Final Report

Second Phase Study of Santa Clara County Steelhead Streams to Identify Priority Locations for Gravel Augmentation and Large Woody Debris Placement Project

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List of Acronyms and Abbreviations

AWR	accelerated wood recruitment
CCC	Central California Coast
CDFW	California Department of Fish and Wildlife
CDFW Manual	California Department of Fish and Wildlife California Salmonid Stream Habitat Restoration Manual
BMPs	best management practices
cfs	cubic feet per second
CMP	corrugated metal pipe
Drawings	conceptual engineering design drawings
DTM	digital terrain model
ELJ	engineered log jam
FAHCE	Fish and Aquatic Habitat Collaborative Effort
FEMA	Federal Emergency Management Agency
KPI	Key Performance Indicator
LWD	large woody debris
Project	Uvas Creek Gravel and Large Wood Augmentation Project
D4	Project D4
SCCC	South-Central California Coast
SCW	Safe Clean Water and Natural Flood Protection Program
SMP	Stream Maintenance Program
Study	Valley Water Study of Santa Clara County Steelhead Streams to Identify Priority Locations for Gravel Augmentation and Large Woody Debris Placement
Valley Water	Santa Clara Valley Water District

1. Introduction

1.1 Executive Summary

This report summarizes the second phase (Phase 2) of the Valley Water Study of Santa Clara County Steelhead Streams to Identify Priority Locations for Gravel Augmentation and Large Woody Debris (LWD) Placement (Study). Phase 2 builds on the first phase (Phase 1) of the Study, which was completed in 2018 (Balance Hydrologics 2018). Of the Santa Clara County steelhead streams not included in Phase 1, six streams were selected for inclusion in Phase 2, including the Pajaro River and Llagas, San Francisquito, Los Trancos, Calero, and Pacheco Creeks.

The Phase 2 Team was comprised of engineers, hydrologists, biologists, geomorphologists and GIS analysts from AECOM and Balance Hydrologics, Inc. The Phase 2 Team developed a GIS-based reach prioritization tool for the Study. The tool consists of workflows for organizing and analysing spatial data sets to divide the Phase 2 Study streams into reaches and then prioritize the delineated reaches for gravel and LWD augmentation based on the following eight reach prioritization criteria:

- Criterion 1: Percent of watershed source area disconnected from reach
- Criterion 2: Protected area within and upstream of reach
- Criterion 3: Level of prior channel modification within the reach
- Criterion 4: Relative proximity of the reach to a sediment sink
- Criterion 5: Reach suitability for steelhead
- Criterion 6: Susceptibility of the reach and downstream areas to flooding
- Criterion 7: Access to the reach and level of effort based on property ownership
- Criterion 8: Number of downstream passage impediments

The Phase 2 reach prioritization criteria were developed in coordination with Valley Water staff by modifying the prioritization criteria used in Phase 1. A GIS geodatabase was developed, assembling all of the spatial datasets required for prioritization of stream reaches for gravel and LWD augmentation.

A GIS-based reach delineation analysis was performed to identify stream reaches that will be used as the basis for reach prioritization and site selection.

The Phase 2 Team developed reach prioritization scoring schemes and reach prioritization criteria weightings for both gravel and LWD in coordination with Valley Water staff. The scoring schemes stipulate how a reach is evaluated for each of the prioritization criteria and how the result of each evaluation is converted to a score. A reach prioritization model was developed that uses the delineated reaches as the foundation for an analysis that scores each reach based on the 8 reach prioritization criteria.

The final reach prioritization scores were presented to Valley Water as Google Earth files in addition to being included in the project GIS geodatabase.

Three of the Phase 2 Study streams, San Francisquito and Los Trancos Creeks and the Pajaro River, do not have any reaches amongst the highest scoring for either gravel or LWD augmentation. The highest scoring reaches for both gravel and LWD augmentation are located on Calero, Llagas and Pacheco Creeks. Scores for reaches along each of these creeks are highest just downstream of their respective dams and become progressively poorer with distance downstream.

In coordination with Valley Water staff, the Phase 2 Team selected a total of 14 field assessment sites on Calero, Llagas, and Pacheco Creeks from the highest scoring, priority reaches. The field assessment sites included:

- Calero Creek: 6 sites between Calero Dam and Harry Road
- Llagas Creek: 3 sites between Chesbro Dam and just downstream of the Oak Glen Ave. crossing
- Pacheco Creek: 5 sites between Pacheco Dam and the confluence with the south fork of the creek.

In addition to reach score for gravel and LWD, the Phase 2 Team also considered factors such as the environmental impact required for construction access and staging and the Distinct Population Segment (DPS) of steelhead present in the stream when selecting field assessment sites.

Field assessment methods included habitat typing as described in Part III of the CDFW California Salmonid Stream Habitat Restoration Manual (Flosi et. al. 2004).

Field assessments also included collection of topographic data, including thalweg longitudinal profiles and channel cross sections sufficient to define the channel geometry at each site well enough to allow for one dimensional hydraulic modeling and sediment transport analyses for each site.

The average instream shelter complexity score for habitat units within each site was less than 2 for nearly all of the sites, no LWD was observed at 10 of the 14 sites and the average percentage of each site having gravel of the size most suitable for steelhead spawning as the most dominant substrate type was approximately 41%. The average pool tail embeddedness value for the sites was 5, as the pool tailout substrate at nearly every site was determined to be unsuitable for spawning.

The Phase 2 Team analyzed the potential for augmentation of gravel and/or LWD at each of the sites to increase the maximum water surface elevation during a 100-year flood event. The results indicated that only Llagas Creek Sites 02 and 03 are sensitive to increases in 100-year flood water surface elevations.

In coordination with Valley Water staff, the Phase 2 Team developed six criteria for selecting which assessed sites to move forward into conceptual design, determined the relative importance of the selection criteria, and selected criteria weights through consideration of numerous weighting combinations. Based on the total scores all six sites on Calero Creek were selected for conceptual design, as were Llagas Creek Site 01 and Pacheco Creek Site 01.

The Phase 2 Team developed conceptual designs for gravel and LWD augmentation at each of the 8 selected sites. The objectives of the conceptual designs are to:

1. Increase the quantity and quality of salmonid spawning habitat.
2. Increase salmonid habitat complexity and cover.

The primary constraints on the conceptual designs are the presence of FEMA regulated floodplains and regulatory floodways downstream of the augmentation sites. FEMA regulations require that any project within a regulatory floodway not increase the maximum water surface elevation of the 100-year flood.

The conceptual designs employ multiple approaches to achieving the design objectives. These can be summarized as follows:

1. Increase the number of riffles and pools by adding gravel to convert portions of long runs and glides into riffles.
2. Add enough LWD to increase instream shelter complexity.
3. Use gravel injection piles to replenish riffles.
4. Locate gravel injection piles where they can be replenished regularly.

Detailed descriptions of the conceptual designs for each site are included in Section 7 and conceptual design drawings are attached as Appendices A, B and C.

The Phase 2 Team analyzed the potential for the proposed gravel and large wood augmentation designs to increase the maximum water surface elevation during a 100-year flood event. The results indicated that additional grading would need to be incorporated into the final designs for sites Calero Creek 04 and Llagas Creek 01.

Two different types of sediment transport analyses were completed to estimate how frequently the proposed gravel might be transported downstream and how often the injection piles might need to be replenished. .The results of the sediment transport analyses suggest that Calero Creek will not have the capacity to transport steelhead spawning gravel on a regular basis. This means that augmenting spawning gravels at any of the conceptual design sites would be unlikely to result in any spawning habitat improvement downstream of the site and that localized spawning habitat improvements may be temporary, as placed gravels might soon be covered by finer sediment. Therefore, it is recommended that any plans for augmentation of spawning gravels on Calero Creek include plans for implementing the release of periodic geomorphic pulse flows from Calero Reservoir. Valley Water manages the reservoirs within the Guadalupe Watershed, including the Calero Reservoir, in accordance with the Fish and Aquatic Habitat Collaborative Effort (FAHCE) Plus Rule Curves. The FAHCE Plus flows were designed to improve passage conditions for salmonids while balancing year-round releases to provide for fish habitat and water supply. The FAHCE Plus Adaptive Management Program offers future opportunities to adjust flows in Calero Creek to enhance the effectiveness of any future fish habitat improvement projects along the creek.

For the conceptual design sites on Llagas and Pacheco Creeks, the results of the sediment transport analyses suggest that these creeks will have more than enough capacity to transport the volume of gravel that is proposed for placement at any one time. Given that there are many sources of uncertainty in these attempts to estimate gravel injection pile lifetime expectancy based on sediment transport calculations, it is recommended that should Valley Water implement any of the conceptual designs, plans for replenishing gravel injection piles be based on annual monitoring of pile volume rather than sediment transport calculations alone.

Success criteria are presented to assess whether individual conceptual design projects that Valley Water might undertake meet the design objectives of increasing the quantity and quality of salmonid spawning habitat and habitat complexity and cover at each site.

It is recommended that two types of post-project monitoring should be completed if any of the conceptual designs are implemented. The first type would be to evaluate the performance of the project relative to the proposed success criteria. These monitoring methods would include habitat surveys of the implementation site including Level IV stream habitat type classification, instream shelter complexity and instream shelter percent covered as described in Part III of the CDFW Manual (Flosi et. al. 2004).

It is also recommended that gravel and LWD augmentation projects should be managed adaptively following implementation. Spawning gravel and LWD placed in channels should be expected to move downstream or degrade over time, and therefore will need to be replenished. The second type of post-project monitoring would be completed for the purpose of determining whether the gravel and LWD installed during a given implementation project needs to be replenished. This would include monitoring of the condition of LWD installations and gravel injection pile volumes.

1.2 Organization of Report

This report is organized as follows:

- Section 1: Project introduction, including executive summary, Study background and selection of Phase 2 streams.
- Section 2: Discussion of GIS-based stream reach prioritization and results.
- Section 3: Discussion of field assessment methods and results.
- Section 4: Discussion of preliminary flood conveyance analysis
- Section 5: Discussion of the selection of sites for conceptual design.
- Section 6: Overview of conceptual design objectives, constraints and approach.
- Section 7: Descriptions of the proposed conceptual designs.
- Section 8: Descriptions of supporting technical analyses including flood conveyance analyses, design gravel gradation, gravel transport and injection pile lifetime expectancy.
- Section 9: Discussion of success criteria, monitoring, and adaptive management.

1.3 Study Background

Valley Water's Project D4 is a part of the Safe Clean Water and Natural Flood Protection Program (SCW) which was originally approved by Santa Clara County voters as Measure B in 2012 and renewed and extended as Measure S in 2020. Project D4 aims to restore and maintain anadromous Central California Coast (CCC) and South-Central California Coast (SCCC) steelhead trout (Oncorhynchus mykiss) populations by improving fish passage and habitat. Dams and other anthropogenic activities in Santa Clara County watersheds reduce the natural supply and transport of gravel and LWD, which diminishes aquatic habitat complexity and thereby adversely impacts the quality of steelhead habitat in county streams. Key Performance Indicator (KPI) 4 for Project D4 (D4) requires a study of all major steelhead streams in the county to identify priority locations for augmentation of LWD and gravel, as appropriate (Study) to mitigate such impacts. The Study also helps support the large woody debris and gravel augmentation mitigation obligations for steelhead from the Valley Water Stream Maintenance Program (SMP). To satisfy D4 KPI 4, the first phase of the Study of eight of the major steelhead streams, was completed in 2018; this report covers the second phase of the Study, which includes six of the remaining streams. D4 KPI 5 under renewed SCW approved by the voters in Nov 2020 requires implementation of five gravel or LWD augmentation projects by 2036. The Uvas Creek Large Wood and Gravel Augmentation Project was completed in summer of 2023, demonstrating progress toward achieving KPI 5.

1.4 Selection of Phase 2 Streams

1.4.1 Rationale for the Selection of Phase 2 Streams

Fisheries Conservation and Stewardship Efforts (Valley Water 2015) provides a summary of Valley Water's policies and efforts to support and maintain healthy and thriving native fish populations and includes a list of all steelhead streams within Santa Clara County. Table 1 below summarizes information from this list, and includes additional information such as stream identification numbers, receiving waters, and Study Phase.

Table 1: Steelhead streams within Santa Clara County. (Adapted from Valley Water 2015, Table 6.)

Number	Stream Name	Receiving Waters	Watershed	DPS	Study Phase
1	Guadalupe River	SF Bay	Guadalupe River	CCC Steelhead	1
2	Guadalupe Creek	Guadalupe River	Guadalupe River	CCC Steelhead	1
3	Alamitos Creek	Guadalupe River	Guadalupe River	CCC Steelhead	1
4	Calero Creek / Arroyo Calero	Alamitos Creek	Guadalupe River	CCC Steelhead	2
5	Los Gatos Creek	Guadalupe River	Guadalupe River	CCC Steelhead	1
6	Coyote Creek	SF Bay	Coyote Creek	CCC Steelhead	1
7	Upper Penitencia Creek	Coyote Creek	Coyote Creek	CCC Steelhead	1
8	Arroyo Aguague Creek	Coyote Creek	Coyote Creek	CCC Steelhead	1
9	Stevens Creek	SF Bay	Stevens Creek	CCC Steelhead	1
10	San Francisquito Creek	SF Bay	San Francisquito Creek	CCC Steelhead	2
11	Los Trancos Creek	San Francisquito Creek	San Francisquito Creek	CCC Steelhead	2
12	Pajaro River	Pacific Ocean	Pajaro River	SCCC Steelhead	2
13	Uvas (Carnadero) Creek	Pajaro River	Pajaro River	SCCC Steelhead	1
14	Solis Creek	Uvas (Carnadero) Creek	Pajaro River	SCCC Steelhead	NA
15	Llagas Creek	Pajaro River	Pajaro River	SCCC Steelhead	2
16	Tar Creek	Uvas (Carnadero) Creek	Pajaro River	SCCC Steelhead	NA
17	Bodfish Creek	Uvas (Carnadero) Creek	Pajaro River	SCCC Steelhead	1
18	Little Arthur Creek	Uvas (Carnadero) Creek	Pajaro River	SCCC Steelhead	1
19	Pacheco Creek	Pajaro River	Pajaro River	SCCC Steelhead	2
20	Cedar Creek	Pacheco Creek	Pajaro River	SCCC Steelhead	NA
21	Pescadero Creek	Pajaro River	Pajaro River	SCCC Steelhead	NA

The primary criterion for inclusion of streams in Phase 2 of the Study was the presence of a dam or other anthropogenic activities. Reservoir operations and other anthropogenic activities in county watersheds reduce the natural supply and transport of gravel and LWD, which diminishes habitat complexity and thereby adversely impacts the quality of steelhead habitat in county streams. Therefore, gravel and LWD augmentation efforts in county streams should coincide with the locations where the natural supply has been interrupted.

Of the steelhead streams not included in Phase 1 of the Study, six streams within Santa Clara County have a dam present or anthropogenic activities occurring that are interrupting the natural supply and transport of gravel and LWD. These streams are Pajaro River and Llagas, San Francisquito, Los Trancos, Calero, and Pacheco Creeks.

The secondary criterion for inclusion of streams in Phase 2 of the Study was tied to Valley Water's goal of contributing to the restoration and maintenance of healthy steelhead populations countywide. Steelhead in the Pajaro River and its tributaries, including Llagas and Pacheco Creeks, belong to a separate Distinct Population Segment (DPS) than steelhead in other Santa Clara County streams that flow to San Francisco Bay. Redundancy of each population is desirable to protect against natural and man-made disasters (Smith 2006). When combined with the streams in Phase 1, the streams selected for Phase 2 will ensure that the Study includes:

- Streams in all five major watersheds in Santa Clara County known to support steelhead populations: Guadalupe River, Coyote Creek, Stevens Creek, San Francisquito Creek, and Pajaro River.
- Both DPS's of steelhead present in Santa Clara County: Central California Coast steelhead and South-Central California Coast steelhead.

Therefore, by including Pajaro River and Llagas, San Francisquito, Los Trancos, Calero, and Pacheco Creeks in Phase 2, the Study will contribute to the restoration and maintenance of healthy steelhead populations countywide.

1.4.2 Rationale for the Exclusion of Remaining Streams

Valley Water's Phase 2 stream selections exclude four steelhead streams in Santa Clara County from the Study. These four streams are Solis, Tar, Cedar, and Pescadero Creeks. The basis for the omission of these streams was the lack of dams or other anthropogenic activities, the lack of other Valley Water projects and programs (such as providing LWD and gravel augmentation mitigation for SMP projects), and the lack of fee or easements along the streams that would allow Valley Water to conduct stream operations and/or maintenance activities.

Solis Creek originates on the eastern side of the Santa Cruz Mountains and flows in a northerly direction until its confluence with Uvas Creek approximately 500 feet below Uvas Reservoir and north of Uvas Road (Fall Creek Engineering 2004) (Figure 1). Tar Creek originates on the eastern side of the hills separating Watsonville from Gilroy and flows in a southeasterly direction until its confluence with Uvas (Carnadero) Creek east of Highway 101 (Figure 2). Cedar Creek originates in the Cañada De La Dormida in Henry W. Coe State Park and flows in a southerly direction until its confluence with Pacheco Creek just south of Highway 152 and approximately 2.5 miles downstream of the confluence of the north and south forks of Pacheco Creek (Figure 3). Pescadero Creek originates in the hills separating Watsonville from Gilroy and generally flows in a southeasterly direction until its confluence with the Pajaro River just north of Highway 129 near the community of River Oaks (Figure 4).

There are no reservoirs or significant impoundments in any of the watersheds contributing to Solis, Tar, Cedar, or Pescadero Creeks. All four watersheds are almost completely undeveloped and, at most, contain a few residential properties, such as those near Uvas Road in the Solis Creek watershed. There has likely been no significant interruption of the natural supply of gravel and LWD to these streams or any corresponding decrease in habitat complexity. Therefore, supplementing the supply of gravel and LWD to these streams would likely be of limited benefit to steelhead. In addition, Valley Water performs no stream operations and maintenance activities along these streams and has almost no fee or easements that would allow it to do so. The Study is intended to support other Valley Water projects and programs, such as providing LWD and gravel augmentation mitigation for SMP projects, and the inclusion of these four streams in Phase 2 would not increase this support.

2. GIS-based Stream Reach Prioritization

The Phase 2 Team was comprised of engineers, hydrologists, biologists, geomorphologists and GIS analysts from AECOM and Balance Hydrologics, Inc. The Phase 2 Team developed a GIS-based reach prioritization tool for the Study. The tool consists of workflows for organizing and analysing spatial data sets to divide the Phase 2 Study streams into reaches and then prioritize the delineated reaches for gravel and LWD augmentation based on the following eight criteria:

- Criterion 1: Source Watershed Disconnection
- Criterion 2: Remaining Source Protection
- Criterion 3: Likelihood to Improve Geomorphic Function
- Criterion 4: Proximity to Sediment Sink
- Criterion 5: Likelihood to Improve Steelhead Habitat
- Criterion 6: Risk of Increased Flooding
- Criterion 7: Ease of Implementation
- Criterion 8: Passage Impediments

The GIS-desktop analyses performed for Phase 2 uses ESRI's ArcGIS suite of software, specifically ArcMap versions 10.7.1. ESRI provides the industry leading software for geospatial data management and analysis. The ArcGIS software platform allows users to leverage geospatial data and relationships in multiple ways, including database management, basic to advanced geoprocessing, and cartography.

Data used to delineate reaches included steam network properties, limits of anadromy, fish functions and values, bed and bank conditions and FEMA floodplains and floodways. The delineation analysis resulted in 161 reaches across the six streams in the Study, with an average reach length of 1,965 feet.

2.1 Selection of Prioritization Criteria

The process of selecting reach prioritization criteria began with the eleven criteria used in Phase 1. Nearly all the Phase 1 criteria were retained for Phase 2, although some of the Phase 1 criteria were combined for Phase 2. For example, Phase 1 included two separate criteria associated with the upstream and downstream proximity of a given reach to a sediment sink, whereas for Phase 2 these were combined to create Criterion 4. Similarly, Phase 1 included two separate criteria related to FEMA flood mapping, whereas for Phase 2, all flood risk related considerations were combined to create Criterion 6.

One Phase 1 criterion not carried forward into Phase 2 considered whether sediment tended to accumulate in each reach and was based on SMP maintenance records. This criterion was not included in Phase 2 because the availability, consistency, and accuracy of SMP records was uncertain. Phase 2 Criterion 8, Passage Impediments, was not included in Phase 1. Based on the idea that steelhead are likely to benefit most from habitat improvements in locations they are able to access, this criterion prioritizes streams reaches having the fewest downstream fish passage impediments listed in the CDFW Passage Assessment Database (PAD).

The Phase 2 Team considered the addition of several other possible prioritization criteria for Phase 2. Reasons these criteria were not added included lack of data availability, lack of applicability to Phase 2 streams, or redundancy. For example, the Team considered adding a prioritization criterion based on NMFS mapping of Intrinsic Potential (IP) values for Central California Coast Steelhead. A new criterion was not added based on this data because the factors used to define IP may not all be appropriate for application to regulated streams and/or urbanized watersheds such as those included in Phase 2 and because an initial review of IP mapping for the Phase 2 streams indicated that IP may not provide much additional value for reach prioritization.

Multiple workshops were held with Valley Water staff, during which all of the prioritization criteria under consideration were discussed in detail and the Phase 2 Team obtained valuable feedback before finalizing the Phase 2 criteria. Table 2 lists the final reach prioritization criteria and the scoring basis for each criterion.

Table 2: Scoring bases for Phase 2 reach prioritization criteria.

Criterion No.	Short Name	Scoring Basis
1	Watershed source area disconnection	Percent of watershed source area disconnected from reach by reservior
2	Remaining source protection	Protected area within and upstream of reach
3	Likelihood to improve geomorphic function	Level of prior channel modification within the reach
4	Proximity to sediment sink	Relative proximity of the reach to upstream or downstream sediment sink
5	Likelihood to improve steelhead habitat	Likelihood to improve steelhead habitat
6	Risk of increased flooding	Susceptibility of reach and downstream areas to flooding/ regulatory hurdles
7	Ease of implementation	Access to the reach and level of effort based on property ownership
8	Passage impediments	Number of downstream passage impediments

2.2 Development of Geodatabase

The first step toward prioritizing Phase 2 stream reaches was development of a GIS geodatabase including all of the required spatial datasets. This included datasets from Valley Water, such as Santa Clara County creeks, water bodies, and instream dam layers, as well as several additional datasets associated with each of the reach prioritization criteria (Table 3). Nearly all of the spatial datasets assembled are publicly available and sources for the spatial datasets included Valley Water, state and federal agencies, local joint powers authorities (JPA) and government funded nonprofits.

Table 3: Spatial data associated with Phase 2 reach prioritization criteria.

Criterion No.	Short Name	Spatial data
1	Watershed source area disconnection	Valley Water subwatersheds/ USGS watersheds
2	Remaining source protection	California Protected Areas Database (CPAD)
3	Likelihood to improve geomorphic function	Valley Water countywide asset assessment (GHD)
4	Proximity to sediment sink	Locations of know sediment sinks (staff input)
5	Likelihood to improve steelhead habitat	Fish functions and values category (SCV HCP)
6	Risk of increased flooding	FEMA mapping and Valley Water FIT hotspots
7	Ease of implementation	Valley Water fee and easement, CPAD
8	Passage impediments	CDFW PAD

2.3 Reach Delineation Model and Workflow

A GIS-based reach delineation analysis was performed to identify stream reaches that will be used as the basis for reach prioritization and site selection. Stream reaches, as defined in Phase 1, are lengths of stream with relative uniformity in slope, discharge, depth, and cross-sectional area (Balance Hydrologics 2018). This desktop analysis uses a specific reach delineation model developed for Valley Water and larger geomorphologic features to identify reach limits.

The reach delineation workflow consisted of a series of sequential steps taken to subdivide the stream lines for Phase 2 streams in the Valley Water Santa Clara County Creeks dataset into reaches such that each reach would have a single attribute value for each of the datasets associated with the reach prioritization criteria.

The steps in the reach delineation workflow and datasets used for each step were:

Step 1: Valley Water tributary and waterbody confluences

Step 2: Fish functions and values category from the SCVHCP mapping

Step 3: GHD 2016 Valley Water Asset Management Report

Step 4: FEMA Flood Data

Step 5: Limits of anadromy

Step 1 in the workflow begins the process by dissolving the county creeks data set by the Phase 2 study area and then subdividing Phase 2 streams at main stem, tributary and waterbody confluences. A flow chart of Step 1 is shown in Figure 1. The result of Step 1 is a preliminary set of Phase 2 stream reaches. All intermediate data created during the steps in the reach delineation workflow are stored in the Phase 2 geodatabase.

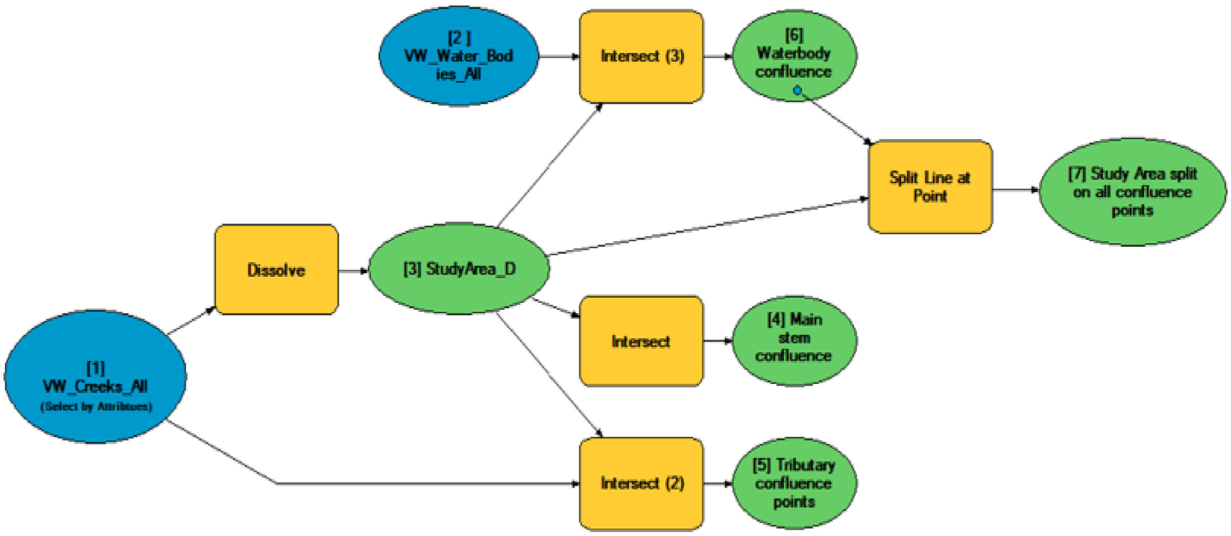

Figure 1: Flow chart of Step 1 in the reach delineation workflow.

Steps 2 through 5 in the reach delineation workflow each involve further subdivision of the preliminary set of stream reaches at the points where the attribute values in the dataset associated with each step change. As we progressed through each reach delineation workflow step, the number of reaches grew and the number of attributes associated with each reach expanded in detail.

For example, in Step 2 the Fish Function and Values (FFVA) dataset (Smith 2006) was used to identify reach boundaries. The FFVA 2006 data was intersected with the Phase 2 Valley Water streams data to capture and tag the associated fish habitat attribute. An "FFVA_2006" field including the FFVA habitat designation for each stream segment was added to the master stream layer's attribute table and the reaches are subdivided such that each reach is assigned only one FFVA habitat designation (Figure 2).

[21] DelineatedReaches

OBJECTID_1 *	Shape *	NAME	FFVA_2006
1	Polyline	CALERO CREEK	CWS
2	Polyline	CALERO CREEK	CWS
3	Polyline	CALERO CREEK	CWS
4	Polyline	CALERO CREEK	CWS
5	Polyline	CALERO CREEK	CWS
6	Polyline	CALERO CREEK	CWS
7	Polyline	CALERO CREEK	CWS
8	Polyline	CALERO CREEK	CWS
9	Polyline	CALERO CREEK	CWS
10	Polyline	CALERO CREEK	CWS
11	Polyline	CALERO CREEK	CWS
12	Polyline	CALERO CREEK	CWS
13	Polyline	CALERO CREEK	CWS
14	Polyline	CALERO CREEK	MR
15	Polyline	CALERO CREEK	MR
16	Polyline	CALERO CREEK	MR
17	Polyline	CALERO CREEK	MR
18	Polyline	CALERO CREEK	MR
19	Polyline	CALERO CREEK	NV
20	Polyline	CALERO CREEK	NV
21	Polyline	CALERO CREEK	NV
22	Polyline	CALERO CREEK	NV
23	Polyline	CALERO CREEK	NV
24	Polyline	CALERO CREEK	NV
25	Polyline	CALERO CREEK	NV
26	Polyline	CALERO CREEK	NV
27	Polyline	LLAGAS CREEK	CWS
28	Polyline	LLAGAS CREEK	CWS
29	Polyline	LLAGAS CREEK	CWS
30	Polyline	LLAGAS CREEK	CWS
31	Polyline	LLAGAS CREEK	CWS
32	Polyline	LLAGAS CREEK	CWS
33	Polyline	LLAGAS CREEK	CWS
34	Polyline	LLAGAS CREEK	CWS
35	Polyline	LLAGAS CREEK	CWS
36	Polyline	LLAGAS CREEK	CWTE
37	Polyline	LLAGAS CREEK	CWTE

Figure 2: Portion of attribute table showing FFVA_2006 field.

2.4 Reach Prioritization Scoring and Weighting

The Phase 2 Team developed reach prioritization scoring schemes for both gravel and LWD. The scoring schemes stipulate how a reach is evaluated for each of the prioritization criteria and how the result of each evaluation is converted to a score. The scoring schemes were designed such that the reach score for each criterion would range from 0 to 10. These values are then multiplied by a percent weighting value, resulting in a weighted reach score for each criterion. The sum of the weighted reach scores gives the reach prioritization score for the reach.

Scores for Criterion 1, watershed source area disconnection, are based on the percent of the watershed draining to a reach that is above a dam. This is calculated by dividing the area of the sub-watershed upstream of the dam by the area of the sub-watershed upstream of the reach, including the area of the sub watershed above the dam. The resulting percentages were converted to scores ranging from 0 to 10 such that reaches having 80 to 100% watershed area disconnection, those located nearest to a dam, received a score of 10 and those with 0% watershed area disconnection, those without a dam upstream, received a score of 10. As shown in Figure 3, percent watershed area disconnection ranging from 1 to 79% were assigned scores ranging from 2 to 8, with each 19 percentage point interval assigned an additional 2 points.

Criterion 2, remaining source protection, assumes that protected, undeveloped areas downstream of a dam are more likely than developed areas to contribute gravel and LWD to streams. Scores for criterion 2 is comprised of two different parts; 2a) the percentage of the watershed upstream of a reach that is protected, excluding watershed areas blocked by a dam and 2b) the percentage of the reach running through protected lands. Criterion 2a is calculated by dividing area upstream of a reach that is protected by the watershed area upstream of that reach. As shown in Figure 3, both 2a and 2b, the calculated percentages were converted to scores ranging from 0 to 10 such that reaches having lower percentages were assigned higher scores.

Scores for Criterion 3, likelihood to improve geomorphic function, are based on channel condition data from the 2016 GHD Asset Management Report (GHD 2016). These assume that gravel and LWD augmentation would be least likely to improve geomorphic function in locations were the channel is “rock lined” because the shape of both the channel bed and banks in these locations has been modified and set in place using rock and/or concrete and most likely to improve geomorphic function where the channel is “natural modified” because the shape of the channel bed and banks has been modified at these locations, but the material is deformable.

Criterion 4, proximity to sediment sink, has two parts, reach proximity to a downstream sink, and reach proximity to an upstream sink. The first part assumes that gravel augmentation at stream reaches located near a downstream sediment sink, such as an instream pond, should not be prioritized because the gravel would provide less habitat benefit before being captured in the sink. The second part assumes that gravel augmentation at stream reaches located near an upstream sediment sink, should be prioritized because gravel supply to these reaches would be most reduced by the sink. Scores for Criterion 4a are calculated by dividing the stream length from a reach to the nearest downstream sediment sink by the maximum distance a reach can be from that same downstream sediment sink. Conversely, Criterion 4b is calculated by dividing the

Criterion 1: Watershed source area disconnection

Score	Percent of watershed source area disconnected from reach by reservior	Weighting Value	Weighted Score
10	80 - 100%		
8	60 - 79%	0.2	0
6	40 - 59%		
4	20 - 39%		
2	1 - 19%		
0	0% (No dam)		
	Criterion 1 Result		

Criterion 2: Remaining source protection

Score	2a: Percent protected area upstream of reach	Sub-Weighting Value	Weighting Value	Weighted Score
10	0 - 19%			
8	20 - 39%	0.75	0.05	0
6	40 - 59%			
4	60 - 79%			
2	80 - 99%			
0	100%			
	Criterion 2a Result			

Score	2b: Percent protected area within reach	Sub-Weighting Value
10	0 - 19%	
8	20 - 39%	0.25
6	40 - 59%	
4	60 - 79%	
2	80 - 99%	
0	100%	
	Criterion 2b Result	

Criterion 3: Likelihood to improve geomorphic function

Score	Level of prior channel modification within the	Weighting Value	Weighted Score
10	Natural Modified or Fish Ladder - Natural		
7	Natural	0.1	0
5	No Data		
1	Rock Lined		
	Criterion 3 Result		

Criterion 4: Proximity to sediment sink

Score	4a: Relative proximity to downstream sediment sink	Sub-Weighting Value	Weighting Value	Weighted Score
0	0 - 0.19			
2	0.2 - 0.39	0.5	0.05	0
4	0.4 - 0.59			
6	0.6 - 0.79			
8	0.8 - 0.99			
10	1.0			
	Criterion 4a Result			

Score	4b: Relative proximity to upstream sediment sink	Sub-Weighting Value
10	0 - 0.19	0.5
8	0.2 - 0.39	
6	0.4 - 0.59	
4	0.6 - 0.79	
2	0.8 - 0.99	
0	1.0	
	Criterion 4b Result	

Reach Score Gravel: 0

Criterion 5: Likelihood to improve steelhead habitat

Weighted Score	Weighting Value	Score	Reach habitat category
		10	Cold Water Steelhead
0	0.2	9	Warm Potential Steelhead
		3	Mixed Native and Warm Water Native
		2	Fish Scarce
		0	Estuarine and No Fish Value
			Criterion 5 Result

Criterion 6: Risk of increased flooding

Weighted Score	Weighting Value	Sub-Weighting Value	Score	6a: Reach susceptibility to flooding
			10	Other/None
0	0.2	0.75	8	Floodplain
			6	Floodplain + FIT hot spots
			3	Floodplain + floodway
			1	Floodplain + floodway + FIT hot spots
				Criterion 6a Result

Sub-Weighting Value	Score	6b: Downstream susceptibility to flooding
	10	1.0
0.25	8	0.8 - 0.99
	6	0.6 - 0.79
	4	0.4 - 0.59
	2	0.2 - 0.39
	0	0 - 0.19
		Criterion 6b Result

Criterion 7: Ease of implementation

Weighted Score	Weighting Value	Sub-Weighting Value	Score	7a: Contiguous length of reach in VW fee or easement
			10	≥300 feet through Fee
0	0.15	0.75	8	50 - 300 feet through Fee
			6	≥50 feet through Fee, plus ≥250 feet through Easement
			4	No Fee, but ≥300 feet through Easement
			2	No Fee, but 50 - 300 feet through Easement
			0	None
				Criterion 7a Result

Sub-Weighting Value	Score	Criterion 7a: Reach overlap with CPAD holding
	10	Special District and County
0.25	6	City
	2	Non-Profit
	0	Private or None
		Criterion 7b Result

Criterion 8: Passage impediments

Weighted Score	Weighting Value	Score	Number of downstream passage impediments
		10	0
0	0.05	8	1
		6	2
		4	3
		2	4
		0	5+
			Criterion 8 Result

Figure 3: Scoring scheme for gravel prioritization.

length from a reach to the nearest upstream sediment sink by the maximum distance a reach can be from that same upstream sediment sink. As shown in Figure 3, scores for Criterion 4a are assigned such that reaches farthest from a downstream sediment sink receive the highest prioritization score and scores for Criterion 4b are assigned such that reaches nearest to an upstream sediment sink receive the highest prioritization scores.

Scores for Criterion 5, likelihood to improve steelhead habitat, are assigned such that the FFVA categories that are best for steelhead receive the highest prioritization scores and those worst for steelhead receive the lowest scores.

Criterion 6, risk of increased flooding, has two parts, 6a) reach susceptibility to flooding and 6b) downstream susceptibility to flooding. Scores for Criterion 6a are based on whether a reach is located within a mapped FEMA 100-year floodplain or FEMA regulatory floodway and whether the reach contains any FIT hot spots. Reaches that are not within a FEMA floodplain or floodway and contain no FIT hot spots are assigned the highest prioritization scores. Scores for Criterion 6b are calculated by dividing the distance a reach is upstream of a FEMA floodway by the maximum distance a reach can be upstream of a FEMA floodway. Reaches farthest from a downstream FEMA floodway were assigned the highest prioritization scores.

Scoring for Criterion 7 assumes that Valley Water is most likely to have the authority to implement augmentation projects within reaches running through Valley Water fee or easement. Scoring for Criterion 7 further assumes that for reaches not running through Valley Water fee or easement, Valley Water is most likely to have the authority to implement augmentation projects within reaches running through protected, public lands. Criterion 7, ease of implementation, has two parts, Criterion 7a) the contiguous length of the reach running through Valley Water fee or easement and 7b) if the reach does not run through Valley Water fee or easement, the owner type of the protected land through which a reach runs, if it runs through protected land. Scores for Criterion 7a were calculated by dividing the contiguous length of a reach within Valley Water fee or easement by the total length of the reach. The highest prioritization scores were assigned to reaches running through Valley Water fee. Scores for Criterion 7b were calculated based on the owner type. Scores were selected based on the assumed likelihood that the property owner would work with Valley Water on project implementation. The highest scores for Criterion 7b were assigned to reaches running through properties owned by Santa Clara County or by special districts such as the Santa Clara Valley Open Space Authority.

Scores for Criterion 8, passage impediments, are based on how many fish passage barriers are present downstream. The highest prioritization scores were assigned to reaches with no fish passage barriers downstream and the lowest scores were assigned to reaches with 5 or more fish passage barriers downstream.

The Phase 2 Team held multiple workshops with Valley Water to discuss the reach prioritization scoring schemes and criteria weightings and the Phase 2 Team obtained valuable feedback before finalizing the Phase 2 scoring schemes and prioritization criteria weightings. Table 4 lists the final reach prioritization criteria weightings for gravel and wood.

Table 4: Final reach prioritization criteria weightings.

Criterion No.	Short Name	Gravel Weighting	Wood Weighting
1	Watershed source area disconnection	20.0%	15.0%
2	Remaining source protection	5.0%	5.0%
3	Likelihood to improve geomorphic function	10.0%	15.0%
4	Proximity to sediment sink	5.0%	0.0%
5	Likelihood to improve steelhead habitat	20.0%	25.0%
6	Risk of increased flooding	20.0%	15.0%
7	Ease of implementation	15.0%	20.0%
8	Passage impediments	5.0%	5.0%

2.5 Reach Prioritization Workflow

The reach prioritization model uses the delineated reaches as the foundation for an analysis that scores each reach based on the 8 reach prioritization criteria. Each criterion is made up of 1 or 2 variables that leverage a GIS-based analysis that allows for reaches to be scored. All criteria are weighted and summed to get a total reach prioritization score. Criterion with 2 variables have a sub-weight applied to further sensitize the analysis.

The flowchart of the Phase 2 reach prioritization model shown in Figure 4 outlines the GIS workflows involved. The delineated reaches layer (yellow octagon on the left) is the input dataset for each of the 8 prioritization criteria GIS workflows (blue ovals). For each criterion, a version of the delineated reaches layer was copied and a corresponding GIS analysis was performed on that feature class. After each prioritization criterion GIS workflow is completed, the resulting delineated reach feature class is used as an input for a python script (pink ovals) to calculate the weighted criterion score for each reach.

After each prioritization criteria analysis is completed, each criteria feature class is dissolved on Stream Name, Reach Number, Reach ID, and the weighted scores are added as statistics fields, with a statistic type of Mean. This ensures that the scores are cleans up the data for inclusion in a final output feature class, named "Reaches_Scored" (green oval).

The entire prioritization process shown on this workflow model is completed twice – once for prioritizing gravel augmentation and a second time for wood augmentation. The attribute table for the "Reaches_Scored" feature class then contains the weighted scores for each reach for prioritization criteria 1 through 8 and for both gravel and wood.

Finally, a "Total Score" python script (magenta rectangle) runs an update cursor on each reach to sum the weighted gravel and wood scores separately and then update the total scores for each reach, which gives the final reach prioritization scores.

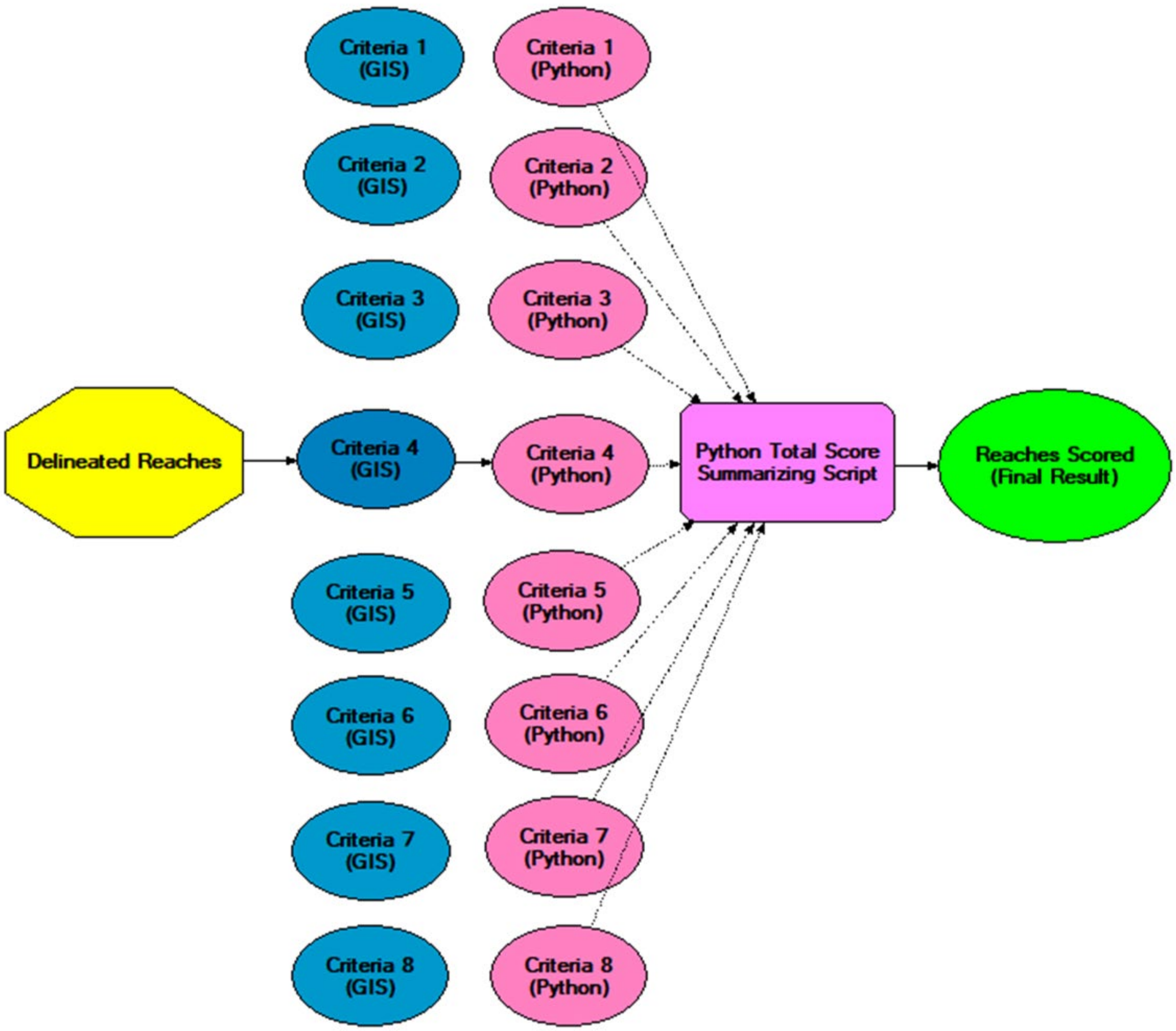

Figure 4: Phase 2 reach prioritization model flow chart.

2.5.1 Presentation of Reach Prioritization Scores

The final reach prioritization scores were presented to Valley Water as Google Earth files in addition to being included in the project GIS geodatabase. The Google Earth files include all of the Phase 2 stream reaches and the reach scores for each prioritization criteria, as well as the total reach scores for both gravel and wood prioritization. These files allowed Valley Water staff to view the reach prioritization results in detail without having to use GIS software. As shown in Figure 5, the Google Earth files allow the user to see all of the scores for any given reach by clicking on the reach on the map.

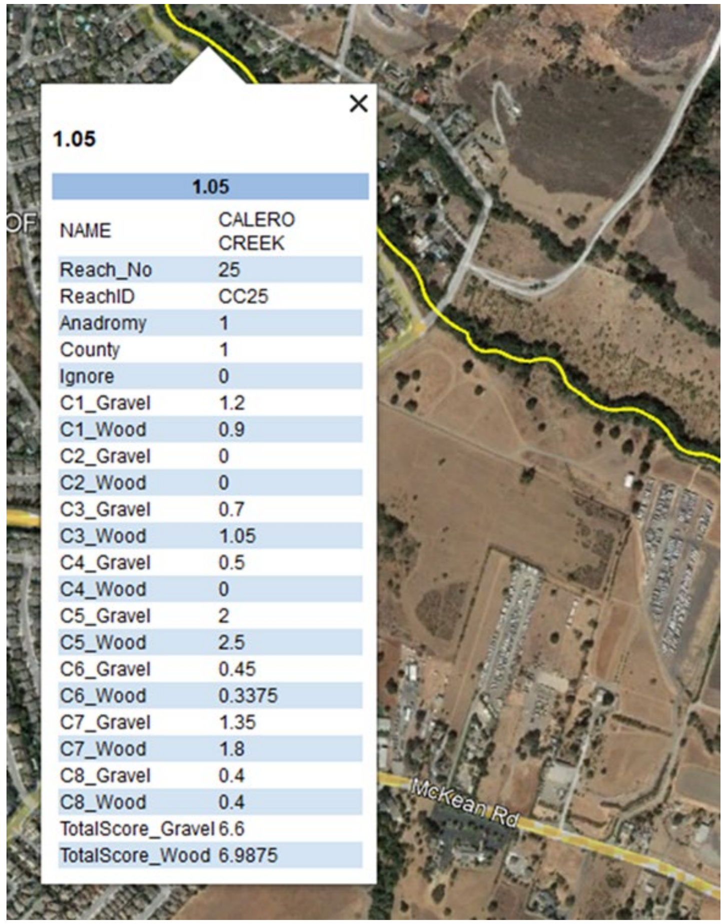

Figure 5: Example of the display of reach prioritization scores in Google Earth.

2.6 Summary of Reach Prioritization Results

Three of the Phase 2 Study streams, San Francisquito and Los Trancos Creeks and the Pajaro River, do not have any reaches amongst the highest scoring for either gravel or LWD augmentation. The highest scoring reaches for both gravel and LWD augmentation are located on Calero, Llagas and Pacheco Creeks. Scores for reaches along each of these creeks are generally highest just downstream of their respective dams and become progressively poorer with distance downstream.

The primary purpose of gravel and LWD augmentation is to counteract the adverse impacts that reservoir operations and other anthropogenic activities in county watersheds have on stream habitat complexity and steelhead habitat quality. Since these adverse impacts are the direct result of reduced natural supply and transport of gravel and LWD, gravel and LWD augmentation efforts in county streams should coincide with the locations where the interruption in natural supply has been most significant.

One of Valley Water's goals is to contribute to the restoration and maintenance of healthy steelhead populations countywide. The most important reasons for this are that steelhead in the Pajaro River and its tributaries, including Llagas and Pacheco Creeks, belong to a separate Distinct Population Segment (DPS) than steelhead in other Santa Clara County streams that flow to San Francisco Bay and that redundancy of each population is desirable to protect against natural and man-made disasters (Smith 2006).

The results of our prioritization of Phase 2 Study stream reaches for further study as potential locations to implement gravel and/or LWD augmentation projects indicate priority reaches located on Calero, Llagas and Pacheco Creeks and no priority reaches located on San Francisquito Creek, Los Trancos Creek or Pajaro River. However, we believe that selection of these priority locations is consistent with the purpose and goals of the Study described above because the priority reaches are all locations where the natural supply of sediment and LWD has been most significantly interrupted and because both steelhead DPSs are represented.

2.6.1 Reach Prioritization Results by Stream

The following stream-by-stream summary of the prioritization results is presented in terms of the results of the four prioritization criteria that most heavily influenced the overall prioritization scores for each reach. The most important prioritization criteria by weighting are:

1. Criterion #1 - Watershed source area disconnection
2. Criterion #5 - Likelihood to improve steelhead habitat
3. Criterion #6 - Risk of increased flooding
4. Criterion #7 - Ease of implementation

San Francisquito Creek – No reaches amongst the highest scoring reaches for either gravel or wood prioritization.

1. All reaches downstream of Sand Hill Road received poor scores for Criterion #5 because the creek is seasonally dry between Sand Hill Road and the tidal reach downstream of Highway 101.
2. All reaches received relatively poor scores for Criterion #1 because Searsville Dam and Reservoir only trap sediment and wood from a relatively small percentage of the total watershed area. Reaches of San Francisquito Creek that are located at least partially within Santa Clara County and included in this Study are not disconnected from gravel and wood sourced from the significant areas of the Bear and Los Trancos Creek subwatersheds.
3. Despite known flooding issues throughout much of the downstream portion of San Francisquito Creek most reaches received relatively good scores for Criterion #6 because of the lack of FEMA regulatory floodways. The scoring scheme for Criterion #6 much more heavily deprioritizes reaches within FEMA floodways than it does reaches within FEMA floodplains.
4. The majority of San Francisquito Creek reaches scored poorly for Criterion #7 due to private ownership and lack of Valley Water fee or easement. This is especially true of the few reaches upstream of San Hill Road that did not receive poor scores for Criterion #5.

Los Trancos Creek – No reaches amongst the highest scoring reaches for either gravel or wood prioritization.

1. Nearly all reaches of Los Trancos Creek received good scores for Criterion #5.
2. All reaches received poor scores for Criterion #1 because there is no instream dam and reservoir on Los Trancos Creek.
3. Most reaches received relatively good scores for Criterion #6 because of the lack of FEMA regulatory floodways.
4. Nearly all reaches of Los Trancos Creek scored poorly for Criterion #7 due to private ownership and lack of Valley Water fee or easement.

Calero Creek (Arroyo Calero) – Many reaches amongst the highest scoring reaches for both gravel and wood prioritization. Nearly all reaches received at least relatively good scores for both gravel and wood prioritization.

1. Nearly all reaches of Calero Creek received good scores for Criterion #5.
2. All reaches of Calero Creek received at least relatively good scores for Criterion #1 because Calero Dam and Reservoir disconnect a significant portion of the watershed from all downstream reaches.
3. Many reaches received at least relatively good scores for Criterion #6 because of the lack of FEMA regulatory floodways. Reaches downstream of Harry Road received the poorest scores for Criterion #6 due to the floodway at that location.
4. Many reaches of Calero Creek received good scores for Criterion #7 due to widespread Valley Water fee and easement.

Llagas Creek – Several reaches amongst the highest scoring reaches for both gravel and wood prioritization.

1. Reaches of Llagas Creek upstream of Watsonville Road received good scores for Criterion #5, while reaches downstream of Lake Silveira generally scored poorly.
2. Generally, Criterion #1 scores were good for reaches of Llagas Creek just downstream of Chesbro Dam and progressively became poorer with distance downstream.
3. Many reaches of Llagas Creek received poor scores for Criterion #6 due to the prevalence of FEMA regulatory floodways.
4. Criterion #7 scores for reaches of Llagas Creek were highly variable due to sporadic Valley Water fee and easement. The reaches of Llagas Creek that scored the highest overall were those where high scores for Criteria #5 and #7 coincided, indicating a coincidence of high steelhead habitat potential and Valley Water fee or easement.

Pacheco Creek – Two reaches amongst the highest scoring reaches for both gravel and wood prioritization.

1. Reaches of Pacheco Creek within a few miles of Pacheco Dam received good scores for Criterion #5. Reach scores for Criterion #5 decrease dramatically near Casa de Fruta and then become poorer with distance downstream.

2. Generally, Criterion #1 scores were good for reaches of Pacheco Creek just downstream of Pacheco Dam and progressively decrease with distance downstream. Criterion #1 scores for the two reaches of North Fork Pacheco Creek upstream of the confluence with South Fork Pacheco Creek received the highest scores for Criterion #1, as reaches downstream of the confluence are not disconnected from gravel and wood sourced from the significant area of the South Fork Pacheco Creek subwatershed.

3. All reaches of Pacheco Creek received good scores for Criterion #6 due to the lack of FEMA regulatory floodways.

4. All reaches of Pacheco Creek scored poorly for Criterion #7 due to private ownership and lack of Valley Water fee or easement.

Pajaro River – No reaches amongst the highest scoring reaches for either gravel or wood prioritization.

1. All reaches of the Pajaro River received relatively poor scores for Criterion #5.

2. All reaches of the Pajaro River received relatively poor scores for Criterion #1.

3. Nearly all reaches of the Pajaro River received average or relatively poor scores for Criterion #6.

4. Nearly all reaches of the Pajaro River scored relatively poorly for Criterion #7 due to private ownership and lack of Valley Water fee or easement.

3. Field Assessment

3.1 Selection of Field Assessment Sites from Priority Reaches

The Team selected a total of 14 field assessment sites on Calero, Llagas and Pacheco Creeks from the highest scoring, priority reaches. Figures 6, 7, and 8 show the locations of sites on Calero, Llagas and Pacheco Creeks, respectively. The field assessment sites include:

- Calero Creek: 6 sites between Calero Dam and Harry Road
- Llagas Creek: 3 sites between Chesbro Dam and just downstream of the Oak Glen Ave. crossing
- Pacheco Creek: 5 sites between Pacheco Dam and the confluence with the south fork of the creek.

Each field assessment site was limited to a maximum length of 300 feet. In addition to reach score for gravel and LWD, the Team also considered factors such as the environmental impact required for construction access and staging and the Distinct

Population Segment (DPS) of steelhead present in the stream when selecting field assessment sites.

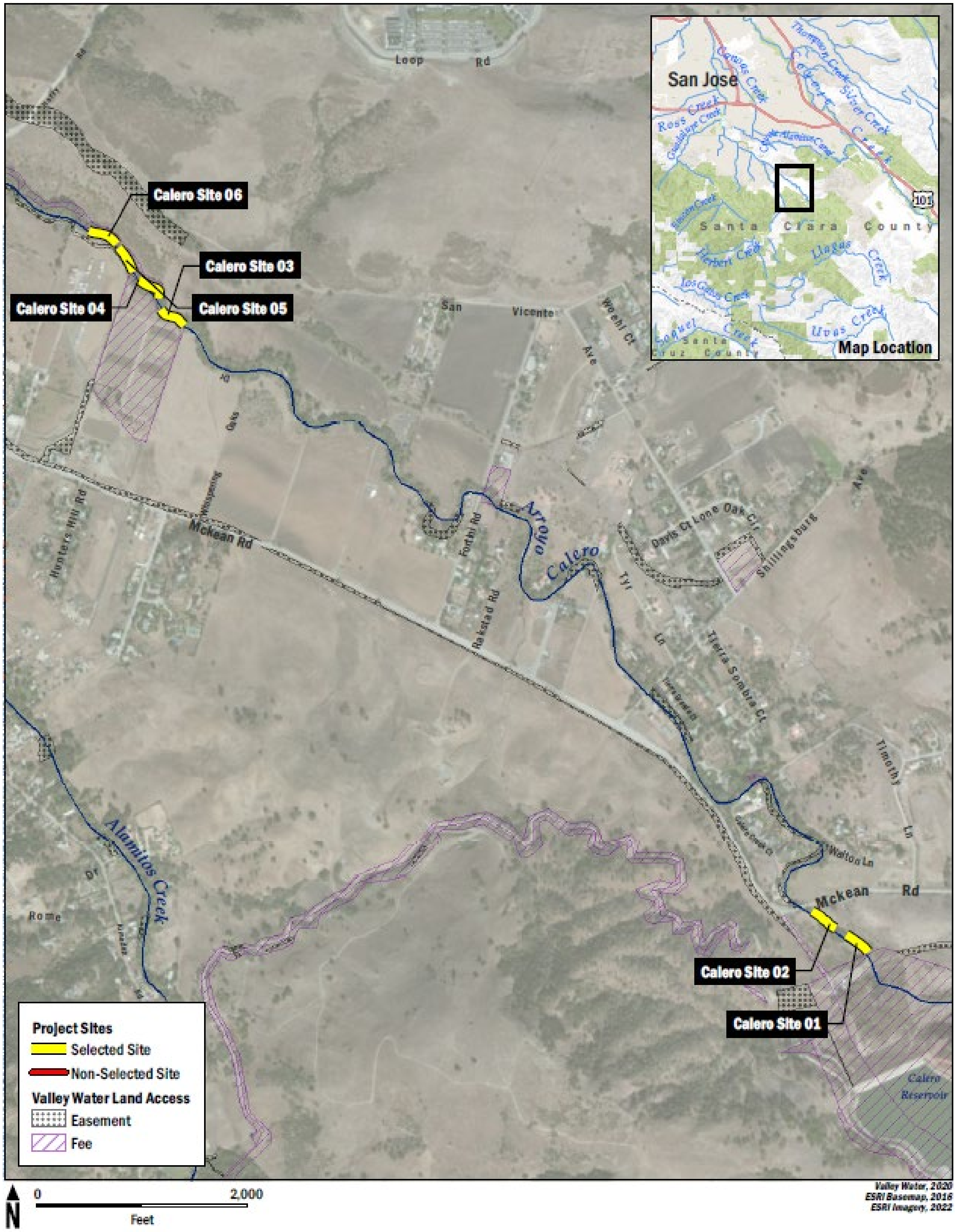

Figure 6: Calero Creek site locations.

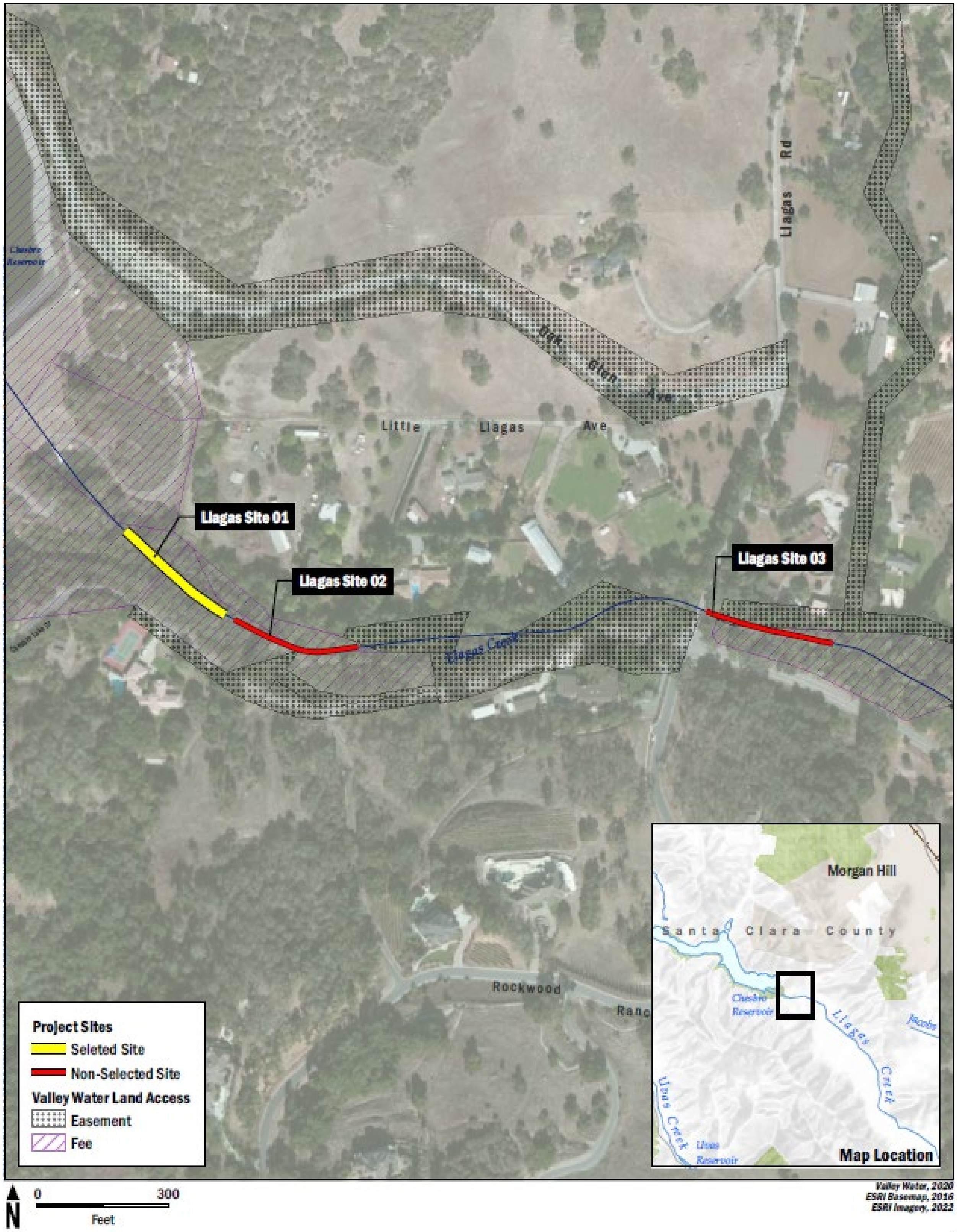

Figure 7: Llagas Creek site locations.

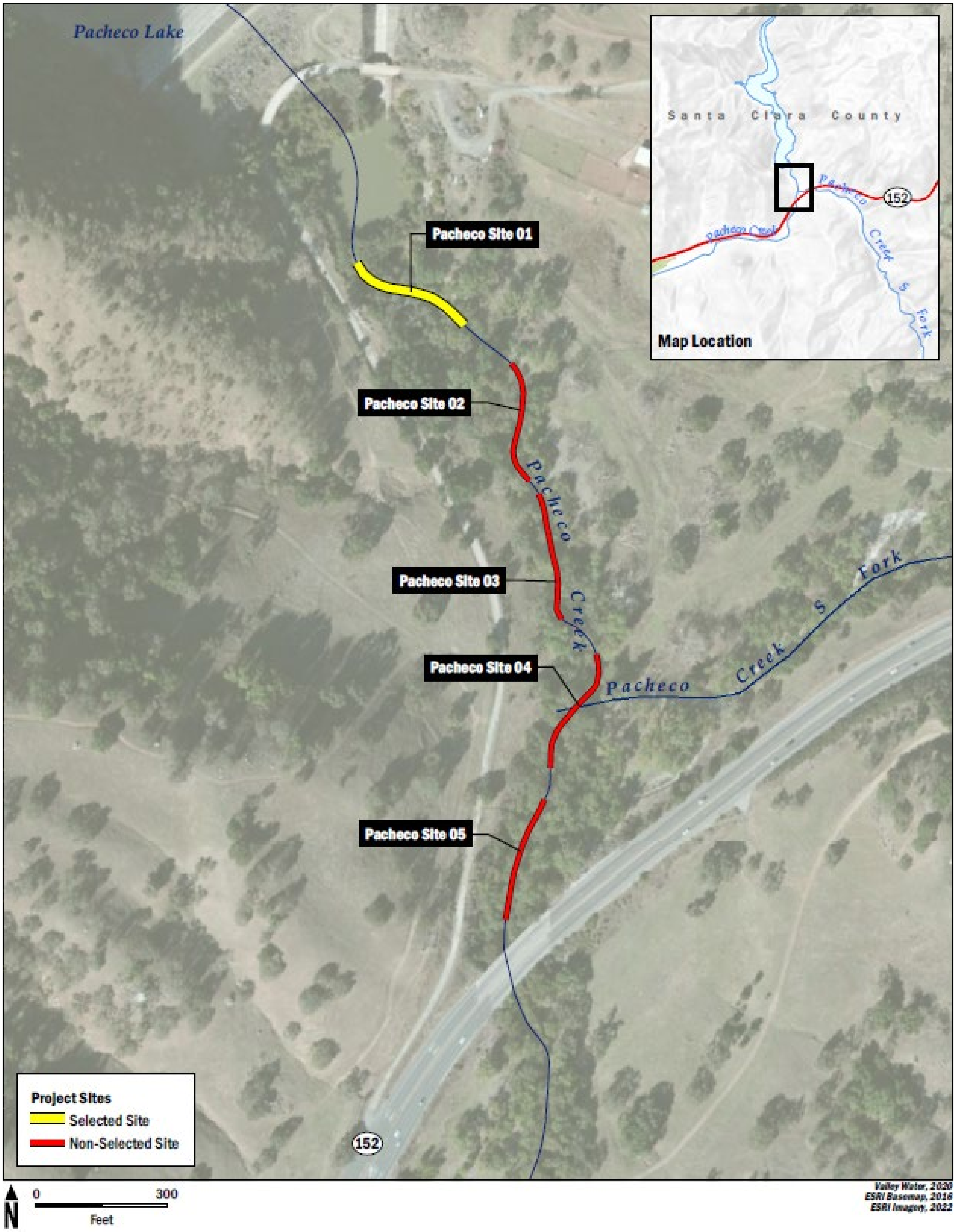

Figure 8: Pacheco Creek site locations.

3.2 Field Assessment Methods

Field assessment methods included habitat typing as described in the CDFW California Salmonid Stream Habitat Restoration Manual. Habitat units occurring within each site were classified to CDFW Level IV, which included differentiation of pool types by location within the stream channel and by cause of formation, as well as differentiation of riffle types by gradient. Data recorded for each habitat unit included instream shelter complexity score, number of pieces of large woody debris (LWD), dominant substrate size and embeddedness of pool tailout substrate.

Field assessments also included collection of topographic data, including thalweg longitudinal profiles and channel cross sections sufficient to define the channel geometry at each site well enough to allow for one dimensional hydraulic modeling and sediment transport analyses for each site. Hydraulic modeling is used in the flood conveyance analyses described in Section 4.

3.3 Field Assessment Results

Table 5 summarizes the habitat survey results and results are discussed below. As shown in Table 5, the average instream shelter complexity score for habitat units within each site was less than 2 for nearly all of the sites, no LWD was observed at 10 of the 14 sites and the average percentage of each site having gravel of the size most suitable for steelhead spawning as the most dominant substrate type was approximately 41%. The average pool tail embeddedness value for the sites was 5 as many sites lack pool habitat and the pool tailout substrate at nearly every site where pools are present was determined to be unsuitable for spawning.

Table 5: Summary of habitat survey results.

Site Name	Average Instream Shelter Complexity Score[1]	LWD Count	Site Length[2] (ft)	LWD/ 100 ft	Length "C" or "D" Substrate Dominant[3]	% of Site "C" or "D" Substrate Dominant[3]	Average Pool Tail Embeddedness Score[4]
Calero 01	1.0	0	168	0.0	0	0%	5
Calero 02	1.0	0	268	0.0	0	0%	5
Calero 03	1.2	2	240	0.8	125	52%	5
Calero 04	1.0	0	290	0.0	268	92%	5
Calero 05	1.0	0	230	0.0	209	91%	5
Calero 06	1.0	0	118	0.0	0	0%	5
Llagas 01	1.4	0	172	0.0	39	23%	5
Llagas 02	1.0	0	198	0.0	0	0%	5
Llagas 03	1.0	0	215	0.0	0	0%	5
Pacheco 01	0.0	0	168	0.0	168	100%	5
Pacheco 02	0.8	1	250	0.4	126	50%	2
Pacheco 03	0.5	0	289	0.0	289	100%	5
Pacheco 04	3.0	3	300	1.0	0	0%	5
Pacheco 05	2.3	5	270	1.9	192	71%	5
Average	**1.2**	**0.8**	**227**	**0.3**	**101**	**41%**	**5**

[1] Instream shelter complexity score ranges from 0 to 3; 0 representing no instream shelter and 3 indicating a combination of multiple types of cover, such as a bubble curtain and boulders and pieces of LWD.

[2] Site length was limited to 300 feet maximum.

[3] "C" and "D" substrate codes collectively include particles with diameters at least 0.08 inches (2mm) and less than 5 inches.

[4] Pool tail embeddedness score ranges from 1 to 5; 1 representing the most suitability for steelhead spawning and 5 the least suitability. Sites lacking pool habitat were assigned an average pool tail embeddedness score of 5.

4. Preliminary Flood Conveyance Analysis

Federal Emergency Management Agency (FEMA) National Flood Insurance Program (NFIP) policies limit increases in the maximum water surface elevation during a 100-year flood event resulting from a project affecting a stream channel. Gravel and LWD augmentation requires placing these materials into a stream channel, which reduces the space available within the channel to convey water and may result in increased water surface elevations during flood events. While modifications to the channel can often be made during an augmentation project to compensate for this reduction in conveyance capacity and prevent increases in water surface elevations, such modifications increase both the cost and environmental impacts of the project.

Since channel conditions and 100-year flood magnitudes vary from site to site, augmentation of gravel and/or LWD at some sites may have a greater potential to increase the maximum water surface elevation during a 100-year flood event than at others. Given the increased cost and impacts associated with mitigating flood water surface elevation increases, gravel and/or LWD augmentation at sites with less potential for flood water surface increases should be prioritized over augmentation at sites with greater potential for flood water surface increases.

4.1 Preliminary Flood Conveyance Analysis Methods

The Team analyzed the potential for augmentation of gravel and/or LWD at each of the sites to increase the maximum water surface elevation during a 100-year flood event. To compare sites with differing channel conveyance capacities and 100-year flood magnitudes, the Team evaluated the sensitivity of the maximum water surface elevation during a 100-year flood event at each site to increases resulting from the same hypothetical conveyance obstruction. The hypothetical conveyance obstruction was sized such that it could represent a small, engineered log jam (ELJ) or gravel injection pile that would be appropriate for placement at any of the sites.

Topographic data collected during the field assessments was used to build one dimensional, existing conditions models of the sites in HEC-RAS. Sites that are located immediately adjacent to one another were included in a single HEC-RAS model. For example, Calero Creek Sites 01 and 02 were represented by a single HEC-RAS model extending from the upstream end of Site 01 to the downstream end of Site 02. Each individual site was represented by between five and ten model cross sections.

Proposed conditions models for each site were created by altering the geometry of one cross section in the existing conditions model to represent the conveyance area that would be obstructed by the hypothetical ELJ or gravel injection pile constructed at that site. A rectangular obstruction, 4 feet in height and 8 feet wide, was applied to the modified cross section for each of the sites. Steady state simulations using the 100-year peak discharge for each creek were completed for all the existing and proposed conditions models.

4.2 Preliminary Flood Conveyance Analysis Results

The results were analyzed to evaluate the sensitivity of the simulated, 100-year water surface profiles to the effects of the obstructions. Table 6 lists the 100-year flood water surface elevation increases and percent increase for each site. The results indicate that only Llagas Creek Sites 02 and 03 are sensitive to increases in 100-year flood water surface elevations.

Table 6: Summary of 100-year flood sensitivity results.

Site Name	100-year Flood Sensitivity Increase in WSEL (ft)	100-year Flood Sensitivity % Increase in WSEL
Calero 01	0.02	0.01%
Calero 02	0.01	0.00%
Calero 03	0.00	0.00%
Calero 04	0.00	0.00%
Calero 05	0.03	0.01%
Calero 06	0.00	0.00%
Llagas 01	-0.02	-0.28%
Llagas 02	0.16	**3.62%**
Llagas 03	0.12	**23.53%**
Pacheco 01	-0.06	-0.02%
Pacheco 02	-0.02	-0.01%
Pacheco 03	-0.01	0.00%
Pacheco 04	-0.01	0.00%
Pacheco 05	-0.01	0.00%

5. Selection of Sites for Conceptual Design

5.1 Site Selection Criteria, Weighting and Scoring

In coordination with Valley Water staff, the Team developed six criteria for selecting which assessed sites to move forward into conceptual design. Four of the six criteria were based on the habitat survey results. These included:

- The number of pieces of LWD per 100 feet of stream channel within the site.
- The percentage of the site where “C” or “D” substrate is dominant.
- The average pool tailout embeddedness score within the site.
- The average shelter complexity score for habitat units within the site.

These four criteria were selected to represent the relative potential for instream shelter complexity, habitat complexity and spawning habitat at each of the sites to be improved by gravel and LWD augmentation. Sites with the fewer pieces of LWD per 100 feet of stream channel have a greater potential for instream shelter and habitat complexity to be improved by LWD augmentation. Sites having a smaller percentage where “C” or “D” substrate is dominant and sites where the average pool tailout embeddedness score is poorer have a greater potential for spawning habitat to be improved by gravel augmentation. Sites with a lower average shelter complexity score have a greater potential for this score to be improved by gravel and LWD augmentation.

The fifth and sixth criteria used to select sites for conceptual design were the relative 100-year flood sensitivity of the sites and a relative “ease of implementation” score used to represent the likelihood of Valley Water having the authority to implement a construction project at each site. The ease of implementation score was carried over from the reach prioritization process and is based on property ownership and access agreements.

Scoring for each of the six criteria was converted to a range of zero to one before a weighting was applied to each. The total weighted score was calculated as the sum of the weighted scores for the six selection criteria. In coordination with Valley Water staff, the Team determined the relative importance of the selection criteria and selected criteria weights through consideration of numerous weighting combinations. Criteria weights were developed with the following considerations:

1. The Calero Creek sites currently contain little or no LWD and are also relatively insensitive to increases in 100-year flood water surface elevations, so criteria weighting should result in the prioritization of these sites.
2. Only Llagas Creek Sites 02 and 03 are sensitive to increases in 100-year flood water surface elevations and should therefore be deprioritized by the selected criteria weights. The flood sensitivity criterion significantly impacts the overall site scoring only when weighted 60% or more.

A weighting of 60% was applied to the flooding sensitivity criterion and a weighting 5% was applied to the ease of implementation criterion. A total weighting of 35% was applied to the habitat related criteria, including 20% for shelter complexity and 5% each for LWD per 100 feet, dominant substrate and pool tailout embeddedness.

5.2 Selected Conceptual Design Sites

Table 7 summarizes the weighted scores for each of the selection criteria and the total scores for all sites. Sites are listed from highest to lowest total score. Based on the total scores all six sites on Calero Creek were selected for conceptual design, as were Llagas Creek Site 01 and Pacheco Creek Site 01.

Table 7: Selection criteria and total scores.

Site Name	Weighted Score for LWD/100ft	Weighted Score for Dominant Substrate	Weighted Score for Pool Tail Embeddedness	Weighted Score for 100-year Flood Sensitivity	Weighted Score for Ease of Implementation	Weighted Score for Shelter Complexity	Total Weighted Score
Calero 06	0.05	0.05	0.05	0.60	0.05	0.13	**0.933**
Calero 02	0.05	0.05	0.05	0.60	0.05	0.13	**0.930**
Calero 01	0.05	0.05	0.05	0.60	0.05	0.13	**0.928**
Llagas 01	0.05	0.04	0.05	0.61	0.05	0.11	**0.903**
Pacheco 01	0.05	0.00	0.05	0.60	0.00	0.20	**0.900**
Calero 05	0.05	0.00	0.05	0.60	0.05	0.13	**0.888**
Calero 04	0.05	0.00	0.05	0.60	0.05	0.13	**0.887**
Calero 03	0.03	0.02	0.05	0.60	0.05	0.12	**0.871**
Pacheco 03	0.05	0.00	0.05	0.60	0.00	0.17	**0.867**
Llagas 02	0.05	0.05	0.05	0.51	0.05	0.13	**0.841**
Pacheco 02	0.04	0.02	0.02	0.60	0.00	0.15	**0.834**
Pacheco 04	0.02	0.05	0.05	0.60	0.00	0.00	**0.723**
Pacheco 05	0.00	0.01	0.05	0.60	0.00	0.04	**0.709**
Llagas 03	0.05	0.05	0.05	0.00	0.04	0.13	**0.325**

Llagas Creek Sites 02 and 03 were not selected for conceptual design because they are sensitive to increases in 100-year flood water surface elevations due to the confinement of the channel between roads and private residences. Implementation of gravel or LWD augmentation projects at these sites would likely require grading to increase the conveyance area of the channel to compensate for the conveyance obstructions caused by the augmented materials, which would increase the costs and environmental impacts of the projects relative to projects implemented at other sites.

Llagas Creek Sites 02 and 03 are also located within a FEMA regulatory floodway. Therefore, implementation of gravel or LWD augmentation projects at these sites would require greater effort than at other sites due to the lengthy FEMA “no-rise” certification process required and design options at these sites would be limited by the requirement not to raise 100-year flood water surface elevations.

Pacheco Creek Sites 02 through 05 were also not selected for conceptual design. For the most part, this is because these sites currently contain more LWD, gravel of the size suitable for steelhead spawning and/or greater instream shelter complexity than the other sites in the Study and therefore, have less potential for habitat improvement via LWD or gravel augmentation. While all the Pacheco Creek sites are located on a single private property, these locations are not very sensitive to increases in 100-year flood water surface elevations due to the broad floodplain located on the east side of the stream. Implementation of gravel or LWD augmentation projects at any of the Pacheco Creek sites would likely require construction access from the gravel road running along the west side of the stream. However, access from this road to Sites 02 through 05 appears to be more difficult than access to Site 01.

6. Overview of Conceptual Design Objectives, Constraints and Approach

6.1 Overview of Design Objectives

The objectives of the conceptual designs are to:

1. Increase the quantity and quality of salmonid spawning habitat.
2. Increase salmonid habitat complexity and cover.

The results of habitat surveys akin to those described in the California Department of Fish and Wildlife (CDFW) California Salmonid Stream Habitat Restoration Manual (CDFW Manual) (Flosi, et. al. 2004) were used as part of the site selection process and are expected to also be used to evaluate success. During these surveys the quantity and quality of salmonid spawning habitat is assessed by recording whether the dominant sediment particle size and embeddedness at pool tailouts where spawning is most likely to occur are suitable for spawning. Spawning steelhead are generally thought to prefer gravels in the 0.5 to 4.0 inch range (12 to 102 mm), (Raleigh, et.al 1984). This range corresponds approximately to CDFW habitat typing substrate codes "C" and "D", which collectively include particles with diameters at least 0.08 inches (2mm) and less than 5 inches (127mm). One of the objectives of the conceptual designs is to increase the presence of pool tailouts where the dominant substrate type is C or D and the percent embeddedness of small cobbles is low.

Habitat surveys also assess how large wood contributes to the variety of habitat types and how the quantity of large wood affects the instream shelter complexity value and instream shelter percent covered. Accordingly, the conceptual designs specifically aim to increase the instream shelter complexity value and instream shelter percent covered, as described in the CDFW Manual, by increasing the average number of pieces of LWD in habitat units within each site.

6.2 Overview of Design Constraints

The primary constraints on the conceptual designs are the presence of FEMA regulated floodplains and regulatory floodways downstream of the augmentation sites. FEMA regulations require that any project within a regulatory floodway not increase the maximum water surface elevation of the 100-year flood. FEMA regulations require that any project within a 100-year floodplain for which base flood elevations have been mapped not increase the maximum water surface elevation of the 100-year flood by one foot or more. Since placement of materials in a creek channel may result in the loss of flood conveyance and cause water surface increases during such a flood, grading is required to remove material to compensate for the addition of gravel and LWD. Furthermore, gravel placed at any of the conceptual design sites will eventually be transported downstream where it may be temporarily deposited in locations where sediment removals are required to maintain flood conveyance capacity. This effectively limits the quantity of gravel and LWD that can be placed at any single site at any one time.

Access constraints were also considered when developing the conceptual designs. While a relative “ease of implementation” score was used to prioritize reaches and select sites where Valley Water is most likely to have the authority to implement a construction project, the width, extents, or public use of the available access routes for construction equipment often factored into the specific locations and methods of gravel and LWD augmentation proposed in the conceptual designs.

6.3 Overview of Design Approach

The conceptual designs employ multiple approaches to achieving the design objectives. These can be summarized as follows:

1. Increase the number of riffles and pools by adding gravel to convert portions of long runs and glides into riffles.
2. Add enough LWD to increase instream shelter complexity.
3. Use gravel injection piles to replenish riffles.
4. Locate gravel injection piles where they can be replenished regularly.

Because the existing habitat in the Project reach is dominated by long glides and runs, one approach employed was to encourage the development of shallower, faster water habitat units within these long, flat water habitat units, thereby increasing the variety of habitat types present. Many of the conceptual designs include adding a relatively modest amount of gravel to a portion of a long glide or run to convert that portion into riffle habitat. Because this approach directly augments the number of riffles present, we refer to it as riffle augmentation.

Another of the design approaches employed was an effort to maximize the number of individual pieces, as well as the area and volume of LWD added to the channel. The CDFW habitat survey protocol notes that the number of pieces of LWD and rootwads in a habitat unit directly affects the instream shelter complexity value for that habitat unit. (Flosi, et. al. 2004) LWD is also one type of shelter contributing to the total percentage of a habitat unit’s area that is occupied by instream shelter, as estimated from an overhead view. In addition, mitigation accounting for LWD for SMP II is based on the volume of LWD removed or added to the creek channel.

While we assumed that the initial placement of LWD and gravel as riffle augmentation at most of the conceptual design sites would require temporarily stream flow diversion and dewatering and mechanized equipment access to the wetted channel, we also sought to limit the extent of habitat disturbance associated the regular replenishment of gravels as they are transported downstream. To this end, we propose that all of the conceptual designs include either a gravel injection pile that can be replenished from the top of the bank or otherwise provide a permanent access path that would allow for additional gravel to be added to the site without the need for equipment to enter the wetted channel.

All of the conceptual designs incorporate sufficient grading at each site to compensate for the maximum flood flow conveyance area that would be occupied by the added gravel and LWD, thereby ensuring that the conceptual designs do not increase the maximum water surface elevation of the 100-year flood in the vicinity each site. Using gravel injection piles that can easily be replenished from permanent access points at the top of bank should also minimize the risk of increasing flooding or sediment removals to maintain flood conveyance downstream of the augmentation sites.

Gravel injection piles mimic the natural addition of sediment into streams in discrete pulses associated with landslides and debris flows. Such sediment pulses are transported downstream through a combination of translation (downstream movement of the entire mass) and dispersion (spreading of the mass in the downstream direction). Studies suggest that sediment pulses mostly move by dispersion, except when the sediment in the pulse is finer than the sediment in the stream (Lisle et al., 2001; Cui et al., 2003a; Sklar et al., 2009). Since the sediment in the proposed gravel injection piles will generally be courser than the dominant substrate in the creek, we expect that gravel will be dispersed downstream. This means that the volume of gravel that could be temporarily deposited in any give location downstream of an injection pile will be less than the initial volume of the pile. The conceptual designs minimize the risk of increasing flooding or sediment removals downstream by limiting the initial volume of the injection piles and locating them where they can be replenished in the future, as needed, rather than proposing larger volume gravel injection piles that may persist much longer.

7. Descriptions of the Proposed Conceptual Designs

The conceptual design drawings are attached as Appendices A, B and C. The conceptual design for each site is described below and include a description of the site location, as well as site specific objectives and constraints.

7.1 Calero Creek Site 01

As shown on Sheet 1.0 in Appendix A, Calero Creek Site 01 is located immediately downstream of Calero dam and Valley Water gaging station 5013. Habitat at the site currently consists of one continuous, 168-foot-long glide. As shown on Sheet 2.0 in Appendix A, the conceptual design for this site will increase instream habitat complexity by using a bar apex jam to bifurcate flow and increase the number and variety of habitat units by creating a scour pool at upstream end of the engineered log jam (ELJ) and riffles along both sides of a mid-channel gravel bar.

The conceptual design for Calero Creek Site 01 will provide supply of spawning gravel adjacent to the low flow channel that can be replenished regularly as it is transported downstream. This site also presents an opportunity to increase the frequency of overbank flow and connection of an existing floodplain swale located to main channel. There is no FEMA floodway and 100-year WSEL is not very sensitive to increases caused by obstructions due to wide, flat floodplain.

Calero Creek Site 01 also presents a possible opportunity for restoration of sycamore alluvial woodland (SAW), often associated with intermittent, braided stream reaches with periodic flooding, on the surrounding floodplain. (San Francisco Estuary Institute-Aquatic Science Center and H.T. Harvey & Associates. 2017) Restored SAW would provide long-term source of LWD to this reach. However, additional studies would be required to determine whether the current flow regime would need to be modified to support SAW restoration. Valley Water manages the reservoirs within the Guadalupe Watershed, including the Calero Reservoir, in accordance with the FAHCE Plus Rule Curves. The FAHCE Plus flows were designed to improve passage conditions for salmonids while balancing year-round releases to provide for fish habitat and water supply. The FAHCE Plus Adaptive Management Program offers future opportunities to adjust flows in Calero Creek to enhance the effectiveness of any future fish habitat improvement projects along the creek.

Despite its close proximity to the dam, Calero Creek Site 01 is located on County Parks property. Valley Water has an easement along the access road from McKean Rd. to the stream flow gage located just upstream of the site, but no fee or easement on the site. Valley Water would need to enter into an agreement with the property owner and to allow for both construction and adaptive management activities by Valley Water at the site.

Design Summary:

1. Construct a small bar apex ELJ (3 rootwads) and associated gravel bar approximately in the center of the site.

2. Assume a minor amount of grading on the right and left banks will be required to compensate for the 100-year flood conveyance loss associated with the bar apex jam, etc.

3. Construct two narrow riffles, one on each side of the mid channel bar.

4. Add one gravel injection pile near the newly constructed riffles. (Mostly likely on the west bank.)

5. Create a permanent access path to allow injection pile and/or riffles to be replenished as needed.

7.2 Calero Creek Site 02

As shown on Sheet 1.0 in Appendix A, Calero Creek Site 02 is located downstream of Calero Creek Site 01 and upstream of McKean Rd. Habitat at the site currently consists of one continuous, 268 ft long glide. As shown on Sheet 3.0 in Appendix A, the conceptual design for this site will increase instream habitat complexity by using a bar apex jam to bifurcate flow and increase the number and variety of habitat units by creating a scour pool at upstream end of the engineered log jam (ELJ) and riffles along both sides of a mid-channel gravel bar.

The conceptual design for Calero Creek Site 02 will provide supply of spawning gravel adjacent to the low flow channel that can be replenished regularly as it is transported downstream. This site also presents an opportunity to increase the frequency of overbank flow, as there is no FEMA floodway and 100-year WSEL is not very sensitive to increases caused by obstructions due to wide, flat floodplain.

Like Calero Creek Site 01, Calero Creek Site 02 also presents a possible opportunity for restoration of sycamore alluvial woodland (SAW) on the surrounding floodplain. Restored SAW would provide long-term source of LWD to this reach. However, additional studies would be required to determine whether the current flow regime would need to be modified to support SAW restoration.

Calero Creek Site 02 is located on County Parks property. Valley Water has an easement along the access road from McKean Rd. to the stream flow gage located just upstream of the site, but no fee or easement on the site. Valley Water would need to enter into an agreement with the property owner and to allow for both construction and adaptive management activities by Valley Water at the site.

Design Summary:

1. Construct a small bar apex ELJ (3 rootwads) and associated gravel bar approximately in the center of the site.

2. Assume a minor amount of grading on the right and left banks will be required to compensate for the 100-year flood conveyance loss associated with the bar apex jam, etc.

3. Construct two narrow riffles, one on each side of the mid channel bar.

4. Add one gravel injection pile near the newly constructed riffles. (Mostly likely on the west bank.)
5. Create a permanent access path to allow injection pile and/or riffles to be replenished as needed.

7.3 Calero Creek Site 03

As shown on Sheet 1.0 in Appendix A, Calero Creek Site 03 is located adjacent to the upstream end of Valley Water siltation pond property on McKean Rd. and within Valley Water's fee title. Habitat at the site currently includes two runs and two rootwad enhanced lateral scour pools. As shown on Sheet 4.0 in Appendix A, the conceptual design for this site will improve spawning habitat and increase habitat complexity by add converting the downstream run into to a riffle.

Since the upstream end of this site is easily accessible from the existing gravel road on the siltation pond property, the conceptual design includes one small, 11 CY, gravel injection pile near upstream end of the site and the creation of permanent access down left bank. This will allow Valley Water to provide supply of spawning gravel adjacent to the low flow channel that can be replenished regularly as it is transported downstream.

The conceptual design for Calero Creek Site 03 would further increase instream shelter and complexity by adding two or more pieces of large wood. The average canopy cover at this site is approximately 77%, which presents a possible opportunity to use accelerated wood recruitment (AWR) to increase sunlight and algae production on the augmented riffle, while also adding LWD to the existing pools. AWR involves selecting and directionally felling riparian trees into the stream channel to create LWD.

Design Summary:

1. Add gravel to the downstream run to create a riffle.
2. Add one small gravel injection pile near upstream end of the site and create permanent access down the west bank.
3. Use AWR to fell trees adjacent to downstream ends of runs/riffles such that the tops of the trees end up submerged in the downstream pools.

7.4 Calero Creek Site 04

As shown on Sheet 1.0 in Appendix A, Calero Creek Site 04 is located immediately downstream of Calero Creek Site 03 and adjacent the downstream end of Valley Water siltation pond property on McKean Rd. and within Valley Water's fee title. Habitat at the site currently includes a 60 ft run, 40 ft riffle, and 20 ft mid-channel pool. As shown on Sheet 5.0 in Appendix A, the conceptual design for this site will improve spawning habitat and increase habitat complexity by expanding the existing riffle and converting the existing run into to a riffle.

While not quite as easily accessible as Site 03, Calero Creek Site 04 is also accessible from the siltation pond property and the conceptual design includes the creation of permanent access down left bank. This will allow Valley Water to provide supply of spawning gravel adjacent to the low flow channel that can be replenished regularly as it is transported downstream.

The conceptual design for Calero Creek Site 04 would further increase instream shelter and complexity by adding two or more pieces of large wood. The average canopy cover at this site is approximately 85%, which presents a possible opportunity to use AWR to increase sunlight and algae production on the riffles, while also adding LWD to the existing pool.

Design Summary:

1. Add gravel to the expand the existing riffle and convert the downstream run into a riffle.
2. Create permanent access down the west bank.
3. Use ARR to fell trees adjacent to downstream ends of runs/riffles such that the tops of the trees end up submerged in the pool.

7.5 Calero Creek Site 05

As shown on Sheet 1.0 in Appendix A, Calero Creek Site 05 is located approximately 700 ft. upstream of Harry Road and within Valley Water's fee title. Habitat at the site currently includes a short 21 ft. long high gradient riffle, an 18 ft. mid-channel pool, 66 ft glide, 48 ft. run, and 77 ft. glide.

The most likely construction access route to this site would be via Calero Creek Trail beginning at Harry Road and proceeding upstream. The width of the trail between the top of bank and fencing along the adjacent property, a walnut orchard between Calero and Santa Teresa Creeks, may be too narrow for heavy equipment and temporary removal of some fencing may be required.

As shown on Sheet 6.0 in Appendix A, the conceptual design for this site will improve spawning habitat and increase habitat complexity by converting a portion of the existing run into to a riffle. Additional spawning gravel would be added at this site in the form of a small, 10 CY, cone shaped injection pile adjacent to the existing upstream riffle. This injection pile could be installed, and replenished as needed, by dumping gravel into the channel from Calero Creek Trail at the top of the east bank.

The conceptual design for Calero Creek Site 05 would further increase instream shelter and complexity by adding two or more pieces of large wood. The average canopy cover at this site is approximately 100%, which presents a possible opportunity to use AWR to increase sunlight and algae production on the augmented riffle, while also adding LWD to the downstream glide.

Design Summary:

1. Add gravel to the existing run to create a riffle.
2. Add gravel injection pile adjacent to the existing, upstream riffle by dumping from Calero Creek Trail at the top of the east bank.

3. Use AWR to fell trees adjacent to the downstream end of newly created riffle such that the tops of the trees end up submerged in the downstream glide.

Photo 1: View looking upstream from Calero Site 05, RAS XS 3. Mid-channel pool is at bottom of photo. Injection pile dumped from the trail at the top of the right bank would be at the base of the steep bank at the center-left of photo.

Photo 2: View looking downstream from Calero Site 05, RAS XS5 towards XS6 and XS7. The run to be converted to a riffle is approx. in the center of the photo.

7.6 Calero Creek Site 06

As shown on Sheet 1.0 in Appendix A, Calero Creek Site 06 is located approximately 350 ft. upstream of Harry Road and within Valley Water's fee title. Habitat at the site currently includes a 40 ft. run and 78 ft glide.

The most likely construction access route to this site would be via Calero Creek Trail beginning at Harry Road and proceeding upstream. The width of the trail between the top of bank and fencing along the adjacent property, a walnut orchard between Calero and Santa Teresa Creeks, may be too narrow for heavy equipment and temporary removal of some fencing may be required.

As shown on Sheet 7.0 in Appendix A, the conceptual design for this site will improve spawning habitat and increase habitat complexity by converting a portion of the existing run into to a riffle. The conceptual design for Calero Creek Site 06 would further increase instream shelter and complexity by adding two or more pieces of large wood.

Design Summary:

1. Add gravel to the existing run to create a riffle.

2. Place rootwad logs along the east bank of glide with rootwad ends extending into low flow and secure to existing tree trunks.

7.7 Llagas Creek Site 01

As shown on Sheet 1.0 in Appendix B, Llagas Creek Site 01 is located immediately downstream of confluence of the channels flowing from the Chesbro Dam spillway and piped outlet pool and within Valley Water's fee title. Habitat at the site includes a sequence of short runs, riffles and glides.

The site is approximately 100 ft. downslope of Valley Water's existing gravel access road below the dam. The conceptual design assumes that a new permanent access path from the existing road would be developed.

As shown on Sheet 2.0 in Appendix B, the conceptual design for Llagas Creek Site 01 will improve spawning habitat by placing small injection pile on the left bank near the run at the upstream end of the site. Due to the FEMA regulatory floodway at this location and the requirement that project implementation would result in no rise in 100-year water surface elevation, the volume of the injection pile would be limited to approximately 1 truck load, or 12 CY. This is shown on the Drawings as a pyramid shaped injection pile with square bottom. The height of the pile would be approximately 5 feet and the sides of the pile would be approximately 14 feet long.

The conceptual design for Llagas Creek Site 01 would further increase instream shelter and complexity by adding two rootwad logs on the east bank side of the channel along the glide downstream of the upstream run. The rootwad logs would be placed with rootwads protruding into the low flow channel and angled such that log ends are somewhat downstream of the rootwad ends. The protruding rootwads should induce scour, deepening the glide and possibly converting it into a pool. The large patch of invasive Arundo donax at this location would be removed as part of flood flow conveyance compensation strategy.

Design Summary:

1. Add small, 12 CY injection pile on the west bank near the upstream run.
2. Remove Arundo donax on the east bank side of the upstream glide and add 2 rootwad logs.

Photo 3: Llagas Site 01 looking upstream from cross section 1. Run in foreground. Flow from spillway plunge pool on photo left. Flow from reservoir outlet pipe on photo right.

Photo 4 Llagas Site 01 looking downstream from cross section 1. Glide in foreground extends to approximately where the V-shaped willow tree is on the left bank. The Arundo patch is shown on the right bank.

7.8 Pacheco Creek Site 01

As shown on Sheet 1.0 in Appendix C, Pacheco Creek Site 01 is located immediately downstream of the Pacheco Dam spillway plunge pool. Habitat at the site includes a 91 ft long high gradient riffle and a 77 ft. long glide. As shown on Sheet 2.0 in Appendix C, the conceptual design for Pacheco Creek Site 01 will improve spawning habitat by placing a gravel injection pile on right bank side of channel at the upstream end of the existing riffle. Valley Water has no fee title or easement at this site and would need to enter into an agreement with the property owner and to allow for both construction and adaptive management activities by Valley Water at the site.

The conceptual design assumes the site would be accessed via the existing gravel access road on the west side of the creek. As shown on Sheet 2.0 in Appendix C, the injection pile would be constructed by dumping gravel from the top of the right steep bank, creating a ramp of gravel extending down into the channel below. The injection pile could be replenished, as needed, in the future using the same access and method.

There is no FEMA floodway on the north fork of Pacheco Creek and 100-year water surface elevation is not very sensitive to increases caused by obstructions due to the wide, flat floodplain on the east side of the channel. Therefore, there is little to no constraint on the size of the injection pile.

On the west bank side of the channel across from the where the east bank injection pile is proposed, there is a large gravel/cobble point bar that extends downstream to the end of the riffle. This point bar could be used to access the glide downstream, where two rootwad logs would be installed on west bank side of the channel to increase instream shelter and complexity. The rootwad logs would be placed with rootwads protruding into the low flow channel and angled such that log ends are somewhat downstream of the rootwad ends. The protruding rootwads should induce scour, deepening the part of the long glide and possibly converting a portion of it into a pool.

Design Summary:

1. Dump gravel from the top of the right bank to create a large gravel injection pile on the east bank side of channel at the head of the existing riffle.
2. Add 2 rootwad logs on the west bank side of the channel along the glide downstream of the riffle to increase instream shelter and complexity.

8. Supporting Technical Analyses

8.1 Flood Conveyance Analysis

The Phase 2 Team analyzed the potential for the proposed design for augmentation of gravel and large wood at each of the sites to increase the maximum water surface elevation during a 100-year flood event. The existing and proposed conditions HEC-RAS models previously created for the preliminary flood conveyance analysis were used as the basis for these analyses. The geometry of multiple cross sections within the proposed conditions model for each site was altered to represent the conveyance area at each model cross section that would be obstructed by the riffle supplementation, gravel injection pile or large wood proposed in the design for that location within the site.

Steady state simulations using the 100-year peak discharge for each creek were completed for all the existing and proposed conditions models. The results were analyzed to evaluate the effects of the proposed design on the 100-year water surface profile at each site. Table 8 lists the maximum 100-year flood water surface elevation increase for each site. The results indicated that additional grading would need to be incorporated into the final designs for sites Calero Creek 04 and Llagas Creek 01. Additional details about the effects of the proposed designs on 100-year flood conveyance and the potential implications are included in the descriptions of the proposed designs.

Table 8: Maximum 100-year flood water surface elevation increases.

Site Name	Maximum Increase in 100-year Flood WSEL (ft)
Calero 01	0.02
Calero 02	0.03
Calero 03	0.10
Calero 04	1.53
Calero 05	0.06
Calero 06	0.04
Llagas 01	0.19
Pacheco 01	0.35

8.2 Design Gravel Gradation, Gravel Transport and Injection Pile Lifetime Expectancy

8.2.1 Design Gravel Gradation

During the implementation of Valley Water’s previous gravel and LWD augmentation project on Los Gatos Creek, the site-specific gradation specified in the design was simplified following that rationale that since the goal is to improve steelhead spawning habitat, the gradation should be a well graded mix of the size of gravels that steelhead prefer when spawning. A local supplier, Graniterock, produces gravels from alluvium harvested from the floodplain of the Pajaro River that consist entirely of gravels that are within the range of sizes preferred by steelhead for spawning. These are typically sold as “spawning mixes” and have been used in other steelhead stream restoration projects in the San Francisco Bay area. The gradation of the gravel material used for Valley Water’s gravel augmentation projects on Los Gatos Creek and Uvas Creek, “Graniterock Streambed Spawning Cobble Mix #240”, was used to estimate an average bedload transport rate for each of the conceptual design sites. The gradation of this gravel material is shown in Table 9.

Table 9. Gradation of Graniterock Streambed Spawning Cobble Mix #240".

Diameter (mm)	% Finer
19	4.7
25	13
37.5	33
50	47
63	66
75	85
100	95
125	97
175	100

8.2.2 Gravel Transport Analyses

The Phase 2 Team completed two different types of sediment transport analyses to estimate how frequently the proposed gravel might be transported downstream and how often the injection piles might need to be replenished. For each of the conceptual designs, we completed an incipient motion analyses using the Shields equation to estimate the discharge at which the D50, or median, size gravel particle in the design gradation would first be mobilized. Then, to estimate the lifetime expectancy of the proposed gravel injection piles and how often they might need to be replenished, we completed calculations to estimate the capacity of the Phase 2 streams to transport the gravel proposed.

A sediment particle on the streambed initially begins to move when the flow exerts drag and lift forces on the particle that exceed the weight and friction forces resisting motion (Table 10, reproduced from Figure E.1 in USFS [2008], adapted from Julien [1995]).

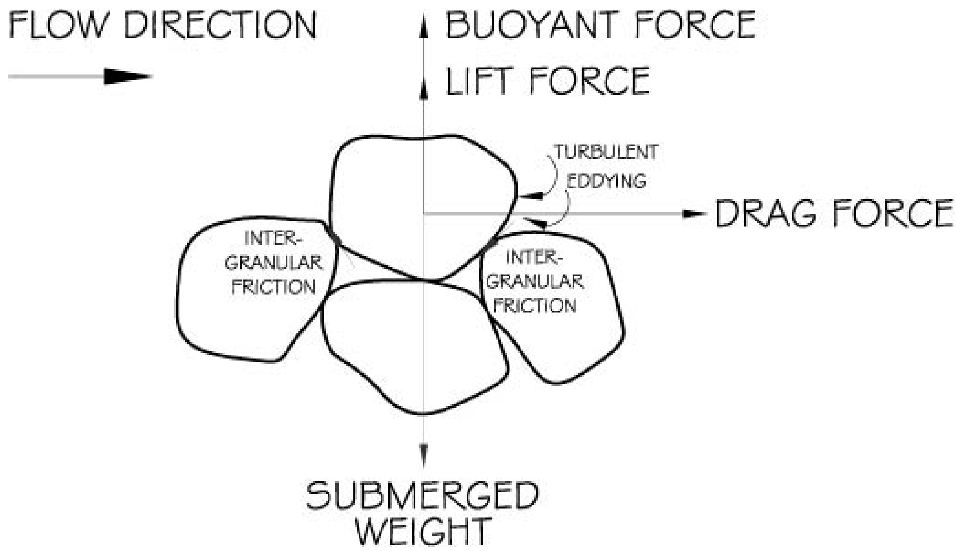

Figure 9: Schematic diagram of the forces acting on a submerged streambed particle.

One measure of the forces exerted by the flow on the streambed is the average boundary shear stress. For a given flow, the average boundary shear stress exerted by the water on its boundary is given by:

$$\tau = gRS$$

where:

τ = average boundary shear stress (lb/ft^2)
g = specific weight of water (62.4 lb/ft^3)
R = hydraulic radius (ft)
S = energy slope or bed slope (ft/ft).

Hydraulic radius is the average flow depth, determined by dividing the cross-sectional flow area by the wetted perimeter of the flow.

Shields equation is commonly used to calculate the shear stress required to initiate particle motion, for a given particle size, usually represented by the D50 size of the streambed. The simplified relationship of forces acting on a sediment particle at the moment that motion is initiated is expressed as a dimensionless ratio known as the Shields parameter:

$$\tau^* = \frac{\tau_c}{(g_s - g)D}$$

where:

τ^* = Shields parameter (unitless)
τ_c = critical average boundary shear stress at which the sediment particle begins to move (lb/ft^2)
g_s = specific weight of the sediment particle (lb/ft^3)
g = specific weight of the fluid (lb/ft^3)
D = median size particle diameter of the channel bed, D50 (ft)

USFS (2008) suggests the use of a range of Shields parameter values originally presented by Julien (1995), which were determined experimentally for a wide range of uniform particle sizes based on the angle of repose of the sediment. Julien's results indicated that Shields parameter increases nonlinearly as particle size increases from 0.029 for medium sands to 0.050 for very coarse gravels and approaches a constant value of 0.054 for particles that are large cobble sized, 128 millimeters in diameter and above (Table 10). The D50 of the design gravel gradation is 52mm. Using Julien's indicated Shields parameter of 0.050 for gravels 32-64mm in diameter and assuming the specific weight of sediment is 165 lb/ft^3 and specific weight of water is 62.4 lb/ft^3, we calculated a critical shear stress of 0.875 lb/ft^2.

Table 10: Range of Shields parameters for various particle sizes.

Particle size classification	*Particle size, D (mm)*	*Angle of repose, ϕ (degrees)*	*Shield's parameter, τ^**	*Critical shear stress, τ_c (lb/ft^2)*
very large boulders	*> 2,048*	*42*	*0.054*	*37.37*
large boulders	*1,024-2,048*	*42*	*0.054*	*18.68*
medium boulders	*512-1,024*	*42*	*0.054*	*9.34*
small boulders	*256-512*	*42*	*0.054*	*4.67*
large cobbles	*128-256*	*42*	*0.054*	*2.34*
small cobbles	*64-128*	*41*	*0.052*	*1.13*
very coarse gravels	*32-64*	*40*	*0.050*	*0.54*
coarse gravels	*16-32*	*38*	*0.047*	*0.25*
medium gravels	*8-16*	*36*	*0.044*	*0.12*
fine gravels	*4-8*	*35*	*0.042*	*0.057*
very fine gravels	*2-4*	*33*	*0.039*	*0.026*

Source: USFS 2008; Julien 1995

Average boundary shear stress was calculated for a wide range of discharges for each of the conceptual design sites and compared to the calculated critical shear stress for the 52mm diameter, D50 of the design gravel gradation to estimate the lowest discharge at which gravel would be mobilized at each site. The results are summarized in Table 11.

Percent exceedance probabilities for the estimated minimum discharges to entrain gravel were estimated using the flow duration curves described in the following section.

Table 11: Summary of results of Shields analyses.

Site Name	Discharge (cfs)	Critical Shear Stress (lb/ft^2)	Average Shear Stress (lb/ft^2)	Exceedance Probability (%)
Calero 01	310	0.875	0.876	< 0.01
Calero 02	NA*	0.875	NA*	0
Calero 03	127	0.875	0.878	< 0.1
Calero 04	212	0.875	0.878	< 0.1
Calero 05	74	0.875	0.881	0.15
Calero 06	66	0.875	0.880	0.18
Llagas 01	32	0.875	0.882	5.0
Pacheco 01	27	0.875	0.881	5.2

* Average boundary shear stress at Calero 02 was calculated for discharges up to 1,000 cfs. All results were significantly less than the critical shear stress value of 0.875 lb/ft^2.

An average bedload transport rate for each conceptual design was estimated using the Bedload Assessment of Gravel-bed Streams (BAGS) tool developed by the United States Forest Service (USFS) National Stream and Aquatic Ecology Center. BAGS is a spreadsheet-based program that predicts bed load transport using six well-known bed load transport equations developed specifically for gravel-bed rivers. Sediment transport estimates are calculated on the basis of field measurements of channel geometry, reach-average slope, and bed material grain size (Pitlick et. al. 2009).

Of the six bedload transport equations available in BAGS, we chose the surface-based equation of Parker (1990). The equation of Parker (1990) was chosen because it is one of two equations that do not require observed sediment transport data for calibration and were developed based on the gradation of the bed surface material, rather than the bed substrate material, or a combination of the surface and substrate. The other bedload sediment transport model, the equations of Wilcock and Crowe (2003), is commonly used because it has the advantage of explicitly accounting for the effect of sand on gravel transport rates. However, use of the Wilcock and Crowe (2003) equations is generally recommended when the bed surface material is at least 5-10% sand, and the design gravel gradation does not include sand. Use of the Parker (1990) equations is also consistent with sediment transport calculations completed for the Phase 1 Study. Details regarding the Parker (1990) equation were included in the Phase 1 Study report. (Balance Hydrologics 2018).

Input data required for calculations of average bedload transport rate using the Parker (1990) equation in BAGS included:

1. The gravel design gradation.
2. The reach averaged bankfull width, as estimated from field surveys.
3. The bed friction slope, as determined from the HEC-RAS models used for flood conveyance analysis.

4. A flow duration curve, based on historical stream flow gaging data.

Flow duration curves were developed for Calero, Llagas and Pacheco Creeks for use in BAGS. 15-minute discharge data for gaging station 5013, Calero Creek below Calero Reservoir, was obtained from Valley Water for the period spanning from April 9, 1975 through February 22, 2022 and used to calculate daily mean discharges. Exceedance probabilities were then calculated to develop the flow duration curve for Calero Creek shown in Table 12.

Table 12. Flow duration curve for Calero Creek.

Discharge (cfs)	Discharge (cms)	Exceedance Probability (%)
0	0.00	100
0.1	0.003	90
1.1	0.03	80
2.0	0.06	70
3.0	0.08	60
3.4	0.10	50
4.5	0.13	40
7.3	0.21	30
11	0.32	20
15	0.44	10
19	0.55	5
30	0.85	2
37	1.05	1
51	1.43	0.5
85	2.42	0.1
331	9.37	0

15-minute discharge data for gaging station 5069, Llagas Creek below Chesbro Reservoir, was obtained from Valley Water for the period spanning from November 11, 1971 through February 22, 2022 and used to calculate daily mean discharges. Exceedance probabilities were then calculated to develop the flow duration curve for Llagas Creek shown in Table 13.

Table 13: Flow duration curve for Llagas Creek.

Discharge (cfs)	Discharge (cms)	Exceedance Probability (%)
0	0.00	100
1.2	0.03	90
2.2	0.06	80
3.3	0.09	70
4.1	0.12	60
5.1	0.14	50
6.4	0.18	40
8.8	0.25	30
11	0.32	20
18	0.52	10
31	0.89	5
111	3.14	2
234	6.64	1
372	10.53	0.5
580	16.43	0.1
1337	37.86	0

15-minute discharge data for gaging station 11153000, Pacheco Creek near Dunneville, CA, was obtained from the USGS for the period spanning from October 1, 2006 through May 24, 2022 and used to calculate daily mean discharges. Daily mean discharges were then scaled by the ratio of the watershed areas above the site and gaging station, 0.46. Exceedance probabilities were then calculated to develop the flow duration curve for Pacheco Creek shown in Table 14.

Table 14: Flow duration curve for Pacheco Creek.

Discharge (cfs)	Discharge (cms)	Exceedance Probability (%)
0.0	0.00	100
0.3	0.01	30
0.7	0.02	25
2	0.05	20
5	0.13	15
8	0.22	10
29	0.82	5
87	2.47	2
208	5.90	1
434	12.29	0.5
1143	32.36	0.1
2032	57.54	0

The results of our calculations of average bedload transport rate using the Parker (1990) equation in BAGS are summarized in Table 15.

Note that the calculated average bedload transport rates in Table 8 assume that the entire bankfull channel at each site is always lined with material having the design gravel gradation. Use of the bedload transport rates for estimating the lifetime expectancy of proposed injection piles is discussed in the following subsection.

Table 15: Summary of BAGS results.

Site Name	Bankfull Width (m)	Friction Slope	Average bedload transport rate (tons/year)	Average bedload transport rate (CY/year)
Calero 01	8.4	0.003	0	0
Calero 02	8.8	0.002	0	0
Calero 03	4.6	0.007	127	85
Calero 04	5.3	0.002	0	0
Calero 05	5	0.001	0	0
Calero 06	5.2	0.0004	0	0
Llagas 01	4.2	0.006	5,056	3,370
Pacheco 01	15.1	0.006	2,634	1,756

8.2.3 Injection Pile Lifetime Expectancy

The results of the sediment transport analyses described in the previous section suggest that, assuming that the future flow regime will be similar to the historical flow regime, Calero Creek will not have the capacity to transport steelhead spawning gravel on a regular basis. This means that augmenting spawning gravels at any of the conceptual design sites would be unlikely to result in any spawning habitat improvement downstream of the site and that localized spawning habitat improvements may be temporary, as placed gravels might soon be covered by finer sediment. Therefore, we recommend that any plans for augmentation of spawning gravels on Calero Creek include plans for implementing the release of periodic geomorphic pulse flows from Calero Reservoir. The FAHCE Plus Adaptive Management Program offers future opportunities to adjust flows in Calero Creek to enhance the effectiveness of any future fish habitat improvement projects along the creek.

For the conceptual design sites on Llagas and Pacheco Creeks, the results of the sediment transport analyses suggest that these creeks will have more than enough capacity to transport the volume of gravel that is proposed for placement at any one time. Since each of the proposed conceptual designs would only include placement of gravel within a portion of the channel at any given cross section location, the average bedload transport results in Table 15 needed to be scaled by the portion of the channel cross section at each site that would be occupied by augmented gravel at given discharge that is great enough to mobilize and transport spawning sized gravel to estimate a rate of transport for the augmented gravel.

The conceptual design for Llagas Creek Site 01 includes a small, 12CY gravel injection that located both just outside of the width of the estimated bankfull flow channel and outside of the flow area at the discharge corresponding to the average bedload transport rate, which suggests that one or more years may go by without the occurrence of a flow event that depletes any of the injection pile. However, the volume of the proposed injection pile is less than one percent of the estimated average bedload transport rate, which suggests that a soon as a flow event occurs that inundates the area where the injection pile is located, the entire pile is likely to be transported downstream.

The conceptual design for Pacheco Creek Site 01 includes a much larger, approximately 320 CY gravel injection pile installed by dumping gravel directly into the channel from the top of the approximately 25-foot-high right bank. The injection pile would be located at an existing riffle and gravel point bar and the toe of the injection pile would occupy nearly half of the existing bankfull channel for a length of approximately 20 feet. Assuming that the future flow regime will be similar to the historical flow regime, flows capable of transporting spawning gravel will occur several times each year, on average, and these flows will always be in contact with the toe of the injection pile. This suggests that the entire injection pile volume could be dispersed in any given year.

Given that there are many sources of uncertainty in these attempts to estimate gravel injection pile lifetime expectancy based on sediment transport calculations, we recommend that should Valley Water implement any of the conceptual designs, plans for replenishing gravel injection piles be based on annual monitoring of pile volume rather than sediment transport calculations alone.

9. Success Criteria, Monitoring, and Adaptive Management

9.1 Success Criteria

As mentioned in Section 1.3, Key Performance Indicator 5 for Project D4 requires implementation of five gravel or LWD augmentation projects, or one in each major watershed. The following criteria are intended to be used to assess the success of individual projects that Valley Water might undertake to implement the conceptual designs presented in this report, rather than the success of Valley Water's gravel and LWD augmentation efforts as a whole.

The objectives of the conceptual designs are to increase the quantity and quality of salmonid spawning habitat and habitat complexity and cover at each site. The designs specifically aim to increase the presence of pool tailouts where the dominant substrate type is C or D and the percent embeddedness of small cobbles is low, the variety of habitat types within each site, as well as the instream shelter complexity value and instream shelter percent covered, as described in the CDFW Manual (Flosi, et. al. 2004). Therefore, the project shall be considered successful if one or more of the following occurs:

1. The presence of pool tailouts where the dominant substrate type is C or D and the percent embeddedness of small cobbles is low at a given site increases relative to pre-project conditions.
2. The number of habitat units or variety of habitat unit types occurring within a given site increases relative to pre-project conditions.
3. The instream shelter complexity value rating for habitat units occurring within a given site increases relative to pre-project conditions.
4. The instream shelter percent covered for habitat units occurring within a given site increases relative to pre-project conditions.

9.2 Monitoring

If any of the conceptual designs are implemented, two types of monitoring should be completed. The first type would be post-project monitoring completed to evaluate the performance of the project relative to the success criteria in the previous section. These monitoring methods will include habitat surveys of the implementation site including Level IV stream habitat type classification, instream shelter complexity and instream shelter percent covered as described in Part III of the CDFW Manual (Flosi et. al. 2004).

If implementation projects are permitted under SMP post-project evaluation would typically occur in years one, three and five following construction and all monitoring information will be reported to the regulatory agencies by Valley Water in the SMP Annual Summary Report.

The second type of post-project monitoring would be completed for the purpose of determining whether the gravel and LWD installed during a given implementation project needs to be replenished. This monitoring would include:

1. Annual walking inspections of LWD installations to determine whether the LWD remains in its original location and configuration and the extent to which the wood has decayed.
2. Topographic surveys of gravel injection piles and tracking of injection pile volume.

Topographic surveys of gravel injection piles could be completed using any traditional survey method. However, recent advances in the 3D scanning capabilities of personal phones and tablets may significantly reduce the effort and expertise required. Relatively inexpensive and intuitive applications are available that will allow anyone with a phone or tablet with 3D scanning capabilities to scan a gravel pile and immediately estimate the volume of the pile. The timing and frequency of topographic surveys could be triggered by the occurrence of flow events having peak discharges equal to or greater than the threshold required to mobilize gravel at each site.

9.3 Adaptive Management

Gravel and LWD augmentation projects should be managed adaptively by Valley Water following implementation. Spawning gravel and LWD placed in channels should be expected to move downstream or degrade over time, and therefore will need to be replenished. The monitoring of the condition of LWD installation and gravel injection pile volumes described above should be used by Valley Water to determine when additional materials should be added at any given implementation site.

The quantities of gravel and LWD proposed for each of the conceptual design sites were chosen to avoid significant impacts to 100-year flood conveyance at the sites and, for the most part, installed gravel is expected to be dispersed downstream rather than moving downstream as a mass. However, at least some portion of the gravel volume placed to improve steelhead spawning habitat will eventually find its way to depositional areas closer to the San Francisco and Monterey Bays including locations where sediment is removed from the channel to maintain flood conveyance. Over time, gradation analyses, in addition to tracking of the volume of sediment removed from the channel would also provide important indication of the gravel transport rate through the system and these records should be used to adjust the volume of gravel placed to replenish injections piles at implementation sites.

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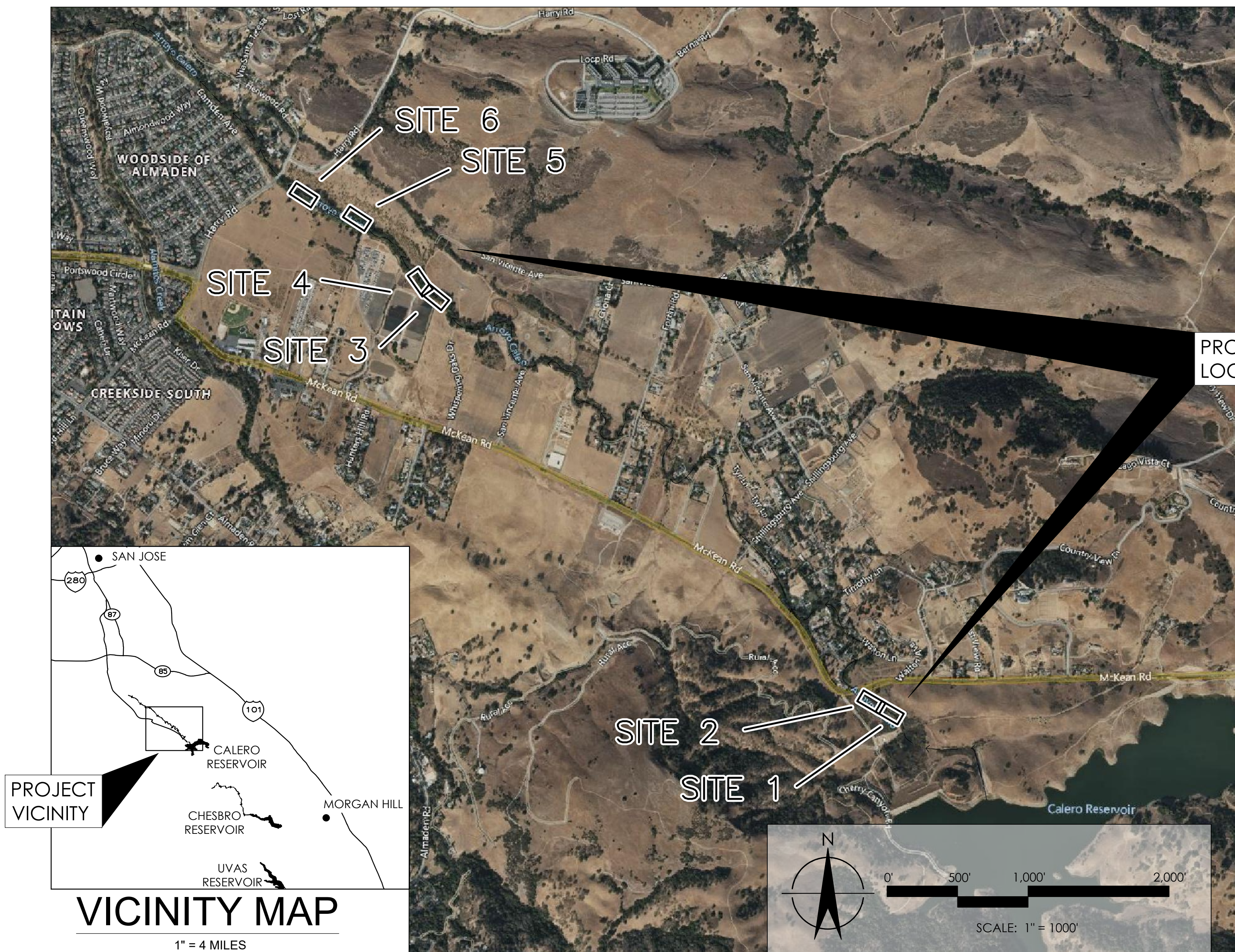
Appendix A Conceptual Design Drawings – Calero Creek

CALERO CREEK GRAVEL AND WOOD AUGMENTATION

CITY OF SAN JOSE, SANTA CLARA COUNTY, CALIFORNIA

Valley Water
Clean Water • Healthy Environment • Flood Protection

LOCATION MAP



VICINITY MAP

1" = 4 MILES

SHEET INDEX

SHEET 1.0: COVER SHEET
SHEET 2.0: SITE 01 PLAN AND PROFILE
SHEET 2.1: SITE 01 SECTIONS
SHEET 3.0: SITE 02 PLAN AND PROFILE
SHEET 3.1: SITE 02 SECTIONS
SHEET 4.0: SITE 03 PLAN AND PROFILE
SHEET 4.1: SITE 03 SECTIONS
SHEET 5.0: SITE 04 PLAN AND PROFILE
SHEET 5.1: SITE 04 SECTIONS
SHEET 6.0: SITE 05 PLAN AND PROFILE
SHEET 6.1: SITE 05 SECTIONS
SHEET 7.0: SITE 06 PLAN AND PROFILE
SHEET 7.1: SITE 06 SECTIONS

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DATE 03-19-2021

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COVER SHEET

CALERO CREEK GRAVEL AND WOOD AUGMENTATION
SANTA CLARA COUNTY, CALIFORNIA

PROJECT NUMBER

SCALE (AT 22" X 34")
AS NOTED

SHEET
1.0

NOTES:

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0' 20' 40' 80'

SCALE: 1" = 20'

SITE 01

LEGEND:

EXISTING MAJOR CONTOUR: 5 FT INTERVAL	200
EXISTING MINOR CONTOUR: 1 FT INTERVAL	
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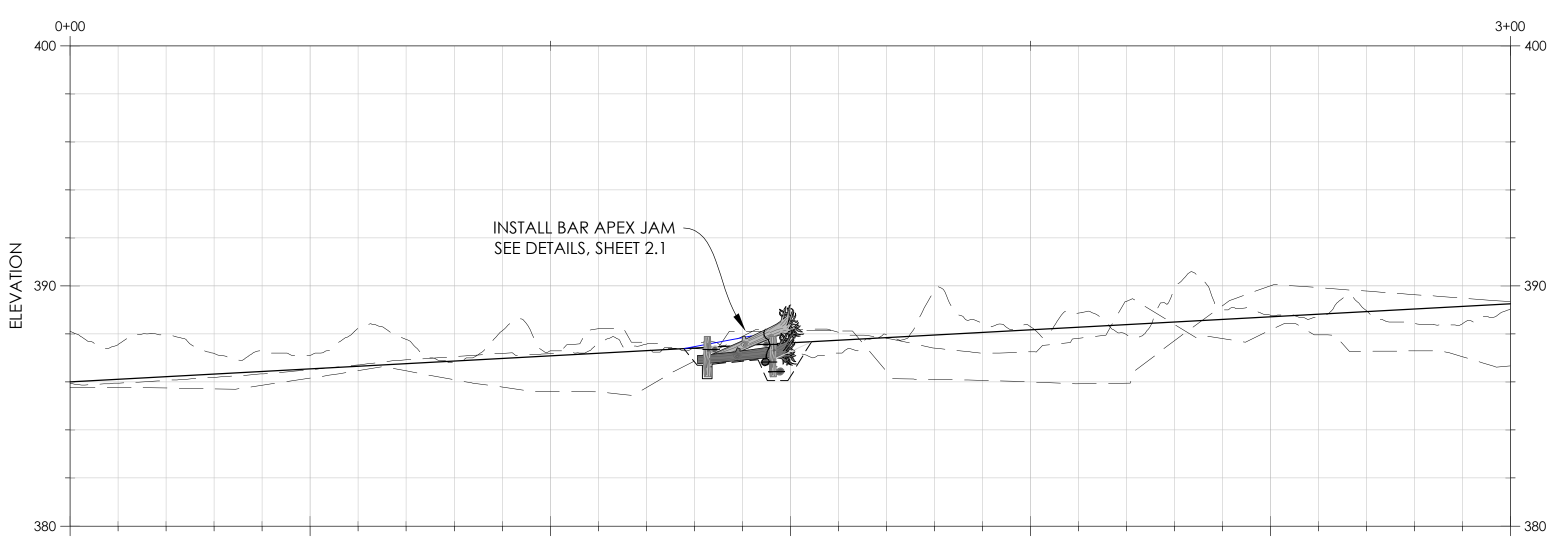
BAR APEX JAM (PLAN VIEW)	
CHANNEL EXCAVATION LIMITS	



1 SITE 01 CHANNEL PROFILE
SCALE: 1" = 20'

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SITE 01 PLAN AND PROFILE

CALERO CREEK
GRAVEL AND WOOD AUGMENTATION
SANTA CLARA COUNTY, CALIFORNIA

PROJECT NUMBER

SCALE (AT 22" X 34")
AS NOTED

SHEET
2.0

NOTES:

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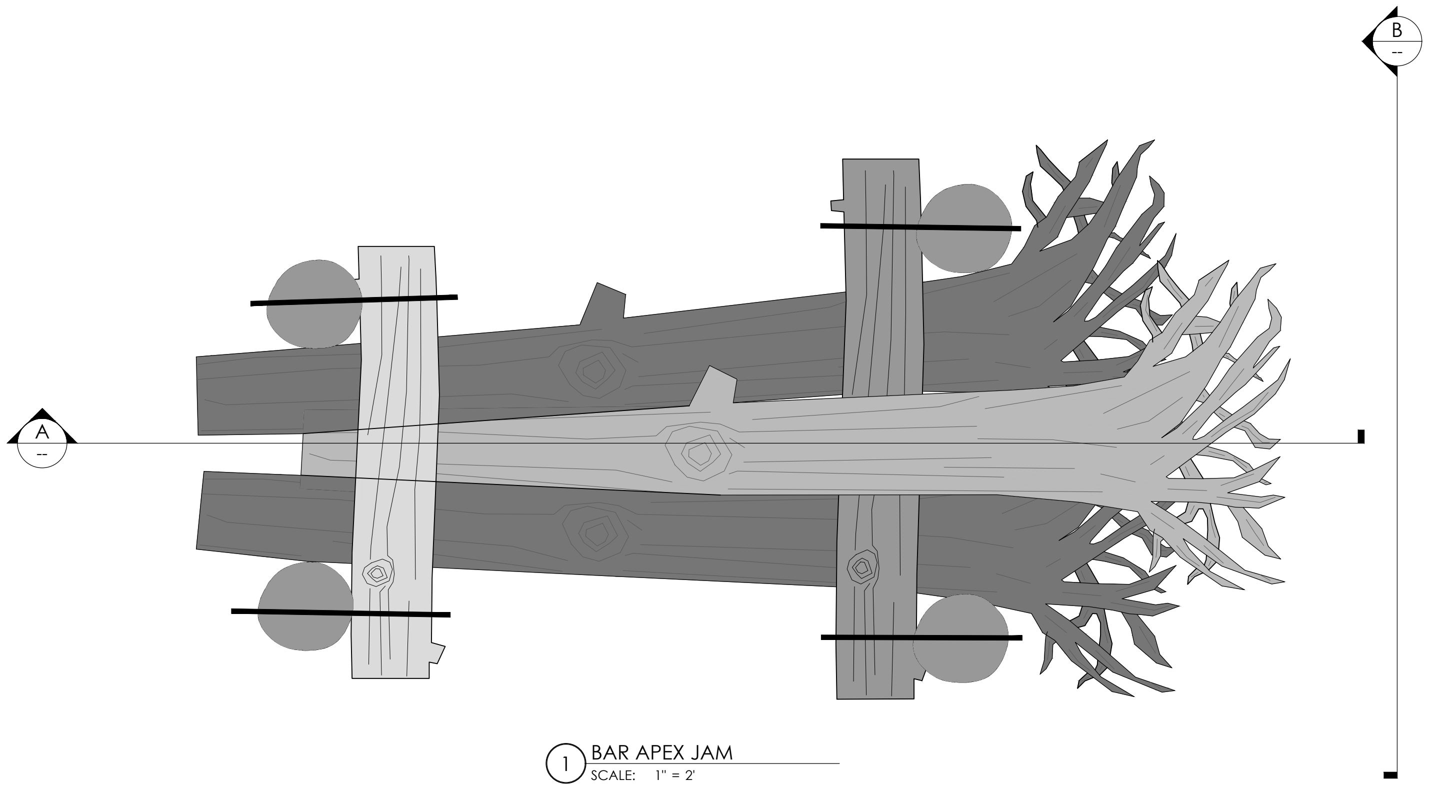

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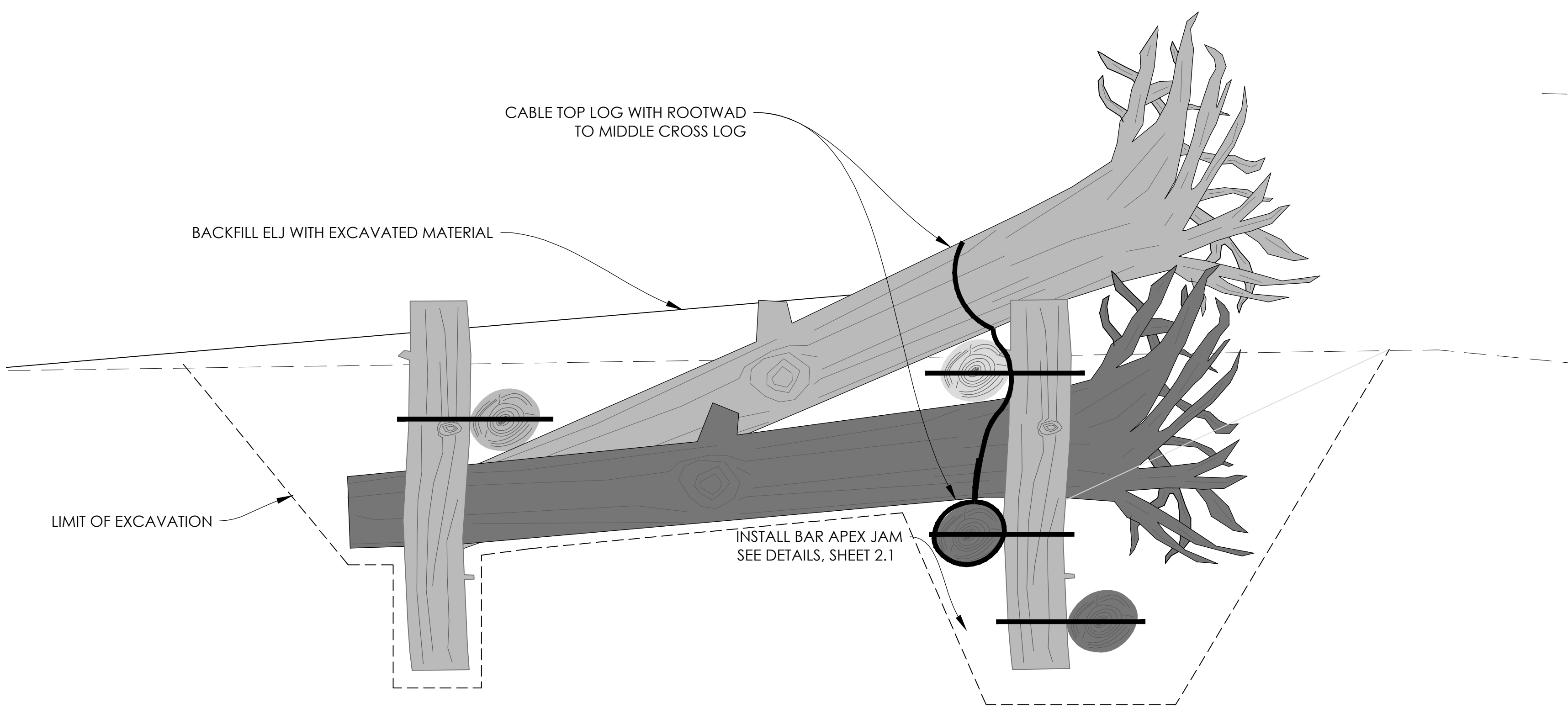

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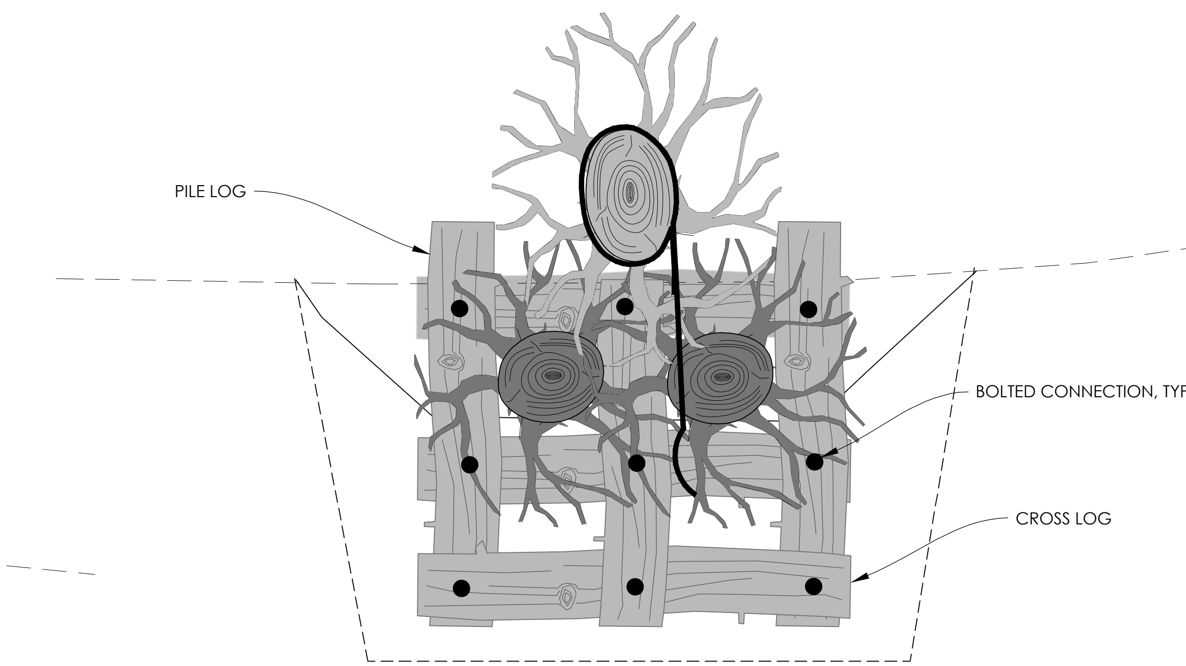

B BAR APEX JAM ELEVATION
SCALE: 1" = 2'

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SITE 01 DETAILS

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GRAVEL AND WOOD AUGMENTATION
SANTA CLARA COUNTY, CALIFORNIA

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SCALE (AT 22" X 34")
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3 OF 13

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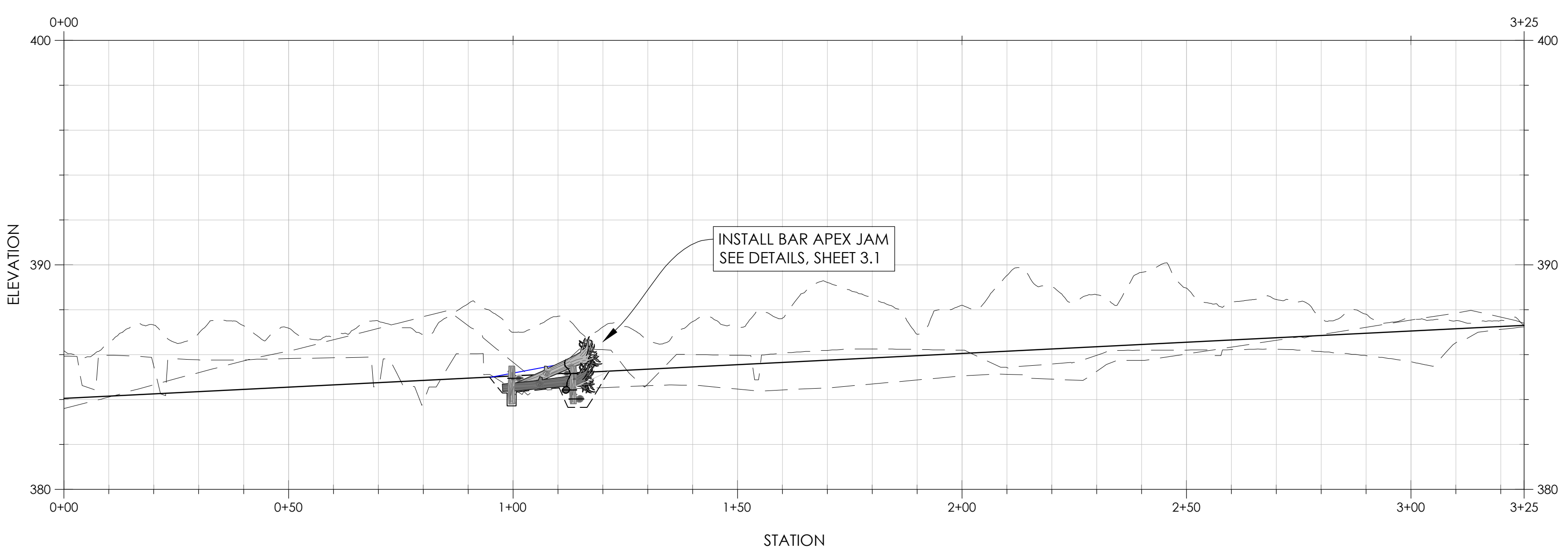

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LEGEND:

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EXISTING MINOR CONTOUR: 1 FT INTERVAL	
CHANNEL STATIONING LINE	1+00
BAR APEX JAM (PLAN VIEW)	
CHANNEL EXCAVATION LIMITS	

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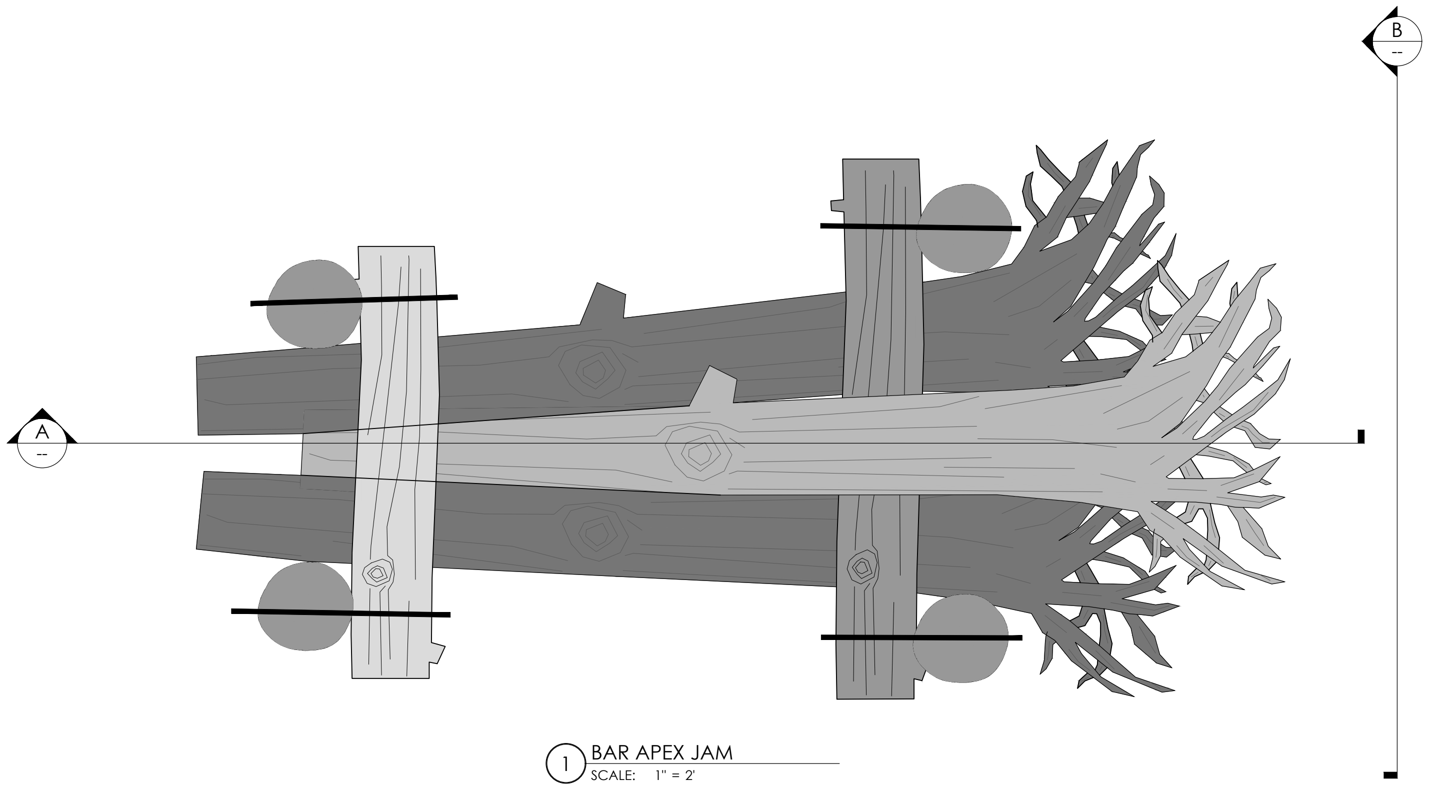

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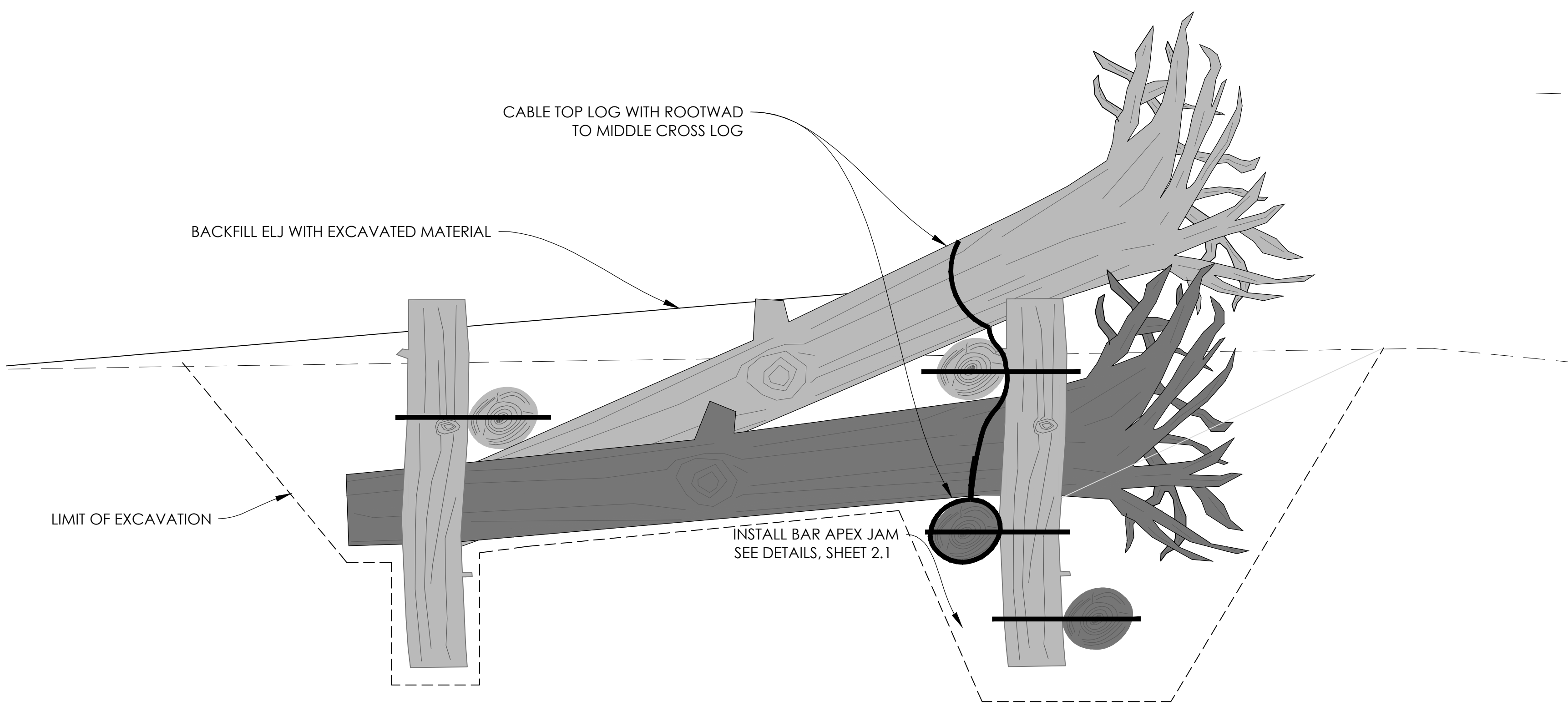

A BAR APEX JAM PROFILE
SCALE: 1" = 2'

NOTES:

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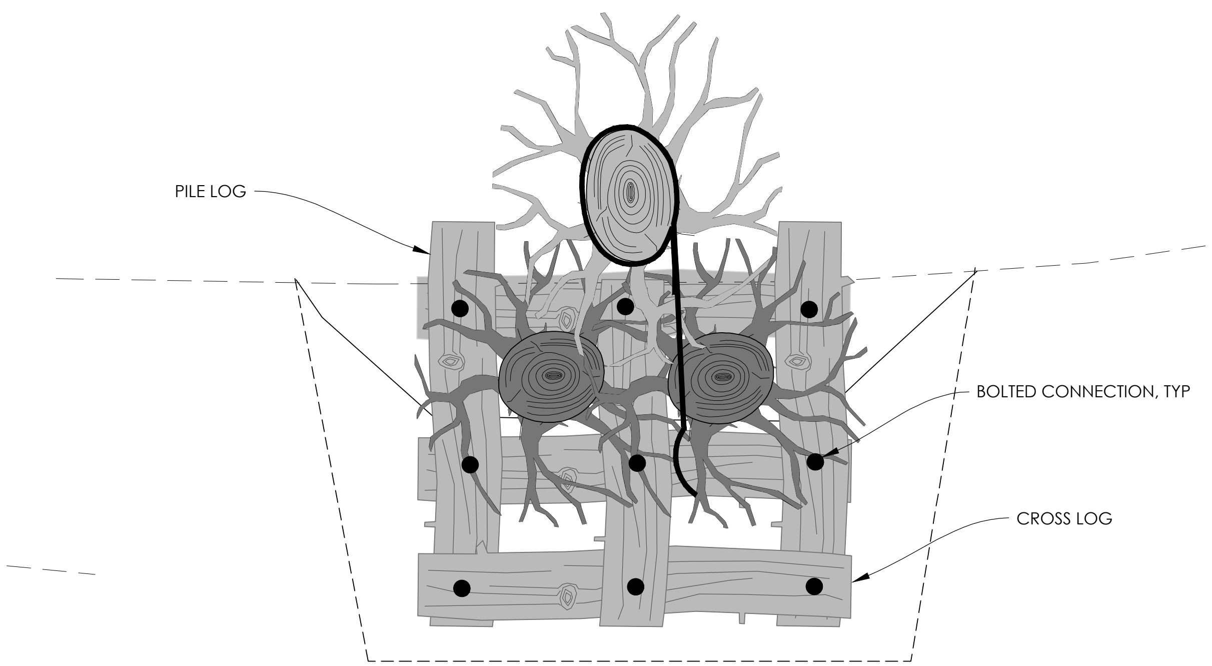

B BAR APEX JAM ELEVATION
SCALE: 1" = 2'

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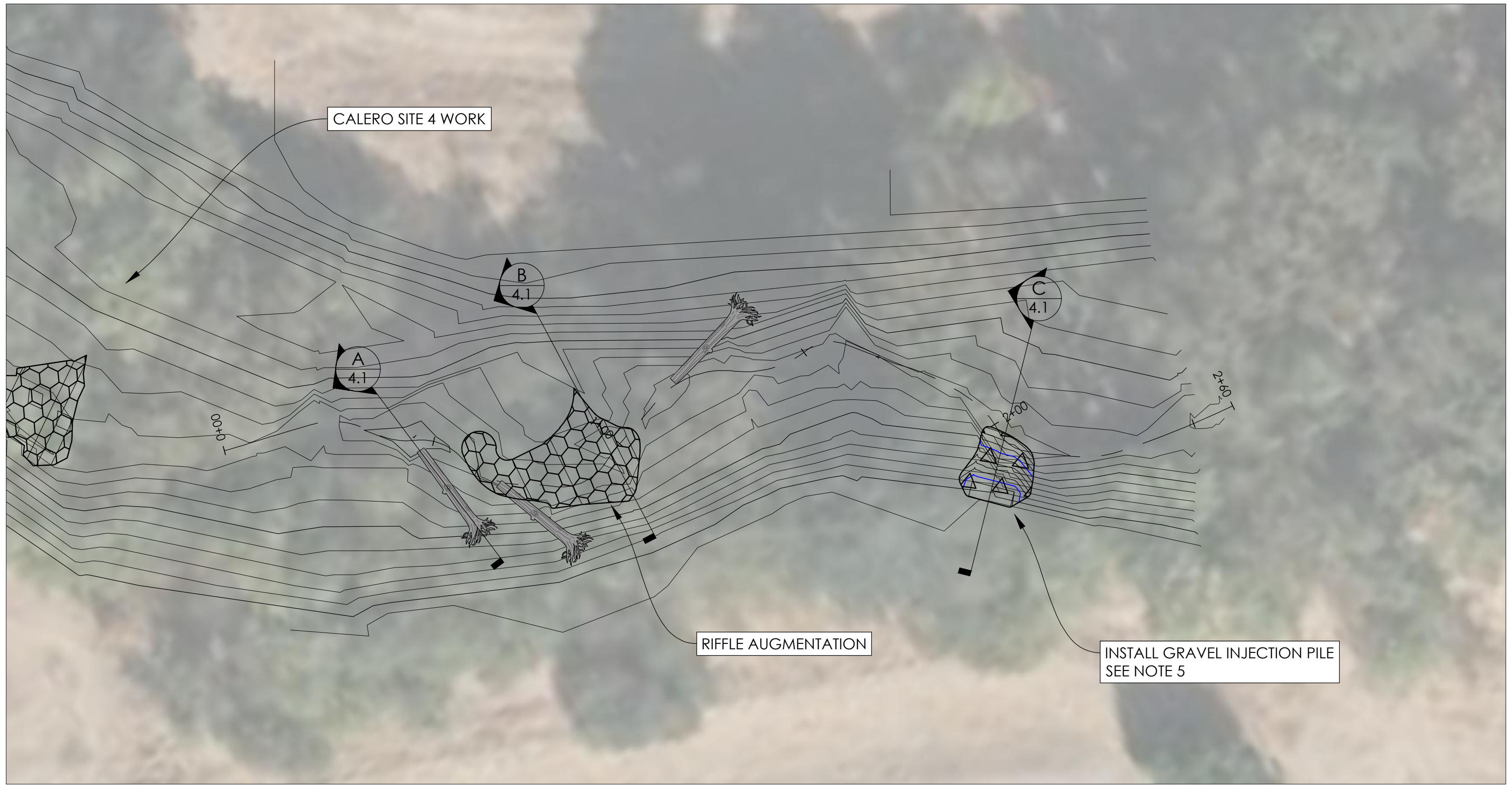

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SCALE: 1" = 20'

SITE 03

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NOTES:

1. LIMITS OF GRADING AND LOG PLACEMENT LOCATIONS SHOWN ON THIS SHEET ARE SUBJECT TO MINOR MODIFICATION IN THE FIELD BY THE ENGINEER OR THE ENGINEER'S REPRESENTATIVE.
2. LOGS SHOWN REPRESENT EXISTING TREES TO BE PULLED OVER USING HAND EQUIPMENT. NO HEAVY EQUIPMENT ACCESS WILL BE NECESSARY ON THE LEFT BANK.
3. VALLEY WATER O&M / CONTRACTOR SHALL STAKE BOTH THE LIMITS OF GRADING AND PROPOSED LOG LOCATIONS FOR APPROVAL OF THE ENGINEERS REPRESENTATIVE 48 HOURS PRIOR TO COMMENCING EARTHWORK.
4. RIFFLE AUGMENTATION AS SHOWN IS 19 CUBIC YARDS OF MATERIAL.
5. GRAVEL INJECTION PILE AS SHOWN IS 11 CUBIC YARDS OF MATERIAL.

LEGEND:

EXISTING MAJOR CONTOUR: 5 FT INTERVAL — 200

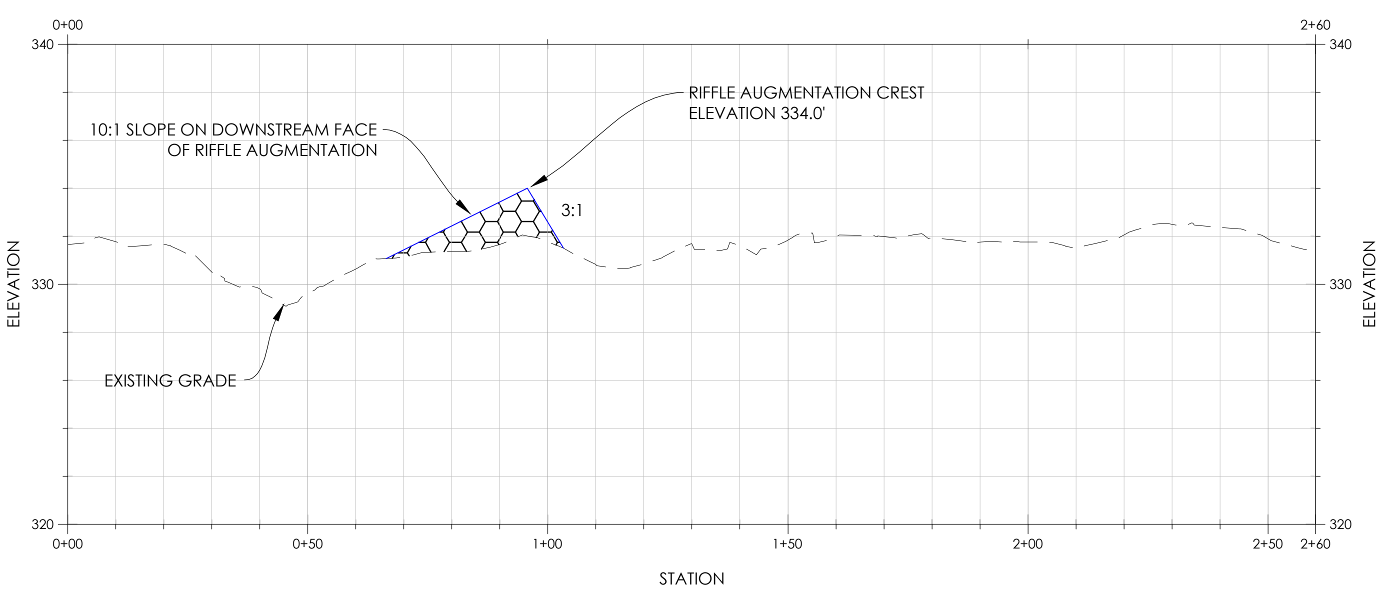
EXISTING MINOR CONTOUR: 1 FT INTERVAL

CHANNEL STATIONING LINE — 1+00

LOG WITH ROOTWAD

GRAVEL INJECTION PILE

RIFFLE AUGMENTATION



1 SITE 03 CHANNEL PROFILE
SCALE: 1" = 20'

CONCEPTUAL DESIGN - NOT FOR CONSTRUCTION

C:\Users\steven.mcneely\OneDrive - AECOM\Documents\Projects\SCVWD-Gravel and Wood\441_Conceptual Design\C3D\218252 Gravel and Wood - Standard\DRIVE_W\CADProjects\218252 GWPII\CALERO CREEK\218252 CALERO SHEET\218252 040 CALERO SITE 3.dwg 12/21/2023 11:50 AM

AECOM
Balance Hydrologics

SUBMITTALS / REVISIONS | BY | DATE

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DRAWN BY D JEPSEN
CHECKED BY S MCNEELY
IN CHARGE S MCNEELY
DATE 03-19-2021

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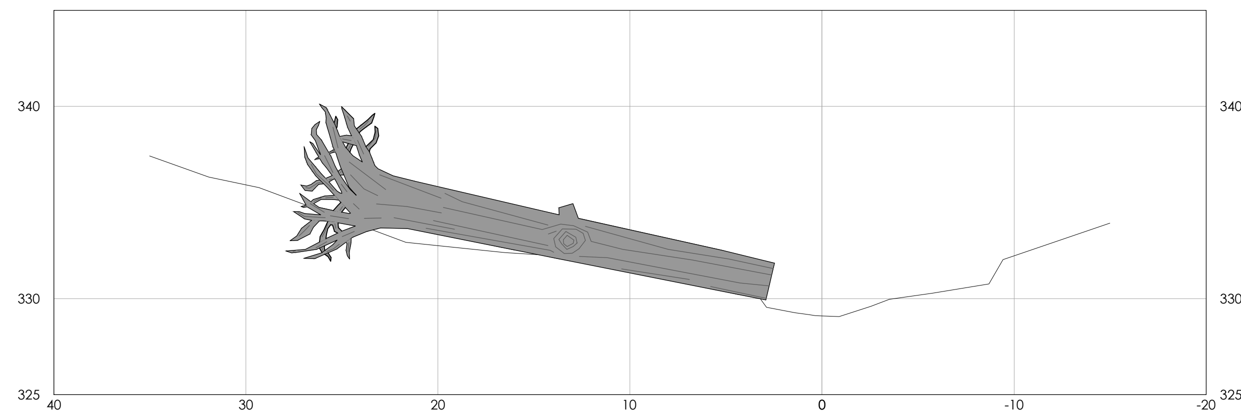
SITE 03 PLAN AND PROFILE

CALERO CREEK
GRAVEL AND WOOD AUGMENTATION
SANTA CLARA COUNTY, CALIFORNIA

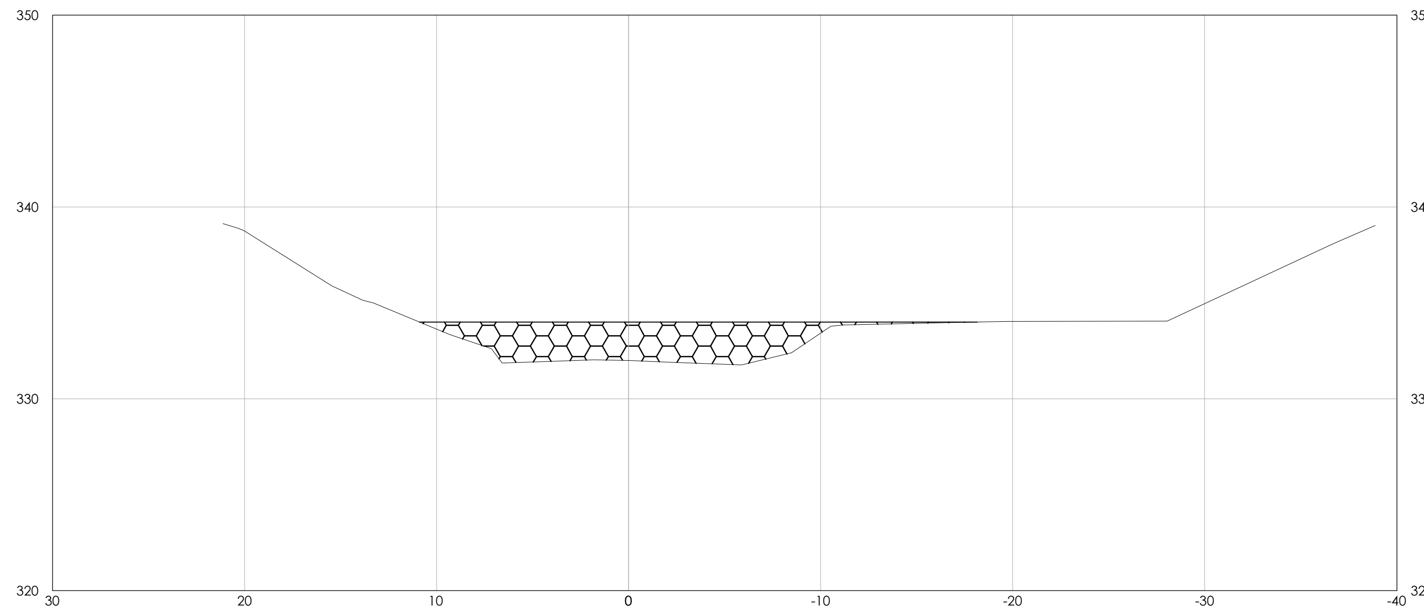
PROJECT NUMBER

SCALE (AT 22" X 34")
AS NOTED

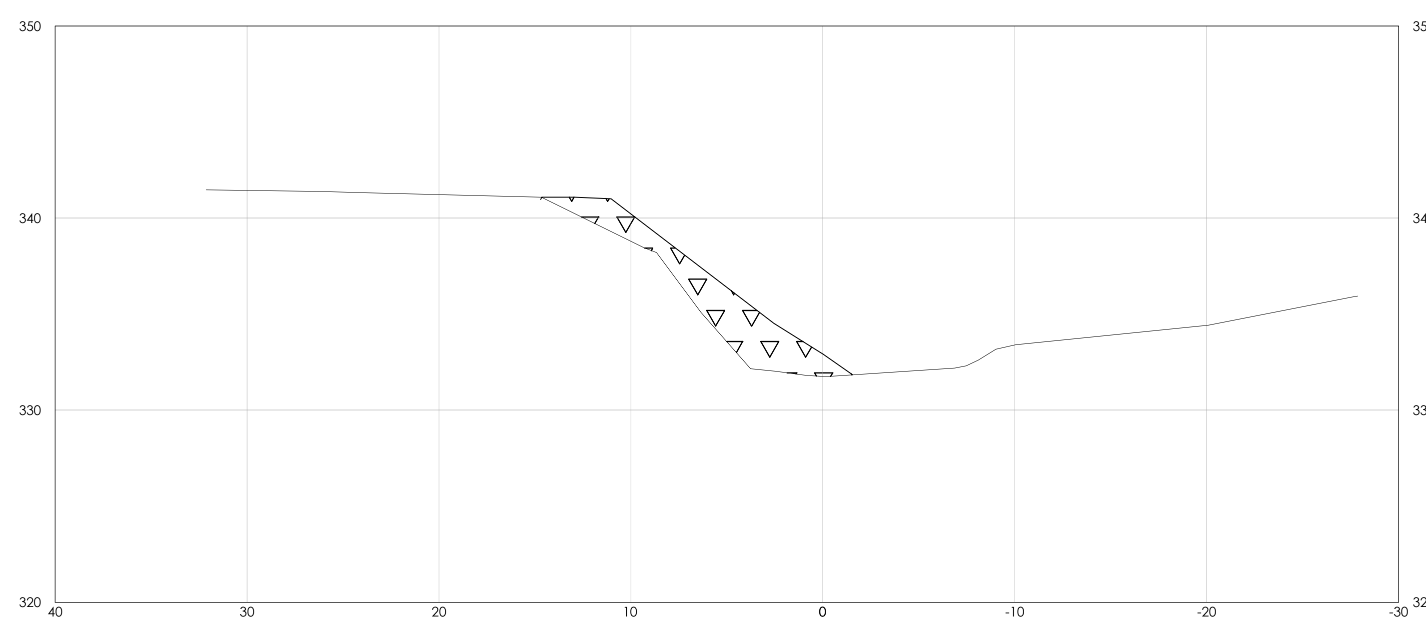
SHEET
4.0



(A) SECTION AT DOWNED TREE
SCALE: 1" = 5'



(B) SECTION AT RIFFLE AUGMENTATION CREST
SCALE: 1" = 5'



(C) SECTION AT INJECTION PILE
SCALE: 1" = 10'

GRAVEL AUGMENTATION

RIFFLE AUGMENTATION

CONCEPTUAL DESIGN - NOT FOR CONSTRUCTION

C:\Users\steven.mcneely\OneDrive - AECOM\Documents\Projects\SCVWD-Gravel and Wood\441. Conceptual Design\C3D\218252 Gravel and Wood - Standard\DRIVE_W\CADProjects\218252 GWPII\CALERO CREEK\218252 CALERO SHEET\218252 041 CALERO SITE 3 SECTIONS.dwg 12/21/2023 3:34 PM

AECOM
Balance Hydrologics

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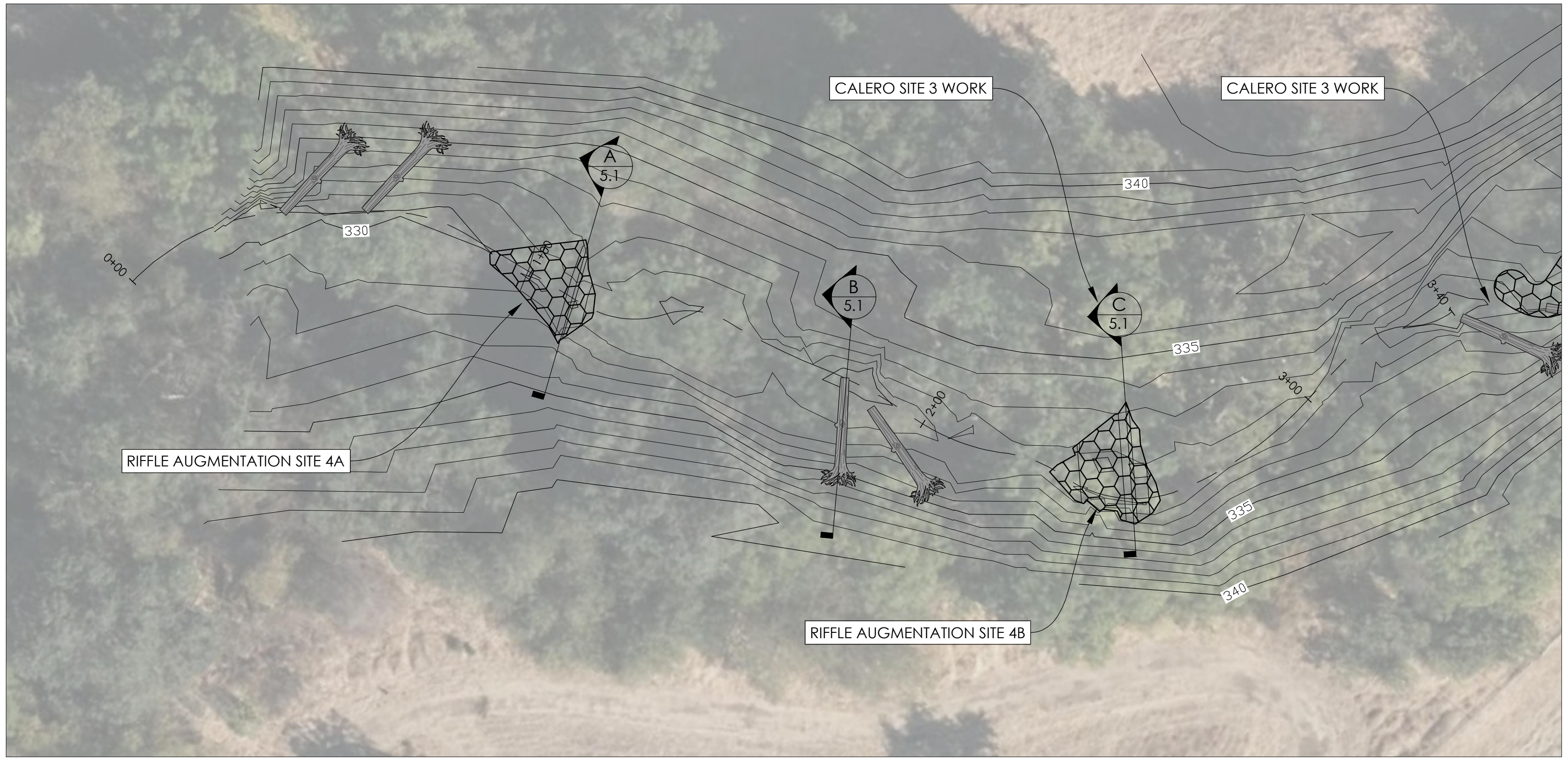
SITE 03 SECTIONS

CALERO CREEK
GRAVEL AND WOOD AUGMENTATION
SANTA CLARA COUNTY, CALIFORNIA

PROJECT NUMBER

SCALE (AT 22" X 34")
AS NOTED

SHEET
4.1



0' 20' 40' 80'

SCALE: 1" = 20'

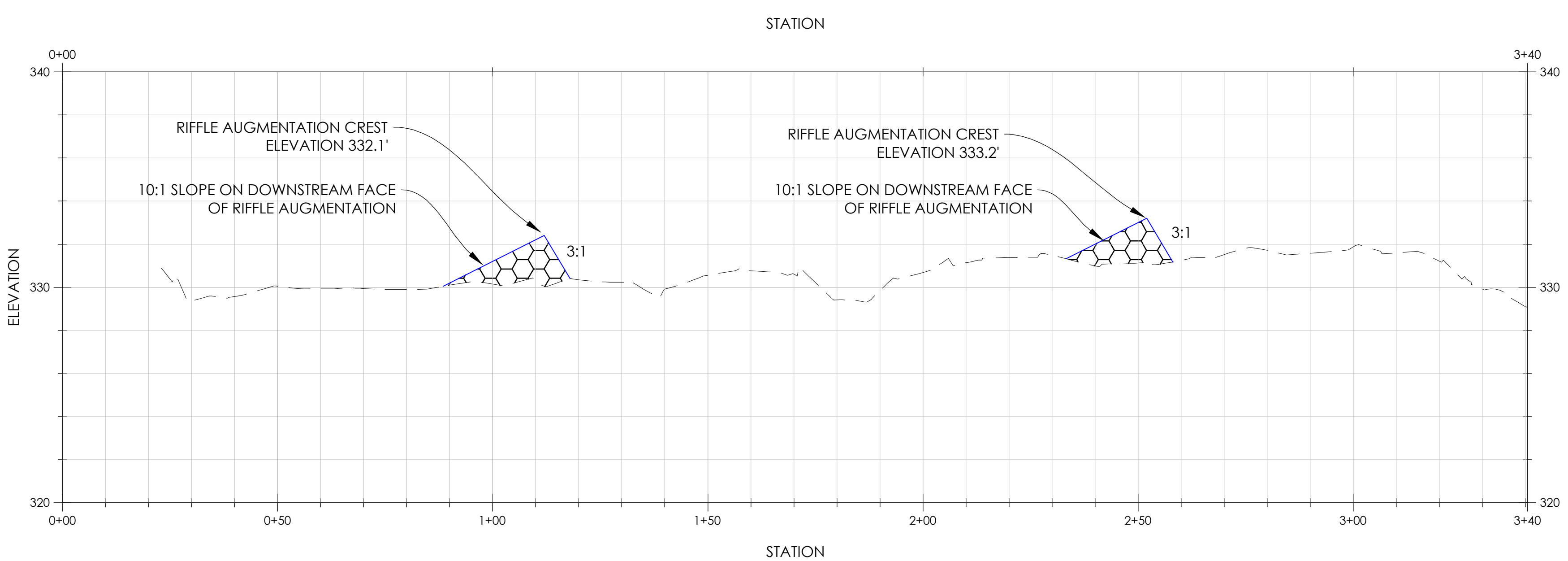
SITE 04

NOTES:

1. LIMITS OF GRADING AND LOG PLACEMENT LOCATIONS SHOWN ON THIS SHEET ARE SUBJECT TO MINOR MODIFICATION IN THE FIELD BY THE ENGINEER OR THE ENGINEER'S REPRESENTATIVE.
2. LOGS SHOWN REPRESENT EXISTING TREES TO BE PULLED OVER USING HAND EQUIPMENT. NO HEAVY EQUIPMENT ACCESS WILL BE NECESSARY ON THE LEFT BANK.
3. VALLEY WATER O&M / CONTRACTOR SHALL STAKE BOTH THE LIMITS OF GRADING AND PROPOSED LOG LOCATIONS FOR APPROVAL OF THE ENGINEERS REPRESENTATIVE 48 HOURS PRIOR TO COMMENCING EARTHWORK.
4. DOWNSTREAM RIFFLE AUGMENTATION, SITE 4A, AS SHOWN IS 10 CUBIC YARDS OF MATERIAL.
5. UPSTREAM RIFFLE AUGMENTATION, SITE 4B, SHOWN IS 12 CUBIC YARDS OF MATERIAL.

LEGEND:

EXISTING MAJOR CONTOUR: 5 FT INTERVAL	200
EXISTING MINOR CONTOUR: 1 FT INTERVAL	
CHANNEL STATIONING LINE	1+00
LOG WITH ROOTWAD	
RIFFLE AUGMENTATION	



1 SITE 04 CHANNEL PROFILE
SCALE: 1" = 20'

CONCEPTUAL DESIGN - NOT FOR CONSTRUCTION

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Balance Hydrologics

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DATE 03-19-2021

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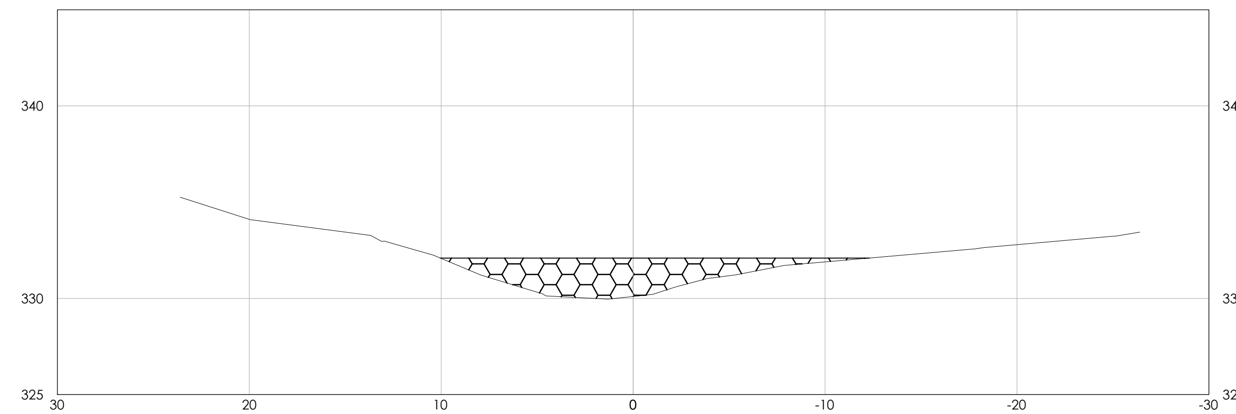
SITE 04 PLAN AND PROFILE

CALERO CREEK
GRAVEL AND WOOD AUGMENTATION
SANTA CLARA COUNTY, CALIFORNIA

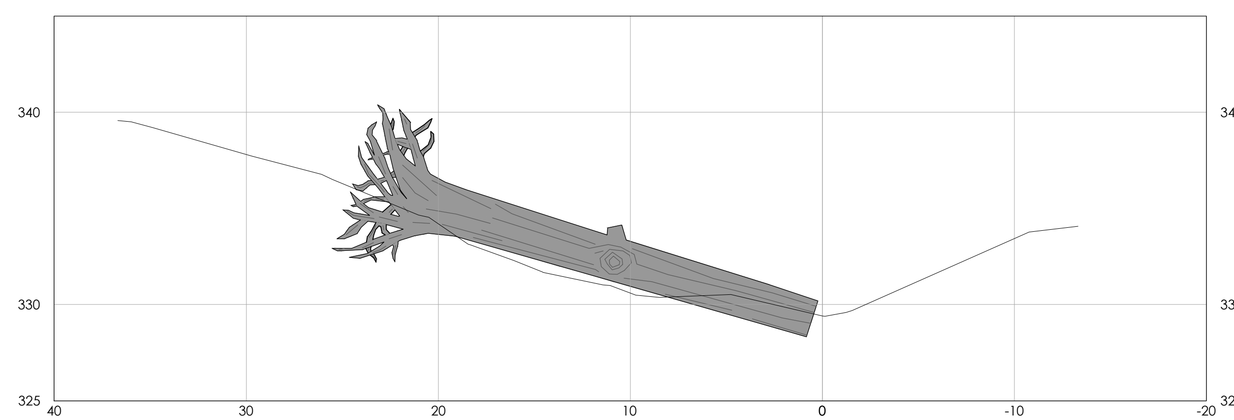
PROJECT NUMBER

SCALE (AT 22" X 34")
AS NOTED

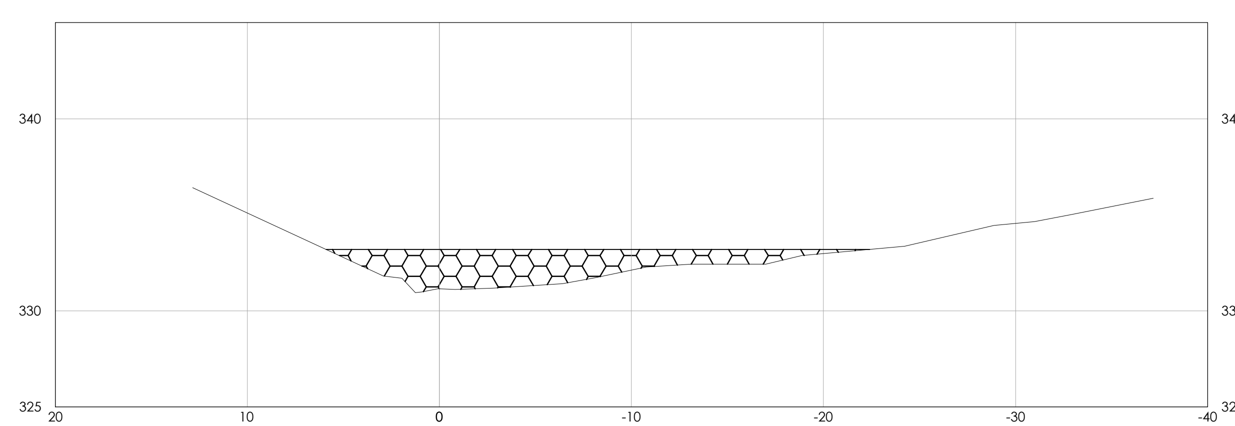
SHEET
5.0



(A) SECTION AT GRAVEL AUGMENTATION
SCALE: 1" = 5'



(B) SECTION AT DOWNED TREE
SCALE: 1" = 5



(C) SECTION AT RIFFLE AUGMENTATION
SCALE: 1" = 5'

RIFFLE AUGMENTATION

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SITE 04 SECTIONS

CALERO CREEK
GRAVEL AND WOOD AUGMENTATION
SANTA CLARA COUNTY, CALIFORNIA

PROJECT NUMBER

SCALE (AT 22" X 34")
AS NOTED

SHEET
5.1
4 OF 13

CONCEPTUAL DESIGN - NOT FOR CONSTRUCTION

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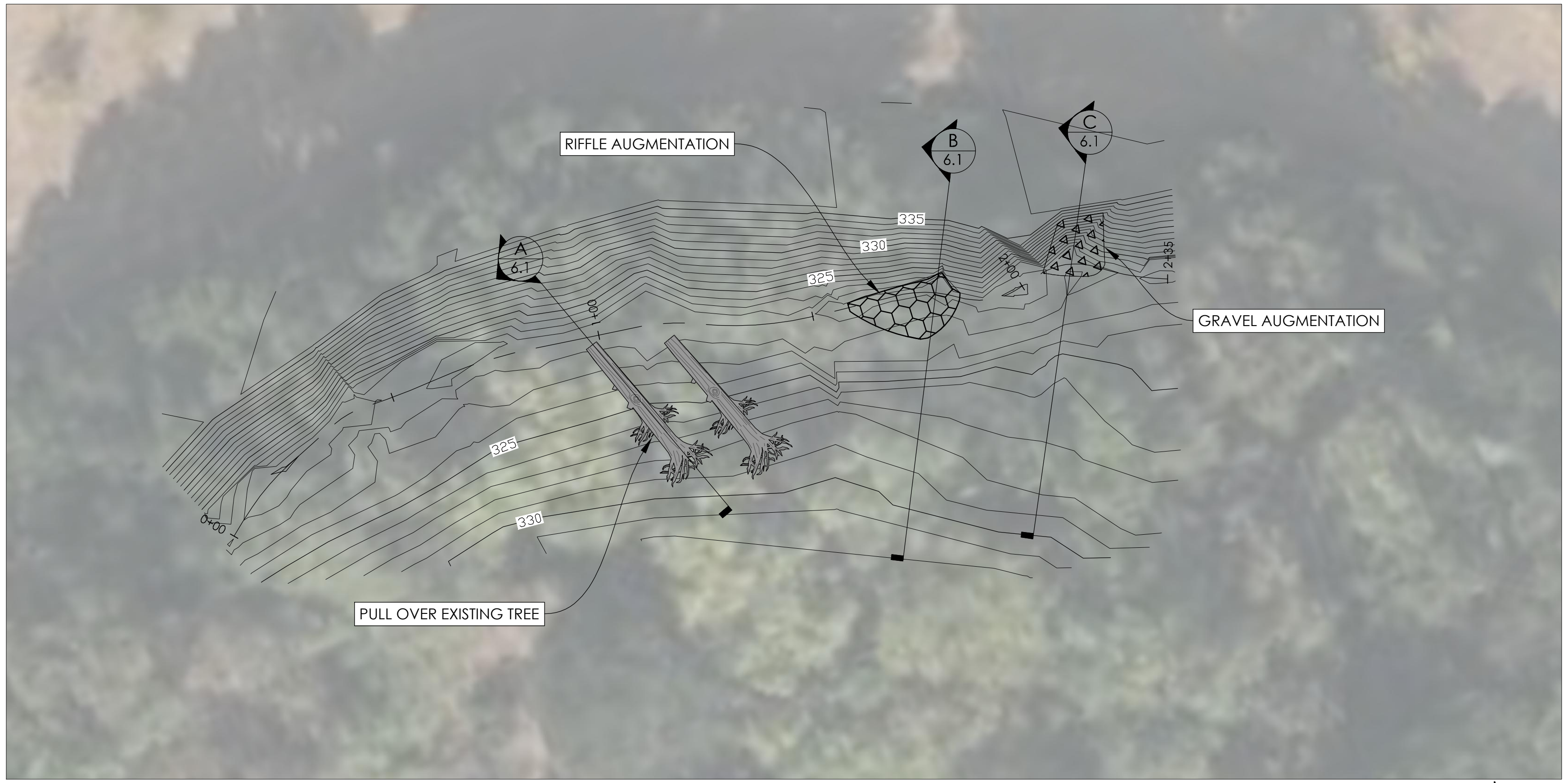


SITE 05

0' 20' 40' 80'

SCALE: 1" = 20'

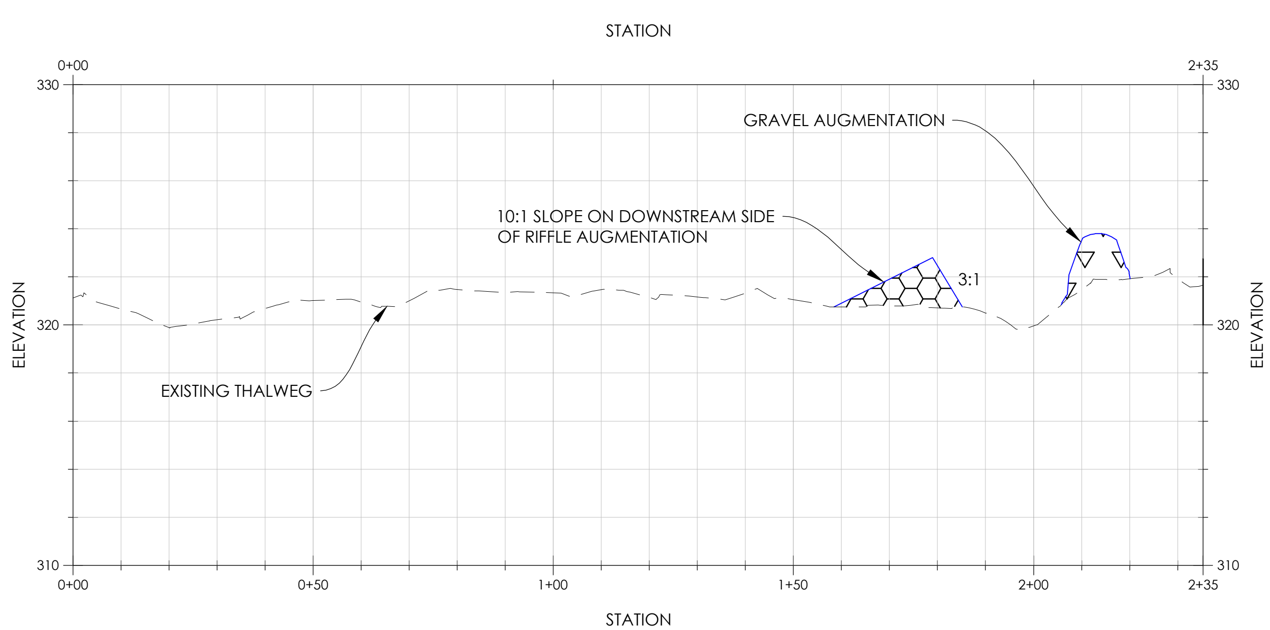
N

NOTES:

1. LIMITS OF GRADING AND LOG PLACEMENT LOCATIONS SHOWN ON THIS SHEET ARE SUBJECT TO MINOR MODIFICATION IN THE FIELD BY THE ENGINEER OR THE ENGINEER'S REPRESENTATIVE.
2. LOGS SHOWN REPRESENT EXISTING TREES TO BE PULLED OVER USING HAND EQUIPMENT. NO HEAVY EQUIPMENT ACCESS WILL BE NECESSARY ON THE LEFT BANK.
3. VALLEY WATER O&M / CONTRACTOR SHALL STAKE BOTH THE LIMITS OF GRADING AND PROPOSED LOG LOCATIONS FOR APPROVAL OF THE ENGINEERS REPRESENTATIVE 48 HOURS PRIOR TO COMMENCING EARTHWORK.
4. GRAVEL AUGMENTATION CONE AS SHOWN IS 10 CUBIC YARDS OF MATERIAL.
5. RIFFLE AUGMENTATION SHOWN IS 6.5 CUBIC YARDS OF MATERIAL.

LEGEND:

EXISTING MAJOR CONTOUR: 5 FT INTERVAL	200
EXISTING MINOR CONTOUR: 1 FT INTERVAL	
CHANNEL STATIONING LINE	1+00
LOG WITH ROOTWAD	
GRAVEL AUGMENTATION	
RIFFLE AUGMENTATION	



1 SITE 05 CHANNEL PROFILE
SCALE: 1" = 20'

AECOM

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SITE 05 PLAN AND PROFILE

CALERO CREEK
GRAVEL AND WOOD AUGMENTATION
SANTA CLARA COUNTY, CALIFORNIA

PROJECT NUMBER

SCALE (AT 22" X 34")
AS NOTED

SHEET
6.0

CONCEPTUAL DESIGN - NOT FOR CONSTRUCTION

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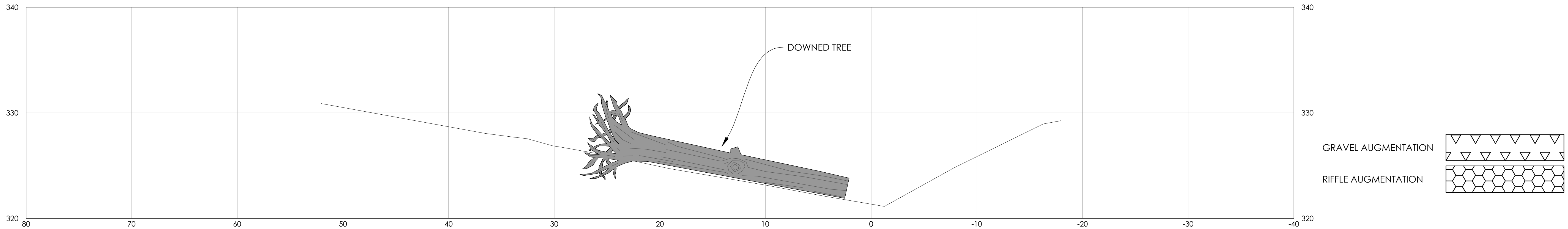
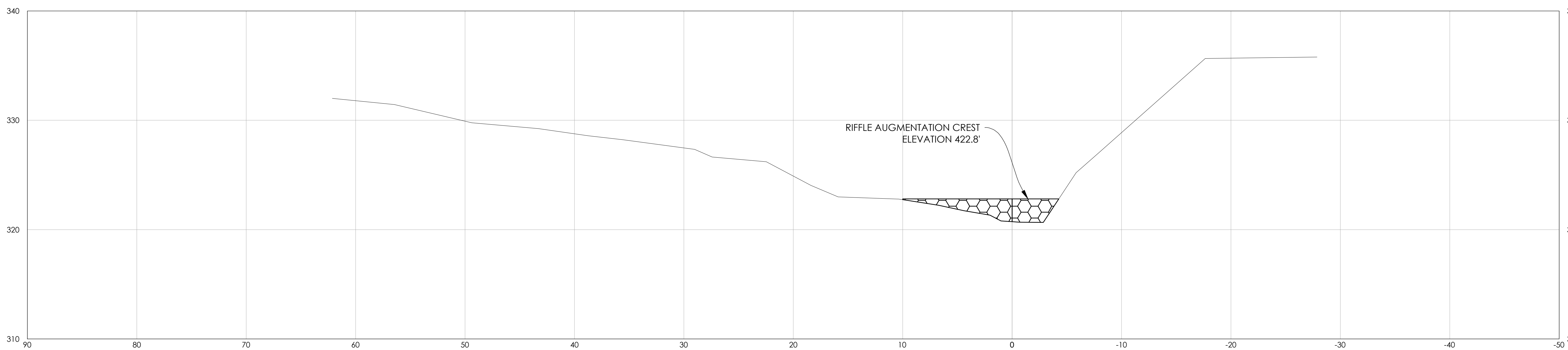
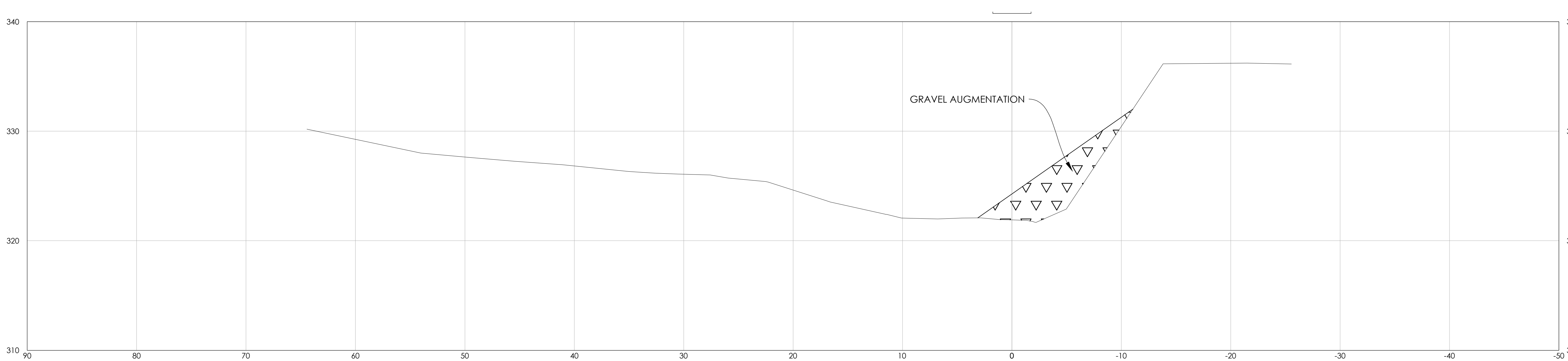


A CROSS SECTION AT DOWNED TREE
SCALE: 1" = 5'



B CROSS SECTION AT RIFFLE AUGMENTATION CREST
SCALE: 1" = 5'



C CROSS SECTION AT GRAVEL AUGMENTATION
SCALE: 1" = 5'

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DATE 03-19-2021

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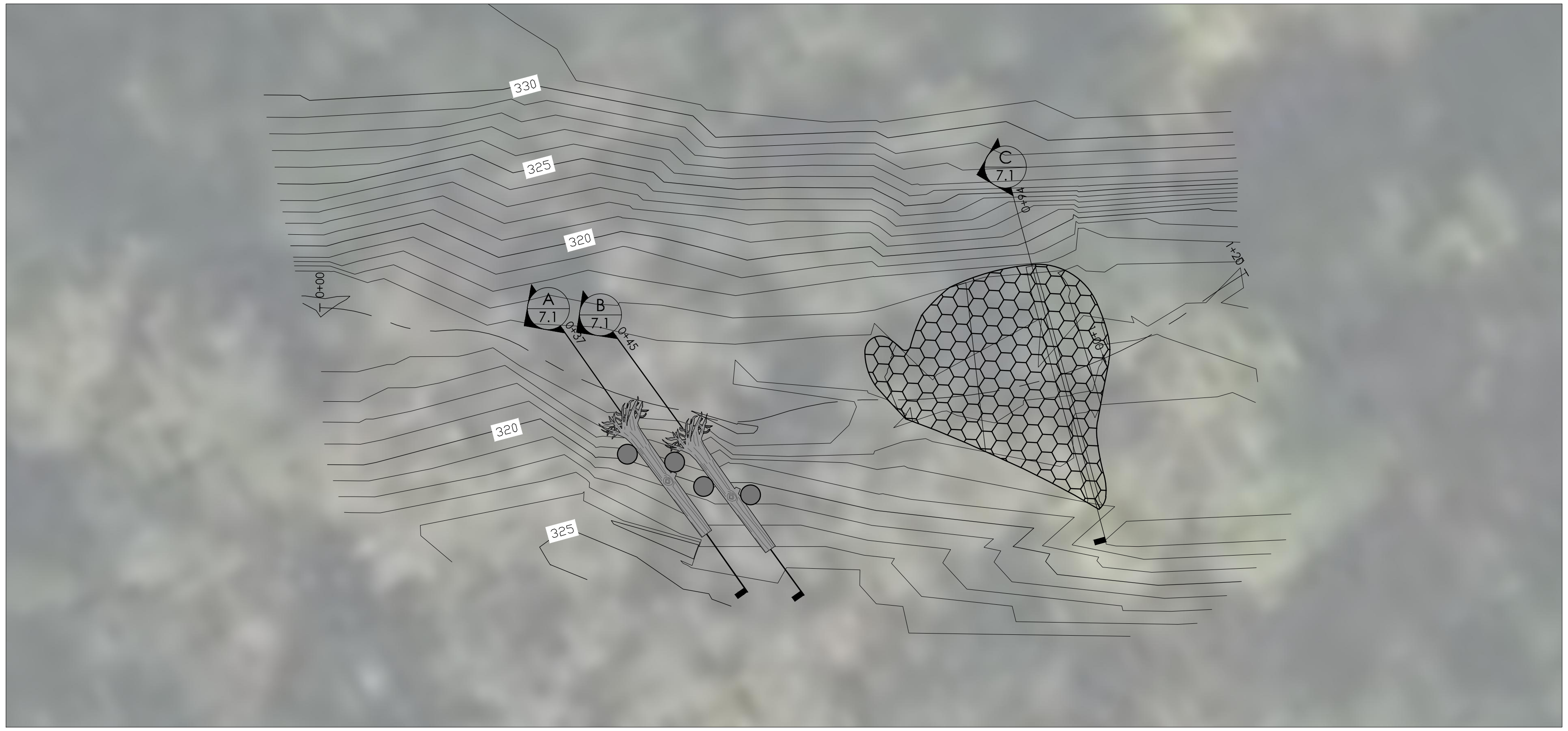
SITE 05 SECTIONS

CALERO CREEK
GRAVEL AND WOOD AUGMENTATION
SANTA CLARA COUNTY, CALIFORNIA

PROJECT NUMBER

SCALE (AT 22" X 34")
AS NOTED

SHEET
6.1
4 OF 13



SITE 06

0' 10' 20' 40'

SCALE: 1" = 10'

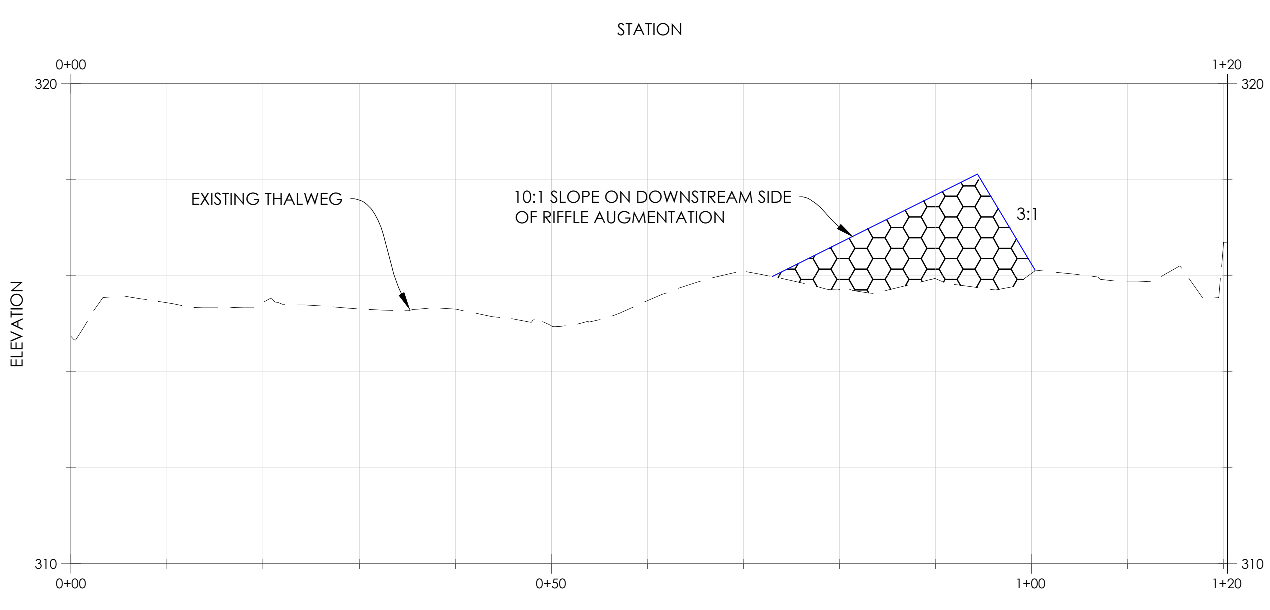
N

NOTES:

1. LIMITS OF GRADING AND LOG PLACEMENT LOCATIONS SHOWN ON THIS SHEET ARE SUBJECT TO MINOR MODIFICATION IN THE FIELD BY THE ENGINEER OR THE ENGINEER'S REPRESENTATIVE.
2. VALLEY WATER O&M / CONTRACTOR SHALL STAKE BOTH THE LIMITS OF GRADING AND PROPOSED LOG LOCATIONS FOR APPROVAL OF THE ENGINEERS REPRESENTATIVE 48 HOURS PRIOR TO COMMENCING EARTHWORK.
3. RIFFLE AUGMENTATION CONE AS SHOWN IS 20 CUBIC YARDS OF MATERIAL.

LEGEND:

EXISTING MAJOR CONTOUR: 5 FT INTERVAL	390
EXISTING MINOR CONTOUR: 1 FT INTERVAL	
CHANNEL STATIONING LINE	1+00
LOG WITH ROOTWAD SECURED BETWEEN EXISTING TREES	
RIFFLE AUGMENTATION	



1 SITE 06 CHANNEL PROFILE
SCALE: 1" = 10' VERT X5

CONCEPTUAL DESIGN - NOT FOR CONSTRUCTION

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IN CHARGE S MCNEELY
DATE 03-19-2021

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SITE 06 PLAN AND PROFILE

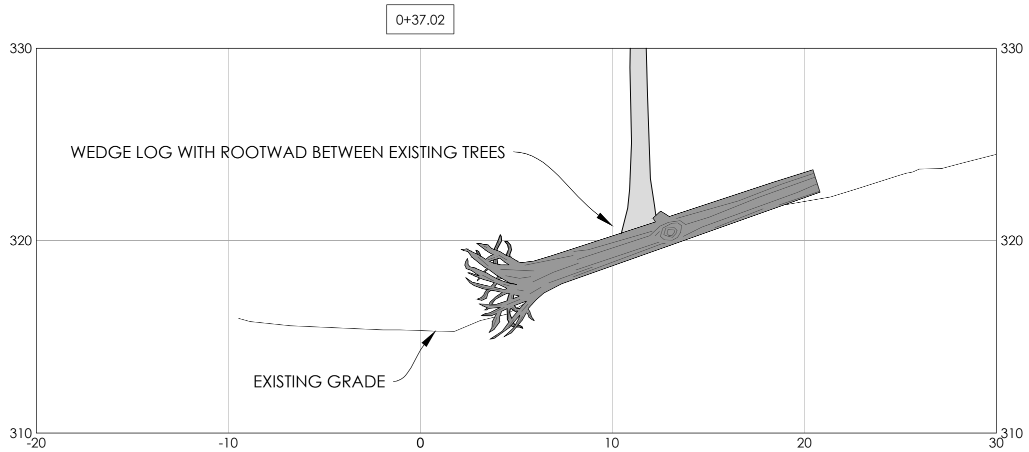
CALERO CREEK
GRAVEL AND WOOD AUGMENTATION
SANTA CLARA COUNTY, CALIFORNIA

PROJECT NUMBER

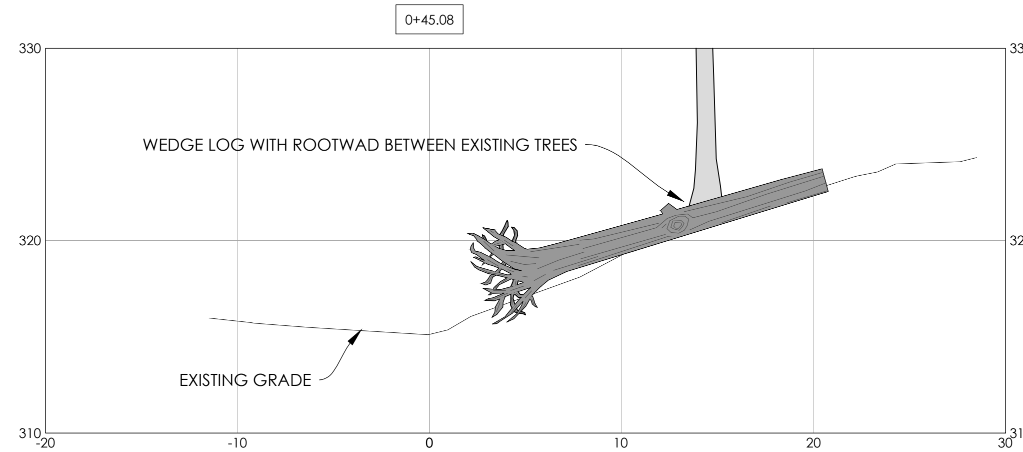
SCALE (AT 22" X 34")
AS NOTED

SHEET
7.0

NOTES:



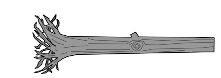
A CROSS SECTION AT LOG
SCALE: 1" = 5'



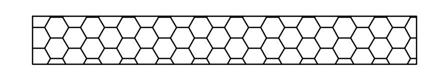
B CROSS SECTION AT LOG
SCALE: 1" = 5'

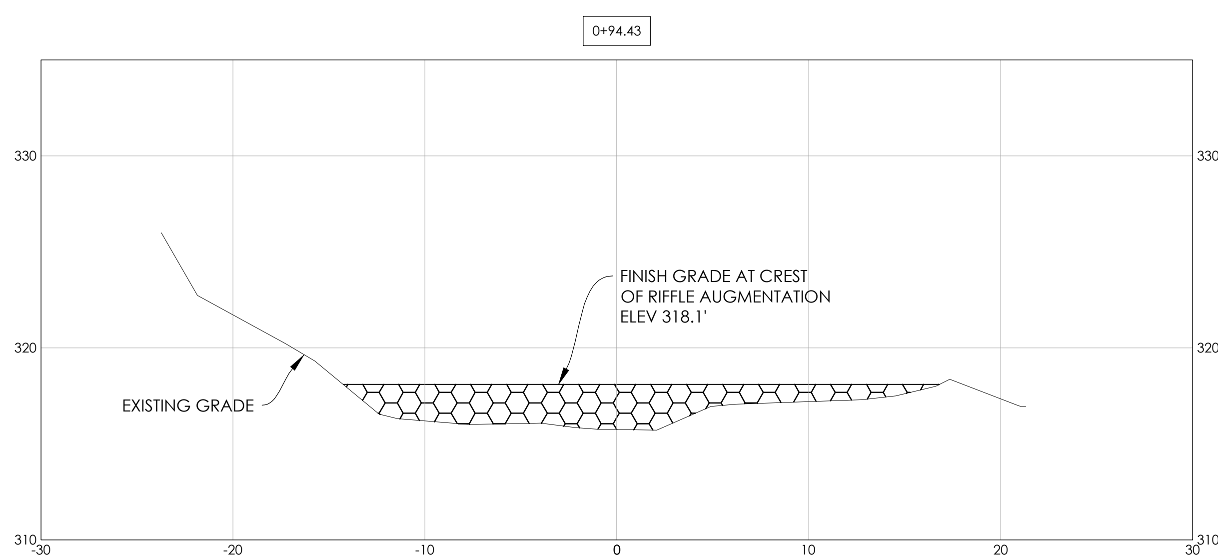
LEGEND:

LOG WITH ROOTWAD



RIFFLE AUGMENTATION





C CROSS SECTION AUGMENTED RIFFLE CREST
SCALE: 1" = 5'

CONCEPTUAL DESIGN - NOT FOR CONSTRUCTION

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DATE 03-19-2021

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SITE 06 PLAN AND PROFILE

CALERO CREEK
GRAVEL AND WOOD AUGMENTATION
SANTA CLARA COUNTY, CALIFORNIA

PROJECT NUMBER

SCALE (AT 22" X 34")
AS NOTED

SHEET
7.1
13 OF 13

Appendix B Conceptual Design Drawings – Llagas Creek

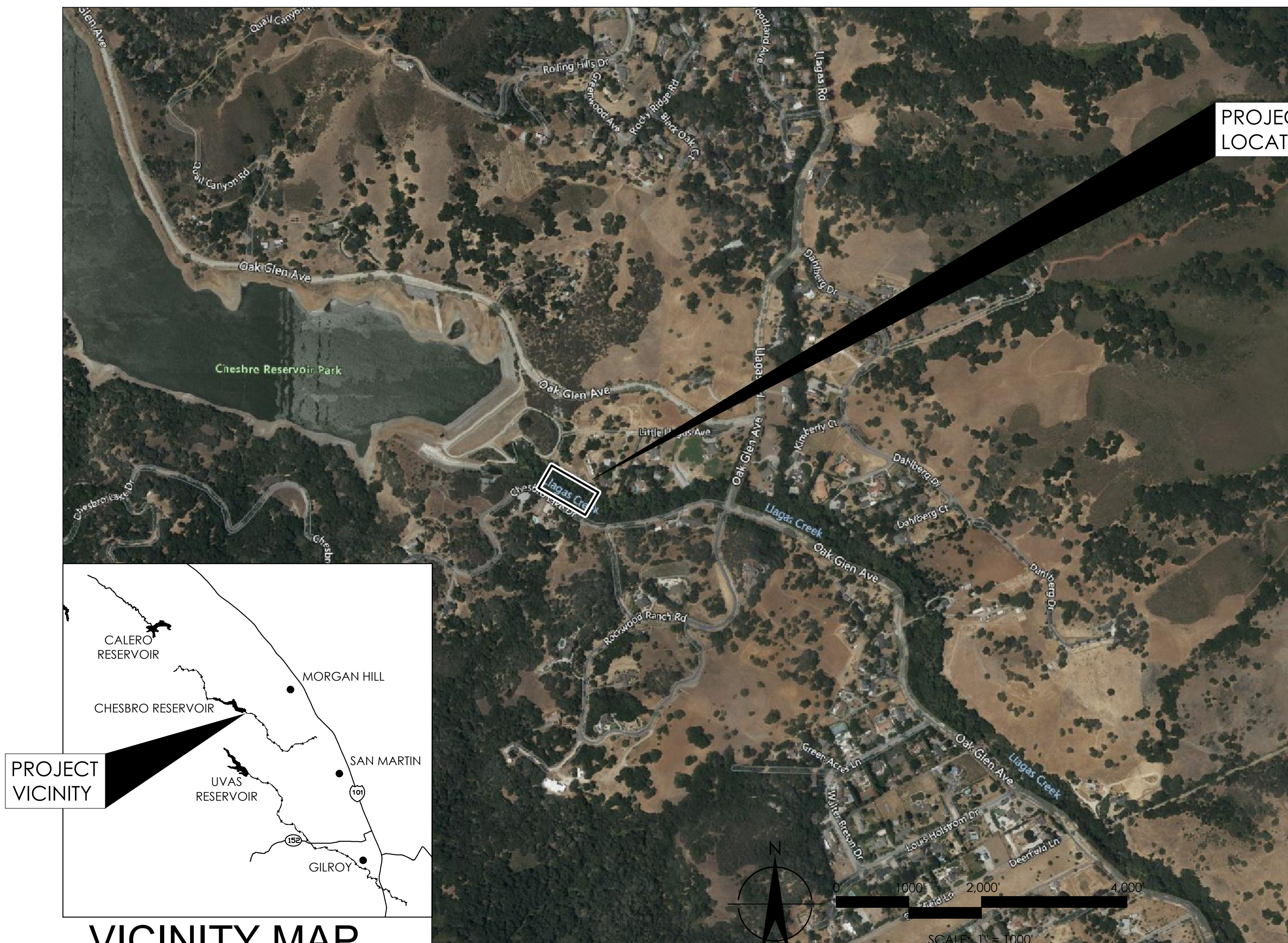
LLAGAS CREEK GRAVEL AND WOOD AUGMENTATION

CITY OF MORGAN HILL, SANTA CLARA COUNTY, CALIFORNIA

Valley Water

Clean Water • Healthy Environment • Flood Protection

LOCATION MAP



VICINITY MAP

1" = 4 MILES

SHEET INDEX

PREPARED FOR

SANTA CLARA VALLEY WATER DISTRICT
JUDY NAM, PE
WATER RESOURCES PLANNING AND POLICY UNIT
5750 ALMADEN EXPRESSWAY
SAN JOSE, CALIFORNIA 95118
TEL. (408) 728-0451

PREPARED BY

AECOM
STEVEN MCNEELY, PE
300 LAKESIDE DRIVE, SUITE 400
OAKLAND, CALIFORNIA 94612
TEL. (510) 893-3600

BALANCE HYDROLOGICS
ERIC DONALDSON, PG
800 BANCROFT WAY, SUITE 10
BERKELEY, CALIFORNIA 94710
TEL. (510) 704-1000

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Balance Hydrologics

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DRAWN BY D JEPSEN
CHECKED BY S MCNEELY
IN CHARGE S MCNEELY
DATE 03-19-2021

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COVER SHEET
LLAGAS CREEK
GRAVEL AND WOOD AUGMENTATION
SANTA CLARA COUNTY, CALIFORNIA

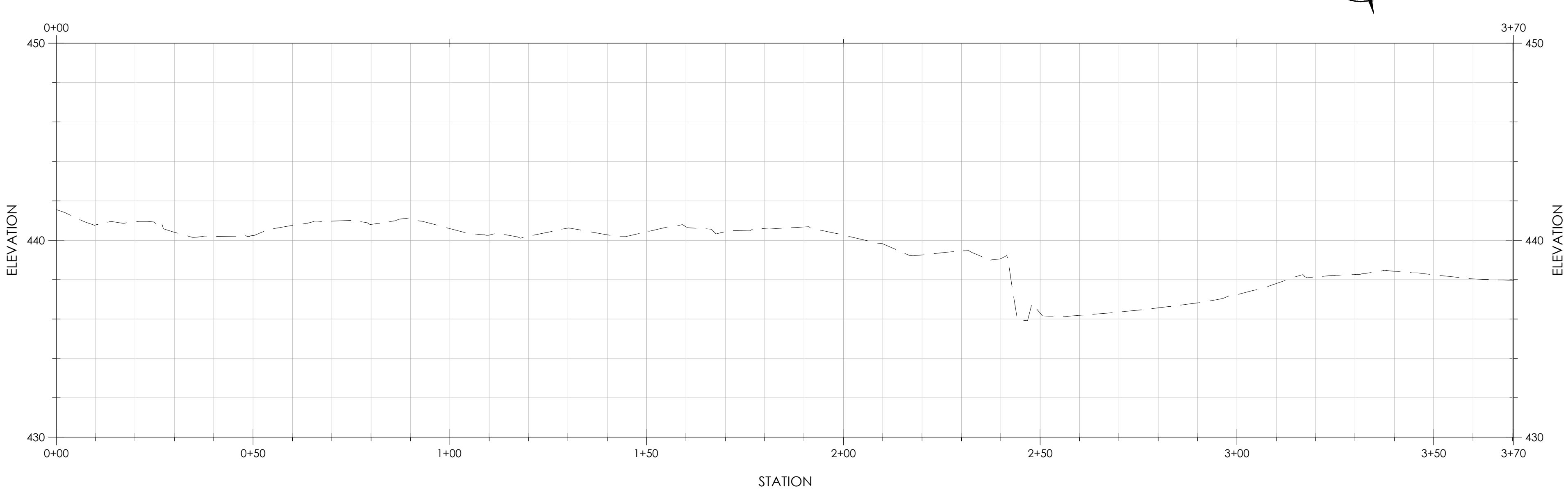
PROJECT NUMBER

SCALE (AT 22" X 34") AS NOTED

SHEET
1.0
1 OF 3

SITE 01

0' 20' 40' 80'
SCALE: 1" = 20'



1 SITE 1 CHANNEL PROFILE
SCALE: 1" = 20'

NOTES:

1. LIMITS OF GRADING AND LOG PLACEMENT LOCATIONS SHOWN ON THIS SHEET ARE SUBJECT TO MINOR MODIFICATION IN THE FIELD BY THE ENGINEER OR THE ENGINEER'S REPRESENTATIVE.
2. LOGS SHOWN REPRESENT EXISTING TREES TO BE PULLED OVER USING HAND EQUIPMENT. NO HEAVY EQUIPMENT ACCESS WILL BE NECESSARY ON THE LEFT BANK.
3. VALLEY WATER O&M / CONTRACTOR SHALL STAKE BOTH THE LIMITS OF GRADING AND PROPOSED LOG LOCATIONS FOR APPROVAL OF THE ENGINEERS REPRESENTATIVE 48 HOURS PRIOR TO COMMENCING EARTHWORK.
4. GRAVEL AUGMENTATION CONE AS SHOWN IS 11 CUBIC YARDS OF MATERIAL.

LEGEND:

EXISTING MAJOR CONTOUR: 5 FT INTERVAL — 200
EXISTING MINOR CONTOUR: 1 FT INTERVAL
CHANNEL STATIONING LINE — 1+00
LOG WITH ROOTWAD
GRAVEL AUGMENTATION

AECOM
Balance Hydrologics

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CHECKED BY S MCNEELY
IN CHARGE S MCNEELY
DATE 03-19-2021

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SITE 01 PLAN AND PROFILE

LLAGAS CREEK
GRAVEL AND WOOD AUGMENTATION
SANTA CLARA COUNTY, CALIFORNIA

PROJECT NUMBER

SCALE (AT 22" X 34")
AS NOTED

SHEET
2.0
2 OF 3

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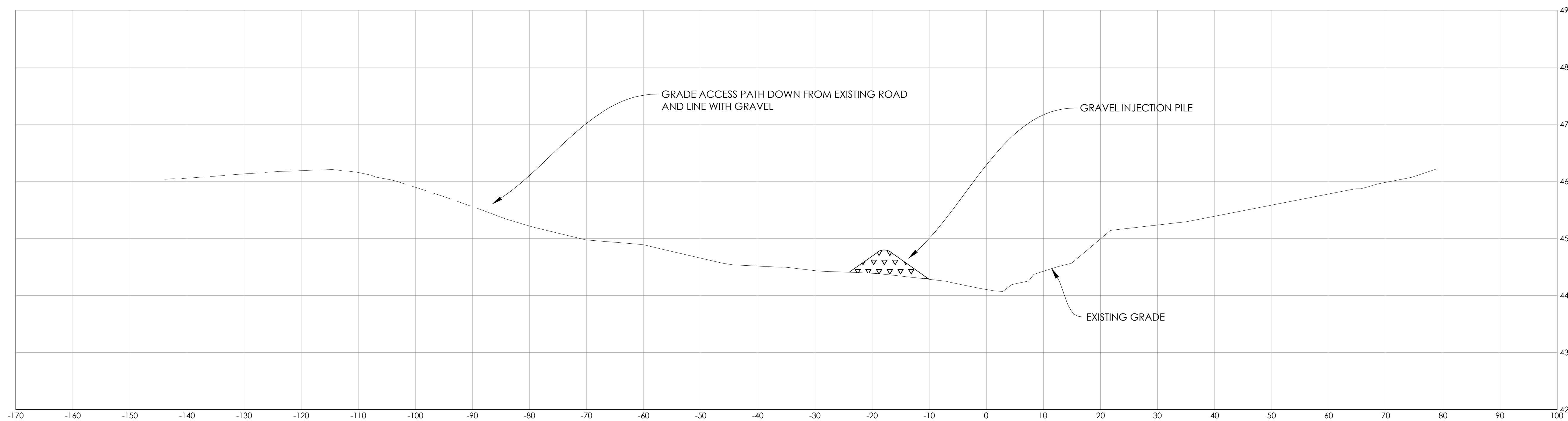
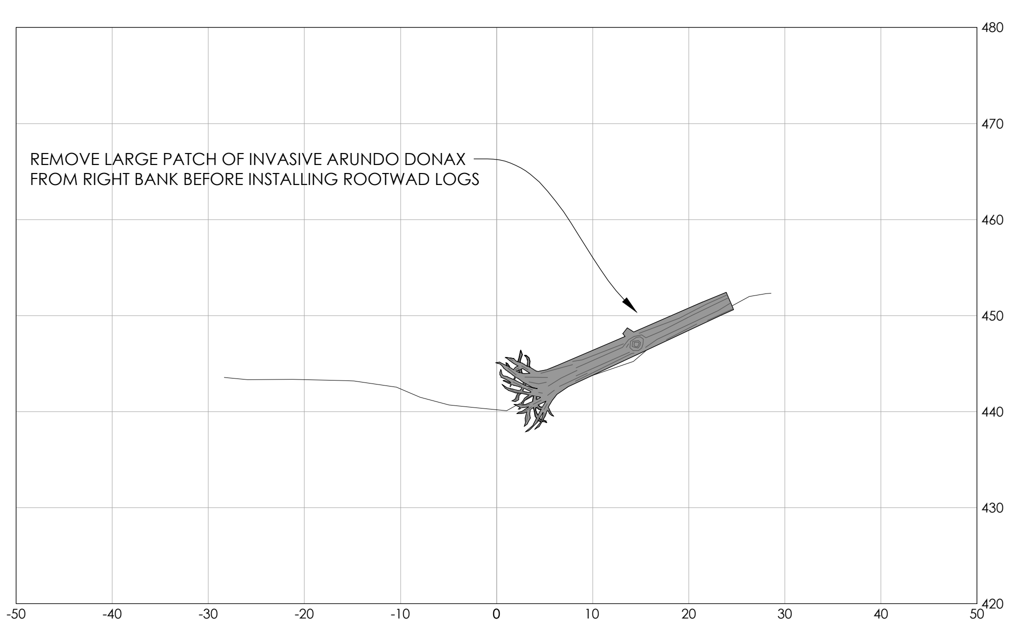
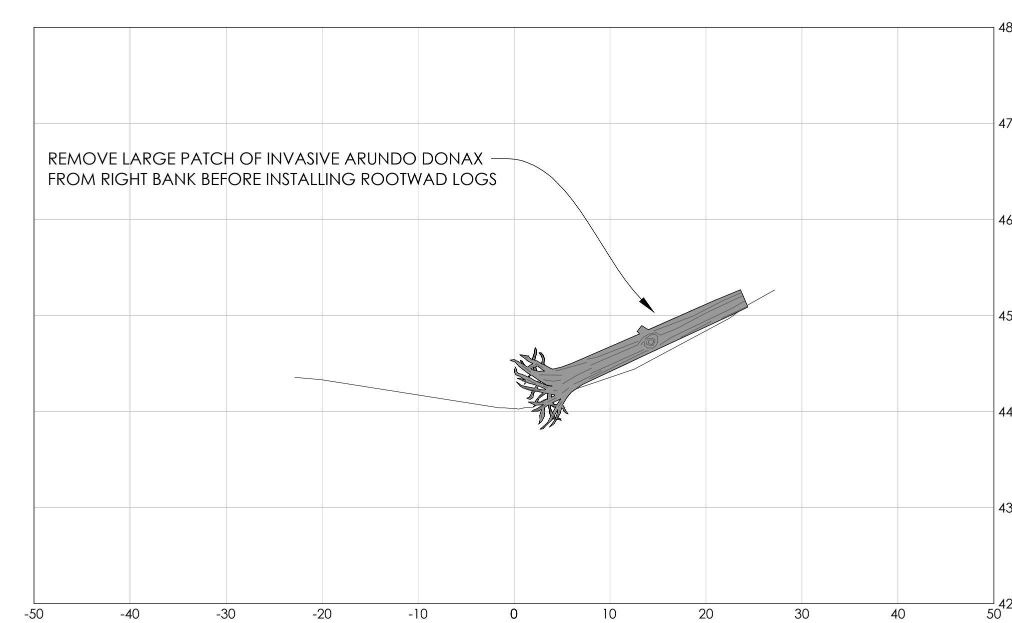


(A) SECTION AT GRAVEL AUGMENTATION
SCALE: 1" = 10'



(B) SECTION AT LOG PLACEMENT
SCALE: 1" = 10'



(C) SECTION AT LOG PLACEMENT
SCALE: 1" = 10'

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Balance Hydrologics

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DATE	BY

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CHECKED BY S MCNEELY
IN CHARGE S MCNEELY
DATE 03-19-2021

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SITE 01 SECTIONS

LLAGAS CREEK
GRAVEL AND WOOD AUGMENTATION
SANTA CLARA COUNTY, CALIFORNIA

PROJECT NUMBER

SCALE (AT 22" X 34")
AS NOTED

SHEET
2.1
3 OF 3

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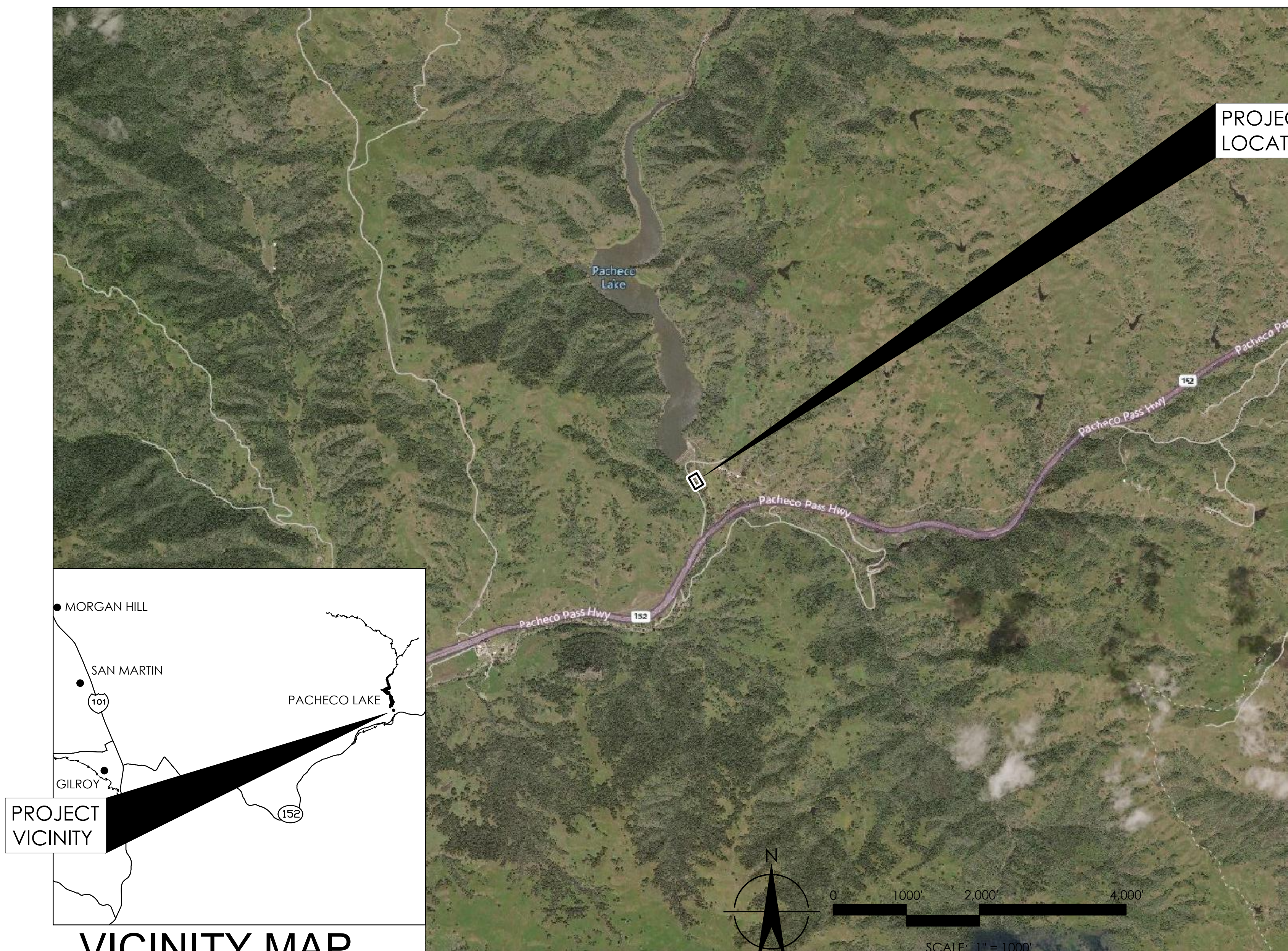
Appendix C Conceptual Design Drawings – Pacheco Creek

PACHECO CREEK GRAVEL AND WOOD AUGMENTATION

SANTA CLARA COUNTY, CALIFORNIA

Valley Water
Clean Water • Healthy Environment • Flood Protection

LOCATION MAP



VICINITY MAP

1" = 4 MILES

SHEET INDEX

PREPARED FOR

SANTA CLARA VALLEY WATER DISTRICT
JUDY NAM, PE
WATER RESOURCES PLANNING AND POLICY UNIT
5750 ALMADEN EXPRESSWAY
SAN JOSE, CALIFORNIA 95118
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CONCEPTUAL DESIGN - NOT FOR CONSTRUCTION

AECOM
Balance Hydrologics

SUBMITTALS / REVISIONS
BY
DATE

DESIGNED BY S MCNEELY
DRAWN BY D JEPSEN
CHECKED BY S MCNEELY
IN CHARGE S MCNEELY
DATE 03-19-2021

NOT FOR CONSTRUCTION

COVER SHEET
PACHECO CREEK GRAVEL AND WOOD AUGMENTATION
SANTA CLARA COUNTY, CALIFORNIA

PROJECT NUMBER
SCALE (AT 22" X 34") AS NOTED
SHEET
1.0
1 OF 3

W:\CADProjects\218252 GWPII\PACHECO CREEK\218252 PACHECO SHEET\218252 010 PACHECO COVER.dwg 6/24/2022 4:58 PM

SITE 01

NOTES:

1. LIMITS OF GRADING AND LOG PLACEMENT LOCATIONS SHOWN ON THIS SHEET ARE SUBJECT TO MINOR MODIFICATION IN THE FIELD BY THE ENGINEER OR THE ENGINEER'S REPRESENTATIVE.
2. VALLEY WATER O&M / CONTRACTOR SHALL STAKE BOTH THE LIMITS OF GRADING AND PROPOSED LOG LOCATIONS FOR APPROVAL OF THE ENGINEERS REPRESENTATIVE 48 HOURS PRIOR TO COMMENCING EARTHWORK.
3. GRAVEL AUGMENTATION CONE AS SHOWN IS 320 CUBIC YARDS OF MATERIAL. THIS ASSUMES A 35 DEGREE ANGLE OF REPOSE FOR GRAVEL MATERIAL.

LEGEND:

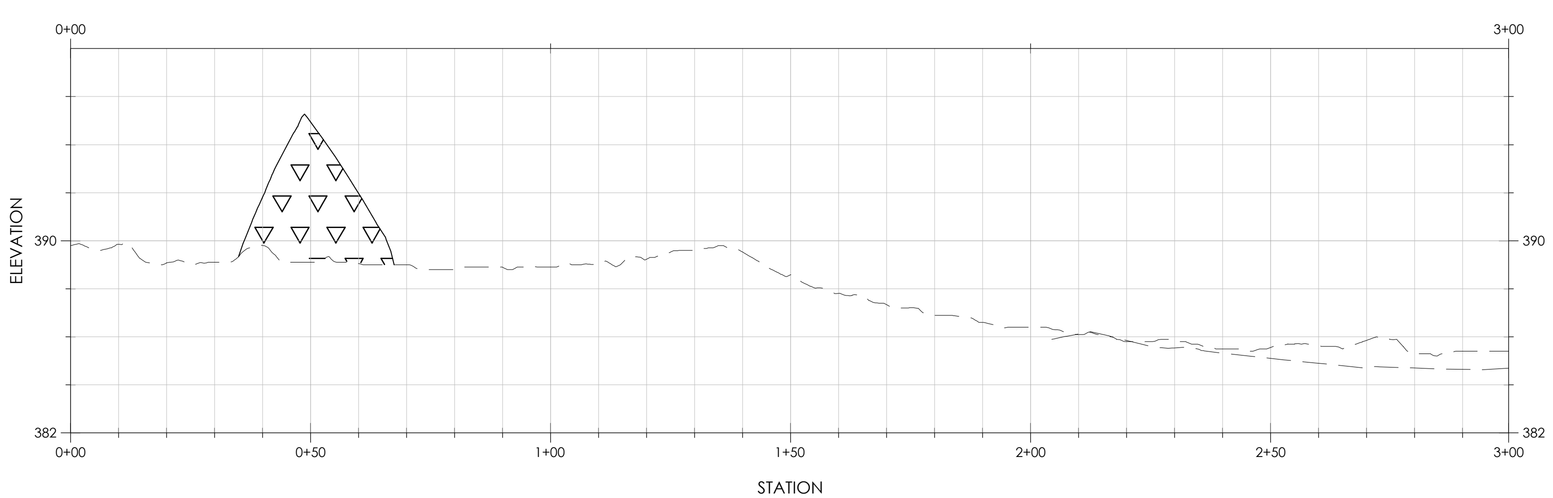
EXISTING MAJOR CONTOUR: 5 FT INTERVAL — 390

EXISTING MINOR CONTOUR: 1 FT INTERVAL

CHANNEL STATIONING LINE — 1+00

LOG WITH ROOTWAD SECURED BETWEEN EXISTING TREES

GRAVEL AUGMENTATION



CONCEPTUAL DESIGN - NOT FOR CONSTRUCTION

1 SITE 1 CHANNEL PROFILE
SCALE: 1" = 20'

C:\Users\steven.mcneely\OneDrive - AECOM\Documents\Projects\SCVWD-Gravel and Wood\441_Conceptual Design\C3D\218252 Gravel and Wood - Standard\DRIVE_W\CADProjects\218252 GWPII\PACHECO CREEK\218252 PACHECO SHEET\218252 020 PACHECO PLAN.dwg 12/21/2023 6:52 PM

AECOM
Balance Hydrologics

SUBMITTALS / REVISIONS	DATE	BY

DESIGNED BY S MCNEELY
DRAWN BY D JEPSEN
CHECKED BY S MCNEELY
IN CHARGE S MCNEELY
DATE 03-19-2021

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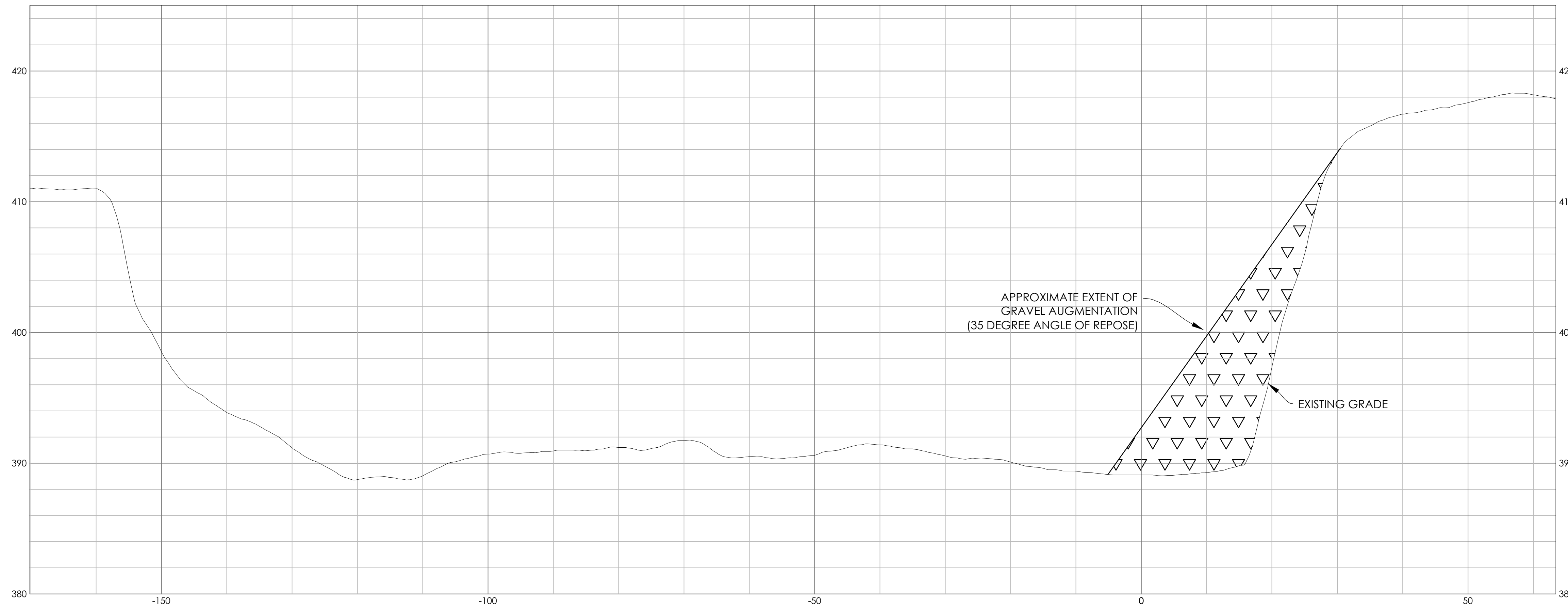
SITE 01 PLAN AND PROFILE

PACHECO CREEK
GRAVEL AND WOOD AUGMENTATION
SANTA CLARA COUNTY, CALIFORNIA

PROJECT NUMBER

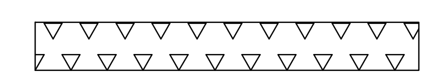
SCALE (AT 22" X 34")
AS NOTED

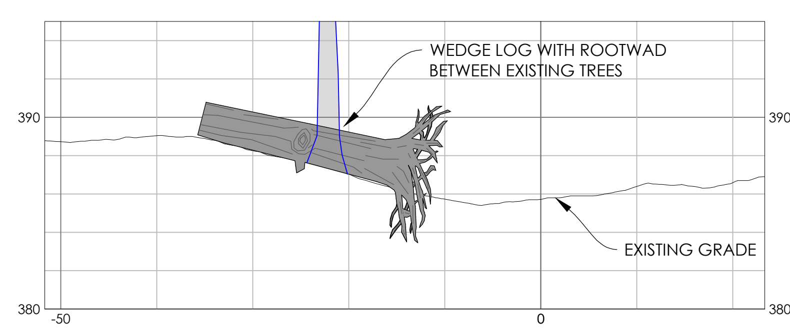
SHEET
2.0



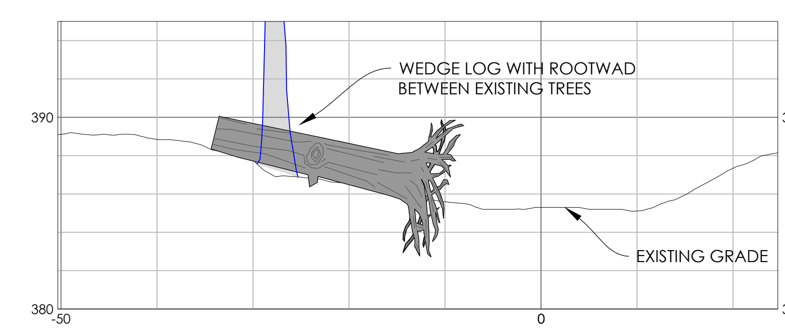
(A) SECTION AT GRAVEL AUGMENTATION PILE
SCALE: 1" = 10'
VERT X2

GRAVEL AUGMENTATION





(B) SECTION AT LOG PLACEMENT
SCALE: 1" = 10'
VERT X2



(C) SECTION AT LOG PLACEMENT
SCALE: 1" = 10'
VERT X2

AECOM

Balance Hydrologics

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SITE 01 SECTIONS

PACHECO CREEK
GRAVEL AND WOOD AUGMENTATION
SANTA CLARA COUNTY, CALIFORNIA

PROJECT NUMBER

SCALE (AT22" X 34")
AS NOTED

SHEET
2.1
3 OF 3

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