4.0 Hydraulics

4.1 METHODOLOGY

Dynamic Hydraulic modeling for the open channel and creek systems was performed with the USACE HEC-RAS (River Analysis System) modeling software (referred to hereafter as HEC-RAS). This allows for unsteady flow conditions modeling using the flow hydrographs generated by the SACCALC and HEC-1 hydrologic modeling software as direct input to the program (via the DSS interface). Unsteady flow modeling is required by Sacramento County for the evaluation of the flow and water surface attenuation characteristics of the open channel systems and the effect of any associated structures including bridges and culverts.

The overall approach for the hydraulic analysis was to apply the proposed land use for the FVGCP to the affected sheds, calculate the resulting outflow hydrographs using HEC-1 for each shed, and use the computed flow data as input to the unsteady flow RAS model for each stream. Each of the three streams/stream groups was modeled for both pre-project and proposed post-project conditions.

Trunk storm drainage systems were prepared and analyzed for the various areas of the FVGCP. For Trunk Storm Drainage System evaluations, the "Nolte" flow was used to size facilities. For systems which intersect, or parallel arterial roadways, the 100-year event was also evaluated to verify that flooding of the arterial roadway would not occur in the 100-year design event. Simple pipe systems and pipe/open channel systems where attenuation (detention) was not a factor were modeled using the CS DRAINAGE STUDIO software. Sacramento County requires that the all roads including collector and residential streets cannot be ponded by more than 6 inches (Appendix H). Street grading for the FVGCP residential streets is not available at this time and so final determination of ponding depths will have to be made when grading plans become available. The CSDS pipe systems analysis results are included in Appendix D CSDS Storm Drainage System Analysis. For trunk systems where attenuation and/or detention were a factor the XP-SWMM software was used to evaluate the trunk facilities.

Appendix E Oversized Exhibits contains larger scale presentations of the FVGCP area proposed drainage facilities including pipe and drainage channel layouts, SWMM model pipes and channels and the major stream channel alignments.

- **Elder and Gerber Creeks**

For the Elder Creek and Gerber Creek stream group the previously prepared unsteady flow HEC-RAS model from the LOMR submittal was used as the pre-

project condition model and the starting point for evaluating the post FVGCP system modifications.

The Elder-Gerber stream group is the most significant of the streams within the plan area. It is also the system with the most significant impact from outside the actual drainage area of the system in the form of inflow from the Laguna Creek spill.

Channel improvements are proposed to provide flood control enhancements to both Elder Creek and Gerber Creek. Proposed channel improvements on Elder Creek extend about 2.2 miles or 11,500 feet from the downstream boundary of the FVGCP area at RM 4.904 to approximately 1,000 feet upstream of Florin Road at RM 7.077. Channel improvements on Gerber Creek extend over 18,000 feet or about 3.5 miles from the confluence with Elder Creek upstream to RM 3.481 just downstream of the crossing at Vineyard Road.

The proposed channel improvements are intended to lower water surface elevations and peak flow rates by lowering the channel inverts and providing additional in stream attenuation. The various proposed detention basins are designed to compensate for the peak flow impacts of the proposed development areas.

- **Laguna Spill**

During extreme events, flow from Laguna Creek spills north along the California Central Traction Railroad (CCTRR) to Gerber Creek. Two of the 34 applications, namely Portico Acres and Gerber-Bradshaw Southwest are located in the path of the spill (Oversized Exhibit SH-1). These proposed developments may not be able to build until the spill from Laguna Creek is cut off. We looked at the possibility of transmitting the spill in a channel to allow development but no cost effective way of collecting the flow into a channel or detention basin within FVGCP was found.

- **Interim Drainage for Bradshaw Northeast and Vintage Ranch**

Interim flood control detention basins will be required for Bradshaw Northeast and Vintage Ranch developments. The detention basins will reduce the post-project flow down to pre-project conditions. Outflow from the detention basins will be discharged to an existing channel. The half-mile section of the channel upstream of Bradshaw Road is proposed to be relocated along the north boundary of Florin-Bradshaw Northeast development (see oversize Interim FP). The channel is proposed to be widened to 20-foot bottom width and 3:1 side slopes. Two new 42-inch culverts are proposed to be added to Bradshaw Road crossing to prevent the 100-year flood from overtopping the roadway under ultimate conditions. Flood control detention for the two applications will not be needed when the regional detention basin E31 along Elder Creek and the proposed channel are constructed. Each development will provide its own water quality treatment facility.

- **Florin Creek**

Previously available hydraulic modeling for Florin Creek consisted of an old steady flow HEC-2 model that extended only as far east as Florin-Perkins Road, approximately ½ mile to the west of the FVGCP area. It was necessary to convert this model to an unsteady flow HEC-RAS model in order to first determine the pre-project conditions for Florin Creek from upstream of Florin-Perkins Road to the area upstream and east of the CCTRR. The updated model provided a basis for the estimated water surface elevations and flow rates,

Within the FVGCP area, the facilities for this system will include trunk storm drain pipe, a stormwater quality basin and detention basins for peak flow mitigation. XP-Software's XP-SWMM (SWMM – storm water management model) program was used to prepare an analysis of the upstream areas of the Florin Creek watershed (See Figure 4.1) where the majority of the conveyance would be provided by a piped system. Hydrographs exported from the hydrologic model using SacCalc were imported into the SWMM model to provide the proper inflows.

The northern reach of Florin Creek is expected to require a system of several detention basins in order to maintain peak flows at acceptable levels for transmission via a piped system. The most downstream of these basins would also provide required water quality treatment storage.

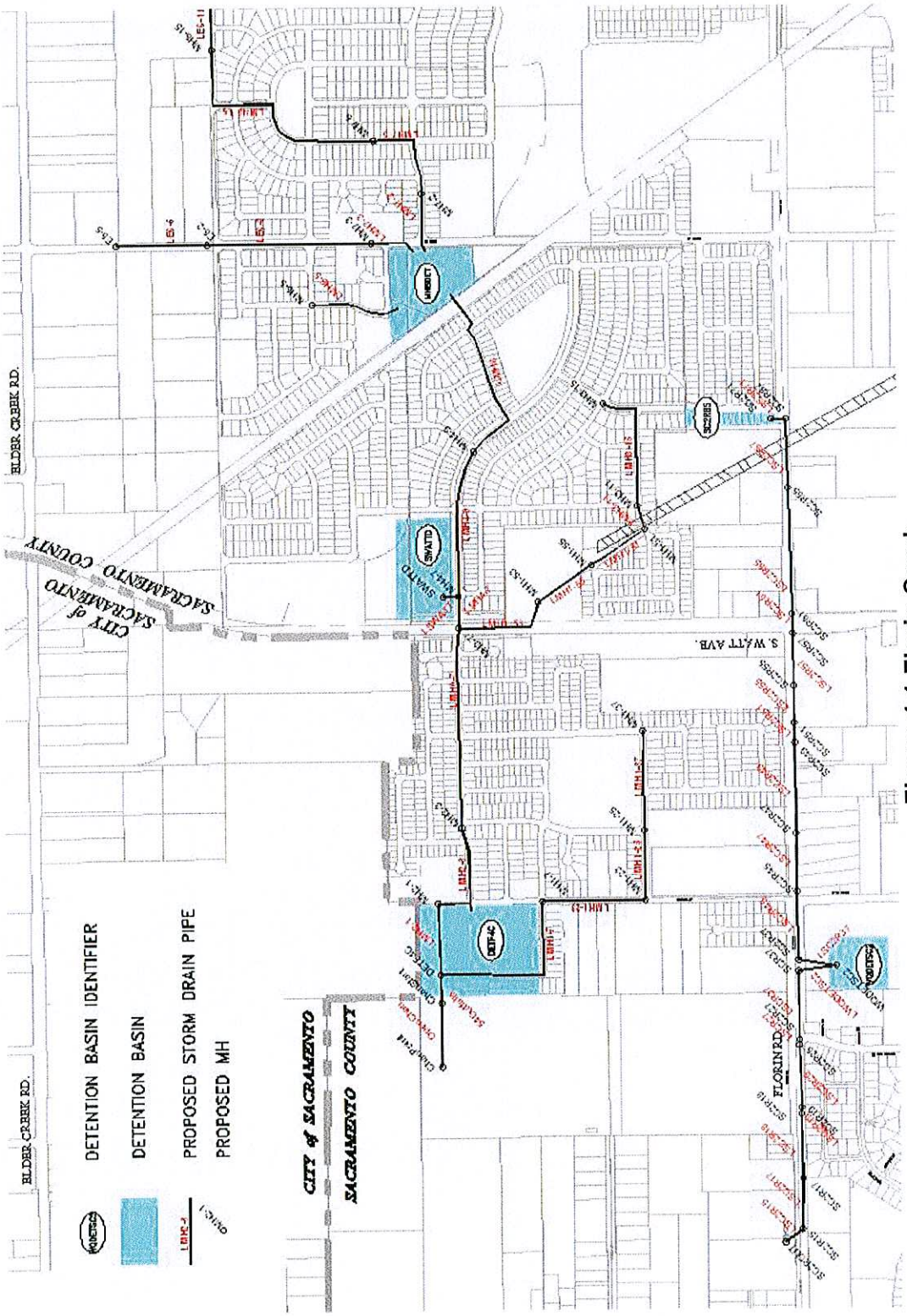

Figure 4.1 Florin Creek
SWMM Model Schematic Layout

The existing southern reach of Florin Creek was determined to be inadequate to convey the peak 100-year flow rates estimated in the modeling. In order to reduce the peak flows to a level which could be conveyed by the existing downstream system two detention basins were added to this portion of the plan. The downstream basin would also provide capacity for water quality treatment.

Following the SWMM computations, two output hydrographs from the downstream ends of the two SWMM models, one for each reach, were exported to be used as the upstream input hydrographs into the RAS model for the remaining downstream portion of Florin Creek. This model was then used to evaluate the effects of the FVGCP on the rest of the Florin Creek system. Schematic layouts of the pre and post FVGCP RAS models are included in Appendix B HEC-RAS Models.

- **Unionhouse Creek**

Unionhouse Creek had previously been analyzed by the older unsteady flow hydraulic modeling software known as UNET. The Unionhouse Creek model had been built using the 3.2 version of the UNET software. The UNET software itself was later upgraded to version 4.0 and subsequently integrated into the unsteady flow version of the HEC-RAS software. Migration of UNET models from one version to another version is usually complicated. Therefore, the original Unionhouse Creek UNET model was converted into an unsteady flow RAS model for use as the base pre-project condition model.

Once this model was created the proposed FVGCP hydrographs were used to assess the impact on the Unionhouse watershed.

The existing detention basin (UHDET1) which was partially constructed with the Tamarindo project to control flood waters, will be enlarged from 25 acre-feet to 37.7acre-feet. Another detention basin, UHDET2, will be required at the downstream boundary of the FVGCP project at UPRR to provide both water quality and flood control detention.

4.2 ELDER-GERBER CREEKS MODELING RESULTS

The Elder-Gerber stream group proposed condition proposes enhancements to the stream channels. As previously noted, improvements would include excavation of over 5 miles of enhanced channel. Channel improvements include deepening and widening of the main channel as well as the overbank areas. Figure 4.2 shows an illustration of a representative improved channel cross-section. Proposed channel cross sections are shown in Appendix G. Oversize Exhibit TR-1 shows the open space/trail features associated with the proposed drainage channels.

In addition to the proposed channel improvements additional detention facilities would be required to mitigate for the increased runoff which is anticipated as a result of development in the FVGCP area. Some modification of the pre-project and/or previously proposed facilities would also be necessary due to changes in the channel configuration. Table 4.2.1 shows detention basin results from the HEC-RAS storage area output table.

Table 4.2.1 - Elder-Gerber Detention Basins

Storage Area Model Designation	Maximum Water Surface Elevation	Minimum Detention Volume Elevation	Approximate Surface Area at Maximum Water Surface	Maximum Detained Volume
	(ft)	(ft)	(acres)	(acre-ft)
With Laguna Spill				
E24A	44.1	36.5	13.6	67.3
E24B	45.6	39.0	6.07	35.7
E26	47.4	42.5	10.4	50.6
E28	49.7	45.0	13.3	93.6
E31	49.8	45.0	11.0	79.0
G41	48.8	41.5	7.9	48.5
G45	56.7	56.0	2.9	12.4
G46	57.2	50.5	11.4	76.7
Without Laguna Spill				
E24A	42.9	36.5	8.0	51.4
E24B	45.6	39.0	6.1	35.4
E26	47.4	42.5	10.4	50.6
E28	49.7	45.0	13.3	93.6
E31	49.9	45.0	11.0	78.7
G41	47.6	41.5	6.4	38.4
G43	51.3	50.8	5.2	24.7
G45	56.7	56.0	2.9	12.4
G46	57.2	50.5	11.4	76.7

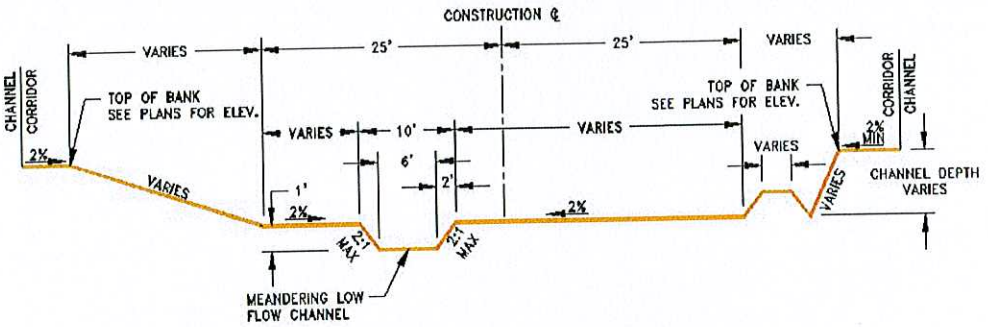

FIGURE 4.2 Sample Proposed Improved Channel Cross-Section

The model results indicate that the peak 100-year water surface elevations for both Elder and Gerber Creek would be generally lower throughout the improved areas with the proposed improvements including channel and detention facilities. Peak flow rates are also reduced except for some portions of Gerber Creek within the plan area. Due to the proposed channel improvements these peak flow increases do not have any adverse impact on Gerber Creek water surface elevations. Figures 4.2.1, 4.2.3 and 4.2.5 illustrate the peak water surface comparisons. Figures 4.2.2, 4.2.4 and 4.2.6 identify the peak 100-year flow rate comparisons.

Exhibit SD in Appendix E identifies the approximate proposed locations and sizes of these facilities.

Although the proposed 100-year post-project with Laguna spill water surface elevations are lower than existing conditions, the water surface elevations are above the channel bank at some locations especially where the excavated channel deviates from the existing channel alignment. At other locations, the water surface elevations are below the channel banks but the available Freeboard is less than one foot. It should be noted that the water surface elevation is not entirely contained in the proposed excavated channel as modeled in the Elder and Gerber Creek and in the North Vineyard Station Specific Plan UNET model. Sacramento County requires excavated channels to have at least one foot of freeboard. It is recommended that the low areas be raised to at least one foot above the 100-year water surface elevation (see oversize exhibit FB Sheets 1-4). Similarly, the water surface elevation for the post-project conditions without Laguna spill is not entirely contained in the proposed excavated channel (see oversize exhibit FB Sheets 5-7). Scalable water surface profile plots are included in Appendix I.

Flood Control Detention Basins

Three flood control detention basins are to be constructed with the FVGCP along Elder and Gerber Creeks. The basins are E28, E31 and G43. Basin G43 will be constructed with the development of the area south of Gerber Creek Road and west of Bradshaw Road which is expected to occur after the Laguna spill is shut off. Weir

crest elevations and lengths for the FVGCP, NVSSP and VSCP flood control detention basins have been optimized in order to reduce downstream flows and stages as much as possible. Table 4.2.2.shows the weir parameters for the post-project conditions with and without Laguna spill. Oversize exhibit DF-1 shows the detention basins that need to be constructed with the different areas in the FVGCP project. Table 5.2 shows which detention basins will be constructed with particular projects.

Table 4.2.2 – Detention Basin Weir Parameters

Detention Basin	Weir Top Width	Weir Crest Elevation		Reduction in Weir Crest Elevation
		With Laguna Spill	Without Laguna Spill	
	(ft)	(ft)	(ft)	(ft)
G45	212	56.1	56.1	0.0
G46	100	56.0	56.0	0.0
G43	60	N/A	50.0	N/A
G41	150	46.5	45.5	1.0
E24A	100	42.0	40.5	1.5
E31	50	51.0	51.0	0.0
E28	100	50.0	50.0	0.0
E24B	100	44.5	44.5	0.0

Detention Basin E20

Borcalli and Associates (B & A) performed an investigation of the need for Detention Basin E20. B & A determined that removal of Basin E20 would result in an increase in the ultimate condition peak stage of 0.4 foot and an increase in peak flow of 127 cfs between Southern Pacific Railroad and Elk Grove- Florin Road. However, the peak flows and stages were significantly below existing conditions. B & A indicated that the locations at which the ultimate conditions stage is above the top of bank would have to be raised with fill to accommodate the resulting increase in the removal of Basin E20. B & A concluded that Basin E20 is not an essential component of the Drainage Master Plan for the Elder and Gerber Creek drainage system.

Civil Solutions analyzed the removal of Basin E20 for FVGCP and NVSSP conditions with inter-basin transfer from Laguna Creek. The results obtained by Civil Solutions are similar to those of B & A. Civil Solutions therefore concurs with B & A conclusion that Basin E20 is not an essential component of the DMP of the Elder and Gerber Creek drainage system.

Elder/Gerber Creek Channel Excavation

Elder Creek reach between River Mile 4.8 and 6.0 is located within FVGCP and is expected to be excavated with the FVGCP development. Another reach of Elder Creek from River Mile 6.9 to 7.2 upstream of Florin Road will also be excavated. A

600-foot reach of Lower Elder creek that parallels Elk Grove-Florin Road provides only 2:1 side slopes along the banks of the channel. The channel cannot be relocated due to environmental reasons. The Sacramento County requirement of 4:1 side slopes could not be provided. The bank slopes will have to be stabilized in accordance with Sacramento County requirements. The constriction will cause increases in the water surface elevation and the overbank area will have to be filled to provide the required one foot freeboard.

Bridges and Culverts

Only one bridge at Elk Grove-Florin Road is located within FVGCP but we understand that the crossing at this location is a Sacramento County project. There are other crossings within NVSSP and VSCP that impact or are impacted by FVGCP flows. It is recommended that the proposed culvert crossings within NVSSP at McCoy Avenue on Elder Creek, Pasalis Lane West, Waterman Road and Pasalis Lane East be enlarged to reduce headlosses in order to minimize fill required to elevate the channel banks to provide the required. Table 4.2.3 shows the recommended culvert sizes.

Table 4.2.3 – Elder-Gerber Recommended Culvert Sizes

Location	Culvert size in UNET	Recommended Culvert Size
McCoy Ave	3- 8'x6' Box	3- 9'x7' Box
Pasalis Lane West	3- 8'x6' Box	3-10'x7' Box
Waterman Road	2- 8'x6' Box 1- 6'x6' Box	2-10'x7.5' Box 1-10'x8.5' Box
Pasalis Lane East	2- 8'x6' Box	2-10'x7.5' Box 1- 8'x8.5' Box

Floodplain Area North of Florin Road

The floodplain area north of Florin Road is not expected to develop due to wetlands. The area was therefore assumed to be open space in the hydrologic analysis and it was not encroached in hydraulics analysis.

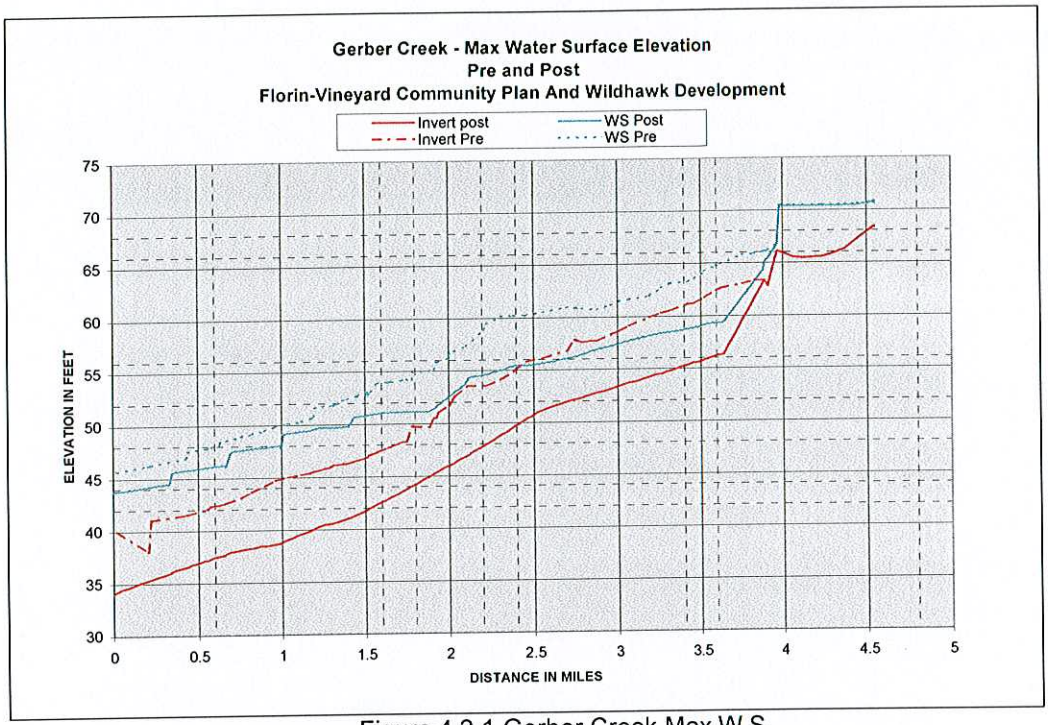

Figure 4.2.1 Gerber Creek Max W.S

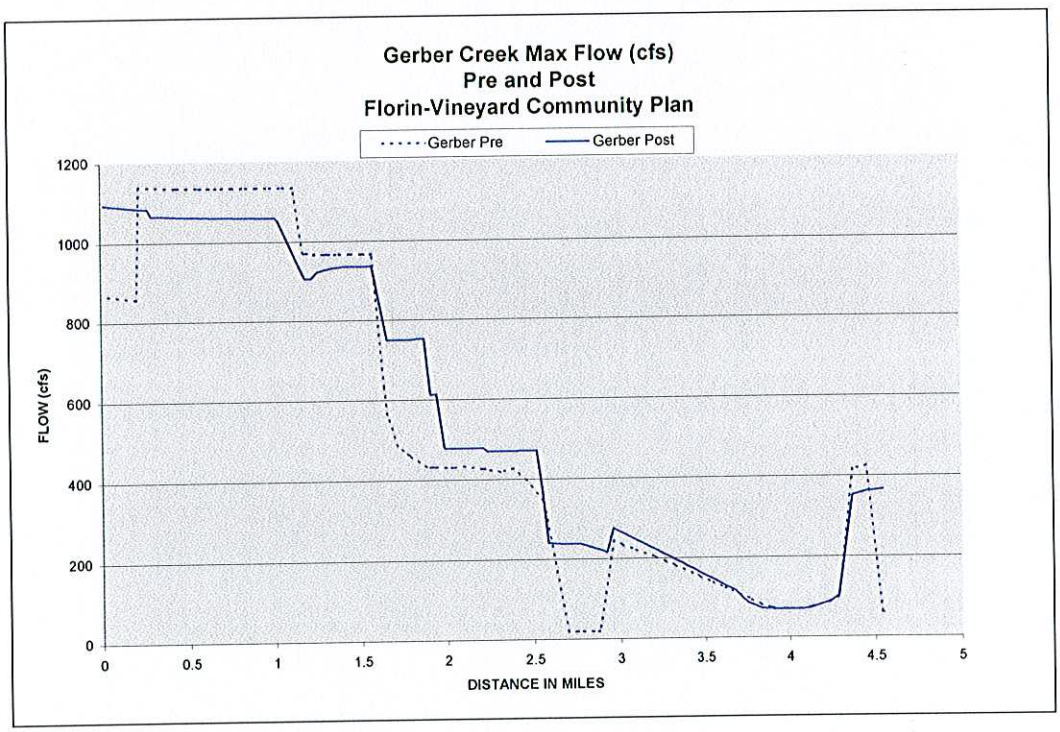

Figure 4.2.2 Gerber Creek Max Flow

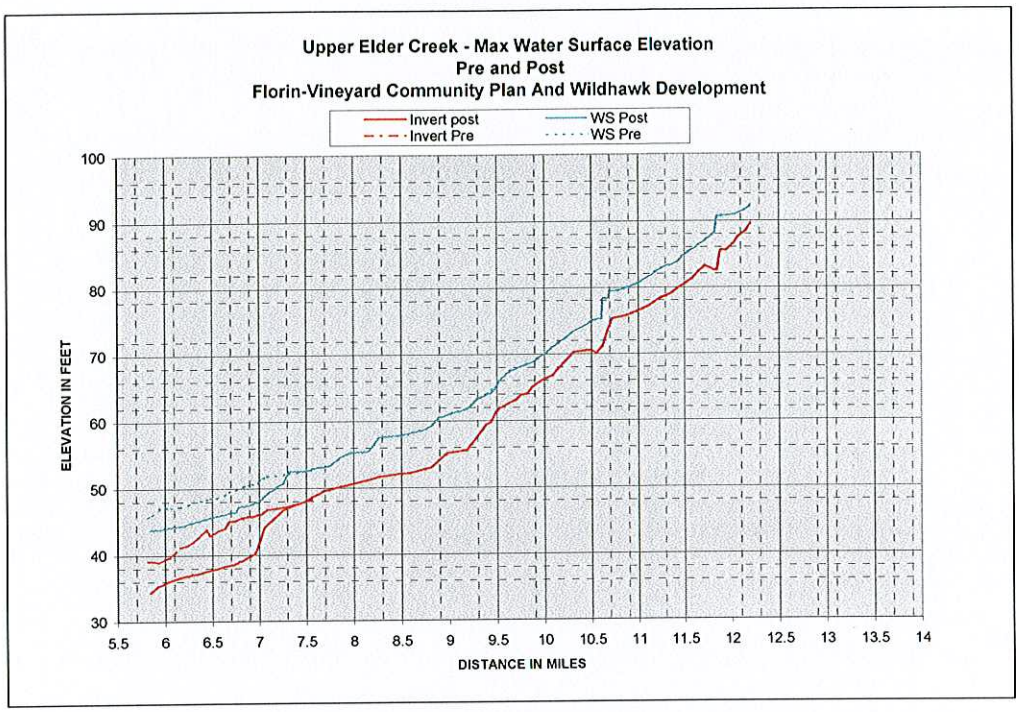

Figure 4.2.3 Upper Elder Creek Max W.S

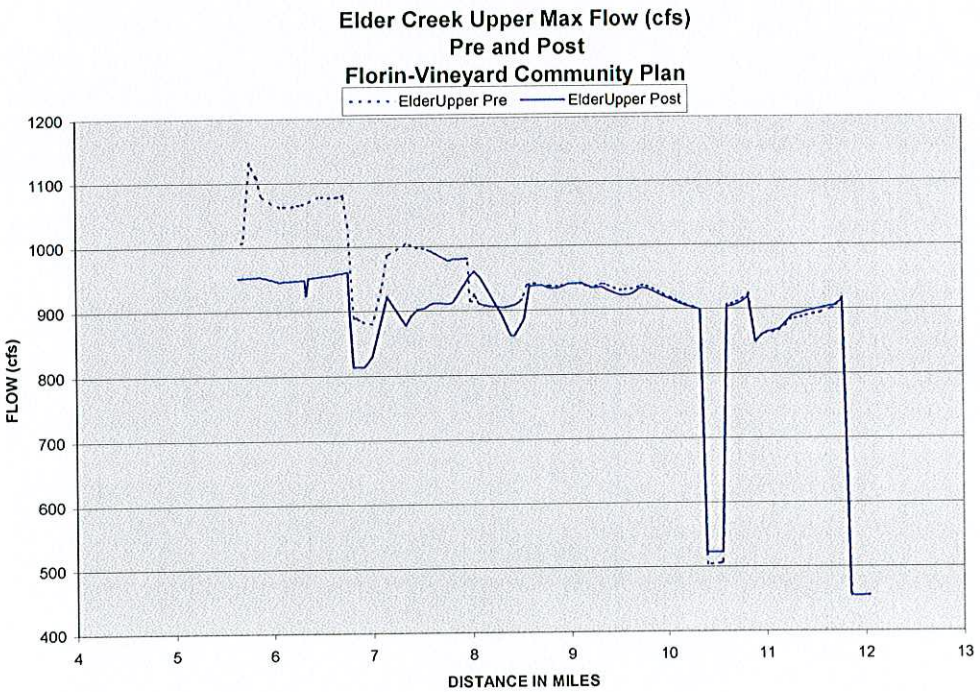

Figure 4.2.4 Upper Elder Creek Max Flow

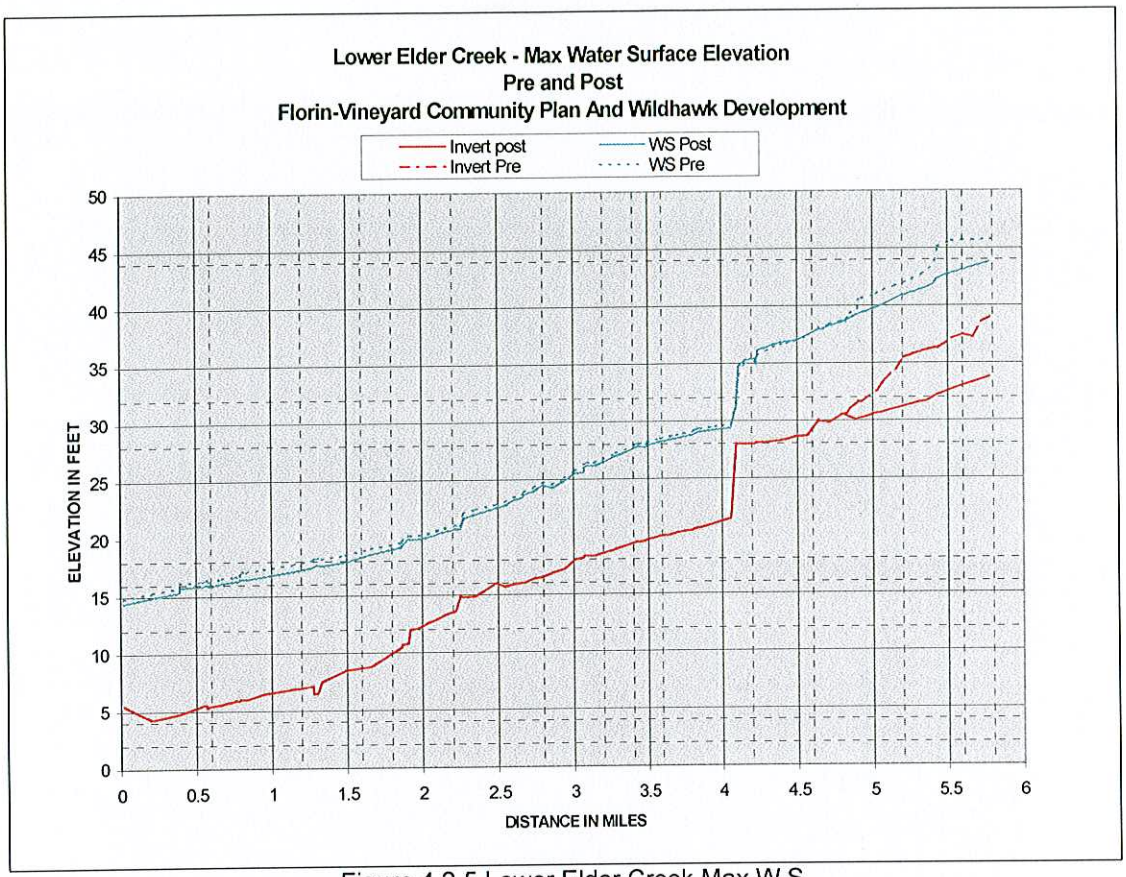

Figure 4.2.5 Lower Elder Creek Max W.S.

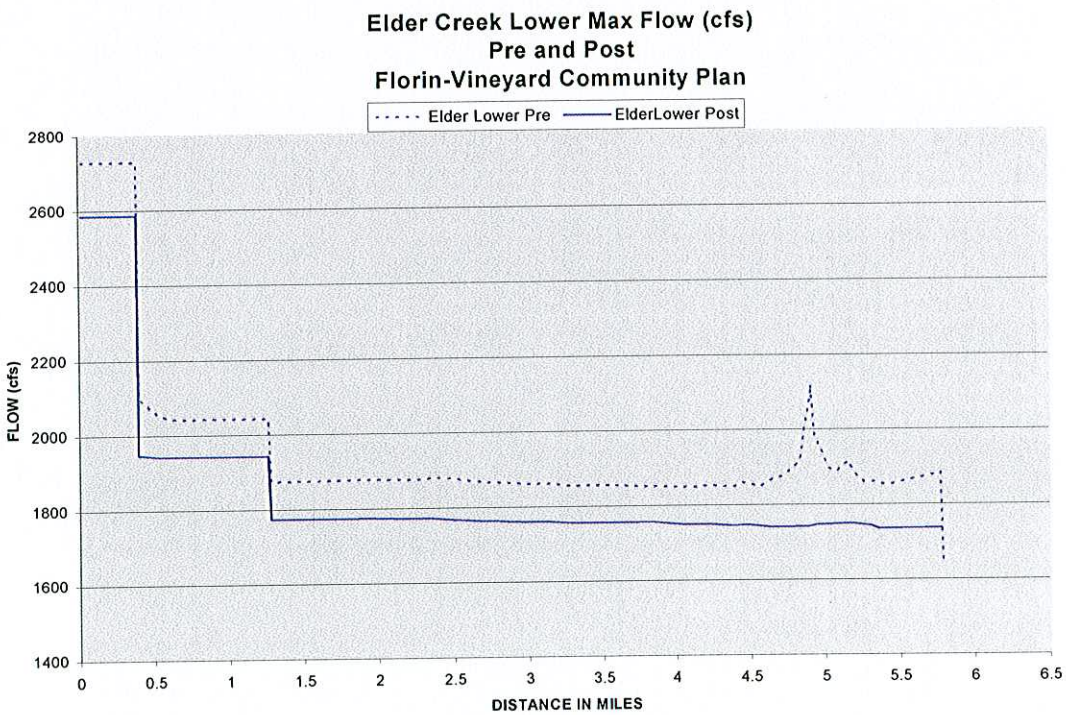

Figure 4.2.6 Lower Elder Creek Max Flow

4.3 FLORIN CREEK MODELING RESULTS

Florin Creek in the upstream area of the FVGCP consists mostly of small shallow ditches and road crossing culverts. A pre-project conditions model for the portions of Florin Creek upstream of Florin-Perkins Road was generated. This model together with revised shed delineations and hydrology modeling indicated that peak flow rates along portions of Florin Creek were less than had been previously indicated by the hydrologic models alone. This result is in conformance with reports indicating less peak flow than predicted and lower water peak surface elevations than expected. This appears to be due primarily to additional upstream ponding and attenuation, including areas upstream of the CCTRR, than was accounted for in previous modeling.

Part of the intent of the proposed changes to the Florin Creek watershed is to provide conveyance of expected "100-year" flows to the downstream side of South Watt Avenue as well as to reduce the peak runoff to the south branch of Florin Creek to compensate for limitations in the capacity of the pre-project facilities.

In order to accomplish the above, and maintain post-project peak flows and water surface elevations at or below pre-project levels, a number of detention basins are proposed for the upstream portion of Florin Creek within the FVGCP plan area. Table 4.3 summarizes the results of the modeling for the proposed detention facilities.

The model indicates that the current constraints on the capacity of the system for the south branch of Florin Creek can be accommodated by the combination of reduced tributary watershed area together with 2 local detention facilities. One basin was placed near the upstream end of the pipe system with an additional detention facility placed just upstream of the western boundary of the FVGCP plan area to provide both detention and water quality treatment

Due to the extent of the modifications to Florin Creek in the FVGCP area a direct graphic comparison of water surface elevations and flow rates such as was prepared for the Elder-Gerber system could not be generated. Instead data tables for the SWMM modeling results are included in the Appendix C. See Figure 4.1 for the SWMM components layout. The oversize exhibits in Appendix E show a schematic of the system layout. The geometry of the Florin Creek system in areas downstream of the FVGCP area remained essentially unchanged facilitating more direct comparison. Figures 4.3.1 and 4.3.2 show HEC-RAS modeling software graphs illustrating the maximum water surface elevations and peak 100-year flow rates for the downstream portions of Florin Creek. The HEC-RAS results section in Appendix B contains the schematic layout for the model.

Table 4.3 Florin Creek Detention Basins				
Proposed Detention Facilities				
Storage Area Model Designation	Maximum Water Surface Elevation (ft)	Minimum Detention Volume Elevation (ft)	Approximate Surface Area at Maximum Water Surface (acres)	Maximum Detained Volume (acre-ft)
WQDETSC2	40.3	37.8	2.4	14.3
MH6DET	47.9	39.6	3.6	25.5
SWATTD	44.3	36.7	5.2	34.9
DETF4C	39.4	37.5	9.1	42.6
SC2R71	46.6	39.5	1.1	6.0

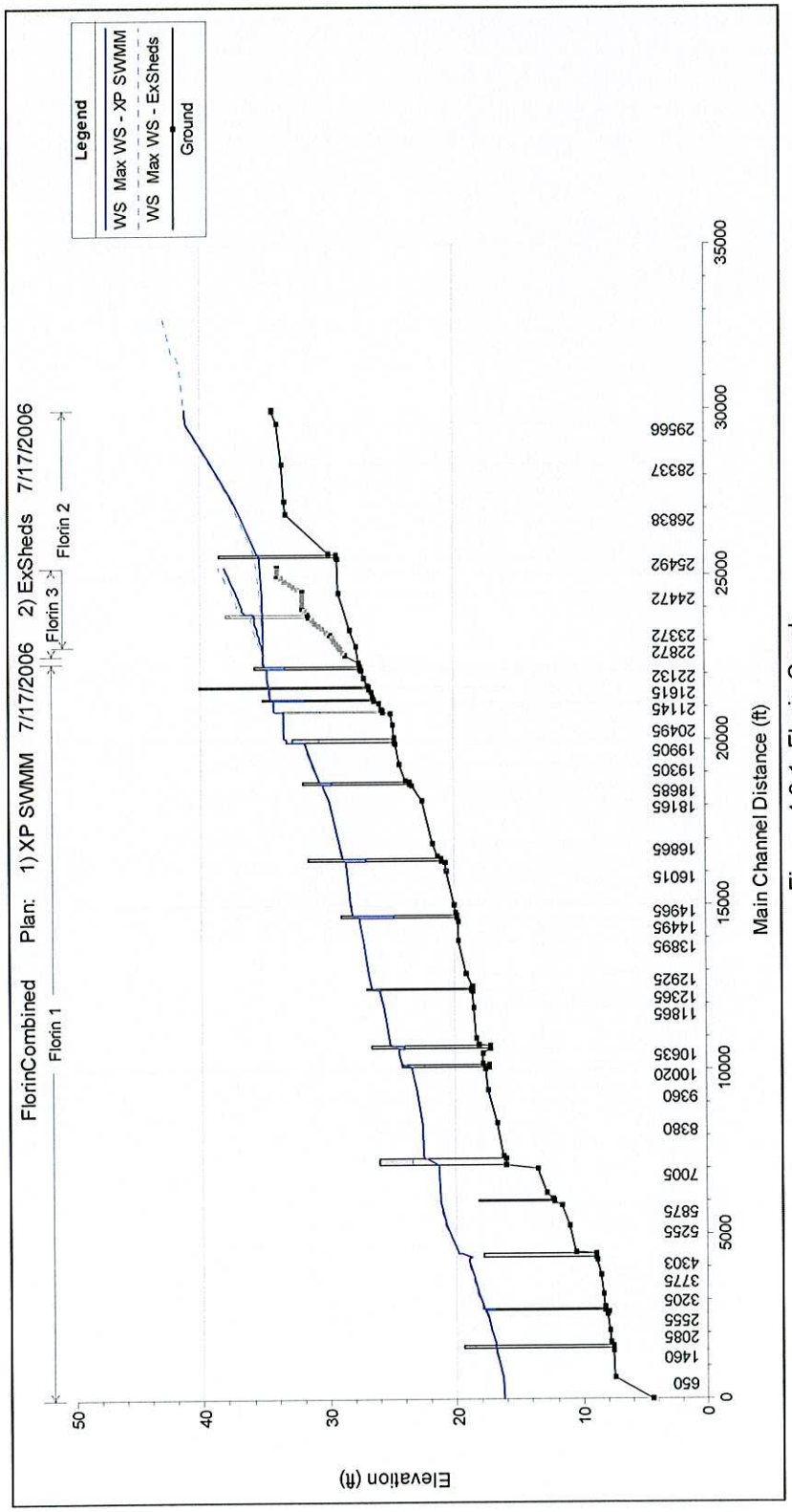

Figure 4.3.1 Florin Creek
Maximum Water Surface Elevation
Pre and Post FVGCP

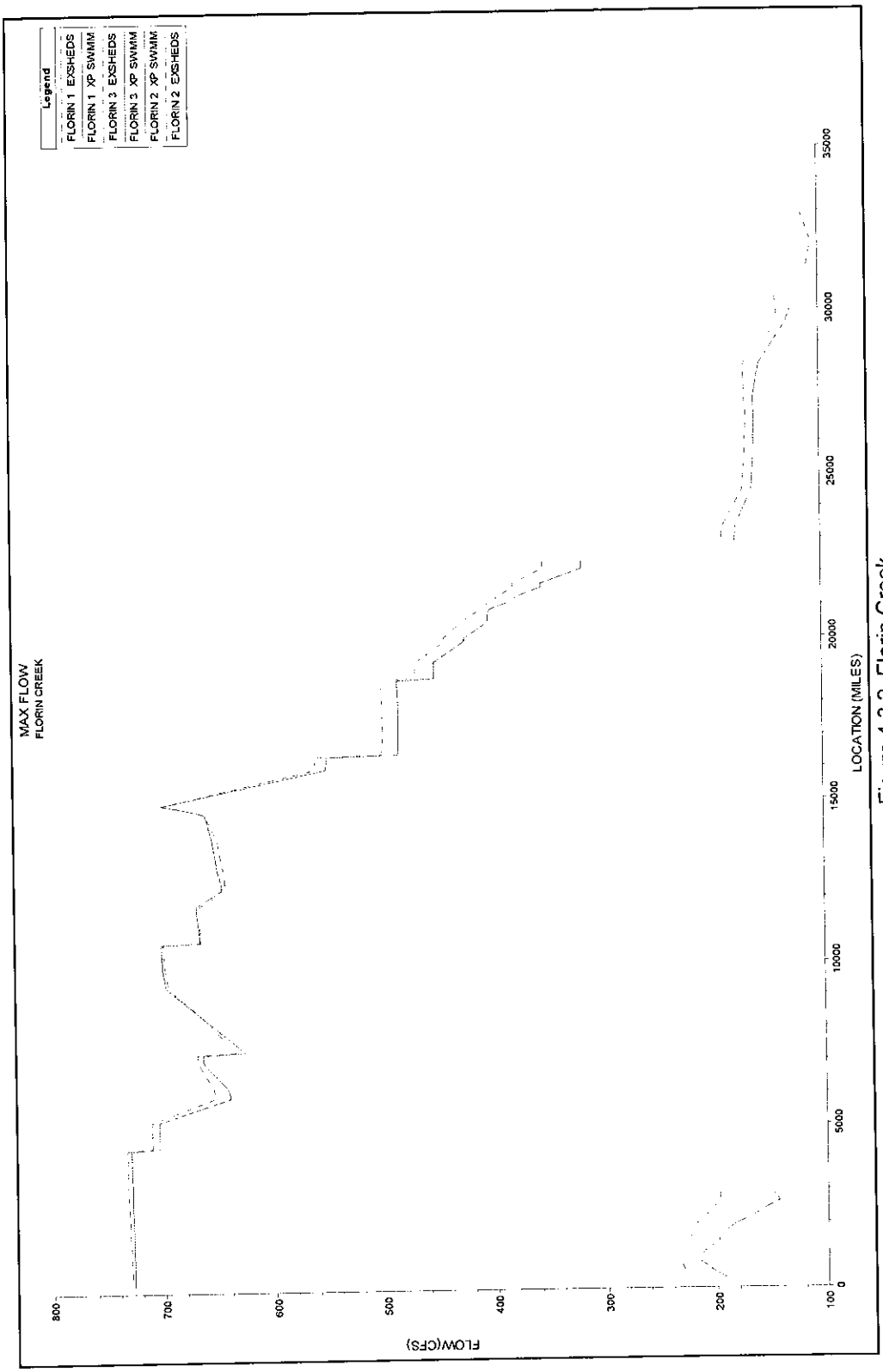

Figure 4.3.2 Florin Creek
Peak Flow Rates
Pre and Post FVGCP

4.4 UNIONHOUSE CREEK MODELING RESULTS

The Unionhouse Creek RAS model required less modification from the pre-FVGCP to post FVGCP condition. The model indicates the existing detention facilities, when expanded to previously estimate future design capacity, would be adequate to provide the necessary mitigation for increases in runoff due to development. Results indicate a detention basin will be required just upstream of the Union Pacific (old Southern Pacific) railroad right of way with the current FVGCP development proposal.

Figure 4.4.1 shows the maximum water surface elevation results of the RAS modeling for Unionhouse Creek for the pre- and post-FVGCP development

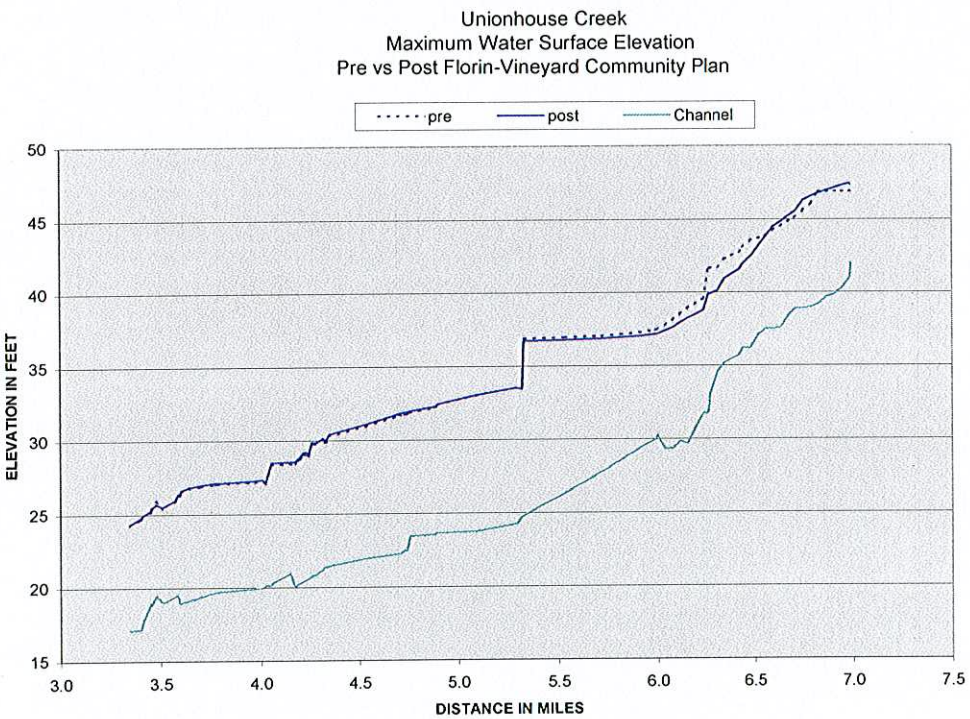

Figure 4.4.1 Unionhouse Creek WS Elevation Comparison

conditions. With the modified detention no increase in downstream maximum water surface elevations is anticipated. Figure 4.4.2 shows the peak flow rate results of the RAS modeling for Unionhouse Creek for the pre- and post-FVGCP development conditions.

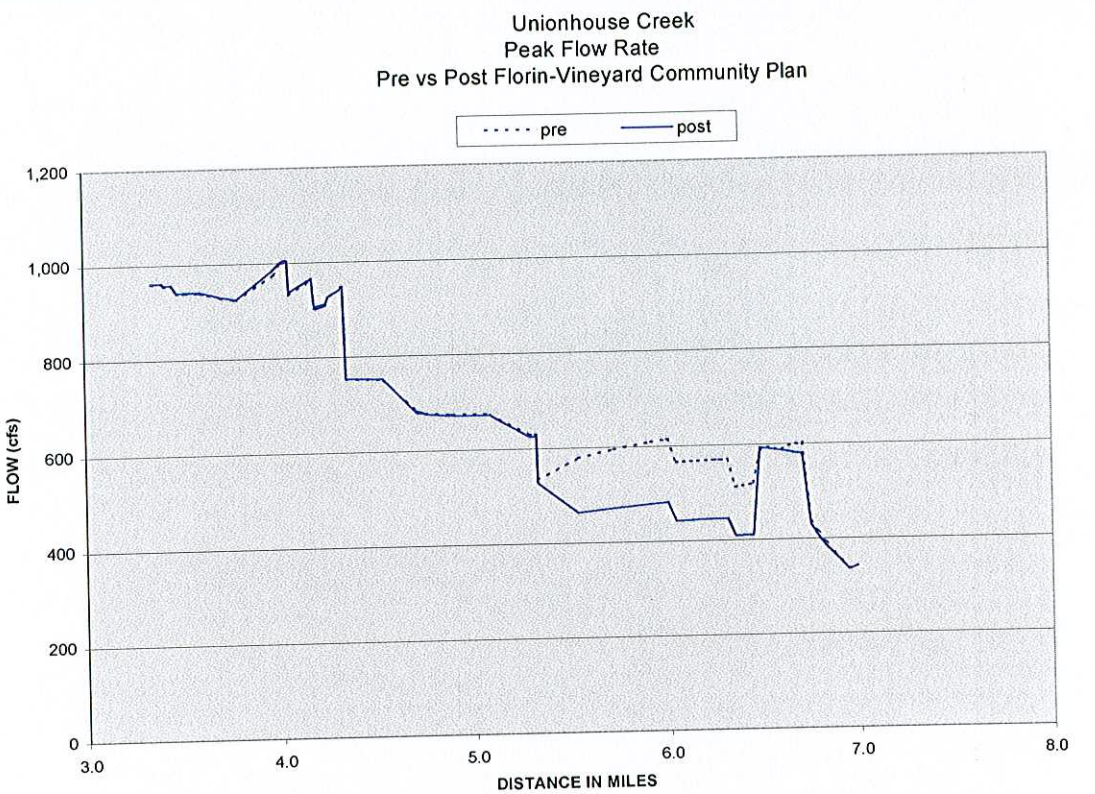

Figure 4.4.2 – Unionhouse Creek Peak Flow Comparison

Table 4.4.1 shows the RAS modeling results for the modified Unionhouse detention and water quality basin.

TABLE 4.4.1 Proposed Detention Facilities Unionhouse Creek

Storage Area Model Designation	Maximum Water Surface Elevation (ft)	Basin Invert Elevation (ft)	Approximate Surface Area (acres)	Maximum Detained Volume (acre-ft)
UHDET1	41.6	34.8	4.9	30.5
UHDET2	35.6	25.0	3.6	38.2

4.5 FUTURE BUILDOUT CONDITIONS

Future build-out analysis outside of the FVGCP, NVSSP and VSCP has not been performed for this master plan. Future development in watersheds E1A, E1B, E1C,

E2 and E3 upstream of the FVGCP will be required to mitigate their impacts to existing conditions.

4.6 ADDITIONAL 1809 UNITS FOR AFFORDABLE HOUSING

An evaluation was made of the impact of increased density due to provision for affordable housing areas within selected areas of the FVGCP. The results of this evaluation indicate that, within the Florin Creek, Elder-Gerber and Unionhouse watersheds, there would be little or no appreciable impact on the overall runoff expected from the affected sheds. This is considered to be due to the relatively small areas involved for each shed which results in the composite land use characteristics for the shed changing by only a small amount if at all.

Table 4.6 Florin Creek Detention Facility Storage Differences Due to Affordable Housing Alternative

Storage Area Model Designation	Maximum Detained Volume With Hi-Dens Alt. (acre-ft)	Maximum Detained Volume Without Hi-Dens Alt. (acre-ft)	Change in Detained Volume Due to Hi-Dens Alt. (acre-ft)
SWATTD	34.9	34.9	0.0
DETF4C	42.6	42.6	0.0

4.7 TRUNK PIPES AND PIPE SHED GROUPS

A preliminary evaluation was undertaken to determine possible alignments and feasibility of trunk pipe drainage (serving 30 acres or more) for the various portions of the FVGCP area. Due to the complexity of the system in the Florin Creek area the XP-SWMM model was used for this analysis. These results are included in the swmm section Appendix C and shown on the oversize exhibits in Appendix E. Elsewhere the CSDS pipe drainage system modeling software was used to evaluate the performance of the proposed pipe systems. The results of these analyses are presented in Appendix D.

All the proposed pipe and channel alignments are shown on the oversize exhibits in Appendix E.