APPENDIX A-1e: Geologic Evaluation of Existing Bedrock Landslides

ALISO CREEK MAINSTEM
ECOSYSTEM RESTORATION STUDY
Orange County, California

September 2017

US Army Corps of Engineers

Orange County Public Works
Environmental Resources
Department

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ALISO CREEK ECOSYSTEM RESTORATION STUDY
ORANGE COUNTY, CALIFORNIA

Preliminary Engineering Geologic Evaluation of Existing Bedrock Landslides

Prepared For:

U.S. Army Corps of Engineers
Los Angeles District
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July 2015

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United States Army Corps of Engineers
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Subject: PRELIMINARY QUALITATIVE EVALUATION OF EXISTING BEDROCK LANDSLIDES
Aliso Creek Eco-Restoration Project
Contract W912PL-12-D-0012, Task Order 0007

As part of Modification 1 of the above referenced Task Order issued by the United States Army Corps of Engineers (USACE) Los Angeles District (LAD), Tetra Tech is pleased to submit this summary of our preliminary qualitative evaluation of the currently mapped bedrock landslides in the proximity of the Aliso Creek Eco-Restoration Project. The evaluation included the following tasks:

- Preparation of GIS-based geologic maps and schematic cross-sections,
- Participation in a day-long workshop meeting which included geotechnical, civil and hydraulic engineering staff from Tetra Tech along with geologic and planning staff from USACE LAD.
- Preparation of a Potential Impact to Landslides Summary table, which presented assumptions, geologic interpretation and evaluation of relative potential impact that each of the current design alternatives could have on existing bedrock landslides,
- Preparation of this summary report,

Thank you for this opportunity to be of continued service. If you should have any questions, please do not hesitate to contact the undersigned.

Respectively submitted,
Tetra Tech, Inc.

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1. INTRODUCTION

Within the limits of the Aliso Creek Ecosystem Restoration project, Aliso Creek meanders through a relatively deep canyon bounded by moderately to steeply sloped hillsides known as the San Joaquin Hills. Bedrock exposed within the hillsides surrounding the creek is predominantly Miocene age Topanga formation downstream of approximately station 200+00, and predominantly Miocene age Monterey Formation upstream of Station 200+00. Numerous landslide features are mapped within the east and west facing hillsides in the area, and several are mapped on the north-facing hillside from approximately Station 170+50 to Station 200+75.

As requested by the USACE LAD, Tetra Tech has prepared GIS-based geologic maps, schematic cross-sections, and a table summarizing existing bedrock landslide masses close to the Aliso Creek alignment. This table also provides a preliminary qualitative assessment of the level of impact the design alternatives might have on each of the landside masses. A brief discussion of the methodology used to develop these items is presented below.

2. GIS-BASED GEOLOGIC MAPS

GIS based geologic maps of the Aliso Creek project area were prepared by Tetra Tech. The maps were based on the existing geologic literature presented in Morton, Edgington and Fife (1974). The maps also included the location of previous subsurface investigation performed along the Aliso Creek alignment by Diaz-Yourman & Associates (2009), and Ninyo & Moore (2011). The boring logs are included in the GIS database accompanying the maps. The geologic maps focus on bedrock landslides that have been mapped by previous researchers within the hillsides immediately adjacent to Aliso Creek. Separate maps were prepared for each of the design alternatives (2 through 4) currently being considered for this project. The maps also show key elements of each design alternative, including alignment stationing, cut and fill grading limits, proposed disposal and backwater areas, riprap riffles and riprap bank protection. The maps also show the location of two sub-alternatives being considered including creek lengthening between roughly Station 155+00 and 170+00, and an ox-bow re-activation between roughly Station 120+00 and 135+00. The geologic maps pertaining to design alternatives 2 through 4 are presented on the attached Plates I though III, respectively.

3. SCHEMATIC CROSS SECTIONS

In order to perform the preliminary qualitative assessment of the existing bedrock landslides in the area of Aliso Creek, Tetra Tech prepared one schematic cross-section through each of the major landslide masses (Cross Section A-A' through G-G'). The cross sections were based on available topographic information, the available surficial geologic mapping, and on the limited amount of existing subsurface boring data. It must be noted that there is essentially no subsurface information regarding the existing landslides. Most of the existing borings were limited to the alluvial overburden. Only a few of the borings encountered landslide material and none of the borings identified a pre-existing slide surface or bottom of landslide mass. With this paucity of data, the plotting of the subsurface geometry of a bedrock landslide is only a rough estimate at best. However, in order to provide some qualitative guidance to the planning process Tetra Tech developed hypothetical landslide geometry on the cross sections. The hypothetical geometry was based on several factors including:

- Surface mapping of the landslide limits performed by others as presented in Morton, et. al (1974),
- Topography of the hillside,
- Surface mapping of geologic structure (bedding),
- Geomorphology of the terrain within and adjacent to the landslide,
- Past experience with landslide investigations within the Topanga and Monterey formations,

The hypothetical landslide geometries are presented on the schematic cross sections along with interpreted depth of alluvial soils. In addition, the proposed grades of the three design alternatives are also presented on the cross sections. Larger scale detail within the area of proposed grading is also provided. The cross sections are attached as Figures 1A through 1G.

4. SUMMARY OF POTENTIAL IMPACTS TO EXISTING BEDROCK LANDSLIDES

Evaluation of the schematic cross-sections was performed in order to produce the Summary of Potential Impacts to Bedrock Landslides Summary tables. One summary table was prepared for each design alternative. A description of each summary item on the table is provided below. A graphical depiction of the key evaluation parameters is also presented in Figure A:

- Landslide Body: Each major landslide mass currently mapped close to the Aliso Creek alignment within the study area was given a Designation Number (I through VI). The study area extends from the SOCWA water treatment plant upstream to the AWMA Road Bridge.

- Cross-Section Number: One schematic cross section was produced through each major landslide mass. The project stationing where the cross-section crosses the project alignment is also noted.

- Approximate Station Range: This is the approximate range of the project alignment stationing where grading could potentially impact the adjacent landslide.

- Critical Bank: This is the side of Aliso Creek (left or right looking downstream) closest to the mapped surface limit of the landslide.

- Interpreted Depth of Alluvium: A rough estimate of the nominal depth of alluvium within the proposed creek improvement area (depicted as D1 in Figure A). This estimate does not include the depth to the incised creek thalweg resulting from the erosion cycle associated with the last glacial period. Such features may be deeper and more localized; and may be filled with older alluvium, landslide deposits, or a combination of Quaternary deposits.

- Interpreted Depth to Base of Slide: A rough estimate of the depth to the base (slide plane) of the hypothetical landslide mass within the proposed creek improvement area, or as projected from the critical bank (depicted as D2 in Figure A). This interpreted depth is a key component in evaluating potential impact to an existing landslide. Generally speaking, the effect of surface grading would become less significant with an increase in the depth to the base of the slide.

- Compound Feature: Indicates whether the current geologic mapping shows the bedrock landslide as one large mass or several separate but interconnected slide masses.

- Interpreted Relative Age: Estimate of the amount of time since the landslide mass underwent significant movement. This is based mainly on the geomorphology of the surface terrain. This factor is also important in evaluating the relative impact on an existing landslide. Generally speaking, the older the landslide feature, the less likelihood that surface grading will have an impact.

- Nearby Borings / Depths: Summarizes existing borings close to the slide mass.

- Associated Civil X-Sections: Available civil cross sections within the range specified in item 3.

- 2-D Relative Impact Ratio: This is one factor that was considered in evaluating potential impact on the existing bedrock landslides. The current state of stability of the existing bedrock landslides depends, at least partially, on the amount of overburden covering the base of the landslide. This overburden acts as a gravity buttress preventing the landslide mass from further movement. This factor is calculated based on the interpreted subsurface conditions for the specified cross section. It is the ratio of the net proposed grading (shown as A_n in Figure A) for a given design alternative (area of fill – area of cut) divided by the rough estimate of the area of overburden above the bottom of the hypothetical landslide mass and below the area of proposed grading (shown as A_o in Figure A). This ratio factor indicates the relative amount of loss, or gain, of buttressing overburden. A positive ratio indicates a net gain in buttressing overburden, a negative ratio indicates a net loss.

- 1-D Relative Impact Ratio. This is another factor that was considered in evaluating potential impact on the existing bedrock landslides. Again, this factor is calculated based on the interpreted subsurface conditions for the specified cross section. It is the ratio of the maximum amount of proposed cut (shown as D3 in Figure A) divided by the estimated depth to the base of the hypothetical landslide (shown as D4 in Figure A) at that location. This factor is based on the conservative assumption that if a landslide mass would re-activate (begin to move) the breakout point would be where the excavation from the proposed grading is greatest. This factor indicates the loss of overburden at that hypothetical breakout point.

- Backwater Areas: This item indicates whether backwater areas are proposed at the specified cross section. Based on discussion with the design engineer any fill or excavation associated with these areas would generally be minimal (less than 4 feet), however, excavation would reduce the buttressing effects of the existing overburden soils.

- Disposal Areas: This item indicates whether soil disposal areas are proposed at the specified cross section. Based on discussion with the design engineer these fill area would generally be less than 6 feet. The proposed disposal areas are not in locations that would negatively impact the existing bedrock landslides. They would typically add to the buttressing effect of the existing overburden and increase the stability of existing bedrock landslides.

- Estimated Qualitative Impact: This item is a qualitative rating of the potential impact a particular design alternative could have on an identified bedrock landslide. The rating is based on the information presented in this table as well as discussions with the USACE LAD geology, planning and design groups, and Tetra Tech design personnel. The ratings are High, Medium and Low.

It must be noted that a particular rating is not necessarily an indication of the likelihood of a bedrock landslide to become unstable, it is rather a qualitative assessment of how much impact the proposed grading could have on the existing level of stability (factor of safety) of a given landslide. Several factors were considered in developing the qualitative rating including the interpreted geometry relative to the proposed grading. The rating evaluation primarily utilized the 1-D and 2-D Relative Impact Ratios (1-D and 2-D ratios) discussed above. The generalized relationship between the Relative Impact Ratios and the assigned Estimated Qualitative Impact rating is presented in Figure B.

Other factors were also considered in the rating including age of the landslide and orientation with regard to the proposed grading. For instance Landslide I (Cross-Section F-F') was considered a medium impact risk based on the Relative Impact Ratios estimated from Cross-Section F-F'. However, the significant proposed grading is only adjacent to the northern limit of the landslide and not within the interpreted direction of movement of the landslide. For this reason the landslide body was given a Low Impact Rating.

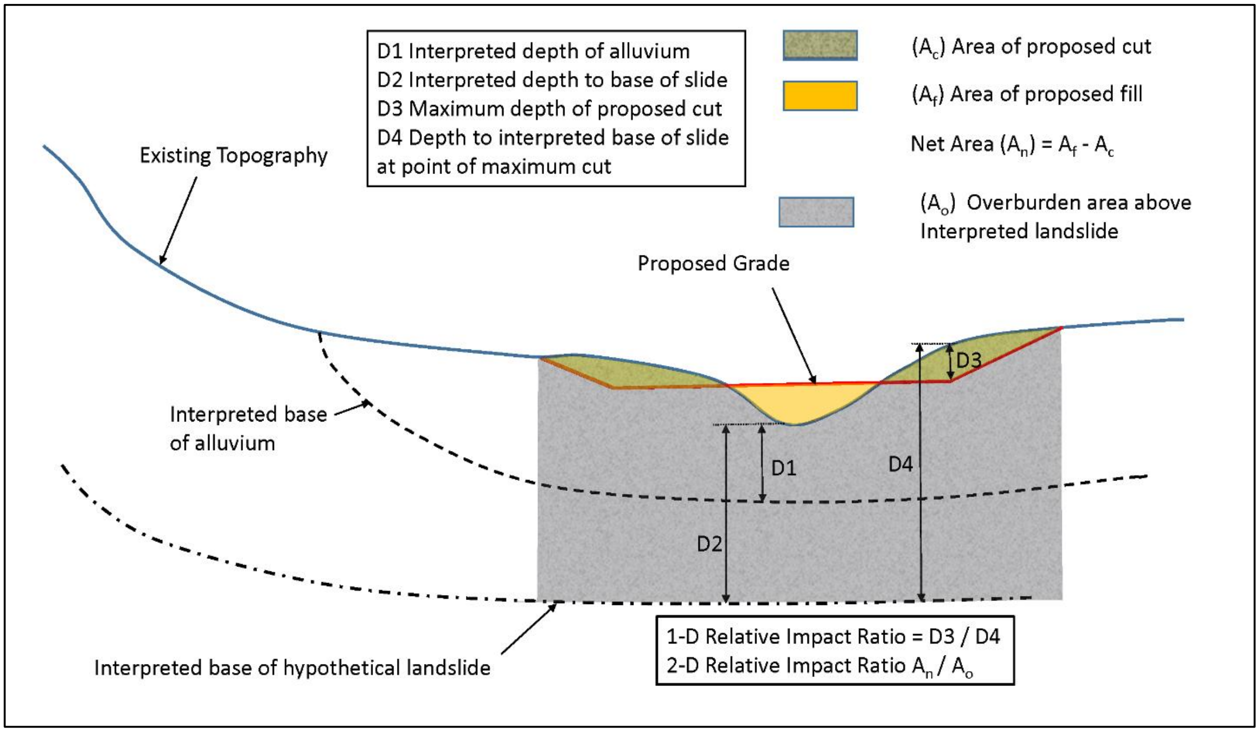

Figure A – Graphical Description of Key Evaluation Parameters

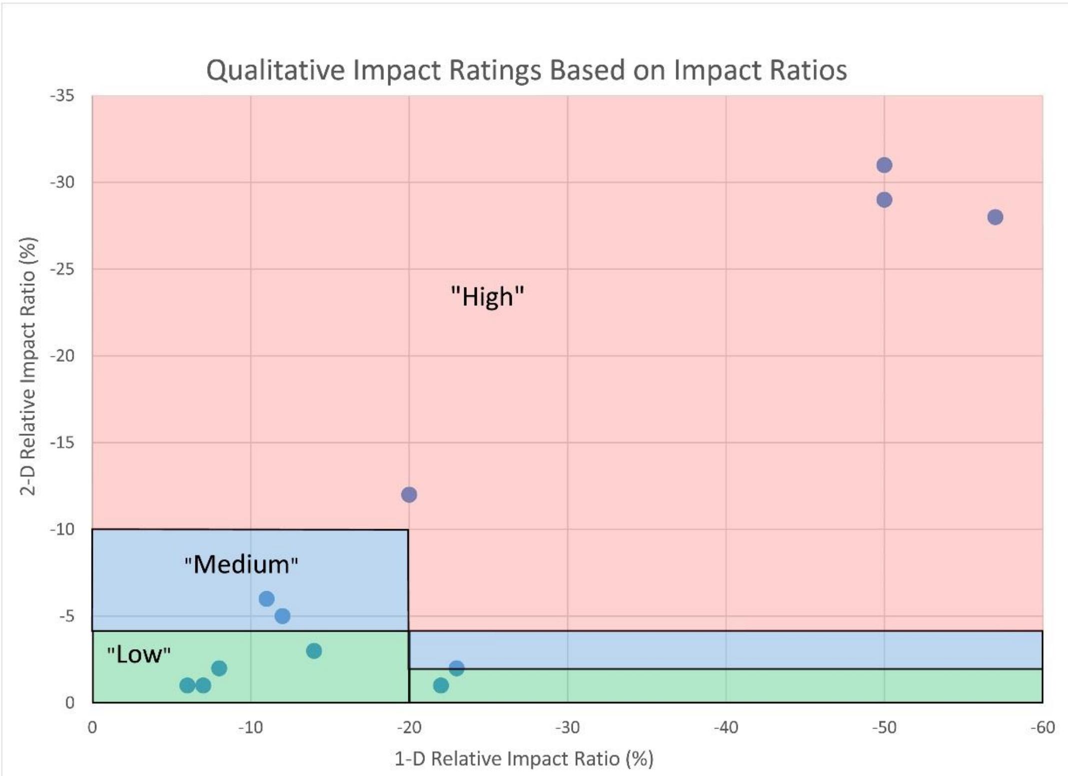

Figure B – Qualitative Impact Ratings Based on 1-D and 2-D Impact Ratios

5. CONCLUSIONS AND RECOMMENDATIONS

The results of this preliminary qualitative evaluation of existing landslides adjacent to the proposed Aliso Creek Ecosystem Restoration project indicates that some of the landslide masses could be impacted by the proposed grading. Details of the evaluation are presented on the Summary of Potential Impacts to Existing Landslides attached to this report. An overview of the potential impact ratings are presented below.

Landslide Body	I	II	IIa (With Ox-Bow)	IIa (Without Ox-Bow)	III	IV	V	VI
Approximate Station Range	59+15 - 80+84	105+00 - 115+70	121+00 - 128+50	121+00 - 128+50	123+20 - 144+00	144+00 - 156+20	175+85 - 195+00	195+00 - 208+20
Alterative 2 Rating	Low	Low	High	Low	Medium	Low	Low	Low
Alterative 3 Rating	Low	Low	High	Low	Low	Low	Medium	Low
Alterative 4 Rating	Low	Low	High	Low	Low	Low	High	Low

It should be noted that in the area where lengthening of the creek alignment is being considered (Station 155+00 and 170+00) both the widening and no widening concepts have a low potential impact rating.

This evaluation did not identify an existing landslide feature that would necessarily make any of the current grading design alternative unfeasible, however, it was concluded that the proposed grading could potentially have significant impact on the degree of stability of some of the existing landslides. The degree of potential impact was qualitatively rated as low, medium and high. The specific conclusion and recommendation of each rating is presented below:

- High: The impact of the proposed grading to the existing stability of the bedrock landslide is considered potentially significant. This does not mean the proposed grading is not feasible, however, a detailed investigation and evaluation of the landslide should be performed during design of the project. The current conceptual design should be re-evaluated in terms of reducing cuts or shifting the proposed grading farther from the mapped landslide area.

- Medium: The impact of the proposed grading to the existing bedrock landslide is a design consideration, however, altering the current conceptual design is not considered necessary at this time. The landslide should be investigated further during the design of the project.

- Low: The impact of the proposed grading to the existing bedrock landslide is considered minimal based on the current information. Detailed investigation of the landslide is likely not warranted. However, during final design, at least one deep boring should be performed between the mapped landslide area and the proposed grading in order to evaluate actual conditions relative to the assumptions made as part of this preliminary work.

6. CLOSURE

This report is based on the project as described and the information obtained from existing geologic literature. The findings, conclusions and recommendations that Tetra Tech may present are also based in part upon data obtained from a limited amount of subsurface exploration performed by others. Such information can be obtained only with respect to the specific locations explored, and, therefore, may not completely define the subsurface conditions. Differing geotechnical or geologic conditions can occur within small distances and under varying climatic conditions. Furthermore, changes in subsurface conditions can and do occur over time. Our firm should be notified of any pertinent change in the project or field conditions. If geotechnical conditions are found to differ from those described herein, it may require a re-evaluation of the recommendations presented.

This document is intended to be used only in its entirety. No portion of the document, by itself, is designed to completely represent any aspect of the project described herein. Tetra Tech should be contacted if the reader requires additional information or has questions regarding the content, interpretations presented, or completeness of this document. Reliance by others on the data presented herein or for purposes other than those stated in the text is authorized only if so permitted in writing by Tetra Tech. It should be understood that such an authorization may incur additional expenses and charges.

Tetra Tech has endeavored to perform its evaluation using the degree of care and skill ordinarily exercised under similar circumstances by reputable geotechnical professionals with experience in this area in similar soil conditions. No other warranty, either expressed or implied, is made as to the conclusions and recommendations contained in this report.

7. REFERENCES

Diaz-Yourman & Associates, 2009, Aliso Creek Ecosystem Restoration Project, Orange County, California, Geotechnical Appendix F3, Geotechnical Report to U.S. Army Corps of Engineers, Los Angeles District, September 2009, Contains logs for borings DYB-2 through DYB-11.

Morton, P.K., Edgington, W.J., and Fife, D.L., 1974, *Geologic Map of the San Juan Capistrano Quadrangle, Orange County, California*, in, *Geology and Engineering Geologic Aspects of the San Juan Capistrano Quadrangle, Orange County, California*, California Division of Mines and Geology Special Report 112, Prepared in cooperation with the County of Orange, Department of Building and Safety, Road Department, and the Orange County Flood Control District, 64 p., map scale 1:12,000.

Ninyo & Moore, 2011, Preliminary Geotechnical Evaluation, Coastal Treatment Plant Export Sludge System, South Orange County Wastewater Authority, Laguna Niguel, California, Prepared for Dudek & Associates, November 18, 2011 (Project No. 202426005), Includes boring logs B-1 through B-19 (8" hollow-stem, report date 12/2000), B-1a through B-2a (8" hollow-stem, report date 5/2000), C-1 and C-2 (rock core logs, report date 12/2001), B-1 through B-4 (30" bucket auger logs, report date 12/2001), and B-1 through B-6 (8" hollow-stem logs, report date 4/2009)

Potential Impact to Existing Landslide Summary

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Aliso Creek Ecosystem Restoration
Summary of Potential Impacts to Existing Bedrock Landslides
(Qualitative Interpretation of Potential Impact of Proposed Grading Alternatives on Significant Landslide Features)

Alternative 2

Landslide Body:	I	II	III	IV	V	VI	II_a
Cross-Section Number:	F-F' (78+87)	E-E' (114+57)	D-D' (141+82)	C-C' (154+97)	B-B' (189+39)	A-A' (202+55)	G-G' (125+60) (Through Oxbow Subalternative)
Approximate Station Range:	59+15 - 80+84	105+00 - 115+70	123+20 - 144+00	144+00 - 156+20	175+85 - 195+00	195+00 - 208+20	121+00 - 128+50
Critical Bank (Looking Downstream):	Right	Right	Left	Left	Left	Left	Right
Interpreted Depth of Qal (ft):	Estimated up to 45' BGS (based on Qal>36' @B1, 500'S, Qal>36.5@B3, 750'N of sectn)	Est. Up to 60' BGS, (based on Qal@elev. 11, C1, Qal>51.5'BGS@B7,B8 oxbow	Est. up to 38' BGS based on NM B9 in Qal@ elev. 56.5, 320' upstream; and DYB-4 Qal? to 39' BGS	Est. at 25' below exist channel	Est @ 28' BGS Based on 28' depth to fat clay in DYB-9, across creek	Est @ up to 60' BGS	Est @ up to 68' BGS, based on Qal>51.5'GBS@B7,B8 and base Qal at Elev 15@DYA B3, downstream
Interpreted Depth to Base of Slide (ft):	est. > 80' BGS (based Qls in C2, max depth 80' BGS)	est. > 85 (based on Qls in C1, max depth = 85' BGS)	est. Approx. 50' below lt bank, based on interpreted geomorphic expression	Top of Qal/Qls ctc est at 28' BGS at left bank, based on projection from DYB-6. Base of Qls est @ 85' BGS @ lt bank.	Base of Qls interpreted at approx 58' BGS at left bank, based on geomorphic expression	Est @ up to 118' BGS	Est @ up to 65' BGS, w of access road
Compound Feature?:	No	Y	Possibly, contains "Qls(?)", which may or may not be distinct features	Yes Right boundary is the Temple Hill fault Regional change in bdg attitude across fault	Feature contains pockets of slopewash Hummocky topography Near fault boundaries	Yes Fault forms left flank Feature may be on w side of margin of Capistrano Basin	Yes Feature is supplemental to main body on north flank.
Interpreted Relative Age:	Ancient (10-20 ka)	No obvious fresh tension cracks, closed depressions, etc. Likely Ancient (10-20 ka)	Ancient (10-20 ka)	Mod. ancient (est. 5 - 10 ka) Based on geomorphic expression, scarp, compound feature	Ancient (10-20 ka)	Ancient (10-20 ka)	Est up to 5 Ka
Nearby borings/depths:	NM C-2 (80'd) NM B-4 (38')	NM C-1 (85') NM B-6 (21')	NM B-9 (31.5', Qal) DYB-4 (51.5', Qal to 39? Over Tt slst)	NM B-4 (16.5' BGS, Qal) DYB-6 (51.5' BGS, Qal over Qls?)	NM B3 (TD 16.5' BGS Qal)	NM B-14 (31.5' BGS Qal)	NM B-7 (51.5' BGS Qal)
Associated Civil X-Sections	80+00	105+00: 110+00: 115+00:	125+00: 130+00: 135+00: 140+00	145+00: 150+00: 155+00:	175+00: 180+00: 184+00:	195+00: 200+00 205+00	N/A
2-D Relative Impact: A(fill)-A(cut)/A(block -below):	-3%	-1%	-3%	-1%	Minor Grading	Minor Grading	-31%
1-D Relative Impact H(cut-max)/D(est. Slide surface):	-14%	-6%	-23%	-22%	Minor Grading	Minor Grading	-50%
Backwater Areas?	No	Yes, E of road & @ Lt bank	Yes	Yes	Yes	Yes	No
Disposal Areas?:	No	No	Yes	Yes	Yes	No	No
Estimated Qualitative Impact (L="Low", M="Medium", H="High"):	**L**	**L**	**M**	**L**	**L**	**L**	**H**

Aliso Creek Ecosystem Restoration
Summary of Potential Impacts to Existing Bedrock Landslides
(Qualitative Interpretation of Potential Impact of Proposed Grading Alternatives on Significant Landslide Features)

Alternative 3

Landslide Body:	**I**	**II**	**III**	**IV**	**V**	**VI**	**II$_a$**
Cross-Section Number:	F-F' (78+87)	E-E' (114+57)	D-D' (141+82)	C-C' (154+97)	B-B' (189+39)	A-A' (202+55)	G-G' (125+60) (Through Oxbow Subalternative)
Approximate Station Range:	59+15 - 80+84	105+00 - 115+70	123+20 - 144+00	144+00 - 156+20	175+85 - 195+00	195+00 - 208+20	121+00 - 128+50
Critical Bank (Looking Downstream):	Right	Right	Left	Left	Left	Left	Right
Interpreted Depth of Qal (ft):	Estimated up to 45' BGS (based on Qal>36' @B1, 500'S, Qal>36.5@B3, 750'N of sectn)	Est. Up to 60' BGS, (based on Qal@elev. 11, C1, Qal>51.5'BGS@B7,B8 oxbow	Est. up to 38' BGS based on NM B9 in Qal@ elev. 56.5, 320' upstream; and DYB-4 Qal? to 39' BGS	Est. at 25' below exist channel	Est @ 28' BGS Based on 28' depth to fat clay in DYB-9, across creek	Est @ up to 60' BGS	Est @ up to 68' BGS, based on Qal>51.5'GBS@B7,B8 and base Qal at Elev 15@DYA B3, downstream
Interpreted Depth to Base of Slide (ft):	est. > 80' BGS (based Qls in C2, max depth 80' BGS)	est. > 85 (based on Qls in C1, max depth = 85' BGS)	est. Approx. 50' below lt bank, based on interpreted geomorphic expression	Top of Qal/Qls ctc est at 28' BGS at left bank, based on projection from DYB-6. Base of Qls est @ 85' BGS @ lt bank.	Base of Qls interpreted at approx 58' BGS at left bank, based on geomorphic expression	Est @ up to 118' BGS	Est @ up to 65' BGS, w of access road
Compound Feature?:	No	Y	Possibly, contains "Qls(?)", which may or may not be distinct features	Right boundary is the Temple Hill fault Regional change in bdg attitude across fault	Feature contains pockets of slopewash Hummocky topography Near fault boundaries	Yes Fault forms left flank Feature may be on w side of margin of Capistrano Basin	Yes Feature is supplemental to main body on north flank.
Interpreted Relative Age:	Ancient (10-20 ka)	No obvious fresh tension cracks, closed depressions, etc. Likely Ancient (10-20 ka)	Ancient (10-20 ka)	Mod. ancient (est. 5 - 10 ka) Based on geomorphic expression, scarp, compound feature	Ancient (10-20 ka)	Ancient (10-20 ka)	Est up to 5 Ka
Nearby borings/depths:	NM C-2 (80'd) NM B-4 (38')	NM C-1 (85') NM B-6 (21')	NM B-9 (31.5', Qal) DYB-4 (51.5', Qal to 39? Over Tt slst)	NM B-4 (16.5' BGS, Qal) DYB-6 (51.5' BGS, Qal over Qls?)	NM B3 (TD 16.5' BGS Qal)	NM B-14 (31.5' BGS Qal)	NM B-7 (51.5' BGS Qal)
Associated Civil X-Sections	-	105+00: 110+00: 115+00:	125+00: 130+00: 135+00: 140+00	145+00: 150+00: 155+00:	175+00: 180+00: 185+00: 190+00 195+00	195+00: 200+00: 205+00:	N/A
2-D Relative Impact: A(fill)-A(cut)/A(block -below):	-2%	+3%	+7%	+9%	-5%	-2%	-20%
1-D Relative Impact H(cut-max)/D(est. Slide surface):	-8%	-3%	-9%	-5%	-12%	-	-50%
Backwater Areas?	Yes	No	Yes	Yes	No	Yes	Left Bank
Disposal Areas?:	No	No	Rt Bank	Rt Bank	Rt Bank	No	No
Estimated Qualitative Impact (L="Low", M="Medium", H="High"):	**L**	**L**	**L**	**L**	**M**	**L**	**H**

Aliso Creek Ecosystem Restoration
Summary of Potential Impacts to Existing Bedrock Landslides
(Qualitative Interpretation of Potential Impact of Proposed Grading Alternatives on Significant Landslide Features)

Alternative 4

Landslide Body:	I	II	III	IV	V	VI	II_a
Cross-Section Number:	F-F' (78+87)	E-E' (114+57)	D-D' (141+82)	C-C' (154+97)	B-B' (189+39)	A-A' (202+55)	G-G' (125+60) (Through Oxbow Subalternative)
Approximate Station Range:	59+15 - 80+84	105+00 - 115+70	123+20 - 144+00	144+00 - 156+20	175+85 - 195+00	195+00 - 208+20	121+00 - 128+50
Critical Bank (Looking Downstream):	Right	Right	Left	Left	Left	Left	Right
Interpreted Depth of Qal (ft):	Estimated up to 45' BGS (based on Qal>36' @B1, 500'S, Qal>36.5@B3, 750'N of sectn)	Est. Up to 60' BGS, (based on Qal@elev. 11, C1, Qal>51.5'BGS@B7,B8 oxbow	Est. up to 38' BGS based on NM B9 in Qal@ elev. 56.5, 320' upstream; and DYB-4 Qal? to 39' BGS	Est. at 25' below exist channel	Est @ 28' BGS Based on 28' depth to fat clay in DYB-9, across creek	Est @ up to 60' BGS	Est @ up to 68' BGS, based on Qal>51.5'GBS@B7,B8 and base Qal at Elev 15@DYA B3, downstream
Interpreted Depth to Base of Slide (ft):	est. > 80' BGS (based Qls in C2, max depth 80' BGS)	est. > 85 (based on Qls in C1, max depth = 85' BGS)	est. Approx. 50' below lt bank, based on interpreted geomorphic expression	Top of Qal/Qls ctc est at 28' BGS at left bank, based on projection from DYB-6. Base of Qls est @ 85' BGS @ lt bank.	Base of Qls interpreted at approx 58' BGS at left bank, based on geomorphic expression	Est @ up to 118' BGS	Est @ up to 65' BGS, w of access road
Compound Feature?:	No	Y	Possibly, contains "Qls(?)", which may or may not be distinct features	Right boundary is the Temple Hill fault Regional change in bdg attitude across fault	Feature contains pockets of slopewash Hummocky topography Near fault boundaries	Yes Fault forms left flank Feature may be on w side of margin of Capistrano Basin	Yes Feature is supplemental to main body on north flank.
Interpreted Relative Age:	Ancient (10-20 ka)	No obvious fresh tension cracks, closed depressions, etc. Likely Ancient (10-20 ka)	Ancient (10-20 ka)	Mod. ancient (est. 5 - 10 ka) Based on geomorphic expression, scarp, compound feature	Ancient (10-20 ka)	Ancient (10-20 ka)	Est up to 5 Ka
Nearby borings/depths:	NM C-2 (80'd) NM B-4 (38')	NM C-1 (85') NM B-6 (21')	NM B-9 (31.5', Qal) DYB-4 (51.5', Qal to 39? Over Tt slst)	NM B-4 (16.5' BGS, Qal) DYB-6 (51.5' BGS, Qal over Qls?)	NM B3 (TD 16.5' BGS Qal)	NM B-14 (31.5' BGS Qal)	NM B-7 (51.5' BGS Qal)
Associated Civil X-Sections	75+00 70+00	105+00: 110+00: 115+00:	125+00: 130+00: 135+00: 140+00	145+00: 150+00: 155+00:	175+00: 180+00: 185+00: 190+00 195+00	195+00: 200+00: 205+00:	N/A
2-D Relative Impact: A(fill)-A(cut)/A(block -below):	-6%	-1%	+3%	+3%	-12%	-5%	-28%
1-D Relative Impact H(cut-max)/D(est. Slide surface):	-11%	-7%	-12%	-10%	-20%	-	-57%
Backwater Areas?	No	No	No	No	No	Yes	Left Bank
Disposal Areas?:	No	No	Rt Bank	Rt Bank	Rt Bank	No	No
Estimated Qualitative Impact (L="Low", M="Medium", H="High"):	**L**	**L**	**L**	**L**	**H**	**L**	**H**

Geologic Maps

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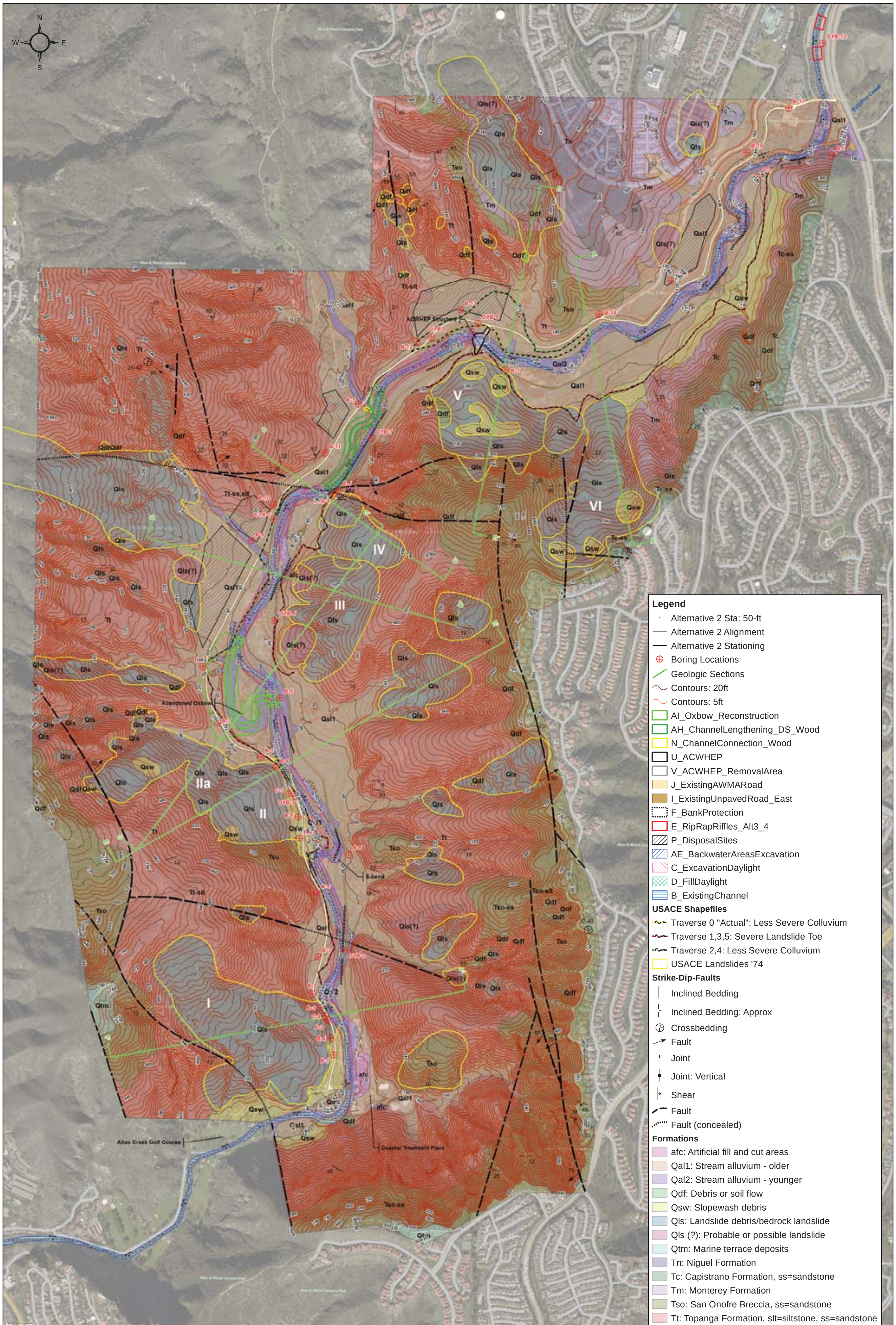
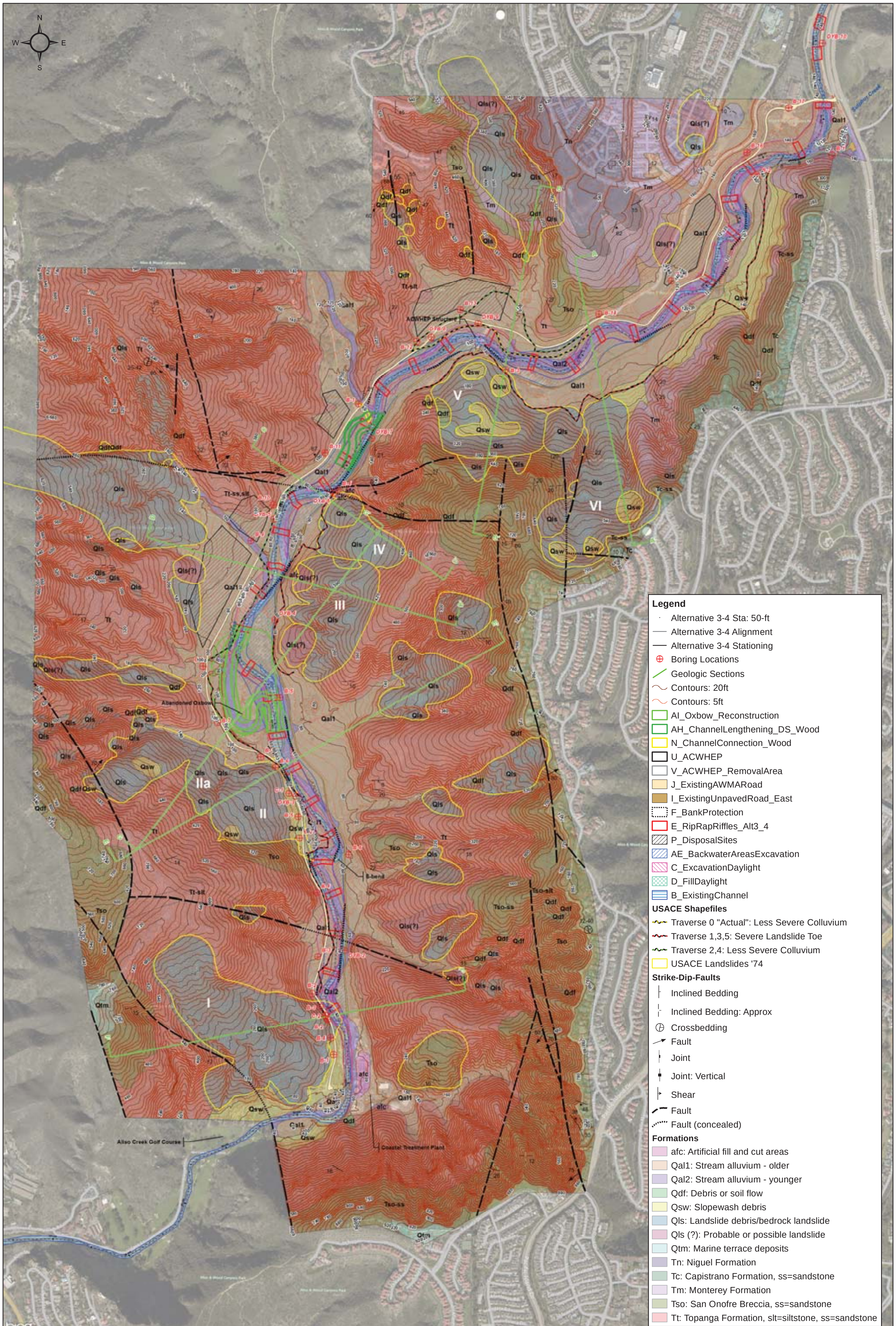


Geologic Map Reference: Morton, Edgington and Fife (1974), "Geology and Engineering Geologic Aspects of the San Juan Capistrano Quadrangle, Orange County, California", CDMG Special Report 112, 1974, 64 p, map (scale 1:12,000)
Other Data Source: Tetra Tech 2014. Aerial Source: BING 2014

Geotechnical Map of Aliso Creek Mainstream Ecosystem Restoration with Digitized Geologic Features, Depicting Baseline Alternative 2

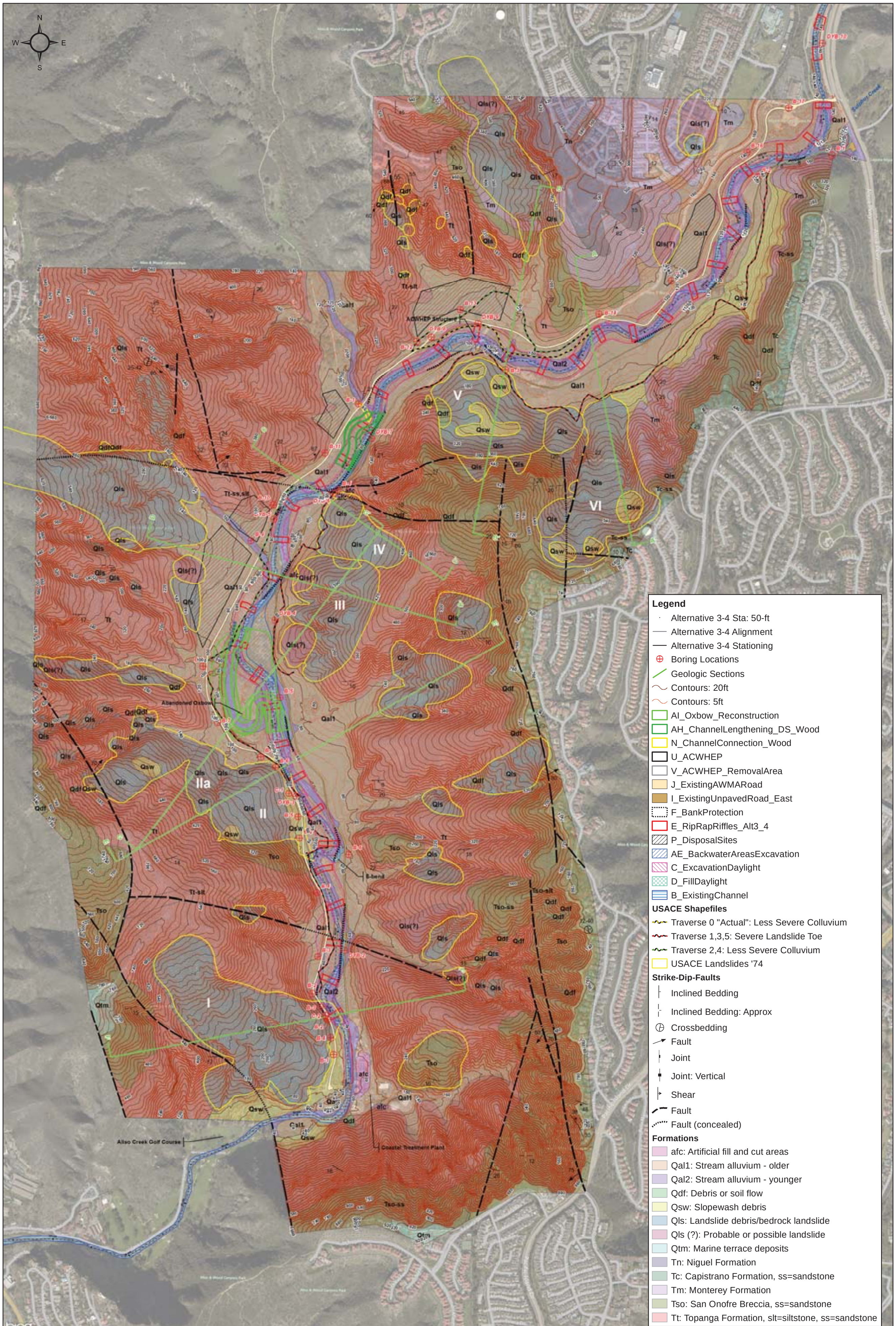


Geologic Map Reference: Morton, Edgington and Fife (1974), "Geology and Engineering Geologic Aspects of the San Juan Capistrano Quadrangle, Orange County, California", CDMG Special Report 112, 1974, 64 p, map (scale 1:12,000)
Other Data Source: Tetra Tech 2014. Aerial Source: BING 2014

Geotechnical Map of Aliso Creek Mainstream Ecosystem Restoration
with Digitized Geologic Features, Depicting Baseline Alternative 3

0 500 1,000 2,000
Feet

PLATE II



Geologic Map Reference: Morton, Edgington and Fife (1974), "Geology and Engineering Geologic Aspects of the San Juan Capistrano Quadrangle, Orange County, California", CDMG Special Report 112, 1974, 64 p, map (scale 1:12,000)
Other Data Source: Tetra Tech 2014. Aerial Source: BING 2014

Geotechnical Map of Aliso Creek Mainstream Ecosystem Restoration with Digitized Geologic Features, Depicting Baseline Alternative 4

0 500 1,000 2,000 Feet

PLATE III

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Geologic Cross Sections A-A' through G-G'

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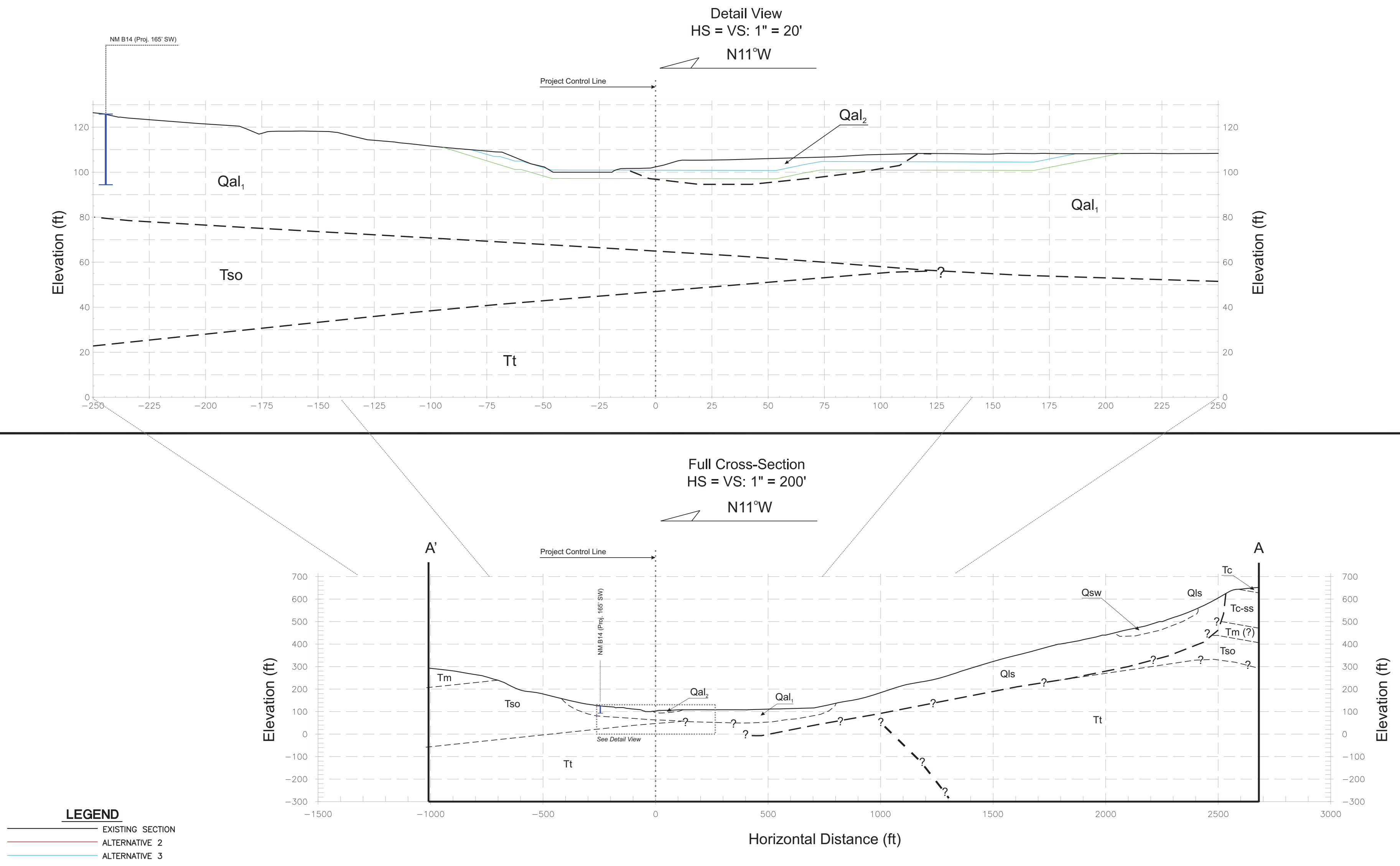

Geologic map reference: Morton, Edgington and Fife (1974), "Geology and Engineering Geologic Aspects of the San Juan Capistrano Quadrangle, Orange County, California, CDMG Special Report 112, 1974, 64 p, map (scale 1:12,000).

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Aliso Creek Eco-System Restoration

Cross-Section A-A'

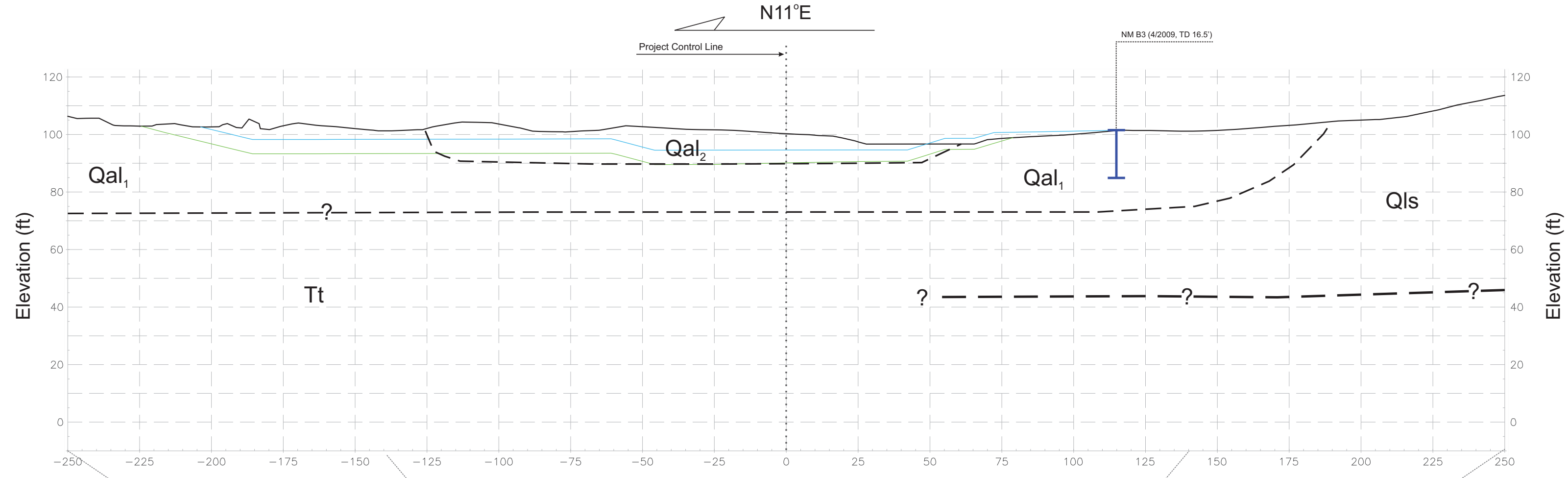
Project Control Sta. 202+55

FIGURE 1A

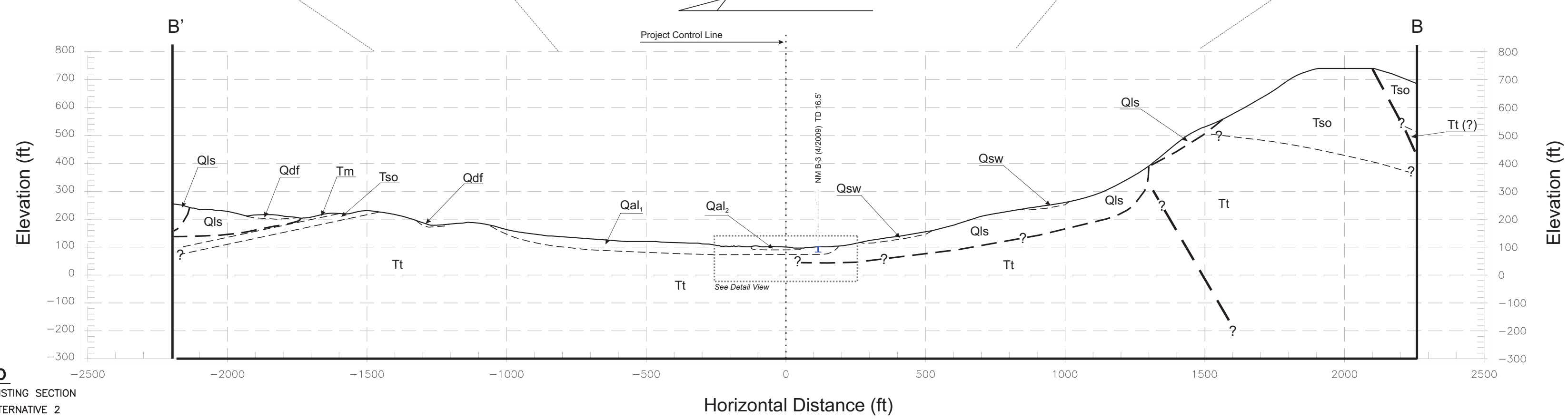
JOB NO.	TET 14-54E
DATE	05-2015
DRAWN BY	ABL
FILE NAME:	33-0095XSEC.DWG

N:\02 - PROJECTS\2014 PROJECTS\TET 14-54E (4552-0054) ALISO CREEK ECO-SYSTEM RESTORATION, LAGUNA NIGUEL\06 DRAFTING\BAS\SHEET FILES\33-0095XSEC.DWG 5/15/2015 3:23 PM

Detail View
HS = VS: 1" = 20'



Full Cross-Section
HS = VS: 1" = 200'



LEGEND

- EXISTING SECTION
- ALTERNATIVE 2
- ALTERNATIVE 3
- ALTERNATIVE 4

Geologic map reference: Morton, Edgington and Fife (1974), "Geology and Engineering Geologic Aspects of the San Juan Capistrano Quadrangle, Orange County, California, CDMG Special Report 112, 1974, 64 p, map (scale 1:12,000).

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Aliso Creek Eco-System Restoration

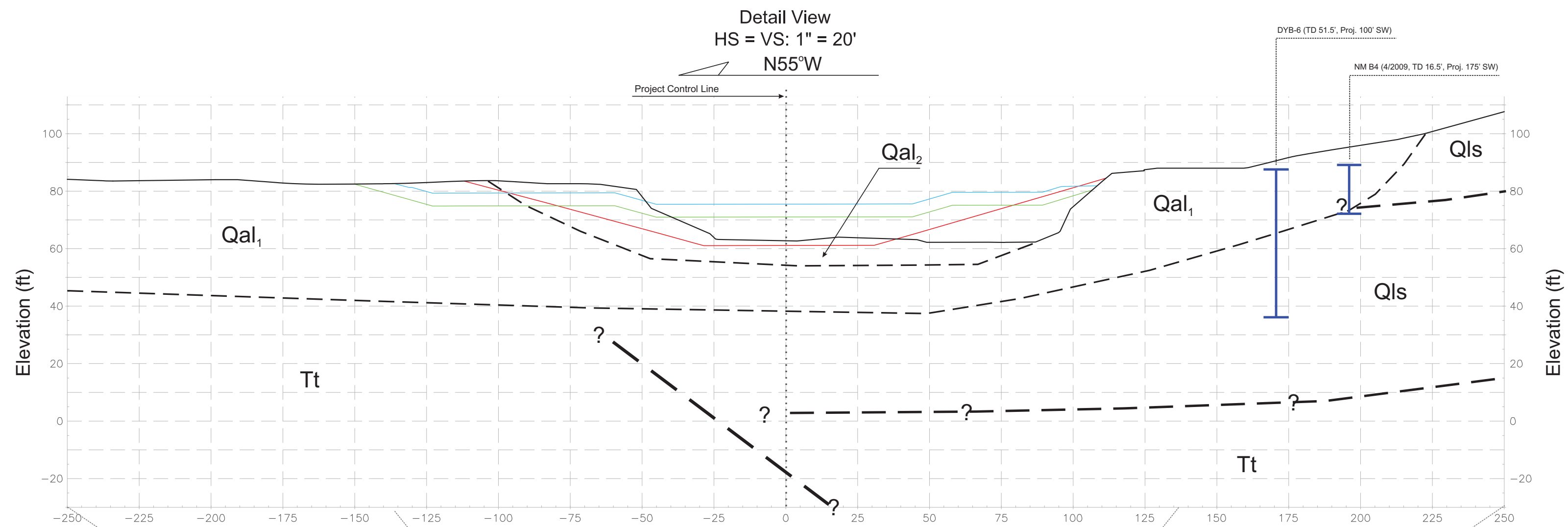
Cross-Section B-B'

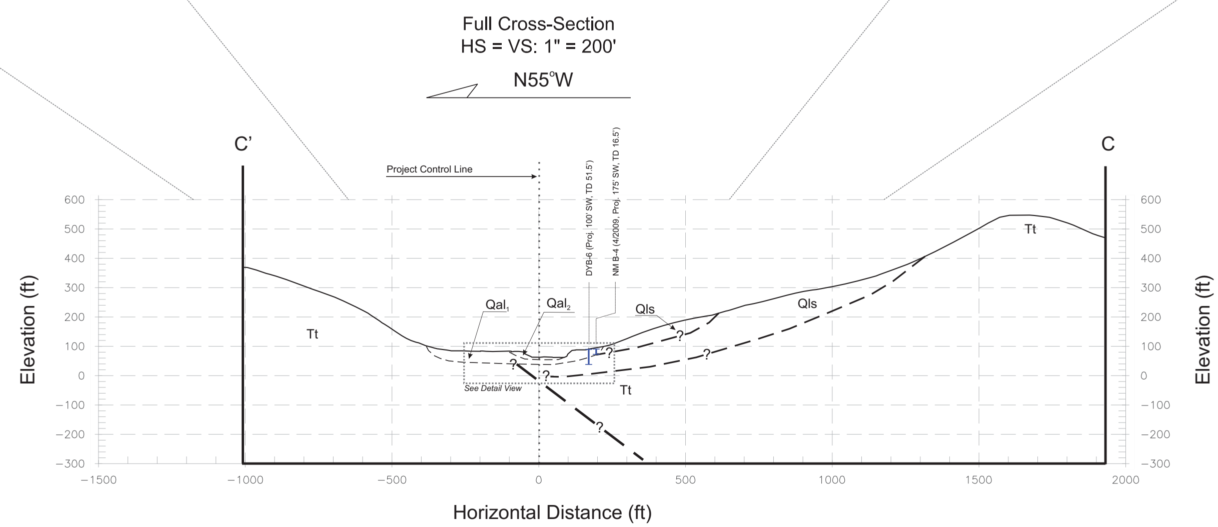
Project Control Sta. 189+39

FIGURE 1B

JOB NO.	TET 14-54E
DATE	05-2015
DRAWN BY	ABL
FILE NAME:	33-0096XSEC.DWG

N:\02 – PROJECTS\2014 PROJECTS\TET 14-54E (4552-0054) ALISO CREEK ECO-SYSTEM RESTORATION, LAGUNA NIGUEL\06 DRAFTING\BAS\SHEET FILES\33-0096XSEC.DWG 5/15/2015 3:45 PM





LEGEND

- EXISTING SECTION
- ALTERNATIVE 2
- ALTERNATIVE 3
- ALTERNATIVE 4

Geologic map reference: Morton, Edgington and Fife (1974), "Geology and Engineering Geologic Aspects of the San Juan Capistrano Quadrangle, Orange County, California, CDMG Special Report 112, 1974, 64 p, map (scale 1:12,000).

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Aliso Creek Eco-System Restoration

Cross-Section C-C'

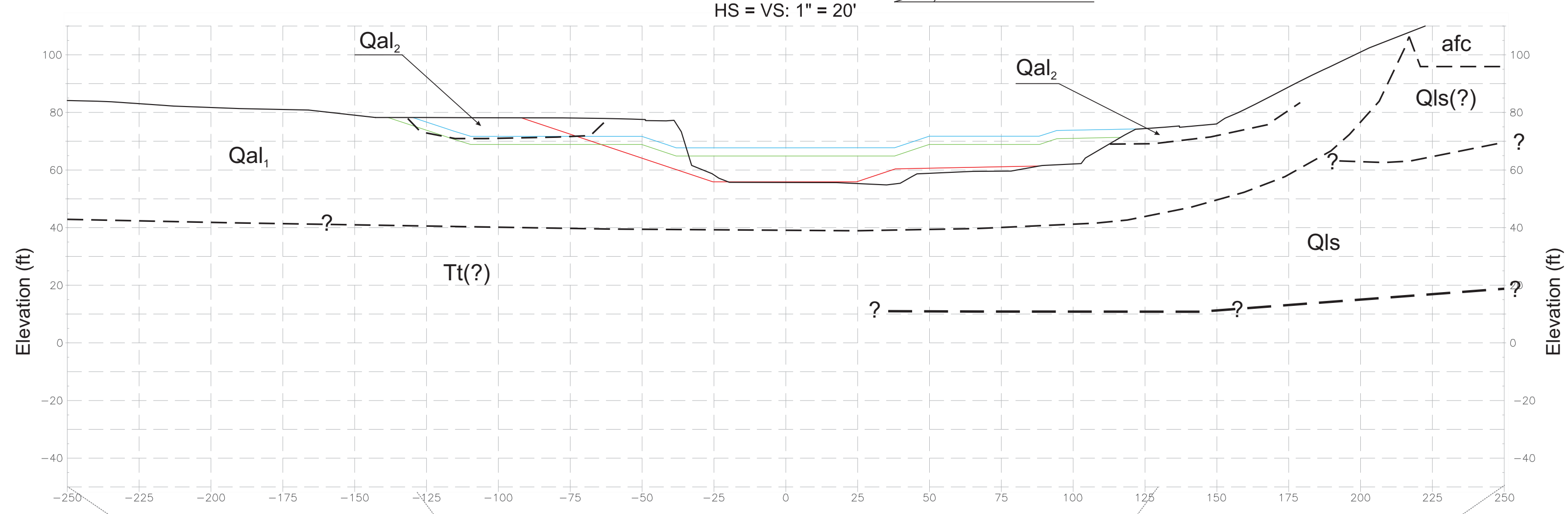
Project Control Sta. 154+97

FIGURE 1C

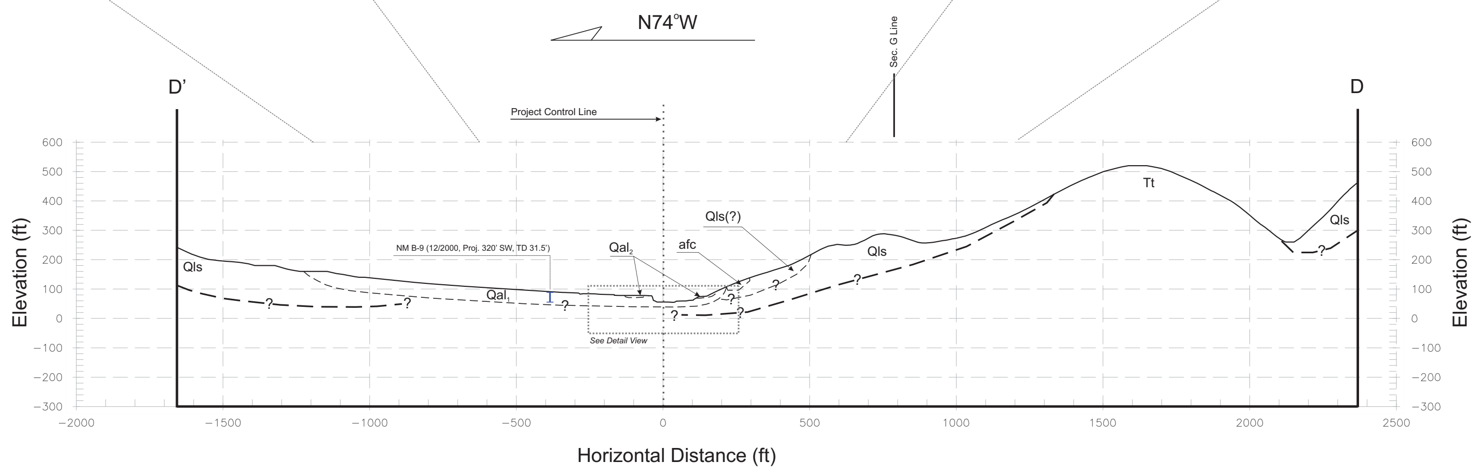
JOB NO.	TET 14-54E
DATE	05-2015
DRAWN BY	ABL
FILE NAME:	33-0097XSEC.DWG

N:\02 – PROJECTS\2014 PROJECTS\TET 14-54E (4552-0054) ALISO CREEK ECO-SYSTEM RESTORATION, LAGUNA NIGUEL\06 DRAFTING\BAS\SHEET FILES\33-0097XSEC.DWG 5/15/2015 4:13 PM

Detail View
HS = VS: 1" = 20'
N74°W



Full Cross-Section
HS = VS: 1" = 200'
N74°W



LEGEND

- EXISTING SECTION
- ALTERNATIVE 2
- ALTERNATIVE 3
- ALTERNATIVE 4

Geologic map reference: Morton, Edgington and Fife (1974), "Geology and Engineering Geologic Aspects of the San Juan Capistrano Quadrangle, Orange County, California, CDMG Special Report 112, 1974, 64 p, map (scale 1:12,000).

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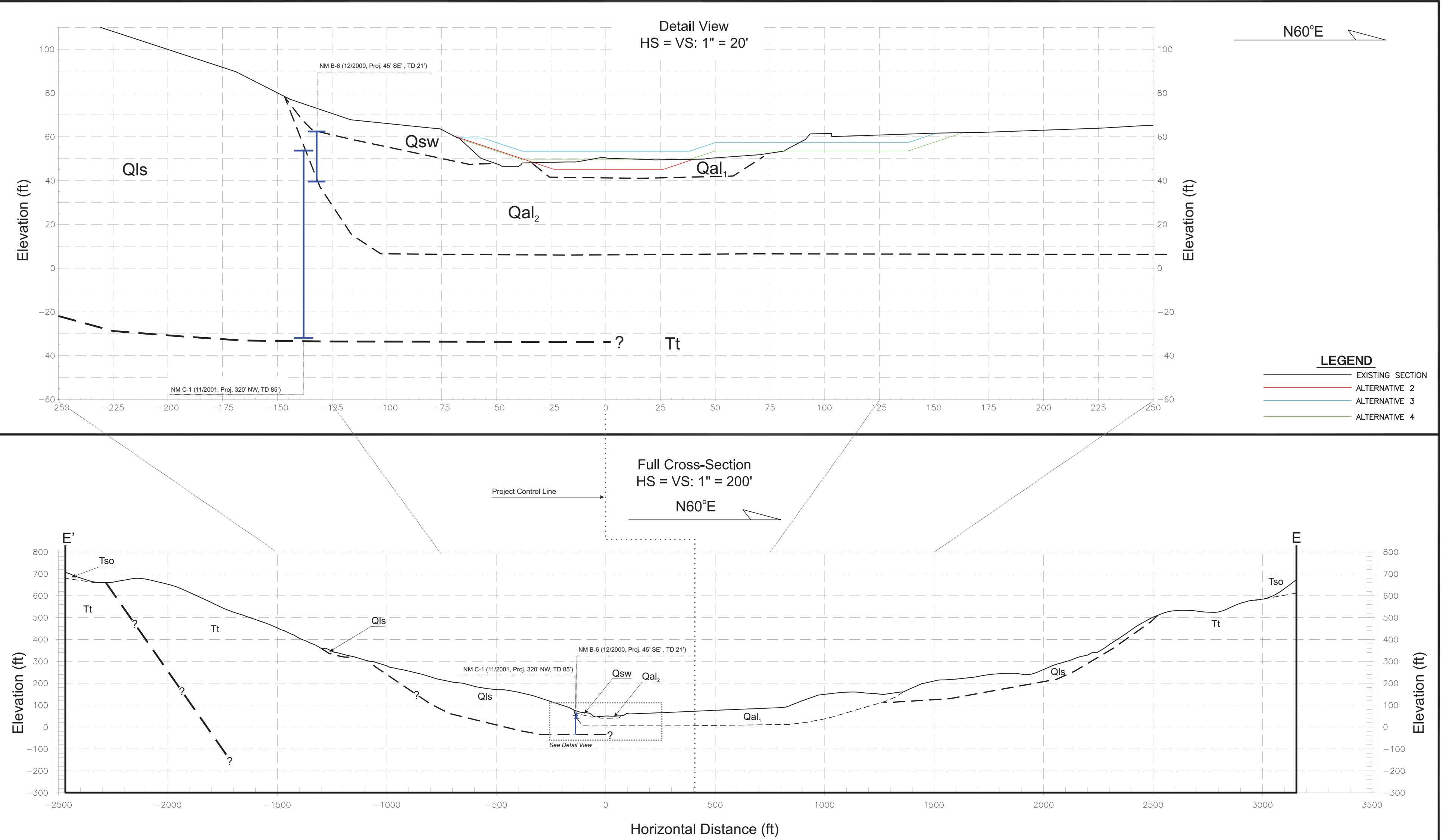
Aliso Creek Eco-System Restoration

Cross-Section D-D'

Project Control Sta. 141+82

FIGURE 1D

JOB NO.	TET 14-54E
DATE	05-2015
DRAWN BY	ABL
FILE NAME:	33-0098XSEC.DWG



Geologic map reference: Morton, Edgington and Fife (1974), "Geology and Engineering Geologic Aspects of the San Juan Capistrano Quadrangle, Orange County, California, CDMG Special Report 112, 1974, 64 p, map (scale 1:12,000).

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Aliso Creek Eco-System Restoration

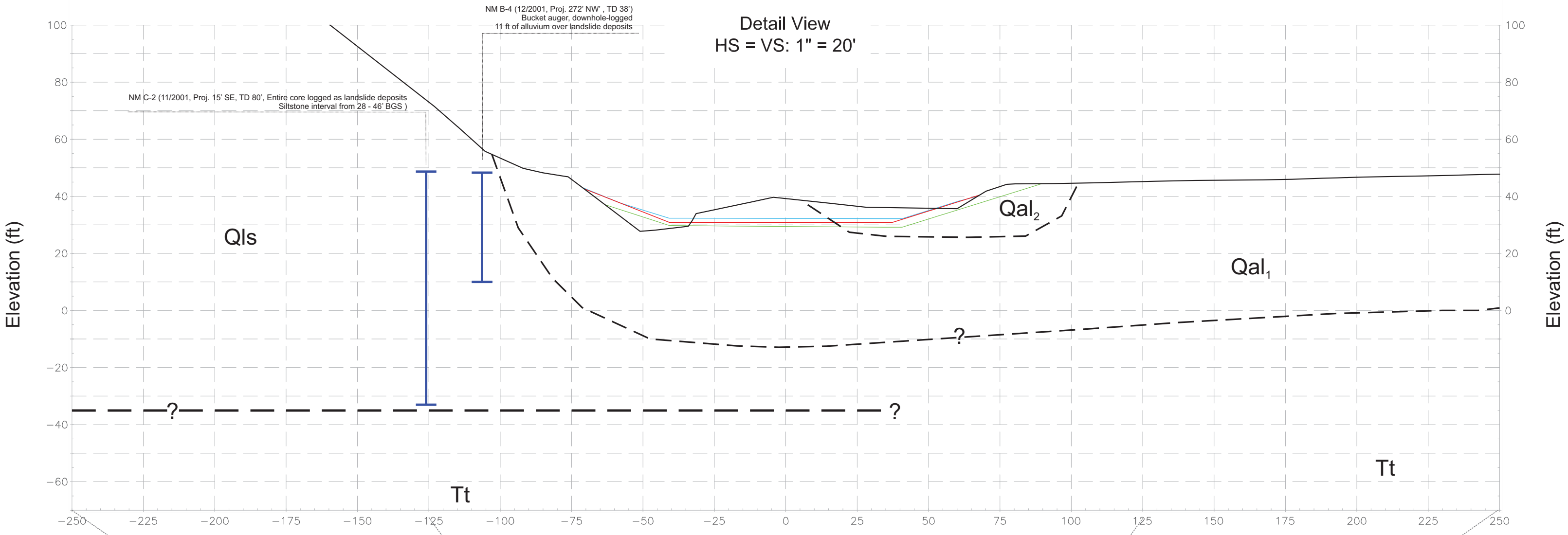
Cross-Section E-E'

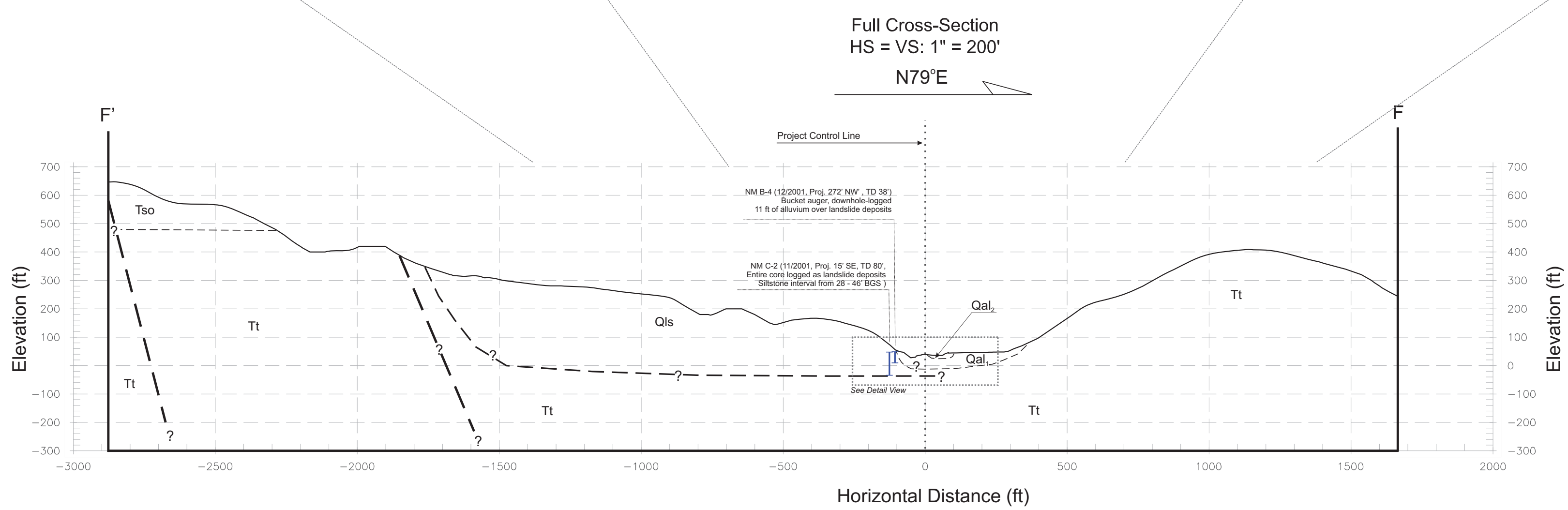
Project Control Sta. 114+57

FIGURE 1E

JOB NO.	TET 14-54E
DATE	05-2015
DRAWN BY	ABL
FILE NAME:	33-0099XSEC.DWG

N:\02 – PROJECTS\2014 PROJECTS\TET 14-54E (4552-0054) ALISO CREEK ECO-SYSTEM RESTORATION, LAGUNA NIGUEL\06 DRAFTING\BAS\SHEET FILES\33-0099XSEC.DWG 5/15/2015 4:49 PM





LEGEND

- EXISTING SECTION
- ALTERNATIVE 2
- ALTERNATIVE 3
- ALTERNATIVE 4

Geologic map reference: Morton, Edgington and Fife (1974), "Geology and Engineering Geologic Aspects of the San Juan Capistrano Quadrangle, Orange County, California, CDMG Special Report 112, 1974, 64 p, map (scale 1:12,000).

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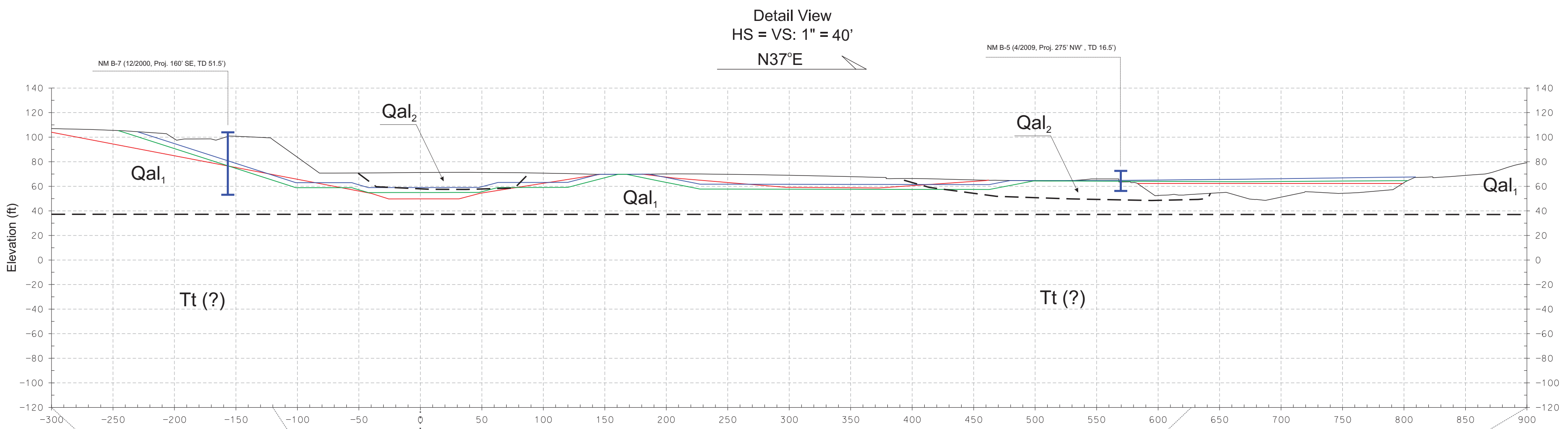
Aliso Creek Eco-System Restoration

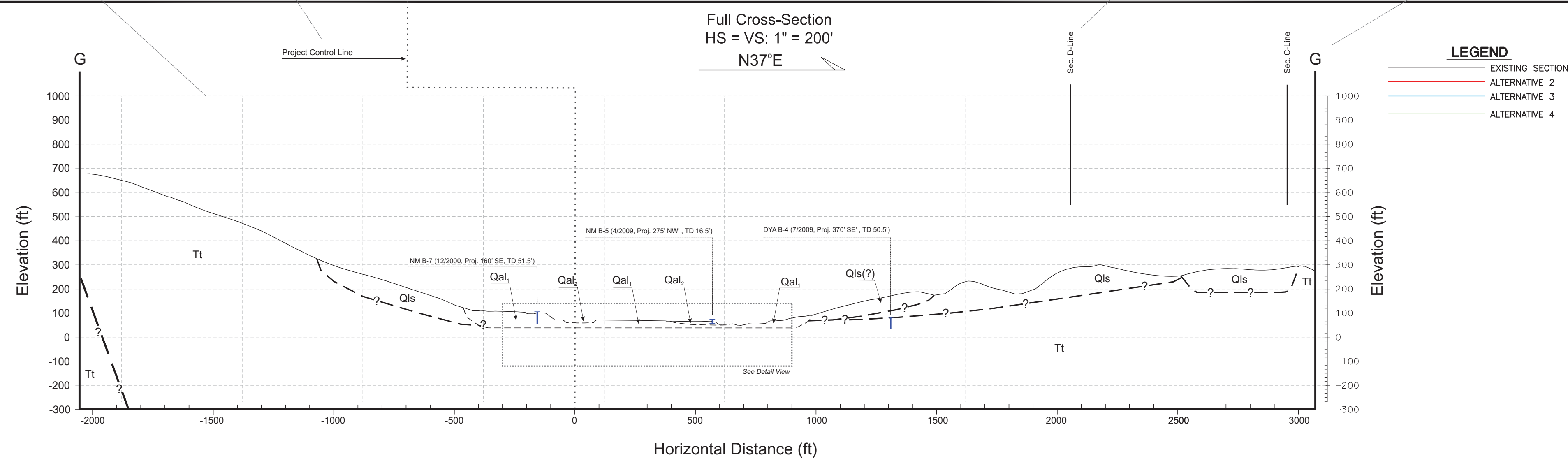
Cross-Section F-F'

Project Control Sta. 78+87

FIGURE 1F

JOB NO.	TET 14-54E
DATE	05-2015
DRAWN BY	ABL
FILE NAME:	33-0100XSEC.DWG





Geologic map reference: Morton, Edgington and Fife (1974), "Geology and Engineering Geologic Aspects of the San Juan Capistrano Quadrangle, Orange County, California, CDMG Special Report 112, 1974, 64 p, map (scale 1:12,000).

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Aliso Creek Eco-System Restoration

Cross-Section G-G'
Optional Reconnection at Oxbow
Project Control Sta. 125+60

FIGURE 1G

JOB NO.
TET 14-54E
DATE
05-2015
DRAWN BY
JPG
FILE NAME:
2015-05-27 Section G-G'

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