

APPENDIX C

Hydraulics and Hydrology

C1 Summary Report on Hydraulic Impact Analyses, Phase 4b Project
(MBK Engineers)

**SACRAMENTO AREA FLOOD
CONTROL AGENCY**

**NATOMAS LEVEE IMPROVEMENT
PROGRAM**

**SUMMARY REPORT
ON
HYDRAULIC IMPACT ANALYSES**

PHASE 4B PROJECT

Prepared for



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TABLE OF CONTENTS

1. Overview	1
2. SRFCP System Background	2
3. Approach to Modeling Analysis	4
4. Results of Modeling Analysis	7
5. Support of Impact Analysis Methodology	15
6. NLIP Coordination with Regional Improvements	16
7. Conclusion	17

LIST OF TABLES

1. Definition of Model Assumptions for Various Conditions
2. Extent of Levee Overtopping, Without Project Conditions, Levees Overtop Without Failing
3. 100-year Maximum Water Surface Elevation Summary, Levees Overtop Without Failing
4. 200-year Maximum Water Surface Elevation Summary, Levees Overtop Without Failing
5. 500-year Maximum Water Surface Elevation Summary, Levees Overtop Without Failing
6. Levee Failure Summary (Number of Levee Failures)
7. 100-year Maximum Water Surface Elevation Summary, Levees Fail When Water Reaches Top of Levee
8. 200-year Maximum Water Surface Elevation Summary, Levees Fail When Water Reaches Top of Levee
9. 500-year Maximum Water Surface Elevation Summary, Levees Fail When Water Reaches Top of Levee

LIST OF FIGURES

1. Sacramento River Flood Control System Map
2. Sacramento River UNET Model Extents
3. Natomas Levee Improvement Program Study Area
4. Model Calibration – Sacramento River Profile
5. Model Calibration – Natomas Cross Canal Profile
6. Model Calibration – Pleasant Grove Creek Canal Profile
7. Model Calibration – NEMDC Profile
8. NLIP Design Top of Levee Profile – Sacramento River
9. NLIP Design Top of Levee Profile – Natomas Cross Canal
10. NLIP Design Top of Levee Profile – Pleasant Grove Creek Canal
11. NLIP Design Top of Levee Profile – NEMDC
12. Typical Natomas Cross Canal Section with Waterside Fill
13. Rock Erosion Protection Berm in Hydraulic Model at NEMDC Northern Erosion Protection Site
14. Rock Erosion Protection Berm in Hydraulic Model at NEMDC Southern Erosion Protection Site
15. SRFCP 1957 Design Profile, Sacramento River Natomas Reach
16. SRFCP 1957 Design Profile, Natomas Cross Canal
17. SRFCP 1957 Design Profile, Pleasant Grove Creek Canal
18. SRFCP 1957 Design Profile, NEMDC

19. 100-year Water Surface Profile – Sacramento River Natomas Reach
20. 100-year Water Surface Profile – Natomas Cross Canal
21. 100-year Water Surface Profile – Pleasant Grove Creek Canal
22. 100-year Water Surface Profile – NEMDC
23. 200-year Water Surface Profile – Sacramento River Natomas Reach
24. 200-year Water Surface Profile – Natomas Cross Canal
25. 200-year Water Surface Profile – Pleasant Grove Creek Canal
26. 200-year Water Surface Profile – NEMDC
27. 500-year Water Surface Profile – Sacramento River Natomas Reach
28. 500-year Water Surface Profile – Natomas Cross Canal
29. 500-year Water Surface Profile – Pleasant Grove Creek Canal
30. 500-year Water Surface Profile – NEMDC

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1. OVERVIEW

The Sacramento Area Flood Control Agency (SAFCA) is proposing to raise and strengthen portions of the federal project levee system protecting the Natomas Basin in Sacramento and Sutter Counties in order to provide urban development in the basin with at least a 100-year level of flood protection as quickly as possible, while laying the groundwork for providing at least a 200-year level of flood protection over time. This effort is referred to as the Natomas Levee Improvement Program (or “NLIP”). It is part of a larger program of improvements, including modifications to Folsom Dam that would provide the Sacramento area as a whole with at least a 200-year level of flood protection.

Under applicable federal law, no federal project levee or related flood control facility may be altered unless: Congress has authorized the alteration; or, pursuant to 33 U.S.C. 408, the Secretary of the Army acting through the Chief of Engineers of the U.S. Army Corps of Engineers (“USACE”) has granted permission for the alteration based on a determination that the proposed work will not be injurious to the public interest and will not otherwise impair the usefulness of the affected facility. Under Title 23 of the California Water Code, such alterations must also be either authorized by the State Legislature; or permitted by the California Central Valley Flood Protection Board (“Board”), formerly the Reclamation Board. In order to coordinate these federal and state decision-making processes, the Board’s recent practice has been to issue a letter to the USACE requesting permission for proposed alterations after the Board has made its own determination that the work will not have a detrimental impact on the affected flood control system.

At the heart of both processes is an analysis of the hydraulic effects of the proposed alteration. SAFCA has historically conducted this analysis by evaluating the potential effects of its levee improvement projects on water surface elevations in the stream and river channels in the project area and in the larger watershed within which the project is situated. This approach was used to evaluate the flood related impacts of the NLIP for purposes of meeting the requirements of the California Environmental Quality Act (CEQA). Specifically, SAFCA’s engineering consultant, MBK Engineers (“MBK”), has used a UNET hydraulic computer model of the Sacramento River Flood Control Project (“SRFCP”), which was reviewed and approved for use for this project in 2006 by the USACE Sacramento District, to compare existing conditions in the waterways surrounding the Natomas Basin and in the larger SRFCP with and without the NLIP improvements and the other improvements comprising the 200-year flood protection program for the Sacramento area. MBK’s initial routings assumed that the levees outside the project area would fail when overtopped. However, in order to test the sensitivity of this assumption, a later set of routings was performed assuming that none of these levees would fail even if overtopped.

The results of the initial routings were presented in the program-level Environmental Impact Report (“EIR”) on Local Funding Mechanisms for Comprehensive Flood Control Improvements for the Sacramento Area, which was certified by the SAFCA Board of Directors in February 2007. Using the same methodology, the analysis was performed again and presented in the Draft EIR for the NLIP Landside Improvements Project in September 2007. The ‘no levee failure’ routings were performed thereafter and presented in the Landside Improvements Final EIR, which was certified by the SAFCA Board in November 2007. The modeling showed that the

proposed NLIP improvements by themselves would not significantly increase any of the identified water surface elevations in the river channels comprising the SRFCP. Moreover, when the NLIP improvements are analyzed as part of the larger 200-year flood protection program for the Sacramento area, including modifications to Folsom Dam, the result is a lowering of water surface elevations for the 100-year and 200-year floods along the lower Sacramento River for most of the reach adjacent to the Natomas Basin. On this basis, SAFCA has concluded that the NLIP improvements would not cause any significant hydraulic impacts.

2. SRFCP SYSTEM BACKGROUND

The perimeter levee system around the Natomas Basin is part of a larger integrated system of levees, dams, and bypass channels comprising the SRFCP (Figure 1). This system encompasses six historic flood basins in the Sacramento Valley (Butte, Colusa, Sutter, Feather, Yolo, and American Flood Basins) and the sub-basins contained therein. Planning, design, and construction of the SRFCP has been ongoing since the early 1900s under the leadership of the USACE and the State of California (State), with local levee and reclamation districts playing a principal role in operating and maintaining the system.

The SRFCP levees were set close to the river channel in order to improve navigation by having the rivers scour hydraulic mining sediments. The design of the system assumed no levee failures, but included five engineered diversions and one natural overflow diversion. The natural diversion is to Butte Basin, which is at the head of the SRFCP levees. This diversion did not include flowage easements because the Butte Basin is a historic flood basin. The five engineered diversions include two additional diversions to Butte Basin (Moulton and Colusa Weirs), one diversion to the Sutter Bypass (Tisdale Weir), and two diversions to the Yolo Bypass (Fremont and Sacramento Weirs). All of the engineered diversions included the acquisition of property rights to support the diversions. The deliberate planning, construction, and maintenance of the diversions ensured that they would function during flood conditions and serve as reliable features of the flood project.

Initially, the river channel and bypass levees in each segment of the system were constructed based on a standard geometry. The levees were designed with a predetermined freeboard allowance tied to specified flows and associated water surface elevations, generally matched to the 1907 and 1909 floods, adjusted for loss of floodplain storage by construction of the SRFCP. Over time, the standard levee section was increased because of numerous levee failures. The minimum standard levee changed from a levee with a top width of 10 feet to one with a top width of 20 feet. In addition, the design flows were modified substantially on the Feather and American Rivers. This was the result of floods that occurred after 1909, which demonstrated these rivers could produce substantially greater flows than occurred during the 1907 and 1909 floods. Because numerous levee failures occurred along the Feather River levees between 1920 and 1934, these levees were set back and enlarged to accommodate greater flows. These changes were summarized in memorandums issued by the USACE which define the minimum freeboard requirements for each segment of the SRFCP, collectively referred to as the "USACE 1957 Profile." Over the years, the capability of the SRFCP to provide higher levels of flood protection was greatly expanded by the construction of five major multiple-purpose reservoirs

(Shasta, Black Butte, Oroville, New Bullards Bar, and Folsom Reservoirs), containing 2.7 million acre-feet of flood control storage space.

The record floods of 1986 and 1997 triggered additional system modifications. Although these floods were significantly larger than the 1907 and 1909 floods, the availability of reservoir storage largely prevented flows in the system from exceeding the design of the SRFCP. Nevertheless, numerous project levees experienced unexpectedly severe stress and some failed. This experience caused the USACE, the State, and their local partners to perform a series of geotechnical evaluations on the SRFCP levees and to adopt new, more rigorous levee design standards, including updated standards for seepage through and under project levees. To meet these standards, USACE, the State, and local flood control agencies have made substantial investments in addressing identified deficiencies in levees throughout the SRFCP and in improving the level of flood protection provided by the levees, particularly in urban areas. Federal, State and local support for these levee improvements has been secured under several federally authorized projects, including the Sacramento Urban Levee Reconstruction Project, the American River Watershed Investigation, the West Sacramento Levee Improvement Project, and the Yuba River Basin Project. In the aftermath of the flooding of New Orleans, these authorized projects are being expanded to support an even broader scope of urban levee improvement activity.

The evolution of these urban levee improvements is occurring within a SRFCP management framework that has historically allowed necessary adaptations to the system without undermining its basic operational principles. These principles may be summarized as follows. First, the SRFCP is not intended to provide a uniform level of flood protection (statistical probability of flooding) to the various sub-basins within the protected area. Rather, each sub-basin is protected by levees that are required to at least meet the SRFCP minimum geometrical standards, including freeboard reflecting the water surface profile prescribed for that segment of the system. Second, each sub-basin's flood protection is dependent on the fitness of its own levees and not on the condition (or failure) of any other sub-basin's levees. Accordingly, each sub-basin has the right to keep its levees in the fittest possible condition to ensure that these levees will perform as reliably as possible in a flood. This right ensures the orderly operation and maintenance of the system since even the most modest levee work has the potential to trigger a "transfer of risk" from one sub-basin to another, at least in theory; and there are no data or modeling tools available to quantify such transfers of risk, assess their significance, or determine how they might be mitigated. Third, for this reason, the administration of the SRFCP has historically relied on "change in design water surface elevation" as the guideline for evaluating the effects of any proposed levee work.

The strictest scrutiny is given to levee work involving physical changes in the geometry of the river channel since these changes have the most potential to alter water surface elevations prescribed by the SRFCP design water surface profiles (SRFCP 1957 profiles). This work includes placement of fill or construction of structures in the floodway, construction of new levees, relocation of existing levees, excavation within the floodway, construction of large berms for protecting riverbanks, raising an existing levee, construction of a new bypass, and planting of vegetation within the floodway. Landside levee work of the type proposed as part of the NLIP, such as placing a cutoff wall in a levee, adding a seepage berm to a levee, placing a field of

seepage relief wells along a levee, raising a levee, widening a levee (increased top width), and relocating a seepage ditch, is also strictly scrutinized; but is not likely to cause impacts.

The standard procedure for this evaluation is to use hydrologic and hydraulic computer modeling tools such as, HEC-1, HEC-2, UNET, HEC-RAS, RMA2, FESWMS, etc. The analysis consists of calibrating the hydraulic model to historic flood events using high-water marks and stream gage data. The calibration activity is normally conducted on a system-wide basis instead of a site-specific basis. However, data available for computer model calibration can be sparse or nonexistent. In addition, assumptions must be made regarding reservoir operations. Because all of the reservoirs that contribute to the operation of the SRFCP (Shasta, Black Butte, Oroville, New Bullards Bar and Folsom) are governed by water control manuals issued by USACE, current reservoir operations are assumed to continue except where it is reasonably foreseeable that the current operation would change. Examples of such changes are at the Folsom Dam and Reservoir: where Congress has directed USACE to formalize the variable space storage operation that has been in effect by agreement between SAFCA and the U.S. Bureau of Reclamation since 1995; and where water control structures are being modified as part of the Folsom Dam Joint Federal Project.

3. APPROACH TO MODELING ANALYSIS

As discussed above, in order to evaluate the hydraulic impacts of the levee alterations proposed as part of the NLIP, MBK used a UNET hydraulic computer model calibrated to historic flood events using high-water marks and stream gage data gathered in connection with the 1997 Flood. The UNET model is a one-dimensional, unsteady flow hydraulic model. It characterizes the hydraulic capacity of the system by use of channel and bypass cross-sections, most of which are positioned every ¼ mile throughout the system. Figure 2 displays the geographical extent of the UNET model. Figure 3 provides the UNET model river mile stationing around the Natomas Basin. Results of the model calibration are shown in Figures 4 through 7.

The hydraulic impacts of the levee alterations proposed as part of the NLIP were evaluated based on the potential of the proposed levee alterations to increase one or more of the SRFCP's recognized design water surface elevations: (1) the SRFCP 1957 water surface profiles that serve as the minimum design standard for the SRFCP; (2) the 100-year flood elevations that govern management of SRFCP protected floodplains under the National Flood Insurance Program (33 CFR. 65.10); and (3) the 200-year water surface elevations that are likely to govern implementation of floodplain management standards recently adopted by the State Legislature (Statutes of 2008, Chapter 364 [adding Water Code Section 9602(i)]). In addition, SAFCA has provided information on the project impacts to the 500-year flood elevation. This flood represents an extreme flood event and is the largest flood event for which hydrologic input data has been developed for the hydraulic simulation model.

The modeling runs compare the “Existing”, “Without Project” and “With Project” conditions under each of the above flood scenarios. The Existing Condition analysis provides an evaluation of the levee and reservoir system as it exists in December 2009. The Without Project condition assumes implementation of federally authorized improvements to Folsom Dam and anticipated

improvements to the levees protecting existing urban areas outside the Natomas Basin (American River Basin, West Sacramento, Yuba Basin, and Sutter Basin) so as to provide these areas with 200-year flood protection. The With Project condition adds the improvements proposed as part of the NLIP to the Without Project condition. The NLIP improvements consist of levee raises on the Sacramento River, Natomas Cross Canal, PGCC, and NEMDC in the locations shown in Figure 3. The magnitude of the levee raise is shown in the levee profile plots provided in Figures 8 through 11. All fill related to the levee raises would occur on the landside of the levees with the exception of an approximately one mile reach of the Natomas Cross Canal where some waterside fill would be required. Figure 12 shows a typical section showing the waterside fill. The low spots in the PGCC levee at Howsley Road and Sankey Road (see Figure 10) are not raised and are assumed to retain their existing configurations in the With Project condition. The levee raising that is part of the Phase 4B EIS/EIR is located on the PGCC and NEMDC, as shown in Figures 3, 10 and 11. The with project condition also includes shaded riverine aquatic habitat mitigation on the Sacramento River from river mile 79.2 to river mile 77.75, erosion repair and rock bank protection at three locations on the PGCC and two locations on the NEMDC, and low flow channel realignment in the NEMDC at Interstate 80. The shaded riverine aquatic habitat mitigation, which consists of increased bank vegetation, was modeled by increasing the bank Manning's n roughness coefficient from 0.045 to 0.10. The PGCC erosion repair was not included in the hydraulic model since it is in an area that is controlled by backwater from the Sacramento River during large flood events; and therefore, would not affect the peak flood stages on the PGCC. The NEMDC erosion repair sites, which include rock berms along the low flow channel, were modeled by modifying the affected cross-sections as shown in Figures 13 and 14. The low flow channel realignment was not included in the hydraulic model since it would not change the cross-sectional area of the NEMDC; and therefore, would not affect the hydraulic capacity of the NEMDC.

In order to compare these conditions, assumptions about the performance of SRFCP levees under flow conditions that exceed the design of the levee system are necessary for the 100-year, 200-year, and 500-year floods. At the request of the USACE, the hydraulic impact analysis assumed that levees would overtop without failing. For comparison purposes, an additional analysis was completed to show impacts with the assumption that levee failures would occur if water reaches the top of levee. The assumptions supporting these modeling scenarios are summarized in Table 1.

Table 1. Definition of Model Assumptions for Various Conditions			
Condition	Top of Levee Assumption	Levee Failure Assumption	Reservoir Ops Assumption
Existing	Existing top of levee grade December 2009 (including California Levee Database information)	Levees overtop without failing.	Existing reservoirs and current (2009) operation criteria
Without Project	Same as Existing with the following changes. Urban area levees outside the Natomas Basin are assumed to have levees at 200-year water surface + 3 feet of freeboard. NLIP levees same as Existing Condition.	Levees overtop without failing.	Same as Existing except Folsom Dam will be operated in accordance with the Joint Federal Project currently under construction
With Project	Same as Without Project except NLIP levees raised to design level	Levees overtop without failing.	Same as Without Project
Sensitivity Analysis - Existing	Same as Existing	Levees fail when water reaches top of levee.	Same as Existing
Sensitivity Analysis - Without Project	Same as Without Project	Levees fail when water reaches top of levee.	Same as Without Project
Sensitivity Analysis - With Project	Same as With Project	Levees fail when water reaches top of levee.	Same as Without Project

As noted above, the Without Project condition assumes that urban areas (outside the Natomas Basin) will be provided with 200-year protection. This is the most likely near term future condition of the levee system based on the information currently available. This condition is reasonable based on California voters' November 2006 approval of a bond measure that would provide over \$3 billion for urban levee improvements in the Central Valley. Additionally, in September 2007, the State Legislature enacted the Central Valley Flood Protection Act of 2008 (Act), Water Code Section 9600 et seq., which was signed into law by the governor in October 2007. The Act is based on the following findings:

- ▶ The Central Valley of California is experiencing unprecedented development, resulting in the conversion of historically agricultural lands and communities to densely populated residential and urban centers.
- ▶ The legislature recognizes that by their nature, levees, which are earthen embankments typically founded on fluvial deposits, cannot offer complete protection from flooding, but can decrease the frequency of flooding.

- ▶ The legislature recognizes that the level of flood protection afforded rural and agricultural lands by the original flood control system would not be adequate to protect those lands if they are developed for urban uses, and that a dichotomous system of flood protection for urban and rural lands has developed through many years of practice.
- ▶ The legislature further recognizes that levees built to reclaim and protect agricultural land may be inadequate to protect urban development unless those levees are significantly improved.
- ▶ Cities and counties rely upon federal floodplain information when approving developments, but the information available is often out of date and the flood risk may be greater than that indicated using available federal information.
- ▶ The legislature recognizes that the current federal (FEMA) flood standard is not sufficient for urban and urbanizing areas within flood prone areas throughout the Central Valley.

(Statutes of 2007, Chapter 364, Section 9.)

Based on these findings, the Act embraces a new flood protection standard for urban areas (defined as “developed areas in which there are 10,000 residents or more”) located in levee-protected floodplains in the Central Valley. This new “urban level of flood protection” is defined as “the level of protection that is necessary to withstand flooding that has a 1-in-200 chance of occurring in any given year using criteria consistent with, or developed by, the Department of Water Resources.” (Statutes of 2007, Chapter 364 [adding Water Code Section 9602(i)]).

4. RESULTS OF MODELING ANALYSIS

The flood routings described herein indicate that under the Existing condition, all SRFCP levees would contain the SRFCP 1957 design flood profile. The 100-year flood would overtop some non-urban levees, but this flood would be contained by all urban levees under the Existing condition. The 200-year flood would generate multiple levee overtopping locations in several non-urban areas under both the Existing and Without Project conditions and along the Lower American River under the Existing condition. However, this flood would be effectively contained under both the Existing and Without Project conditions by all existing urban levees outside the American River basin, including the levees around the Natomas Basin. The 500-year flood would cause massive levee overtopping affecting all segments of the system under the Existing and Without Project conditions. Only West Sacramento and the Natomas Basin would avoid overtopping under these conditions with upstream levee failures. Table 2 provides a summary of the extent of levee overtopping in the Without Project condition simulations.

River	Leveed Length (miles)	Approximate Length of Overtopped Levee (miles)					
		Left Bank ^a			Right Bank ^a		
		100-yr	200-yr	500-yr	100-yr	200-yr	500-yr
American River	13	0	0	5.1	0	0	7.8
Feather River	50	0	0	5.9	0	0	7.5
Natomas Cross Canal	5	0	2.0	3.3	0.1	2.0	2.3
Sacramento Bypass	1.7	0	0	0	0	0	0.2
Sacramento R. upstream of Natomas Cross Canal	90	0	1.0	5.1	0.5	1.6	3.6
Sacramento R. Adjacent to Natomas	18	0	<0.1	2.3	0	2.6	3.5
Sacramento R. downstream of American R.	60	0	0.2	0.5	0	0	0.9
Sutter Bypass	30	0	1.4	2.0	0	2.4	3.9
Tisdale Bypass	4	0	0	1.4	0	0	2.0
Wadsworth Canal	4	0	0	0	1.6	1.9	2.9
Yolo Bypass	37	0	0.3	2.3	0	0	0

^a Left and right bank reference based on downstream facing orientation.

Tables 3, 4 and 5 summarize the computed maximum water surface elevations at several locations in and around the project area for the Existing, Without Project, and With Project conditions for the 100-year, 200-year and 500-year flood events, respectively, for the levee overtop without failure condition.

Computed water surface elevation profiles for each of the key flow conditions in the project area (Sacramento River channel downstream of the Fremont Weir) are shown in Figures 15 through 30. Figures 15 through 18 show the relationship between the 1957 design and the height of the levees for the Sacramento River, Natomas Cross Canal, PGCC, and NEMDC, respectively. Figure 15 also shows the locations in which the non-urban Sacramento River west levee would be raised to meet the minimum freeboard requirements of the SRFCP 1957 design standard under the sensitivity analysis. Figures 19 through 22 show the profile of the current 100-year flood. Figures 23 through 26 show the profile of the 200-year design condition (no levee failure) flood. Figures 23 through 26 also show the likely 200-year water surface profile assuming upstream levee failures in non-urban areas. Figure 23 shows that the current height of the Sacramento River east levee along the Natomas Basin is essentially at the same elevation as the 200-year (no levee failure) design water surface profile and considerably higher than the likely water surface profile assuming upstream levee failures. It also shows the extent to which the Sacramento River west levee across from Natomas would be overtopped in a 200-year flood. Figures 27 through 30 show the profiles for the 500-year flood with upstream levee failures. The 500-year (with levee failures) water surface elevation in the Sacramento River channel is lower throughout the most critical portion of this reach than the 200-year (no levee failure) design water surface elevation. As reflected in Figures 27 through 30, under the likely assumption that upstream levees will fail when water reaches the top of the levee, the water surface elevations around Natomas would be dramatically lower than the 200-year (no levee failure) profile that was used for design of NLIP. This 200-year levee design condition thus represents a worst-case scenario for the Sacramento River and the Natomas Cross Canal, and underscores the high

degree of protection against Natomas Basin levee overtopping that would be provided by the design of the NLIP improvements.

Location (Comp Study River Mile)	Maximum Water Surface Elevation (ft NAVD88)			Change (ft)	
	Existing	Without Project	With Project	Existing to Without Project	Without Project to With Project
Sacramento River					
at Knight's Landing (90.22)	44.55	44.53	44.53	-0.02	0
at Fremont Weir, west end (84.75)	42.60	42.56	42.56	-0.04	0
at Natomas Cross Canal (79.21)	43.44	43.38	43.39	-0.06	+0.01
at I-5 (71.00)	39.18	38.94	38.92	-0.24	-0.02
at Sacramento Bypass (63.82)	34.27	33.69	33.69	-0.58	0
at NEMDC (61.0)	34.81	34.25	34.24	-0.56	-0.01
at I St. (59.695)	34.54	33.97	33.96	-0.57	-0.01
at Freeport Bridge (46.432)	28.19	27.78	27.78	-0.41	0
Natomas Cross Canal					
u/s Hwy 99/70 (4.82)	43.50	43.44	43.45	-0.06	+0.01
Pleasant Grove Creek Canal					
at Sankey Rd. gap (SA25)	43.36	43.30	43.30	-0.06	0
at Fifield Rd. (1.475)	43.50	43.44	43.44	-0.06	0
at Howsley Rd. (0.41)	43.51	43.45	43.45	-0.06	0
Natomas East Main Drainage Canal					
at Elverta Road (10.402)	34.26	34.26	34.26	0	0
at Elkhorn Blvd. (8.352)	33.47	33.48	33.48	+0.01	0
at Main Ave. (6.09)	39.71	39.69	39.69	-0.02	0
at West El Camino Ave. (2.96)	36.85	36.18	36.18	-0.67	0
Feather River					
at Nicolaus Gage (8.00)	50.98	50.97	50.97	-0.01	0
Yolo Bypass					
at Woodland Gage (51.10)	35.59	35.48	35.48	-0.11	0
American River					
at H St. (6.471)	45.40	43.11	43.11	-2.29	0

Note: Water surface elevations originally calculated in NGVD29 vertical datum. Converted to NAVD88 by adding 2.3 ft. (0 NGVD29 = 2.3 NAVD88).

Table 4. 200-year Maximum Water Surface Elevation Summary, Levees Overtop Without Failing

Location (Comp Study River Mile)	Maximum Water Surface Elevation (ft NAVD88)			Change (ft)	
	Existing	Without Project	With Project	Existing to Without Project	Without Project to With Project
Sacramento River					
at Knight's Landing (90.22)	45.20	45.20	45.20	0	0
at Fremont Weir, west end (84.75)	44.04	44.02	44.03	-0.02	+0.01
at Natomas Cross Canal (79.21)	44.91	44.89	44.92	-0.02	+0.03
at I-5 (71.00)	40.66	40.35	40.35	-0.31	0
at Sacramento Bypass (63.82)	37.19	35.76	35.76	-1.43	0
at NEMDC (61.0)	37.97	36.34	36.34	-1.63	0
at I St. (59.695)	37.68	36.05	36.05	-1.63	0
at Freeport Bridge (46.432)	30.76	29.64	29.64	-1.12	0
Natomas Cross Canal					
u/s Hwy 99/70 (4.82)	44.94	44.92	44.95	-0.02	+0.03
Pleasant Grove Creek Canal					
at Sankey Rd. gap (SA25)	44.69	44.68	44.70	-0.01	+0.02
at Fifield Rd. (1.475)	44.89	44.88	44.90	-0.01	+0.02
at Howsley Rd. (0.41)	44.93	44.91	44.94	-0.02	+0.03
Natomas East Main Drainage Canal					
at Elverta Road (10.402)	38.25	38.23	38.33	-0.02	+0.10
at Elkhorn Blvd. (8.352)	38.11	38.09	38.19	-0.02	+0.10
at Main Ave. (6.09)	44.18	41.05	41.05	-3.13	0
at West El Camino Ave. (2.96)	42.28	38.44	38.44	-3.84	0
Feather River					
at Nicolaus Gage (8.00)	53.32	53.32	53.32	0	0
Yolo Bypass					
at Woodland Gage (51.10)	36.93	36.87	36.88	-0.06	+0.01
American River					
at H St. (6.471)	49.61	46.72	46.72	-2.89	0
Note: Water surface elevations originally calculated in NGVD29 vertical datum. Converted to NAVD88 by adding 2.3 ft. (0 NGVD29 = 2.3 NAVD88).					

Table 5. 500-year Maximum Water Surface Elevation Summary, Levees Overtop Without Failing

Location (Comp Study River Mile)	Maximum Water Surface Elevation (ft NAVD88)			Change (ft)	
	Existing	Without Project	With Project	Existing to Without Project	Without Project to With Project
Sacramento River					
at Knight's Landing (90.22)	45.49	45.51	45.52	+0.02	+0.01
at Fremont Weir, west end (84.75)	44.91	44.95	44.99	+0.04	+0.04
at Natomas Cross Canal (79.21)	45.57	45.59	45.77	+0.02	+0.18
at I-5 (71.00)	41.54	41.55	41.61	+0.01	+0.06
at Sacramento Bypass (63.82)	38.66	38.71	38.72	+0.05	+0.01
at NEMDC (61.0)	39.57	39.68	39.68	+0.11	0
at I St. (59.695)	39.24	39.38	39.38	+0.14	0
at Freeport Bridge (46.432)	31.74	31.91	31.91	+0.17	0
Natomas Cross Canal					
u/s Hwy 99/70 (4.82)	45.54	45.55	45.76	+0.01	+0.21
Pleasant Grove Creek Canal					
at Sankey Rd. gap (SA25)	45.35	45.35	45.48	0	+0.13
at Fifield Rd. (1.475)	45.59	45.60	45.75	+0.01	+0.15
at Howsley Rd. (0.41)	45.60	45.61	45.79	+0.01	+0.18
Natomas East Main Drainage Canal					
at Elverta Road (10.402)	41.90	41.90	42.23	0	+0.33
at Elkhorn Blvd. (8.352)	41.75	41.75	42.10	0	+0.35
at Main Ave. (6.09)	47.03	47.09	47.09	+0.06	0
at West El Camino Ave. (2.96)	45.32	45.41	45.41	+0.09	0
Feather River					
At Nicolaus Gage (8.00)	55.79	55.93	55.94	+0.14	+0.01
Yolo Bypass					
At Woodland Gage (51.10)	38.03	38.08	38.21	+0.05	+0.13
American River					
At H St. (6.471)	50.54	50.61	50.61	+0.07	0

Note: Water surface elevations originally calculated in NGVD29 vertical datum. Converted to NAVD88 by adding 2.3 ft. (0 NGVD29 = 2.3 NAVD88).

A summary of the number of levee failures that occur in the simulations that assumed levees would fail when the water reached the top of the levee is provided in Table 6. The computed maximum water surface elevations at several locations in and around the project area for the Existing, Without Project, and With Project conditions for the 100-year, 200-year and 500-year flood events with assumed levee failures are shown in Tables 7, 8 and 9.

Condition	Event Flood			
	SRFCP (1957)	100-year	200-year	500-year
Existing	0	13	58	129
Without Project	0	12	32	135
With Project	0	12	32	133

Table 7. 100-year Maximum Water Surface Elevation Summary, Levees Fail When Water Reaches Top of Levee

Location (Comp Study River Mile)	Maximum Water Surface Elevation (ft NAVD88)			Change (ft)	
	Existing	Without Project	With Project	Existing to Without Project	Without Project to With Project
Sacramento River					
at Knight's Landing (90.22)	43.95	43.95	43.95	0	0
at Fremont Weir, west end (84.75)	42.22	42.19	42.19	-0.03	0
at Natomas Cross Canal (79.21)	42.87	42.82	42.82	-0.05	0
at I-5 (71.00)	38.74	38.50	38.48	-0.24	-0.02
at Sacramento Bypass (63.82)	34.04	33.43	33.42	-0.61	-0.01
at NEMDC (61.0)	34.55	33.96	33.96	-0.59	0
at I St. (59.695)	34.28	33.69	33.68	-0.59	-0.01
at Freeport Bridge (46.432)	28.00	27.51	27.50	-0.49	-0.01
Natomas Cross Canal					
u/s Hwy 99/70 (4.82)	42.94	42.94	42.95	0	+0.01
Pleasant Grove Creek Canal					
at Sankey Rd. gap (SA25)	42.80	42.82	42.83	+0.02	+0.01
at Fifield Rd. (1.475)	42.91	42.92	42.93	+0.01	+0.01
at Howsley Rd. (0.41)	42.91	42.93	42.93	+0.02	0
Natomas East Main Drainage Canal					
at Elverta Road (10.402)	34.26	34.34	34.35	+0.08	+0.01
at Elkhorn Blvd. (8.352)	33.47	33.49	33.49	+0.02	0
at Main Ave. (6.09)	39.70	39.74	39.74	+0.04	0
at West El Camino Ave. (2.96)	36.81	36.16	36.15	-0.65	-0.01
Feather River					
at Nicolaus Gage (8.00)	50.87	50.86	50.86	-0.01	0
Yolo Bypass					
at Woodland Gage (51.10)	35.22	35.13	35.13	-0.09	0
American River					
at H St. (6.471)	45.39	43.08	43.08	-2.31	0

Note: Water surface elevations originally calculated in NGVD29 vertical datum. Converted to NAVD88 by adding 2.3 ft. (0 NGVD29 = 2.3 NAVD88).

Table 8. 200-year Maximum Water Surface Elevation Summary, Levees Fail When Water Reaches Top of Levee

Location (Comp Study River Mile)	Maximum Water Surface Elevation (ft NAVD88)			Change (ft)	
	Existing	Without Project	With Project	Existing to Without Project	Without Project to With Project
Sacramento River					
at Knight's Landing (90.22)	43.96	43.96	43.96	0	0
at Fremont Weir, west end (84.75)	42.80	42.82	42.82	+0.02	0
at Natomas Cross Canal (79.21)	43.29	43.28	43.30	-0.01	+0.02
at I-5 (71.00)	39.58	39.30	39.30	-0.28	0
at Sacramento Bypass (63.82)	36.39	35.10	35.10	-1.29	0
at NEMDC (61.0)	37.13	35.66	35.66	-1.47	0
at I St. (59.695)	36.84	35.38	35.38	-1.46	0
at Freeport Bridge (46.432)	30.02	28.88	28.89	-1.14	+0.01
Natomas Cross Canal					
u/s Hwy 99/70 (4.82)	43.42	43.45	43.47	+0.03	+0.02
Pleasant Grove Creek Canal					
at Sankey Rd. gap (SA25)	43.43	43.48	43.51	+0.05	+0.03
at Fifield Rd. (1.475)	43.52	43.57	43.60	+0.05	+0.03
at Howsley Rd. (0.41)	43.49	43.53	43.56	+0.04	+0.03
Natomas East Main Drainage Canal					
at Elverta Road (10.402)	34.66	34.66	34.66	0	0
at Elkhorn Blvd. (8.352)	33.78	33.78	33.78	0	0
at Main Ave. (6.09)	43.70	41.03	41.03	-2.67	0
at West El Camino Ave. (2.96)	42.28	38.31	38.30	-3.97	-0.01
Feather River					
at Nicolaus Gage (8.00)	52.42	52.48	52.48	+0.06	0
Yolo Bypass					
at Woodland Gage (51.10)	35.91	35.85	35.86	-0.06	+0.01
American River					
at H St. (6.471)	49.28	46.62	46.62	-2.66	0
Note: Water surface elevations originally calculated in NGVD29 vertical datum. Converted to NAVD88 by adding 2.3 ft. (0 NGVD29 = 2.3 NAVD88).					

Table 9. 500-year Maximum Water Surface Elevation Summary, Levees Fail When Water Reaches Top of Levee

Location (Comp Study River Mile)	Maximum Water Surface Elevation (ft NAVD88)			Change (ft)	
	Existing	Without Project	With Project	Existing to Without Project	Without Project to With Project
Sacramento River					
at Knight's Landing (90.22)	44.10	44.11	44.12	+0.01	+0.01
at Fremont Weir, west end (84.75)	43.62	43.64	43.64	+0.02	0
at Natomas Cross Canal (79.21)	44.21	44.24	44.24	+0.03	0
at I-5 (71.00)	39.92	39.45	39.47	-0.47	+0.02
at Sacramento Bypass (63.82)	37.10	36.71	36.70	-0.39	-0.01
at NEMDC (61.0)	37.93	37.40	37.38	-0.53	-0.02
at I St. (59.695)	37.62	37.10	37.08	-0.52	-0.02
at Freeport Bridge (46.432)	30.49	30.16	30.15	-0.33	-0.01
Natomas Cross Canal					
u/s Hwy 99/70 (4.82)	44.42	44.43	44.44	+0.01	+0.01
Pleasant Grove Creek Canal					
at Sankey Rd. gap (SA25)	44.45	44.45	44.46	0	+0.01
at Fifield Rd. (1.475)	44.59	44.59	44.60	0	+0.01
at Howsley Rd. (0.41)	44.57	44.57	44.58	0	+0.01
Natomas East Main Drainage Canal					
at Elverta Road (10.402)	36.46	36.72	37.04	+0.26	+0.32
at Elkhorn Blvd. (8.352)	35.97	36.35	36.75	+0.38	+0.40
at Main Ave. (6.09)	45.62	45.28	45.28	-0.34	0
at West El Camino Ave. (2.96)	43.49	43.25	43.25	-0.24	0
Feather River					
At Nicolaus Gage (8.00)	54.27	54.27	54.27	0	0
Yolo Bypass					
At Woodland Gage (51.10)	36.57	36.62	36.62	+0.05	0
American River					
At H St. (6.471)	49.39	50.11	50.11	+0.72	0

Note: Water surface elevations originally calculated in NGVD29 vertical datum. Converted to NAVD88 by adding 2.3 ft. (0 NGVD29 = 2.3 NAVD88).

5. SUPPORT OF IMPACT ANALYSIS METHODOLOGY

California Legislature

Consistent with its approval of a new more rigorous standard for urban flood protection, the State Legislature also approved “the project features necessary to provide a 200-year level of flood protection along the American and Sacramento Rivers and within the Natomas Basin as described in the final engineer’s report dated April 19, 2007, adopted by the Sacramento Area Flood Control Agency.” (Statutes of 2007, Chapter 641 [amending Water Code Section 12670.14(b)]). Moreover, in connection with this approval, the legislature adopted the following findings and declarations (Statutes of 2007, Chapter 641, Section 1[k]):

As evidenced by the environmental impact reports certified in connection with these projects, including the hydrology and hydraulics impact analysis set forth in the environmental impact report prepared by the Sacramento Area Flood Control Agency with regard to local funding mechanisms for comprehensive flood control improvements for the Sacramento area dated February 2007, the increase in flood protection associated with improving the American and Sacramento River levees and modifying Folsom Dam will be accomplished without altering or otherwise impairing the design flows and water surface elevations prescribed as part of the Sacramento River Flood Control Project. Accordingly, these improvements will not result in significant adverse hydraulic impacts to the lands protected by the Sacramento River Flood Control Project. Thus, it is not necessary or appropriate to require these projects to include hydraulic mitigation.

The projects authorized in Section 12670.14 of the Water Code will increase the ability of the existing flood control system in the lower Sacramento Valley to protect heavily urbanized areas within the City of Sacramento and the Counties of Sacramento and Sutter against very rare floods without altering the design flows and water surface elevations prescribed as part of the Sacramento River Flood Control Project or impairing the capacity of other segments of the Sacramento River Flood Control Project to contain these design flows and to maintain water surface elevations. Accordingly, the projects authorized in that section will not result in significant adverse hydraulic impacts to the lands protected by the Sacramento River Flood Control Project and neither the Reclamation Board nor any other state agency shall require the authorized projects to include hydraulic mitigation for these protected lands.

Although these findings are not legally binding, they indicate the legislature’s concurrence with SAFCA’s approach to analyzing hydraulic impacts. Congressional authorization for raising and strengthening a twelve-mile reach of the Sacramento River east levee in the 1996 Water Resources Development Act (“WRDA”), and for raising and strengthening all five-plus miles of the NCC south levee in the 1999 WRDA, without in either case requiring hydraulic mitigation, offers additional indirect legislative support for SAFCA’s approach.

USACE HQ

USACE has been using a risk-based analysis for economic evaluation for some time and has been moving to a risk-based analysis for system performance, largely for certification of levees for FEMA. However, in his memo dated *August 2, 2007, Subject: Section 408 Approval of a Flood Control Project Alteration - Sacramento River Flood Control Project, Feather and Yuba Rivers, California* (copy enclosed), Deputy Director of Civil Works Steven L. Stockton indicated that the discussion of flood protection in terms such as 100-year or 200-year level of protection is acceptable to comply with NEPA and other environmental statutes. However, a risk-based analysis as required by ER 1105-2-100 and ER 1105-2-101 will be needed to determine the terms of any eventual Section 104 reimbursement. SAFCA has prepared and submitted a risk-based analysis to USACE as part of the 408 Summary Report for Phase 3.

6. NLIP COORDINATION WITH REGIONAL IMPROVEMENTS

SAFCA's approach to providing an urban standard of flood protection to the Natomas Basin is being replicated in the other urbanizing sub-basins in the lower Sacramento Valley (West Sacramento, Marysville extending south to Reclamation District 784, and Yuba City). However, these improvements are intended to complement rather than substitute for pursuing improvements on a regional scale that would improve the flow of water through the Yolo and Sacramento Bypass systems and lower water surface elevations throughout the lower Sacramento Valley. In 2002 through 2003, SAFCA made substantial investments in hydraulic studies and analyses of the improvements that would be required to move more flood water into and through the Yolo Bypass during large flood events in the Sacramento-Feather River watershed to reduce flows and water surface elevations in the Sacramento River channel downstream of the Fremont weir. The Lower Sacramento River Regional Project Initial Report (SAFCA 2003) indicated that this could be accomplished by widening the Fremont weir; setting back the levees on the east side of the Yolo Bypass; discharging flood flows into the Sacramento Deep Water Ship Channel; and eliminating low, restricted elevation levees at the lower end of the Yolo Bypass. However, these improvements would be extremely costly and time consuming to implement; they would occur entirely outside SAFCA's jurisdiction; and would require extraordinary cooperation among affected federal, state, and local interests; and they would not resolve the seepage problems affecting the Sacramento River east levee and the Natomas Cross Canal south levee adjacent to the Natomas Basin. For these reasons, SAFCA concluded that this alternative would not achieve the objectives of the NLIP; and therefore, it was not carried forward for further analysis.

On a long-term basis; however, regionally oriented improvements to the Yolo and Sacramento Bypass systems may help to address potential changes in hydrology due to climate change and may reduce the risk of uncontrolled flooding on a system-wide basis. Although this flooding is most likely to occur in lightly populated agricultural areas, reducing its frequency by increasing the conveyance capacity of the SRFCP would avoid the cost of repairing and reconstructing damaged levees and other public infrastructure and would increase public support for the "dichotomous system of flood protection for urban and rural lands" that exists in the Sacramento Valley. Early implementation of the NLIP, as well as early implementation of proposed

improvements to SRFCP levees protecting other urban areas, would not preclude any of the alternatives contemplated for the update of the Central Valley Flood Protection Plan.

7. CONCLUSION

Raising and strengthening portions the federal project levee system protecting the Natomas Basin in Sacramento and Sutter Counties as proposed by SAFCA would not result in any significant, adverse hydraulic impacts to other sub-basins protected as part of the SRFCP. Furthermore, these improvements would be consistent with the principles that have guided the management of the SRFCP over the past century and with the policies adopted by the State Legislature calling for an immediate and comprehensive effort to increase the level of flood protection provided to Sacramento and the other urban areas within the SRFCP. The NLIP improvements would also be consistent with the direction given by Congress when it approved raising and strengthening 12 miles of the Sacramento River east levee (WRDA 1996) and 5.3 miles of the Natomas Cross Canal south levee (WRDA 1999).

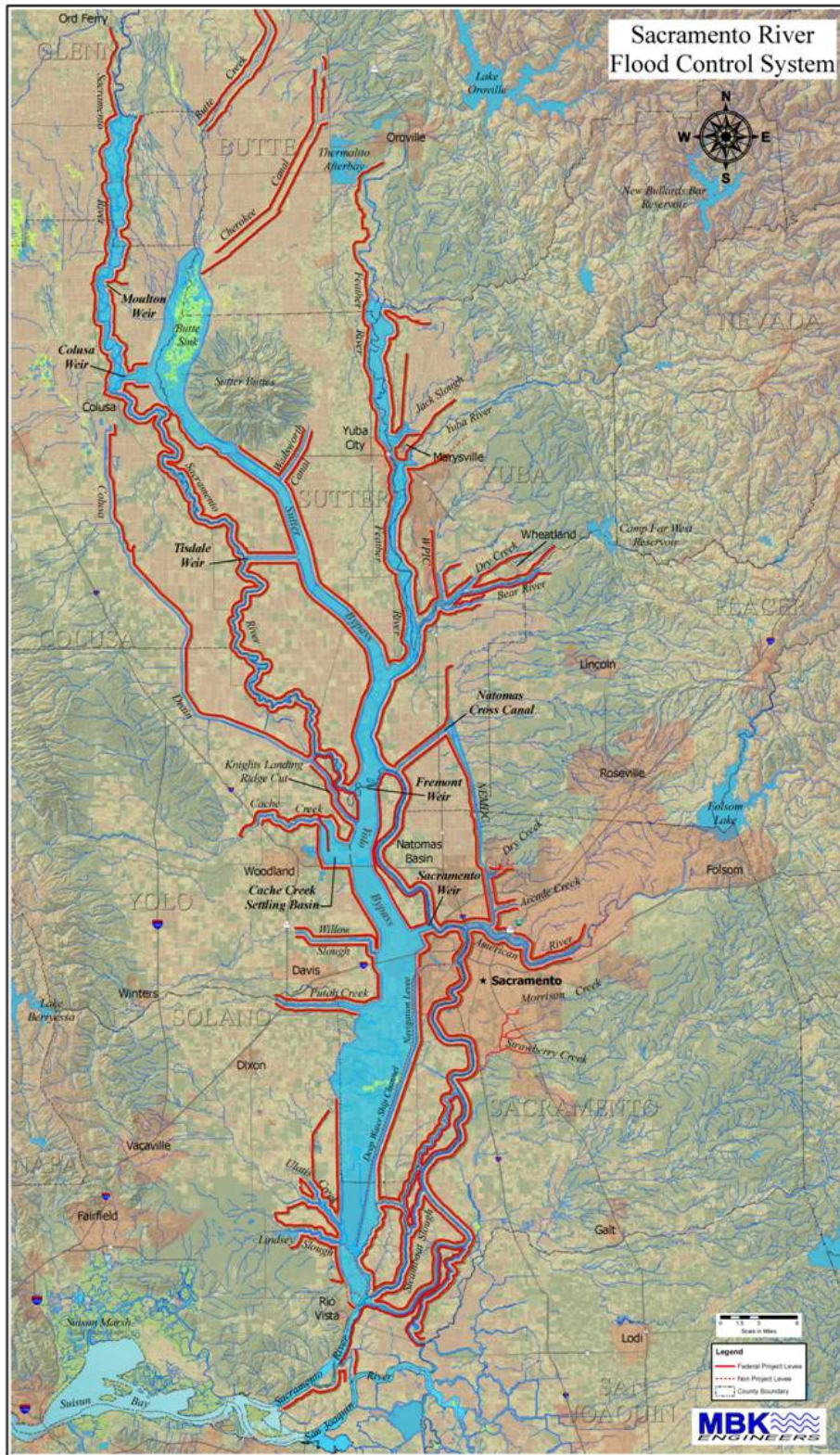


Figure 1. Sacramento River Flood Control System Map

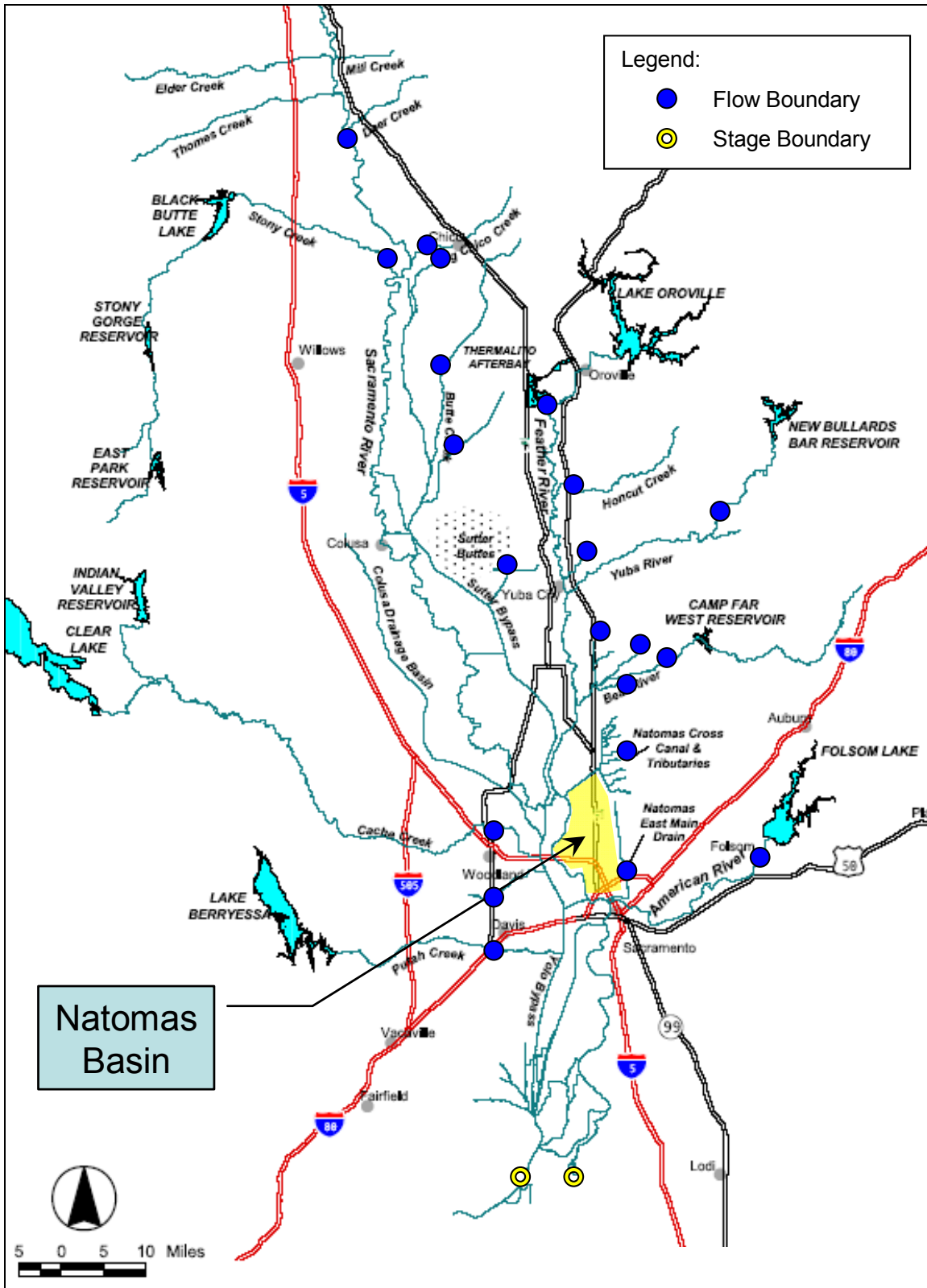


Figure 2. Sacramento River UNET Model Extents

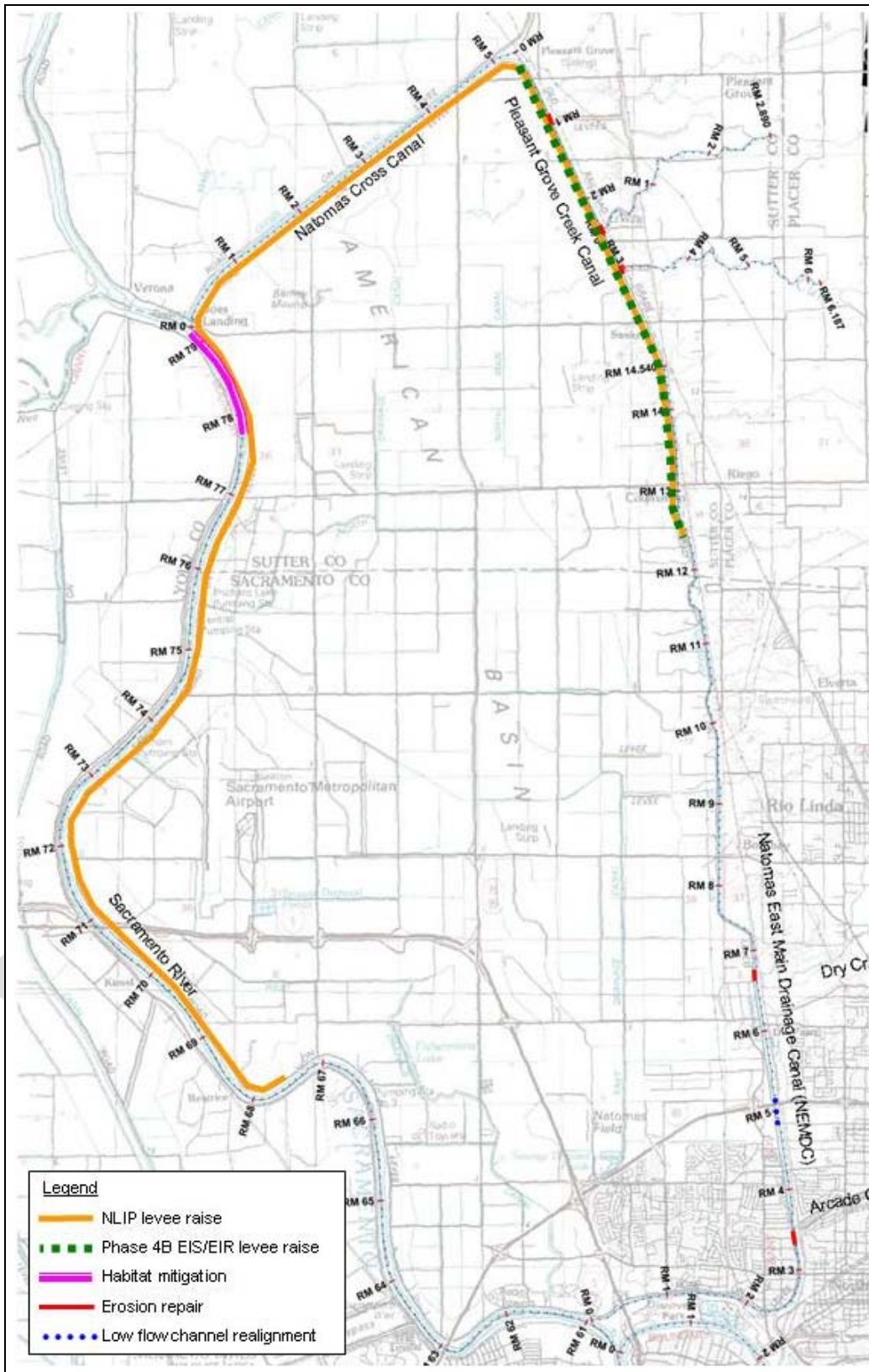


Figure 3. Natomas Levee Improvement Program Study Area

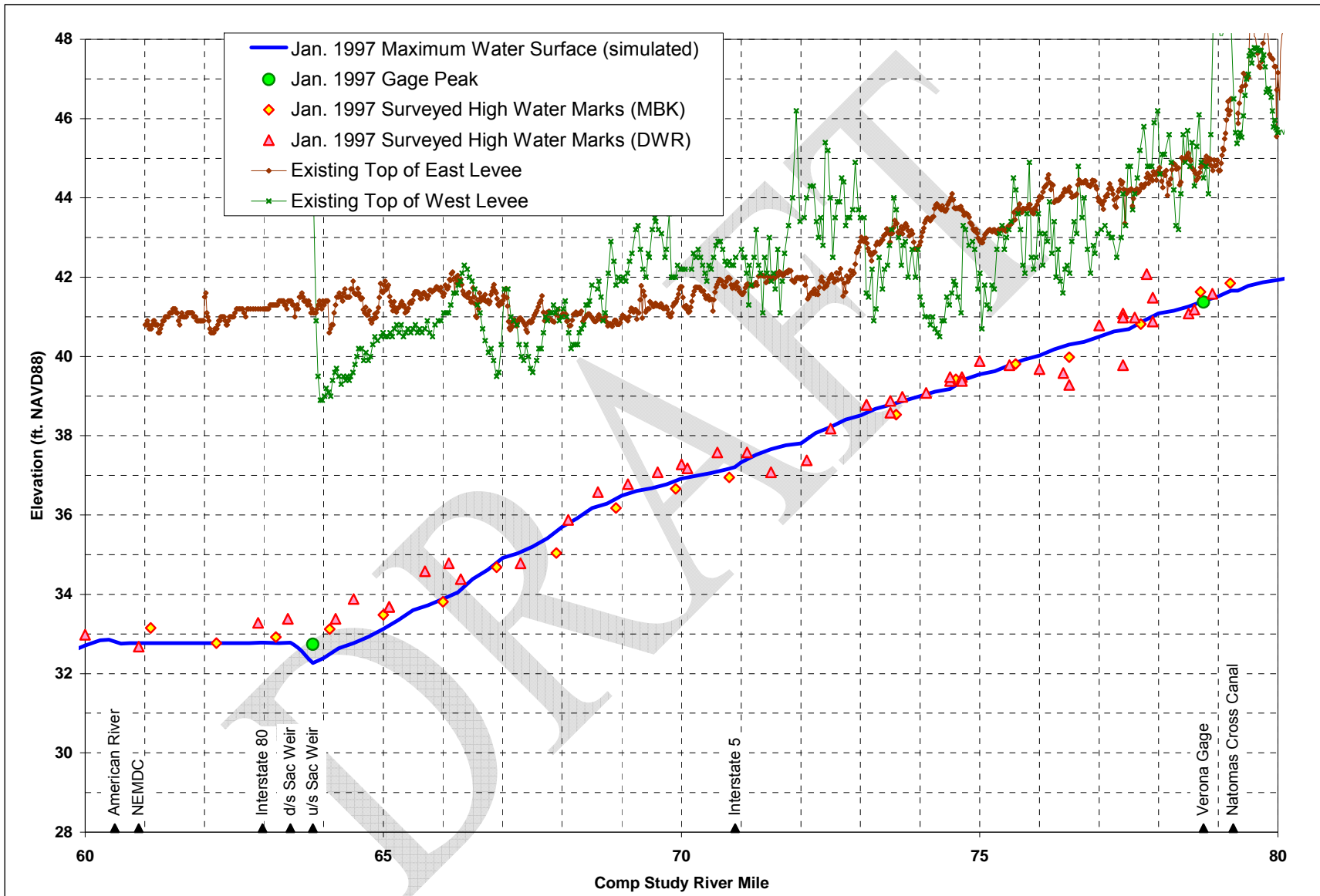


Figure 4. Model Calibration – Sacramento River Profile

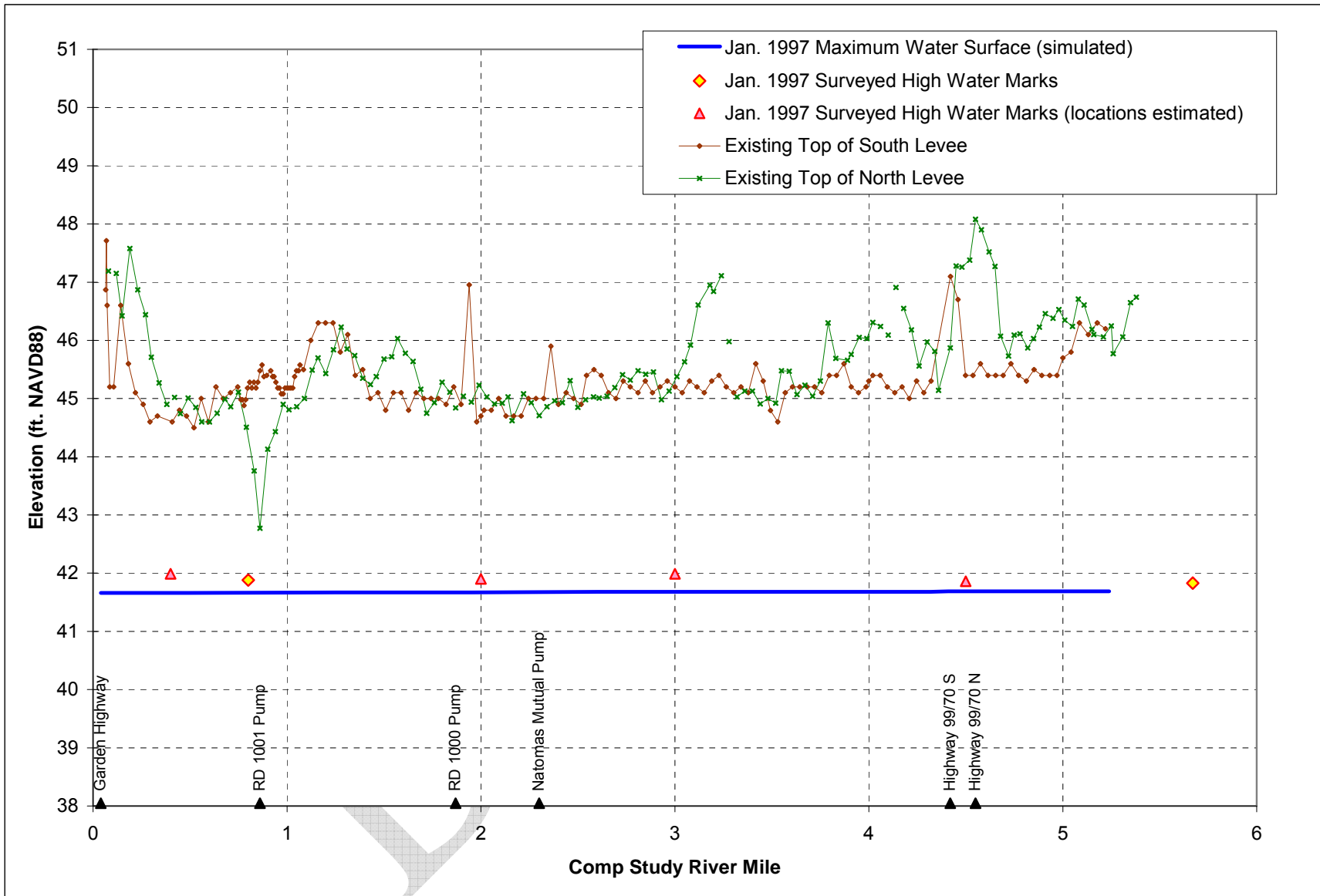


Figure 5. Model Calibration – Natomas Cross Canal Profile

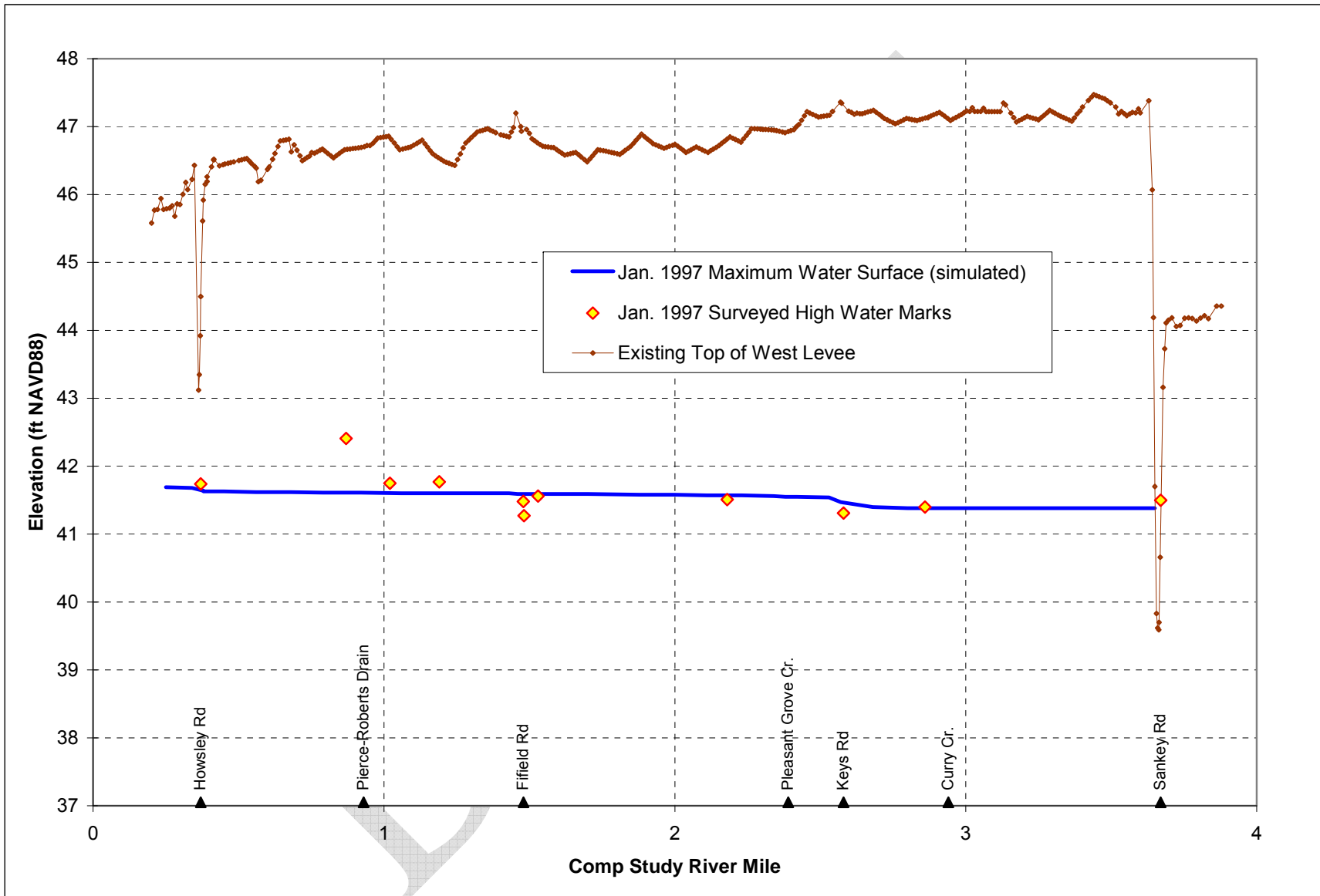


Figure 6. Model Calibration – Pleasant Grove Creek Canal Profile

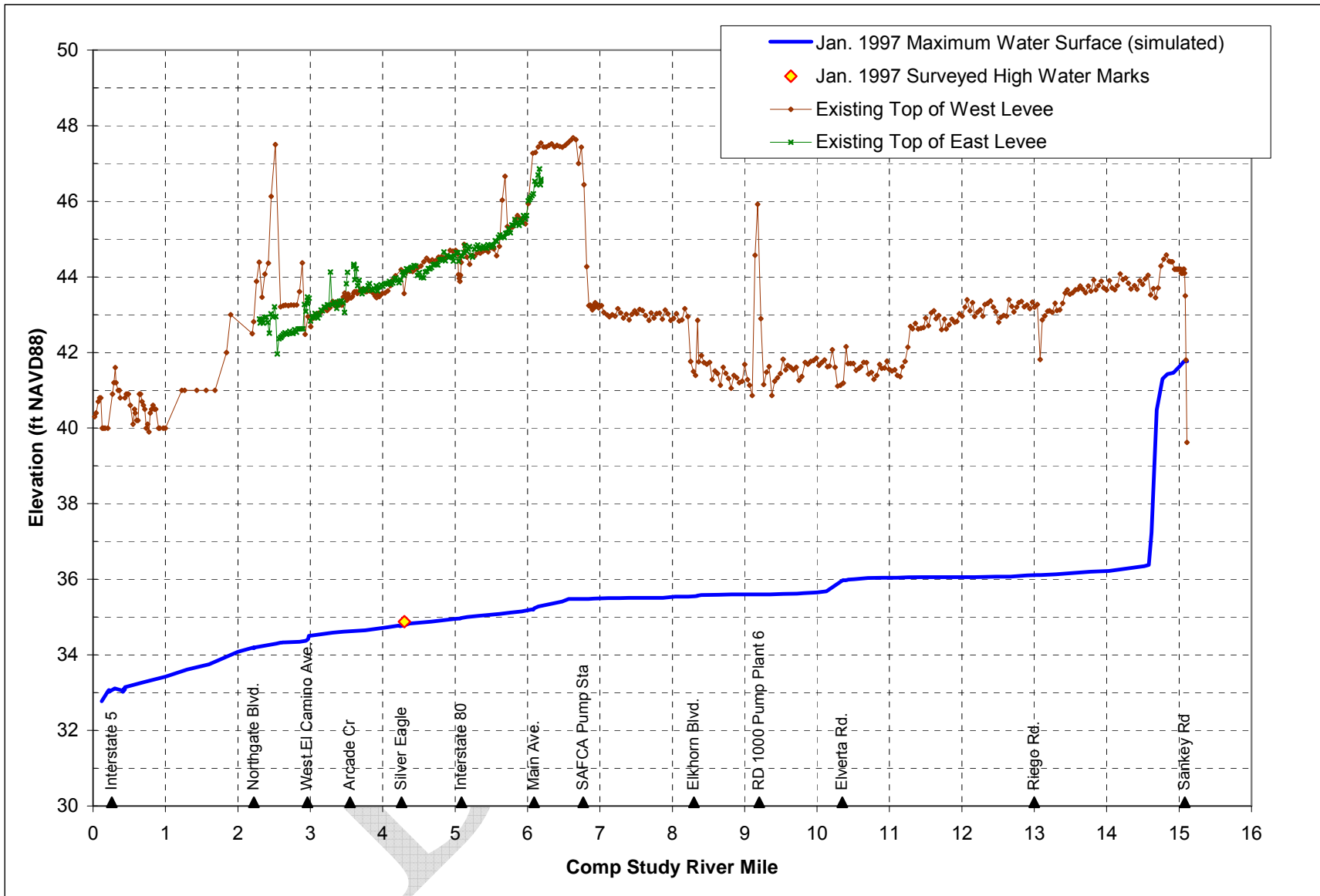


Figure 7. Model Calibration – NEMDC Profile

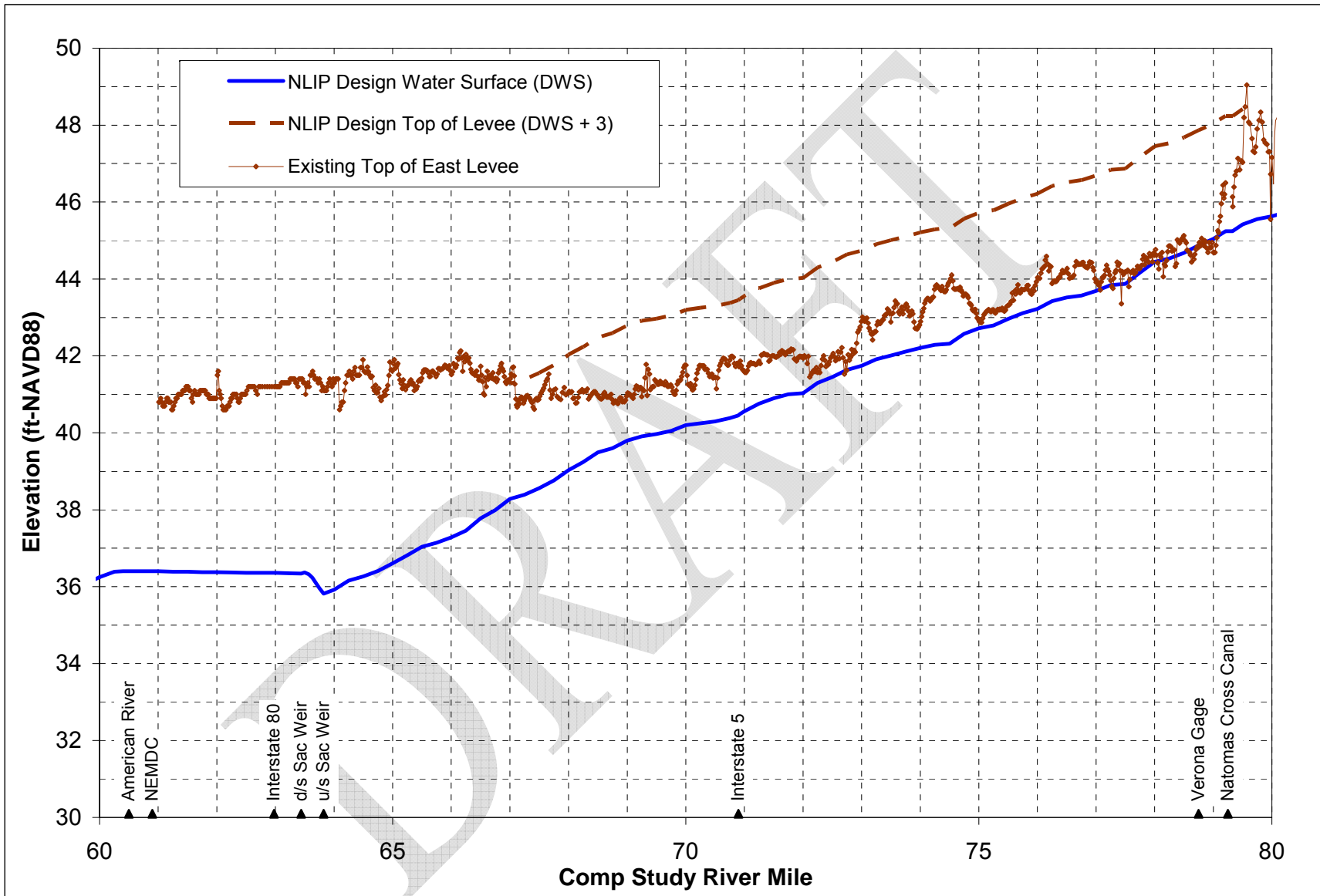


Figure 8. NLIP Design Top of Levee Profile – Sacramento River

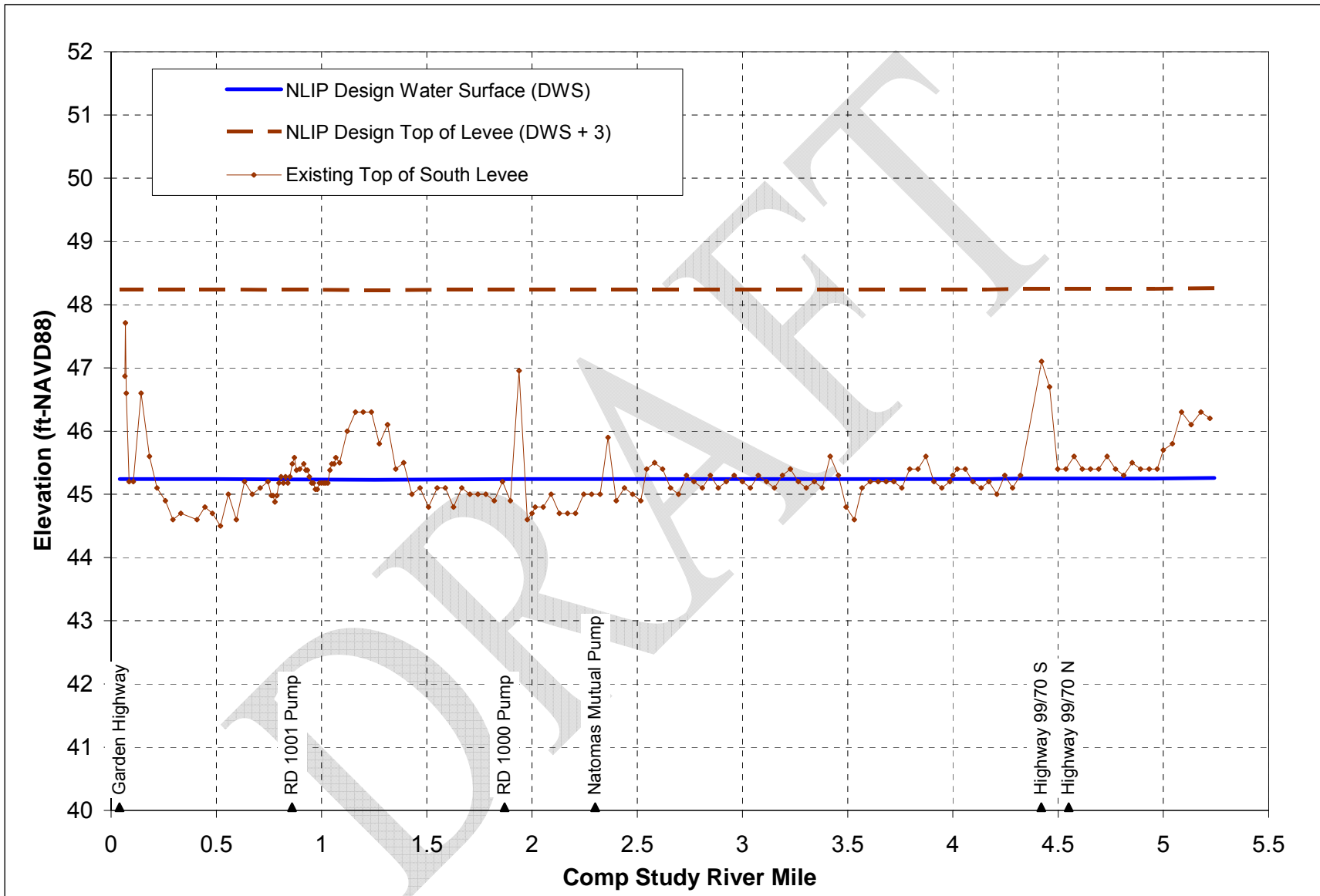


Figure 9. NLIP Design Top of Levee Profile – Natomas Cross Canal

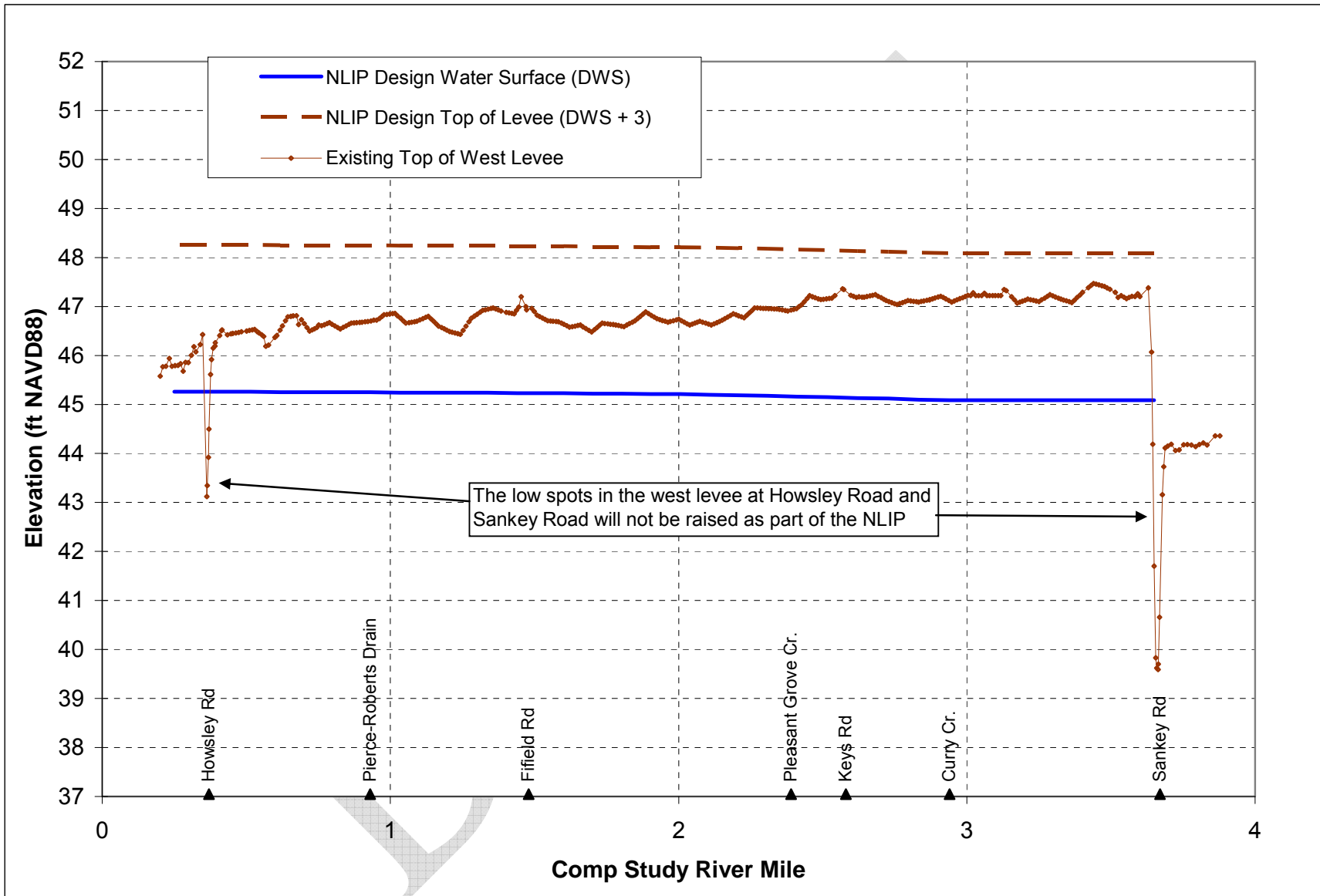


Figure 10. NLIP Design Top of Levee Profile – Pleasant Grove Creek Canal

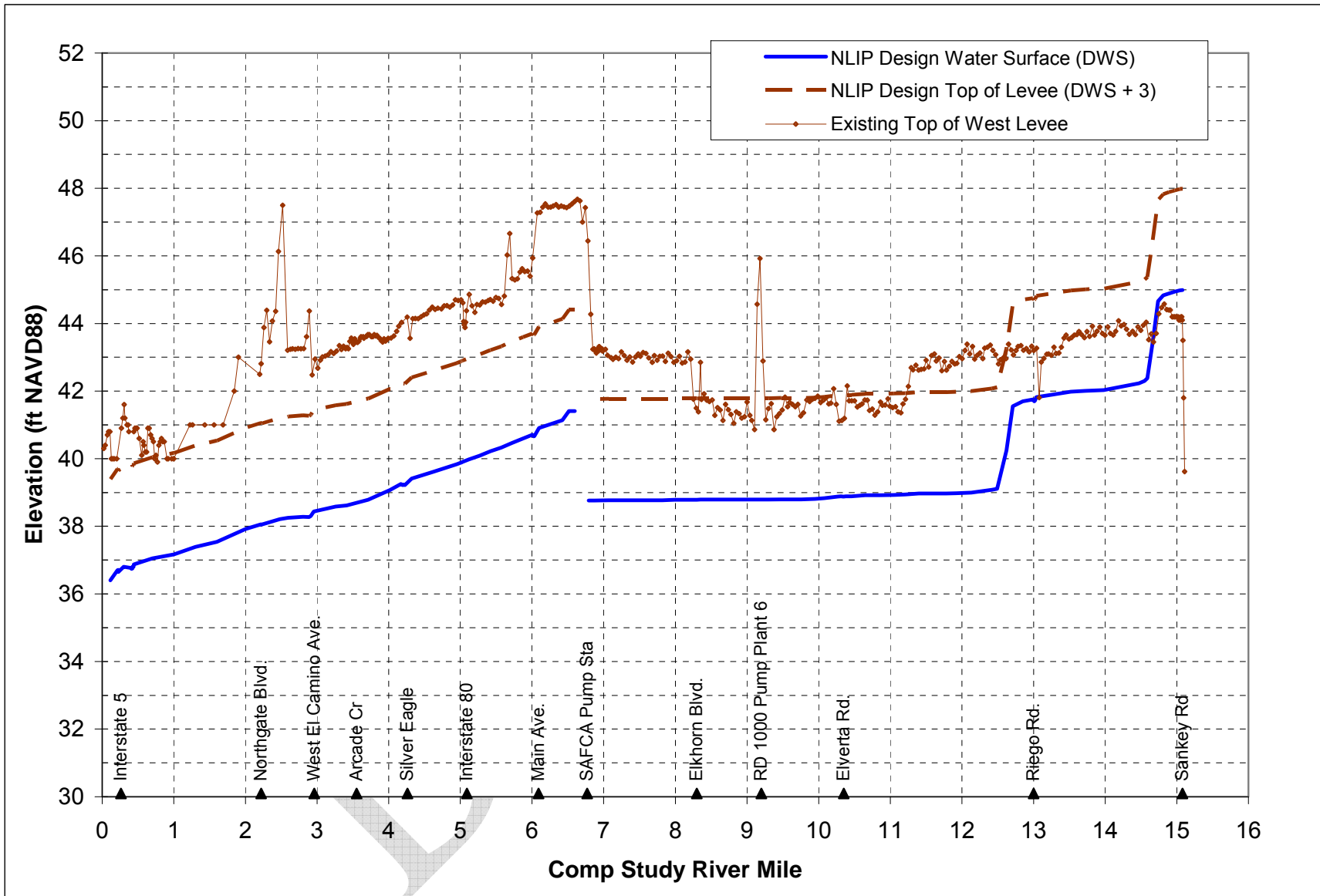


Figure 11. NLIP Design Top of Levee Profile – NEMDC

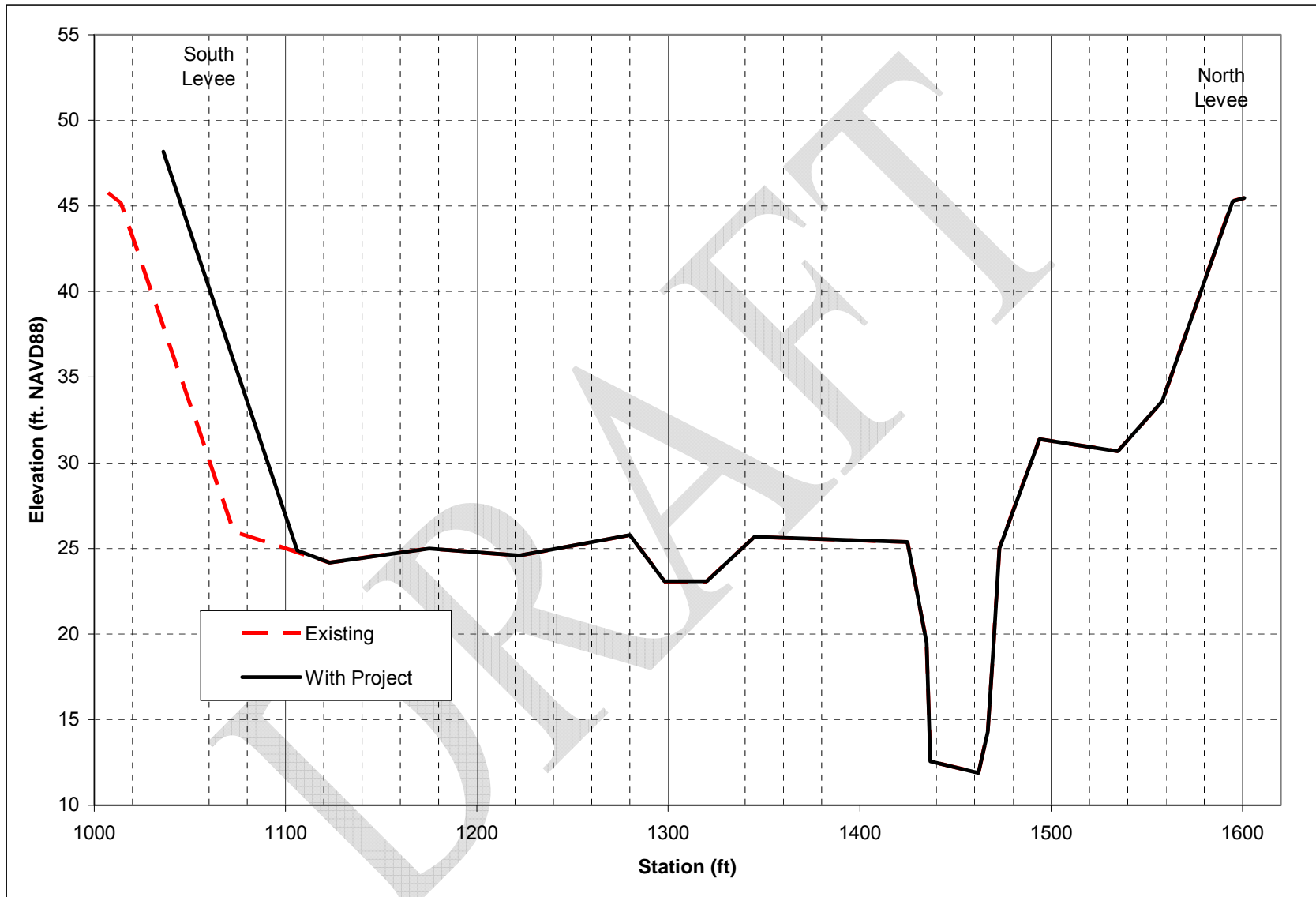


Figure 12. Typical Natomas Cross Canal Section with Waterside Fill

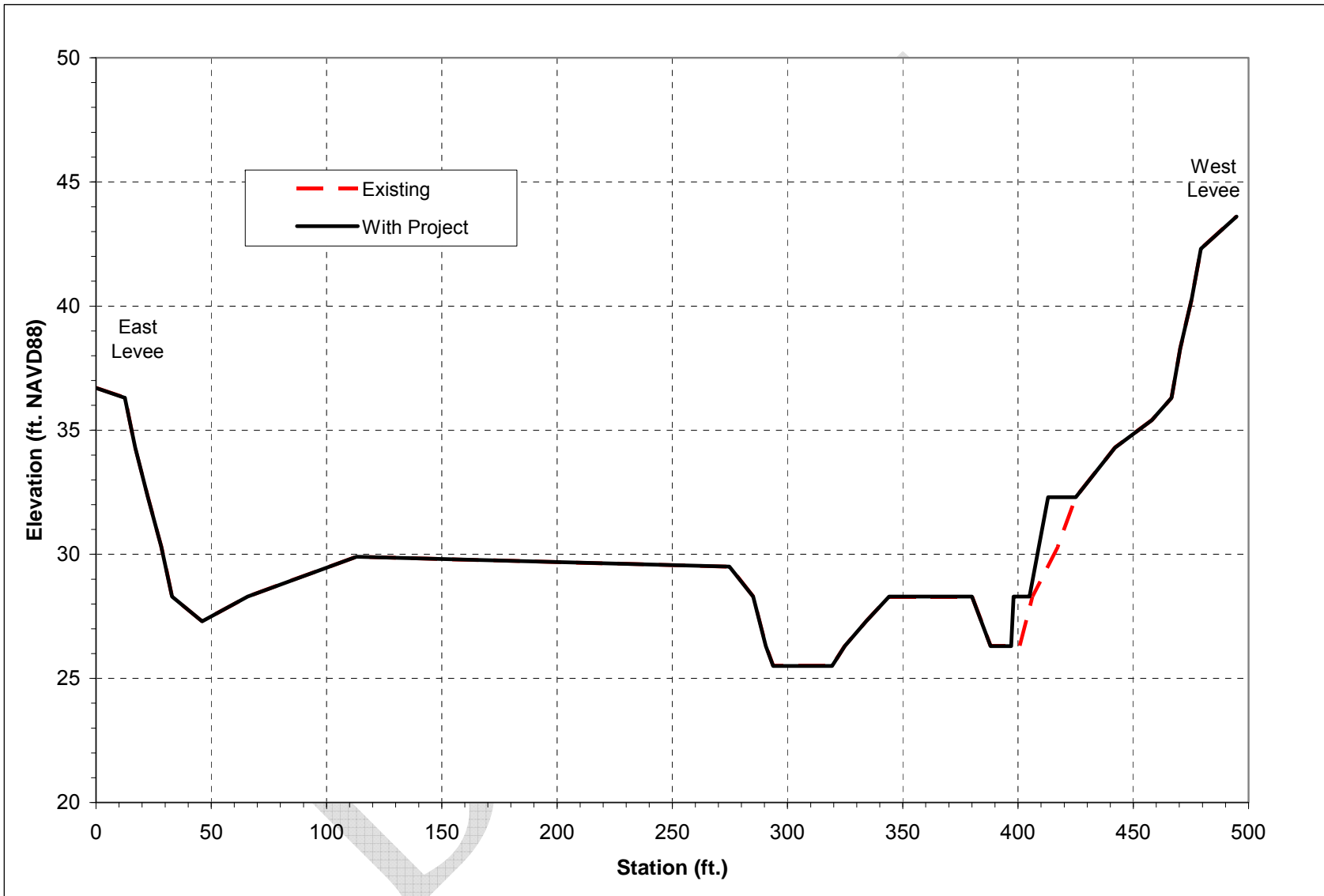


Figure 13. Rock Erosion Protection Berm in Hydraulic Model at NEMDC Northern Erosion Protection Site

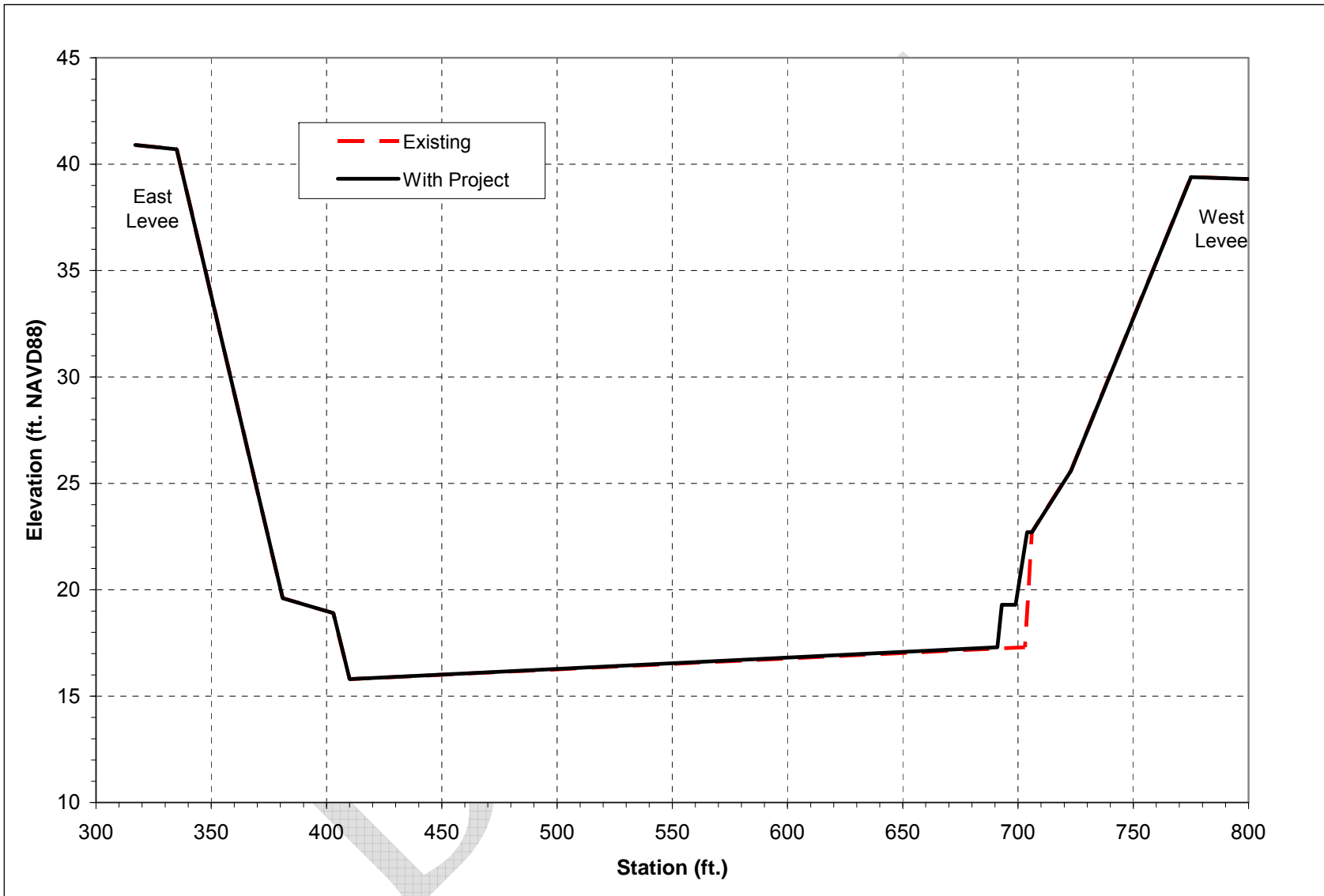


Figure 14. Rock Erosion Protection Berm in Hydraulic Model at NEMDC Southern Erosion Protection Site

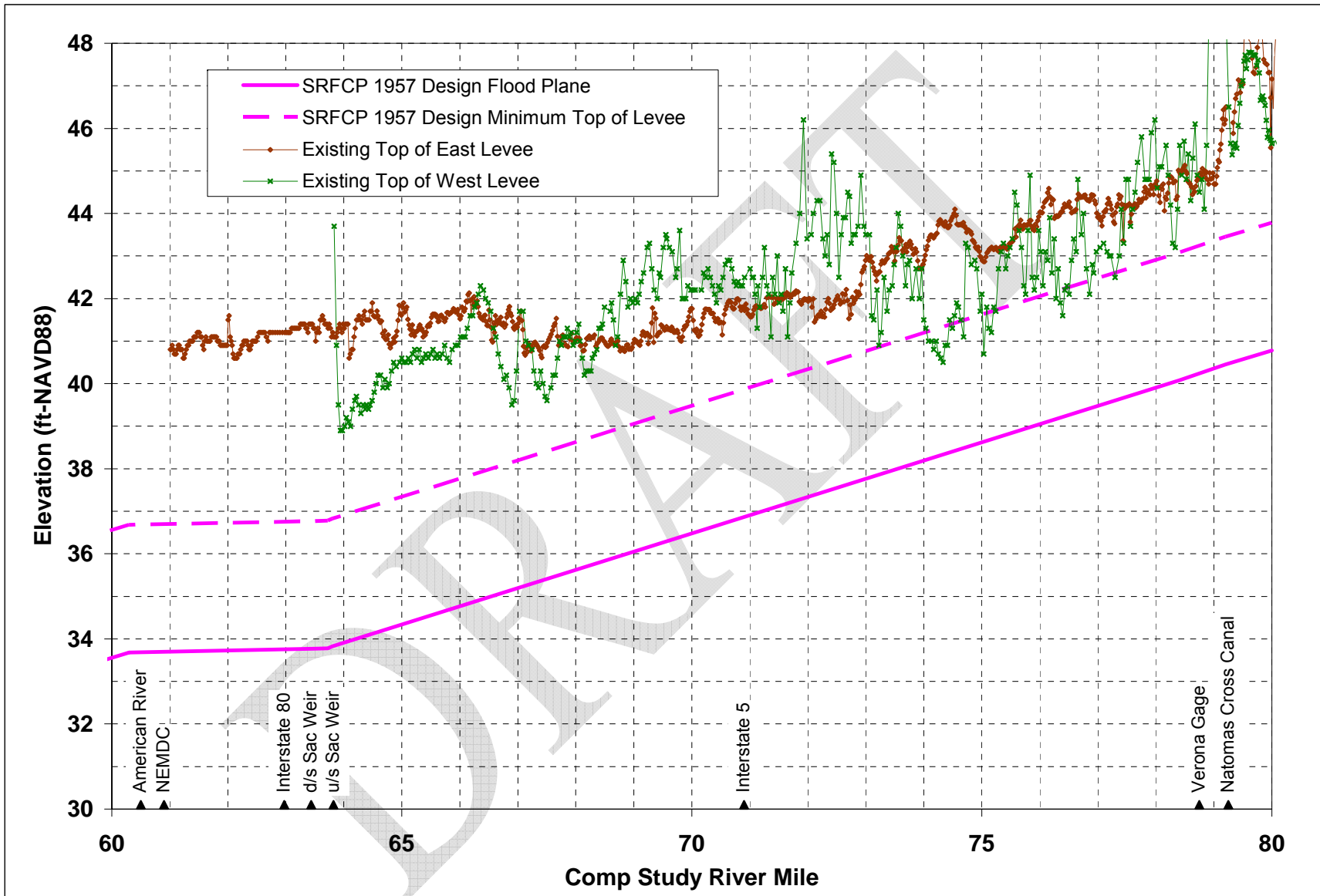


Figure 15. SRFCP 1957 Design Profile, Sacramento River Natomas Reach

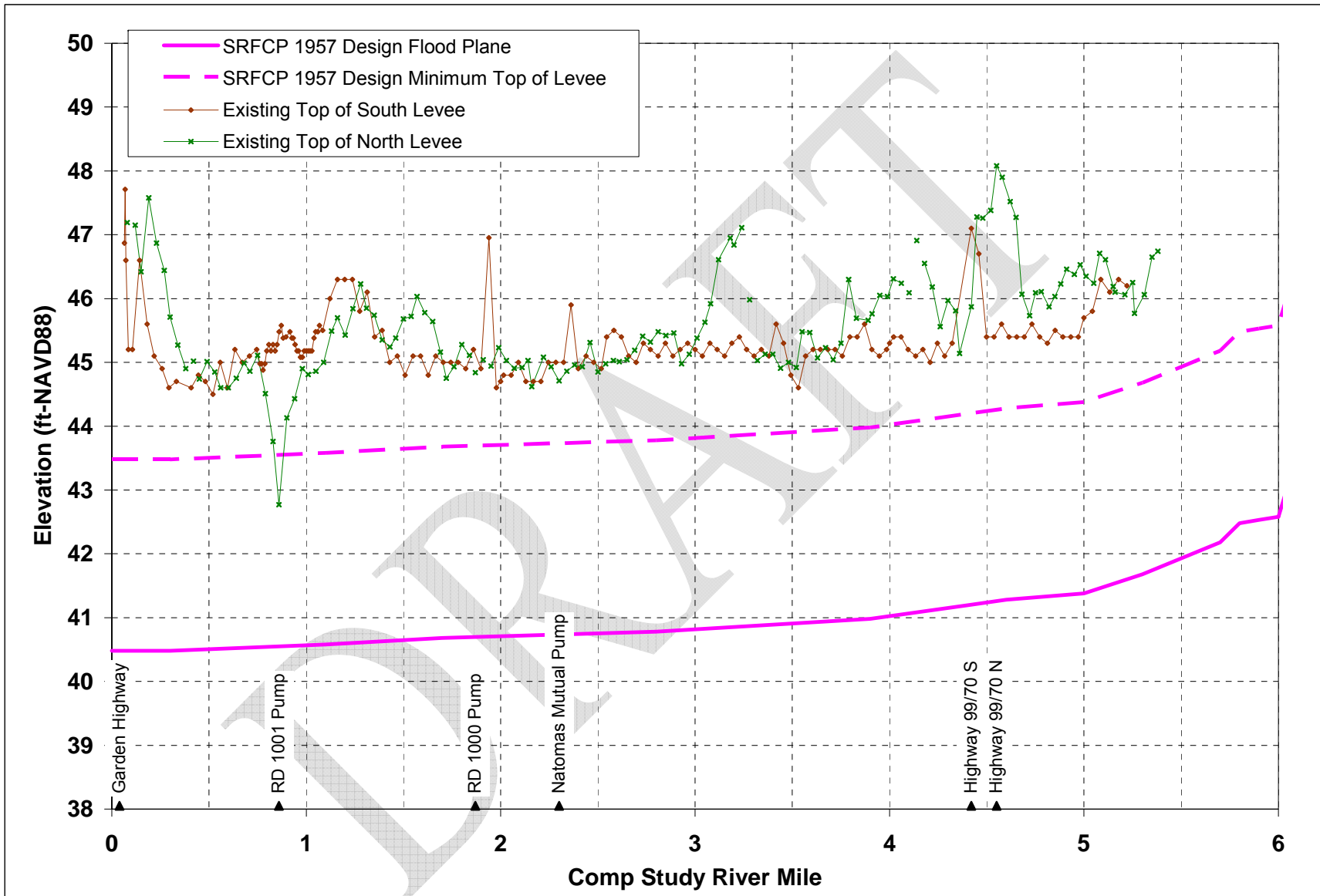


Figure 16. SRF 1957 Design Profile, Natomas Cross Canal

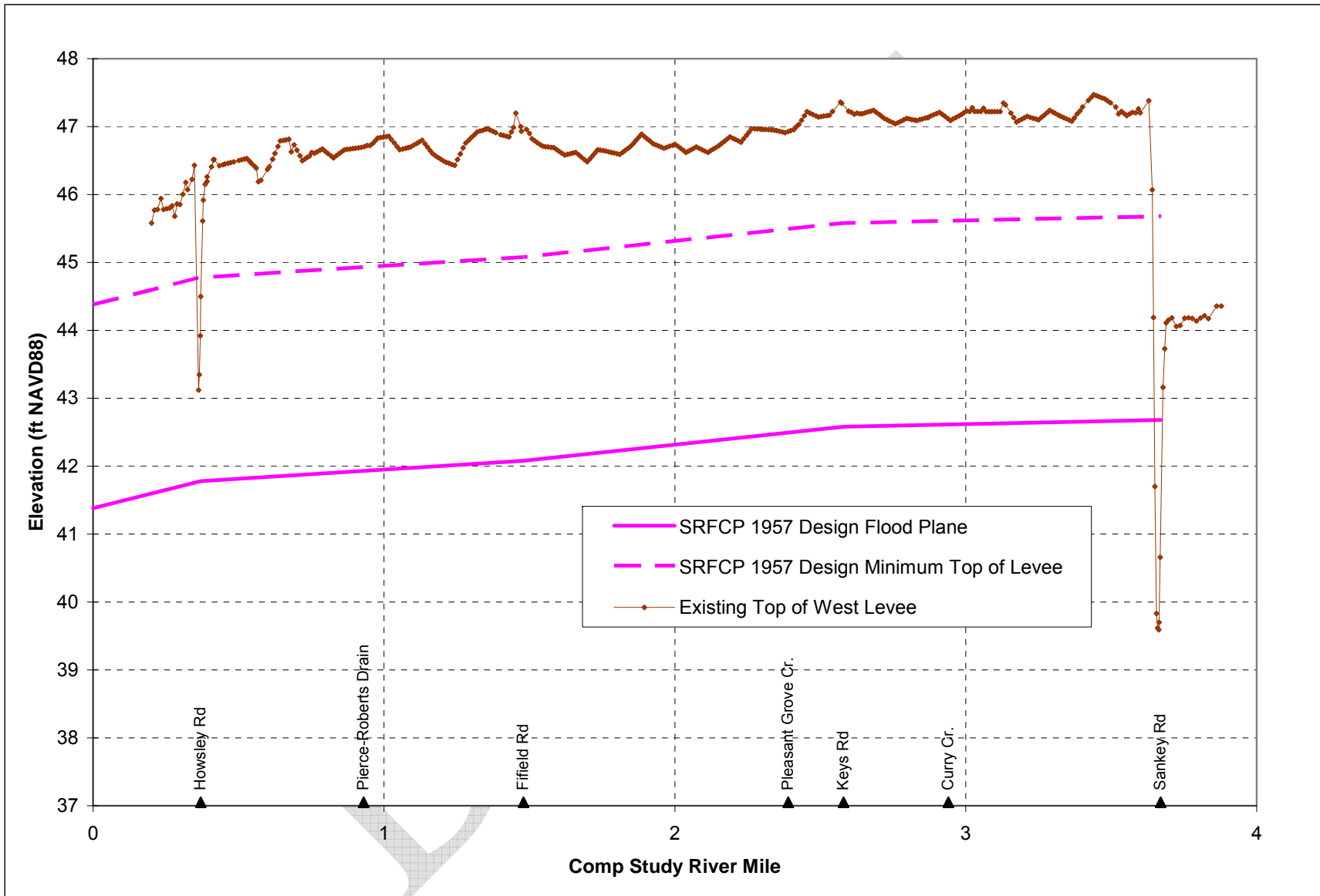


Figure 17. SRFCP 1957 Design Profile, Pleasant Grove Creek Canal

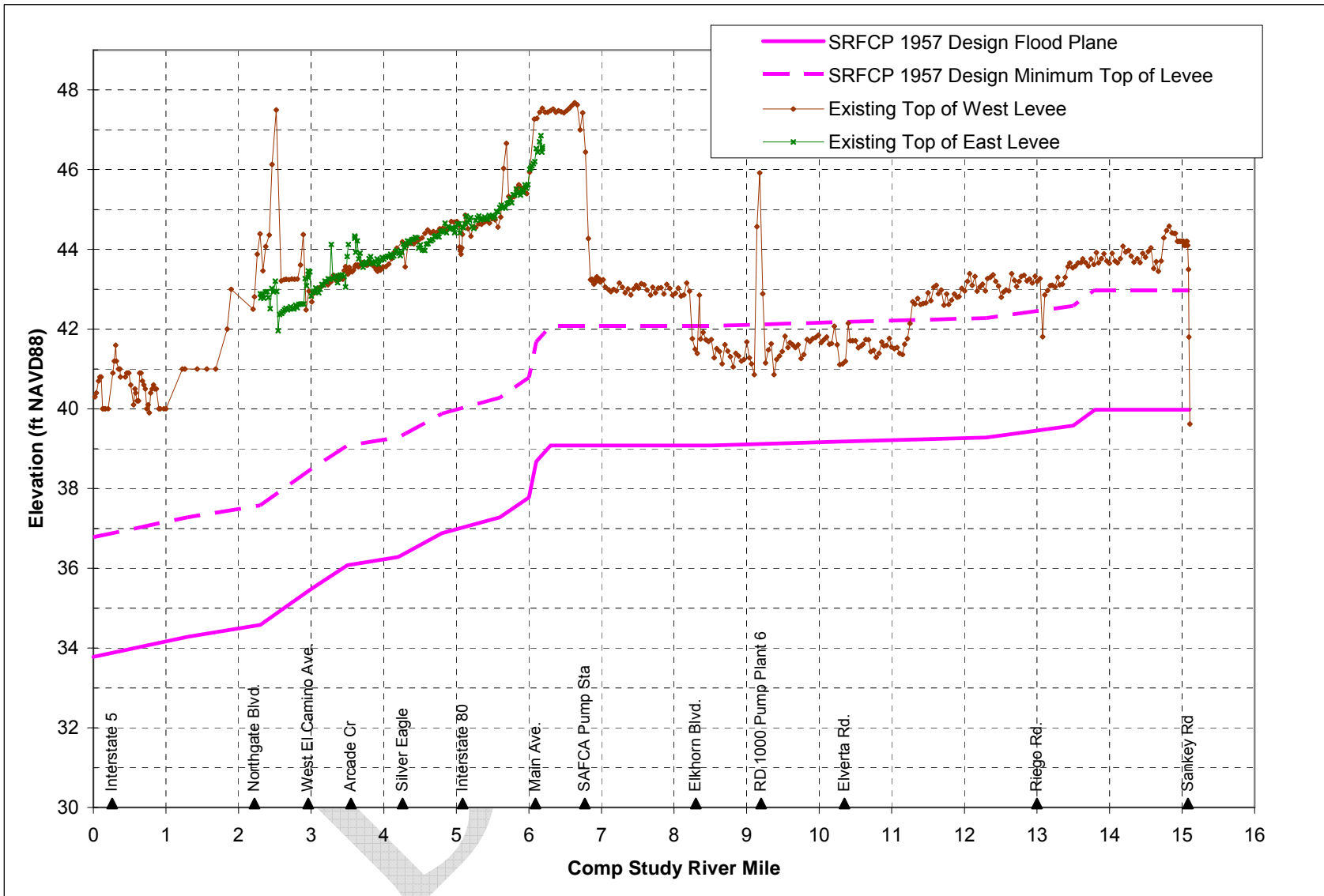


Figure 18. SRFCP 1957 Design Profile, NEMDC

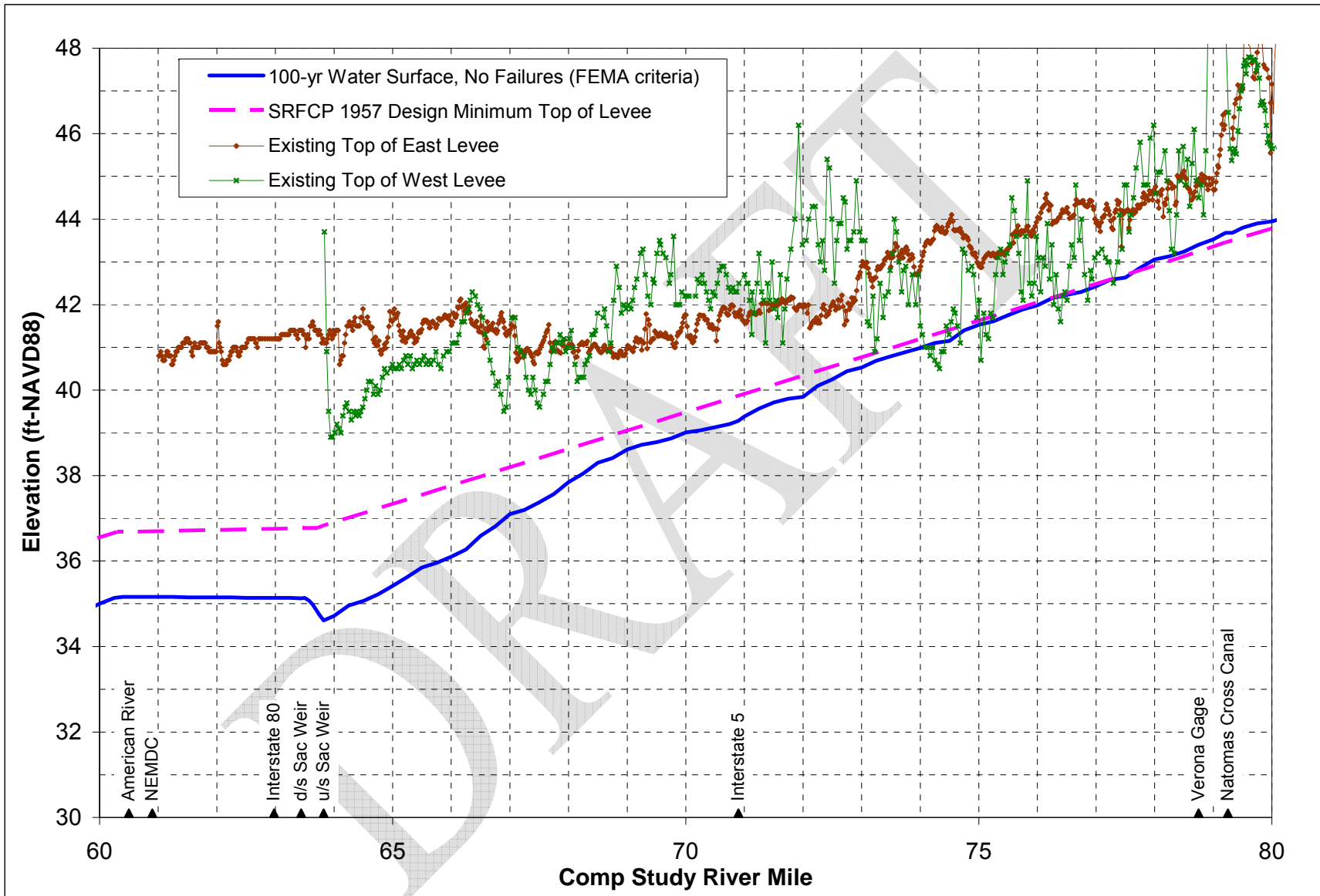


Figure 19. 100-year Water Surface Profile – Sacramento River Natomas Reach

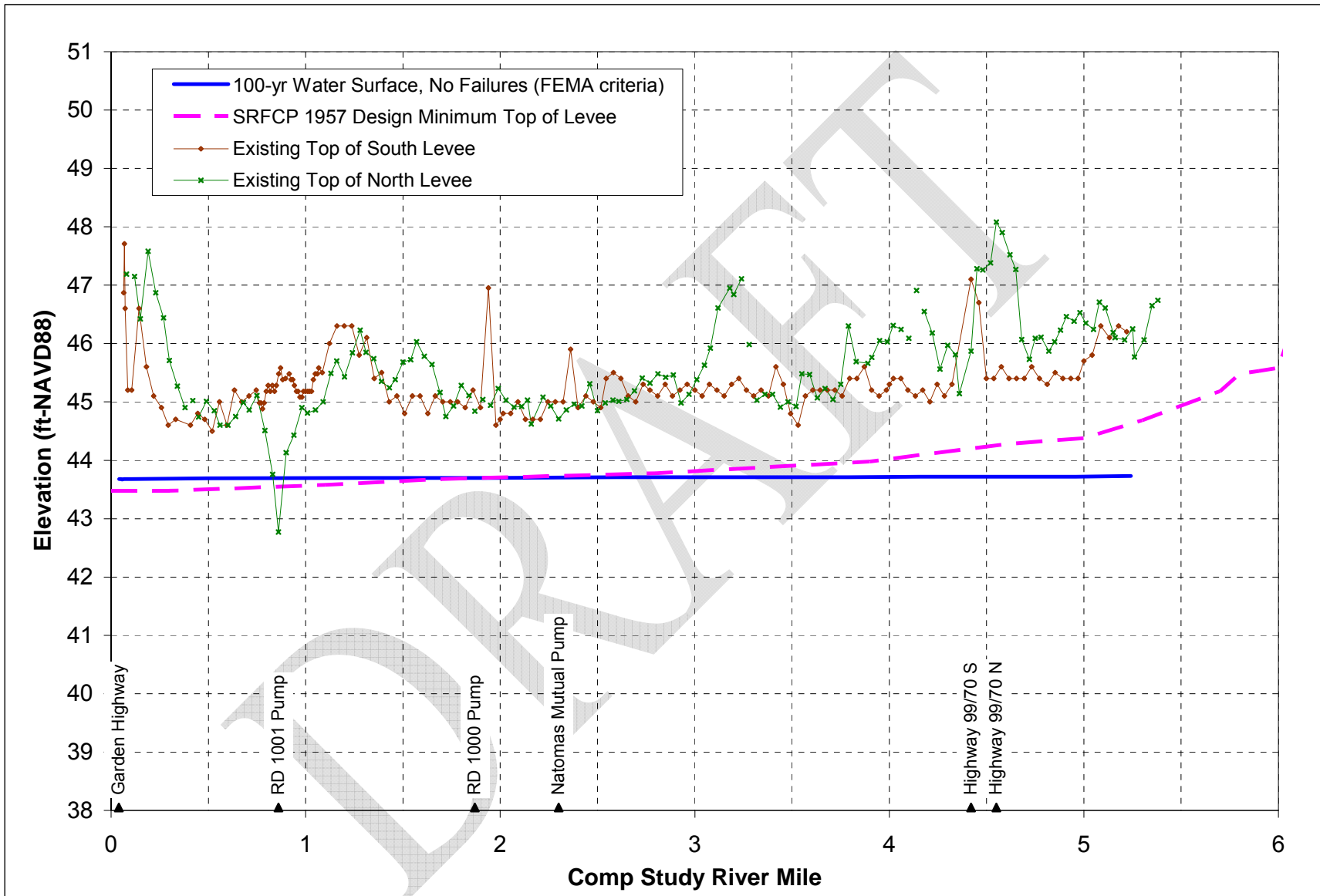


Figure 20. 100-year Water Surface Profile – Natomas Cross Canal

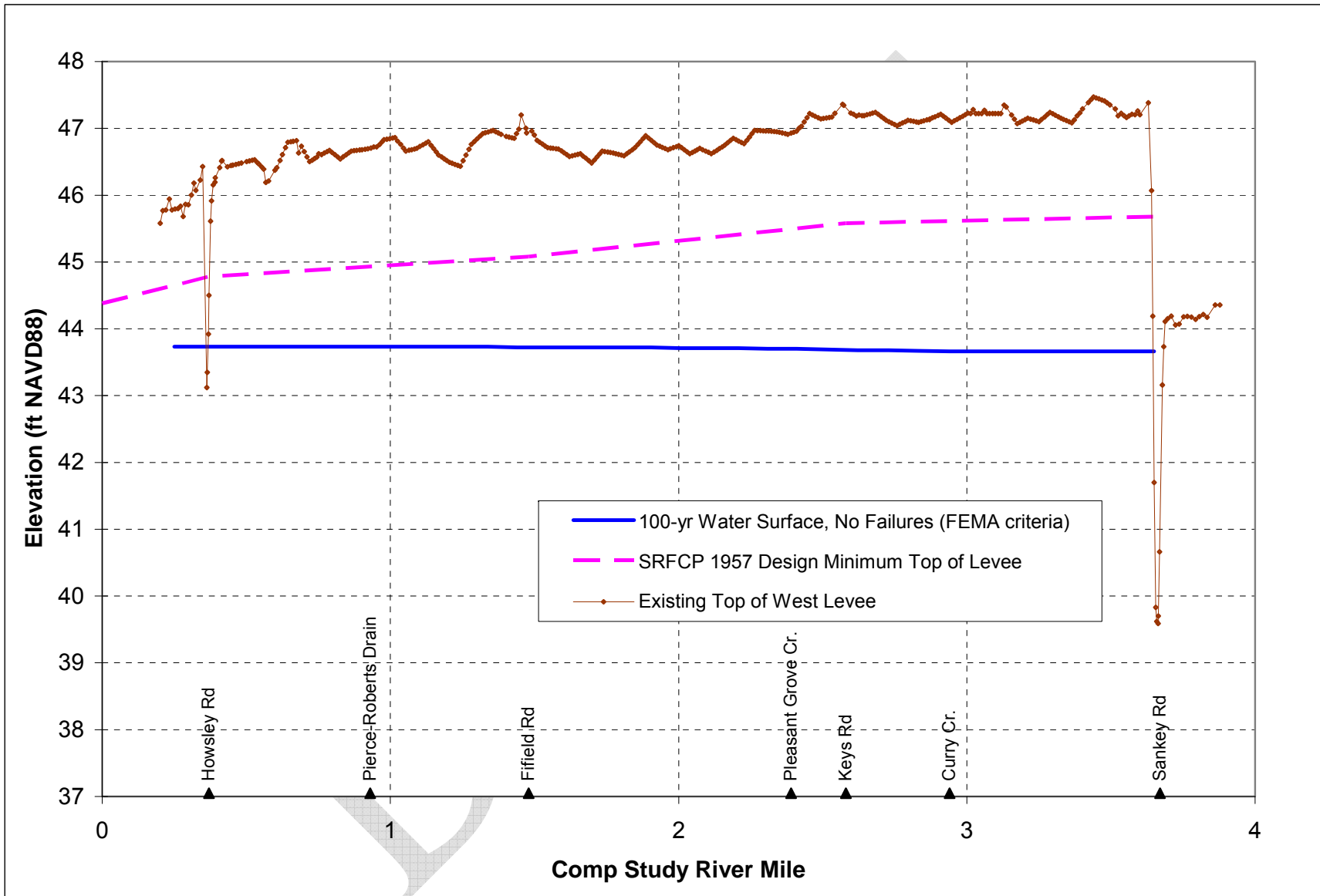


Figure 21. 100-year Water Surface Profile – Pleasant Grove Creek Canal

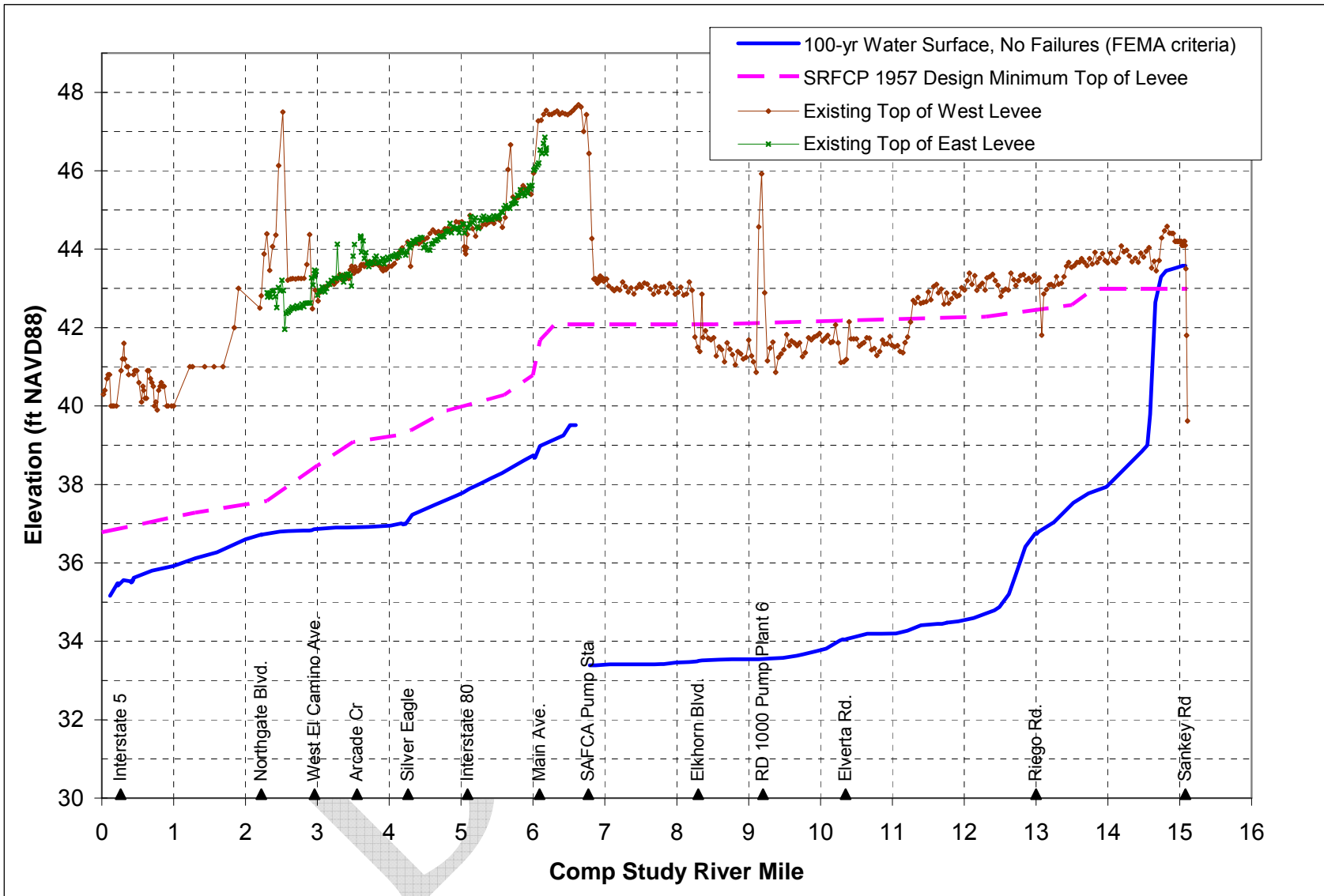


Figure 22. 100-year Water Surface Profile – NEMDC

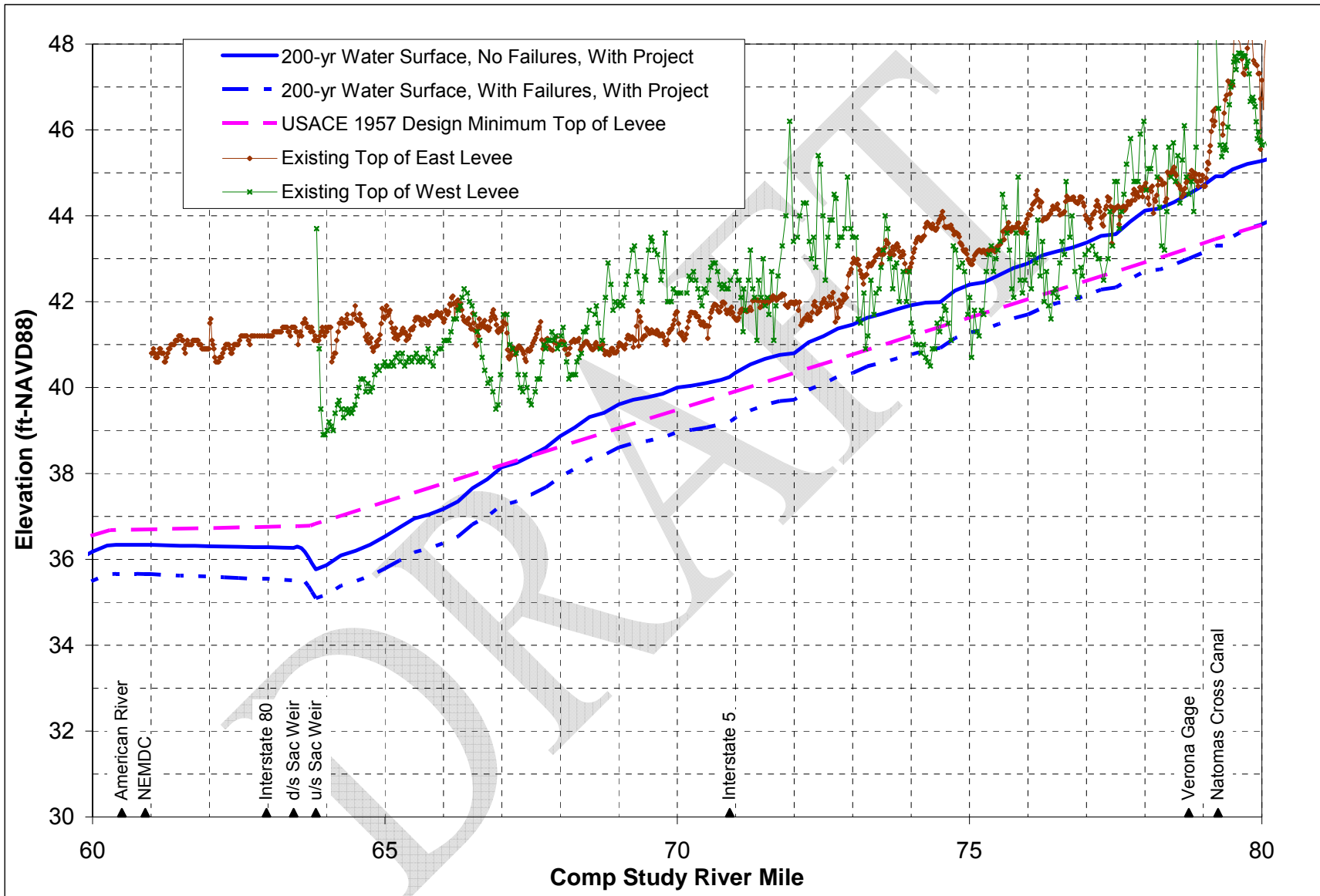


Figure 23. 200-year Water Surface Profile – Sacramento River Natomas Reach

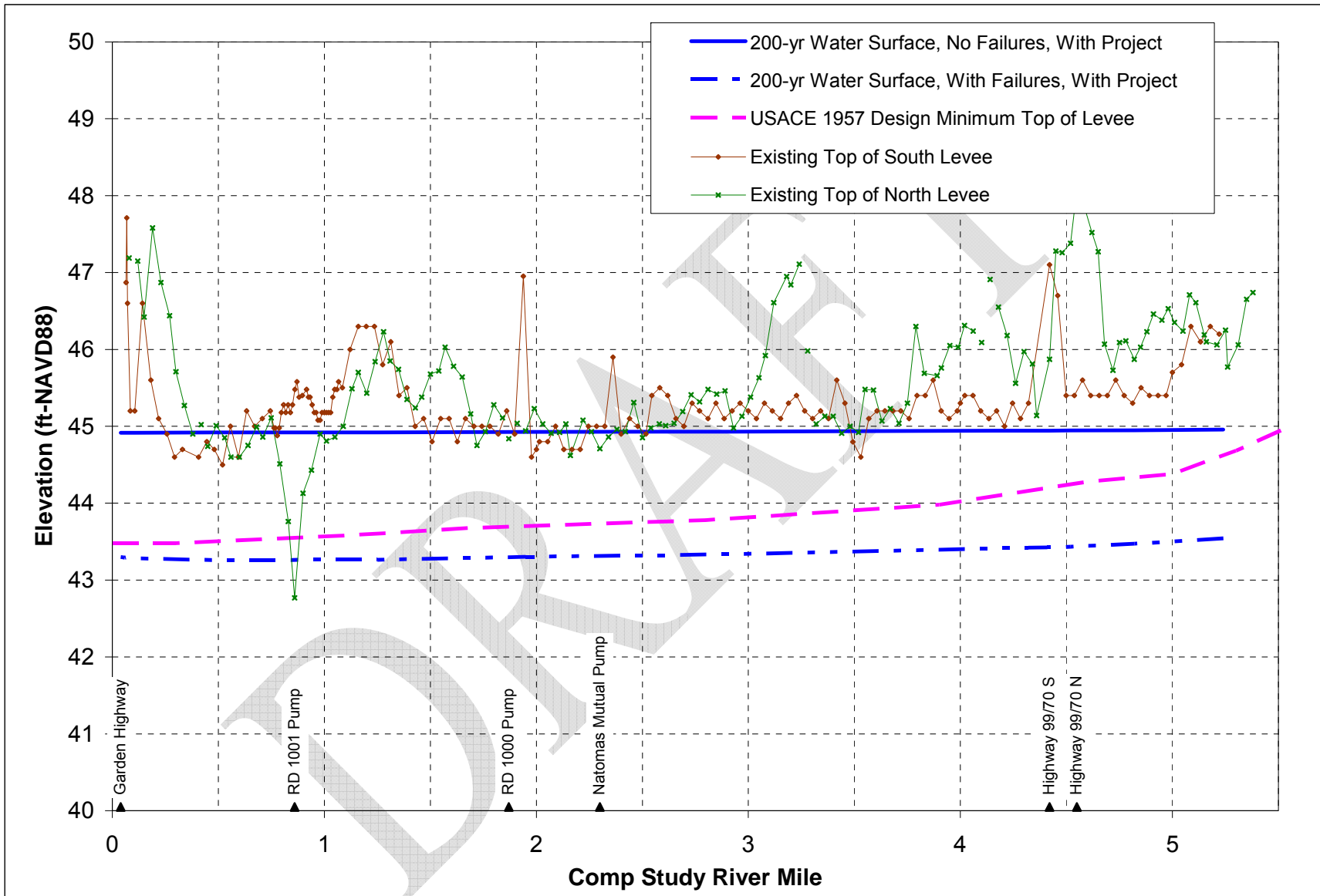


Figure 24. 200-year Water Surface Profile – Natomas Cross Canal

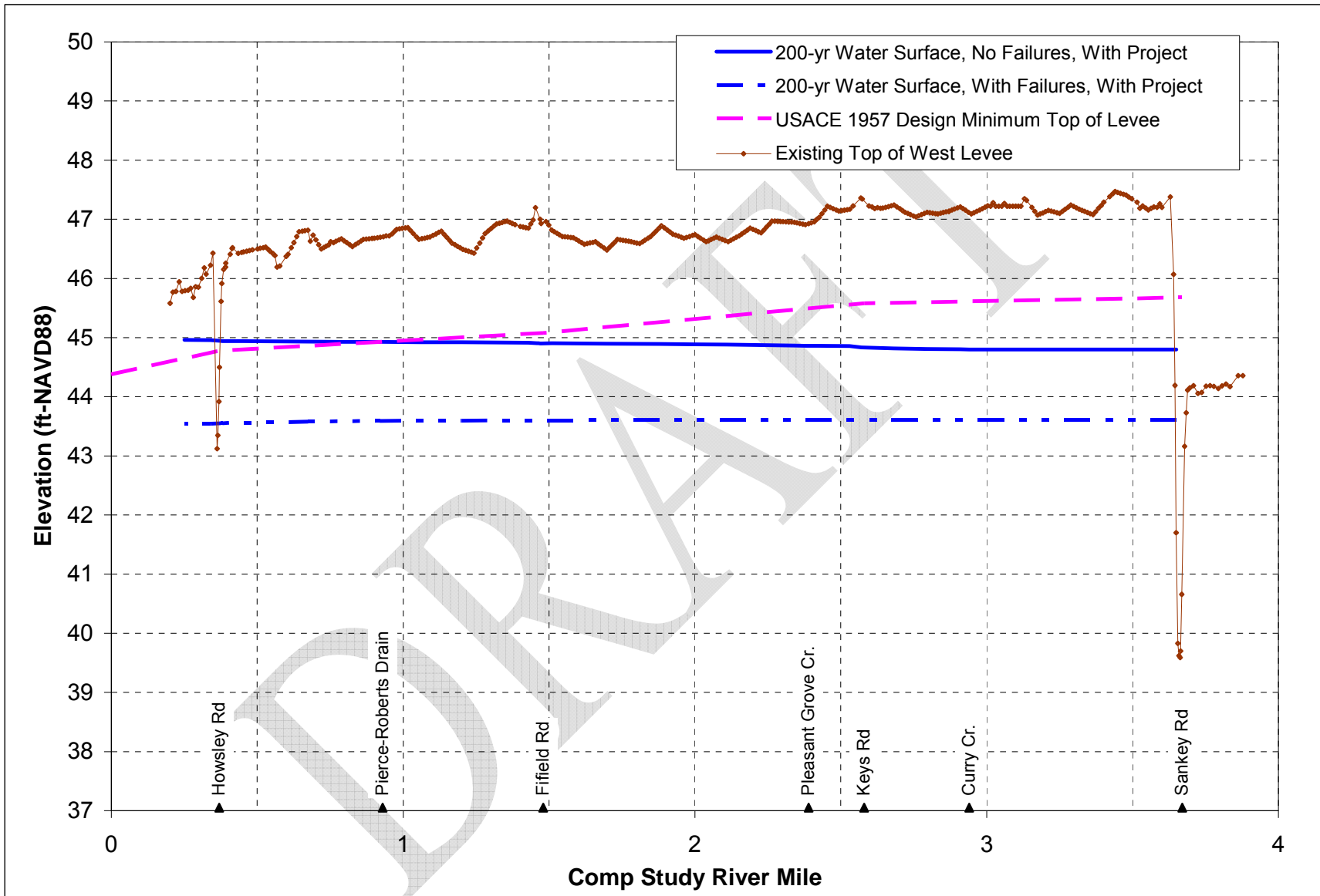


Figure 25. 200-year Water Surface Profile – Pleasant Grove Creek Canal

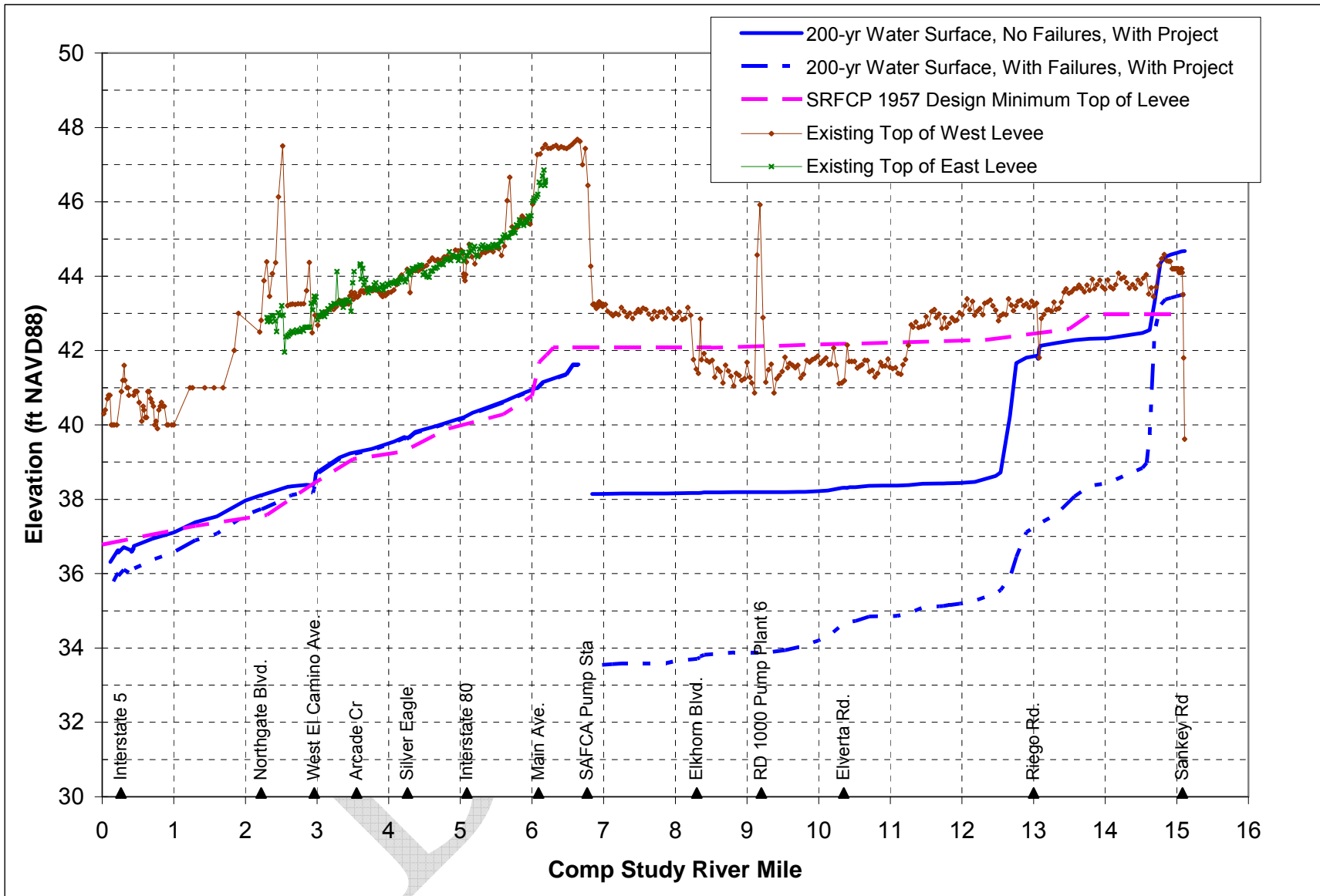


Figure 26. 200-year Water Surface Profile – NEMDC

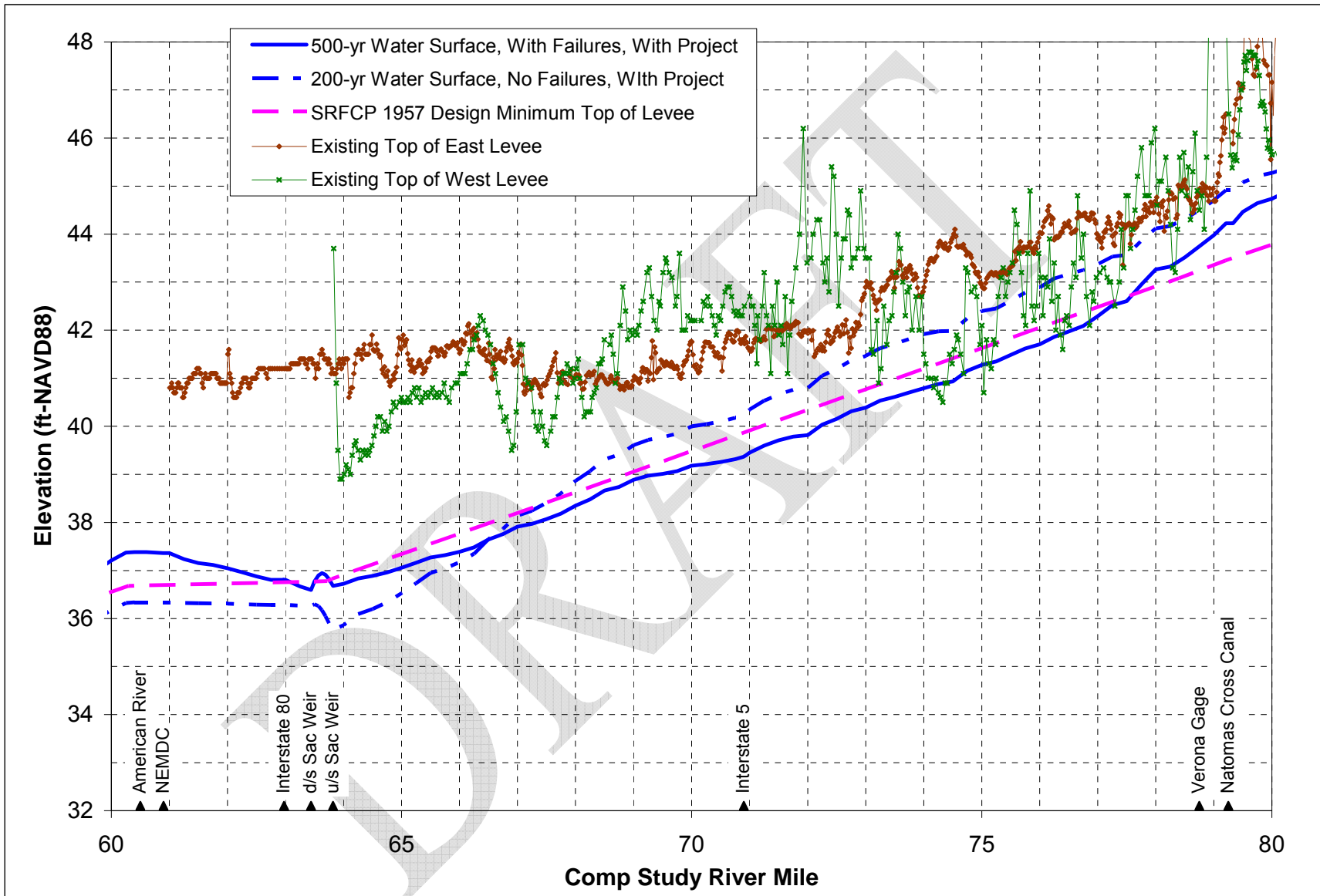


Figure 27. 500-year Water Surface Profile – Sacramento River Natomas Reach

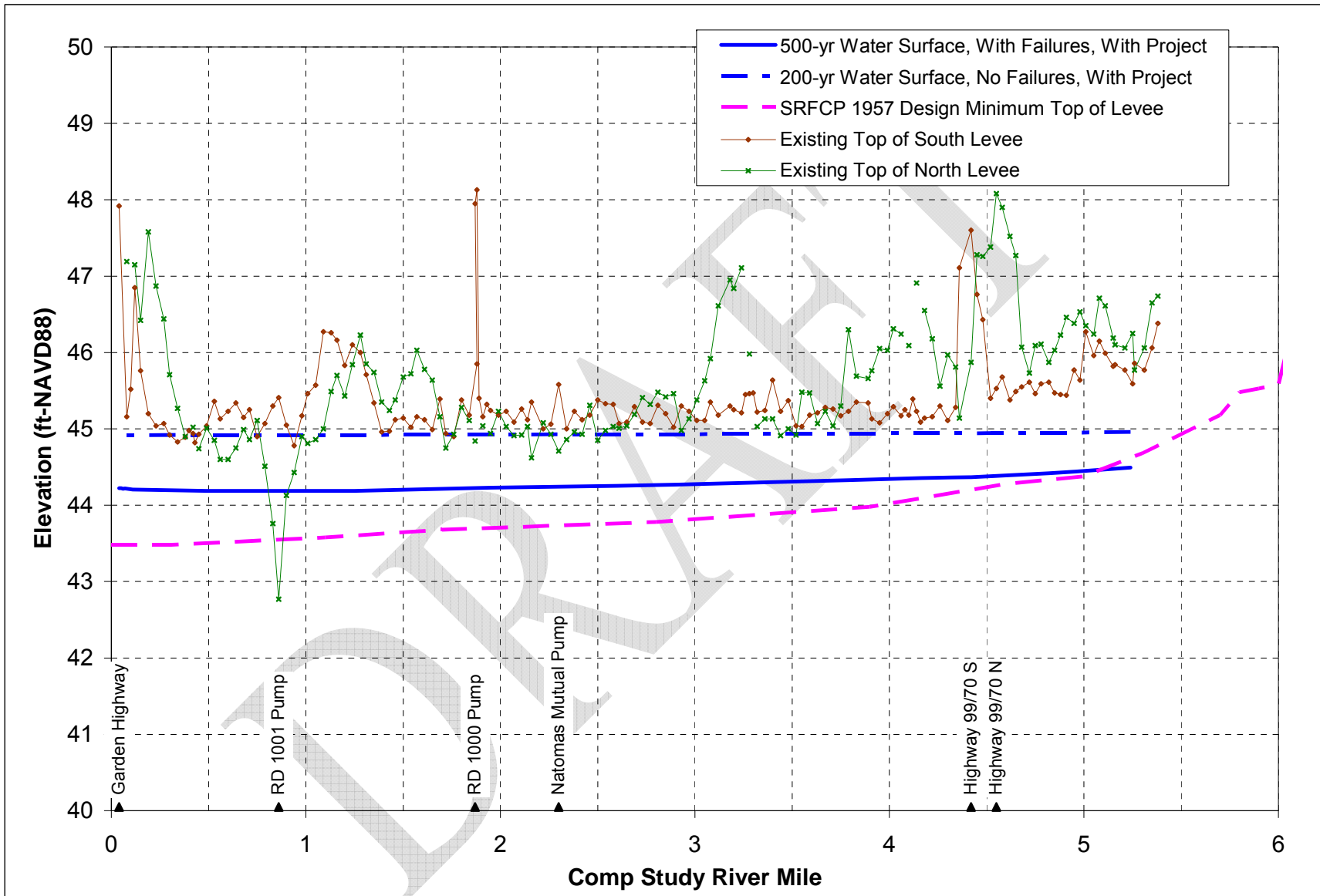


Figure 28. 500-year Water Surface Profile – Natomas Cross Canal

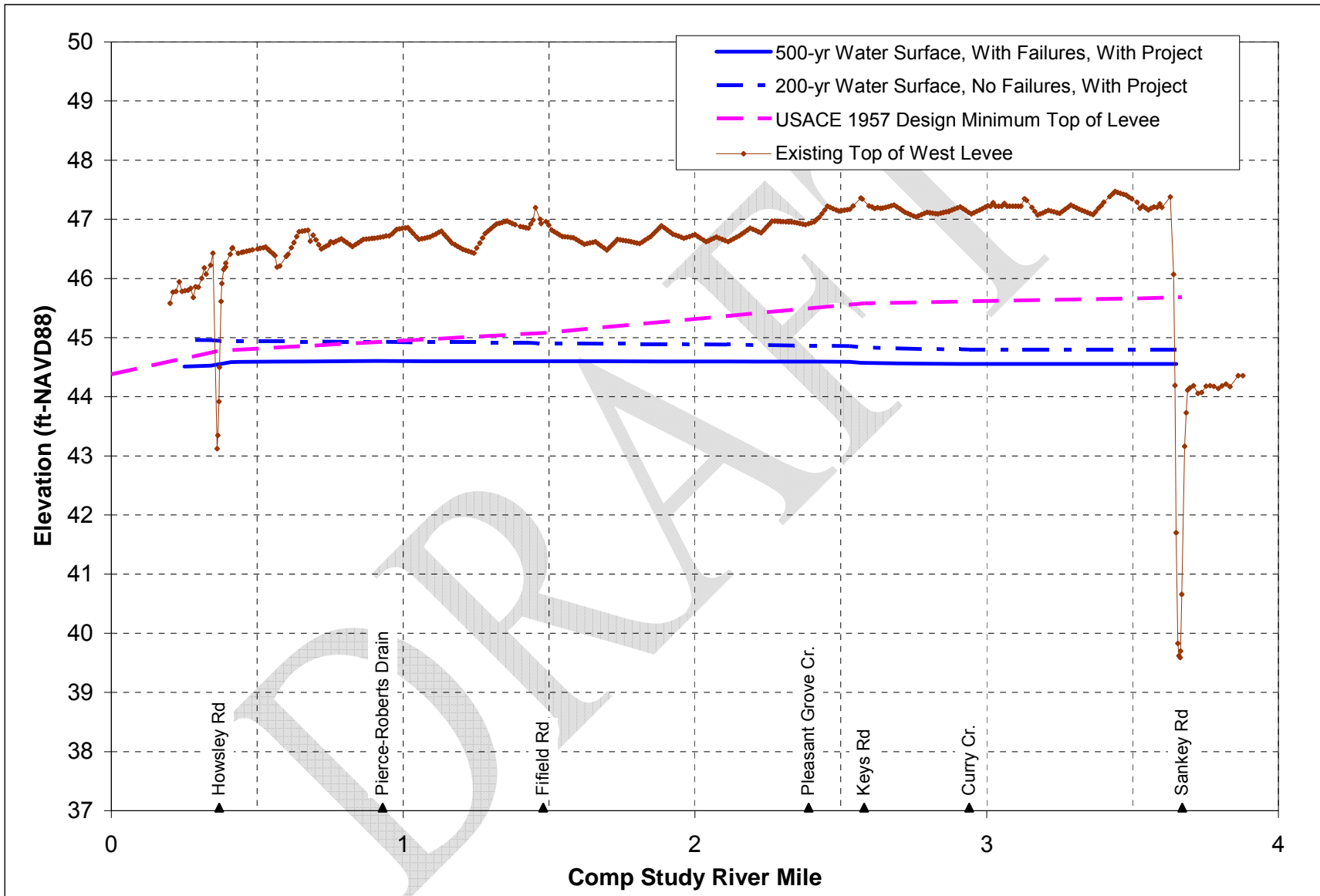


Figure 29. 500-year Water Surface Profile – Pleasant Grove Creek Canal

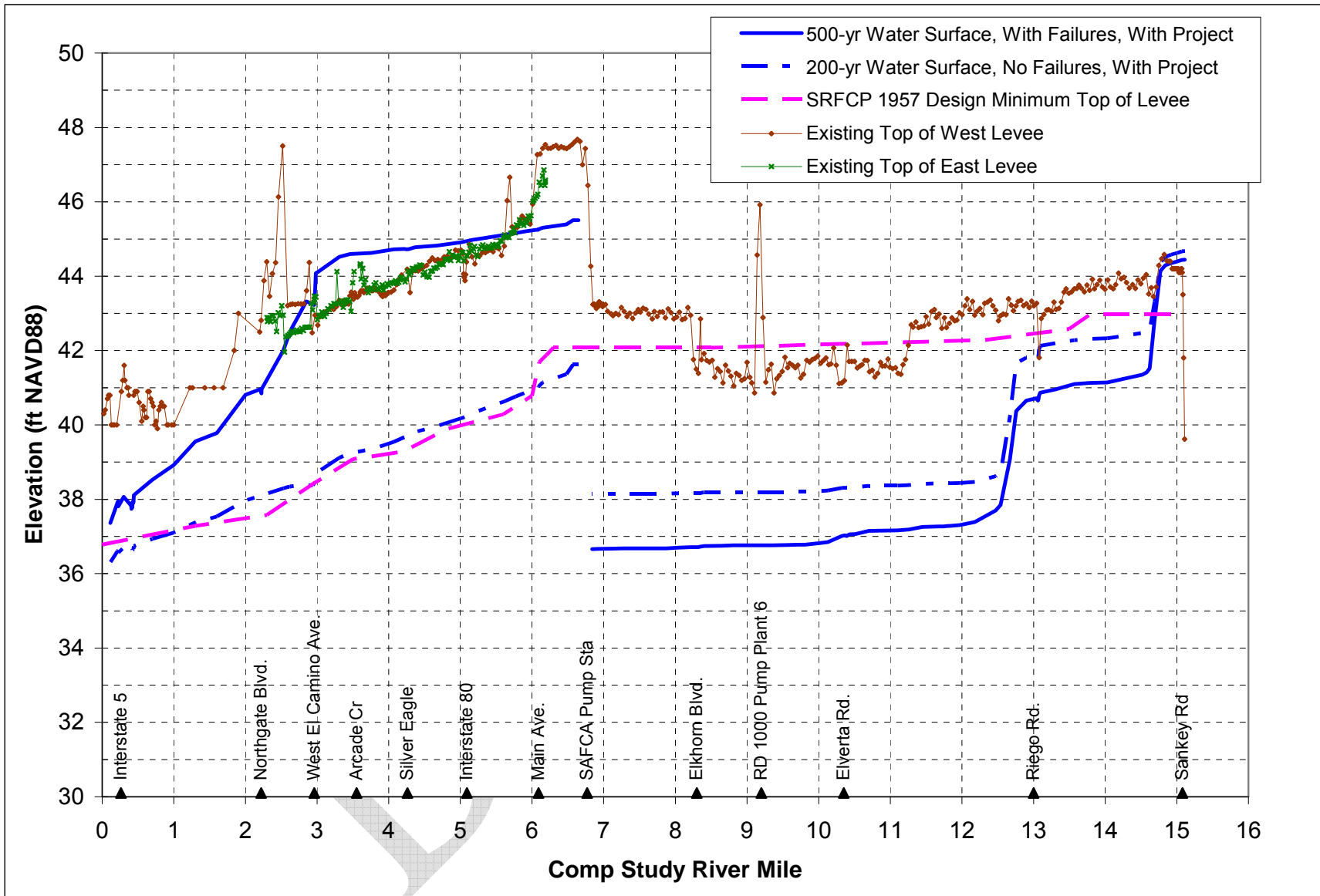


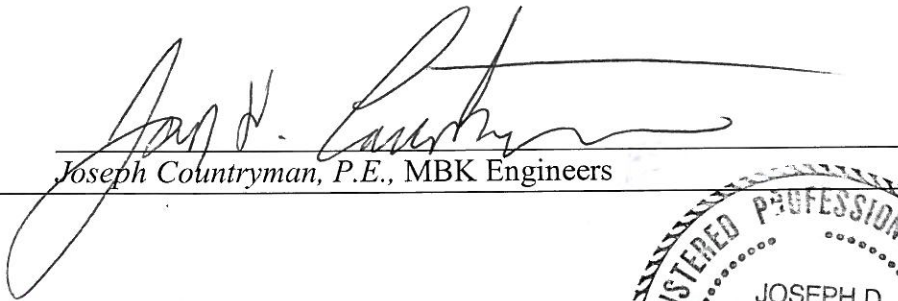
Figure 30. 500-year Water Surface Profile – NEMDC



Quality Control Certification
for
Natomas Levee Improvement Program - Summary Report on Hydraulic Impact
Analyses, Phase 4b Project

Certification of Internal Quality Control

I hereby certify that I have reviewed the January 11, 2010 draft report entitled *Natomas Levee Improvement Program - Summary Report on Hydraulic Impact Analyses, Phase 4b Project* and that the report adequately addresses and presents the impacts of the described project.



Joseph Countryman, P.E., MBK Engineers

January 11, 2010
Date

