MATILIJA DAM
Ecosystem Restoration Feasibility Study

Appendix A
CIVIL DESIGN

September 2004

Design Appendix

MATILIJA DAM ECOSYSTEM RESTORATION
Feasibility Study
Final Report

1. Introduction

Matilija Dam is located on Matilija Creek in the Los Padres National Forest about 70 miles northwest of Los Angeles and about 5 miles north west of the City of Ojai. Matilija Creek combines with North Fork Matilija Creek about .6 miles downstream of the dam to form the Ventura River which flows about 16 miles to the Pacific Ocean.

1.1 Purpose of project and report

The objective of the Matilija Dam Ecosystem Restoration project is to provide fish passage to the historical spawning areas of Matilija Creek that existed prior to construction of Matilija Dam in 1947. Restoration of the natural shoreline and streambank sedimentation regime, creating greater habitat value to the project site and providing better recreational access to the project site are also project objectives. The focus of the project is on the damsite and reservoir area above the dam, however, downstream areas along Matilija Creek and Ventura River have also been investigated for mitigating adverse impacts caused by the changes in the sedimentation regime. The purpose of this feasibility study appendix is to document engineering data and analysis used in the evaluation of alternatives to identify a recommended plan. Design data and calculations were developed sufficiently to determine the project schedule, cost estimates and economic feasibility of the alternative. The recommended plan provides a base design leading to the development of the construction plans and specifications.

1.2 History of project area

Matilija Dam was constructed in 1946 and 1947 by the Ventura County Flood Control District primarily to provide water supply for agricultural needs and for limited flood control. Since it's completion, the concrete making up the dam has deteriorated due to an alkali-aggregate reaction. A 280-foot-long by 30-foot-deep notch was constructed in 1965 to alleviate concerns about the stability of the dam due to the deteriorated concrete. The notch was widened to 385 feet in 1977. Sedimentation in the reservoir and notching of the dam has resulted in the reduction of the 7,000 acre-feet to 400 acre-feet of storage capacity in 1998.

2. Description of alternatives

The alternatives considered are presented in table 1.

TABLE 1 – DESCRIPTION OF ALTERNATIVES

Alternative	Option	Features
1. Full dam removal, mechanical sediment transport: dispose fines, sell aggregate		Reservoir area materials would be slurried to a disposal site downstream of the Robles Diversion structure. High flow bypass structure at Robles.
2. Full dam removal, natural sediment transport	a. Slurry reservoir area sediments offsite	Reservoir area materials would be slurried to a disposal site downstream of the Robles Diversion Structure. High flow bypass structure at Robles. A desilting basin running parallel to the Casitas Diversion Canal would be constructed
	b. Natural transport of all reservoir basin sediments	High flow bypass structure to be constructed at Robles Diversion.
3. Incremental dam removal, natural sediment transport	a. Slurry reservoir area sediments offsite	Reservoir area materials would be slurried to a disposal site downstream of the Robles Diversion Structure. High flow bypass structure at Robles. A desilting basin running parallel to the Casitas Diversion would be constructed.
	b. Natural transport of all reservoir basin sediments	High flow bypass structure to be constructed at Robles Diversion.
4. Full dam removal, sediment stabilization on site	a. Permanent stabilization of sediments	Reservoir area materials would be slurried to a downstream disposal site. A 60' wide channel would be constructed through project site. High flow bypass structure to be constructed at Robles Diversion.
	b. Temporary stabilization of sediments	Reservoir area materials would be slurried to a downstream disposal site. Rate of erosion would be controlled. High flow bypass structure at Robles Diversion and a 100' wide channel along pre-dam alignment to be constructed

2.1 Alternative 1: Full Dam Removal/Mechanical Sediment Transport: Dispose Fines, Sell Aggregate

In this alternative, roughly 2.1 million cubic yards (mcy) of reservoir area sediments are excavated and transported to an offsite disposal area utilizing slurry. Following removal of the fine sediments, the lake will be drained and the dam removed. Of the remaining 3.8 mcy of sediment, 3.0 mcy of sand and gravel will be sold from the site for use as aggregate and .8 mcy of fines will be trucked to the slurry disposal site. A high flow by-pass will be constructed at the Robles diversion structure. Figure 1 presents a schematic diagram showing the primary components of this alternative.

2.1.1 Streamflow Diversion

The Reservoir area will be dredged; diversion in the Delta and Upstream Channel areas will consist of a training dike to route flows away from the north (left) side where aggregate operations will be set up. Flows downstream of the dam will be maintained by releases through the existing outlets. Temporary channel construction following completion of dredging is discussed below.

2.1.2 Structural Removal

The portion of the dam at the left abutment will be demolished early to improve access to Highway 33. Following dredging of the Reservoir area, the remainder of the structure above the original streambed (approximate elevation 975) will be removed. For purposes of this report, the assumed quantity of in-place concrete is 51,100 cubic yards, and the method of dam removal is as described in the Bureau of Reclamation's April 2000 Appraisal Report. This will be done by controlled blasting, in approximately 15-foot vertical increments.

This alternative assumes that concrete from the dam structure deconstruction will be crushed by the contractor at the site, recycled and sold as aggregate. Metal debris will be hauled from the site and salvaged when possible. Non-salvageable items will be landfilled at the Toland Road landfill, 41 miles away, between Santa Paula and Fillmore. The truck route would be Highway 33 to U.S. 101 to Highway 126.

2.1.3 Earthwork/Sediment Removal

During the slurry operation, the site will be stripped of all vegetation. Areas where arundo is removed from will be treated with Rodeo or a similar herbicide. Arundo will be chipped and temporarily stockpiled. Following completion of work at the disposal area, arundo will be spread to dry at that site. Once dried, the arundo can be removed and used as dried mulch.

Two 12-inch cutter head suction dredges working 24 hours a day, 7 days a week will be utilized to slurry the 2.1 million cubic yards of fine sediment in approximately 9 months. Fresh water from Lake Casitas (4,500 acre-feet) would be used for the slurrying media. The slurry would then pass through a stationary screen to eliminate any coarse material and enter a thickener. The thickener would be used to increase the solids concentration of the slurry and recycle water for the dredging operation. A make-up water pump would be required to pump water back to the dredges. The slurry would then be transported by pipeline to disposal sites located near the Baldwin Road Bridge. A single 400-horsepower pump would be required at the dam to maintain slurry velocity in the pipeline. An 8 mile long fresh water pipeline and pumping system would be needed from Lake Casitas. The fresh water pipeline would be carbon steel and the slurry pipeline would be high density polyethylene (HDPE).

Additionally, a 90,000 gallon water storage tank would be placed at the left abutment to provide surge capacity. The thickener overflow can be fed directly into the storage tank if sufficient elevation difference between the thickener and storage tank is made available.

2.1.4 Fine Sediment Disposal

Fine sediments from the reservoir area will be slurried to four locations in the floodplain of the Ventura River in the vicinity of the Baldwin Road bridge between river mile 12.0 and 9.7.

2.1.5 Sale of Coarse Fraction

This alternative assumes that approximately 3.0 million cubic yards of sand and gravel from the Delta and Upstream Channel areas will be sold for use as aggregate and/or fill. It is assumed that the material can be removed within a ten-year period. Project cost savings are realized since the material will be mined and processed at the site and then trucked directly to the user (i.e., there are no project costs for the trucking). It is assumed that an aggregate producer will pay a fee for every cubic yard sold from the site; however, for planning purposes, no credit for that sale has been taken.

It is estimated that approximately 0.8 million cubic yards of material finer than the number 100 sieve (0.115mm) will remain following extraction of marketable aggregate. This residual material will be stockpiled and transported for disposal at the Baldwin Road bridge disposal site.

A 60-foot wide channel will be excavated through the Delta and Upstream Channel areas. To protect the sand and gravel from erosion during major events, the left bank will be temporarily armored with slope protection (see Figure 2). An 8-foot wide section of soil cement will be placed on a 3H:1V slope. The height of the soil cement will be 13 feet in order to contain a 100-year event. The slope protection would be completely removed and the material recycled at completion of the aggregate operation**.**

2.1.6 Final Clean-up

Following termination of construction activities, including the aggregate mining, all areas will be re-vegetated. Graded areas will be re-vegetated with locally native stock or sterile annual grasses to control erosion. Large rock found in the sediment will be left in the reservoir area to provide a more natural appearance.

2.1.7 Maintenance

Maintenance items will consist of road repairs from damage/wear caused by truck traffic during the 10-year selling period, riprap repairs at downstream slope protection, removal of channel sediment upstream of the Santa Ana Bridge and Arundo removal. Removal of sediment at Robles Diversion Dam was not assumed because additional sedimentation generated by the removal of the dam will be mitigated by the high flow diversion structure to be constructed at Robles.

2.1.8 Real Estate

Disposal sites and a site for the high flow diversion structure at Robles Dam will need to be procured. Right of way for the slurry pipeline of approximately 30 feet will be required. The fresh water pipeline from Lake Casitas to the disposal area would be placed along the existing maintenance road along the CMWD canal from Casitas to Robles. Special considerations would be required at several crossings. Upstream of the disposal area, the fresh water pipe would utilize the same right of way as that required for the slurry pipe.

As a result of the potential for increased flooding downstream, Matilija Hot Springs and 11 other structures in the flood plain would be purchased and removed. Additional right of way would be required for the new/raised levees and flood walls identified above.

2.1.9 Schedule

Following notice to proceed, 24 months would be required for the slurry operations and the dam removal. Concurrent dredging and removal of the dam may be required. As discussed above, sale of the coarse material is assumed to take approximately ten years; completion of the project, including re-vegetation, is assumed to occur 10 years after notice to proceed.

2.2 Alternative 2: Full Dam Removal/Natural Sediment Transport

In this alternative, a quantity of fine sediment is excavated and the dam is fully removed. The remaining sediment is then eroded by storms and naturally transported downstream. In Alternative 2a, the 2.1 million cubic yards in the Reservoir area is excavated and slurried to offsite disposal (see Figures 3 and 4). A high flow sediment by-pass structure will be constructed at the Robles Diversion Dam. In Alternative 2b, a quantity of material immediately behind the dam sufficient to allow safe removal of the dam is excavated and stockpiled upstream. All sediment is then eroded by storms and naturally transported downstream. A desilting basin is included in Alternative 2a to reduce impacts to quantity and quality of water diverted to Lake Casitas.

Differences between Alternatives 2a and 2b are summarized below.

2.2.1 Alternative 2a: Slurry "Reservoir Area" Fines Offsite

2.2.1.1 Streamflow Diversion

In that the excavation of the Reservoir area will be conducted in the wet, no diversion will be made during dredging. Flows downstream of the dam will be maintained by releases through the existing outlets. Following completion of the slurry operation, a pilot channel will be cut through the Delta and Upstream Channel areas. A small cofferdam will be constructed at the upstream extent of the Upstream Channel to direct flows into this channel.

2.2.1.2 Structural Removal

The dam removal is as discussed in Alternative 1. Concrete rubble will be processed after blasting as required for transportation to a commercial concrete recycling plant, assumed to be Hanson Aggregates (approximately 28 miles from Matilija Dam). For estimating purposes, the concrete will be assumed to be processed to a maximum diameter of two feet and all reinforcement, or other embedded metal will be cut flush with the concrete, by torch, as required by the aforementioned recycling plants. The processing of any concrete which remains too large after blasting will be assumed to be performed by a hoe-ram. It should be noted that the contractor may choose to process the material for sale on site. Non-recyclable debris will be sent to Toland Landfill.

2.2.1.3 Earthwork/Sediment Removal

Arundo will be treated as in Alternative 1. To minimize impacts to the diversion operation at Robles Dam, the fine sediment from the Reservoir will be excavated, transported and permanently placed as discussed in Alternative 1. A high flow sediment by-pass is added to reduce diversion losses. A shallow pilot channel will be cut through the Delta and Upstream Channel areas. A small cofferdam would be constructed to direct flows into this channel.

2.2.1.4 Desilting Basin

To reduce the impacts of fine sediment on the diversion canal or quality of the water delivered to Casitas, a sedimentation basin will be constructed on-line with the canal. Conceptually, flows diverted at Robles will fill the basin where the decrease in velocity will result in precipitation of fines. Clean water will be released through the siphon to Casitas Lake.

2.2.1.5 Final Clean-up

After a large percentage of the Delta and Upstream Channel sediments have eroded, the site will be re-vegetated as in Alternative 1. For this alternative it is assumed that the re-vegetation will be completed 7 years after notice to proceed.

2.2.1.6 Maintenance

Maintenance work will consist of repairs to downstream slope protection, channel sediment removal upstream of Santa Ana Bridge and Arundo removal for the life of the project. For the 10-year construction period, 600 cy and 2 cy will need to be removed from the Robles Canal/Fish Screen and Robles Fishway, respectively. The removal of 16,000 cy of material from the desilting basin will take place over a 20 year period. Because of the high flow by-pass at Robles Diversion, the sediment deposited at the Robles Diversion structure for about the first 5 years will be approximately equal to the amount that would be deposited under equilibrium conditions with the dam removed.

2.2.1.7 Real Estate

For the dam and mechanical sediment removal portions of this alternative, real estate requirements are the same as in Alternative 1, as is the need to purchase and remove Matilija Hot Springs and 11 other structures. This alternative (as well as Alternatives 2b, 3a, 3c, and 4b) will require a greater quantity of additional right of way for the new/raised levees and flood walls than will Alternatives 1 and 4, as well as an approximately 20 acre site for the desilting basin.

2.2.1.8 Schedule

It is estimated that this alternative would require approximately 24 months from notice to proceed to remove the fine sediment and the dam. Removal of the remaining sediments will be variable and dependent upon the hydrology; the final phase, re-vegetation, is assumed to be completed 7 years after notice to proceed.

2.2.2 Alternative 2b: Natural Transport of "Reservoir Fines"

2.2.2.1 Streamflow Diversion

A shallow pilot channel will be excavated through the Delta and Upstream Channel sediments. Immediately following removal of the dam, a small cofferdam will be constructed in the Delta area. To reduce turbidity during non-storm flows, low flows will be routed through the Reservoir area to downstream of the dam location through a 36-inch corrugated polyethylene pipe. For stability the pipe will be trenched or otherwise anchored. During a storm event which exceeds the capacity of the cofferdam, erosion of the Reservoir area materials will occur and the pipe will be washed away.

2.2.2.2 Structural Removal

Structural removal is as discussed in Alternative 2a.

2.2.2.3 Earthwork/Sediment Removal

Arundo will be treated as discussed in Alternative 1. Sediment immediately behind the dam is excavated by two barge-mounted clam shell dredges and stockpiled upstream, within the approximate limits shown in Figure 5. The material would be placed on barges and off-loaded in the Delta area using land-based clamshells. The precise quantity sufficient to allow safe removal of the dam is unknown at this time but, due to the nature of the saturated silts and clays is assumed to be 520,000 cubic yards. Assuming that the dredges are working 20 hours per day, the time required to excavate the sediment is nine months. Following removal of the dam, all sediment is then eroded by storms and naturally transported downstream.

2.2.2.4 Final Clean-up

After a large percentage of the Delta and Upstream Channel sediments have eroded, the site will be re-vegetated as in Alternative 1. For this alternative it is assumed that the re-vegetation will be completed 6.5 years after notice to proceed.

2.2.2.5 Maintenance

Maintenance work will consist of repairs to downstream slope protection, channel sediment removal upstream of Santa Ana Bridge and Arundo removal for the life of the project. Because of the high flow by-pass at Robles Diversion, the sediment deposited at the Robles Diversion structure for about the first 5 years will be approximately equal to the amount that would be deposited under equilibrium conditions with the dam removed.

2.2.2.6 Real Estate

Same as Alternative 2a except that the site for the desilting basin is not included in this alternative.

2.2.2.7 Schedule

While removal of the sediments will be variable and dependent upon the hydrology, it is estimated that this alternative would require approximately 6.5 years from notice to proceed to completion.

2.3 Alternative 3. Incremental Dam Removal/Natural Sediment Transport

Alternative 3 is distinguished from Alternative 2 in that the dam demolition process is conducted in two phases. Interruption of demolition allows eroded reservoir sediments to stabilize downstream of the dam and gives the river an opportunity to adjust to sediment inflows. As formulated in this alternative, the dam would be removed in two phases and impacts from sediment downstream of the dam monitored. The second phase of the dam removal may require an interval of several years to allow erosion of a sufficient quantity of the impounded sediments. A high flow sediment by-pass will be constructed at Robles Dam. In Alternative 3a, as in Alternative 2a, a desilting basin will be included in a future revision of this alternative to reduce impacts to quantity and quality of water diverted to Lake Casitas.

Differences between Alternatives 3a and 3b are summarized below.

2.3.1 Alternative 3a: Slurry "Reservoir Area" Fines Offsite

2.3.1.1 Streamflow Diversion

Same as Alternative 2a, except that the shallow pilot channel will be excavated after both removal phases.

2.3.1.2 Structural Removal

As previously discussed, with the exception that the dam would be removed over a longer time period. In the two increment scenario, all downstream structures, except the outlet works, will be removed during the first construction season. The outlet works will be closed after each phase of dam excavation and will remain closed until the reservoir drainage is required for the next increment of dam excavation. The entire dam structure above elevation 1000 would be removed in Phase I (the estimated quantity of concrete is 39,100 cubic yards). The remaining 12,000 cubic yards would be removed in Phase II. Materials will be disposed of as discussed in Alternative 2a.

2.3.1.3 Earthwork/Sediment Removal

Phase I of sediment removal is the same as Alternative 2a. A high flow sediment by-pass is added at Robles to reduce diversion losses. Following a period of storms, assumed to be two years, an additional 25,000 cubic yards will be excavated to allow access to the dam for the second phase of demolition. The material will be stockpiled upstream. This material will be primarily sands and gravels; conventional equipment will be used. Dewatering would be accomplished primarily using sump pumps and the existing outlet.

2.3.1.4 Sediment Basin

See description in Alternative 2a.

2.3.1.5 Final Clean-up

After a large percentage of the Delta and Upstream Channel sediments have eroded, the site will be re-vegetated as in Alternative 1. For this alternative it is assumed that the re-vegetation will occur after 7 years after notice to proceed.

2.3.1.6 Maintenance

Maintenance work will consist of repairs to downstream slope protection, channel sediment removal upstream of Santa Ana Bridge and Arundo removal for the life of the project. For the 10-year construction period, 600 cy and 2 cy will need to be removed from the Robles Canal/Fish Screen and Robles Fishway, respectively. The removal of 16,000 cy of material from the desilting basin will take place over a 20 year period. Because of the high flow by-pass at Robles Diversion, the sediment deposited at the Robles Diversion structure for about the first 5 years will be approximately equal to the amount that would be deposited under equilibrium conditions with the dam removed.

2.3.1.7 Real Estate

See description in Alternative 2a.

2.3.1.8 Schedule

It is estimated that this alternative would require approximately 18 months from notice to proceed to complete the Phase I removal of the fine sediment and the dam. While removal of the remaining sediments will be variable and dependent upon the hydrology, it is assumed here that Phase II will be initiated two years after completion of Phase I. The final phase, re-vegetation, is assumed to be completed 7 years after notice to proceed.

2.3.2 Alternative 3b: Natural Transport of "Reservoir Fines"

2.3.2.1 Streamflow Diversion

Following the Phase I dam removal, streamflow diversion will be the same as Alternative 2b. Following the Phase II dam removal, a shallow pilot channel will be excavated through the remaining sediments.

2.3.2.2 Structural Removal

Same as Alternative 3a except that in Phase I the dam would be lowered only to elevation 1030 and approximately 27,100 cubic yards of concrete removed. In Phase II the dam would be completely removed (an additional 24,000 cubic yards of concrete). Materials will be disposed of as discussed in Alternative 2a.

2.3.2.3 Earthwork/Sediment Removal

Arundo will be treated as discussed in Alternative 1. In Phase I, approximately 300,000 cubic yards of sediment immediately behind the dam is excavated by a barge-mounted clam shell dredge and stockpiled upstream as discussed in Alternative 2b. A high flow sediment by-pass is added at Robles to reduce diversion losses. In Phase II the 320,000 cubic yards would be excavated utilizing a combination of clamshell excavation from the top of the remaining dam and a truck-mounted dragline on the delta.

2.3.2.4 Final Clean-up

At some point, the site will be re-vegetated as in Alternative 1. It is here assumed that re-vegetation will be completed 6.5 years after notice to proceed.

2.3.2.5 Maintenance

See description in Alternative 3a.

2.3.2.6 Real Estate

See description in Alternative 2b.

2.3.2.7 Schedule

It is estimated that this alternative would require approximately 18 months from notice to proceed to completion of Phase I. While removal of the remaining sediments will be variable and dependent upon the hydrology, it is assumed here that Phase II will be initiated two years after completion of Phase I. The final phase, re-vegetation, is assumed to be completed 6.5 years after notice to proceed.

2.4 Alternative 4: Full Dam Removal/Sediment Stabilization on Site

In this alternative, material from the reservoir area would be slurried to a downstream disposal site and a channel would be excavated through the sediments upstream of the reservoir area. The excavated materials would be placed in the reservoir area to form the channel and excess material would be placed in designated locations within the delta and upstream channel areas. In Alternative 4a, these materials would be stabilized and protected in place and in Alternative 4b, these materials would be allowed to erode naturally, but at a rate controlled so as to minimize downstream impacts. A high flow sediment by-pass would be constructed at Robles Dam

2.4.1 Alternative 4a: Permanent Stabilization

2.4.1.1 Streamflow Diversion

During construction, a cofferdam will be constructed upstream of the project area to capture low creek flows and direct them to a 36" corrugated metal pipe which would run on the south side of the project site and discharge back into the stream below the dam.

2.4.1.2 Structural Removal

Same as Alternative 1, except that the structure could be removed over a longer period of time. This alternative will assume that the concrete and reinforcement will be buried in the fill, though the contractor may select to crush and sell it. Metalwork and other debris will be delivered to Toland Landfill.

2.4.1.3 Earthwork/Sediment Removal

All arundo will be treated as previously discussed except that construction at the site will preclude utilizing the upstream area for drying. Following chipping the material will be transported to, spread and dried at the same downstream area assumed in other alternatives for sediment stockpiling.

A channel will be excavated along the southern side of the reservoir basin (i.e. right side, looking downstream). The excavated materials will be placed upstream of the dam along the north side of the reservoir basin, adjacent to the channel. The excavated channel will have a similar streambed elevation to the original pre-dam streambed, though it will be slightly straighter and slightly steeper.

The excavated channel will have a base width of 60 feet. The left side slope will be 3H:1V. Throughout the reservoir, slope protection will not be applied to the right bank. As a result of natural erosion processes, it is expected that this will result in a natural appearance. The channel, including slope protection, will be designed to convey the 100-year recurrence level flood, approximately 21,600 ft^3/sec. Slope protection on the north (left) side of the channel will consist of 4 to 5 ton derrick stone, underlain by appropriately graded stone. The slope protection will extend 11 feet above channel invert and 5 feet below the channel invert to prevent undercutting of the slope. In addition, due to the minimal amount of material not excavated in the channel construction, no riprap will be placed in the canyon from the dam to approximately 300 feet upstream. Figure 6 presents a plan view of the components. Figures 7 and 8 show the typical cross-sections through the Delta and Upstream Channel areas.

Fine materials immediately upstream of the dam will be excavated at slopes as flat as 10H:1V. It is anticipated that these materials will be excavated using a barge-mounted clamshell and then placed in an upstream area and allowed to drain prior to final placement on the north side of the reservoir. In order to reduce displacement, from the downstream end of the Delta area to the beginning of the canyon (approximately 300 feet upstream of the dam face), coarse materials borrowed from the Upstream Channel area will be placed at the toe of the excavated slope to form a foundation for the slope protection. Figure 9 shows the typical cross-section through the Reservoir area.

A meandering low flow channel will establish itself within the 60 foot wide main channel. The 60 foot dimension may increase as the unprotected south side of the channel may erode. Native vegetation such as willows will be allowed to become established within the channel.

2.4.1.4 Maintenance

See description in Alternative 1.

2.4.1.5 Real Estate

As discussed in Alternative 1, except that there is no requirement for the downstream disposal area for sediment disposal. It is assumed that area will be used for approximately one year for drying of the arundo.

2.4.1.6 Final Clean-up

See description in Alternative 1.

2.4.1.7 Schedule

The duration of the project is expected to be 3 years.

2.4.2 Alternative 4b: Temporary Stabilization

2.4.2.1 Streamflow Diversion

In that the excavation of the Reservoir area will be conducted in the wet, no diversion will be made during dredging. Flows downstream of the dam will be maintained by releases through the existing outlets.

2.4.2.2 Structural Removal

As discussed in Alternative 1 except that concrete from the dam will be transported to the commercial concrete recycling plant, Hanson Aggregates.

2.4.2.3 Earthwork/Sediment Removal

The fine sediments of the Reservoir area will be slurried to the downstream disposal area. A channel, approximating the location of the channel prior to construction of the dam, will be excavated through the delta and upstream channel areas. Material excavated from the delta area will be placed in the previously excavated reservoir area to form a channel to have a minimum capacity to convey the 10-year frequency runoff event. The base width and side slopes of the channel are 100 feet and 3H:1V, respectively. Soil cement will be placed along both sides of the channel through the reservoir and delta areas to a height of 7 feet which corresponds to the water surface of the 10-year runoff event. The purpose of the soil cement is to control the rate of erosion and, for flows less than the 10-year runoff event, to avoid degradation of water quality since a percentage of materials in the delta area are composed of fine sediments. Excess material excavated to form the channel through the delta and upstream areas will be distributed between four identified disposal sites within the reservoir area (see figure 9).

2.4.2.4 Final Clean-up

Staged removal of the soil cement will occur as portions of the sediment are eroded from the reservoir basin. The staged removal will be according to the established adaptive management plan. For this alternative it is assumed that the re-vegetation will occur after 20 years after notice to proceed.

2.4.2.5 Maintenance

For the Matilija Reservoir area, approximately 2000cy of material will be graded behind the soil cement revetment for the first 10 years of the post-adaptive management phase. Maintenance of downstream features will be the same as for alternative 2a.

2.4.2.6 Real Estate

See description in Alternative 2a.

2.4.2.7 Schedule

It is estimated that this alternative would require approximately 3 years from notice to proceed to complete the removal of Reservoir area sediment and the dam. While removal of the remaining sediments will be variable and dependent upon the hydrology, it is assumed here that the final phase, re-vegetation, will be completed 20 years after notice to proceed.

3. Downstream Impacts and Mitigation Measures

Downstream impacts will consist of increase in the flood hazard due to the increase in sediment load and a decrease of water quality primarily due to increase of suspended fine materials. The following measures will be taken to mitigate for the increase in flood hazards: Purchase the Matilija Hot Springs facility and structures at Camino Cielo; Reconstruct the Camino Cielo Bridge; Modify the Santa Ana Bridge; Construct a sediment bypass structure at the Robles Diversion Dam; and raise and/or provide new levees/floodwalls at Meiners Oaks, Live Oaks and Casitas Springs. The sediment by-pass structure (120foot long radial gate structure) has been designed by the Bureau of Reclamation. Details are presented in the Hydrology, Hydraulics and Sediment Studies appendix and also in the main report. To mitigate for decrease in water quality, a desilting basin will be constructed at CMWD diversion facilities and two wells will be installed at City of Ventura’s water supply facilities at Foster Park. The discussion regarding downstream impacts and mitigation measures in the following paragraphs of this section was developed during an earlier iteration of this study and applies to all of the alternatives under consideration. More recent studies of impacts for the recommended plan have been performed and are reported in the Hydraulics and Economics Appendices and in the main body of the report.

3.1 Planning Objectives and Constraints

The objective of the overall planning process is to determine the most cost-effective and most environmentally beneficial plan for ecosystem restoration within the study area.
The purpose of the narrowly-focused effort presented herein is to determine the modifications needed to mitigate for increased sediment and/or discharge in the reaches of Matilija Creek and the Ventura River downstream of Matilija Dam in the event of dam removal. As there are a number of potential removal options (presented above), there are also a number of potential mitigation measures needed to ensure that adequate flood and sediment inundation protection is provided to residents of the floodplain downstream of the dam. Because a selected plan must be technically sound, environmentally feasible, and economically effective, the larger study process will focus on numerous other aspects of the potential impacts of project implementation. The focus of this section is solely on offering sound technical solutions to potential increases in sediment and discharge in the downstream channel of each downstream alternative's impacts to flood control.

3.2 Data and Assumptions Used in the Analysis

3.2.1 Mapping

Topographic mapping used in this study was provided in the Corps of Engineers' "Matilija Dam Ecosystem Restoration Feasibility Study F3 Milestone – Baseline Conditions" document (COE, 2002) and on digital mapping provided by the Watershed Protection District.
It is assumed that no significant changes to topography within the study area will occur within the timeframe covered by this analysis. Aside from localized areas of scour and deposition within the channel, no significant changes will occur to either the channel or floodplain.

3.2.2 Aerial Photography

The Ventura County Watershed Protection District provided aerial photography, on which structure locations were based. The photography is recent and was verified by field observation for general accuracy.

3.2.3 Hydrology, Hydraulics, and Sediment Transport

Hydrology, hydraulics, and sediment transport analyses for the "without-project" were performed by the Bureau of Reclamation and provided in the technical appendices to the Corps' F3 Report (COE, 2002). Modeling of the potential "with-project" conditions created by implementation of preliminary alternatives 2b, 1 and 4a was provided by the Bureau of Reclamation (Reclamation, 2003).

3.2.4 Impact of Dam on Flood Discharges

Matilija Dam possesses less than 500 acre-feet of remaining storage. The dam is ungated. The dam currently has no appreciable effect on peak flows from the upper watershed for any large flood events.

3.2.5 Hydrologic Assumptions Used in Modeling

The 50-year period of analysis ("project life") was simulated by the Bureau of Reclamation using the ten-year 1991 to 2001 hydrologic record, repeated five times. The hydrologic record does not include any simulated events of larger than 20-year magnitude (5% exceedance) (Reclamation, 2003).

A "100-year/50% probability" event was used for the 100-year flood event simulation. This event does not imply with any confidence any certainty above 50% that the event will not be larger than the assumed discharge value (Reclamation, 2003).

Flows on Matilija Creek and the Ventura River are less than 10 cubic feet per second between 60% and 80% of the time (COE, 2002).

3.2.6 Hydraulic Assumptions

Data supplied on potential water surface elevations associated with the 100-year event assume that no change in channel geometry or channel roughness will occur during the 50-year project life.

The 100-year floodplain maps included in the Corps' F3 Report (COE, 2002) were used in the assessment for this report. To account for uncertainty in the discharge estimates for the 100-year flood event coincident with the worst-case sediment deposition scenario, three feet of freeboard was applied to all levee heights under the "normal" and "high" levels of design, but was not assumed under the calculated levee heights provided by the Bureau of Reclamation.

3.2.7 Sediment Transport Assumptions

Sediment transport modeling (Reclamation, 2003) only considered sediment greater than .0625 mm in diameter. It appears that suspended sediment load was not included in the analysis. Capacity concentrations were found to be relatively constant throughout the river, except for the following locations:

a) The upstream end and between RM 13 and 14, due to large size capacity decreases.
b) At RM 9 there is a decrease due to the Santa Ana bridge constriction.
c) At Casitas Vista Bridge, due to capacity at 100-year event.

3.2.8 Reservoir Sediments

Reservoir sediment is currently estimated at approximately 82% "fines" (sediment smaller than .0625 mm. in diameter). Reservoir sediments contain approximately 17% sand and <1% gravel. The assumption made in the modeling is that sediment discharged into the downstream channel would match this gradation (COE, 2002).

3.2.9 Suspended Sediment Measurements

Measurement of sediment content in flood flows indicate that 98% of sediment suspended is finer than sand (COE, 2002). Sediment samples taken in this watershed over a ten-year period indicate that 92% of the sediment was transported by only five floods, averaging ten days each.

3.2.10 Bed Materials

In-field observation of bed materials indicates that most fines delivered into the downstream channel are carried through the upper reaches with little deposition. Much of the bed material is extremely coarse, with an average sediment diameter (d50) of >100 mm (4 in) and a maximum (d100) in the upper reach of >2400 mm (8 feet) in diameter. Little sand is observed in the upper reaches, despite its obvious production in the upper watershed.

Lower reaches exhibit a broader distribution of sediment sizes. Production of sediment in interim contributory drainages provides considerable sediment to the system, particularly from tributaries like San Antonio Creek. Bank and bed erosion are also contributory sources throughout the watershed. Regardless, the mean sediment size (d50) at the ocean is still about three inches in diameter (70-80mm), and the average for all reaches (d50) is four inches (100 mm) (COE, 2002).

3.3 Existing Developed Areas by Reach

The Ventura River and Matilija Creek were divided into reaches for analysis. Reaches are numbered high to low, from top to bottom of the watershed. Reaches 7 through 9 lie at or above the dam site and are, therefore, not included in this analysis.

3.3.1 Reach 6 – RM 16.5-15.0

Reach 6 begins immediately downstream of Matilija Dam and extends downstream to the canyon mouth. This reach contains little development except the former “Matilija Hot Springs” facility.

3.3.2 Reach 5 – RM 15-14.15

Reach 5 begins at the canyon mouth and extends downstream to immediately upstream of Robles Diversion Dam. There are approximately 50 structures in Reach 5. All structures appear to be within the 100-year regulatory floodplain.

3.3.2.1 Camino Cielo

There are at least two houses situated along the south bank of the river on the floodplain surface, one upstream and one downstream of the Camino Cielo Bridge. There are nine structures that appear to be primarily vacation cabins, located upstream of the Camino Cielo Bridge on the north bank of the channel. They are located at a variety of elevations, with the highest being some ten feet above the floodplain surface, and at least five of these being less than one foot above the floodplain surface. The canyon is extremely narrow at this point, with a minimum width of 280 feet, and is only a short distance downstream of Matilija Dam. These structures have a considerable risk of inundation, both in the without- and with-project conditions. Numerous structures are located within 50 feet of the channel bank. All but the structures on the high terrace are within the 100-year floodplain.

3.3.2.2 Meiners Oaks Area

There are approximately 20 structures located along Oso Road and North Rice Road between RM 14.4 and 14.15 within Reach 4. (There are additional structures within this community downstream of 14.15, but located in Reach 3.) All of these structures are constructed at grade, with no significant first floor elevation above the floodplain. There is no functional levee. All of these structures are located in the 100-year floodplain.

3.3.3 Reach 4 – RM 14.15 – 7.93

3.3.3.1 Robles Diversion

Robles Diversion Dam is located at the head of Reach 4. It crosses the Ventura River channel and is situated within the 100-year floodplain.

3.3.3.2 Continuation of Meiners Oaks Area

There are also numerous structures located along Oso Road south of 14.15, many of which are situated within the 100-year floodplain. There are additional structures located along Meyer Road. There is a stable, a residence, and appurtenant structures located south of Meyer Road within the 100-year floodplain. All of these structures are constructed at grade, with no significant first floor elevation above the floodplain. There is no functional levee.

3.3.3.3 Live Oak Acres

There are at least fifty residences located on the north bank of the river between RM 10.4 and 9.4. They are currently protected by a small levee approximately three feet high at the upstream end, and a newer five-foot levee and floodwall extending down to Santa Ana Bridge at RM 9.4. The floodwall and levee appear to have been constructed to alleviate backwater conditions caused by large flood flows at the bridge. The levee could potentially be circumvented by flanking either upstream or downstream of the bridge during higher-than-design events.

3.3.4 Reach 3 – RM 7.93-0.6

3.3.4.1 Casitas Springs

There are at least fifty mobile homes in close proximity to the channel at RM 7.85. The channel at this location is less than 10 feet deep and highly choked with vegetation. The entire mobile home park is at risk of flooding. There is no protective levee at this location. There are numerous structures on Ranch Road, Edison Drive, and Sycamore Drive at Casitas Springs. There is a protective levee at this location that does not provide protection in the 100-year flood.

There are at least three residences located on the south bank of the river downstream of Casitas Vista Bridge (~ RM 6.8). Foster Park is located within the 100-year floodplain and is at risk of flooding.

Further downstream, there are residences, a school, the City of Ventura Water Filtration Plant, and a gasoline refinery located on the south side of the channel. These structures are all located within the 100-year floodplain.

3.4 Description of Impacts Caused by Alternatives

Analysis of the preliminary alternatives to-date has consisted of hydrologic, hydraulic, and sediment transport analysis of various removal scenarios (Reclamation, 2003). The preliminary alternatives, and the implications of their implementation, were modeled, and the results are summarized below:

3.4.1 The "No-Action Alternative. This alternative assumes that nothing is done to restore the ecosystem along the Ventura River downstream of its confluence with Matilija Creek, on Matilija Creek downstream of the dam and within the reservoir area, that the dam is not modified from its current configuration, and that no sediment is removed from the reservoir area. The dam and sediments remain in place. Sediment would continue to be removed from the system by deposition within the reservoir area and immediately upstream at a rate averaging 60,000 cubic yards per year for 50 years, with most of the deposition occurring within the next 10 years (Reclamation, 2003). Approximately 2,000 cubic yards of sediment per year is assumed to deposit behind Robles Diversion Dam. This depositional trend would presumably actually be the reverse of that at Matilija as depositional rates at Matilija decline over time. It is anticipated that as sediment storage above the dam is completely filled, sediment yield to the downstream channel will begin to increase, and will eventually return to its "pre-dam" levels. While most fine sediment will be washed through the system, it is anticipated that the sand-sized and larger fraction will deposit at various locations along the downstream channel. This sediment deposition may eventually cause decreases in channel capacity, with an attendant lowering of the level of protection offered by the channel.

3.4.2 Full Dam Removal with Natural Sediment Transport (slurry "Reservoir area" fines offsite – Alternative 2a). This alternative has the dam being removed all at once. Sediment is controlled during removal, with most fines being removed (by either slurry or mechanical means), and all sand and larger particles re-introduced within the reservoir area. Modeling by the Bureau of Reclamation indicates that approximately 1.7 million cubic yards of sediment would be transported from the reservoir area into downstream reaches and the ocean within the first year, given the occurrence of a 100-year flood event. The pre-dam thalweg (centerline) of the upstream channel would be regained the first year. Approximately 56,000 cubic yards of sediment (54,000 cubic yards more than that expected to occur with the dam in place; Reclamation, 2003) would deposit behind Robles Diversion Dam during the first year. Current modeling indicates that significant deposition will occur in the channel between the dam (RM 16.5) through the reach occupied by Robles Diversion Dam (at RM 14.15) and downstream to San Antonio Creek (RM 13) during the 50-year project life or during a single, large flood event. By comparison of altered waters surface elevations, modeling indicates sediment deposition of 6 feet at RM 15.7, 10 feet at RM 15.62, and 6 feet at RM 15.42 downstream of Camino Cielo bridge. It is stated that channel invert elevations will rise an average of approximately 4 feet between RM 14.2 and 13.7. Plots of the increased water surface elevations caused by sediment deposition indicate approximately 6 feet of deposition at RM 14.4, declining to about 1 foot at RM 14.18, increasing downstream to over 12 feet at RM 14.05, declining once again to 4 feet at RM 13.8, increasing once again to 11 feet at

13.53, and then declining to 0 feet at RM 13.43. While some aggradation does occur between RM 13.4 and 10.4, the absence of significant damageable property in close proximity to the channel resulted in no plots of water surface elevations in this reach (Reclamation, 2003). Plots indicate approximately 2 to 3 feet of aggradation between RM 10.4 and 9.6, increasing to slightly more than 4 feet at the bridge at RM 9.38. Plotted increased water surface elevations of slightly less than 5 feet at RM 7.8 extend downstream to over 7 feet at RM 7.1, down to 4 feet at RM 7.0, and average about that much downstream to RM 6.2. Presumably, all of the sediment causing decreases in conveyance capacity is believed to be coarse (sand-sized and larger) in nature, as no apparent difference exists in depositional behavior between Alternatives 2a and 2b. This is despite the presumed content value of the flow of up to 20% sediment (Reclamation, 2003), which would contain between 50 and 82% fines. This condition is considered to be the second most severe alternative for planning purposes of downstream impacts over the 50-year project life time frame.

3.4.3 Full Dam Removal with Natural Sediment Transport (natural transport of "Reservoir fines" – Alternative 2b). This alternative has the dam being removed all at once. Sediment is controlled during removal, but is later subject to immediate erosion by storm and flood events. No control of sediment flow would occur. Modeling by the Bureau of Reclamation indicates that approximately 2.0 million cubic yards of sediment would be transported from the reservoir area into downstream reaches and the ocean within the first year, given the occurrence of a 100-year flood event. The pre-dam thalweg of the upstream channel would be regained the first year. Approximately 68,000 cubic yards of sediment (66,000 cubic yards in excess of that occurring currently) would deposit behind Robles Diversion Dam. As with Alternative 2a, current modeling indicates that significant deposition will occur in the channel between the dam (RM 16.5) and San Antonio Creek (RM 13) during the 50-year project life. Modeling indicates approximate sediment deposition (by comparison of altered water surface elevations) of 6 feet at RM 15.7, 10 feet at RM 15.62, and 6 feet at RM 15.42 downstream of Camino Cielo Bridge. It is stated that channel invert elevations will rise an average of approximately 4 feet between RM 14.2 and 13.7. Plots of the increased water surface elevations caused by sediment deposition indicate approximately 6 feet of deposition at RM 14.4, declining to about 1 foot at RM 14.18, increasing downstream to over 12 feet at RM 14.05, declining once again to 4 feet at RM 13.8, increasing once again to 11 feet at 13.53, and then declining to 0 feet at RM 13.43. While some aggradation does occur between RM 13.4 and 10.4, the absence of significant damageable property in close proximity to the channel resulted in no plots of water surface elevations in this reach. Plots indicate approximately 2 to 3 feet of aggradation between RM 10.4 and 9.6, increasing to slightly more than 4 feet at the bridge at RM 9.38. Plotted increased water surface elevations of slightly less than 5 feet at RM 7.8 extend downstream to over 7 feet at RM 7.1, down to 4 feet at RM 7.0, and average about that much downstream to RM 6.2. Reductions in conveyance capacity in the reach are presumably all related to sediment content within the flow and increased bedload conveyance. This condition is considered to be the worst-case condition for planning purposes of downstream impacts over the 50-year project life time frame.

3.4.4 Incremental Dam Removal with Natural Sediment Transport (slurry "Reservoir area" fines offsite – Alternative 3a). This alternative has the dam being removed in two phases, but as in Alternative 2a, with prior removal of most fines. Sediment is controlled during removal of the dam, but is later subject to immediate erosion by storm and flood events. No control of sediment flow would occur. An amount stated as "less than that of 2a" (Reclamation, 2003) would be transported from the reservoir area into downstream reaches and the ocean within the first year (presumably given the occurrence of a large storm and flood event). The pre-dam thalweg of the upstream channel would be regained, presumably within the first year of the second (and final) notching. Modeling of deposition behind Robles Dam under this scenario is currently yielding unsatisfactory results and no estimate can be made at this time. While no specific modeling of this "Two-Notch" scenario has been conducted at this time, the results of such modeling cannot be considered to be much different from those of Alternatives 2a and 2b for the following reasons:

1) The initial notch will be sufficiently deep to expose sufficient sediment to erosion, which would result in similar downstream sediment transport rates under the same flood event (and occurrence frequency) scenarios as used above.
2) The 1,700,000 cubic yards discharged downstream as stated as the maximum of Alternative 2a would be less than that potentially exposed by the initial notching of Alternative 3a, and there is an excess of sediment available for transport under this scenario.

Therefore, unless a shallow initial notch is created (and not as yet modeled under scenario Alternative 3a) to limit the potential supply of sediment to the downstream channel, the potential sediment supply, and thus degree of aggradation, must be assumed to be similar to that of Alternative 2a.

3.4.5 Incremental Dam Removal with Natural Sediment Transport (natural transport of "Reservoir fines" – Alternative 3b). This alternative has the dam being removed in two phases, but as in Alternative 2b, with no prior removal of fines. Sediment is controlled during removal of the dam, but is later subject to immediate erosion by storm and flood events. No control of sediment flow would occur. An amount stated as "less than that of 2b" (Reclamation, 2003) would be transported from the reservoir area into downstream reaches and the ocean within the first year (presumably given the occurrence of a large storm and flood event). The pre-dam thalweg of the upstream channel would be regained, presumably within the first year of the second (and final) notching. Modeling of deposition behind Robles Dam under this scenario is currently yielding unsatisfactory results and no estimate can be made at this time. While no specific modeling of this "Two-Notch" scenario has been conducted at this time, the results of such modeling cannot be considered to be much different from that of Alternative 2b for the following reasons:

1) The initial notch will be sufficiently deep to expose sufficient sediment to erosion that would result in similar downstream sediment transport rates under the same flood event and occurrence frequency scenarios as used above.
2) The 2,000,000 cubic yards discharged downstream as stated as the maximum of Alternative 2b would be less than that potentially exposed by the initial

notching of Alternative 3b, and there is an excess of sediment available for transport under this scenario.

Therefore, unless a shallow initial notch is created under Alternative 3b to limit the potential supply of sediment to the downstream channel (which cannot be assumed from the modeling results) the potential sediment supply, and thus degree of aggradation, must be assumed to be similar to that of Alternative 2b.

3.4.6 Full Dam Removal with Mechanical Sediment Transport (Alternative 1) or Permanent Sediment Stabilization onsite (Alternative 4a). These alternatives have the dam being removed in a single phase, but only after removal or permanent stabilization of all sediment above and beyond that considered necessary for recontouring of the interior topography and dam site. Presumably, sediment production at the dam site would be anticipated to be no more than that of the pre-dam condition within the reservoir area. All sediment from the upper watershed would now flow unimpeded into downstream channel reaches, except for that small volume perhaps deposited within the channel of the now-restored channel within the former reservoir site. The pre-dam thalweg of the upstream channel would be regained during the final phases of sediment removal. As all sediment would be removed from the reservoir area under this scenario, presumably no more than 2,000 cubic yards of sediment per year (on average) would deposit behind Robles Diversion Dam.

Because of the vast amount of sediment exposed to erosion and possible transport under Alternatives 2a through 3b and 4b and the determination that sediment concentrations by volume may be as much as 20% by volume for up to two years following dam removal, it must be assumed that up to 20% of available capacity could be lost. Thus, at a minimum, it should be considered that 20% of available conveyance capacity would also be lost to sediment conveyance needs throughout the entire channel downstream of the dam at some time during project life.

3.4.7 Full Dam removal with Temporary Sediment Stabilization Upstream (Alternative 4b). Sediment transport modeling for this scenario has not been performed to date. This alternative and effects on downstream areas are most similar to Alternative 2a (Full Dam Removal with Natural Sediment Transport) with the main difference being that there will be more control over the rate of erosion of sediments for Alternative 4b. It is, thus, expected that downstream impacts will be somewhat less severe than for Alternative 2a. For current screening purposes, it is assumed that downstream impacts for Alternative 4b are the same as for Alternative 2a.

3.5 Measures Needed in Downstream Areas to Mitigate Impacts Due to Project Implementation

Modeling performed to date indicates that there are few significant differences between Alternatives 2a, 2b, 3a, 3b, and 4b as currently formulated. Although it is assumed that Alternatives 2a ,3a and 4b have most fines removed from the sediment load issuing downstream, modeling by the Bureau of Reclamation indicates that there is little difference in resultant water surface elevations between those model runs that have "no fines" and those that do. This may be due to the assumption in the modeling that particles only in excess of 1 mm are present. This is clearly not the case in reality. Additionally, if all fines are assumed to transport without deposition through the entire study reach, then there is no contribution of fines to the bedload in movement in excess of “without-project” conditions. Given these constraints in the model and the fact that the modeling results for scenarios 2a, 2b, 3a, 3b, and 4b are so similar, the worst-case scenario resulting from the modeling of Alternative 2b was used to establish potential mitigation measures needed downstream. Plotted water surface elevations resulting from a 100-year flood event were compared for the without-project condition, and also for the “100-year event overlaid on top of the worst-case sediment deposition” condition. The resulting differences between the two were assumed to result wholly from sediment deposition within the cross-section of channel were used to establish potential levee heights needed to mitigate the potential impacts.

In order to also model an adequate range of potential conditions, however, it is necessary to simulate more than one potential sediment condition. It was also assumed that a more extreme case could occur than that yielded in the model runs. This type of event could occur in the presence of debris flow/mudflow activity, in which flows become burdened with sediment in excess of that carried under normal conditions. It may also occur during unusually high discharge from a given frequency storm event, in which case water surface elevations may be higher than projected under 100-year flood conditions. Under these scenarios, with extraordinary conditions, sediment deposition within the downstream channel may exceed that of any normal sediment transport situation. For this reason, a more conservative estimate (greater assumed depth) of sediment deposition was assumed, and levee/floodwall heights were raised accordingly. This recommended level of protection is referred to as the “high” level of protection.

For the purposes of establishing potential mitigation for other alternatives, such as a complete stabilization scenario, or other less impacting alternatives, a smaller event condition was also chosen for analysis. This condition assumes that a more restrictive notch might be used to control sediment discharge into the downstream channel and that sediment deposition might be less than under a worst-case scenario. This is referred to as a “low” level of protection. The following measures are considered necessary to adequately mitigate for increased sediment volumes in the downstream channels resulting from dam removal:

3.5.1 Reach 6 – RM 16.5-15.0

Reach 6 begins immediately downstream of Matilija Dam and extends downstream to the Canyon mouth. This reach contains little development except the former Matilija Hot Springs facility.

The former Matilija Hot Springs facility will be at risk during extremely high flow events, particularly those resulting from debris/mud flow activity. Due to its close proximity to the dam site and channel, the narrowness of the canyon, and the issues related to the volume and proximity of this much sediment, there is no conceivable way of protecting this property under Alternatives 2a, 2b, 3a, 3b, and 4b. It is only realistic to purchase and vacate the property; perhaps set it aside until after the sediment has been evacuated, then make a decision regarding its disposition.

Under Alternatives 1 and 4a (the complete sediment removal or stabilization scenario), sediment and discharge are expected to be the same as in the "No-Action" Alternative. However, in a sediment stabilization scenario, because of uncertainties in sediment behavior once the dam is removed, it is still recommended that this facility be purchased and vacated until such time as the channel system reaches an equilibrium condition in regards to sediment transport and bed elevations.

3.5.2 Reach 5 – RM 15.0-14.15

Reach 5 begins at the canyon mouth and extends downstream to immediately upstream of Robles Diversion Dam.

3.5.2.1 Camino Cielo

There are at least two houses situated along the south bank of the river on the floodplain surface, one upstream and one downstream of the Camino Cielo Bridge. There are nine structures located upstream of the Camino Cielo Bridge on the north bank of the channel. They are located at a variety of elevations, with the highest being some ten feet above the floodplain surface, and at least five of these being less than one foot above the floodplain surface. The canyon is extremely narrow at this point, with a minimum width of 280 feet and is only a short distance downstream of Matilija Dam.

All structures at Camino Cielo have a considerable risk of inundation, both in the without-project condition, and under all alternatives. All structures are currently within the 100-year floodplain. All structures located in the vicinity of the Camino Cielo Bridge are subject to inundation by either floodwater and/or sediment during high flow events. Due to their close proximity to the channel, the narrowness of the canyon, and the lack of sufficient room for flood conveyance, even under a without-project future condition, the area cannot be protected by reasonable means. The location and constricted nature of the Camino Cielo Bridge require its demolition and restoration of the channel cross section. Removal of the bridge and approaches will improve conveyance through this reach and prevent backwater effects, particularly during high sediment-loaded events.

3.5.2.2 Meiners Oaks Area

There are numerous structures located along Oso Road and North Rice Road between RM 14.4 and 14.15 (at Robles Diversion). All of these structures are constructed at grade, with no significant first floor elevation above the floodplain. A levee/floodwall approximately 5,023 feet long, extending from approximately RM 14.4 to 13.45 and tying into high ground at either end would protect these properties. The levee/floodwall would average 5 feet high above the existing bank for high level of protection and 2.8 feet for low level of protection.

3.5.3 Reach 4 – RM 14.15 – 7.93

3.5.3.1 Robles Diversion

Robles Diversion is located at the head of Reach 4. It crosses the channel and is situated within the 100-year floodplain. Under Alternatives 2a, 2b, 3a, 3b, and 4b Robles Diversion Dam will be impacted by sediment-laden flood flows. It is not expected that it

will suffer severe damage by simple inundation. The facility cannot be protected by levees or floodwalls but may be flood/sediment-proofed from significant damage.
For Alternatives 1 and 4a, it can be assumed that sediment transport conditions will be similar to that of the existing condition, and there would be no cost differential.

3.5.3.2 Live Oak Acres

There are at least fifty residences located on the north bank of the river between RM 10.4 and 9.4. They are currently protected by a small levee approximately 3 to 4 feet high at the upstream end and a newer 5-foot levee and floodwall extending down to Santa Ana Bridge at RM 9.4. Under Alternatives 2a, 2b, 3a, 3b, and 4b a levee will function in the upstream portion of this reach, but due to the close proximity of houses to the channel, only a floodwall could adequately protect the downstream-most portion of this site. A levee/floodwall approximately 6512 feet long and averaging 4 and 1 feet high for high and low levels of protection, respectively, would be needed
Replacement of the Santa Ana Bridge is required under all alternatives, with the exception of the "No-Action" Alternative. The bridge is only capable of passing a 100-year discharge under no additional sediment load conditions. Backwater effects under heavy bedload conditions, which may occur in a 25-year or larger flood event, will cause inundation of many properties on the north side of the channel unless surrounded by an unacceptably high floodwall/levee.

3.5.4 Reach 3 – RM 7.93-0.6

3.5.4.1 Casitas Springs

There are at least fifty homes in close proximity to the channel at RM 7.85. A levee at the upper end, with a floodwall adjacent to the mobile home park, and a levee extending downstream from this point, would protect this site. A levee/floodwall approximately 5,260 feet long, and averaging 5 and 2.4 feet for high and low level of protection, respectively, would be needed.

4. Design criteria and assumptions

4.1 Hydraulics

The Bureau of Reclamation of the U.S Department of Interior is providing hydraulic inputs to this study. Hydraulic inputs consist of overflow analyses, sedimentation studies and hydraulic designs. Results of the hydraulic studies, the design criteria and assumptions are presented in the Hydraulics technical appendix.

4.2 Geotech

The Geotechnical Branch of the Army Corps of Engineers and the Ventura County Watershed Protection District through the Bureau of Reclamation provided geotechnical input to this study. The Bureau of Reclamation was responsible for conducting all the drilling, coring, and sample collection to obtain subsurface data and sample material. This responsibility included all regulatory coordination, access road development and addressing all issues associated with placing and operating the barge in the reservoir and drill rigs on land. The Bureau of Reclamation provided the field geologists, prepared logs and documented the exploration and sampling. The Corps of Engineers was responsible for the laboratory processing of samples, site characterization which included grain-size distribution and contamination of sediments, asses uses of sediments, summarizing existing literature on the nature and condition of the concrete in the dam and provide goetech parameters to the various designs.

The Geotech input and assumptions are summarized in the Geotech technical appendix.

5. References

Reclamation, 2003; "Hydrology, Hydraulics and Sediment Studies of Alternatives for the Matilija Dam Ecosystem Restoration Project, Ventura, CA."; U.S. Department of the Interior, U.S. Bureau of Reclamation, draft, March 24, 2003.

COE, 2002; U.S. Army Corps of Engineers, Los Angeles District; "Matilija Dam Ecosystem Restoration Feasibility Study; Baseline Conditions Draft Report (F3) Milestone, August 2002."; US Army Corps of Engineers

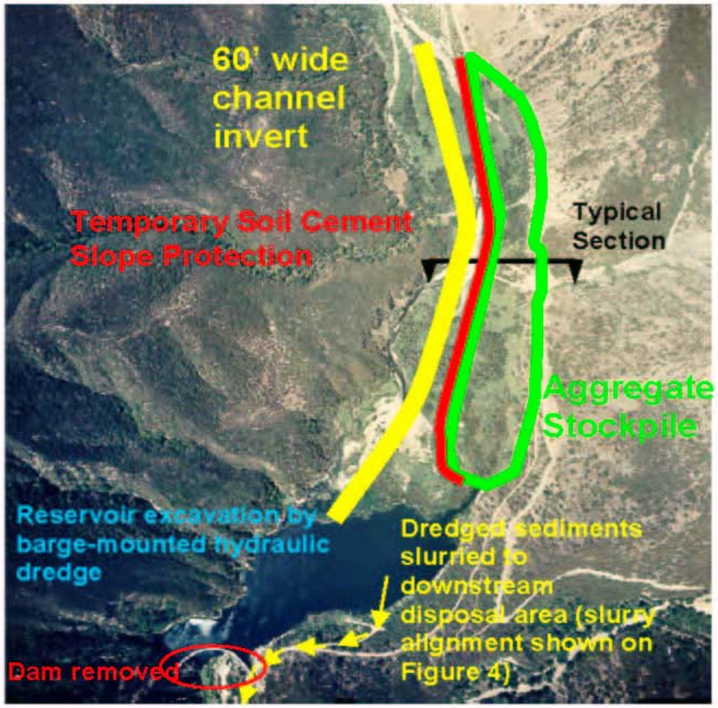


Figure 1: Plan View of Alternative 1 Components

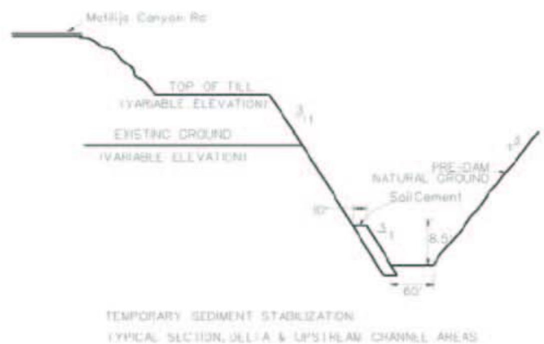


Figure 2: Alternative 1,
Typical Section at stockpile

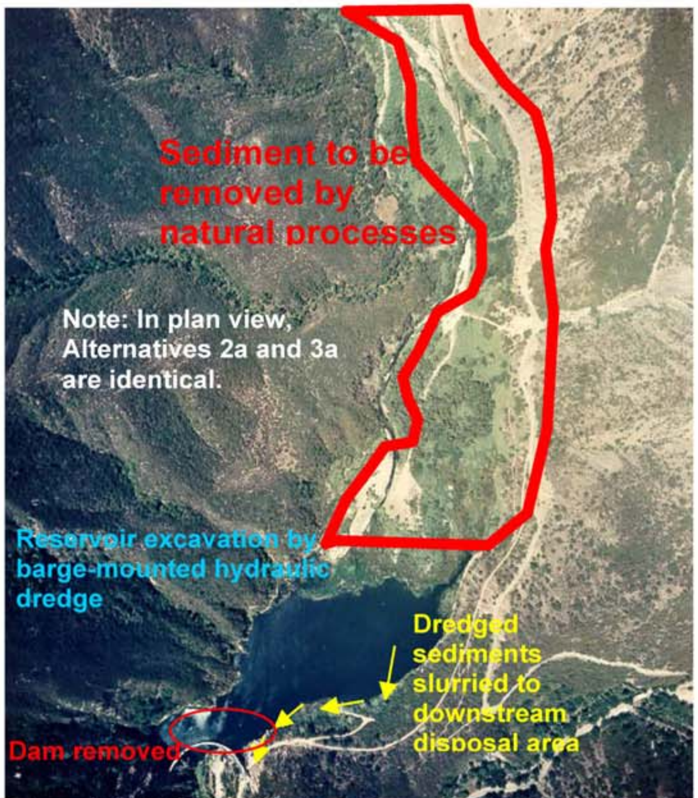


Figure 3: Plan View of Alternatives 2a and 3a Components

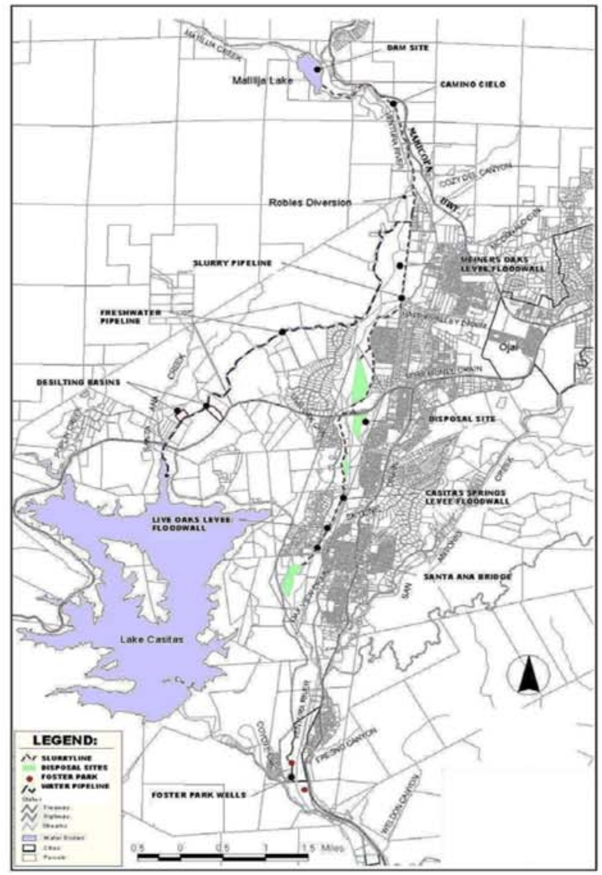


Figure 4: Disposal Area Locations for Alternatives 1, 2a, 3a and 4b

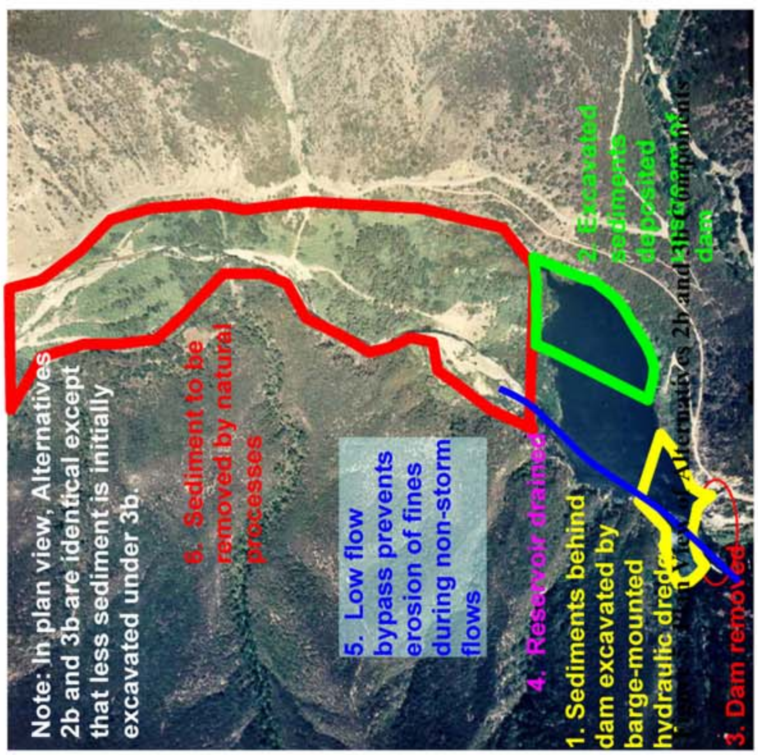


Figure 5: Plan View of Alternatives 2b and 3b Components

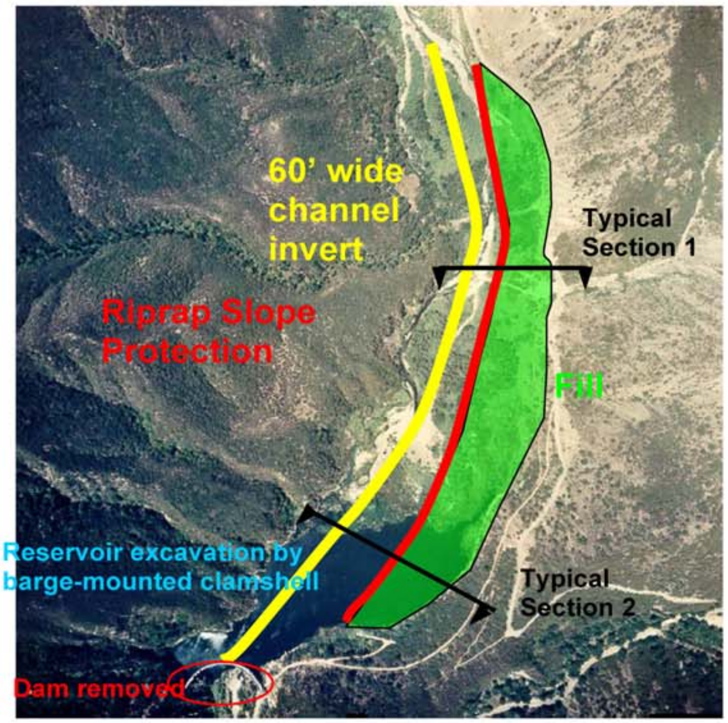


Figure 6: Plan View of Alternatives 4a Components

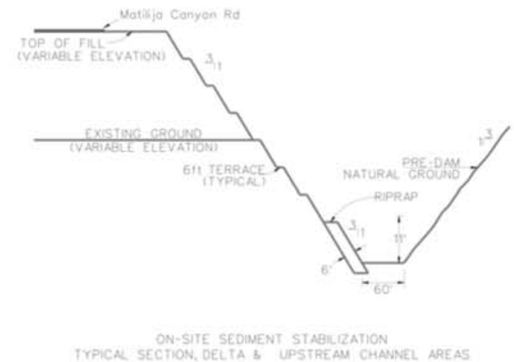


Figure 7: Typical Section 1

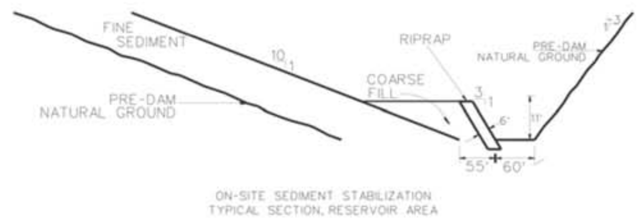


Figure 8: Typical Section 2

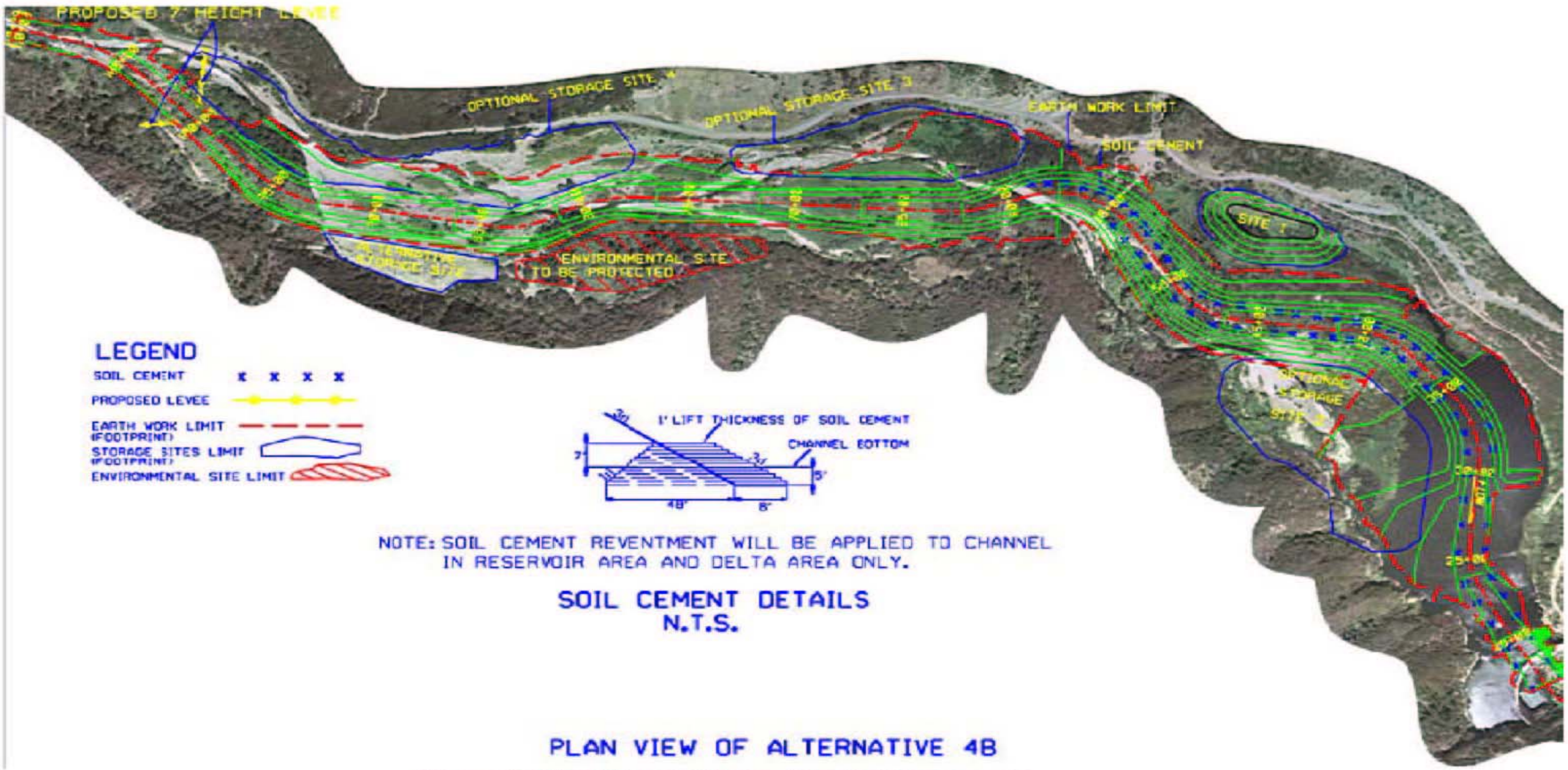
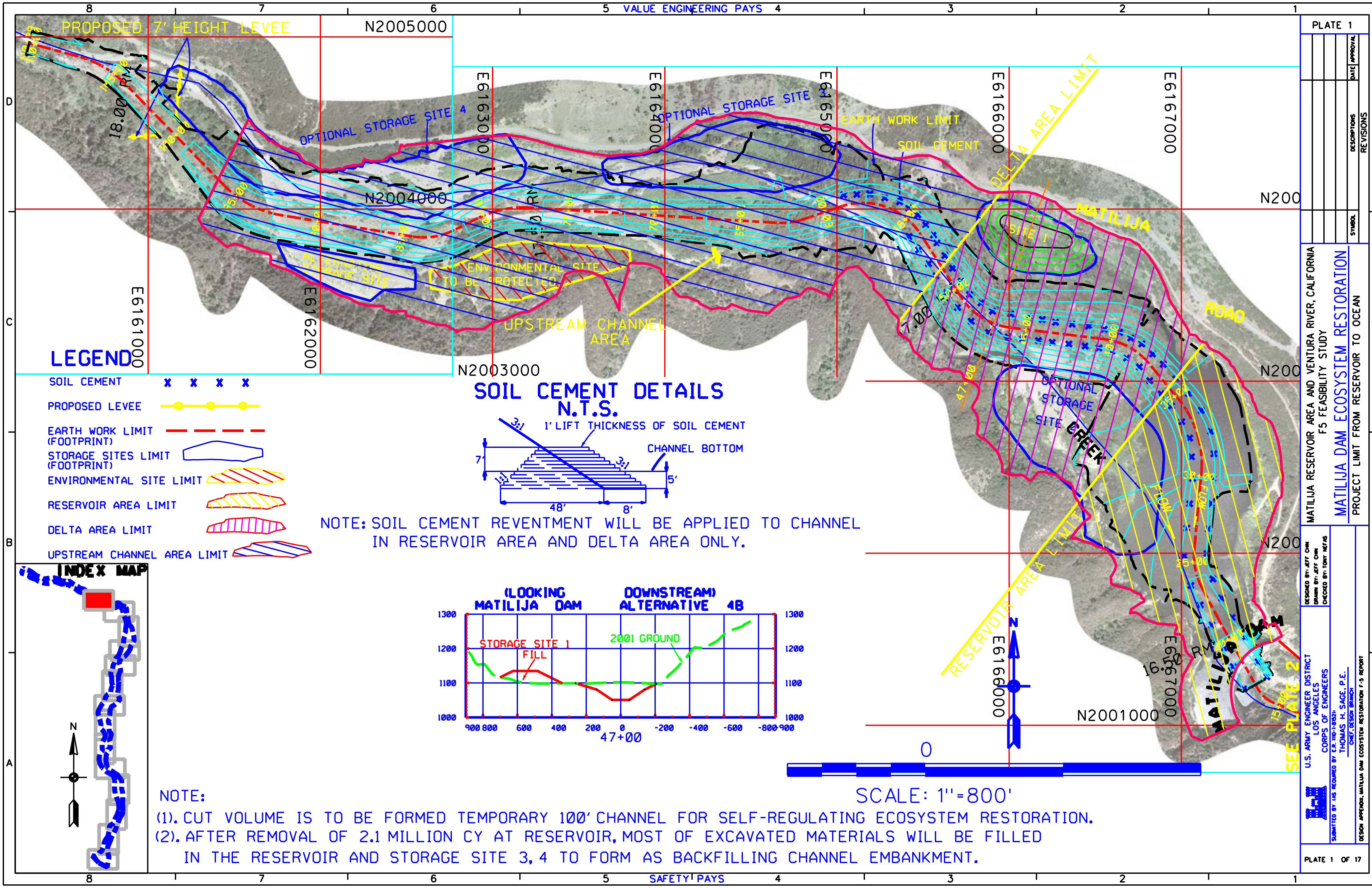


Figure 9: Plan View of Alternative 4b Components



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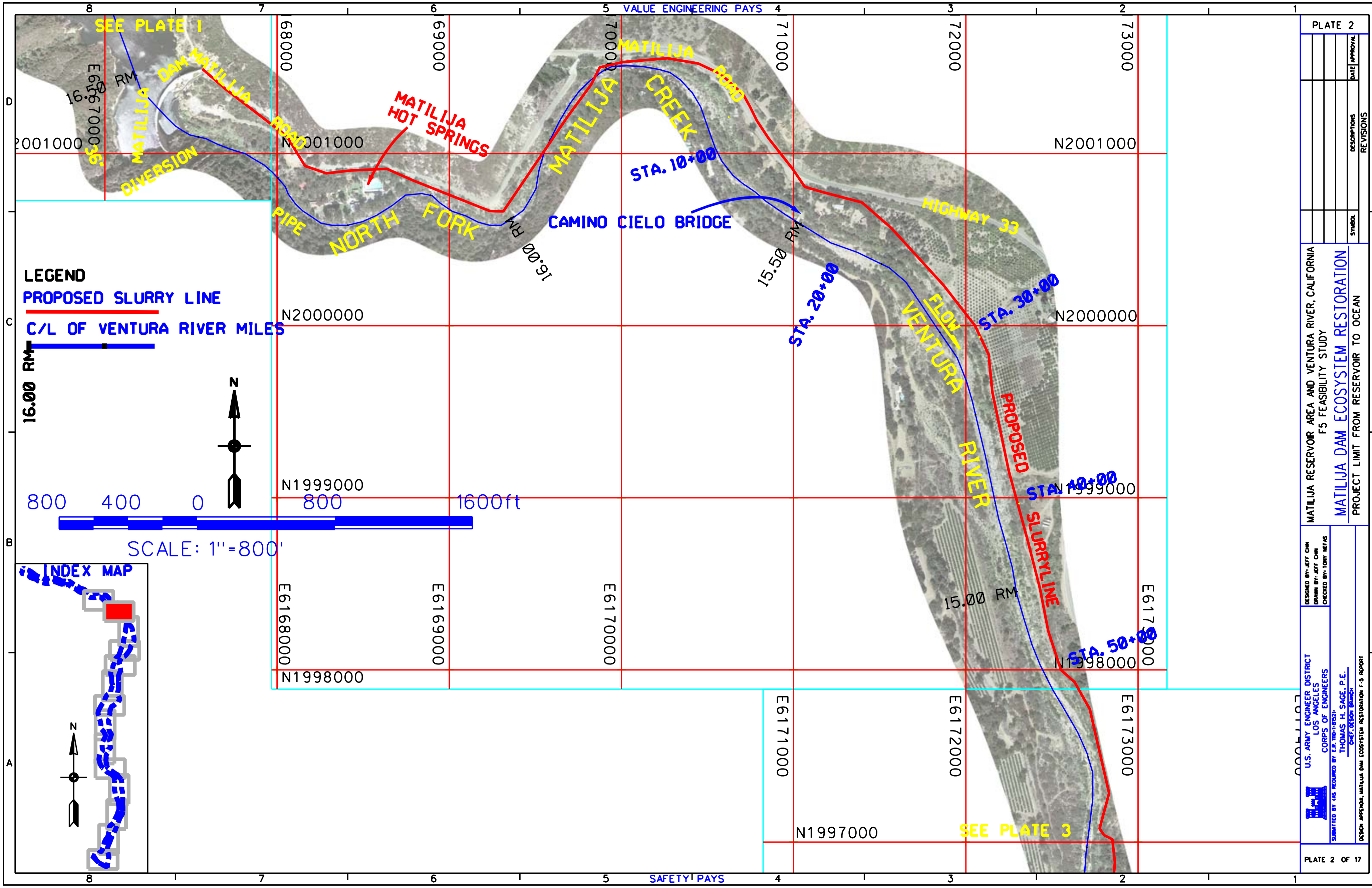

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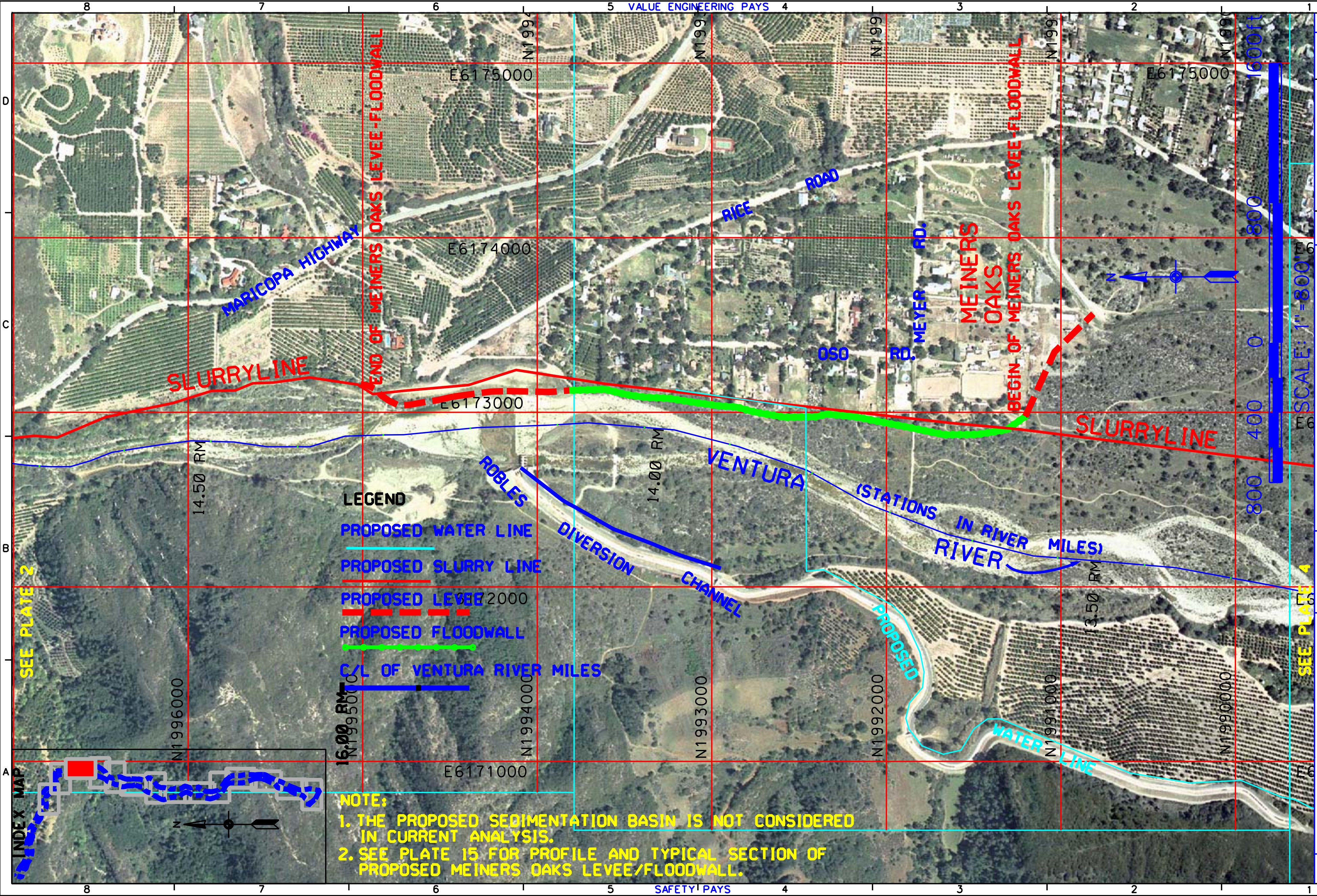


U.S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

SUBMITTED BY IAS REQUIRED BY E.R. 1110-1-8152:
THOMAS H. SAGE, P.E.
CHIEF, DESIGN BRANCH

DESIGN APPENDIX, MATILIJA DAM ECOSYSTEM RESTORATION F-5 REPORT

DESIGNED BY: JEFF CHIN
DRAWN BY: JEFF CHIN
CHECKED BY: TONY MEYAS

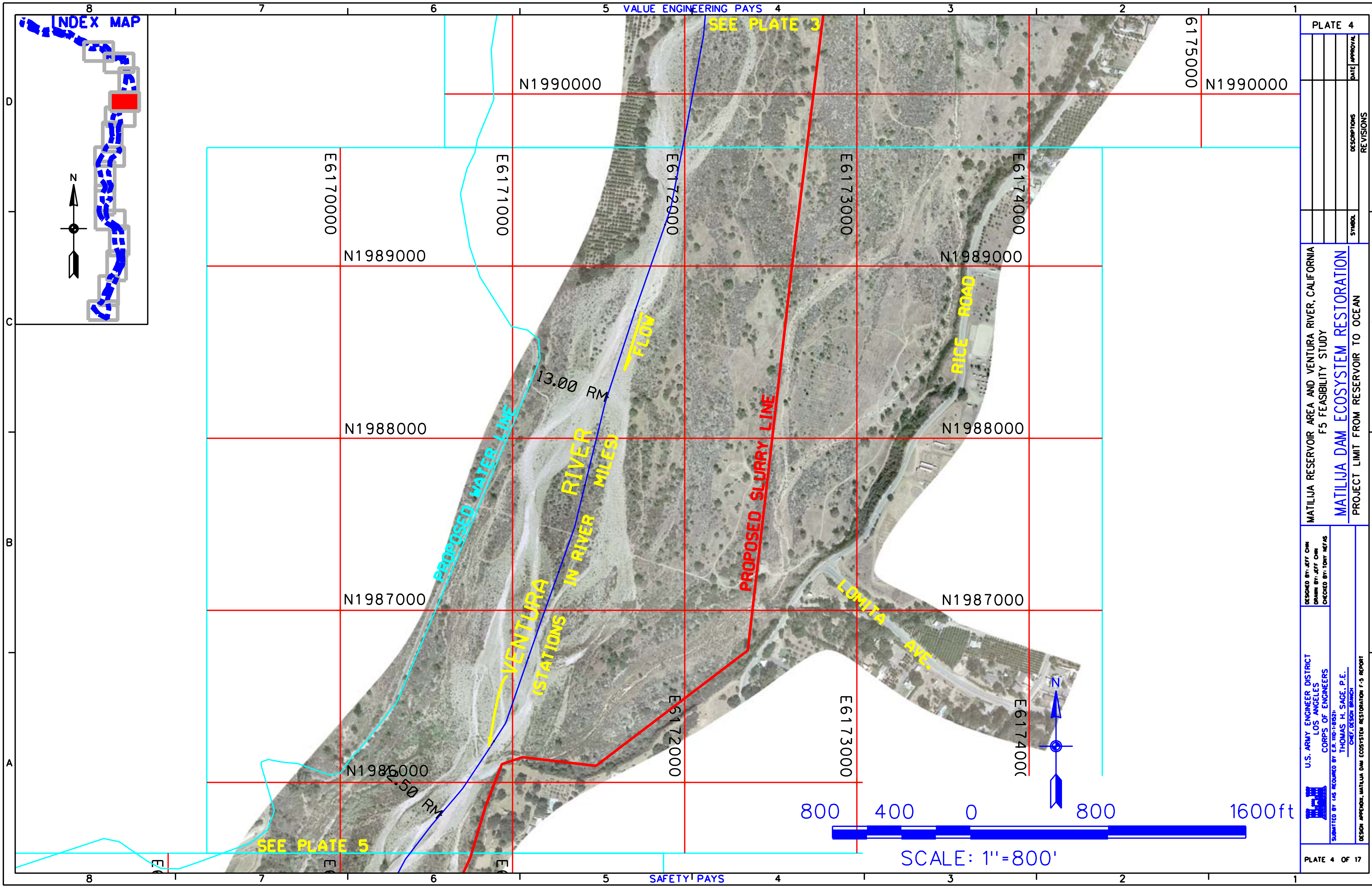
MATILIJA RESERVOIR AREA AND VENTURA RIVER, CALIFORNIA
F5 FEASIBILITY STUDY
MATILIJA DAM ECOSYSTEM RESTORATION
PROJECT STUDY LIMIT FROM RESERVOIR TO OCEAN

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

PLATE 3

PLATE 3 OF 17



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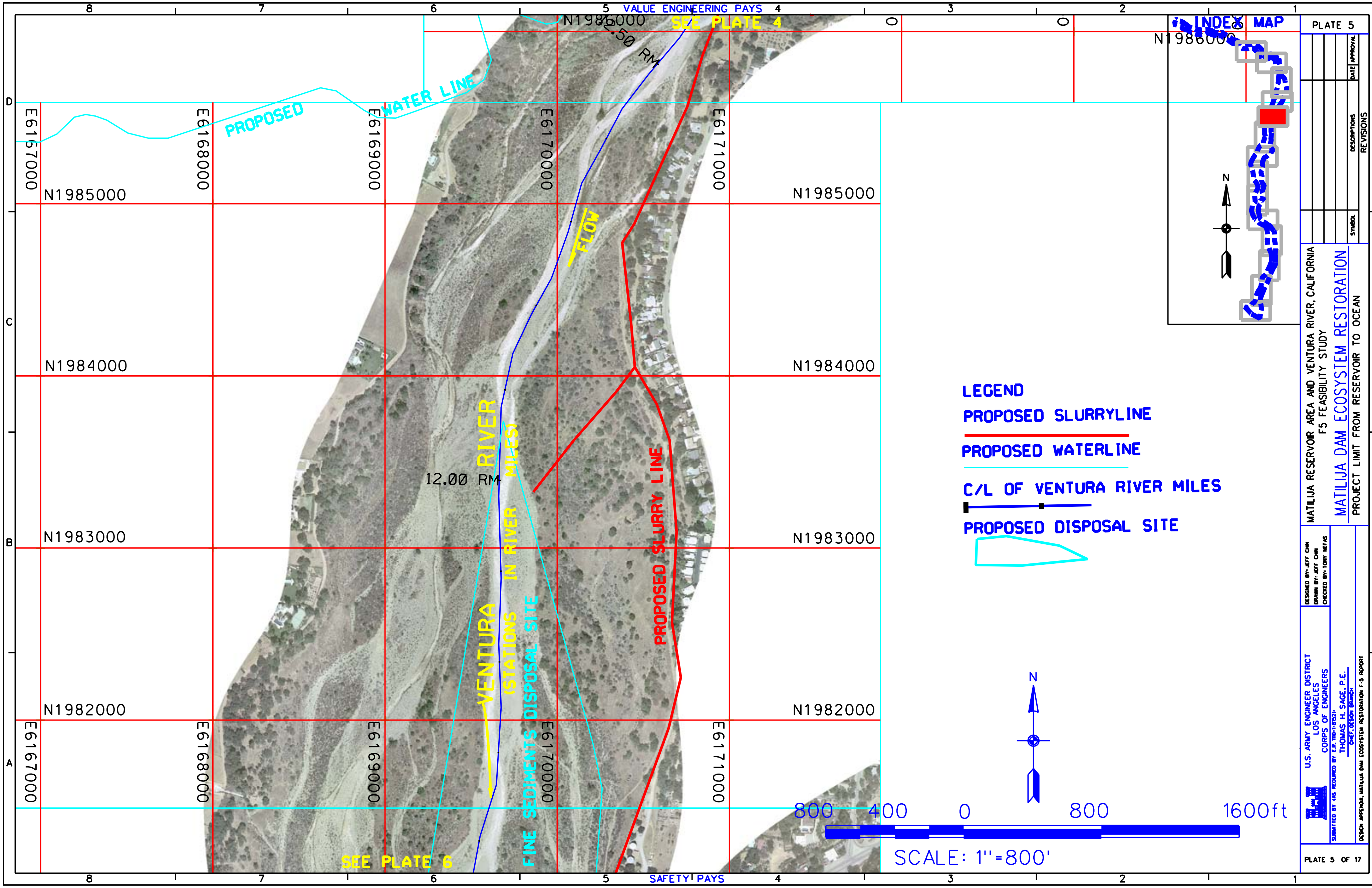

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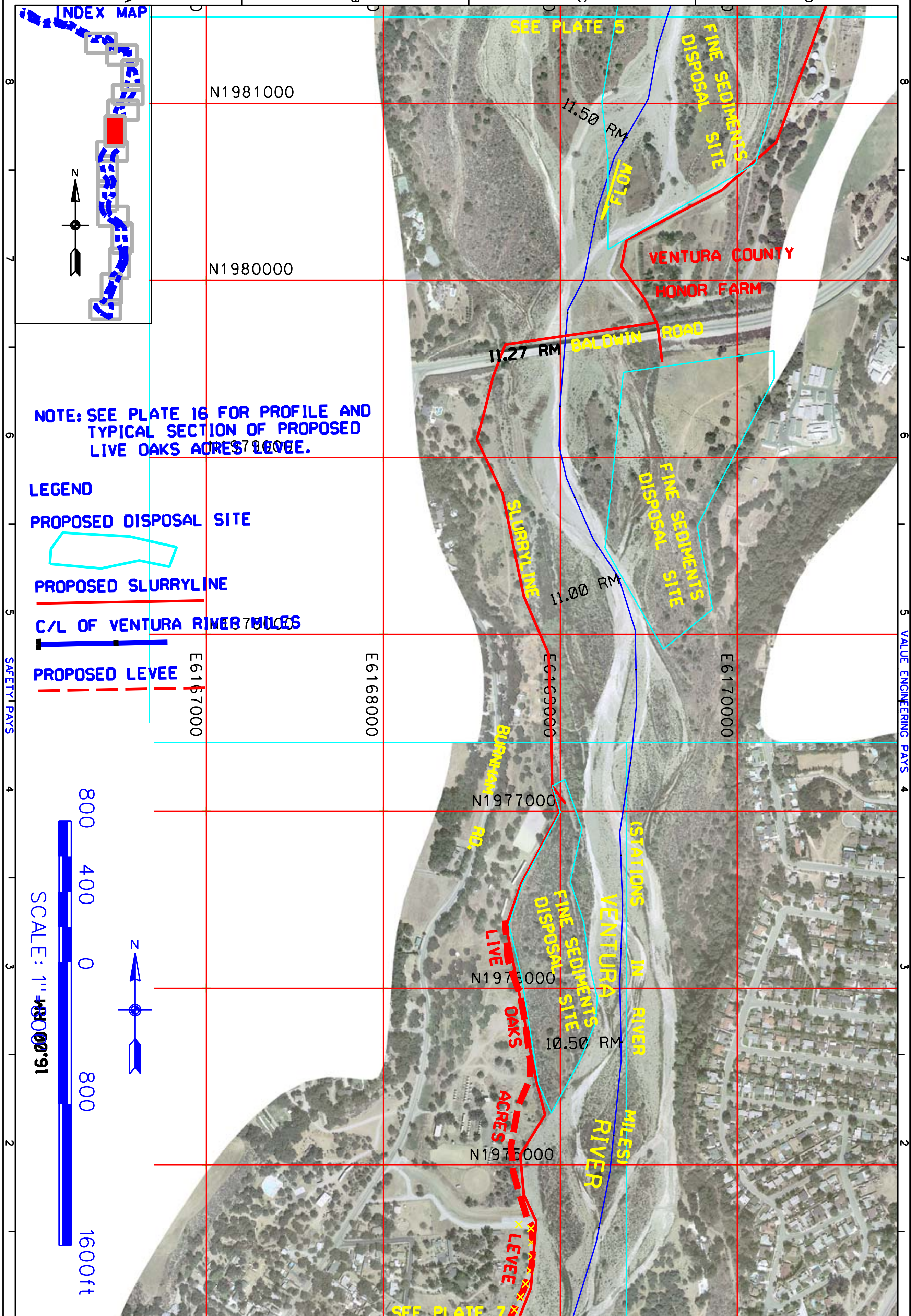

PLATE 6 OF 17

U.S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY: JEFF CHIN
DRAWN BY: JEFF CHIN
CHECKED BY: TONY NEFAS

SUBMITTED BY (AS REQUIRED BY E.R. 1110-1-8152):
THOMAS H. SAGE, P.E.
CHIEF, DESIGN BRANCH

DESIGN APPENDIX, MATILIJA DAM ECOSYSTEM RESTORATION F-5 REPORT

MATILIJA RESERVOIR AREA AND VENTURA RIVER, CALIFORNIA
F5 FEASIBILITY STUDY

MATILIJA DAM ECOSYSTEM RESTORATION

PROJECT LIMIT FROM RESERVOIR TO OCEAN

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

PLATE 6

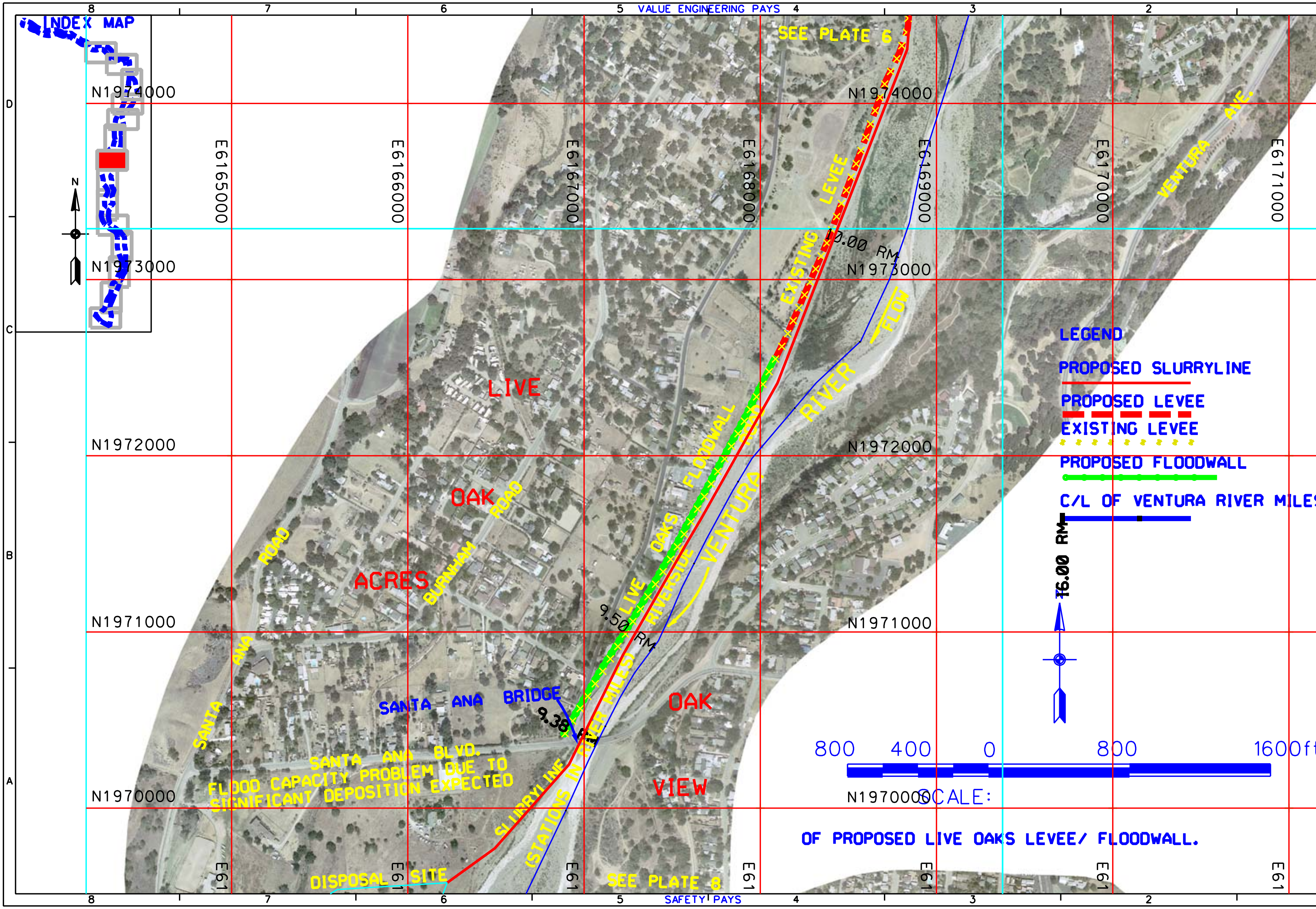

PLATE 7

REVISIONS
DESCRIPTIONS
DATE
APPROVAL
SYMBOL

MATILIJA RESERVOIR AREA AND VENTURA RIVER, CALIFORNIA
F5 FEASIBILITY STUDY

MATILIJA DAM ECOSYSTEM RESTORATION

PROJECT LIMIT FROM RESERVOIR TO OCEAN

DESIGNED BY: JEFF CHIN
DRAWN BY: JEFF CHIN
CHECKED BY: TONY NEFAS

U.S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

SUBMITTED BY (AS REQUIRED BY E.R. 1110-1-8152):
THOMAS H. SAGE, P.E.
CHIEF, DESIGN BRANCH

DESIGN APPENDIX, MATILIJA DAM ECOSYSTEM RESTORATION F-5 REPORT

PLATE 7 OF 17

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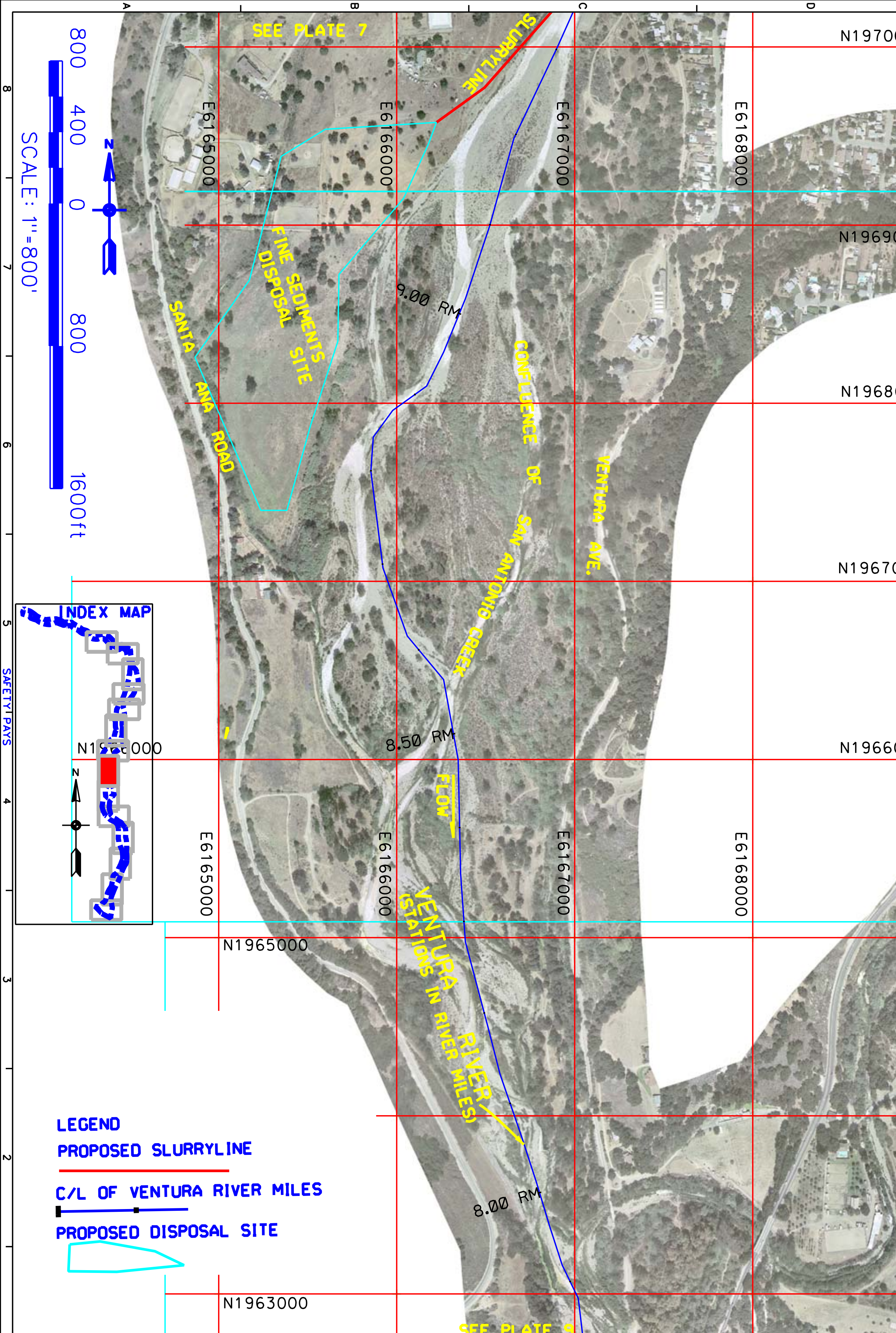

PLATE 8 OF 17

U.S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

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DRAWN BY: JEFF CHIN
CHECKED BY: TONY NEFAS

SUBMITTED BY (AS REQUIRED BY E.R. 1110-1-8152):
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MATILIJA RESERVOIR AREA AND VENTURA RIVER, CALIFORNIA
F5 FEASIBILITY STUDY

MATILIJA DAM ECOSYSTEM RESTORATION

PROJECT LIMIT FROM RESERVOIR TO OCEAN

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

PLATE 8

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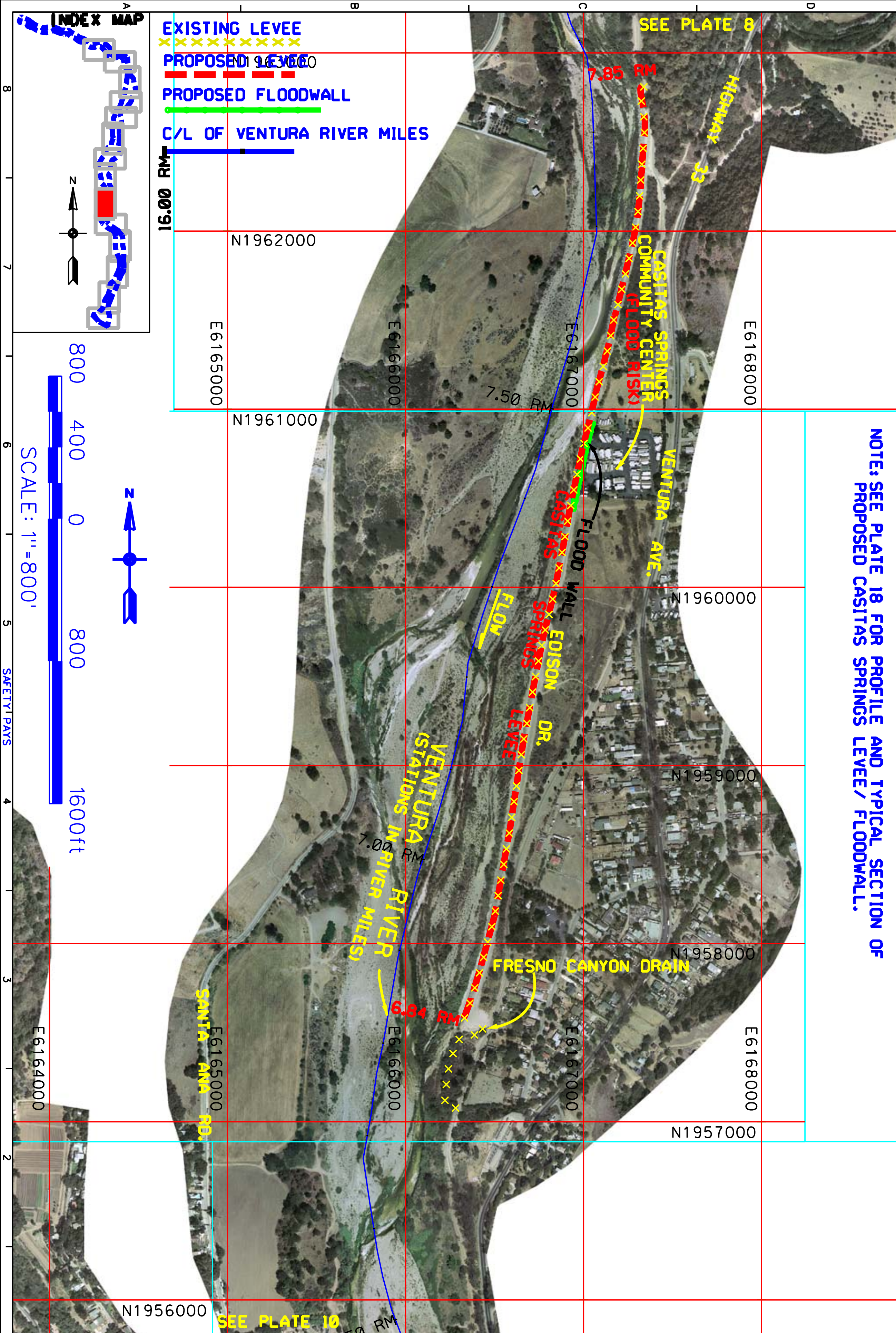

PLATE 9 OF 17

U.S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY: JEFF CHIN
DRAWN BY: JEFF CHIN
CHECKED BY: TONY NEFAS

SUBMITTED BY (AS REQUIRED BY E.R. 1110-1-8152):
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F5 FEASIBILITY STUDY

MATILIJA DAM ECOSYSTEM RESTORATION

PROJECT LIMIT FROM RESERVOIR TO OCEAN

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

PLATE 9

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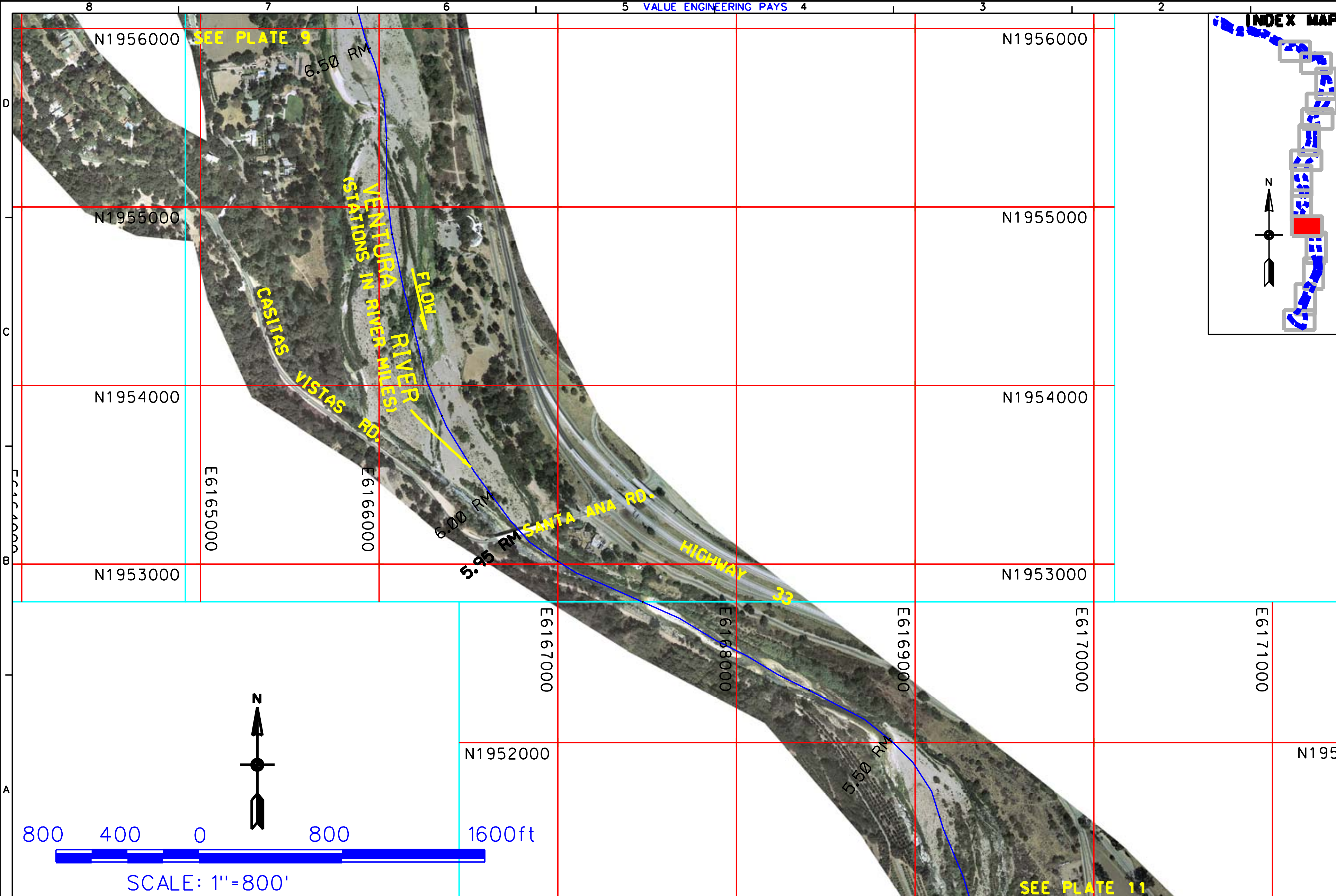

PLATE 10

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

MATILIJA RESERVOIR AREA AND VENTURA RIVER, CALIFORNIA
F5 FEASIBILITY STUDY

MATILIJA DAM ECOSYSTEM RESTORATION

PROJECT LIMIT FROM RESERVOIR TO OCEAN

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U.S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

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CHIEF, DESIGN BRANCH

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PLATE 10 OF 17

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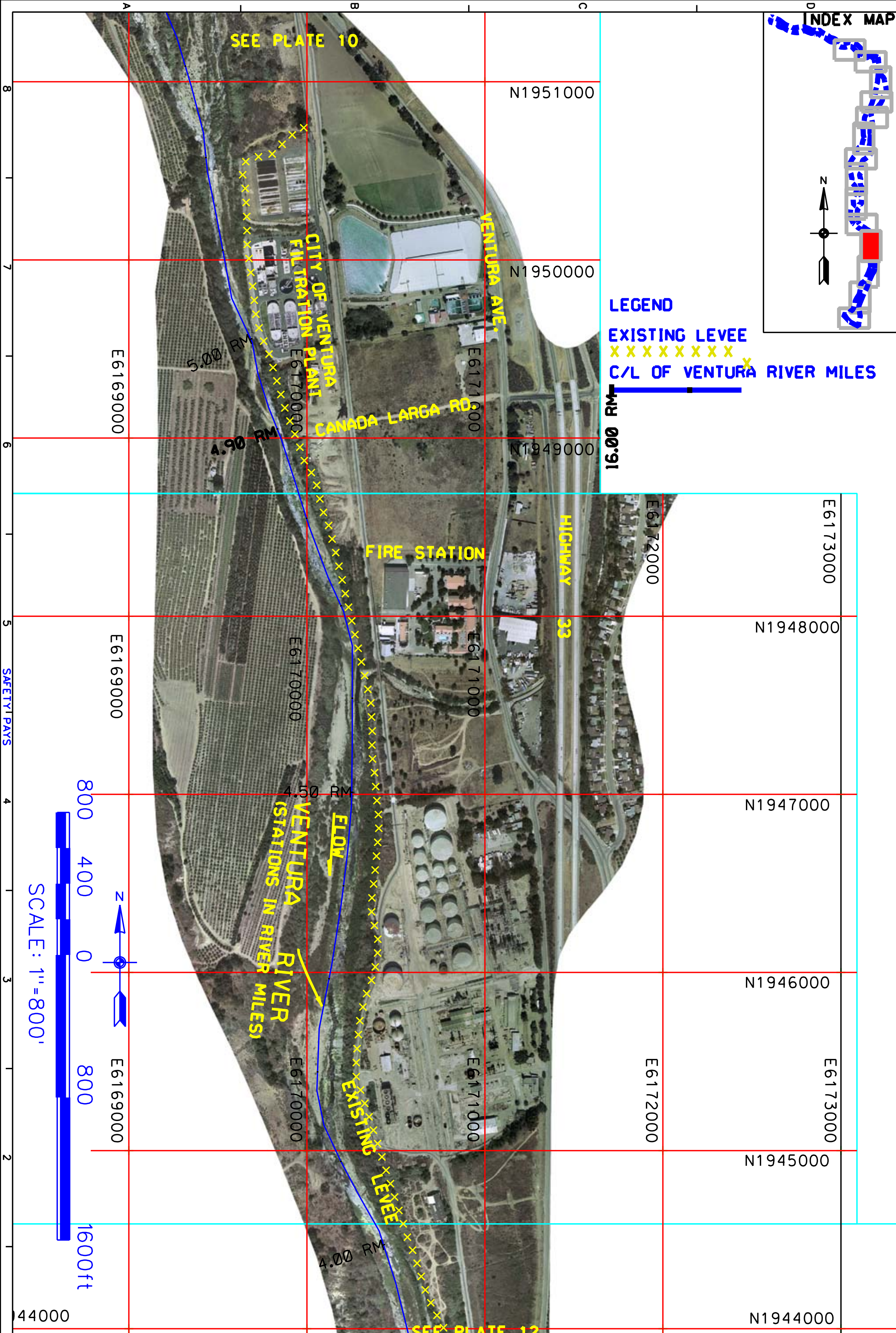

PLATE 11 OF 17

U.S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

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THOMAS H. SAGE, P.E.
CHIEF, DESIGN BRANCH

DESIGNED BY: JEFF CHIN
DRAWN BY: JEFF CHIN
CHECKED BY: TONY NEFAS

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F5 FEASIBILITY STUDY

MATILIJA DAM ECOSYSTEM RESTORATION

PROJECT LIMIT FROM RESERVOIR TO OCEAN

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

PLATE 11

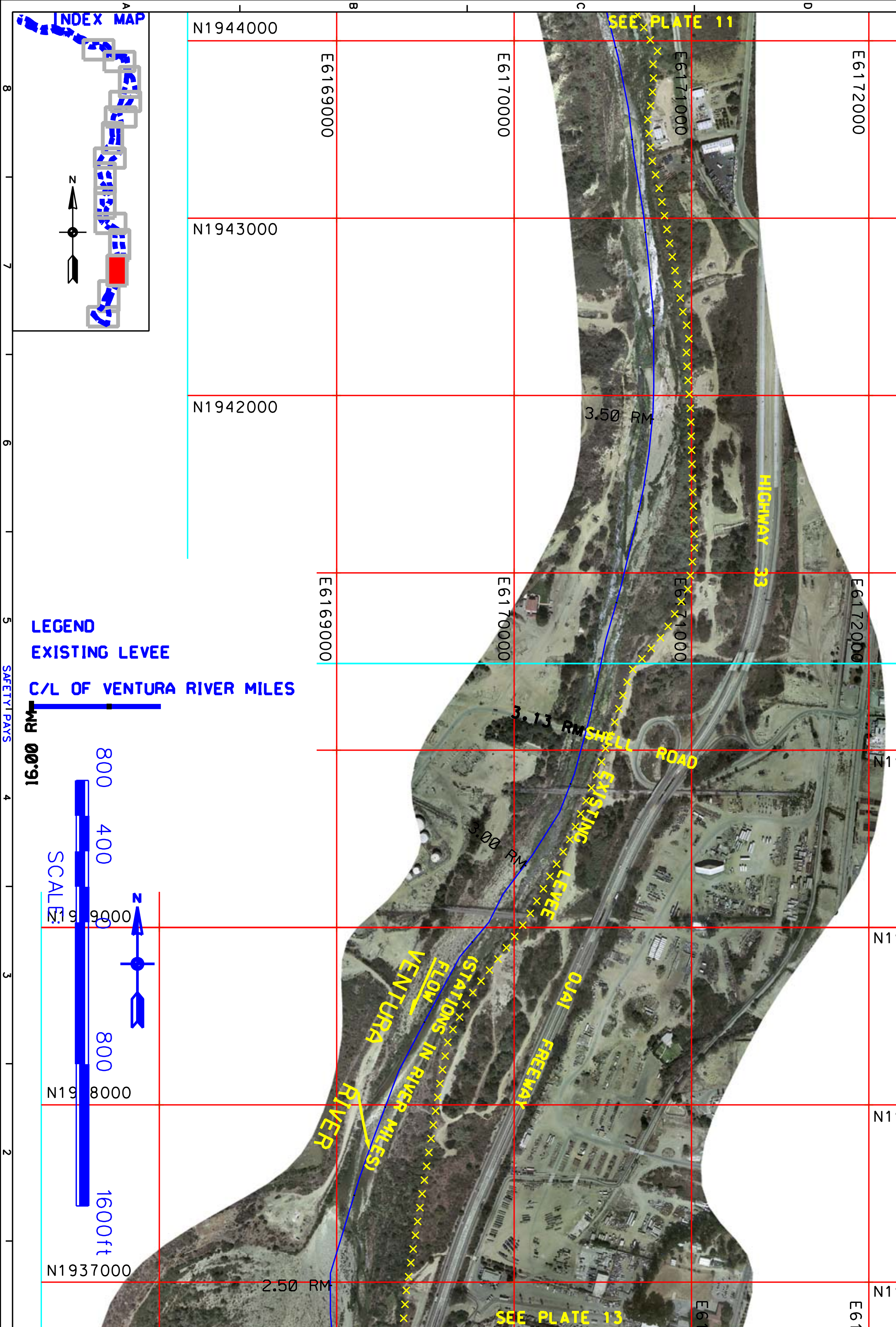

PLATE 12 OF 17

U.S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY: JEFF CHIN
DRAWN BY: JEFF CHIN
CHECKED BY: TONY NEFAS

SUBMITTED BY (AS REQUIRED BY E.R. 1110-1-8152):
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F5 FEASIBILITY STUDY

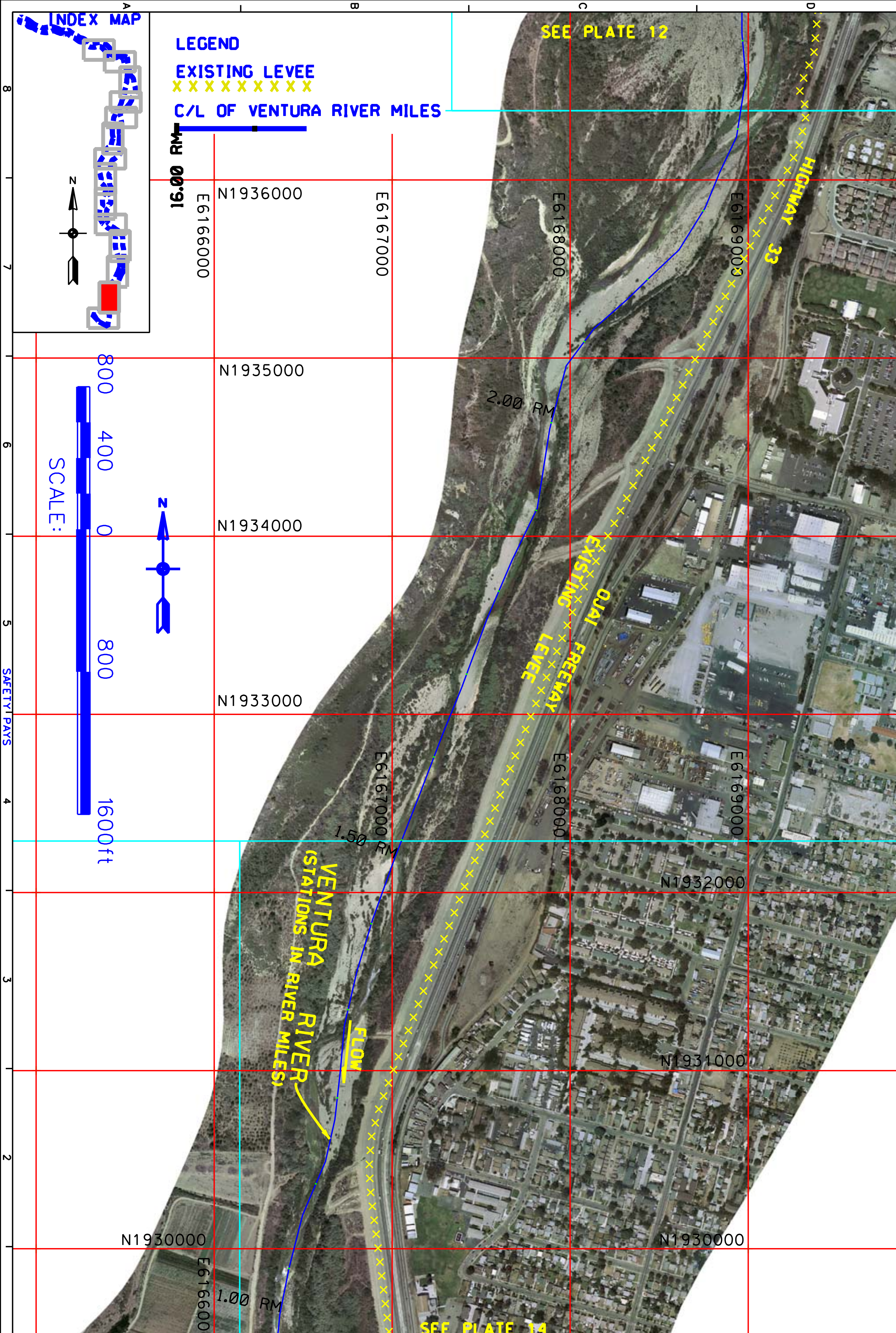
MATILIJA DAM ECOSYSTEM RESTORATION

PROJECT LIMIT FROM RESERVOIR TO OCEAN

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

PLATE 12



U.S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

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F5 FEASIBILITY STUDY

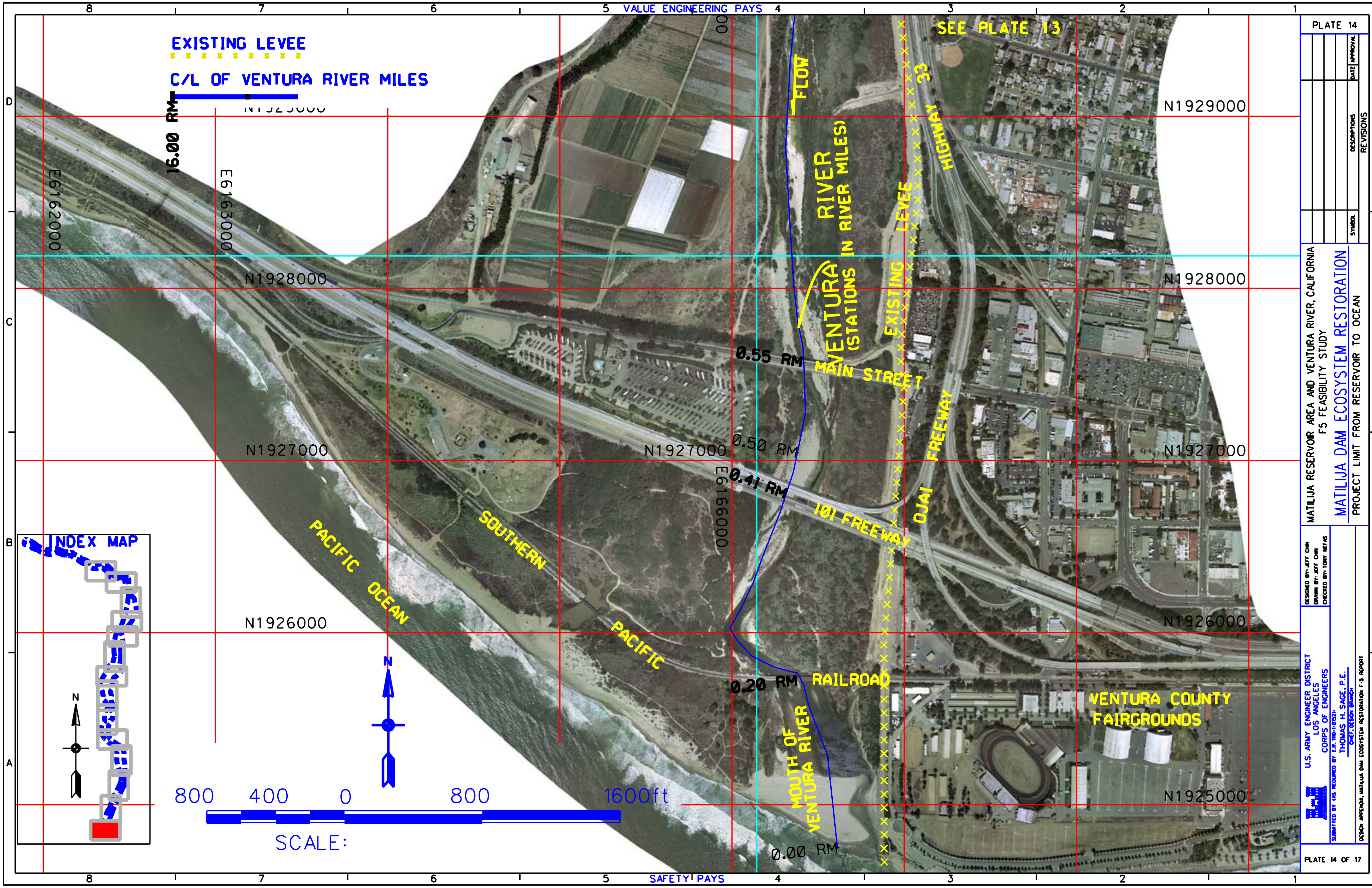
MATILIJA DAM ECOSYSTEM RESTORATION

PROJECT LIMIT FROM RESERVOIR TO OCEAN

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

PLATE 13



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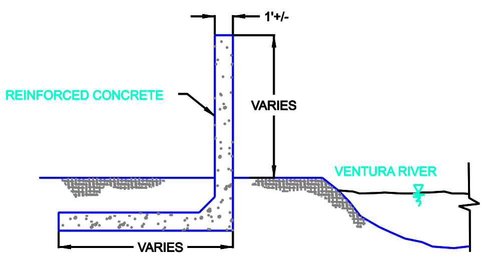
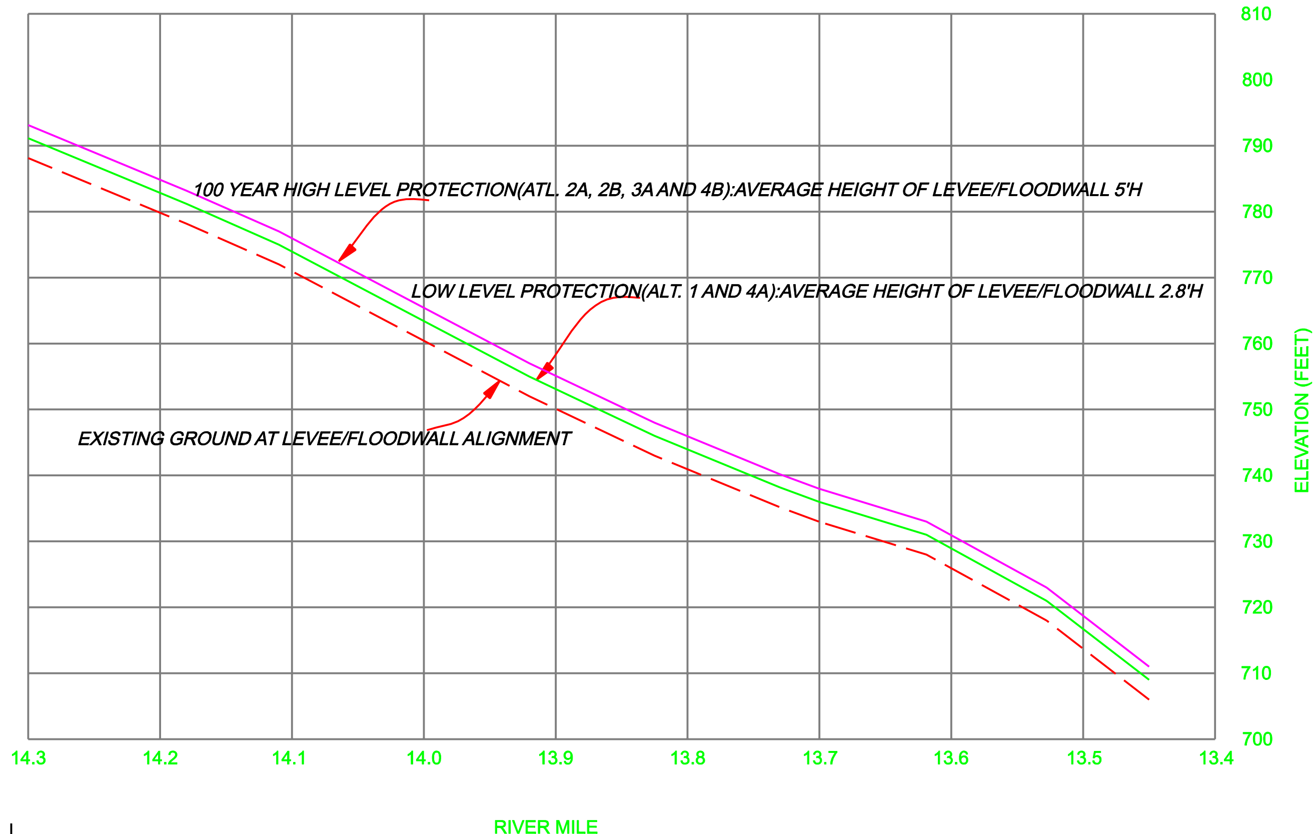
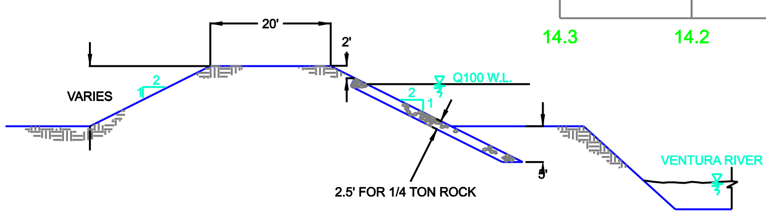


(LOOKING DOWNSTREAM)
TYPICAL SECTION OF FLOODWALL
N.T.S.

PROFILE OF LEVEE/FLOODWALL AT MEINERS OAKS





NEW LEVEE
N.T.S.
(LOOKING DOWNSTREAM)

SCALES: 1" = 0.10 MILE (HORIZ.)
1" = 20 FEET (VERT.)

U.S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

SUBMITTED BY (AS REQUIRED BY E.R. 1110-1-8152):
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CHIEF, DESIGN BRANCH

DESIGNED BY: JEFF CHIN
DRAWN BY: JEFF CHIN
CHECKED BY: TONY NEFAS

MATILIJA RESERVOIR AREA AND VENTURA RIVER, CALIFORNIA
F5 FEASIBILITY STUDY

MATILIJA DAM ECOSYSTEM RESTORATION
PROFILE OF LEVEE/FLOODWALL AT MEINERS OAKS

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

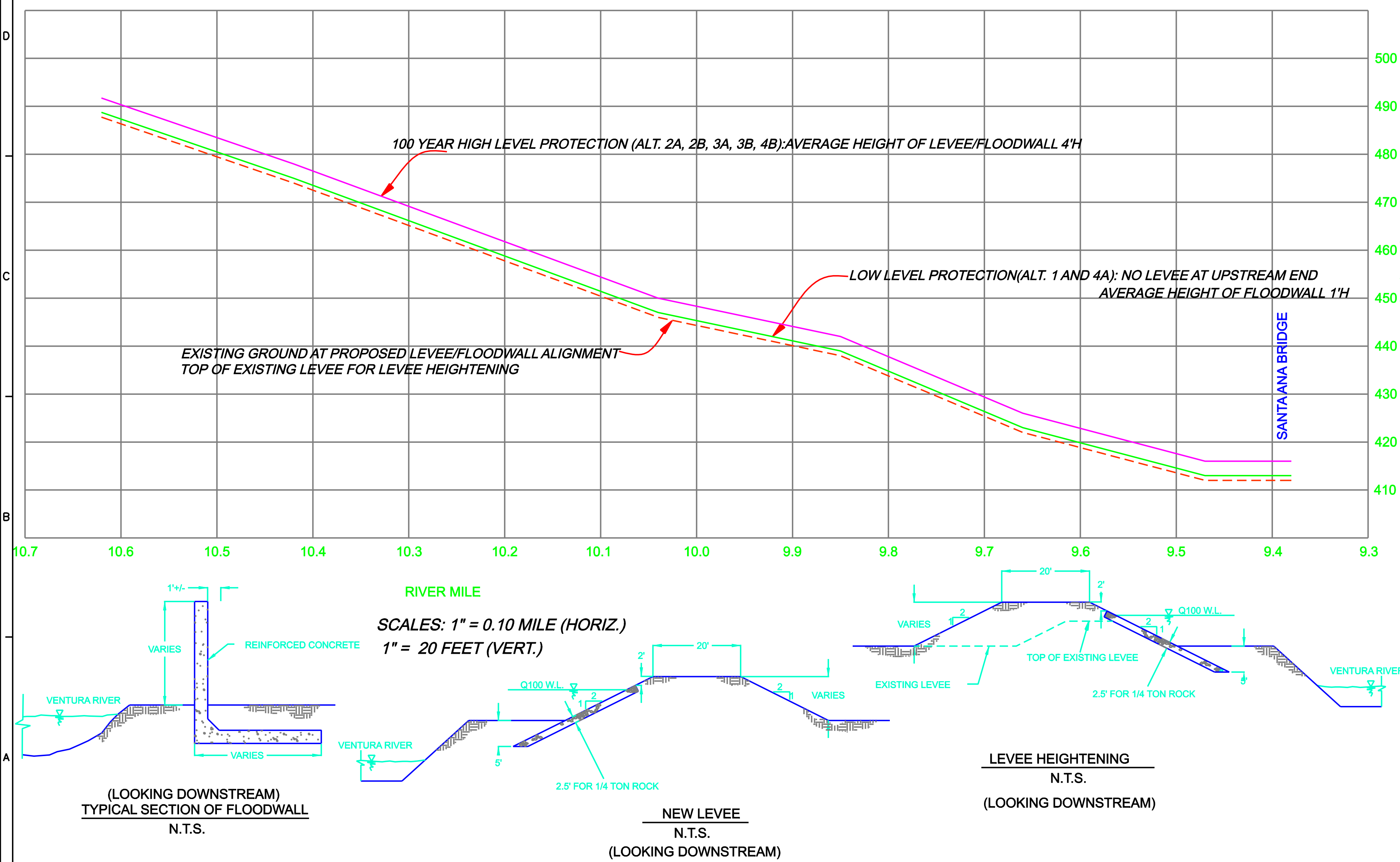
REVISIONS

PLATE 16

DESIGN APPENDIX, MATILIJA DAM ECOSYSTEM RESTORATION F-5 REPORT

PLATE 15 OF 17

PROFILE OF LEVEE/FLOODWALL AT LIVE OAK ACRES



VALUE ENGINEERING PAYS

SAFETY PAYS

U.S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

SUBMITTED BY (AS REQUIRED BY E.R. 1110-1-8152):
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CHIEF, DESIGN BRANCH

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DRAWN BY: JEFF CHIN
CHECKED BY: TONY NEFAS

MATILIJA RESERVOIR AREA AND VENTURA RIVER, CALIFORNIA
F5 FEASIBILITY STUDY

MATILIJA DAM ECOSYSTEM RESTORATION

PROFILE OF LEVEE/FLOODWALL AT LIVE OAK ACRES

DESIGN APPENDIX, MATILIJA DAM ECOSYSTEM RESTORATION F-5 REPORT

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

PLATE 17

PLATE 16 OF 17

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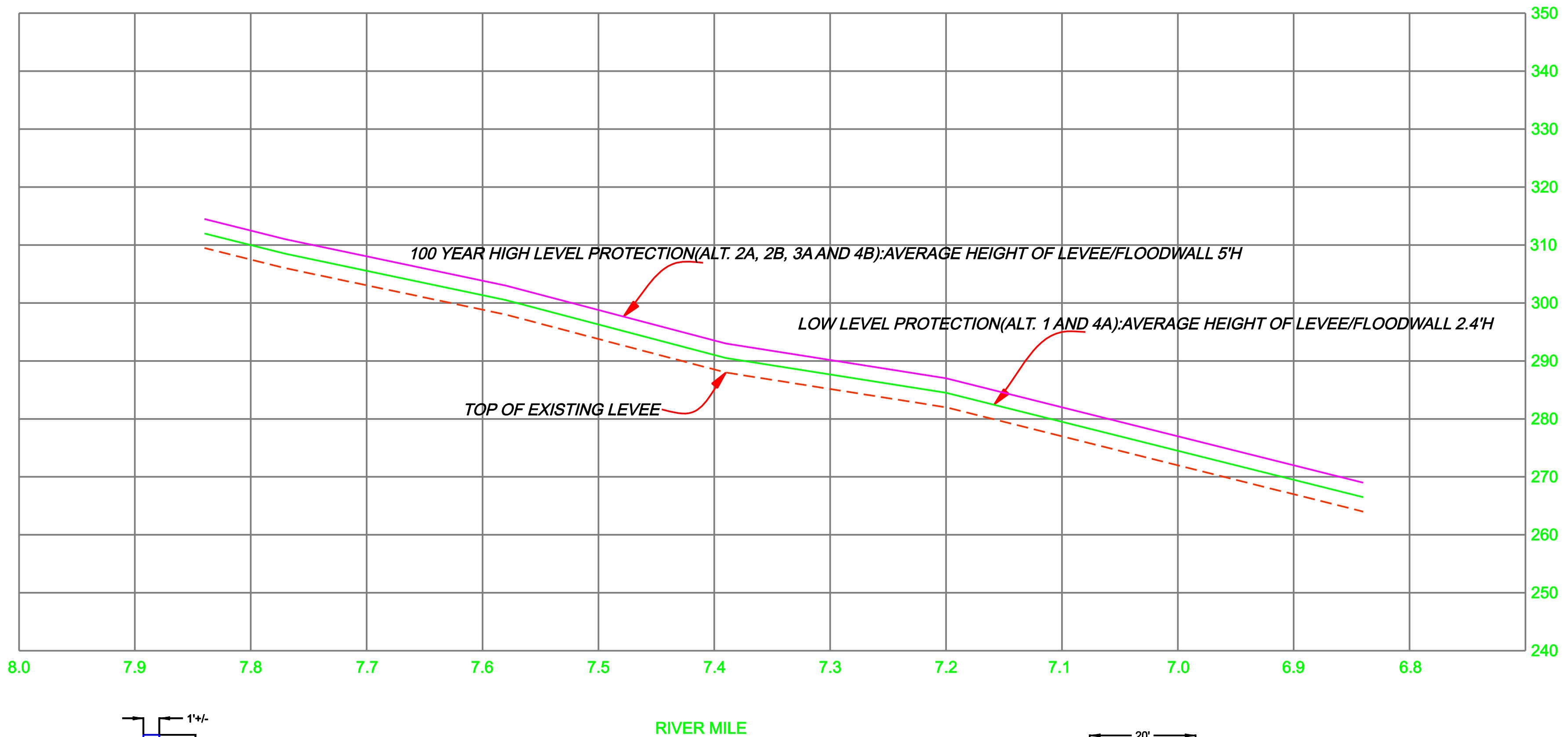
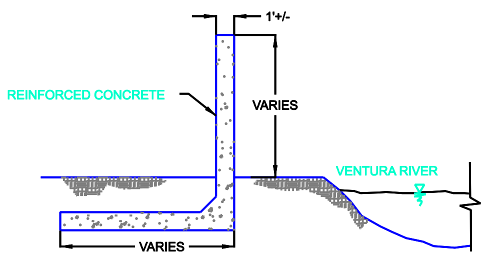
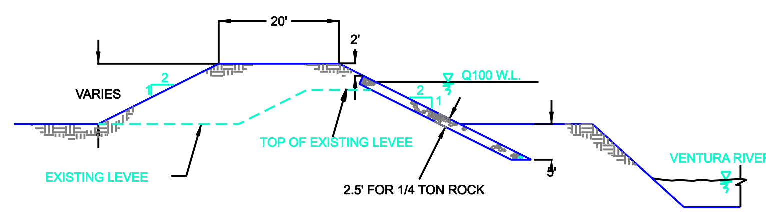
PROFILE OF LEVEE/FLOODWALL AT CASITAS SPRINGS



SCALES: 1" = 0.10 MILE (HORIZ.)
1" = 20 FEET (VERT.)



(LOOKING DOWNSTREAM)
TYPICAL SECTION OF FLOODWALL
N.T.S.



LEVEE HEIGHTENING
N.T.S.
(LOOKING DOWNSTREAM)

U.S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

SUBMITTED BY (AS REQUIRED BY E.R. 1110-1-8152):
THOMAS H. SAGE, P.E.
CHIEF, DESIGN BRANCH

DESIGNED BY: JEFF CHIN
DRAWN BY: JEFF CHIN
CHECKED BY: TONY NEFAS

MATILIJA RESERVOIR AREA AND VENTURA RIVER, CALIFORNIA
F5 FEASIBILITY STUDY

MATILIJA DAM ECOSYSTEM RESTORATION
PROFILE OF LEVEE/FLOODWALL AT CASITAS SPRINGS

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

PLATE 18

DESIGN APPENDIX, MATILIJA DAM ECOSYSTEM RESTORATION F-5 REPORT

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