3 DSM2 San Joaquin River Boundary Extension

3.1 Introduction

The purpose of the DSM2 model boundary extension is to create a direct dynamic link between the Delta and the State's second longest river, the San Joaquin. Many Delta water supply, water quality, and fishery issues are closely linked to conditions in the San Joaquin River (SJR). Extension of the SJR boundary will provide a tool to investigate how the Delta may respond to different SJR management strategies.

The system domain for this project is the portion of the SJR from near Vernalis to the Mendota Pool (see Figure 3-1). The project was divided into two phases because of substantial gaps in bathymetry data. Phase I is that portion of the domain from the Bear Creek confluence near Stevinson down to the current boundary near Vernalis. Phase II is that portion of the domain from Stevinson to Mendota Pool. In general, the SJR boundary extension work reported herein is limited to Phase I.

3.2 Model Development

A set of USGS 7.5-minute topographic maps encompassing the project area was used to discretize the domain into 92 reaches with 93 nodes (Phase I & II). The locations of the nodes generally correspond to a hierarchy of major tributaries, possible point sources of inflow and outflow, or convenient landmarks. The geographic coordinate of each node was manually measured from the maps using the Universal Transverse Mercator, Zone 10 (UTM) reference system. The length of each reach was manually measured from the maps using a digital planimeter. Three values per reach were measured then averaged. The reaches are approximately 1-2 miles long.

Bathymetry data for the system domain were obtained from the U.S. Army Corps of Engineers (USACE). The data were transformed from the latitude/longitude coordinate system to the UTM coordinate system using "Corpscon," public domain software developed by USACE. The transformed bathymetry data and nodal coordinates were then input into the Department's Cross Section Development Program (CSDP).

CSDP was used to define the system geometry, such as channel alignment and cross sections, for input to DSM2. The model's river reaches were defined by aligning centerlines to follow the thalweg (low flow channel) that was visually located from the bathymetry data graphically displayed by CSDP. A new function was added to CSDP that calculates the reach length from the aligned centerlines. However, special care is necessary for this function to give sufficient results. The thalweg can be difficult to visually extract from the data and is highly sinuous. The placement of many short centerline segments may be necessary to accurately define a meandering channel alignment. Many short segments were used to describe the channels in CSDP. As a benchmark, the reach lengths computed by CSDP were compared to the manual planimeter measurements. The net difference between the two methods was small (approximately two feet), with CSDP yielding the greater length.

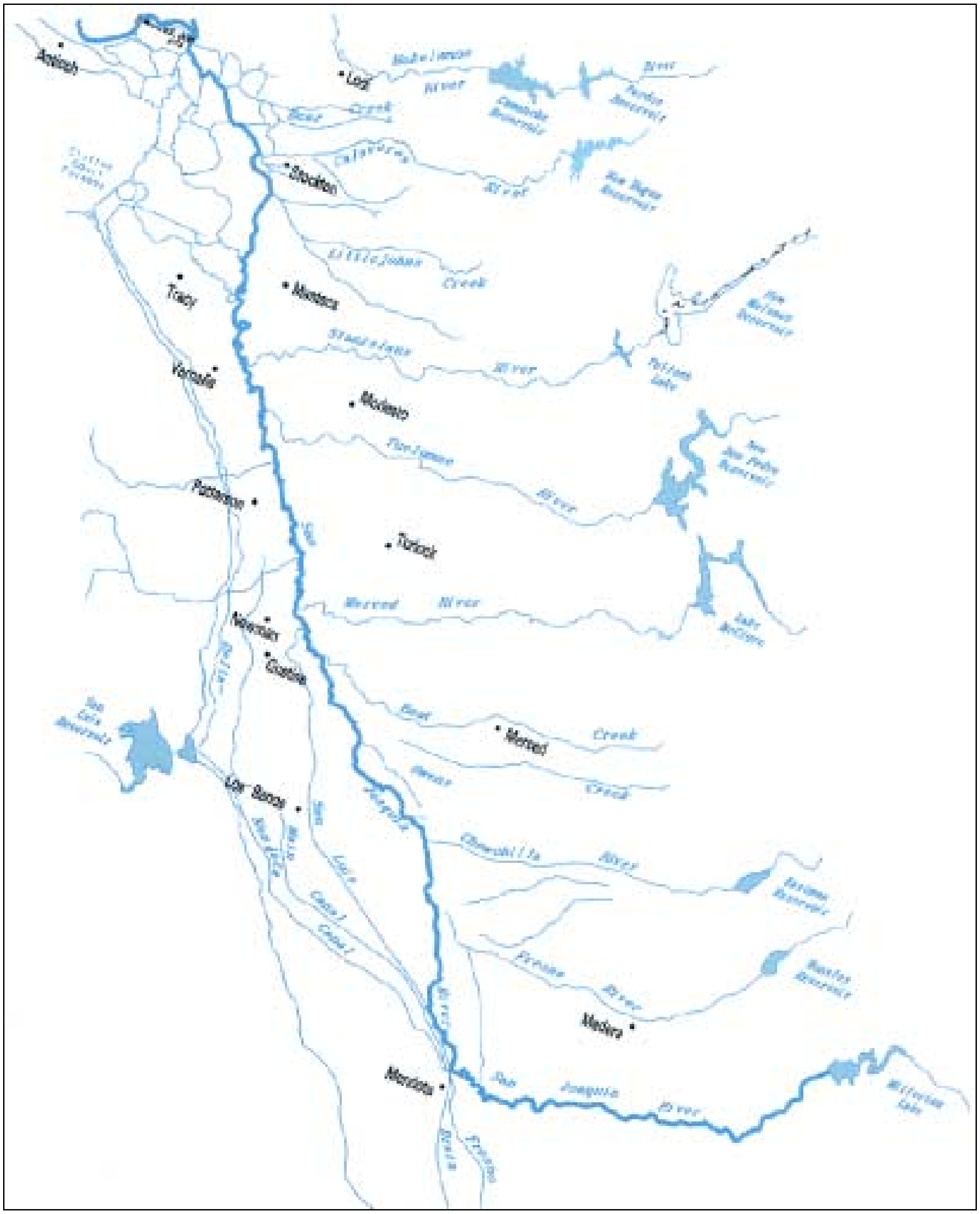

Figure 3-1: San Joaquin River.

Irregular cross sections were developed using CSDP to approximate the river's existing natural shape. Every channel has at least one representative irregular cross section and some have as many as three. Personal engineering judgement and ability to distinguish a realistic cross section from the data displayed at chosen locations determined the initial location of the cross sections within a channel. In most cases the thalweg of the cross section was well defined but the floodplain was not. Digital aerial photos were used to reasonably approximate the shape and extent of the flood plains.

Even with the use of irregular cross sections, DSM2 still requires the definition of two rectangular cross sections per channel segment. These rectangular cross sections are only used if there is not at least one irregular cross section in a given channel segment. Therefore, a homogeneous rectangular cross section width of 500 feet was specified at the upstream and downstream sides of each node with a linear bottom slope between nodes. The slope was calculated using the change in channel elevation from the upstream boundary near Stevinson to Vernalis, approximately 60 feet (msl) to 0 feet (msl), respectively, divided by the number of reaches between those locations. A stage of 12 feet above the bottom elevation was specified for the initial condition.

3.3 Pre-Calibration Model Runs

A mock planning study was developed for the first trial run of the model. The purpose of this exercise was to test the planning mode input files and new geometry for design flaws. A few select periods with hydrologic conditions representative of dry, normal and wet scenarios were chosen. The hydrology for the Delta and major SJR tributaries was obtained from the DWR Planning Simulation Model (DWRSIM). Agricultural consumptive use was not readily available for the SJR and was neglected for these preliminary simulations.

The major problem encountered in the first trial run was channels drying up for the dry hydrologic scenario. DSM2 will not allow a discontinuity in the flow regime and model calculations will not proceed if a channel dries up. This error can typically be attributed to large changes in cross sectional area or dramatic changes in bottom elevation between irregular cross sections.

A systematic approach was developed to debug the geometry design. The model was run until a channel segment dried up then the irregular cross section(s) with that channel segment was (were) removed and the model ran again. If no irregular cross sections are defined for a given channel segment, then the model will default to the rectangular cross section defined for that channel segment. This process was repeated until the model ran to a successful completion. Approximately 40 percent of the irregular cross sections were removed, most of them consecutive and localized to four general areas. This consecutive and highly localized trend suggested that not all of the cross sections removed were problematic.

The elevation of a default rectangular cross section in one channel segment may not closely match an irregular cross section in a neighboring channel. This requires the introduction of a continuous block of rectangular cross sections where the elevations of the upstream and downstream ends of this section approximate the elevations of the neighboring irregular cross sections. Also, a problematic cross section may not cause an error in its own channel segment but may cause an error in other channel segments in close proximity. In some cases where a channel segment had multiple cross sections, only one cross section was the source of error.

Based on these conclusions, a refinement process was conducted to differentiate potentially good cross sections from the problematic ones. Each problem area was investigated independently of the others. Irregular cross sections were reintroduced and removed in systematic combinations until only a minimal number of irregulars were necessary to be removed. This process reduced the number of likely problematic cross sections to approximately 35 percent.

The next step was to determine which cross section was the likely source of the problem for the group. Two visualization methods were applied. The first step was to plot a family of stage to cross sectional area relationship curves for a problematic cross section and a few upstream and downstream of that cross section (see Figure 3-2). The other was to sequentially plot the bottom elevations of a problematic cross section and a few neighboring cross sections (see Figure 3-3). These tools were valuable assets to determine which geometric attribute was most likely to be causing the problem. In all cases, the bottom elevation transition was found to be the problem. The model generally experienced channel drying with changes in elevation greater than 5 feet between cross sections, sometimes more or less depending on the horizontal distance between them.

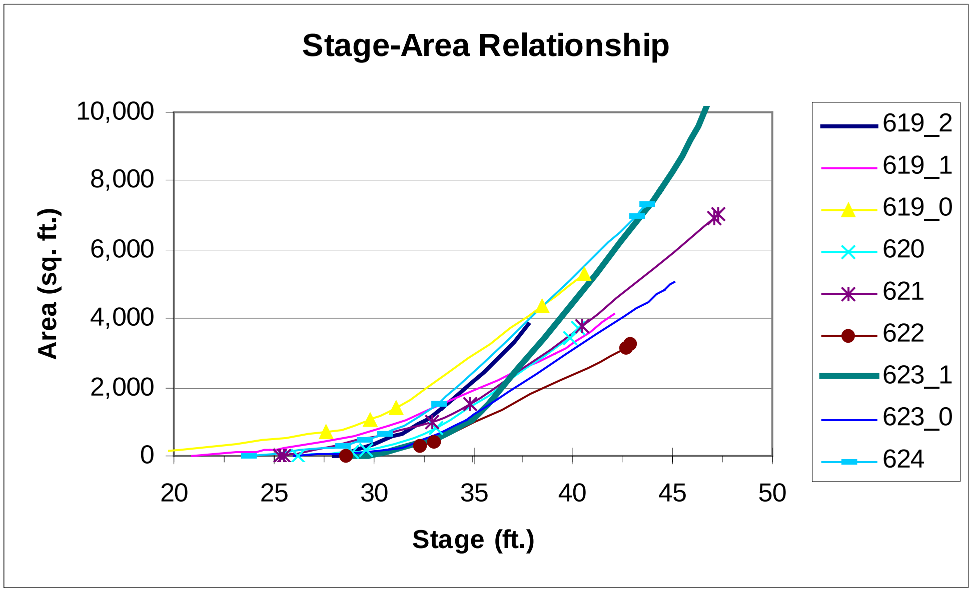

Figure 3-2: Stage-Area Relationship for channels 619 to 624.

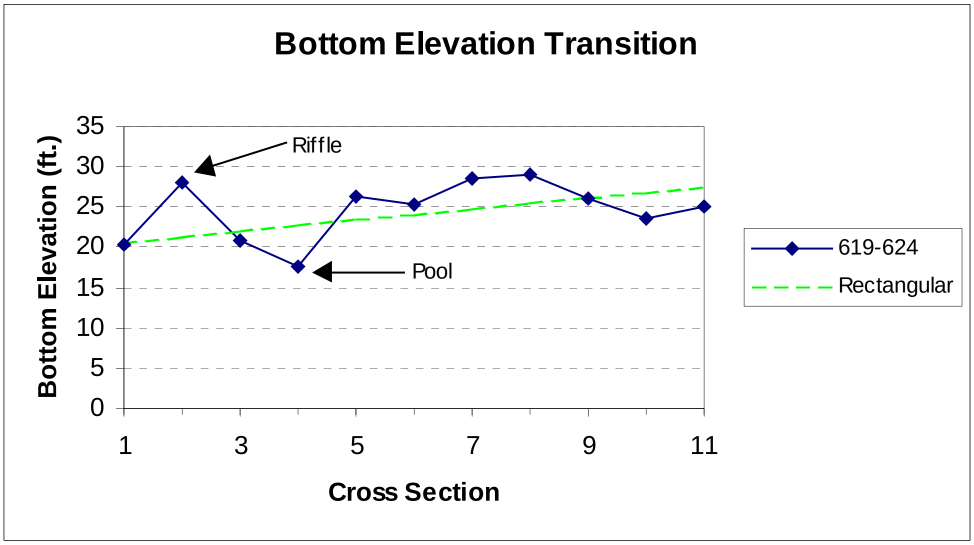

Figure 3-3: Bottom Elevation Transition for the Irregular Cross Sections from Channels 619 – 624.

Some of the deep poles and shallow riffles needed to be averaged. The bottom elevations of the corresponding rectangular cross sections were superimposed on a "bottom elevation transition" plot such as shown in Figure 3-3. This provided a reference baseline to a working slope since the model ran successfully when those cross sections were used as substitutes. The bathymetry data was revisited to determine a better location in the channel to draw a representative cross section with a bottom elevation closer to this baseline. In a few cases where a channel had more than one irregular cross section, a surplus section was deleted when relocation failed. After some iteration, the model ran to a successful completion without substitution of rectangular cross sections.

3.4 Future Directions

In coordination with the SJRMP's Water Quality Subcommittee,

1. Collect historical hydrology data and calibrate DSM2-HYDRO for the boundary extension;
2. Collect historical water quality data and calibrate DSM2-QUAL for the boundary extension; and
3. Complete Phase II.