GRADATION CORR. = 76.2%

Sieve Designation (in,#)	(mm)	Area Within Size Fraction	Size Fraction Percent	Corrected Size Fraction Percent	Armor Layer Percent Passing	Sieve Analysis Percent Passing	Sieve Size Fraction Percent	Corrected Sieve Analysis Percent	Combined Size Fraction Percent	Combined Percent Finer	Combined Percent Retained
14¼	362.0										
10	254.0										
7 1/8	181.0				100.0%					100.0%	0.0%
5	125.0	41490	14.7%	11.2%	88.8%				11.2%	88.8%	11.2%
3½	90.0	68974	24.4%	18.6%	70.3%				18.6%	70.3%	29.7%
2	50.0	116343	41.1%	31.3%	39.0%	100			31.3%	39.0%	61.0%
1½	37.5	28883	10.2%	7.8%	31.2%	94	6.0%	1.4%	9.2%	29.8%	70.2%
1	25.0	27378	9.7%	7.4%	23.8%	78	16.0%	3.8%	11.2%	18.6%	81.4%
3/4	19.0					66	12.0%	2.9%	2.9%	15.7%	84.3%
1/2	12.5					52	14.0%	3.3%	3.3%	12.4%	87.6%
3/8	9.50					46	6.0%	1.4%	1.4%	11.0%	89.0%
1/4	6.30					39	7.0%	1.7%	1.7%	9.3%	90.7%
#4	4.76					36	3.0%	0.7%	0.7%	8.6%	91.4%
#8	2.36					31	5.0%	1.2%	1.2%	7.4%	92.6%
#10	2.00					30	1.0%	0.2%	0.2%	7.1%	92.9%
#16	1.00					26	4.0%	1.0%	1.0%	6.2%	93.8%
#30	0.60					18	8.0%	1.9%	1.9%	4.3%	95.7%
#40	0.425					14	4.0%	1.0%	1.0%	3.3%	96.7%
#50	0.300					11	3.0%	0.7%	0.7%	2.6%	97.4%
#100	0.150					5	6.0%	1.4%	1.4%	1.2%	98.8%
#200	0.075					2.6	2.4%	0.6%	0.6%	0.6%	99.4%
TOTALS		283068	100.0%	76.2%			97.4%	23.2%	99.4%		

SAMPLE NO. 6 (SLIDE NO. 17)

FRAME DIMENSIONS: (inches)

HL =	23.20
HR =	23.10
T =	22.87
B =	25.25

SAMPLE AREA:

Ag =	557.0 sq. in.
Ag =	359347.0 sq. mm.

AVG. FRAME DIM. =	23.6 in
TRUE FRAME DIM. =	24 in
CORR. FACTOR =	1.02
AREA OF PARTICLES >1" =	283068 sq. mm.
NO. OF PARTICLES >1" =	83

	PARTICLE AXIS (in) MAJOR	MINOR	CORR. MINOR (mm)	PARTICLE AREA	PARTICLES IN INTERVAL	INTERVAL AREA sq. mm.
1	7.2	6.1	157.5	24817		
2	7.5	5.0	129.1	16673	2	41490
3	5.3	4.4	113.6	12912		
4	7.4	4.3	111.0	12332		
5	6.0	3.8	98.1	9631		
6	5.9	3.6	93.0	8643	7	68974
7	4.4	3.6	93.0	8643		
8	4.5	3.6	93.0	8643		
9	5.1	3.5	90.4	8170		
10	4.9	3.4	87.8	7710		
11	4.4	3.3	85.2	7263		
12	5.7	3.3	85.2	7263		
13	6.3	3.3	83.9	7044		
14	3.9	3.1	80.1	6409		
15	6.3	2.8	72.3	5229		
16	3.6	2.8	72.3	5229		
17	3.0	2.7	69.7	4862		
18	2.9	2.6	67.1	4508		
19	2.8	2.6	67.1	4508		
20	4.1	2.5	64.6	4168		
21	3.5	2.5	64.6	4168	27	116343
22	6.2	2.5	64.6	4168		
23	6.0	2.5	64.6	4168		
24	3.6	2.4	62.0	3842		
25	2.9	2.3	59.4	3528		
26	5.1	2.3	59.4	3528		
27	2.9	2.2	56.8	3228		
28	3.2	2.2	55.5	3083		
29	2.9	2.1	54.2	2941		
30	2.6	2.1	54.2	2941		

31	3.0	2.1	54.2	2941		
32	2.6	2.1	54.2	2941		
33	2.3	2.0	51.7	2668		
34	2.8	2.0	51.7	2668		
35	3.5	2.0	51.7	2668		
36	3.3	2.0	51.7	2668		
37	2.7	1.9	49.1	2408		
38	2.4	1.8	46.5	2161		
39	2.9	1.8	46.5	2161		
40	3.4	1.8	46.5	2161		
41	3.2	1.7	43.9	1927		
42	2.8	1.7	42.6	1816		
43	1.9	1.7	42.6	1816		
44	2.4	1.6	41.3	1707	16	28883
45	3.3	1.6	41.3	1707		
46	2.7	1.6	41.3	1707		
47	1.9	1.6	41.3	1707		
48	1.7	1.6	40.0	1602		
49	1.7	1.5	38.7	1501		
50	1.8	1.5	38.7	1501		
51	3.1	1.5	38.7	1501		
52	2.0	1.5	38.7	1501		
53	2.2	1.4	36.2	1307		
54	2.7	1.4	36.2	1307		
55	1.5	1.4	34.9	1215		
56	2.9	1.4	34.9	1215		
57	1.8	1.3	33.6	1127		
58	1.7	1.3	33.6	1127		
59	2.1	1.3	33.6	1127		
60	2.3	1.3	33.6	1127		
61	1.8	1.3	33.6	1127		
62	1.7	1.2	31.0	960		
63	1.5	1.2	31.0	960		
64	2.8	1.2	31.0	960		
65	2.5	1.2	31.0	960		
66	2.7	1.2	29.7	882		
67	1.4	1.2	29.7	882		
68	1.3	1.1	28.4	807	31	27378
69	1.9	1.1	28.4	807		
70	1.2	1.1	28.4	807		
71	1.4	1.0	25.8	667		
72	2.5	1.0	25.8	667		
73	1.3	1.0	25.8	667		
74	1.3	1.0	25.8	667		
75	1.3	1.0	25.8	667		

76	1.4	1.0	25.8	667
77	1.2	1.0	25.8	667
78	1.2	1.0	25.8	667
79	1.1	1.0	25.8	667
80	1.7	1.0	25.8	667
81	1.7	1.0	25.8	667
82	1.8	1.0	25.8	667
83	1.3	1.0	25.8	667

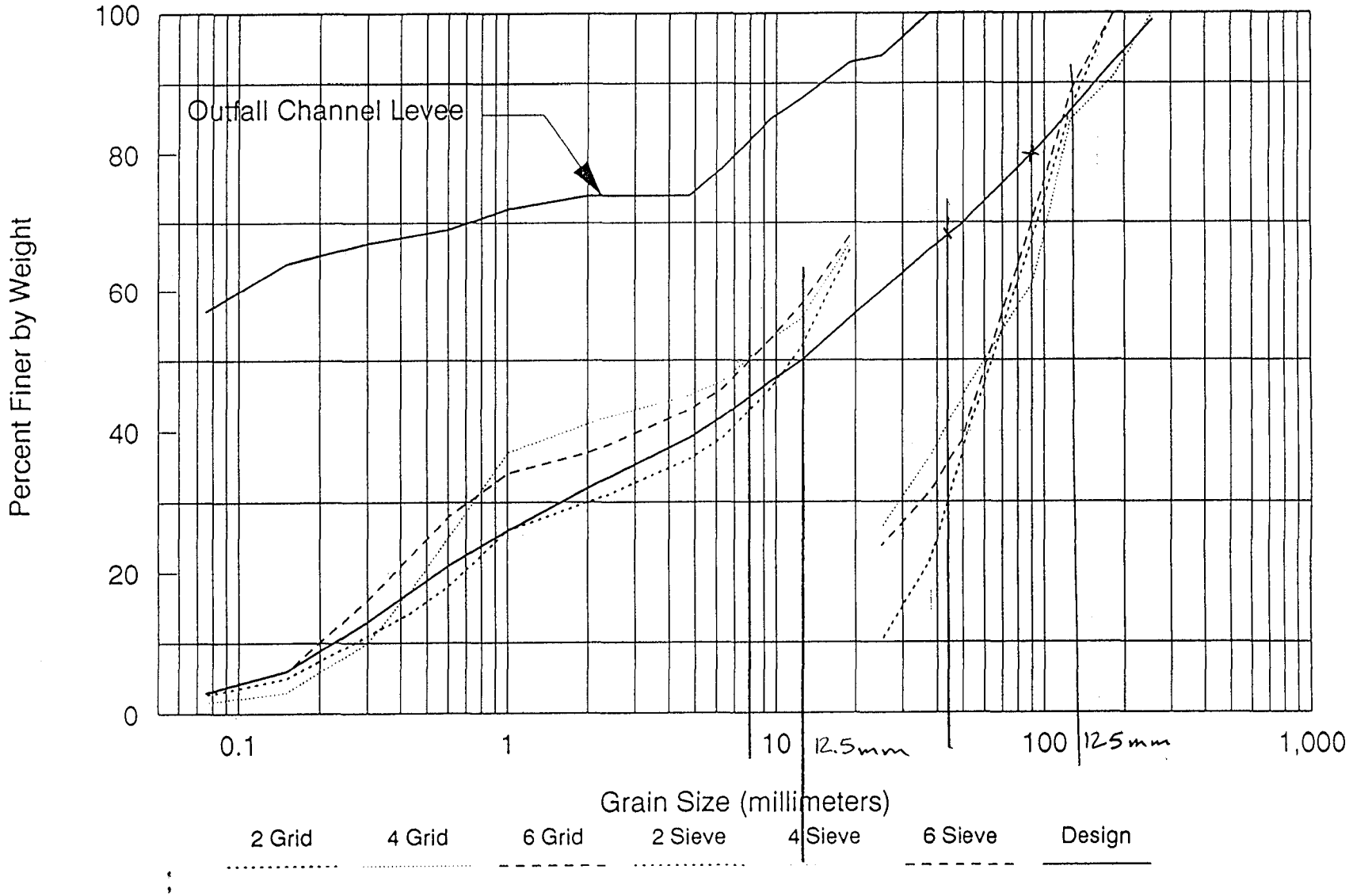
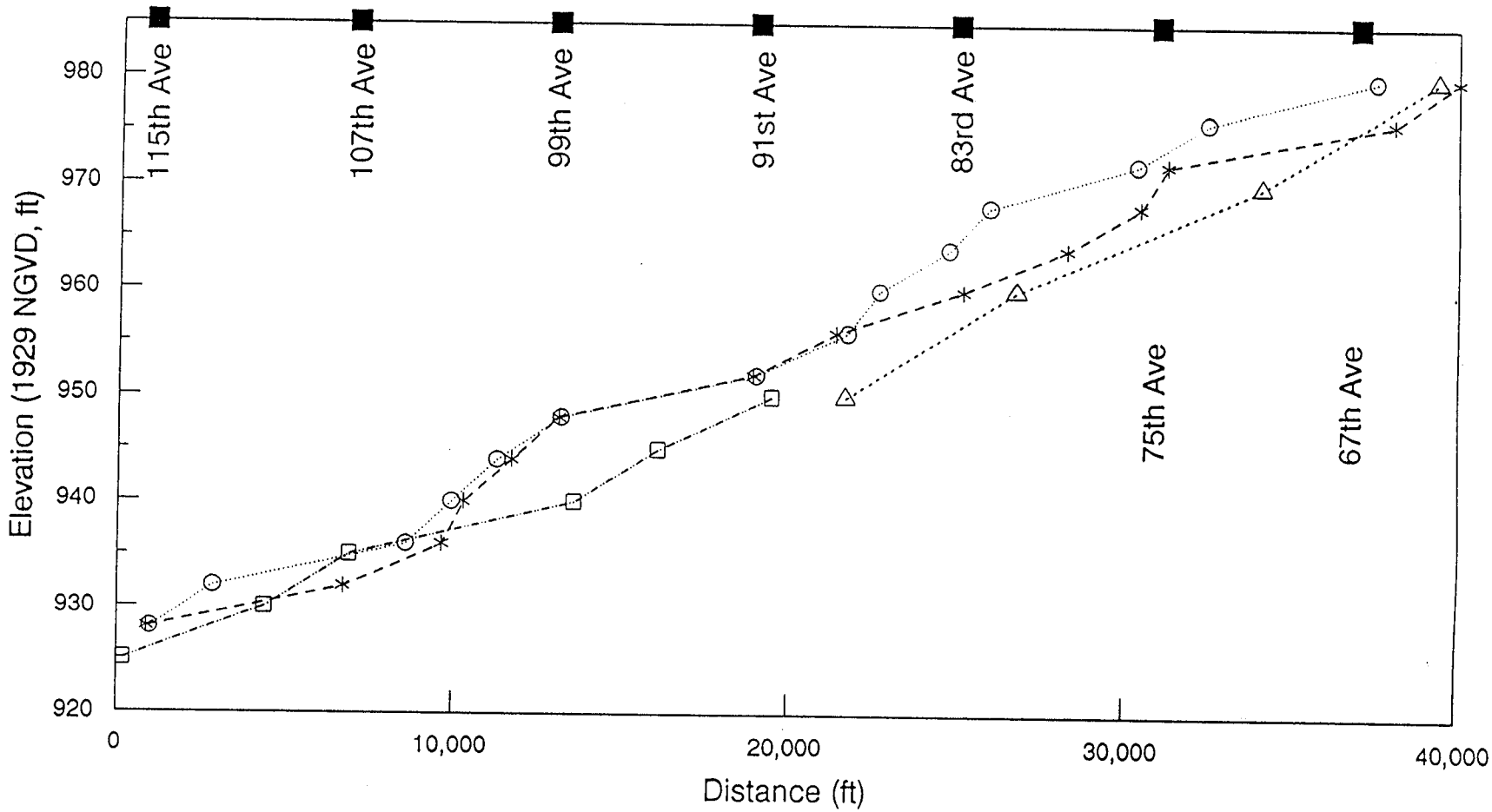


Figure No. 22. Salt River Study Reach Sediment Gradation Analyses



NOTES:

1. 1952 & 57 mapping from USGS Quads
2. 1983, 92 from FIS work maps

LEGEND:

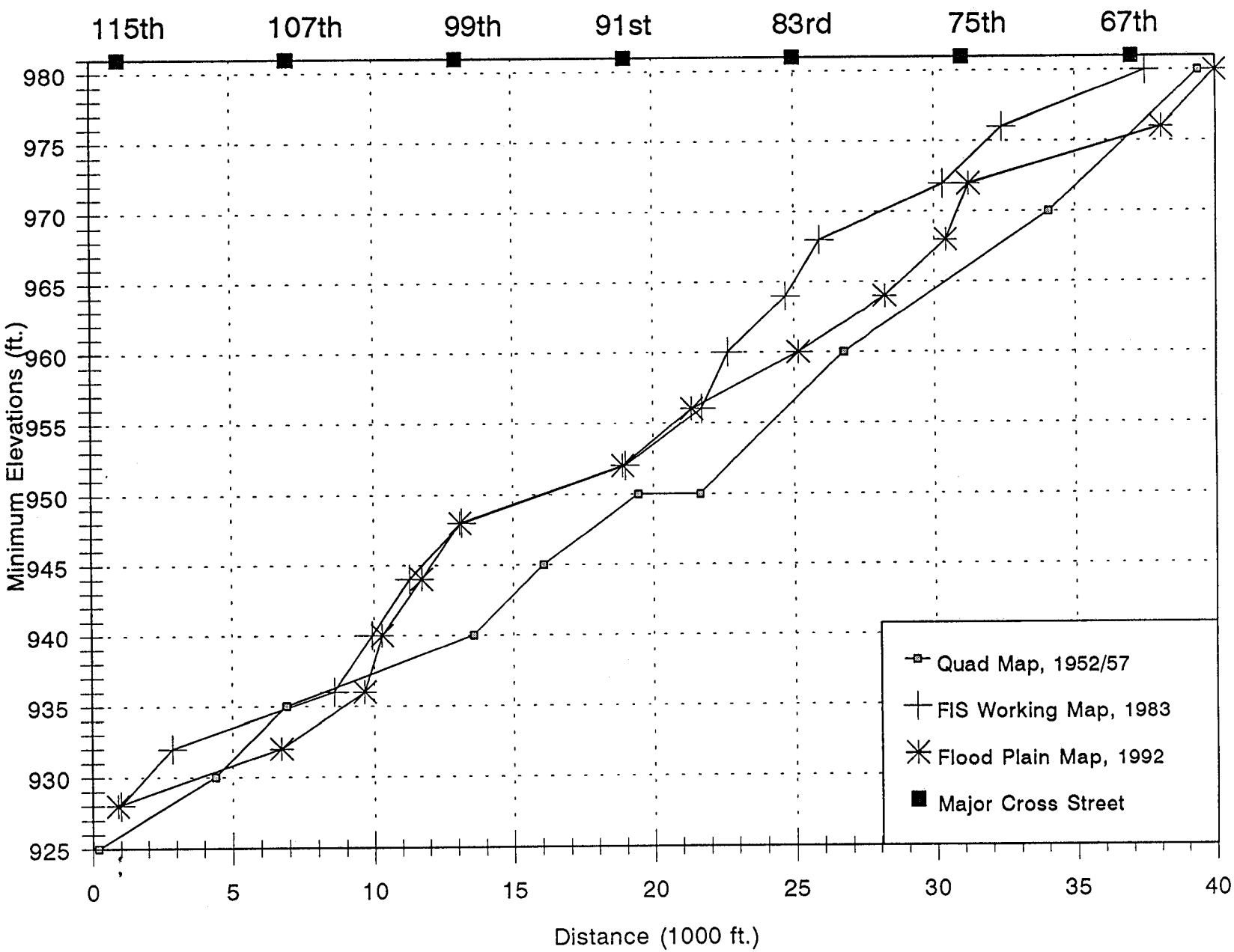
1952 1957 1983 1992

Figure No. 23. Salt River Study Reach Profile Comparison

Simons, Li & Associates, Inc.
Water Resources & Civil Engineering Consultants

Salt River Profiles

115th Ave. to 67th Ave.



Simons, Li & Associates, Inc.

sla
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CLIENT: MCDOT
PROJECT: 116th Ave. Bridge
DETAIL: Invert Profile
JOB NO.: PAZHANIEDI
DATE CHECKED:
CHECKED BY:
PAGE: 1/1
DATE: 9/13/94
COMPUTED BY: TDM

Source	99th Ave. (m)	107th Ave. (m)	115th Ave. (m)	123rd Ave. (m)	Dysart Rd. (m)
1903 USGS 2" = 1 mile CI = 5' (MSL)	287.4	284.7*	281.9	272.8*	277.4
USGS Quad Tolleson 1957	287.7	285.0	281.9	280.4	278.3
USCOE/ FIS 1983 1" = 200' CI = 4'	287.7	285.0	283.0	279.4	277.4
Baker Re. FIS 1993 Topo 1" = 400' CI = 4'	288.0	285.4	283.1	280.0	278.3

*based on slope between points

sla
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CLIENT _____ JOB NO. _____ PAGE _____
PROJECT PAZHMEO1 DATE CHECKED _____ DATE 8/3/94
DETAIL _____ CHECKED BY _____ COMPUTED BY TDM

Define Study Area into two Reaches

Reach 1 107th Avenue alignment to 115th Avenue alignment

Reach 2 115th Avenue to 123rd Ave

Sinousity Ratio = $\frac{\text{Thalweg}}{\text{D.V. length}}$

D.V. length 10,400

Map Year	Thalweg length (ft)	Sinousity Ratio
1957	11,600'	1.12
1993	16,000	1.54

APPENDIX I

INTERNATIONAL SYSTEM OF MEASUREMENT (SI) CONVERSION FACTORS

SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

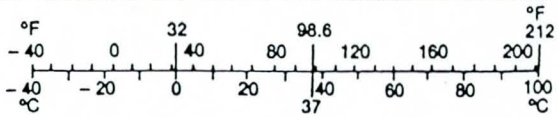
Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimetres	mm
ft	feet	0.305	metres	m
yd	yards	0.914	metres	m
mi	miles	1.61	kilometres	km
		AREA		
in^2	square inches	645.2	millimetres squared	mm^2
ft^2	square feet	0.093	metres squared	m^2
yd^2	square yards	0.836	metres squared	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	kilometres squared	km^2
		VOLUME		
fl oz	fluid ounces	29.57	millilitres	mL
gal	gallons	3.785	litres	L
ft^3	cubic feet	0.028	metres cubed	m^3
yd^3	cubic yards	0.765	metres cubed	m^3

NOTE: Volumes greater than 1000 L shall be shown in m^3.

Symbol	When You Know	Multiply By	To Find	Symbol
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams	Mg
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5(F-32)/9	Celcius temperature	°C

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimetres	0.039	inches	in
m	metres	3.28	feet	ft
m	metres	1.09	yards	yd
km	kilometres	0.621	miles	mi
		AREA		
mm^2	millimetres squared	0.0016	square inches	in^2
m^2	metres squared	10.764	square feet	ft^2
ha	hectares	2.47	acres	ac
km^2	kilometres squared	0.386	square miles	mi^2
		VOLUME		
mL	millilitres	0.034	fluid ounces	fl oz
L	litres	0.264	gallons	gal
m^3	metres cubed	35.315	cubic feet	ft^3
m^3	metres cubed	1.308	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.205	pounds	lb
Mg	megagrams	1.102	short tons (2000 lb)	T
		TEMPERATURE (exact)		
°C	Celcius temperature	1.8C + 32	Fahrenheit temperature	°F



* SI is the symbol for the International System of Measurement

(Revised April 1989)

Simons, Li & Associates, Inc.

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SIMONS, Li & ASSOCIATES, INC.

CLIENT _____ JOB NO. _____ PAGE _____
PROJECT PAZHME-01 DATE CHECKED _____ DATE 8/3/94
DETAIL English to Metric CHECKED BY _____ COMPUTED BY TDM
116th Ave

ft^3/s to m^3/s use 0.02831685

Discharge @ 116th Ave. (CP 1310 from CAWCS)

	CFS	m^3/s		
5-yr	40,000	1132.6	use	1133 cms
10-yr	95,000	2690.1	use	2690 cms
20-yr	135,000	3822.8	use	3823 cms
50-yr	200,000	5663.4	use	5663 cms
100-yr	250,000	7079.2	use	7079 cms
200-yr	295,000	8353.5	use	8354 cms
500-yr	360,000	10,194.1	use	10,194 cms
1993	138,000	3908	use	3908 cms
Future 100-yr	210,000	5946.5	use	5947 cms

1' = 0.3048 m

3.5' = 1.0668 m

APPENDIX J

ENCROACHED FUTURE CONDITIONS

(SEPARATELY BOUND)