APPENDIX A-1a: Design Report

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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CLARIFICATION SHEET

EXPANATORY NOTE FOR DEVELOPMENT OF ALTERNATIVES

The development of the focused array of alternatives (described in Chapter 3 of the Draft IFR) consisted of assessing measures which could be combined with each base alternative (i.e. Base Alternative 2, 3, and 4) to create variations of the alternatives. Cost effectiveness and incremental cost analysis was utilized to develop cost effective alternatives.

This appendix refers to a list of the measures, also referred to as "additional measures". It should be noted some measures listed were subsequently screened out, and not carried forward in the alternatives development. Some of the names appear differently in other reports, and are noted here for clarification, if applicable.

The table below summarizes these actions.

Measure	**Other Names Used**	**Screening: Retained?**
East Bank Access Road Construction		Yes; combined with Base alt
Repurposing of AWMA Road	Old AWMA Road	Yes; combined with Base alt
Reconnection of Abandoned Oxbow		Yes
Stream Lengthening Downstream of Wood Canyon Creek Confluence	Sinuosity or Stream Lengthening downstream of Wood Canyon Creek	Yes
Wood Canyon Connection		Yes
Recontouring of Existing Channel Betwn ACWHEP and AWMA Rd Bridge		Yes
Sulphur Creek Connection		Yes, but added to base alternatives
Removal of two 10 ft high vertical drop structures		Yes
Widening in vicinity of Aliso Creek Road Bridge		Yes
Recontouring Existing Channel from 1,400 ft upstream of Aliso Creek Road Bridge to Pacific Park Drive		No
Skate Park/Soccer Field Relocation		No
Stream Lengthening at Skate Park		No
Stream Lengthening Downstream of Pacific Park Drive	Sinuosity downstream of Pacific Park Drive	Yes
Construction of Newbury Riffle Structure	Newbury Riffle Weir	Yes
FRM (Flood Risk Management) Riprap Bank Protection	Streambank Protection (Buried)	Yes, but not under FRM category
Construction of Backwater Areas		No

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ALISO CREEK ECOSYSTEM RESTORATION STUDY
ORANGE COUNTY, CALIFORNIA

TSP DRAFT
DESIGN APPENDIX
ALTERNATIVES 2, 3, AND 4

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February 2015
Revised March 2017

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EXECUTIVE SUMMARY

The study area is located in southern California, approximately 40 miles southeast of the city of Los Angeles. Aliso Creek is located in Orange County on the coast of California. The overall project area (as revised in 2009) includes the lower reaches of Aliso Creek from Pacific Park Drive (upstream limit) to the Pacific Ocean (downstream limit) plus the lower reach of Wood Canyon Creek and the lower reach of Sulphur Creek. Within the overall project limits, the design implementation will be limited to the portion of Aliso Creek between the Pacific Park Drive Bridge (upstream limit) and the South Orange County Wastewater Authority (SOCWA) Coastal Treatment Plant (CTP) Bridge (downstream limit).

Tetra Tech provided hydrologic, hydraulic, and sediment transport engineering; civil engineering design; and cost engineering services in support of the Aliso Creek Mainstem Ecosystem Restoration Study for the U.S. Army Corps of Engineers (USACE), Los Angeles District. Basic alternatives had been established previously by means of the plan formulation process associated with the SMART Planning guidelines for USACE feasibility studies. The engineering analyses in the current project were performed in support of the Tentatively Selected Plan (TSP) to assist USACE in the selection of an agency-recommended plan. This design report concerns the aspects of the project that are related to civil engineering design.

The purpose of the proposed ecosystem restoration project is to improve the stream bank and invert stability, protect the infrastructure, provide riparian habitat, and achieve aquatic wildlife connectivity within the project limits. Overall, this study evaluates four alternatives, including a “No Action” alternative (Alternative 1) under which the creek would remain in its existing condition. Alternative 2 consists of stabilizing the existing streambed downstream of the Aliso Creek Wetland Habitat Enhancement Project (ACWHEP) structure and constructing an associated floodplain within the incised channel margins. Alternative 3 is based on raising the streambed to approach the pre-incised elevations and provide reconnection to the historic floodplain to the extent possible. Alternative 4 is based on raising the streambed to an intermediate elevation between that of the current streambed and that of the historical pre-incised streambed and constructing an associated floodplain.

The development of the channel templates was guided by fluvial geomorphology principles upon which the hydrologic and hydraulic analyses were based. The channel template for Alternative 2 is a trapezoidal section with a bottom width similar to the existing geometry (~50 feet) and stable sideslopes (3 feet horizontal to 1 foot vertical). The channel template for Alternatives 3 and 4 is a compound trapezoidal section with a 100-foot-wide 2-year channel and 200-foot-wide 10-year channel.

In this design report, the goals for channel stability and aquatic wildlife connectivity that each alternative is designed to achieve are compared for the various channel reaches of Aliso Creek. The design components of each alternative are categorized as the ‘“baseline” features, which are necessary to accomplish the improvement purposes of each alternative, and “additional measures,” which are included in addition to the baseline design to provide additional benefits. The design evaluation includes other design considerations such as existing infrastructure and natural constraints, earthwork balancing, and riprap bank protection (labeled as ‘Flood Risk Management’) and geotechnical considerations such as stable bank slope, streambed protection, sheet pile wall embedment, and geologic stability. Also considered for the project were the opportunity for backwater areas and potential sites for disposing of excess earthwork material.

In the baseline design, for Alternative 2, the proposed channel template (trapezoidal section with a 50-foot-wide bottom) approximately follows the horizontal alignment and vertical profile of the existing incised channel between the SOCWA CTP Bridge and ACWHEP structure. For Alternatives 3 and 4, the 200-foot-wide, 10-year flow channel template was placed in a narrow natural valley between the existing utilities to be protected in place (east bank) and high hills (west bank). The 100-foot-wide, 2-year flow channel section, which is allowed to meander within the 10-year channel, approximately follows the horizontal alignment of the existing incised channel. The vertical profile for Alternative 3 was raised using 9-inch- and 18-inch-high riffle structures to provide the best chance for reconnection with the existing floodplain and for earthwork balance, while providing stable slopes between the riffles. The vertical profile for Alternative 4 follows intermediate elevations between those of Alternatives 2 and 4 and was achieved by installing 18-inch-high riffle structures with uniform spacing. A typical riffle structure includes a ramp portion with a 5 percent slope to cover the target height difference. For a 6-foot-high grouted riprap riffle (for an additional measure only), ridge rocks were considered along the sloped ramp portion to provide rest areas for migrating fish.

The additional measures considered for the alternatives are as follows:

A. East bank access road construction

B. Repurposing of AWMA Road

C. Reconnection of abandoned oxbow

D. Stream lengthening downstream of Wood Canyon Creek confluence

E. Wood Canyon Creek connection

F. Re-contouring of existing channel between ACWHEP and the AWMA Road Bridge

G. Sulphur Creek connection

H. Removal of two 10-foot- high vertical drop structures

I. Widening in the vicinity of the Aliso Creek Road Bridge

J. Re-contouring of the existing channel from 1,400 feet upstream of the Aliso Creek Road Bridge to Pacific Park Drive

K. Skate park/soccer field relocation

L. Stream lengthening at skate park

M. Stream lengthening downstream of Pacific Park Drive

N. Construction of Newbury riffle structure

FRM (Flood Risk Management). Riprap bank protection

BA. Construction of backwater areas

The raised streambed associated with Alternatives 3 and 4 would create more opportunity for channel breakout near ACWHEP structure, which would be removed as part of the design, and will result in better supply of water to the roots of existing vegetation because of the raised groundwater level. The compound channel section associated with Alternatives 3 and 4 will provide a wider floodplain (benches) during a flood event up to the 10-year flow. However, because of the significant incision of the existing channel, any potential channel breakout from the proposed channel, even during the 100-year flood event, would likely be contained within the channel banks in most of the areas. Therefore, the potential for flooding over the historic floodplain is limited.

The identification of areas for construction access and staging associated with the construction downstream and upstream of the AWMA Road Bridge considered potential difficulties related to access, physical constraints, and the availability of suitable areas for construction staging.

An estimate of quantities was developed on the feasibility-level for all the alternatives for use in the cost engineering appendix. Earthwork quantities for the feasibility-level design of each alternative were estimated on the basis of the three-dimensional surfaces created with MicroStation and InRoads software for use in the cost engineering. Design drawings showing the baseline design and additional measures were also prepared using Bentley MicroStation and InRoads software.

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1. Introduction

1.1 Description of Watershed

The Aliso Creek watershed, which includes Aliso Creek (main stream) and several tributaries, is located in Orange County on the coast of Southern California (Figure 1.1). It drains a long, narrow coastal watershed from the Cleveland National Forest to the Pacific Ocean. The terrain is generally hilly and varies from somewhat steep in the upper reaches to somewhat flat in the middle reaches. The lower reach has steep hillsides surrounding a narrow canyon. The 34.6-square-mile watershed includes portions of Cleveland National Forest and cities of Lake Forest, Aliso Viejo, Mission Viejo, Laguna Niguel, Laguna Hills, and Laguna Beach.

Aliso Creek is mostly a natural channel within the overall project limits from the Pacific Ocean (downstream limit) to Pacific Park Drive (upstream limit), as shown in Figure 1.2. From Pacific Park Drive to the skate park (located in Laguna Niguel), the creek is in a natural condition, flowing south and located parallel to Alicia Parkway. In the vicinity of the Aliso Creek Road crossing between the AWMA Road Bridge and the skate park, the channel is fully engineered with riprap bank protection and a soft bottom and includes two large drop structures. Downstream of the AWMA Road Bridge, the creek turns into a natural channel, and its low flow channel meanders between the existing paved road on the west bank and the dirt access road on the east bank of the creek. Aliso Creek enters the Aliso and Wood Canyons Wilderness Park just downstream of the AWMA Road Bridge. Approximately 800 feet downstream of the bridge, Sulphur Creek enters Aliso Creek from east at the wide bend, after flowing through the existing culverts underneath Alicia Parkway. Aliso Creek continues a little more than a mile before it joins Wood Canyon Creek, a tributary that drains a 3.8-square-mile subarea within the park. The combined flows continue south through a narrowing canyon. Just before the outlet at the Pacific Ocean, the creek passes through a private golf course at the mouth of the canyon and finally through a narrow strip of development around the Pacific Coast Highway within the city of Laguna Beach.

A significant structure within the project limits is the Aliso Creek Wetland Habitat Enhancement Project (ACWHEP), which was built to provide habitat along the creek banks by diverting water into the floodplain to support growth of riparian vegetation. The grouted rock structure is currently being damaged by erosion in the downstream toe area. However, the structure is apparently providing stability to the upstream channel.

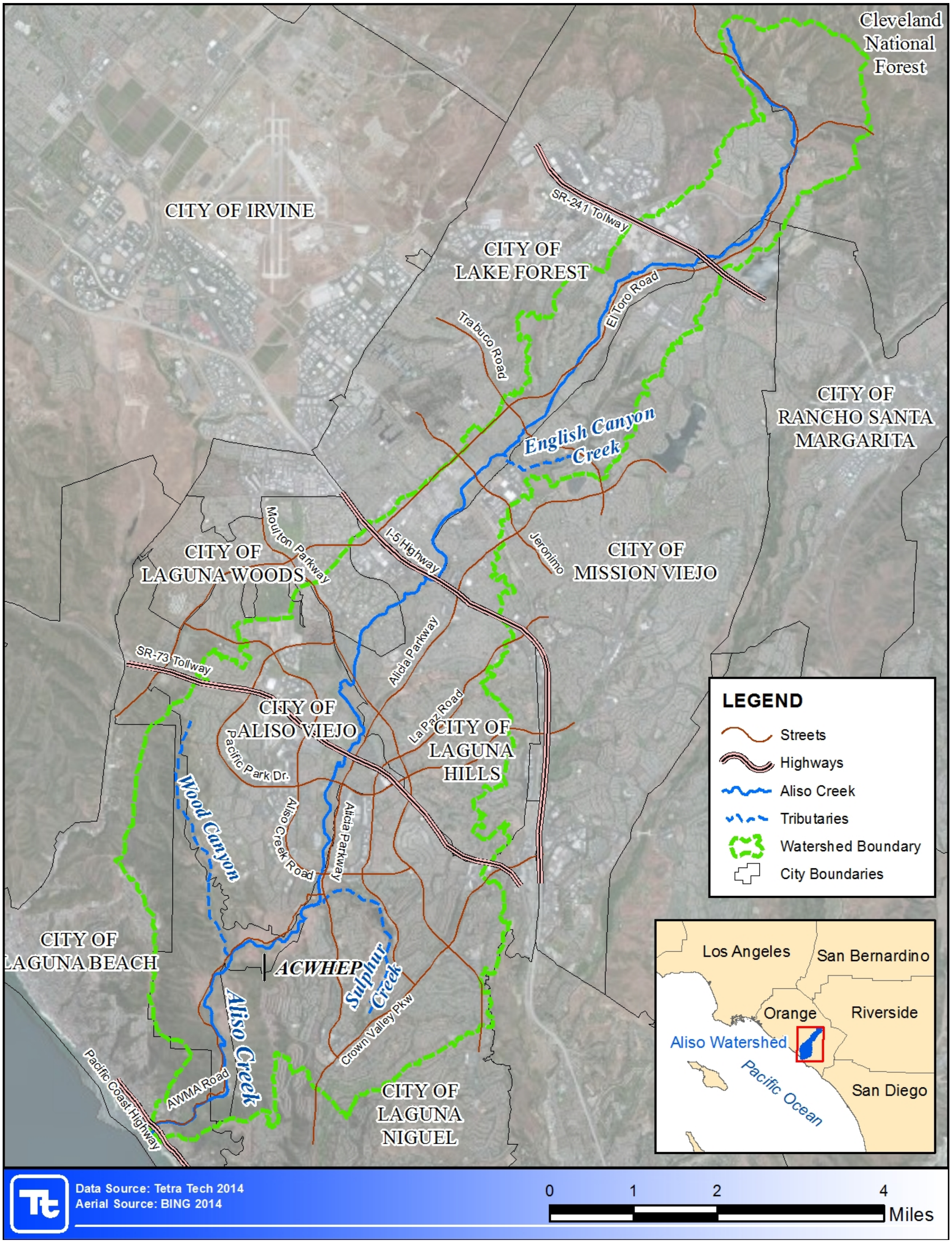

Figure 1.1 – Aliso Creek Watershed Map

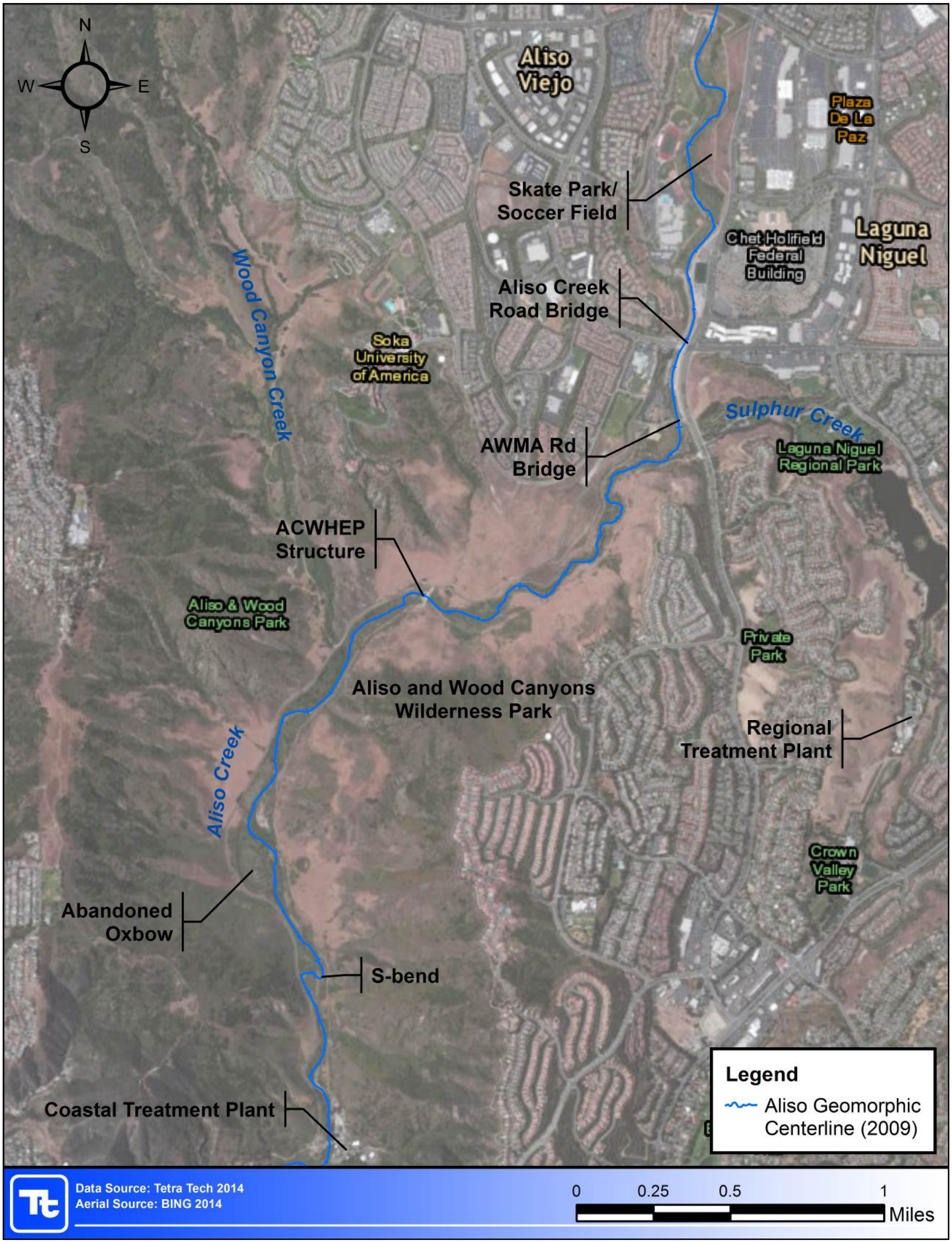

Figure 1.2 – Location Map

1.2 Purpose and Scope of Work

In support of the Aliso Creek Mainstem Ecosystem Restoration Study for the U.S. Army Corps of Engineers (USACE), Los Angeles District., Tetra Tech is contracted to provide hydrologic, hydraulic, and sediment transport engineering; civil engineering design; and cost engineering services. Basic alternatives had been established previously by means of the plan formulation process associated with the SMART Planning guidelines for USACE feasibility studies. The engineering analyses for the current project are performed in support of the Tentatively Selected Plan (TSP) to assist USACE in the selection of an agency-recommended plan. This design report concerns the aspects of the project that are related to civil engineering design.

The purpose of the ecosystem restoration project is to improve the existing stream bank and invert stability, to provide riparian habitat, to protect existing infrastructure, and to provide aquatic wildlife connectivity within the project limits. Overall, four restoration alternatives are being evaluated as part of this study.

Alternative 1 is a “No Action” alternative that reflects the existing condition along Aliso Creek. Under this alternative, no design improvements are planned; therefore, no design drawings were prepared.

The purpose of Alternative 2 (stabilizing the existing streambed and constructing associated floodplain within the incised channel margins) is to establish a stable channel geometry along the existing streambed invert that would create stabilized banks between the South Orange County Wastewater Authority (SOCWA) Coastal Treatment Plant (CTP) Bridge and ACWHEP structure.

The purpose of Alternative 3 (raising the streambed to achieve reconnection to the historic floodplain) is to formulate a feasibility design to achieve channel stabilization by providing riffle structures and stable invert slopes between them, and establishing a stable channel geometry that would create a low flow channel for the 2-year flow (Q_2) and riparian benches for the 10-year flow (Q_{10}) between the SOCWA CTP Bridge and the Pacific Park Drive Bridge. The design targeted a balance of earthwork quantities (excavation and fill placement). The ACWHEP structure and existing drop structures in the vicinity of the Aliso Creek Road Bridge would be removed or modified as necessary to create stable invert slopes.

The purpose of Alternative 4 (raising the streambed to an intermediate elevation between that of the current streambed and that of the historic pre-incised streambed) is to formulate feasibility designs to achieve channel stabilization by providing riffle structures and stable invert slopes between them, and establishing a stable channel geometry that would create a low flow channel for the Q_2 and riparian benches for the Q_{10} between the SOCWA CTP Bridge and the Pacific Park Drive Bridge. The proposed channel elevations are between the profiles of Alternatives 2 and 3. The ACWHEP structure and existing drop structures in the vicinity of the Aliso Creek Road Bridge would be removed or modified as necessary to create stable invert slopes.

For each alternative, additional design measures will be considered to evaluate their benefits and impacts on the ecosystem.

Feasibility-level design drawings have been prepared for the alternatives to show the layout of the proposed improvements (Attachment A). An estimate of quantity calculation was developed for planning and comparison purposes only, to be used as a basis for the cost estimates in the separate report, *Cost Engineering Appendix* (Tetra Tech, 2015a), prepared as part of the overall project.

Within the overall project limits, the implementation of both baseline design and additional design measures is limited to the reach between the SOCWA CTP Bridge (downstream limit) and the Pacific Park Drive Bridge (upstream limit).

1.3 Survey Mapping

For the existing topographic mapping of the project area, per the scope of work, the surveyed mappings from previous studies were merged. From the CTP Bridge to the ACWHEP structure, the channel bank-to-bank mapping based on the ground cross-sectional survey at approximately 50-foot intervals in April 2006 (provided by the Orange County Resources and Development Management Department, RDMD), was merged with the overbank area information from 2-foot-contour mapping (also provided by RDMD in February 2006).

For the area from the ACWHEP structure to the skate park, mapping with 1-foot contours generated from 1:4,300-scale light detection and ranging (LiDAR) photographs, taken in March 2008 at an altitude of 2,000 feet above the terrain, was used. This mapping covers Aliso Creek from downstream of the ACWHEP structure to upstream of the Aliso Creek Road Bridge and Sulphur Creek from the confluence to immediately upstream of the culvert under Alicia Parkway.

For the area upstream of the Aliso Creek Road Bridge near the skate park, mapping with 2-foot contours generated from LiDAR photographs, taken in August 2008 at an altitude of 3,600 feet above the terrain and provided by USACE, was used.

The horizontal control of the project topographic mapping is based on the California Coordinate System (CCS83) Zone VI, North American Datum of 1983 (NAD 83), and the vertical control is based on the North American Vertical Datum of 1988 (NAVD 88). All units are in U.S. survey feet.

Although the existing topographic mappings are based on surveys completed more than 6 years prior to this project, it was assumed that for the level of detail required for this study, these survey mappings would be sufficient to achieve the project goals. It is recommended that, in the future, a survey of current topographic conditions be conducted for the construction-level design phase of the work.

1.4 Field Investigation

The Tetra Tech team conducted a field investigation of the project area on August 27, 2014. The field investigation included a visual field assessment and documentation of existing features that affect the hydrologic and hydraulic modeling and the design of improvement features to be constructed within the project limits. Field measurements of the features were performed as necessary to supplement the topographic mappings described in Section 1.3. The main features that were assessed during the field investigation were as follows:

- Reinforced concrete box (RCB) culverts under Pacific Park Drive
- Relocation of skate park/soccer field area to be relocated
- Federal building parking lots on the east side of Alicia Parkway (potential skate park/soccer field relocation site)
- Concrete drop structures in vicinity of Aliso Creek Road Bridge
- Previously improved reach (approximately 2,000 feet long) upstream of the AWMA Road Bridge
- Bridges (Aliso Creek Road and AWMA Road crossings)
- Sulphur Creek confluence
- ACWHEP structure

- Wood Canyon confluence
- Abandoned oxbow area
- SOCWA CTP Bridge

Photographs with field notes taken during the investigation are provided in Attachment B.

2. HYDROLOGIC AND HYDRAULIC ANALYSES

The methodologies and results from the hydrologic and hydraulic analyses of existing conditions (Alternative 1) and proposed conditions (Alternatives 2, 3, and 4) are discussed in the separate report, *Hydrology and Hydraulics (H&H) Appendix* (Tetra Tech, 2015b), prepared as part of the overall project. The H&H appendix report also discusses sediment transport and scour analyses, risk and uncertainty analysis, erosion rate evaluation, and rock sizing.

2.1 Discharge Rates

Based on the hydrology analysis in the H&H Appendix report, the adopted peak discharge rates for a 2-year, 10-year, and 100-year level floods at various locations along Aliso Creek within the project limits are summarized in Table 2.1.

Table 2.1 – Adopted Peak Discharges along Aliso Creek

Location	Drainage Area (sq. mi.)	2-year (cfs)	10-year (cfs)	100-year (cfs)
Pacific Park Retention Basin Outflow	17.0	1,560	2,830	4,450
Upstream of Sulphur Creek Confluence	17.9	1,590	2,900	4,560
Downstream of Sulphur Creek Confluence	28.1	1,590	3,810	7,240
Downstream of Wood Canyon Creek Confluence	31.9	1,620	4,170	8,120
Upstream of Abandoned Oxbow	32.5	1,620	4,250	8,300
Upstream of S-Bend	33.4	1,640	4,400	8,400
Upstream of SOCWA Treatment Plant	33.8	1,650	4,450	8,550
Upstream end of Golf Course	34.3	1,670	4,550	8,610
Pacific Coast Highway	34.6	1,620	4,270	8,480

2.2 Design Channel Geometry

2.2.1 Cross Sectional Geometry

The design channel templates developed for the H&H Appendix report, are based on fluvial geomorphic principles. For Alternative 2, a single trapezoidal section with a 50-foot-wide bottom was designed (Figure 2.1). The trapezoidal section is 4.5 feet deep to contain the 2-year flow at a proposed invert slope of 0.4 percent and side slopes of 3 feet horizontal to 1 foot vertical (3[H]:1[V]). Above the 4.5-foot channel, the bank slopes extend outward at a slope of 3(H):1(V) or 5(H):1(V) until they reach daylight.

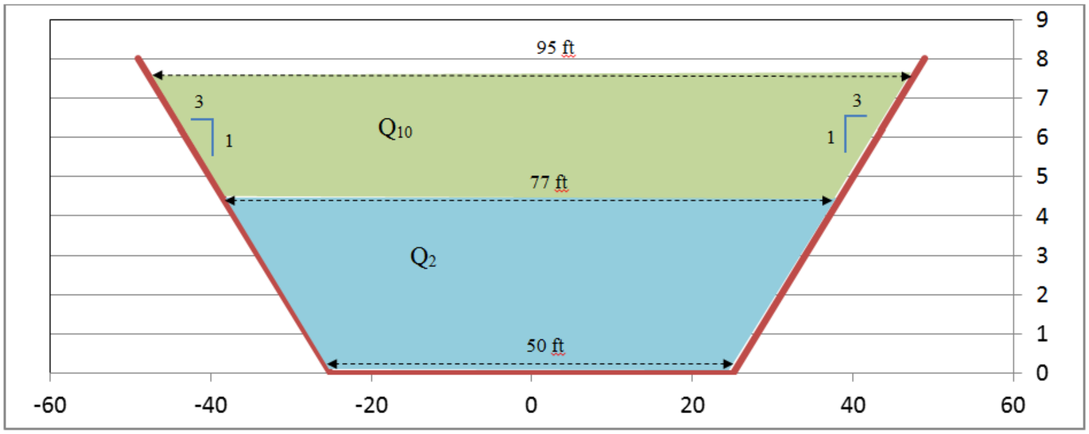

Figure 2.1 – Design Channel Template in Alternative 2

For Alternatives 3 and 4, a compound trapezoidal template with a 100-foot-wide, 2-year flow channel and a 200-foot-wide, 10-year flow channel was designed (Figure 2.2). Above the 10-year flow channel, the banks extend upward at a slope of 3(H):1(V) until they reach daylight. The targeted invert slope is approximately 0.25 percent.

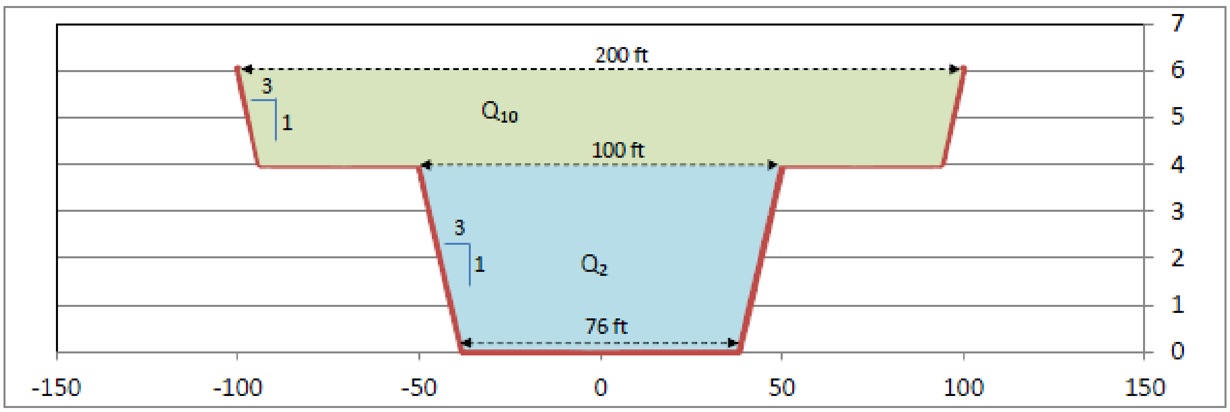

Figure 2.2 – Design Channel Template in Alternatives 3 and 4

2.2.2 Channel Profile

The maximum (equilibrium) slopes were determined in the H&H Appendix report, for channels with the given design channel templates, described in Section 2.2.1 above, and dominant discharges (2-yr and 10-year level floods) in Table 2.1. For Alternative 2, this equilibrium slope is 0.4% which is close to the existing bed slope downstream of ACWHEP structure. For Alternatives 3 and 4, the equilibrium slope is 0.25%. The H&H Appendix report states that this invert slope for Alternatives 3 and 4 is consistent with the observed bed profile in the stabilized reach upstream of the ACWHEP structure.

2.3 Flow Velocity

Based on the design channel geometry described in Section 2.2, the flow velocities were determined in the H&H Appendix report. According to the report, the resulting flow velocities for the alternatives are summarized in Table 2.2 with the higher velocities typically occurring as water flows over riffle structures (see Section 3.6 for description on riffle structures).

Table 2.2 – Subcritical Flow Velocities along Aliso Creek

	Flow Velocity (fps)								
	SOCWA CTP Bridge to ACWHEP			ACWHEP to AWMA Rd Bridge			AWMA Rd Bridge to Pacific Park Drive*		
Alternative	Q2	Q10	Q100	Q2	Q10	Q100	Q2	Q10	Q100
2	4.3 to 7.3	6.1 to 9.6	5 to 9	4.2 to 7.1	4.2 to 7.3	5.5 to 11.5	3.0 to 5.3	3.5 to 5.8	5.5 to 12
3	2.9 to 5.1	3.8 to 5.9	6 to 11	2.8 to 5.2	3.8 to 5.5	6 to 11	3.0 to 5.3	3.5 to 5.8	5.5 to 12
4	2.9 to 5.3	3.9 to 5.9	6 to 11	2.8 to 5.2	3.9 to 5.7	6 to 11	3.0 to 5.3	3.5 to 5.8	5.5 to 12

* The reach between AWMA Road Bridge and Pacific Park Drive is part of 'additional measure' features.

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3. Design Evaluation

3.1 Comparison of Design Goals Associated with Alternatives

As described in Section 1.2, this study analyzes three design alternatives for stabilizing the existing streambed and banks and providing aquatic wildlife connectivity within the project limits. As part of the baseline design, each alternative incorporates a unique combination of horizontal alignment, vertical invert profile, and cross-sectional geometry to achieve the channel stability and aquatic wildlife connectivity goals. For each alternative, localized implementation of additional design features with specific restoration goals (additional measures) is also considered to supplement the benefits of the baseline design. The channel stability and wildlife connectivity goals associated with the four alternatives are compared in Tables 3.1 and 3.2, respectively.

Table 3.1 – Comparison of Channel Stability Goals Associated with Alternatives

	Goal (Channel Stability)				
Alternative	CTP Bridge to ACWHEP	ACWHEP to AWMA Rd.	AWMA Rd. to Pacific Park Dr.	Aliso Creek to Wood Canyon Creek	Aliso Creek to Sulphur Creek
1[1]	/	/	/	/	/
2	**Yes**	**Yes** [2]	**Yes** [2]	**Yes**	No
3	**Yes**	**Yes**	**Yes** [2]	**Yes**	**Yes** [2]
4	**Yes**	**Yes**	**Yes** [2]	**Yes**	**Yes** [2]

1. Alternative 1 is an existing condition channel.
2. Stability goal is met when additional measure(s) is implemented in this reach.

Table 3.2 – Comparison of Wildlife Connectivity Goals Associated with Alternatives

	Goal (Aquatic Wildlife Connectivity [2])				
Alternative	CTP Bridge to ACWHEP	ACWHEP to AWMA Rd.	AWMA Rd. to Pacific Park Dr.	Aliso Creek to Wood Canyon Creek	Aliso Creek to Sulphur Creek
1[1]	/	/	/	/	/
2	**Yes**	Turtles only	Turtles only [3]	No	Turtles only
3	**Yes**	**Yes**	**Yes** [4]	**Yes** [4]	Turtles only
4	**Yes**	**Yes**	**Yes** [4]	Turtles only [3]	Turtles only

1. Alternative 1 is an existing condition channel.
2. Full aquatic wildlife connectivity is achieved only when there is connectivity for both fish and turtles.
3. Aquatic wildlife connectivity (for turtles only) is achieved when additional measure(s) is implemented in this reach.
4. Full aquatic wildlife connectivity (for both fish and turtles) is achieved when additional measure(s) is implemented in this reach.

Based on the various goals required for each alternative (Tables 3.1 and 3.2), the channel improvement features were designed for each alternative. The following subsections describe the design components and pertinent analyses for each alternative.

3.2 Baseline Design Features and Additional Measures

The design components of each alternative are categorized into the “baseline” design features, which are necessary to meet the improvement purpose of each alternative described in Section 1.2, and “additional measures”, which would be considered in addition to the baseline designs to provide additional benefits. The impacts and benefits of the additional measures can be independently evaluated and considered, but they need to be implemented in conjunction with the baseline designs for their benefits to be realized to the fullest extent. The additional measures from downstream to upstream are listed in Table 3.3.

Table 3.3 – List of Additional Design Measures

Additional Design Measures (from downstream to upstream)
A. East bank access road construction B. Repurposing of AWMA Road C. Reconnection of abandoned oxbow D. Stream lengthening downstream of Wood Canyon Creek confluence E. Wood Canyon Creek connection F. Re-contouring of existing channel between ACWHEP and the AWMA Road Bridge G. Sulphur Creek connection H. Removal of two 10-foot-high vertical drop structures I. Widening in the vicinity of the Aliso Creek Road Bridge J. Re-contouring of the existing channel from 1,400 feet upstream of the Aliso Creek Road Bridge to Pacific Park Drive K. Skate park/soccer field relocation L. Stream lengthening at Skate Park M. Stream lengthening downstream of Pacific Park Drive N. Construction of Newbury riffle structure FRM (Flood Risk Management). Riprap bank protection BA. Construction of backwater areas

The design components that are considered for each alternative are summarized in Table 3.4.

Table 3.4 – Design Components of Each Alternative

Alternative	Baseline Improvements	Additional Design Measures
2	Stabilize existing streambed: CTP to ACWHEP	A, B, C, D, F, H, I, J, K, L, M, N, FRM
3	Raise to historic elevation: CTP to AWMA Road Bridge	A, B, C, D, E, G, H, I, J, K, L, M, FRM
4	Raise to intermediate elevation between that of historic and existing: CTP to AWMA Road Bridge	A, B, C, D, E, G, H, I, J, K, L, M, FRM

3.3 Design Considerations

Within the project limits, Aliso Creek flows mostly in a narrow valley between existing access roads and buried utility lines running parallel to existing channel banks. The existing utilities buried along the east bank are owned and operated by the Moulton Niguel Water District (MNWD) and SOCWA; the eastern limit of the design channel will be established to protect the utilities in place. The existing access road (AWMA Road) on the west bank will be realigned farther away from the channel to accommodate the construction of the design channel as needed. However, if the access road is relocated too far away from the current alignment, the steep hills in the overbank areas would require a significant amount of earthwork (cutting of hills) in some locations.

Over the years, some existing localized measures for protecting against channel erosion were constructed by the local agencies within the project limits. These protective measures were placed under emergency conditions with minimal engineering consideration. Because these features are unlikely to provide the level of protection this project requires, it is assumed that they will be removed and disposed of as part of the channel excavation.

One of the most important design considerations is balancing out the earthwork excavation and fill quantities to the extent possible while meeting the goals and limitations of each alternative. Balancing the earthwork would minimize project costs by reducing hauling and off-site disposal of the excavated material and minimizing the need to import additional material. Because the cross-sectional geometry and invert slope of the proposed channel are dictated by the hydraulic and geomorphic requirements, the earthwork quantities would be balanced primarily by raising/lowering the entire streambed profile and varying the spacing between riffle structures and structure heights within allowable limits.

During Pre-Construction Engineering and Design phase, the final typical sections and horizontal alignment of the selected alternative can be further analyzed and adjusted to seek even more balancing of the earthwork quantities. This may require some adjustment to the hydraulic, geomorphic and design parameters used for the current analysis, and would also assess any further design changes relevant to geotechnical or cultural resource considerations.

Riprap bank protection will be constructed along both banks of the channel where the proposed channel gets too close to the banks or where an outside bend of the channel poses a higher risk of bank erosion and undermining of the existing infrastructures. This bank protection is considered as Flood Risk Management (FRM) in the economic analysis discussed in the Cost Engineering Appendix (Tetra Tech, 2015a). The locations for the riprap bank protection will be based on the risk areas identified in the previous erosion study (Tetra Tech 2012) and engineering judgment.

Within the project limits, culturally sensitive areas have been identified and considered in designing the proposed channel. Currently, the existing banks near these identified areas are steep and subject to bank failure. The proposed grading associated with the channel design places compacted fill and/or riprap on these banks to stabilize the slopes in the vicinity of culturally sensitive areas.

3.4 Geotechnical Considerations

Slope Construction

During previous field reconnaissance, several areas of oversteepened slopes within the alluvial soils exposed in the creek banks were noted. These steep slopes have been formed due to erosion of the creek bank during times of high flow in Aliso Creek and are generally in a meta-stable condition (factor of safety near unity). A preliminary evaluation of existing slopes along Aliso Creek was performed in the previous study (Tetra Tech 2012). The evaluation was based on limited strength data for the creek bank materials and, therefore, used fairly conservative assumptions regarding the shear strength of various materials. The findings indicated that slope angles to achieve a factor of safety of 1.5 varied from approximately 2(H):1(V) to flatter than 2.5(H):1(V), depending on the slope height and type of soil exposed in the creek bank. This evaluation pertained to existing slopes that were unprotected from erosion and subject to desiccation cracking. In the absence of site-specific information, slopes that will not be protected by riprap armoring or another form of slope face protection should be constructed in accordance with the recommendations in the 2012 slope evaluation. For slopes that will have slope face protection extending down to the design scour elevation, the slope may be constructed at an angle of 2(H):1(V).

It should be noted that for the No-Action Plan (Alternative 1), the near vertical slope faces found within portions of the existing creek bank will persist as continued bank erosion continues. These steep slopes will likely inhibit re-vegetation of the slope.

Streambed Protection

Where channel streambed protection (such as riffle structures) is implemented, the upstream and downstream edges of the protection should be embedded below the design scour depth. Due to the permeable nature of riffle structures, erosion due to confined underseepage is not anticipated to be a design consideration. Where grouted rock protection is proposed (such as a 6-foot-high riffle structure), filter-protected weep holes should be provided at regular intervals of no more than 50 feet.

Sheet Pile Walls

The feasibility-level design of sheet pile walls should use an embedded length of at least twice the cantilever length (or exposed length). A site-specific geotechnical investigation should be performed for the construction-level design of sheet pile wall structures. Geotechnical properties of the soil, including density, shear strength, and corrosion potential should be considered in the design.

Geologic Stability Issues

Within the project limits, 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 channel station 200+00 and predominantly Miocene-age Monterey Formation upstream of the station. The Topanga Formation has been described as yellowish to orange brown weakly to strongly cement sandstone with some reddish brown to gray weakly to moderately indurated siltstone (Ninyo & Moore 2011). The Monterey Formation is described as predominantly a marine silicious siltstone or shale, with lenticular sandstone, breccia, and conglomerate (Vedder et al. 1975). 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 channel station 170+50 to station 200+75 (Vedder et al. 1975). Quaternary-age alluvial soils overlie the bedrock within the floor of the canyon. The alluvium is generally composed of unconsolidated deposits of sand, silts, and clays that have been encountered in previous investigations to a depth of 20 feet or more below existing grade.

In several areas along the creek alignment, significant excavation of creek deposits is being considered. Some of these areas are relatively close to mapped landslides in the adjacent hillside. Current mapping indicates that none of these planned excavations will extend directly into landslide material, but they will remove alluvial soils that may sit above or adjacent to these landslides. The areas where existing landslide features within the bedrock of the adjacent hillside could impact the proposed improvements are summarized in Tables 3.5 through 3.7.

Based on the feasibility-level design alternatives and location of each landslide feature, one of the two following conditions have been found to apply:

- Condition 1 – Proposed grading may have some de-stabilizing effects on the existing landslide. Further investigation and study should be performed in future.

- Condition 2 – Proposed grading does not appear to have de-stabilizing effects on the existing landslide. However, the existing condition may have stability factors of safety below those typically required by the USACE design manuals. Further investigation and study should be considered in the future.

These recommended studies include a review of existing geologic literature and aerial photography and the development of full cross sections that include the hillside topography. Where deemed necessary, subsurface exploration of the existing landslide should be performed.

Table 3.5 – Significant Mapped Landslides Adjacent to Proposed Channel Excavation (Alternative 2)

Adjacent Extent of Mapped Landslide			Cross-Sectional Data		
Begin Approx. Station	End Approx. Station	Bank	Station	Cut/Fill at Bank Closest to Landslide [1]	Recommended Action Condition [2]
45+00	82+00	Right	70+00 to 78+00 80+00	Minor Cut/Fill Fill	2
105+00	117+00	Right	105+00	Cut (17' V)	1
			110+00 115+00	Fill Fill	2
124+00	160+00	Left	120+00 125+00 130+00 135+00 140+00 145+00 150+00 155+00	Cut (8' V) Fill Cut (8' V, 60'± H) Cut (7' V, 75' H) Fill Cut (11' V, 7' H) Cut (6' V, 50' H) Fill	1
175+00	208+00	Left	170+00 175+00	Cut (35' V, 50'± H) Cut (28' V, Sliver)	1
			180+00 184+00	Fill (No cut or fill)	2
218+00	222+00	Right			N/A
235+00	240+00	Right			N/A
208+00	240+00	Left			N/A

Note:

1. Banks to receive fill or cut obtained from Cross-Sections on Sheet Numbers C-12 through C-14 (Sta 90+00 through 184+00)
2. Recommended Action Conditions:
   - Condition 1: Proposed grading may have some destabilizing effect on the existing landslide. Further investigation and study should be performed in future.
   - Condition 2: Proposed grading does not appear to have destabilizing effect on the existing landslide. However, the existing condition may have stability factors of safety below those typically required by USACE design manuals. Further investigation and study should be considered in future.

Table 3.6 – Significant Mapped Landslides Adjacent to Proposed Channel Excavation (Alternative 3)

Adjacent Extent of Mapped Landslide			Cross-Sectional Data		
Begin Approx. Station	End Approx. Station	Bank	Station	Cut/Fill at Bank Closest to Landslide [1]	Recommended Action Condition [2]

Adjacent Extent of Mapped Landslide			Cross-Sectional Data		
Begin Approx. Station	End Approx. Station	Bank	Station	Cut/Fill at Bank Closest to Landslide [1]	Recommended Action Condition [2]
45+00	82+00	Right	70+00 to 80+00 85+00 90+00	Minor Cut/Fill Cut (8' V, 80'+ H) Cut (37' V, 150' H)	1
105+00	117+00	Right	105+00 110+00 115+00	Cut (12' V, 110' H) Cut (8' V, 15' H) Fill	1
124+00	160+00	Left	120+00 125+00 130+00 135+00 140+00 145+00 150+00 155+00	Fill Fill Fill Fill Fill Fill (19' V) + Cut (4' V) Fill (17' V) + Cut (5' V) Fill (20' V)	2
175+00	208+00	Left	170+00 175+00 180+00 185+00 190+00 200+00 205+00 210+00	Fill (24' V + Cut (3' V, 40' H) Fill (25' V) + Cut (3' V) Fill (24') Fill Cut (5') Cut (7') Cut (8') Fill	1
218+00	222+00	Right	220+00	Cut (15' V, 200'+ H)	1
235+00	240+00	Right	230+00 235+00 240+00 245+00	Cut (16' V, 150' H) Cut (20' V, 175' H) Cut (21' V, 200' H) Cut (22' V, 200' H)	1
208+00	240+00	Left	210+00 215+00 220+00 225+00 230+00 235+00 240+00	Fill (8') Cut (10'V, 110' H) Fill (15') Cut (18'V, 150' H) Fill (10') Cut (22'V, 140' H) Fill (12')	1

Note:

1. Banks to receive fill or cut obtained from Cross-Sections on Sheet Numbers C-14 through C-19 (Sta 85+00 through 325+00)
2. Recommended Action Conditions:
   - Condition 1: Proposed grading may have some destabilizing effect on the existing landslide. Further investigation and study should be performed in future.
   - Condition 2: Proposed grading does not appear to have destabilizing effect on the existing landslide. However, the existing condition may have stability factors of safety below those typically required by USACE design manuals. Further investigation and study should be considered in future.

Table 3.7 – Significant Mapped Landslides Adjacent to Proposed Channel Excavation (Alternative 4)

Adjacent Extent of Mapped Landslide			Cross-Sectional Data		
Begin Approx. Station	End Approx. Station	Bank	Station	Cut/Fill at Bank Closest to Landslide [1]	Recommended Action Condition [2]
45+00	82+00	Right	70+00 75+00 85+00 90+00	Minor Cut/Fill Minor Cut Cut (16' V, 200'± H) Cut (38' V, 225' H)	1
105+00	117+00	Right	105+00 110+00 115+00	Cut (15' V, 170' H) Cut (10' V, 40' H) Fill	1
124+00	160+00	Left	120+00 125+00 130+00 135+00 140+00	Fill Fill Fill Fill Fill	2
			145+00 150+00 155+00	Fill (15' V) + Cut (8' V) Fill (14' V) + Cut (8' V, 70'+ H) Fill (16')	
175+00	208+00	Left	170+00 175+00 180+00 185+00 190+00 195+00 200+00 205+00 210+00	Fill (20' V) + Cut (8'V, 60'H) Fill (20'V) + Cut (8'V, 50' H) Fill (22' V) + Cut (5' V) Minor Fill + Minor Cut Cut (10' V, 75'± H) Cut (11' V, 100'± H) Cut (13' V, 100'± H) Cut (12' V, 150'± H) Fill	1
218+00	222+00	Right	215+00 220+00	Cut (16' V, 80' H) Cut (16' V, 150'± H)	1
235+00	240+00	Right	230+00 235+00 240+00 245+00	Cut (17' V, 175'± H) Cut (24' V, 80' H) Cut (22' V, 190' H) Cut (23' V, 200'± H)	1
208+00	240+00	Left	210+00 215+00 220+00 225+00 230+00 235+00 240+00	Fill (7') Cut (18'V, 130'H) Fill (18') Cut (18'V, 150'H) Fill (10') Cut (23'V, 150'H) Fill (14')	1

Note:

1. Banks to receive fill or cut obtained from Cross-Sections on Sheet Numbers C-14 through C-18 (Sta 70+00 through 295+00)
2. Recommended Action Conditions:
   - Condition 1: Proposed grading may have some destabilizing effect on the existing landslide. Further investigation and study should be performed in future.
   - Condition 2: Proposed grading does not appear to have destabilizing effect on the existing landslide. However, the existing condition may have stability factors of safety below those typically required by USACE design manuals. Further investigation and study should be considered in future.

3.5 Channel

Alternative 2

Under Alternative 2, the proposed baseline design channel will have a single trapezoidal template with a 50-foot-wide bottom (Figure 3.1) and will extend from the SOCWA CTP Bridge to ACWHEP structure. The trapezoidal section includes a 4.5-foot-deep, 2-year flow channel with side slopes of 3(H):1(V). Above the 2-year flow channel, the cross-sectional geometry will extend outward at a slope of 3(H):1(V) to 5(H):1(V) until the slope reaches daylight with the existing ground. The proposed channel will keep the horizontal and vertical alignments of the existing channel while providing stabilization for steep banks.

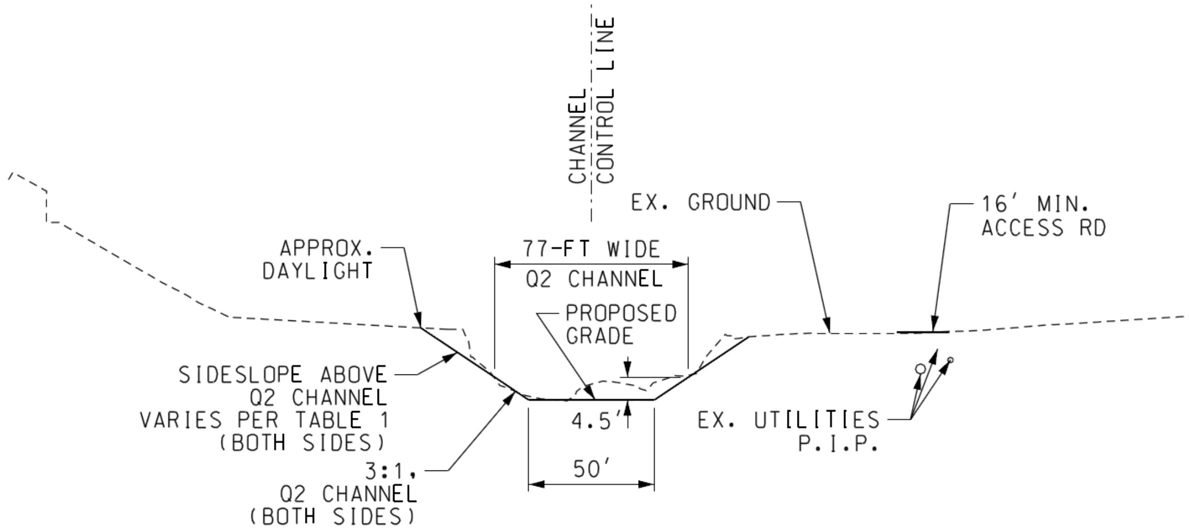


Figure 3.1 – Typical Channel Design Section (Alternative 2)

In the areas where the proposed channel gets too close to the existing utilities along the east bank, or where a sharp outside bend of the channel may erode the bank and expose the existing utilities over time, riprap bank protection will be constructed and buried under compacted fill with toedown depth of 6 feet under the channel invert to provide erosion protection against the 100-year flood event (design flood), as shown in Figure 3.2. The protection extends only 2 feet above the 100-year water surface elevation because the intent is to protect against the design flood. The riprap bank protection is considered as 'Flood Risk Management (FRM)' measure.

The horizontal alignment of the proposed channel generally follows that of the existing channel unless the proposed channel is too close to the buried utilities. In those areas near the buried utilities, the new alignment is shifted away from the bank, and riprap bank protection is provided (Figure 3.2). In the S-curve area near station 100+00, where two sharp reverse curves join, the horizontal alignment is smoothed out with two new reverse curves with larger radii.

The vertical alignment, or profile, of the proposed channel generally follows the existing streambed elevations, with a constant slope of 0.40 percent upstream from the SOCWA CTP Bridge. Because the invert slope of 0.4 percent was found to be vertically stable (based on the sediment transport analysis), no riffle structures or grade control structures are necessary for the baseline design (Tetra Tech 2015b).

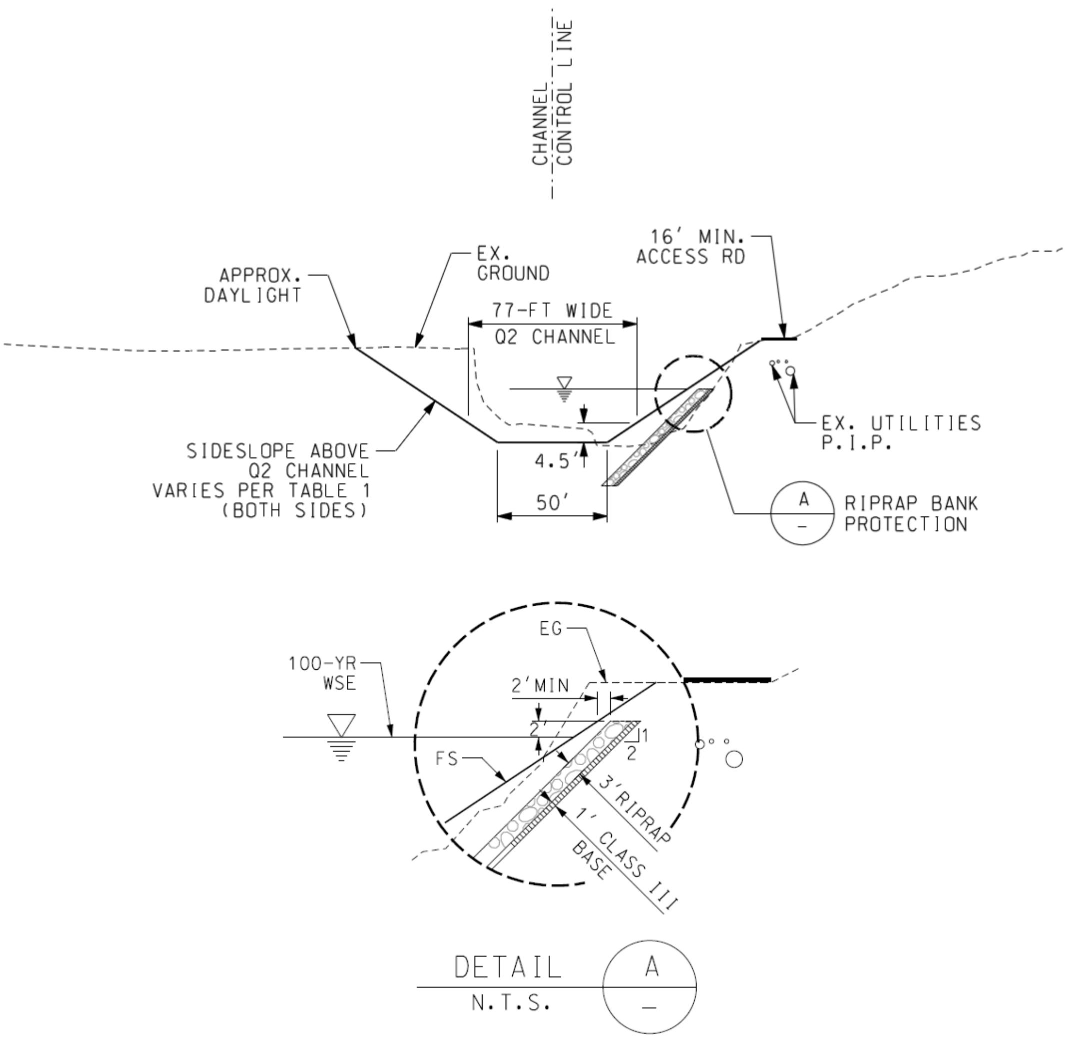


Figure 3.2 – Typical Channel Design Section at Bends (Alternative 2)

<u>Alternatives 3 and 4</u>

Under Alternatives 3 and 4, the proposed baseline design channel will have a compound trapezoidal template with a 100-foot-wide, 2-year flow channel and a 200-foot-wide, 10-year flow channel (Figure 3.3). A flow larger than the 10-year flood would break out of the compound template and, depending on the elevation of the adjacent ground, flood the existing floodplains (where possible). The flat areas immediately outside of the 2-year flow channel, but within the 10-year flow limits, are considered terraces (benches) that will provide opportunities for landscaping and plant establishment. The side slopes of the channel section above the 10-year channel will be at 3(H):1(V) to daylight with existing ground, except in the areas where the existing utilities (to be protected in place) do not allow such slopes. In these localized areas, the side slopes above the 10-year flow channel will be controlled by the horizontal locations of proposed daylights at least 5 feet away from the existing utilities [rather than by a fixed side slope, making the slopes steeper than 3(H):1(V) but flatter than 2.75(H):1(V) for bank stability].

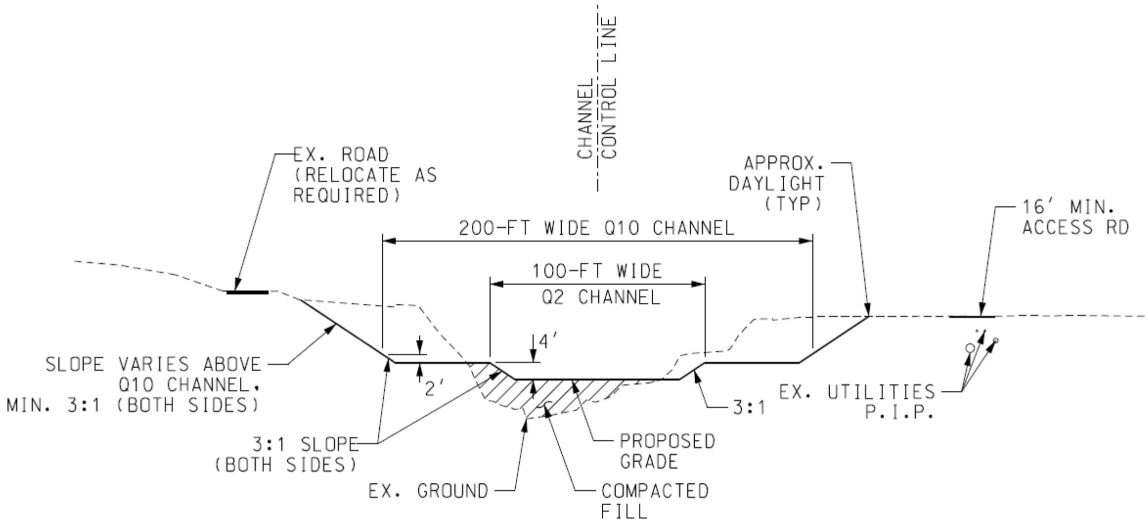


Figure 3.3 – Typical Channel Design Section (Alternatives 3 and 4)

In the areas where the proposed channel gets too close to the existing utilities along the east bank, or where a sharp outside bend of the channel may erode the bank and expose the existing utilities over time, riprap bank protection will be constructed and buried under compacted fill with toedown depth of 6 feet under the channel invert to provide erosion protection against the 100-year flood event (design flood), as shown in Figure 3.4. The protection extends only 2 feet above the 100-year water surface elevation because the intent is to protect against the design flood. The riprap bank protection is considered as 'Flood Risk Management (FRM)' measure.

The horizontal alignment of the 10-year flow channel would be determined by the existing utilities to be protected in place (east bank) and high hills (west bank), while generally following the existing channel alignment as much as possible. In the areas where the proposed channel is too close to the buried utilities, the new alignment is shifted away from the bank in addition to the riprap bank protection. In the S-curve area near station 100+00, where two sharp reverse curves join, the horizontal alignment is smoothed out with two new reverse curves with larger radii. The 2-year flow channel would be allowed to move laterally within the 10-year flow channel.

For Alternative 3, the vertical alignment, or profile, of the proposed channel would be determined based on several factors: a stable invert slope (approximately 0.25 percent as described in Section 2), allowable height and spacing of riffle structures (described in Section 3.6), existing features to be removed, and physical constraints such as bridges. For Alternative 3, various combinations of factors such as the height and spacing of the riffle structures were modeled and compared, using the MicroStation InRoads software, Roadway Modeler, before determining the profile elevations that would provide the best chance for reconnection with the adjacent existing floodplains and balancing the earthwork. Higher profile elevations downstream of the ACWHEP structure were able to generate enough fill placement quantity to allow the reuse of a significant percentage of the material excavated from the upstream reach. The variation in spacing of riffle structures was possible only downstream of the AWMA Road Bridge. Between the SOCWA CTP Bridge and AWMA Road Bridge, a total of 34 riffle structures are constructed at various spacings to cover the difference in invert elevation between the two bridges. Upstream of the AWMA Road Bridge (the reach that is considered as an additional measure), due to a large elevation difference to cover for a short distance between the bridges, only one combination of the riffle placement, which includes 18-inch- and 6-foot-high riffle structures and a channel profile slope of 0.25 to 0.45 percent, would be practical.

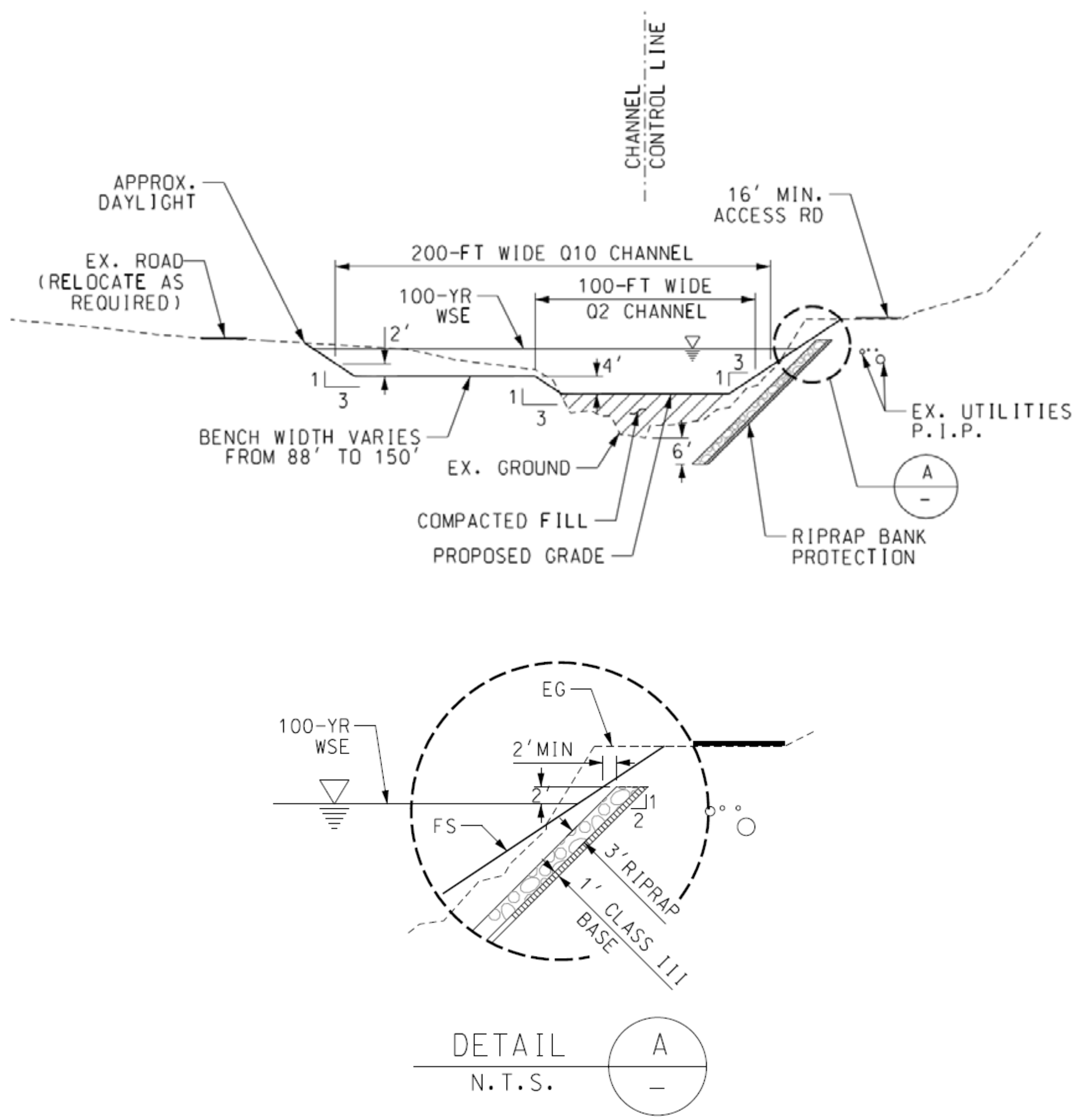


Figure 3.4 – Typical Channel Design Section at Protected Bends (Alternatives 3 and 4)

For Alternative 4, just like Alternative 3, the vertical alignment of the proposed channel would be determined based on several factors: a stable invert slope (approximately 0.25 percent as described in Section 2), allowable height and spacing of riffle structures (described in Section 3.6), existing features to be removed, and physical constraints such as bridges. Additionally, the intent of Alternative 4 is to provide lower streambed elevation at ACWHEP structure, somewhere between the profiles of Alternatives 2 and 3. However, in the vicinity of ACWHEP structure, the streambed profile of Alternative 4 is closer to that of Alternative 3 than that of Alternative 2, because of the given design constraints or factors described above. If the Alternative 4 profile was lower than the current design elevations near ACWHEP structure, higher riffles and shorter riffle spacing would be necessary upstream of ACWHEP to catch up to the AWMA Road Bridge (upstream limit of the baseline design profile).

Between the SOCWA CTP Bridge and AWMA Road Bridge, a total of 37 riffle structures are constructed at a uniform spacing of 480 feet (which is chosen within the allowable range) to cover the differences in invert elevation between the two bridges. Upstream of the AWMA Road Bridge (the reach that is considered as an additional measure), due to a large height difference to cover for a short distance between bridges, only one combination of the riffle placement, which includes 18-inch- and 6-foot-high riffle structures and a channel profile slope of 0.25 to 0.45 percent, would be practical.

Upstream of the Wood Canyon Creek confluence, between station 210+00 and station 240+00 for Alternatives 3 and 4, the existing paved AWMA Road along the west bank will be replaced with a 6-foot-wide decomposed granite (DG) road with a retaining wall and safety rail (Figure 3.5), constructed on the sideslope of the proposed channel, to accommodate the channel grading in the narrow valley portion of Aliso Creek.

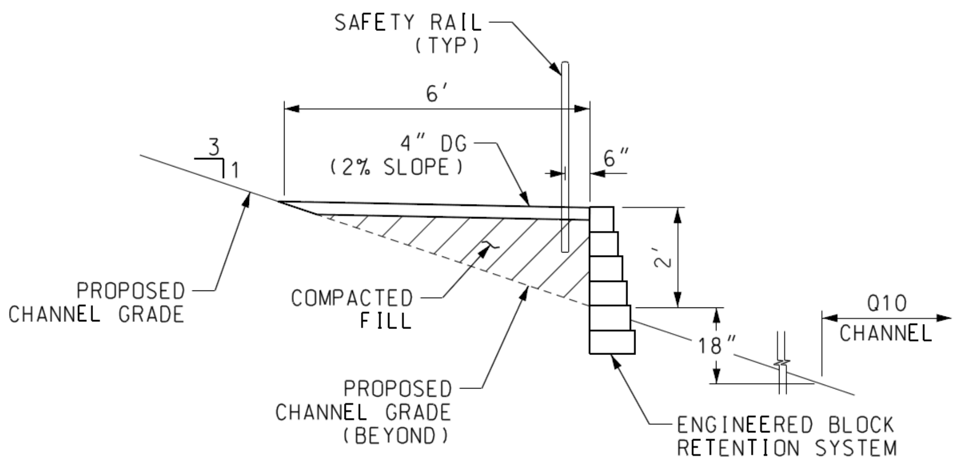


Figure 3.5 – Typical 6-Foot-Wide Decomposed Granite Road with Retaining Wall

For Alternatives 2, 3, and 4, the channel designs on the design drawings have been prepared using the MicroStation InRoads software, based on the existing condition topographic Digital Terrain Model (DTM, a three-dimensional surface model), the design channel templates, and the horizontal and vertical alignments. The InRoads-generated outputs include proposed line work and a proposed condition DTM, which is used in the quantity calculations.

3.6 Riffle Structure

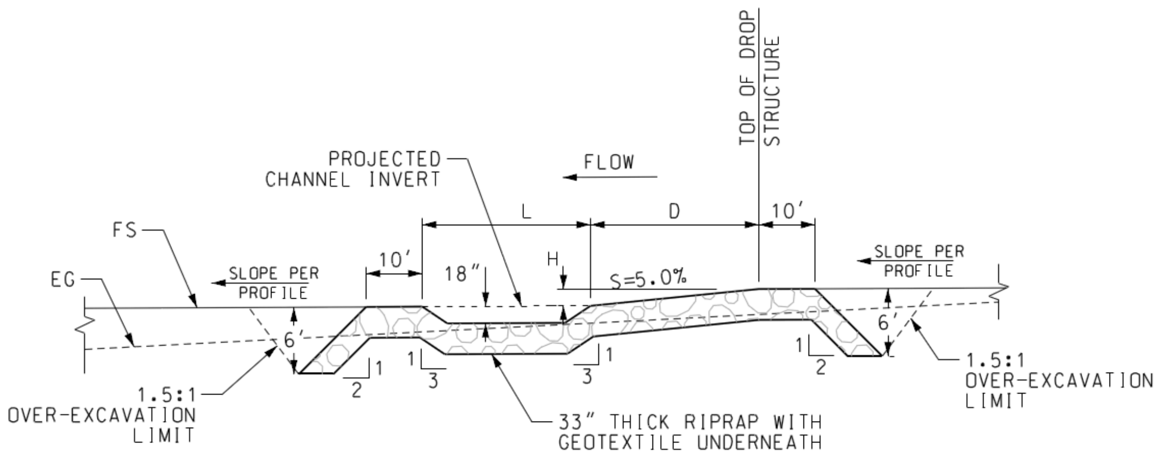
Alternative 2

Because the proposed channel invert slope of 0.4 percent was found to be vertically stable for the channel geometry of Alternative 2, no riffle structure or grade control structure is proposed (Tetra Tech, 2015b).

Alternatives 3 and 4

Based on the hydraulic analysis, the long-term stable channel slope was determined to be approximately 0.25 percent for these Alternatives 3 and 4. Due to the fact that the project invert slope (0.25 percent) is much flatter than the existing channel slope and to account for the removal of the existing drop structures and the ACWHEP structure, riffle structures would be added to accommodate the elevation differences. The riffle structures would be constructed with loose angular riprap at a minimum thickness of 33 inches (Figure 3.6). The structures will consist of 9-inch-, 18-inch-, or 6-foot-high riffles at the 5 percent maximum slope and 18-inch-deep pools immediately downstream of the riffles. Among the three, only the 6-foot-high riffle structure will be grouted because of the high flow velocity over the slope. Spacing of the structures will be varied within the allowable range (400 to 700 feet) in order to achieve the design goals. The allowable range of spacing is approximately 5 to 7 times the average channel width (Tetra Tech, 2015b).

The toedown depth, or buried depth of riprap, of 6 feet at both the upstream and downstream edges of the riffle structures, was determined on the basis of the computed local scour depths (Tetra Tech 2015b) and engineering judgment based on recent projects in the vicinity.



RIFFLE STRUCTURE DIMENSIONS

DROP HEIGHT, H	DROP LENGTH, D	POOL LENGTH, L	ROCK TYPE
9″	15′	20′	UNGROUTED
18″	30′	20′	UNGROUTED
6′	120′	30′	GROUTED

Figure 3.6 – Typical Riffle Structure (Profile View)

Based on the profiles in the design plans (Attachment A), a total of 34 riffle structures and 37 riffle structures will be constructed for Alternatives 3 and 4, respectively, under the baseline design (downstream of the AWMA Road Bridge). Additionally, for the reach upstream of the AWMA Road Bridge, a total of 5 riffle structures will be constructed as part of additional measures H and I (within the previously improved reach), and a total of 8 riffle structures will be constructed as part of additional measure J (upstream of the previously improved reach).

Riffle structures are designed to withstand the flow conditions of the 100-year flow event, including the potential local scour upstream and downstream of the structure. However, in an emergency case, if the structure is damaged or washed out, the streambed it was holding immediately upstream will be quickly washed out and eroded away. For a fail-safe protection of the riffle structures, an additional design feature such as vinyl sheet pile can be constructed across the structure and embedded along the top of structure. This way when the structure starts to lose riprap rocks, the sheet pile will ultimately hold riprap and dirt at the designed elevation until the riffle structure can be repaired.

Ridge Rock

Flow over the 5 percent sloped riffle structures can create a high velocity with relatively shallow depth, which can be adverse to fish migration. For a 6-foot-high riffle structure, providing rest areas or pools along a 120-foot-long slope for migrating fish is necessary. On the surface of the 6-foot-high riffle structures, a series of transverse ridge rocks will be placed perpendicular to the flow direction to provide zones of low flow velocity and short pool sections between the ridges to mimic natural stream flow conditions. The ridges will be constructed in accordance with *the Culverts Fishway Planning and Design Guidelines* (Kapitzke 2010). A typical series of transverse ridge rock from the guidelines that would be applied to the riffle structures can be seen in Figure 3.6A below. The ridge rocks will be constructed only within the 100-foot-wide, 2-year flow channel, because a higher flood event will create a deep enough (4 feet+) pool for fish migration. The ridge rocks will be about 30 to 40 inches high and embedded in the grouted slope. The rocks will be placed in a single row at each transverse ridge, creating V-shaped gaps between closely abutting ridge rocks. The transverse rows of ridge rock will be placed at approximately 6- to 7-foot intervals.

Figure 3.6A – Typical Series of Transverse Ridge Rock in Creek (Kapitzke 2010)

3.7 Additional Design Measures

To supplement the baseline design improvements, additional design measures are considered (see Table 3.3). The additional measures that can be implemented for each alternative are indicated in Table 3.4 and described in the following subsections.

3.7.1 Roadway Construction (Additional Measures A and B)

A permanent access road (additional measure A) will be constructed along the top of the east bank from the SOCWA CTP Bridge to Alicia Parkway near the Sulphur Creek confluence. The access road will be a paved road with a minimum width of 16 feet.

The existing paved AWMA Road (along the west bank) between the SOCWA CTP Bridge and the reinforced concrete culverts at the Wood Canyon Creek confluence will be realigned as needed to accommodate the proposed channel grading. As part of the repurposing of the road, the existing pavement will be removed and replaced with 12-foot-wide DG material along this segment (additional measure B).

3.7.2 Reconnection of Abandoned Oxbow (Additional Measure C)

As part of additional measure C, an abandoned oxbow located between stations 118+00 and 132+00 on the west side of the channel will be connected to the active channel by realigning an active stream line through the area. The horizontal alignment of the realigned stream line will follow the historical low flow channels through the abandoned oxbow area, identified in a Geomorphic Assessment Report prepared by USACE (2014), as shown in Figure 3.7.

According to Figure 3.7, which was developed with the use of aerial photographs in the Geomorphic Assessment Report (Tetra Tech 2014), from 1939 to 1964, the low flow of Aliso Creek traveled through the floodplain of the abandoned oxbow area before shifting to the current alignment. The realigned channel would follow these historical, pre-1964 stream lines and provide an opportunity to revitalize the future vegetation in the oxbow to its historical condition. The relocation would also add new stream length of approximately **830 feet** to Aliso Creek which allows the elimination of one of the riffle structures in the baseline design.

This additional design measure will be applied to Alternatives 2, 3, and 4, although the final grading of the reconnected oxbow will be different for all the alternatives, because of the differences between them in terms of the main channel profile.

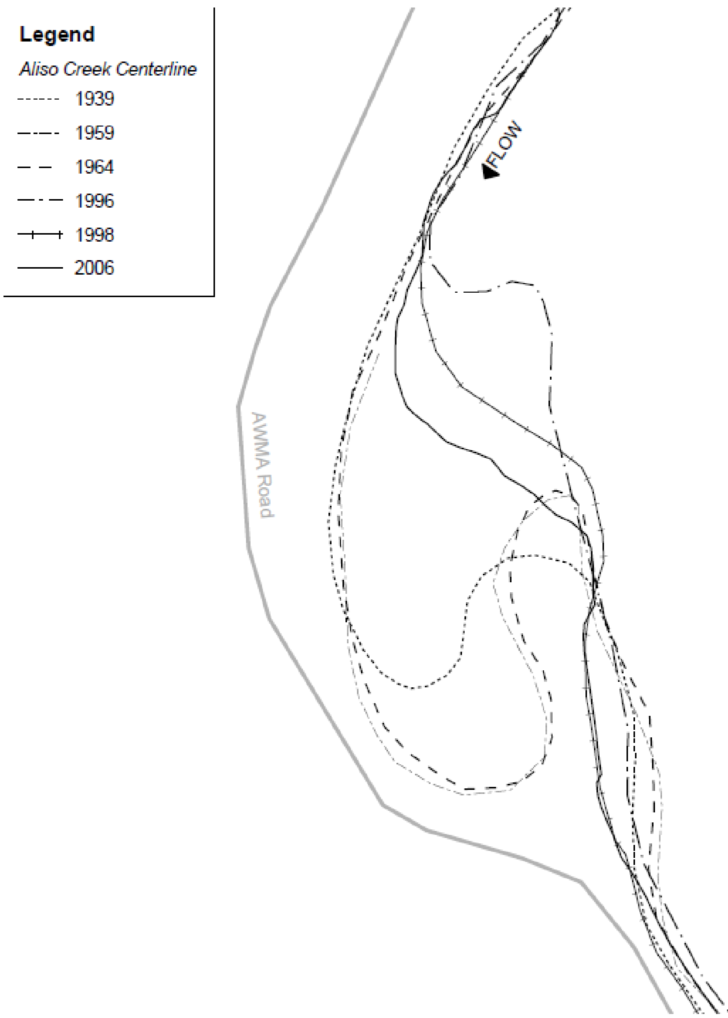


Figure 3.7 – Historical Centerlines of Aliso Creek in Abandoned Oxbow Area

3.7.3 Stream Lengthening (Additional Measures D, L, and M)

As part of additional measures D, L, and M, potential sites for stream lengthening were investigated. Stream lengthening would be achieved by zigzagging an entire channel section (zigzagging the 2-year flow channel for Alternative 2 and the 200-foot-wide, 10-year flow channel for Alternatives 3 and 4) in open fields or by adding more sinuosity to a 100-foot-wide, 2-year flow channel within the current 10-year flow channel alignment (Alternatives 3 and 4 only). Because of the existing utilities to be protected in place and the steep hills, the open fields for meandering of the 10-year flow channel alignment are limited to only three potential sites, as shown on the design plans (Attachment A): (1) a reach downstream of Wood Canyon Creek confluence (additional measure D), (2) the skate park area (additional measure L), and (3) a reach downstream of Pacific Park Drive (additional measure M). The alignments of the stream lengthening would be determined to maximize the extent of the open space. In the stream lengthening, realignment of the existing AWMA Road on the west bank was not considered because the potential realignment of the road was already maximized during the preparation of the baseline channel design. Any further realignment, or pushing out the road, would result in excessive excavation into steep hill areas at these stream lengthening sites.

As part of another additional design measure (K), the recreational complex that includes a skate park, soccer field, and associated parking lots, located on the east bank upstream of the Aliso Creek Road Bridge, would be relocated to an underutilized federal parking lot just across Alicia Parkway. This park area can be used as a stream lengthening site (additional measure L) only after the surface features of the park are relocated.

The reconnection of the abandoned oxbow area (additional measure C) would also provide the lengthening of the stream after the channel realignment is completed. However, for this project, the oxbow reconnection is not considered as an additional measure for stream lengthening. Instead, the reconnection is considered as a stand-alone additional measure because it is returning a lost element to the system versus creating new opportunities for stream lengthening as is the focus of this measure.

The potential net gain in stream length resulting from the incorporation of the stream lengthening additional measures is approximately 198 feet for Alternative 2 and 206 feet for Alternatives 3 and 4, as shown in Tables 3.8 and 3.9, respectively.

Table 3.8 – Summary of Stream Lengthening (Additional Measures for Alternative 2)

	Along Design Control Line			Additional Measure	Net Gain
	Station		Length	Length	Length
Location	Begin	End	(feet)	(feet)	(feet)
Downstream of Wood Canyon Creek	155+72	170+24	1,452	1,505	53
Near skate park [1]	272+44	286+15	1,371	1,485	114
Downstream of Pacific Park Drive	289+67	309+30	1,963	1,996	33
				Total Net Gain (feet):	**198**

1. Stream lengthening near the skate park should take place in conjunction with another additional measure, the skate park/soccer field relocation (additional measure K).

Table 3.9 – Summary of Stream Lengthening (Additional Measures for Alternatives 3 and 4)

	Along Design Control Line			Additional Measure	Net Gain
	Station		Length	Length	Length
Location	Begin	End	(feet)	(feet)	(feet)
Downstream of Wood Canyon Creek	159+57	167+69	812	871	59

	Along Design Control Line			Additional Measure	Net Gain
	Station		Length	Length	Length
Location	Begin	End	(feet)	(feet)	(feet)
Near Skate Park [1]	272+44	286+15	1,371	1,485	114
Downstream of Pacific Park Drive	289+67	309+30	1,963	1,996	32
Total Net Gain (feet):					**206**

1. Stream lengthening near the Skate Park should take place in conjunction with another additional measure, the skate park/soccer field relocation (additional measure K).

3.7.4 Wood Canyon Creek Connection (Additional Measure E)

To provide aquatic wildlife connectivity with Wood Canyon Creek, which is a tributary of Aliso Creek, a connection channel would be constructed at the confluence for Alternatives 3 and 4. A 20-foot-wide riprap-lined channel would be provided between the proposed main channel bottom and the downstream end of the existing concrete culvert at Wood Canyon Creek. Because the proposed Aliso Creek channel design raises the streambed by more than 10 feet for Alternative 3 and 5 feet for Alternative 4 at the confluence, the connection channel would have a flatter profile slope than the current profile, which includes a vertical drop immediately downstream of the culvert. For Alternative 3 only, where the streambed of the main channel is raised high enough at the confluence, a 5 percent profile slope can be achieved for the connection channel if the existing culvert is replaced with a new culvert to accommodate the target profile slope. The 5 percent profile slope would target wildlife connectivity for both pond turtles and fish.

In February 2017, USACE issued an addendum to this TSP design report to address a steep existing profile slope upstream of the existing culvert at Wood Canyon Creek (USACE 2017). This addendum discusses replacing the culvert with a bridge and extending the 5 percent profile slope further upstream along the creek for approximately 700 feet. A typical profile of the addendum design is shown in Figure 3.7 A.

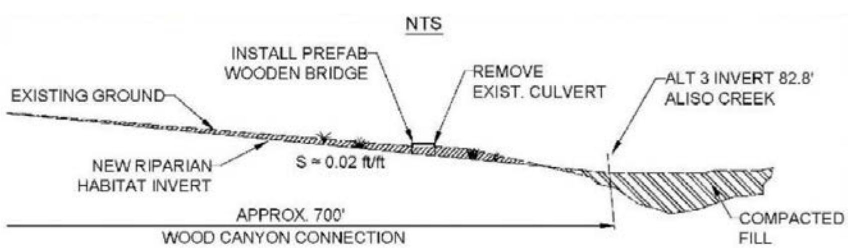


Figure 3.7A – Profile along Wood Canyon Creek from Addendum Design (USACE 2017)

For Alternative 2, the proposed Aliso Creek streambed will be at the existing invert, and any potential connection channel is likely to be as steep as the existing connection channel. Therefore, this measure is not considered for Alternative 2.

3.7.5 Re-contouring of Existing Channel between ACWHEP structure and the AWMA Road Bridge (Additional Measure F)

For Alternative 2 only, steep existing channel banks would be re-contoured, or graded, to the stable side slope of 3(H):1(V) between ACWHEP structure and the AWMA Road Bridge. The purpose of this measure is to stabilize the incised main channel and not to grade the steep hills above the floodplains. The existing streambed would not be altered in terms of elevation or width. In the areas where the steep channel banks are identified in the topographic mapping, they would be flattened by holding the existing toe of the bank in place and grading them to the design slope. In some areas along the east bank, if bank flattening would expose the buried utilities, the re-contouring may require the placement of fill to achieve the design slope.

3.7.6 Sulphur Creek Connection (Additional Measure G)

At the Sulphur Creek confluence, a short segment of Sulphur Creek between the confluence and the existing RCB culvert underneath Alicia Parkway would be raised to meet the raised streambed of Aliso Creek for Alternatives 3 and 4 as part of the baseline design. The raised channel of Sulphur Creek would be lined with riprap to protect the existing steep banks, which include the culturally sensitive area on the north bank and the existing buried utilities along the south bank. This connection would provide aquatic wildlife connectivity only for turtles.

For Alternative 2, there is no channel improvement along Aliso Creek at the Sulphur Creek confluence. Therefore, this measure is not considered for Alternative 2.

3.7.7 Removal of Two 10-Foot-High Vertical Drop Structures (Additional Measure H)

An approximately 2,000-foot-long reach in the vicinity of the Aliso Creek Road Bridge was previously improved with a soft bottom and riprap sideslopes. In this reach are two concrete drop structures with vertical drops greater than 10 feet high that will be removed as part of this project. Once the drop structures are removed, a series of 18-inch- and 6-foot-high riffle structures will be constructed along the streambed to accommodate the elevation difference over the 2,000-foot reach. The placement of the riffles will need to consider the locations and elevations of the existing utilities that cross the streambed in the vicinity of the Aliso Creek Road Bridge and protect them in place.

3.7.8 Channel Widening in Vicinity of Aliso Creek Road Bridge (Additional Measure I)

An approximately 2,000-foot-long reach in the vicinity of the Aliso Creek Road Bridge was previously improved with a soft bottom and riprap side slopes. Alicia Parkway runs along the eastern overbank, somewhat limiting channel expansion in that direction. On the western overbank, due to the existing pipeline facilities, the expansion or modification of the channel bank is impractical. Also, current bridge designs of the Aliso Creek Road and AWMA Road crossings would prevent significant channel modification in this reach without costly bridge replacements.

To provide maximum expansion of riparian habitat from the AWMA Road Bridge to approximately 1,400 feet upstream of Aliso Creek Road Bridge, a vertical sheet pile wall would be installed along the east channel bank (Figure 3.8). To protect well-established existing vegetation on the channel banks immediately upstream of the AWMA Road Bridge, the widening would start approximately 500 feet upstream of the bridge. Along this 500-foot-long transition between the bridge and the downstream limit of widening, the channel side slopes would be left unchanged; however, the streambed would need to be gradually raised along this reach to accommodate the removal of the existing 10-foot-high drop structures.

Along the widened reach, the sheet pile wall would provide enough space along the eastern side of the channel for a riparian bench with a varying width of 3 to 50 feet, while allowing the existing access road/equestrian trail to remain on top of the bank. The width of the access road would be reduced to 16 feet. It should be noted that if the access road on the east bank can be eliminated, a portion of the sheet pile would not be necessary, providing cost savings and possibly further habitat expansion. The west channel bank is to remain in place with limited modifications. On average, the riparian expansion along this reach is approximately 25 feet. The 2-year flow channel would be modified to have an average bottom width of 76 feet and a depth of 4 feet.

The construction-level design of the sheet pile wall will need to include utility openings for the existing pipelines crossing the channel near the Aliso Creek Road Bridge.

Immediately upstream and downstream of the bridges, channel transitions should be constructed between the widened sections and existing bridge abutments which would be protected in place.

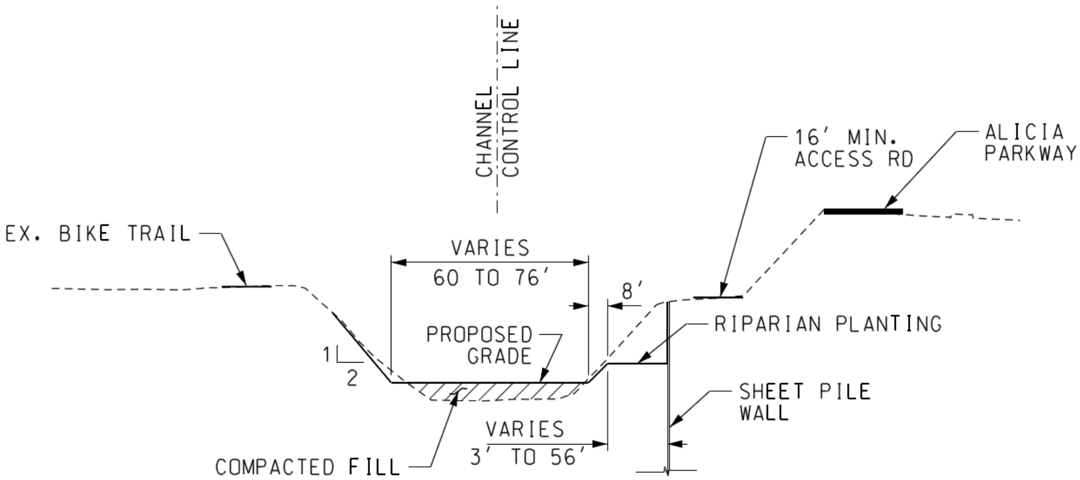


Figure 3.8 – Typical Channel Widening near Aliso Creek Road Bridge

Although this is an independent measure, the channel widening is likely to be implemented in conjunction with the removal of the two 10-foot-high vertical drop structures (additional measure H) because the channel widening would expose the sides of the drop structures if they are not removed.

3.7.9 Re-contouring of Existing Channel from 1,400 Feet of Upstream Limit of Aliso Creek Road Bridge to Pacific Park Drive (Additional Measure J)

An approximately 2,000-foot-long reach in the vicinity of the Aliso Creek Road Bridge was previously improved. The reach upstream of this previously improved reach will be re-contoured using the same design template as that used in the baseline design for Alternatives 3 and 4 and a series of 18-inch- and 6-foot-high riffle structures to provide a stable profile slope of 0.25 to 0.30 percent. This reach extends upstream from the upstream limit of the channel widening reach (additional measure I) to a point approximately 320 feet downstream of the culvert outlets at Pacific Park Drive.

The proposed channel will have a compound trapezoidal template with a 100-foot-wide 2-year flow channel and a 200-foot-wide 10-year flow channel, as shown in Figure 3.3 (Section 3.5). A flow greater than the 10-year flood would break out of the compound template and, depending on the elevations of adjacent ground, flood the existing floodplains (where possible). The flat areas immediately outside of the 2-year flow channel, but within the 10-year flow limits, are considered terraces (benches) that will provide opportunities for landscaping and plant establishment. The side slopes of the channel section above the 10-year flow channel will be 3(H):1(V) to daylight with existing ground.

3.7.10 Skate Park/Soccer Field Relocation (Additional Measure K)

The recreational complex which includes a skate park, soccer field, and associated parking lots, located on the east bank upstream of the Aliso Creek Road Bridge, would be relocated to an underutilized federal parking lot just across Alicia Parkway. The measure would include the relocation of all the surface features to the new location and the removal of earthen fill from the park footprints so that the site could be used as additional riparian habitat or a potential site for stream lengthening. The re-graded park elevations will tie into the top of bank elevations of the proposed channel geometry and have positive drainage slopes toward the channel. Also, the sheet pile wall and access road on top from additional measure “I” will need to be relocated against the embankment of Alicia Parkway.

3.7.11 Newbury Riffle Structure (Additional Measure N)

In the baseline design of Alternative 2, no grade control structure or riffle structure as used in Alternatives 3 and 4 is required for the proposed channel design to prevent vertical streambed movement (i.e., aggradation or degradation), based on the hydraulic analysis (Tetra Tech 2015b). However, in order to create shallow pools at desired depths along the streambed and limit lateral migration of the channel platform, a Newbury riffle structure, based on the restoration handbook from the Natural Resources Conservation Service (NRCS 2007), can be considered at approximately 500-foot spacing (five to seven channel widths) as an additional design measure (N) (Figure 3.9). With this spacing (500 feet), approximately 23 Newbury riffle structures would be constructed along the streambed between the SOCWA CTP Bridge and ACWHEP structure (the baseline design reach). Pools would form immediately upstream of the Newbury riffle structures up to the height of the riffles. It should be noted that additional sediment transport and hydraulic analyses are needed to verify how these structures would affect the stability of the proposed channel.

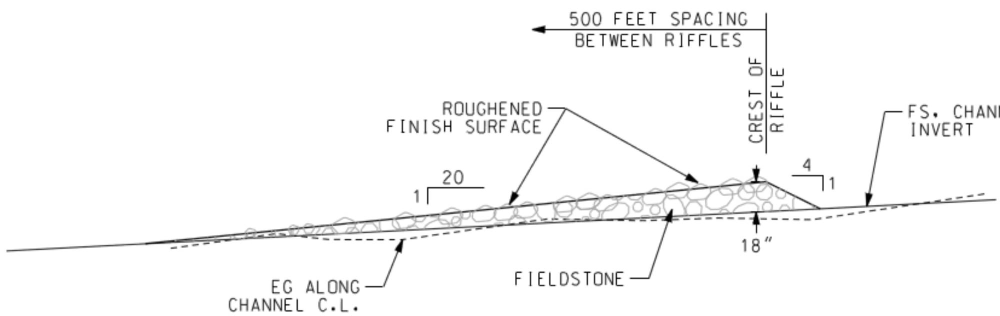


Figure 3.9 – Typical Newbury Riffle Structure (Profile View)

It should be noted that a Newbury riffle structure is not designed to raise or change streambed elevations. Therefore, it can only be used in Alternative 2 where the design streambed profile is approximately at the elevations as the existing.

3.8 Other Design Considerations

Opportunity for Backwater Areas

Areas of slow-moving water are important to aquatic wildlife species, especially during storm events. A design feature such as a Newbury riffle structure (additional measure N) would result in habitat complexity by providing pools and creating backwater areas along the streambed. These design features can be placed along straight segments of the channel to form pools behind the structures, while natural pools are typically formed on the outside bends of the curved channel segments.

Pools and backwater areas can also be created offline from the main channel. This would require sufficient space adjacent to the main channel, where the existing floodplains are graded as necessary to ensure the propagation of backwater. Potential sites for this offline backwater area are the existing oxbow, the area upstream of ACWHEP structure, and the Skate Park once its relocation is completed (additional measure K).

Disposal of Excess Material

This project involves a significant amount of earthwork in both excavation and fill quantities. A large percentage of the excavated material is expected to be transferred within the project limits to be reused as fill material. However, any excess material that cannot be reused will need to be disposed of on the adjacent floodplains to the extent possible in order to minimize costly hauling and off-site disposal. Potential disposal sites for the excess materials are identified within the project limits mostly downstream of AWMA Road (Figure 3.10). Preferably, the disposal sites should be uniformly sloped and easy to access from the construction areas. The identified sites are mostly grass lands. Fill would be placed and minimally compacted for future vegetation growth. Before any excess material is placed on these sites, a biological survey and assessment is recommended to identify any existing vegetation or species that need to be protected.

3.9 Design Impacts

The proposed channel design reshapes the existing Aliso Creek channel within its footprint. Under Alternatives 3 and 4, the design channel section, which is wider than the existing incised low-flow channel, would require excavation into the existing banks, removing existing vegetation from the streambed and banks. However, once the proposed channel is established, it is likely that vegetation would again flourish on the designed benches because the new channel design is likely to minimize channel scour and bank erosion. Replacement of the existing channel (less than 80 feet wide) with a 200-foot-wide compound channel would create a wider floodplain (on benches) and more opportunity for planting to accommodate a flood event up to the 10-year flow. Furthermore, the existing vegetation outside the channel is likely to also benefit because the raised streambed downstream of the ACWHEP structure (under Alternatives 3 and 4) would not only increase the chance of potential flooding of the floodplain, but also raise the groundwater table supplying water to the plant roots.

It should be noted that, according to the results of the hydrologic and hydraulic analyses performed as part of this study (Tetra Tech 2015b), any channel breakouts for both Alternatives 3 and 4 are localized and mostly contained within the steep banks of the incised channel. Consequently, the increase in floodplain size does not significantly improve connection with historic floodplains for the alternatives with raised bed. This is the result of multiple project constraints (see Section 3.3 for design considerations) that were imposed on the design alternatives to achieve geomorphic channel stability and aquatic wildlife connectivity within the project limits. The area that would benefit most from potential

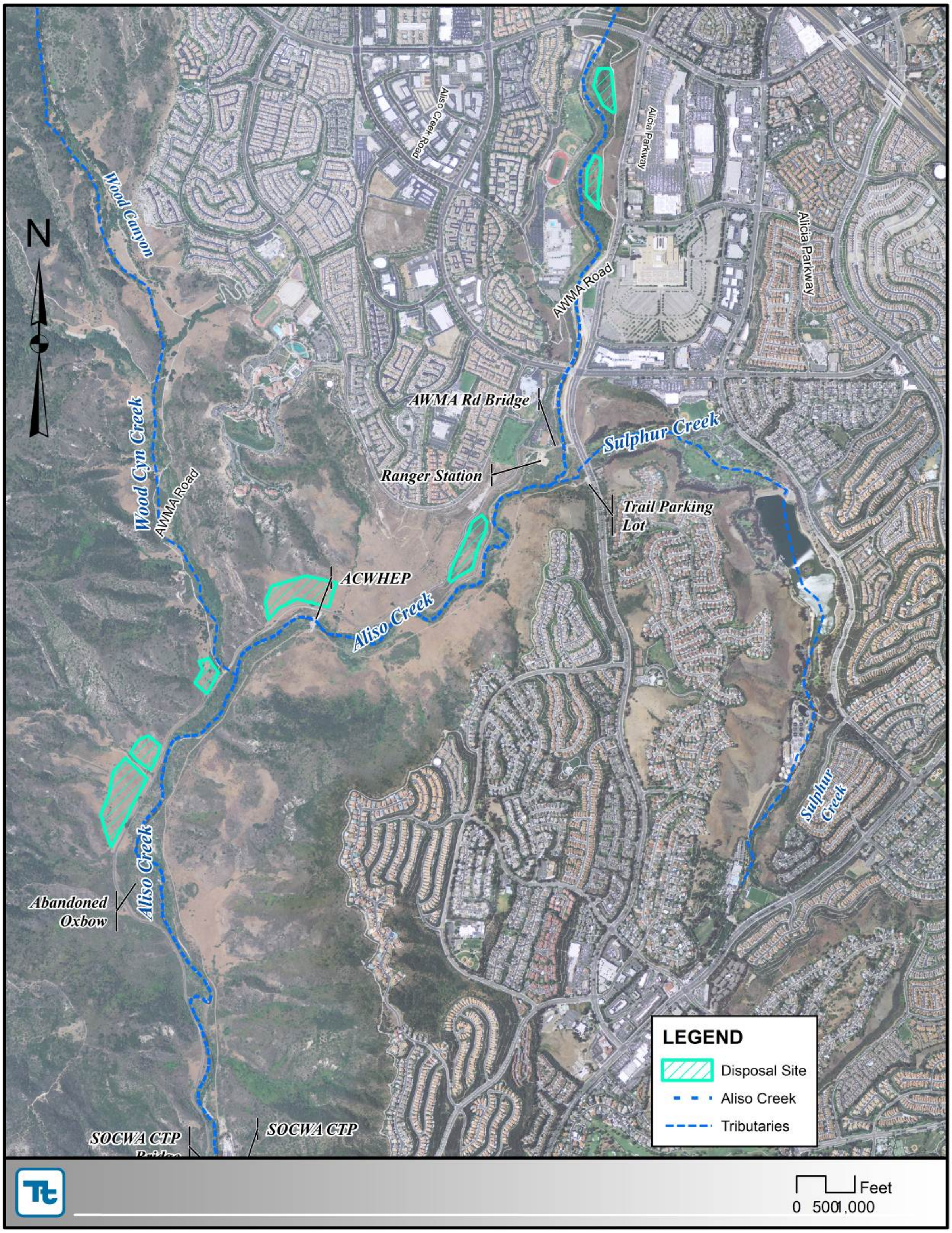


Figure 3.10 – Potential Disposal Sites for Excess Material

flooding during the 100-year storm is the area immediately downstream of ACWHEP structure (Alternatives 3 and 4), because the streambed is raised the most in this particular area after the removal of the ACWHEP structure. However, the flooding in this area would still be limited because of the incised condition of Aliso Creek. In the next phase of this study, localized design features and other opportunities that would improve the floodplain reconnection further should be considered.

The removal of the existing drop structures, including the ACWHEP structure and two 10-foot vertical drop structures in the vicinity of the Aliso Creek Road Bridge, and their replacement with the mild-sloped ramps of the riffle structures would enhance aquatic connectivity within the project limits. Also, raising the streambeds and providing riprap ramps (Alternatives 3 and 4) at the Wood Canyon Creek confluence would provide aquatic connectivity for fish and/or turtles between the main channel and the tributary.

Once the proposed improvements have replaced the current steep banks with flatter (3[H]:1[V]) and more stable banks, the existing utilities buried along the east channel bank would be protected from bank erosion and potential bank failure, which would expose the utilities. The riprap bank protection placed on the outer bends of the low flow channel would provide further protection for these banks and buried utilities.

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4. CONSTRUCTION CONSIDERATIONS

4.1 Construction Access and Staging Areas

For construction downstream of the AWMA Road Bridge, the points of project entrance and exit would be located at either the trail parking lot off Alicia Parkway just south of Sulphur Creek, which leads to the existing dirt access road, or the ranger station near the bridge, which leads to the paved AWMA Road along the west bank of Aliso Creek (Figure 4.1). Potential staging areas include the trail parking lot, an open space in the vicinity of the ranger station, and relatively flat open spaces along the east bank and downstream of the Wood Canyon Creek confluence along the west bank. The potential staging areas were selected on the basis of factors such as minimal removal of existing vegetation, the footprints of the proposed improvements, and a relatively flat and uniform ground slope (~2 percent). Open fields in the vicinity of the abandoned oxbow and beyond the construction access roads have an average ground slope of about 5 percent and may be considered as optional staging areas.

For construction upstream of the AWMA Road Bridge, the points of project entrance and exit would be located at either the maintenance access at the bridge, which leads to a dirt access road along the east bank of Aliso Creek, or the parking lot access to the skate park off Alicia Parkway, which leads to a dirt access road along the east bank (Figure 4.2). Potential staging areas include flat open spaces on the east bank upstream of the skate park. If the relocation of the skate park (an additional measure) becomes part of the construction, a phasing plan may be necessary to accommodate the channel construction and the park relocation.

The size and number of the potential staging areas are based on the availability of areas that would meet the staging area requirements, rather than the actual construction needs. Because the use of these areas is likely to require the removal of existing vegetation, a biologist should be consulted to ensure the appropriateness of these areas.

As described in Section 3.3, *Design Considerations*, one of the primary design considerations for the project is a balance of the earthwork quantities (excavation and fill) to the extent possible, which would minimize the quantities of imported soil and the quantities excess materials requiring off-site disposal. However, achieving a balance between excavation and fill may also require frequent transfers of excavated material between the upstream and downstream areas. Because of the limited height underneath the bridges, vehicles hauling the material may need to drive along Alicia Parkway even for a short distance, which would require frequent traffic control.

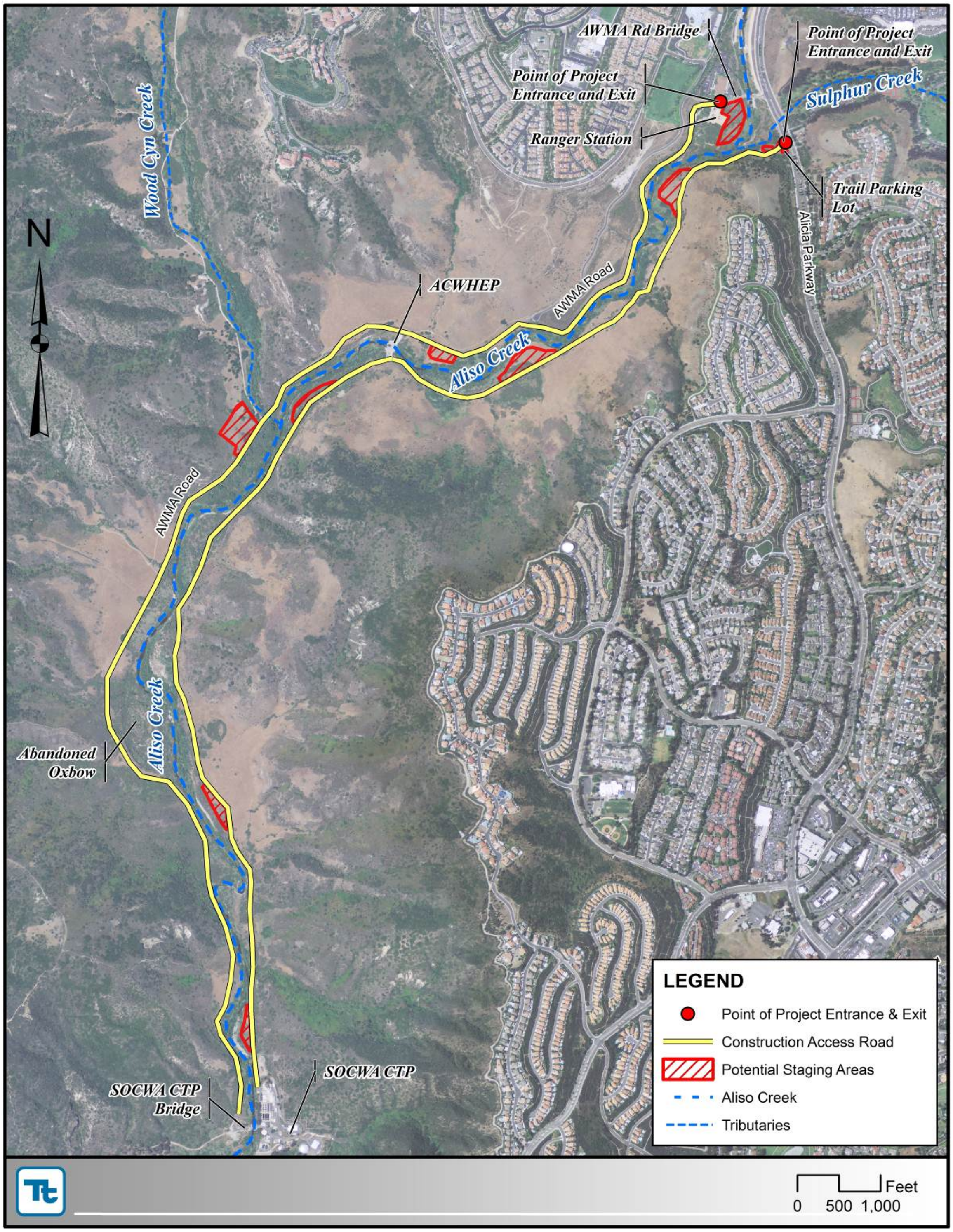

Figure 4.1 – Construction Access Roads and Staging Areas (Downstream of AWMA Road Bridge)

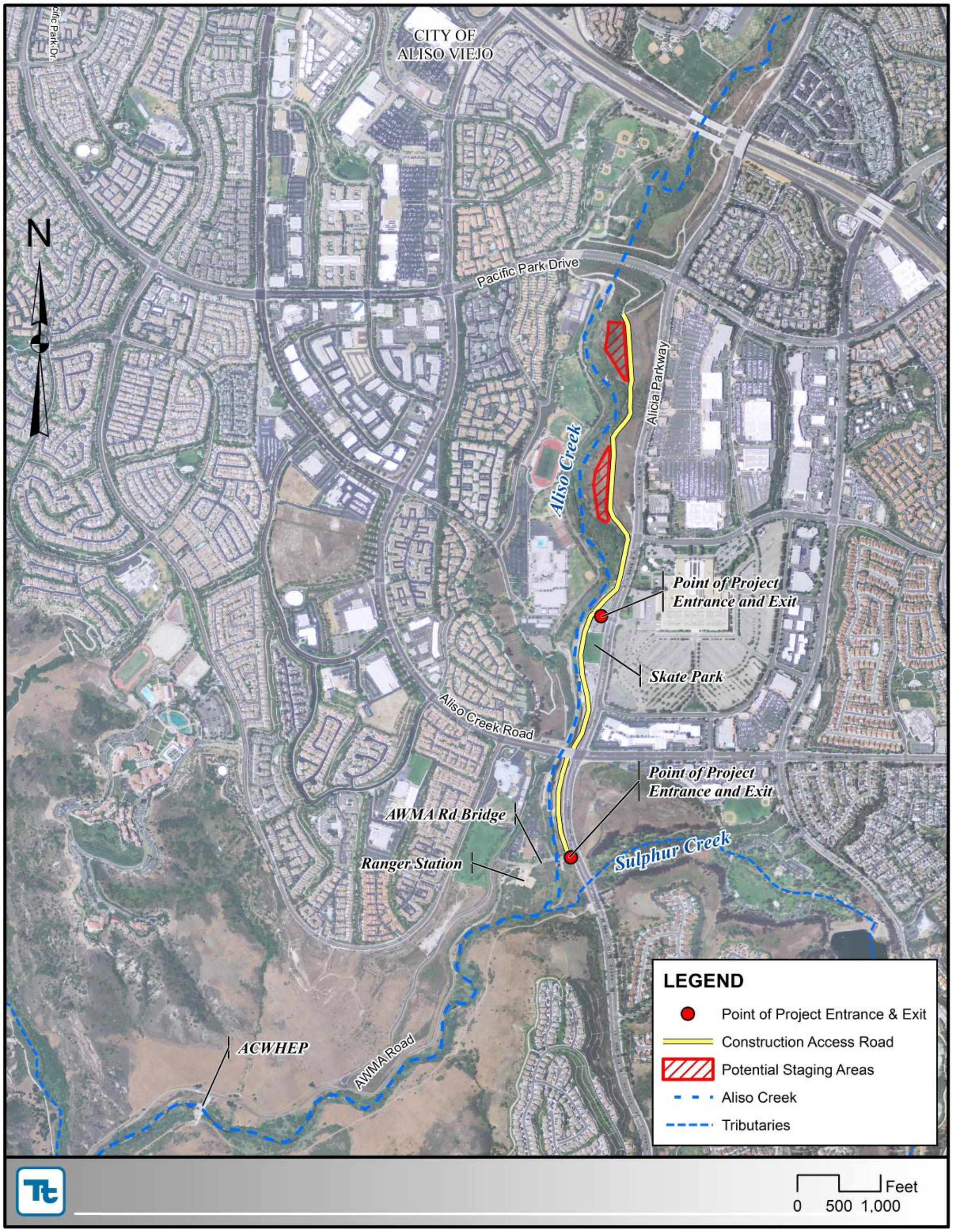

Figure 4.2 – Construction Access Road and Staging Areas (Upstream of AWMA Road Bridge)

4.2 Diversion and Control of Water

Aliso Creek is a perennial stream, and the control of water during construction would be important. Because the footprint of the proposed channel follows the existing channel alignment and is wider than the existing channel, the entire channel flow would need to be diverted at the upstream end of the construction reach, by means of a diversion pipe or other methods. Considering the length of the proposed channel (approximately 4.8 miles) and the impracticability of diverting flow over the entire channel length, the construction should be divided into multiple construction reaches and phased. The construction may take place in an individual reach or in more than one reach at the same time, preferably starting from the downstream end. However, for Alternatives 3 and 4, because of the project requirement for reuse or on-site disposal of excavated material as much as possible, construction in phases may require paring of an upper construction reach (net excavation) with a lower construction reach (net fill placement). This method of paring would allow the immediate transfer of excavated material from one reach to another without stockpiling for an extended period. The reach division should be determined on the basis of the physical construction constraints (such as the bridges and ACWHEP structure) and the need for and practicality of diverting water, in addition to other construction needs and environmental requirements.

Any runoff generated within the project limits during the construction period should be handled in accordance with the guidance and requirements of the project-specific Stormwater Pollution Prevention Plan (SWPPP). All other construction activities should adhere to the requirements of SWPPP. Construction within the channel during the rainy season would be in accordance with the environmental requirements of federal, state, and local permits.

5. QUANTITY CALCULATIONS

An estimate of project quantities was developed for the feasibility-level design alternatives (Alternative 2, 3, and 4) on the basis of the typical sections in Section 3, surface volume calculations using MicroStation and Bentley InRoads software, and engineering calculations.

The quantities are broken down into multiple reaches for consistency with the Cost Engineering Appendix (Tetra Tech, 2015a). Based on a previous hydrology and hydraulic analysis (USACE 2009), Aliso Creek from the Pacific Ocean to the Pacific Park Detention Basin in Aliso Viejo was divided into 14 individual reaches along Aliso Creek and 1 additional reach for Wood Canyon Creek, a tributary, each with similar hydraulic and geomorphic characteristics within itself. For the quantity calculation and subsequent cost engineering associated with this current study, nine of the individual reaches are within the Aliso Creek design implementation limits of Aliso Creek (Table 5.1).

Table 5.1 – Summary of Reach Breakdown

Reach No.[1]	Downstream Limit		Upstream Limit	
	Station	Description	Station	Description
4	69+70	SOCWA CTP Bridge	133+00	Upstream limit of Abandoned Oxbow
5	133+00	Upstream limit of Abandoned Oxbow	167+80	Wood Canyon Creek Confluence
6	167+80	Wood Canyon Creek Confluence	185+50	ACWHEP Structure
7	185+50	ACWHEP Structure	211+00	Channel Bend (near 15' high banks)
8	211+00	Channel Bend (near 15' high banks)	245+19	Sulphur Creek Confluence
9	245+19	Sulphur Creek Confluence	261+85	Ex. Concrete Drop Structure No. 1
10	261+85	Ex. Concrete Drop Structure No. 1	275+73	Ex. Concrete Drop Structure No. 2
11	275+73	Ex. Concrete Drop Structure No. 2	302+00	Ex. Riprap Drop Structure near Foxborough Park
12	302+00	Ex. Riprap Drop Structure near Foxborough Park	331+33	Pacific Park Drive

1. The original reach numbers are based on the USACE's 2009 report, Aliso Creek Mainstem Restoration Study (USACE 2009).

Earthwork quantities were calculated by developing three-dimensional surfaces, or DTMs, using MicroStation and Bentley InRoads software. The existing surfaces were based on previous surveys performed for various projects, as described in Section 1.4. The proposed surfaces were developed by running multiple design templates along vertical and horizontal alignments defined in Bentley InRoads. The earthwork quantities were then determined by calculating the difference in volume between the existing surface and the proposed surface. With this process and adjustment for riprap structures, excavation quantities and fill quantities for channel grading associated with the baseline designs of the alternatives were calculated (Table 5.2). A shrinkage factor of 10 percent, which was an average value, based on the previous geotechnical reports available, was incorporated into the fill quantity prior to subtracting it from the excavation quantity to determine the net earthwork quantity.

Table 5.2 – Summary of Earthwork Calculations (Baseline Designs)

Alternative	Excavation (cubic yards)	Fill (cubic yards)	Net (cubic yards)
2	224,600	50,300	169,300
3	566,900	487,200	31,000
4	884,300	279,400	577,000

In Table 5.2, the baseline design for Alternative 2 whose limits are between the SOCWA CTP Bridge and ACWHEP generated far less volumes of both excavation and fill when compared to Alternatives 3 and 4 whose limits are between the SOCWA CTP Bridge and AWMA Road Bridge. Between Alternatives 3 and 4, Alternative 4 whose streambed profile is lower than that of Alternative 3 generated more excavation while providing less opportunity to place fill.

No subsurface analysis was performed for this study, and an updated geotechnical exploration may alter the quantities calculated. Additionally, the existing topographic mapping for the design was created by merging multiple files from several previous projects (dated between 1998 and 2008) in the area per the Scope of Work. Therefore, the accuracy of the quantity calculation is limited by the accuracy of the existing topographic mapping that is a composite of survey results obtained more than 6 years before this project.

The quantity calculations for the baseline designs of Alternatives 2 through 4 are summarized in Tables 5.3 through 5.5, respectively. The quantity calculations for FRM are summarized in Table 5.6. The quantity calculations for additional measures A, B, E, F, G, H, I, and J for Alternatives 2 through 4 are summarized in Table 5.7. The quantity calculations for additional measures C, D, L, and M for Alternatives 2 through 4 are summarized in Tables 5.8 through 5.10, respectively. The quantity calculations for additional measure K are summarized in Table 5.11.

Table 5.3 – Summary of Quantity Calculations (Alternative 2, Baseline Design)

				Quantity Breakdown by Reach								
				Study Reach No.								
				4	5	6	7	8	9	10	11	12
No.	Contract Items	Unit	Net Quantity	CTP Bridge (Sta. 69+70) to Abandoned Oxbow (Sta. 133+00)	Abandoned Oxbow (Sta. 133+00) to Wood Canyon Creek Confluence (Sta. 167+80)	Wood Canyon Creek Confluence (Sta. 167+80) to ACWHEP (Sta. 185+50)	ACWHEP (Sta. 185+50) to High Banks (Sta. 211+00)	High Banks (Sta. 211+00) to Sulphur Creek Confluence (Sta. 245+19)	Sulphur Creek Confluence (Sta. 245+19) to Ex. Drop Structure No.1 (Sta. 261+85)	Ex. Drop Structure No.1 (Sta. 261+85) to Ex. Drop Structure No.2 (Sta. 275+73)	Ex. Drop Structure No.2 (Sta. 275+73) to Foxborough Park (Sta. 302+00)	Foxborough Park (Sta. 302+00) to Pacific Park Drive (Sta. 331+33)
	Baseline Design											
1	Clearing and Grubbing	AC	56.85	37.92	12.13	6.80						
2	Excavation (Channel Grading)	CY	224,600	96,700	80,900	47,000						
3	Compacted Fill (Channel Grading)	CY	50,300	17,600	21,700	11,000						
	Net Earthwork (Net Excavation)	CY	**169,300**	**77,300**	**57,000**	**34,900**						
4	Riprap Downdrain for Ex. Pipe Outlet	EA	5	3	2	0						
5	Ex. Storm Drain Outlet Modification	EA	0									
6	Hydroseed Slopes	SY	79,306	52,337	20,593	6,376						
7	Landscape Improvements	LS	1									
8	Riprap Protection at Wood Canyon Creek Confluence	CY	340		340							

Table 5.4 – Summary of Quantity Calculations (Alternative 3, Baseline Design)

				Quantity Breakdown by Reach								
				Study Reach No.								
				4	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
No.	**Contract Items**	**Unit**	**Net Quantity**	CTP Bridge (Sta. 69+70) to Abandoned Oxbow (Sta. 133+00)	Abandoned Oxbow (Sta. 133+00) to Wood Canyon Creek Confluence (Sta. 167+80)	Wood Canyon Creek Confluence (Sta. 167+80) to ACWHEP (Sta. 185+50)	ACWHEP (Sta. 185+50) to High Banks (Sta. 211+00)	High Banks (Sta. 211+00) to Sulphur Creek Confluence (Sta. 245+19)	Sulphur Creek Confluence (Sta. 245+19) to Ex. Drop Structure No.1 (Sta. 261+85)	Ex. Drop Structure No.1 (Sta. 261+85) to Ex. Drop Structure No.2 (Sta. 275+73)	Ex. Drop Structure No.2 (Sta. 275+73) to Foxborough Park (Sta. 302+00)	Foxborough Park (Sta. 302+00) to Pacific Park Drive (Sta. 331+33)
	Baseline Design											
1	Clearing and Grubbing	AC	104	35	20	10	13	21	6			
2	Excavation (Channel Grading)	CY	566,900	165,900	59,800	13,100	85,500	193,800	48,800			
3	Compacted Fill (Channel Grading)	CY	487,200	105,700	183,200	132,100	5,500	43,000	17,700			
	Net Earthwork (Net Excavation)	CY	**31,000**	**49,600**	**(141,700)**	**(132,200)**	**79,500**	**146,500**	**29,300**			
4	Riprap (9" High Riffle Structures, Total of 2)	CY	3,390	0	0	0	1,711	1,679	0			
5	Riprap (18" High Riffle Structures, Total of 41)	CY	65,692	23,186	16,363	6,052	7,967	10,141	1,983			
6	Riprap (6' High Riffle Structures, Total of 0)	CY	0	0	0	0	0	0	0			
7	Riprap Downdrain for Ex. Pipe Outlet	EA	6	3	2	0	1					
8	Ex. Storm Drain Outlet Modification	EA	6				2	4				
9	Hydroseed Slopes	SY	122,167	52,337	20,593	6,376	7,141	26,281	9,439			
10	Landscape Improvements	LS	1									
11	6' Wide DG Road (Station 210+00 to 240+40 along West Bank)	LF	2,430				100	2,330				
12	4" DG, 12' Wide Road (West Bank)	LF	960				470	490				
13	Riprap Protection at Wood Canyon Creek Confluence	CY	340		340							
14	Ex. Grouted Riprap Removal (Drop Structure Immediately Downstream of AWMA Road)	CY	385						385			

Table 5.5 – Summary of Quantity Calculations (Alternative 4, Baseline Design)

				Quantity Breakdown by Reach								
				Study Reach No.								
				4	5	6	7	8	9	10	11	12
No.	**Contract Items**	**Unit**	**Net Quantity**	CTP Bridge (Sta. 69+70) to Abandoned Oxbow (Sta. 133+00)	Abandoned Oxbow (Sta. 133+00) to Wood Canyon Creek Confluence (Sta. 167+80)	Wood Canyon Creek Confluence (Sta. 167+80) to ACWHEP (Sta. 185+50)	ACWHEP (Sta. 185+50) to High Banks (Sta. 211+00)	High Banks (Sta. 211+00) to Sulphur Creek Confluence (Sta. 245+19)	Sulphur Creek Confluence (Sta. 245+19) to Ex. Drop Structure No.1 (Sta. 261+85)	Ex. Drop Structure No.1 (Sta. 261+85) to Ex. Drop Structure No.2 (Sta. 275+73)	Ex. Drop Structure No.2 (Sta. 275+73) to Foxborough Park (Sta. 302+00)	Foxborough Park (Sta. 302+00) to Pacific Park Drive (Sta. 331+33)
	Baseline Design											
1	Clearing and Grubbing	AC	104	35	20	10	13	21	6			
2	Excavation (Channel Grading)		884,300	271,900	119,900	41,600	166,800	231,400	52,700			
3	Compacted Fill (Channel Grading)	CY	279,400	32,300	113,200	84,600	1,400	31,800	16,100			
	Net Earthwork (Net Excavation)	CY	577,000	236,400	(4,600)	(51,500)	165,300	196,400	35,000			
4	Riprap (18" High Riffle Structures, Total of 46)	CY	73,371	23,796	13,881	7,932	9,915	13,881	3,966			
5	Riprap (6' High Riffle Structures, Total of 0)	CY	0	0	0	0	0	0	0			
6	Riprap Downdrain for Ex. Pipe Outlet	EA	6	3	2	0	1					
7	Ex. Storm Drain Outlet Modification	EA	6				2	4				
8	Hydroseed Slopes	SY	122,167	52,337	20,593	6,376	7,141	26,281	9,439			
9	Landscape Improvements	LS	1									
10	6' Wide DG Road (Sta. 210+00 to Sta. 240+40 along West Bank)	LF	2,430				100	2,330				
11	4" Decomposed Granite, 12' Wide Road (West Bank)	LF	960				470	490				
12	Riprap Protection at Wood Canyon Creek Confluence	CY	340		340							
13	Ex. Grouted Riprap Removal (Drop Structure Immediately Downstream of AWMA Road)	CY	385						385			

Table 5.6 – Summary of Quantity Calculations (Flood Risk Management)

No.	Contract Items	Unit	Net Quantity	Quantity Breakdown by Reach – Study Reach No. 4: CTP Bridge (Sta. 69+70) to Abandoned Oxbow (Sta. 133+00)	5: Abandoned Oxbow (Sta. 133+00) to Wood Canyon Creek Confluence (Sta. 167+80)	6: Wood Canyon Creek Confluence (Sta. 167+80) to ACWHEP (Sta. 185+50)	7: ACWHEP (Sta. 185+50) to High Banks (Sta. 211+00)	8: High Banks (Sta. 211+00) to Sulphur Creek Confluence (Sta. 245+19)	9: Sulphur Creek Confluence (Sta. 245+19) to Ex. Drop Structure No.1 (Sta. 261+85)	10: Ex. Drop Structure No.1 (Sta. 261+85) to Ex. Drop Structure No.2 (Sta. 275+73)	11: Ex. Drop Structure No.2 (Sta. 275+73) to Foxborough Park (Sta. 302+00)	12: Foxborough Park (Sta. 302+00) to Pacific Park Drive (Sta. 331+33)
	Flood Risk Management (FRM)											
1	Riprap Bank Protection	CY	31,521	10,532	10,495	3,899	2,004	4,591	0			

Table 5.7 – Summary of Quantity Calculations (Additional Measures A, B, E, F, G, H, I, and J)

No.	Contract Items	Unit	Net Quantity	Quantity Breakdown by Reach – Study Reach No. 4: CTP Bridge (Sta. 69+70) to Abandoned Oxbow (Sta. 133+00)	5: Abandoned Oxbow (Sta. 133+00) to Wood Canyon Creek Confluence (Sta. 167+80)	6: Wood Canyon Creek Confluence (Sta. 167+80) to ACWHEP (Sta. 185+50)	7: ACWHEP (Sta. 185+50) to High Banks (Sta. 211+00)	8: High Banks (Sta. 211+00) to Sulphur Creek Confluence (Sta. 245+19)	9: Sulphur Creek Confluence (Sta. 245+19) to Ex. Drop Structure No.1 (Sta. 261+85)	10: Ex. Drop Structure No.1 (Sta. 261+85) to Ex. Drop Structure No.2 (Sta. 275+73)	11: Ex. Drop Structure No.2 (Sta. 275+73) to Foxborough Park (Sta. 302+00)	12: Foxborough Park (Sta. 302+00) to Pacific Park Drive (Sta. 331+33)
	Additional Measures (A, B, E, F, G, H, I, J)											
	Additional Measure A											
A.1	6" AC, 16' Wide Access Road (East Bank)	LF	16,460	5,340	3,310	1,420	2,550	3,170	670			
	Additional Measure B											
B.1	Ex. AC Pavement Removal (West Bank)	SY	18,622	11,089	7,533							
B.2	Repurposing of AWMA Road (4" DG, 12' Wide, West Bank)	LF	8,380	4,990	3,390							
	Additional Measure E											
E.1	Channel Connection (Riprap, Wood Canyon Creek Confluence)	LS	1		1							
	Additional Measure F											
F.1	Excavation (Channel Grading)	CY	29,098				2,106	24,413	2,578			
F.2	Compacted Fill (Channel Grading)	CY	167				4	163	0			
	Net Earthwork (Net Excavation)	CY	28,900				2,100	24,200	2,600			
	Additional Measure G											
G.1	Channel Connection (Riprap, Sulphur Creek)	LS	1					1				
	Additional Measure H & I											

				Quantity Breakdown by Reach								
				Study Reach No.								
				4	5	6	7	8	9	10	11	12
No.	Contract Items	Unit	Net Quantity	CTP Bridge (Sta. 69+70) to Abandoned Oxbow (Sta. 133+00)	Abandoned Oxbow (Sta. 133+00) to Wood Canyon Creek Confluence (Sta. 167+80)	Wood Canyon Creek Confluence (Sta. 167+80) to ACWHEP (Sta. 185+50)	ACWHEP (Sta. 185+50) to High Banks (Sta. 211+00)	High Banks (Sta. 211+00) to Sulphur Creek Confluence (Sta. 245+19)	Sulphur Creek Confluence (Sta. 245+19) to Ex. Drop Structure No.1 (Sta. 261+85)	Ex. Drop Structure No.1 (Sta. 261+85) to Ex. Drop Structure No.2 (Sta. 275+73)	Ex. Drop Structure No.2 (Sta. 275+73) to Foxborough Park (Sta. 302+00)	Foxborough Park (Sta. 302+00) to Pacific Park Drive (Sta. 331+33)
HI.1	Ex. Drop Structure Removal	EA	2						1	1		
HI.2	Clearing and Grubbing	AC	10.14						4	4.72	1.42	
HI.3	Excavation (Channel Grading)		81,500						31,700	38,000	11,800	
HI.4	Compacted Fill (Channel Grading)	CY	10,100						4,200	4,700	1,200	
	Net Earthwork (Net Excavation)	CY	**70,400**						**27,100**	**32,800**	**10,500**	
HI.5	Riprap (18" High Riffle Structures, Total of 3)	CY	1,982						0	1,982	0	
HI.6	Riprap (6' High Riffle Structures, Total of 3)	CY	6,033						2,011	2,011	2,011	
HI.7	Sheet Pile Retaining Wall	SF	78,783						21,827	44,026	12,930	
HI.8	Ex. Storm Drain Outlet Modification	EA	9						2	7		
HI.9	Hydroseed Slopes	SY	10,265						726	3,114	6,425	
HI.10	Landscape Improvements	LS	1									
HI.11	16' Wide Paved Access Road (East Bank Upstream of AWMA Road)	LF	2,745						885	1,430	430	
HI.12	Ex. Grouted Riprap Removal (4' Drop Structure Downstream of Aliso Creek Road)	CY	600						600			
	Additional Measure J											
J.1	Clearing and Grubbing	AC	23.93								11.52	12.41
	-											
J.2	Excavation (Channel Grading)		118,500								64,800	53,700
J.3	Compacted Fill (Channel Grading)	CY	80,000								32,900	47,100
	Net Earthwork (Net Excavation)	CY	**30,500**								**28,600**	**1,900**
J.4	Riprap (18" High Riffle Structures, Total of 6)	CY	12,987								9,020	3,967
J.5	Riprap (6' High Riffle Structure, Total of 1)	CY	4,018								0	4,018
J.6	Hydroseed Slopes	SY	27,329								8,495	18,834
J.7	Landscape Improvements	LS	1									
J.8	16' Wide Paved Access Road (East Bank Upstream of AWMA Road)	LF	960								960	

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Table 5.8 – Summary of Quantity Calculations (Additional Measures C, D, L, and M – Alternative 2)

No.	Contract Items	Unit	Net Quantity	Additional Measure C Abandoned Oxbow (Sta. 119+00 to Sta. 134+00)	D Downstream of Wood Canyon Creek (Sta. 156+20 to Sta. 170+70)	L Near Skate Park (Sta. 271+70 to Sta. 287+00)	M Downstream of Pacific Park Drive (Sta. 286+40 to Sta. 310+00)
	Baseline Design						
1	Excavation (Channel Grading)	CY	178,900	22,000	50,200	29,600	77,100
2	Compacted Fill (Channel Grading)	CY	60,700	5,300	6,600	8,000	40,800
	Additional Measures						
3	Excavation (Channel Grading)	CY	543,800	290,300	94,800	56,600	102,100
4	Compacted Fill (Channel Grading)	CY	45,800	2,300	6,000	8,800	28,700
	Change in Excavation	CY	**364,900**	268,300	44,600	27,000	25,000
	Change in Compacted Fill	CY	**(14,900)**	(3,000)	(600)	800	(12,100)
	Baseline Design						
5	Riprap (18" High Riffle Structure)	CY	15,236			5,224	10,012
	Additional Measures						
6	Riprap (18" High Riffle Structure)	CY	15,236			5,224	10,012

Table 5.9 – Summary of Quantity Calculations (Additional Measures C, D, L, and M – Alternative 3)

				Additional Measure			
				C	**D**	**L**	**M**
No.	**Contract Items**	**Unit**	**Net Quantity**	Abandoned Oxbow (Sta. 119+00 to Sta. 134+00)	Downstream of Wood Canyon Creek (Sta. 156+20 to Sta. 170+70)	Near Skate Park (Sta. 271+70 to Sta. 287+00)	Downstream of Pacific Park Drive (Sta. 286+40 to Sta. 310+00)
	Baseline Design						
1	Excavation (Channel Grading)	CY	150,100	22,000	21,400	29,600	77,100
2	Compacted Fill (Channel Grading)	CY	208,200	78,300	81,100	8,000	40,800
	Additional Measures						
3	Excavation (Channel Grading)	CY	388,800	196,300	33,800	56,600	102,100
4	Compacted Fill (Channel Grading)	CY	204,000	86,100	80,400	8,800	28,700
	Change in Excavation	CY	**238,700**	174,300	12,400	27,000	25,000
	Change in Compacted Fill	CY	**(4,200)**	7,800	(700)	800	(12,100)
	Baseline Design						
5	Riprap (18" High Riffle Structure)	CY	27,181	5,965	5,978	5,225	10,012
	Additional Measures						
6	Riprap (18" High Riffle Structure)	CY	25,690	4,474	5,978	5,225	10,012
	Change in Riprap	CY	**(1,491)**	(1,491)	0	0	0

Table 5.10 – Summary of Quantity Calculations (Additional Measures C, D, L, and M – Alternative 4)

				Additional Measure			
				C	D	L	M
No.	Contract Items	Unit	Net Quantity	Abandoned Oxbow (Sta. 119+00 to Sta. 134+00)	Downstream of Wood Canyon Creek (Sta. 156+20 to Sta. 170+70)	Near Skate Park (Sta.2 71+70 to Sta. 287+00)	Downstream of Pacific Park Drive (Sta. 286+40 to Sta. 310+00)
	Baseline Design						
1	Excavation (Channel Grading)	CY	199,000	40,100	52,200	29,600	77,100
2	Compacted Fill (Channel Grading)	CY	136,800	35,900	52,100	8,000	40,800
	Additional Measures						
3	Excavation (Channel Grading)	CY	388,800	196,300	33,800	56,600	102,100
4	Compacted Fill (Channel Grading)	CY	204,000	86,100	80,400	8,800	28,700
	Change in Excavation	CY	**189,800**	156,200	(18,400)	27,000	25,000
	Change in Compacted Fill	CY	**67,200**	50,200	28,300	800	(12,100)
	Baseline Design						
5	Riprap (18" High Riffle Structure)	CY	27,136	5,949	5,949	5,226	10,012
	Additional Measures						
6	Riprap (18" High Riffle Structure)	CY	25,648	4,462	5,949	5,226	10,012
	Change in Riprap	CY	**(1,487)**	(1,487)	0	0	0

Table 5.11 – Summary of Quantity Calculations (Additional Measure K)

No.	Contract Items	Unit	Net Quantity
1	Mobilization	LS	1
2	Removal of Skate Ring	SY	2,220
3	Removal of Building - 25'x35'	EA	1
4	Removal of Building - 20'x40'	EA	1
5	Removal of Canopies	EA	2
6	Removal of Concrete Paving	LS	1
7	Removal of Asphalt Paving	LS	1
8	Removal and Salvaging of Electrical Poles	EA	15
9	Removal of Artificial Grass - 360'x210'	LS	1
10	Removal of Fence	LS	1
11	Excavation	CY	104,000

6. RISKS INHERENT TO THE PROJECT

The project is to be designed as an ecosystem restoration project. It is assumed that the general intent of the Aliso Creek Ecosystem Restoration project is to create a soft-bottom channel with riffle structures and to promote native vegetation growth on flatter side slopes. The upstream and downstream portions of the project are not being designed for flood control or flood risk management associated with a particular design flood event that would normally use reinforced concrete, grouted stone, or riprap to provide fully lined erosion protection. Rather, projects such as the Aliso Creek Ecosystem Restoration project that are not fully lined along their length are regarded as having inherent risk for erosion typical of a natural system, especially during the plant establishment period. This period, which often requires adaptive management, usually extends approximately 5 years beyond construction completion. Planting of native species will require special attention to ensure their successful establishment.

If fail-safe grade stabilization (soil cement, sheet pile, etc.) is not incorporated and one or more of the riffle structures are lost due to scour, there is a high potential for significant erosion and soil loss, loss of connectivity, and utility damage.

There is a potential for sedimentation (deposition) due to constrictions near the existing bridges/culverts (SOCWA CTP, AWMA Road, Aliso Creek Road, Pacific Park Drive, etc.), as well as other areas. Regular maintenance (sediment removal) in these areas may be necessary to prevent the loss of connectivity and design flood freeboard.

For the middle portion of the project area between the AWMA Road Bridge and the Aliso Creek Road Bridge, the channel is surrounded by the existing buried utilities running along both banks and other above-ground infrastructures. The expanding of the channel geometry in this stretch is limited and thus will have fewer opportunities for restoration and habitat connectivity that may reduce species movement.

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