Los Peñasquitos Lagoon Restoration – Phase 1

Hydrologic and Sediment Modeling for Freshwater Channels – 90% Design

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1.0 Introduction

Phase 1 of the Los Peñasquitos Lagoon Restoration Project proposes constructing floodplain enhancements, a network of freshwater channels to improve conveyance of freshwater, and restoration of a portion of the upper lagoon with increased tidal influence through new tidal channels and removal of accumulated sediment and invasive plants. Phase 1 will be implemented in the following construction subphases:

- Phase 1A: Upstream coarse-grained sediment management through the floodplain enhancements and adjacent low flow channel improvements, and freshwater management channels and habitat enhancement within the Coastal Conservancy parcel.
- Phase 1B: Freshwater management through new primary and secondary channels and low flow diversion to convey persistent dry weather flows away from and reduce storm water retention time within salt marsh restoration area.
- Phase 1C: Restoration of degraded salt marsh dominated with non-native ryegrass (Festuca perennis) in the downstream portion of Phase 1 and construction of new tidal channels to extend tidal influence into a portion of the restored salt marsh while leaving transition zones for future sea level rise.

Phase 1 is planned to be constructed in subphases to address constraints in conducting clearing, grubbing, and major grading activities during the bird nesting season. Construction activities that may include fine grading, revegetation and material off-haul may extend into the bird nesting season based on bird monitoring and implementation of required mitigation measures. The sequence of these subphases is important as sediment and freshwater management measures need to be in-place prior to the salt marsh restoration.

This memorandum focuses on the design basis for the freshwater channels to be constructed in Phases 1A and 1B. This memorandum summarizes the findings from the hydraulic and sediment modeling performed to evaluate the performance of the 60% and 90% design of the freshwater channels: understanding the sensitivity of different project components.

Table 1.1 presents the 60% and 90% Design refinements for the freshwater channels based on the design goals and the design approach/criteria used to achieve these goals:

Table 1-1: Basis of Design Refinements - Freshwater Channels

Design Goal	Design Approach/Criteria	60% and 90% Design Refinements
Dry Weather Flows: • Convey dry weather freshwater flows and minimize ponding in areas designated for salt marsh restoration / preservation.	• Provide sufficient and continuous channel capacity within new freshwater management channels to convey dry weather flows	• In addition to freshwater management channels, add a low flow diversion feature around most of the salt marsh restoration area to more effectively convey dry weather flows away from the Phase 1C salt marsh restoration area to the downstream tidal channel.
Storm Flows: • Reduce the storm inundation period, particularly within the Phase 1C salt marsh restoration • Convey freshwater storm flows through the lagoon to reduce ponding and slow the trend of salt marsh habitat to freshwater habitat.	• Convey frequent storms up to 85^{th} percentile storm event (0.65 inches over 24 hr.) within the primary and secondary new channels to reduce ponding and storm inundation time within salt marsh restorations areas compared to existing conditions. • Convey 85^{th} percentile storm event flow in separate channel than new tidal channel. • Utilize existing channels and the newly constructed main & secondary channels and benched floodways to convey infrequent storms (larger intensity)	• Main and secondary channels are sized to convey 85^{th} percentile storm event. More frequent storm flows will be conveyed downstream of the Phase 1C salt marsh restoration to the existing tidal channel where the flows mix with tidal flows and then enter the salt marsh restoration from this downstream location through a separate new tidal channel. • Add low flow diversion feature to more effectively direct more frequent storm events conveyed by the freshwater primary and secondary channels (sized to convey 85^{th} percentile storm event) away from the Phase 1C salt marsh restoration. Keeps freshwater flows separate from new tidal channel. Diversion acts similar to the existing berm around the former industrial pond where salt marsh vegetation has remained intact. • The grading within the salt marsh restoration and new tidal channels provide improved drainage of storm flows that reduce the time of retention and inundation. Larger (10 year and greater events) overtop the low flow diversion and will flow into the restoration area.

Design Goal	Design Approach/Criteria	60% and 90% Design Refinements
	• Reduce ponding of storm flows at "pinch point" to reduce current freshwater inundation time in the planned salt marsh restoration area	• Additional excavation and benching at the "pinch point" planned to allow for both more storm flow out and more tidal flow into the salt marsh restoration. This design reduces the retention of storm flows in the restoration area that currently backs up due to the hydraulic "pinch point" created by the railroad embankment and bluff slope. Elevations on the Phase 2 side of the railroad trestle at this location are much higher and does not provide for effective drainage of the "pinch point" area.
Sediment – Salt Marsh: • Reduce coarse-grained sediment, which can impact sediment salinity and establishment of salt marsh vegetation, entering the restored salt marsh.	• Reduce the annual excess loading and accumulation of coarse-grained sediment in the salt marsh restoration to levels that will not impact restored habitat function. • Maintain and manage the sediment accumulation within the restored salt marsh to account for sea level rise.	• Upstream floodplain enhancements reduce excess coarse-grained sediment loading to the Lagoon and downstream salt marsh restoration toward TMDL reduction goals. • Add a low flow diversion feature to provide separation between freshwater channels conveying sediment and the salt marsh restoration area which will reduce the annual loading and sediment accumulation in the area. • Design allows for sediment deposition during more frequent events but at lower loading rate as storm flows enter at the downstream end of the restoration area where the new tidal channel enters. Higher storm events will overtop low flow diversion and deposit sediment in the restoration area.
Channel Scour & Erosion • Address areas of high channel velocity to prevent scour.	• Prevent scouring of channel bottom and banks for more frequent storm events (2-year event) with consideration of stability of measures up to the 10-year event.	• Hydraulic modeling of the 90% design site and channel grading Identified potential scour areas requiring reinforcement of the channel bottom and side slopes.

Design Goal	Design Approach/Criteria	60% and 90% Design Refinements
		• 90% Design includes use of cobble to stabilize channel bottoms and vegetated soil lifts on the channel side slopes to address scouring and to maintain channel capacity. • Channel bottoms are not vegetated as they will be subject to persistent dry weather flows. The capacity of these channels is to be maintained for dry weather and frequent storm flow conveyance to meet the hydraulic design goals and criteria. Channel banks/ side slopes will be vegetated with native plants. • The 60% & 90% Designs include installation of biodegradable erosion netting for all channel side slopes following construction to stabilize the banks as vegetation is established. • 90% Design addresses potential scouring within channel segments where flow velocity and shear force exceed thresholds based on modeling of the 2-yr storm events by placing cobble on the bottom of the channel (not on side slopes). Cobble size is based on 10-year event velocities to control downstream migration. • Channels segments where the modeled 2-year event velocities would result in bank/ side slope erosion even after some vegetation is established, are further stabilized with bioengineered vegetated soil lifts with stabilized boulder toe of slopes. Channel banks that are steep due to site constraints such as the railroad or developed private parcels that will be difficult to establish vegetation and subject to erosion during 2- to 10-year events will also include vegetated soil lifts.

Design Goal	Design Approach/Criteria	60% and 90% Design Refinements
Sediment Deposition in Channel • Minimize O&M of channel from significant sediment deposition	• Design channel grading to minimize sediment accumulation and to focus maintenance to reduce continuous biological impacts by focusing areas of potential sediment accretion that can reduce channel capacity	• Designed channel grades to minimize sediment deposition and provided areas where sediment deposition is anticipated in the future with maintenance access to allow for focused sediment removal. • Areas of sediment deposition are anticipated in the segment within the Coastal Conservancy Parcel. Additional excavation and grading in this area is designed to account for additional sediment deposition adjacent to the channel. Adaptive Management Access Roads are located along this segment and the secondary channel from Floodplain Enhancement 3. • Channel segment from the Coastal Conservancy parcel to the low flow diversion feature does not have Adaptive Management Roads and will be allowed to naturally meander as vegetation grows in the channel and sediment deposition occurs. This area has multiple secondary channels and existing channels that have been connected to provide continued conveyance capacity. • Channel segment along the low flow diversion is not anticipated to have sediment deposition as it is subject to higher velocities.
Wildlife Corridor • Provide improved wildlife access and passage from Los Peñasquitos Creek to the Lagoon particularly for listed Ridgeway Rail.	• Reduce channel slope grade and expand channel bench where possible throughout the main freshwater channel to allow for improved wildlife access and passage	• 90% Design includes reduced and expanded side slopes. Side slopes were regraded from 3:1 to either 5:1 or 10:1 (where possible) in order to provide a gentler slope for Ridgeway Rail and other wildlife access along the main channel from Flood Plain Enhancement 2 to the low flow diversion feature. • 90% Design revised plant schedule for channel banks to better accommodate wildlife passage

1.1 Outline

This memorandum is structured as follows:

- Section 1 provides the introduction and the outline.
- Section 2 presents the design refinements completed between the 60% and 90% Design submittals to address comments from the Technical Advisory Committee (TAC) and resource agencies as part of the permit application process. These comments were added to the design goals and design approach summarized in Section 1 and include improving wildlife access that resulted in regrading the channel side slopes to be flatter and wider. Section 2 also presents the hydraulic and sediment modeling results for the 90% design that are the basis for the refinements of the freshwater channel design elements.

2.0 Freshwater Channels Design Refinements

The freshwater primary channel begins at the transition from the concrete lined Carroll Canyon Creek flood control channel to the earthen bottom channel that runs along Floodplain Enhancement 1 (approximately Sta. 163+81) (See Figure 2.1). The freshwater primary channel continues through the confluence of Carroll Canyon Creek and Los Peñasquitos Creek at Floodplain Enhancement 2. The freshwater channel then continues through the California Coastal Conservancy parcel and connects with new secondary channels from Estuary Way and Floodplain Enhancement 3. The primary channel continues through the upper Lagoon from the Coastal Conservancy parcel to a wider portion of the marsh plain and connects with existing isolated channels not currently connected to the upstream creeks. The primary channel continues to the new low flow diversion along the railroad embankment to the existing tidal channel. The tidal channel then continues nearly one mile to approximately Sta. 0+00 at the Lagoon inlet. The freshwater channels will be constructed in two phases, Phase 1A and Phase 1B, with the northwest edge of the Coastal Conservancy property parcel representing the transition between the subphases.

The following sections discuss refinements completed between the 60% and 90% Design submittals to address comments from the resource agencies and Technical Advisory Committee (TAC) on the 60% Design. These comments were added to the design goals and design approach summarized in Section 1 and include improving wildlife access.

2.1 Hydraulic and Sediment Transport Modeling Approach

2.1.1 Hydraulic Analysis

Hydraulic modeling was performed using HEC-RAS (River Analysis System), Version 5.0.7 (HEC, 2019) to evaluate 90% design development. A two-dimensional (2-D) hydraulic model was used to compute flood elevations and depths, flow velocities, shear stress, and floodplain boundaries for the 2-, 5-, 10-, 25-, and 100-year return period events. This model was also used to assess the scouring potential based on flow velocities for a 2-year event storm and for sedimentation potential using the 85th percentile storm. Model development is presented in the H&H Report for Floodplain Enhancements.

2.1.2 Sediment Transport

Sediment transport modeling was performed using SRH-2D (Sediment & River Hydraulics – Two-Dimensions), Version 3.2 (USBR, 2020). Model construction, including mesh creation, boundary conditions, and results viewing were performed using the SMS (Surface-Water Modeling System) software, Version 13.0.14 (Aquaveo, 2020). SRH-2D is a hydraulic model developed by the U.S. Bureau of Reclamation (USBR) in collaboration with the Federal Highway Administration (FHWA). SRH-2D was chosen because it contains a two-dimensional solution of mobile-bed sediment transport hydraulics, allowing for multi-size and suspended-, bed-, and mixed-load sediment transport simultaneously.

The SRH-2D two-dimensional (2-D) sediment transport and hydraulic model was used to compute flood sediment transport through the project reach and the effectiveness of the low flow diversion feature to not increase the amount of excess sediment depositing in the salt marsh restoration area. Model development is presented in the H&H Report for Floodplain Enhancements.

Figure 2-1: New Freshwater Channels Stations

2.2 Phase 1A to 1B Boundary Relocation for Greater Habitat Enhancement Opportunities

Based on discussions with the City's Development Services Department (DSD) on the overall site impact and mitigation analysis and discussion with resource agencies as part of the permitting process, the limit of Phase 1A presented on the 60% design plans was extended from Sta. 141+50 to Sta. 127 +75 on the 90% design plans in order to provide additional habitat enhancement opportunities as part of Phase 1A. The previous extent of Phase 1A was at the downstream boundary of Floodplain Enhancement 2.

The areas of habitat enhancement are limited along Floodplain Enhancements 1 and 2 as they are bounded by the business park and the MTS railroad. The extension of Phase 1A to the downstream parcel boundary of the Coastal Conservancy property allows for greater balance in disturbed impact areas and mitigated habitat enhancement areas in this initial construction subphase.

Within the Coastal Conservancy parcel, areas of invasive plants have been identified for removal and revegetation with native plants. The area within this parcel is also dominated by impacted understory vegetation from excess coarse grained sediment deposition and introduction of invasive plants. Accumulated coarse sediments and impacted understory will be removed as part of Phase 1A and the riparian corridor habitat restored with native vegetation and improved upstream sediment management provided by the Floodplain Enhancements.

The extension of Phase 1A also provides for improved conveyance of storm flows through this area with the grading of the new freshwater channel from the re-aligned low flow channel along Floodplain Enhancement 2. A temporary channel to the existing "pilot channel" that ends within the Coastal Conservancy parcel had been planned in the 60% Design. With the 90% Design, storm flows will now be conveyed through this parcel (instead of into the "pilot channel" with a constricted outlet) and to a wider area of the marsh with less hydraulic restriction (see Figure 2-2). The 90% design also provides for a connection to a secondary overflow channel that will complement the improved drainage. This improved flow will also help minimize interim sedimentation in Phase 1A. The freshwater channel will be continued in Phase 1B through the upper Lagoon and to the existing tidal channel to provide a continuous conveyance of both dry weather and more frequent storm flows as part of the freshwater management of the overall restoration project.

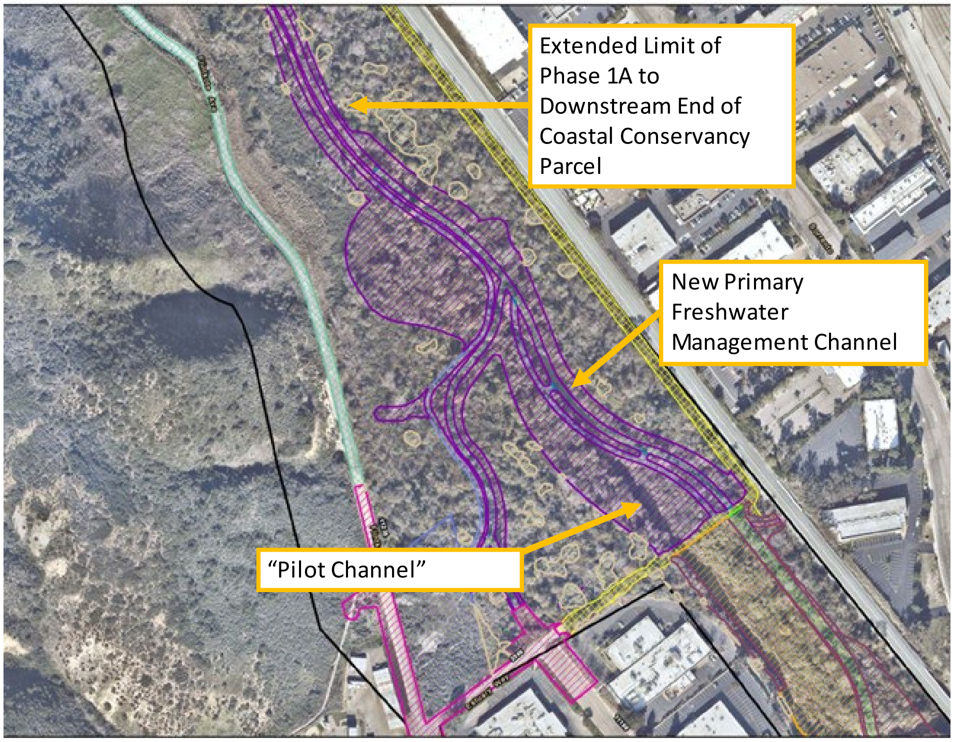

Figure 2-2: Extension of Phase 1A Freshwater Channel Work into Coastal Conservancy Parcel

2.3 Channel Side Slope Regrading & Benching

Based on comments on the 60% Design from the United Stated Fish and Wildlife (USFW) and State Parks who are members of the TAC, the 90% design was refined to address comments regarding wildlife access, in particular, access for the listed light-footed Ridgeway Rail. Ridgeway Rail surveys have indicated presence of this listed species upstream of the Phase 1 project in the riparian corridor in Los Peñasquitos Preserve and in the freshwater marsh area of Phase 2 (Zembal, 2022, 2023). Comments from USFW and State Parks included improving access from where Los Peñasquitos Creek enters Phase 1 to the Phase 1 marsh plain and connections from Phase 1 to Phase 2 freshwater marsh through the existing railroad trestles. These comments were addressed by increasing the width of the wildlife corridor between Floodplain Enhancement 2 and the MTS railroad by reducing the size of Floodplain Enhancement 2 by 15 feet. Discussion of this design refinements to Floodplain Enhancement 2 is presented in the 90% Design Hydraulic and Hydrology Report for the Floodplain Enhancements.

In addition, these comments were addressed by reducing the grades of the freshwater channel side slopes to allow for improved access and mobility of the Ridgeway Rail using the freshwater channels to access Phases 1 and 2. To achieve this, the inside bends of the main sinusoidal freshwater channel between Floodplain Enhancement 2 up to the low flow diversion feature were regraded from 3:1 presented in the 60% design plans to either 5:1 or 10:1 slopes in the 90% design plans to allow easier

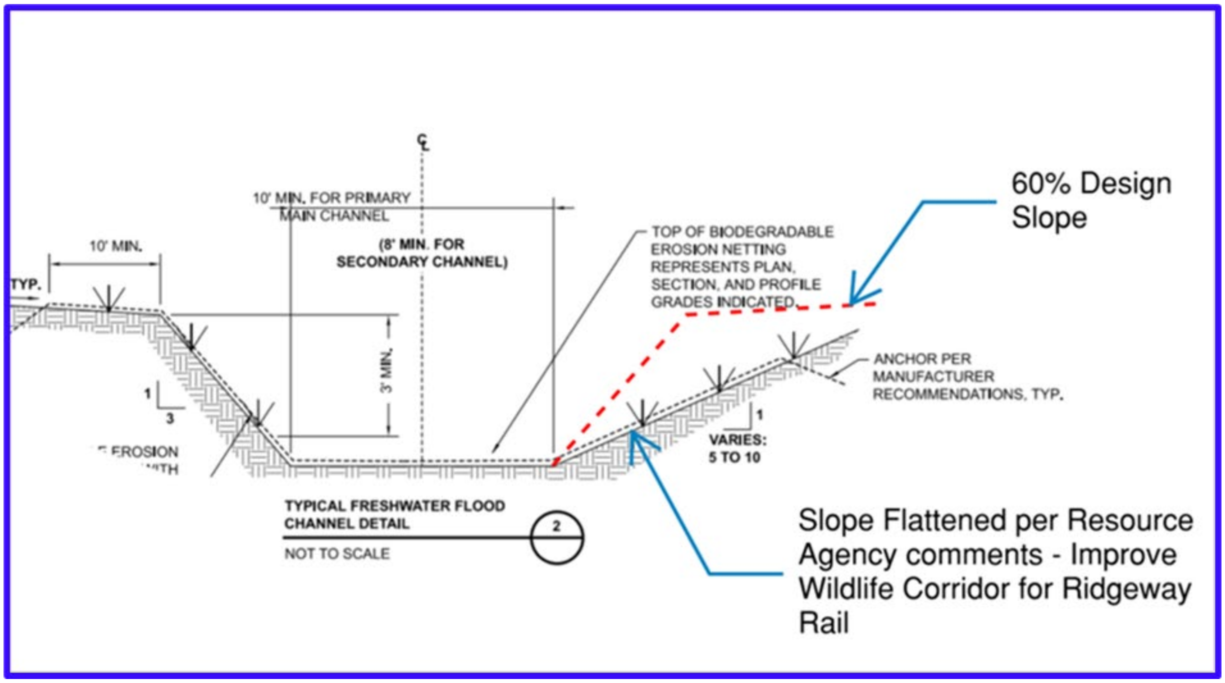

Figure 2-3: Flattening of the Freshwater Channel Side Slopes for Wildlife Access

access for the Ridgeway Rail to enter and leave the freshwater channel (see Figure 2-3). The slopes vary between 5:1 and 10:1 and regrading focused to one side of the channel in order to balance the need for wildlife access with increased disturbance and impacts to existing sensitive habitat. Flattening channel slopes increases the extent of grading and potential impact. This refined design significantly increased the amount of excavation and off-haul for Phases 1A and 1B by approximately 43,000 cubic yards (at an approximate cost of $4 million) due to the additional excavation and grading to make the channel banks gentler for wildlife access.

2.4 Cobble Placement Reduction in Freshwater Channels

Based on comments from USFW and State Parks, who are members of the TAC, on the 60% Design, as well as resource agencies as part of the permit process, the use of cobbles in the bottom of the freshwater channels is to be limited for use to control channel scoring and erosion from storm flows. The reduction in use of cobble with the refinements of the channel side slopes discussed in the previous section will provide for a more natural channel design that addresses both channel scouring and wildlife access. The 90% design has refined the use of cobble to only those channel segments where the maximum permissible velocity for earthen bottom channel composed of alluvial silts (see Figure 2-4) for a 2-year storm event would be exceeded. Cobble was removed from segments that do not meet this design criteria. The cobble size is based on velocities molded for a 10-year storm event to control downstream migration of cobbles to tidal channels.

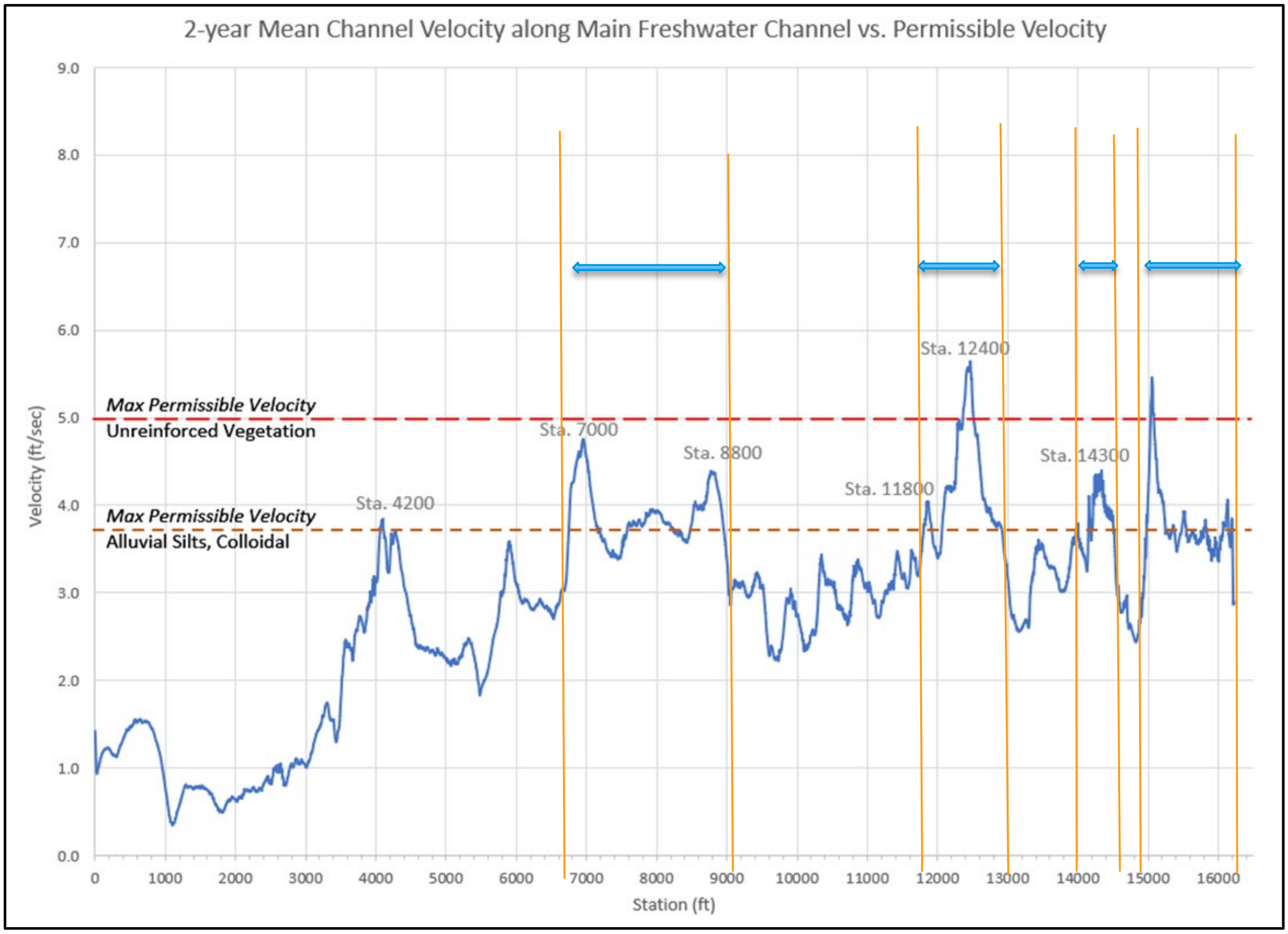

Figure 2-4: Channel Velocity & Placement of Cobble in Channel Bottom to Control Scouring

As shown on Figure 2-4, hydraulic calculations were completed and indicated the need for cobble placement at the following approximate station locations (segments within blue arrows between the orange lines):

- Sta. 162+50 to 149+00 and Sta. 146+00 to 140+00 – Segments of low flow channel along Floodplain Enhancements 1 and 2 where flows from Carroll Canyon and Los Peñasquitos Creeks enter the more constricted channel and flow increases channel flow velocity.
- Sta. 130+00 to 118+00 – Segment of channel through the Coastal Conservancy parcel, directly before the marsh plain width becomes narrower increasing flow velocity.
- Sta. 91+00 to 67+00 - Segment of channel where the larger marsh plain adjacent to the channel becomes narrower as the main channel runs between the railroad and the low flow diversion feature around the tidal salt marsh restoration. This segment runs the full length of the freshwater channel between the railroad and the low flow diversion.

This cobble placement represents the necessity to reduce flow rates and minimize scouring in these areas, as well as a reduction of overall planned cobble placement within the channels. Figure 2-5 presents the results of the hydraulic modeling of the 2-year storm event and the velocity of the flows in the freshwater channels. The higher velocities are shown in red and orange. The channel segment stations are shown that begin the upstream end at the confluence of Carroll Canyon Creek with Floodplain Enhancement 1 at station 163+00 to the downstream end of the freshwater channel. No cobble is placed in the tidal channels of Phase 1.

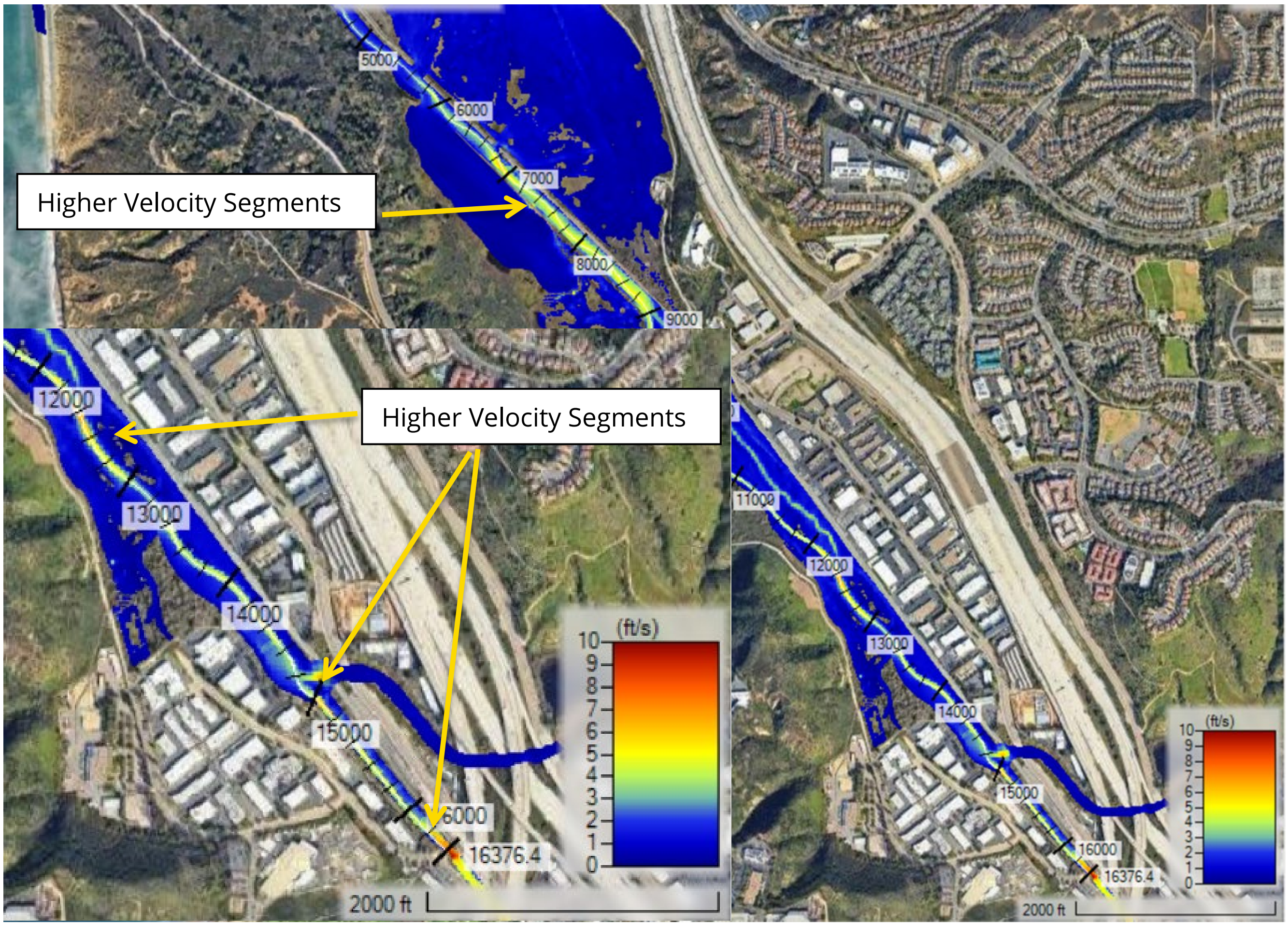

Figure 2-5: Freshwater Channel Velocities for 2-Year Storm Event

To address the concern of the design team with maintaining channel conveyance capacity of dry weather and low flow during more frequent storm events in segments where access will be removed after construction and no cobble will be placed, grading in these channel segments was modified to allow for overflow to existing channels. These segments are between the downstream end of the Coastal Conservancy parcel and the low flow diversion around the tidal salt marsh restoration. This design refinement adds to the overall channel system capacity. Segments of the new channel that will not be maintained are anticipated to have reduced capacity from vegetation growth and sedimentation over time. The refined grading connects the new channel to existing channels providing greater overall capacity to continue to convey dry weather and more frequent (85th percentile and lower) storm flows through the creation of a natural braided channel system. A 50-foot-wide lower bench has been graded in the 90% design plans on the northeast side of the channel near Sta. 13+200 in order to allow for dry weather and storm flows during more frequent storm events to spread out and flow into adjacent freshwater channels in the area should the new freshwater channel capacity decrease overtime.

2.5 Prescriptive Vegetated Soil Lifts

As discussed in the previous section, the use of cobbles at the bottom of the channel is limited to where the anticipated velocities exceed the limits for scour potential for a 2-year storm event for silty soils with no vegetation (3.75 ft./sec – see Figure 2-4). The bottom of the channel will not be vegetated as these channels will be subject to continuous dry weather flows. Cobble will be placed only on the bottom of the channel at these locations and not on the side slopes. A 2-year storm event was used for the determination of cobble placements in consideration of balancing channel bed scouring protection with more natural channel design based on input from the TAC. As mentioned, the cobble size is based on 10-year storm flow velocities to address potential migration of cobble during these larger events.

In order to reinforce the channel side slopes from erosion due to higher velocity storm flows, bioengineered vegetated soil lifts (VSL) were proposed in the 60% design for select segments. The placement of these VSL was further refined in the 90% design based on hydraulic modeling of the revised channel grading of the freshwater channels as discussed previously for wildlife access. The gentler slopes of the freshwater channel slide slopes to address wildlife access required re-running the hydraulic model analysis for various storm events to better assess the need for additional bank stabilization for the 90% Design.

Freshwater channel banks will be re-vegetated follow grading. Typical channel banks/side slopes will receive jute erosion matting following grading to help reduce erosion while the vegetation is being established. During the plant establishment period, erosion damage from storm flows will be identified and repaired by filling, grading and replanting. The hydraulic modeling assessed the need for additional reinforcement in areas susceptible to high flow velocities after some vegetation has established.

The Manning's coefficient (n) used for the hydraulic modeling to determine channel flow velocities for various storm events was 0.04. The Manning's n for natural channels varies from approximately 0.025 for unvegetated earthen channels without stones to 0.05 or greater for channels with large stones, or thick weeds/brush/debris. The n value of the freshwater channels will vary over time as the new channels are established and plants begin to mature and naturally stabilize. The n value of 0.04 was used to represent the freshwater channels after some vegetation has been established during the Adaptive Management period but not overgrown.

The Adaptive Management period will extend five years following construction of Phase 1C and potentially 8 years following the construction of the freshwater channels. For this reason, in addition to the 85th percentile and 2-year storm event, a 10-year storm event was also assessed. VSL are bioengineered to use willow and mule fat stakes placed between the soil lifts to readily establish a root system to stabilize the channel slope. A velocity threshold of approximately 5 ft/sec for stabilized banks for the 10-year storm condition was used for the assessment and placement of VSL. The slope of the channel banks is also used to assess VSL placement. Segments of the channels that have slopes greater than 3:1 with higher velocities were also considered for VSL placement as establishment of vegetation on these steeper slopes may require additional stabilization techniques.

As shown on Figure 2-6, the refined modeling identified channel segments where the maximum allowable velocities for vegetated streambanks exceeded 5 ft./sec under a 10-year storm event. VSL are proposed for these segments to address concerns regarding erosion and channel maintenance for storm events that may occur during 5-year Adaptative Management period. During the 5-year Adaptative Management period these segments can be further assessed for the need for additional stabilization for the long-term maintenance period.

In addition, VSL were considered where the bank of the channels where steep due to existing space constraints that may constrain the establishment of vegetation. These segments include the channels along Floodplain Enhancement 1 where the slope adjacent to the developed private parcels limits grading of the slope. The other segment is a portion of the channel that runs between the low flow diversion and the MTS railroad embankment. The existing railroad embankment cannot be modified and is steep. Velocities in this area are also higher and warrant additional stabilization than just revegetation.

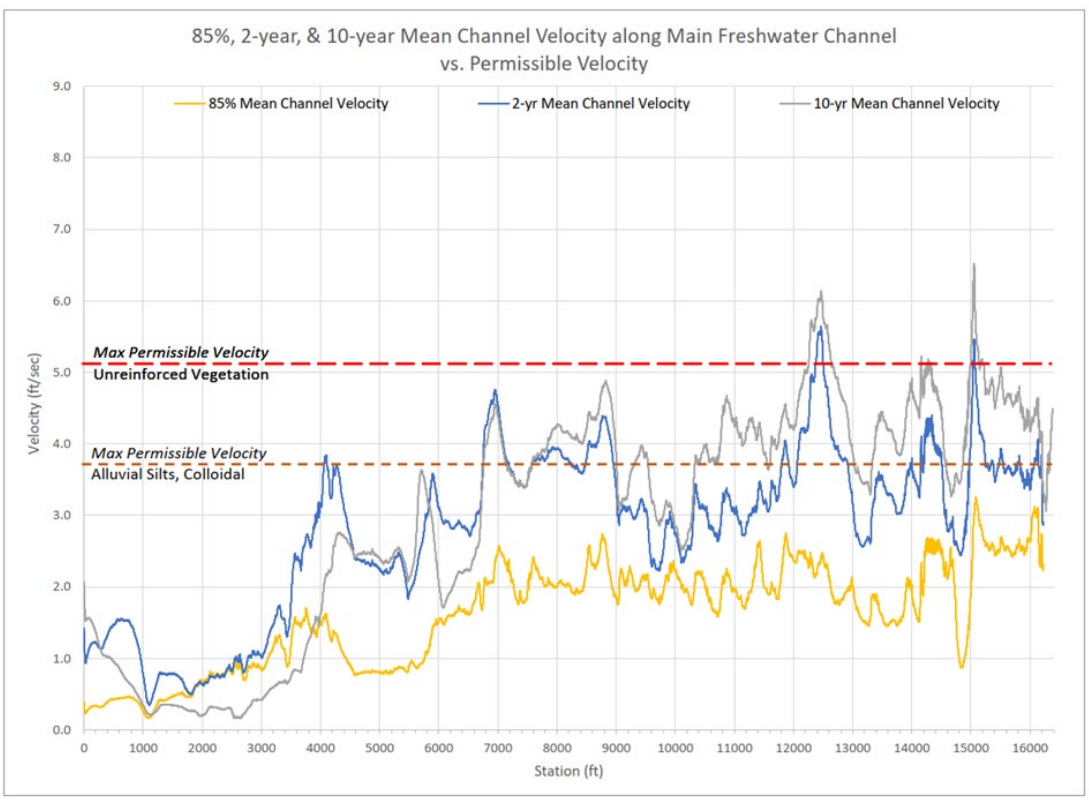

Figure 2-6: Results of Hydrology Model for Various Storm Events Compared to Channel Scour Thresholds

Table 2-2 summarizes the location of where VSL will be constructed to provide for channel slope stabilization to control scour and erosion damage during storm events.

Table 2-1: Vegetated Soil Lift (VSL) Locations - 90% Design

VSL LOCATION TABLE			
LOCATION NO.	APPROX. LENGTH (FT.)	START AND END STATION	PLANTINGS
1	550	55+50 TO 59+50 (EAST BANKS AND EXTENDING UNDER RAILROAD TRESTLE, BOTH SIDES)	SALT MARSH
2	250	60+50 TO 63+00	SALT & FRESHWATER
3	500	64+50 TO 68+00 (EAST BANKS AND EXTENDING UNDER RAILROAD TRESTLE, BOTH SIDES)	SALT & FRESHWATER
4	250	69+50 TO 72+00	FRESHWATER
5	300	73+50 TO 76+50	FRESHWATER
6	350	77+50 TO 81+00	FRESHWATER
7	300	82+50 TO 85+50	FRESHWATER
8	150	86+00 TO 87+50	FRESHWATER
9	350	88+00 TO 91+50	FRESHWATER
10	300	~90+25 EXTENDING UP EAST BANK OF SECONDARY CHANNEL	FRESHWATER

2.6 Low Flow Diversion Feature Design

The low flow diversion feature was added to the 60% design based on the results of the hydraulic and sediment transport modeling of the 30% design that indicated higher retention time of storm flows and sediment loading to the salt marsh restoration area than targeted to achieve the design goals. Key design goals that are summarized in Table 1-1 include:

- Convey dry weather freshwater flows and minimize ponding in areas designated for salt marsh restoration / preservation.
- Reduce the storm inundation period, particularly within the Phase 1C salt marsh restoration.
- Convey freshwater storm flows through the lagoon to reduce ponding and slow the trend of salt marsh habitat to freshwater habitat.
- Reduce coarse-grained sediment, which can impact sediment salinity and establishment of salt marsh vegetation, entering the restored salt marsh.

The low flow diversion is designed to function similar to the existing berm of the former industrial pond that has maintained intact salt marsh vegetation within the bermed area by limiting sediment deposition and freshwater input. As shown in Figure 2-7, surrounding the former bermed pond is degraded salt marsh that is dominated by invasive Italian rye grass which has been subject to dry weather, longer storm flow retention times, and excess sediment deposition. The low flow diversion expands this protective berm around the Phase 1C salt marsh restoration that consists of both tidal and non-tidal salt marsh restoration and enhancement.

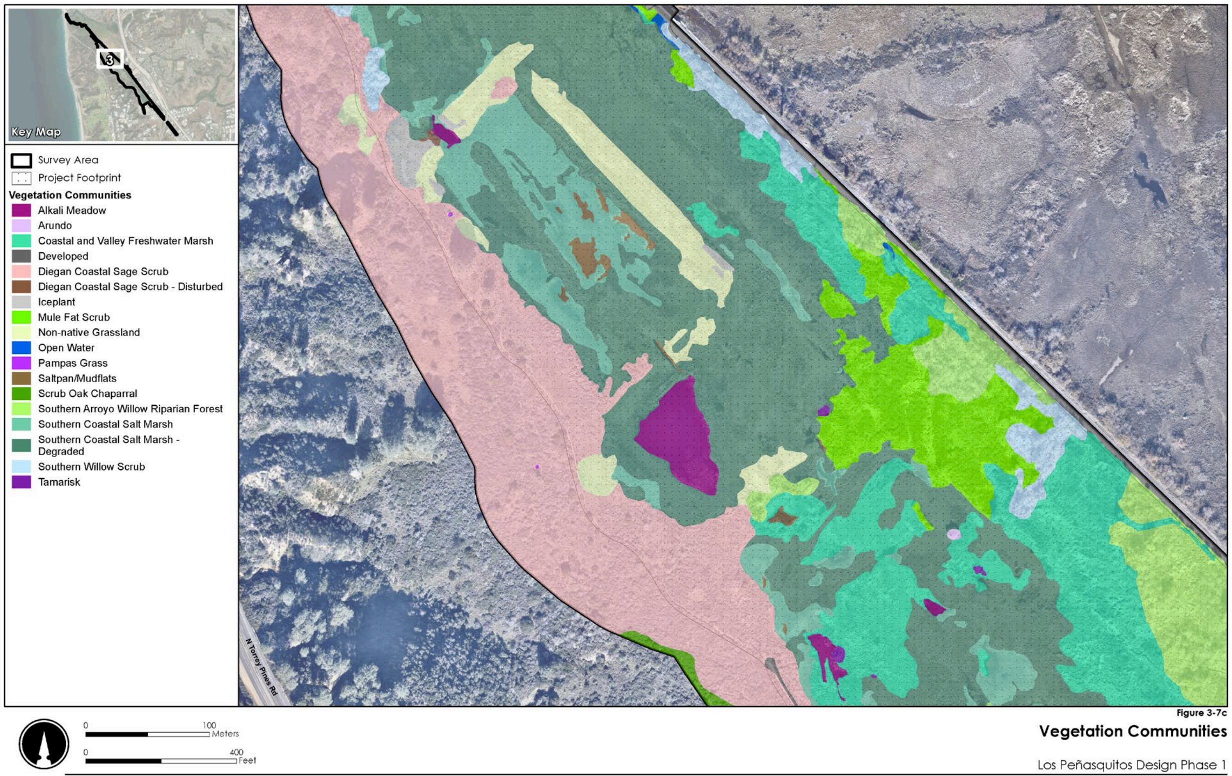

Figure 2-7: Existing Vegetation Map - Light Colored Existing Berms Protect Intact Salt Marsh (Lighter Olive Green)

Figure 2-8 is a photograph of this area under current conditions that shows the ponded water following a storm event. This retained ponded water has contributed to the establishment of the non-native Italian Rye grass outside of the bermed area. The low flow diversion will divert dry weather flows away from the salt marsh restoration area and reduce the retention time of storm flows that promotes the establishment of the invasive grasses and other plant types.

Figure 2-8: Existing Conditions - Ponded Stormflows in Area of Planned Salt Marsh Restoration and Existing Degraded Non-tidal Salt Marsh

The reduction in retention time of storm flows is achieved by limiting the inflow of more frequent storm events to the downstream end of the salt marsh restoration where the new tidal channel enters this area. During storm events, freshwater will backflow into the salt marsh area by this tidal channel. The low flow diversion reduces the retention time of the freshwater inundation for more frequent storm events by limiting these flows into the restoration area and the positive drainage established in the restoration areas from re-grading, the new tidal channel, and the widened tidal channel through the downstream pinch-point.

Larger storm events (greater than a 10-year storm event) will overtop the berm and inundate the salt marsh. Figures 2-9 present the results of the 60% design hydraulic modeling for the 2-year and 10-year storm event showing the inundation of the salt marsh area. Partial periodic freshwater inundation during storm events that are important for the overall function of the salt marsh will continue even under more frequent smaller events through the new tidal channel where more mixing with tidal flows will increase salinity. As modeled, full inundation of the salt marsh within the low flow diversion occurs for the 10-year storm and larger storm events. Tidal influence in this area will increase with future sea level rise and the various salt marsh zones will gradually transition upgradient within this area.

2 & 10-Year Storm Flow / Inundation

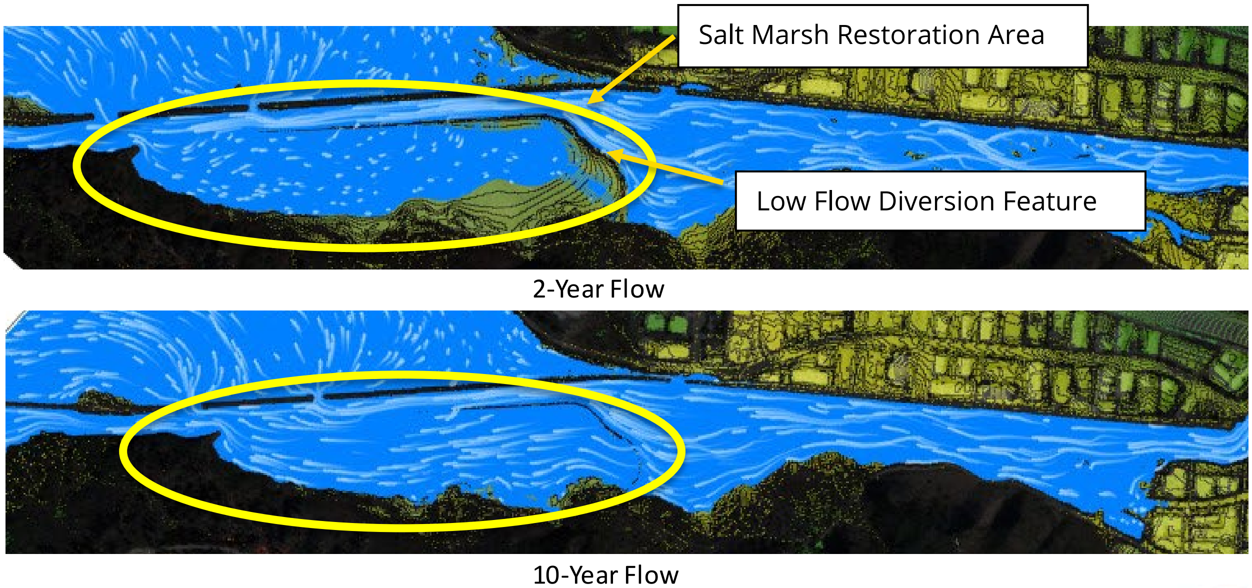

Figure 2-9: Freshwater Inundation of the Salt Marsh within Low Flow Diversion

Results of the sediment transport modeling during the 30% Design indicated the new continuous freshwater channel increased the amount of excess sediment entering the salt marsh restoration area and potentially depositing and impacting the sustainability of the restoration. The low flow diversion was added to the 60% Design to direct storm flows with excess sediment loads away from the salt marsh restoration, while still allowing for more controlled storm flows carrying sediment at the downstream end of the salt marsh restoration through the new tidal channel. Sediment will still be deposited in the salt marsh restoration during storm flows, but at lower rates than the 30% Design and less than the current sediment loading. Table 2-2 presents the results of the sediment transport modeling for the 30% 60% and 90% Design as a percentage of total existing sediment load being deposited into salt marsh restoration area for a 2-year storm event.

Current Sediment Deposited in Salt Marsh Restoration Segment (TONS)– 2-year Storm Event	Percent of Current Loading - 30% Design (no low flow diversion feature)	Percent of Current Loading - 60%-90% Design (added low flow diversion feature)
1,033	148%	26%

At larger storm events (10-year event and greater) sediment laden stormwater will overtop the low flow diversion feature and deposit greater amounts of sediment. The 90% Design therefore reduces the amount of excess sediment deposited in the salt marsh restoration for more frequent storm events but allows for continued sediment deposition at reduced rates and greater amounts during larger events. The 90% Design also includes transition zones for future sea level rise as discussed in the Hydraulic and Hydrology Report for the salt marsh restoration (Phase 1C).

The low flow diversion will average four feet in height with 4:1 side slopes and a 15-foot wide top. An Adaptive Management access road will be constructed along the top of the berm for construction and maintenance access to the freshwater channel and salt marsh restoration area.

A refinement to the 90% design included moving the low flow diversion feature outside of the privately owned parcel within the Preserve. No grading or filling is now planned within this parcel. Additionally, the Adaptive Management access road to the low flow diversion was relocated to reduce potential impacts to designated wetland areas of southern willow scrub riparian habitat. This area of riparian willow scrub is characterized by year-round high groundwater. The re-aligned access road is located in upland coastal sage habitat. The access road at this location will be removed and the area restored with native coastal sage scrub vegetation following the Adaptive Management period. The access road located on top of the low flow diversion will be removed and restored with freshwater wetland vegetation.

2.7 Sedimentation Analysis

Sedimentation has adversely impacted the lagoon and is one of the predominant drivers of this project. By implementing Flood Plain Enhancements 1 and 2, the coarse sediment loading entering the lagoon is greatly reduced. The lagoon is, by nature, an area where water velocities are slower and suspended sediment is prone to settlement. The threshold minimum velocities identified to minimize sedimentation in the channels are shown on the velocity-station chart in Figure 2-10 below. As the initial basis of design for the channels, the 85th percentile storm velocities were compared against the minimum required velocity for suspension of fine sand (0.6 ft./sec.).

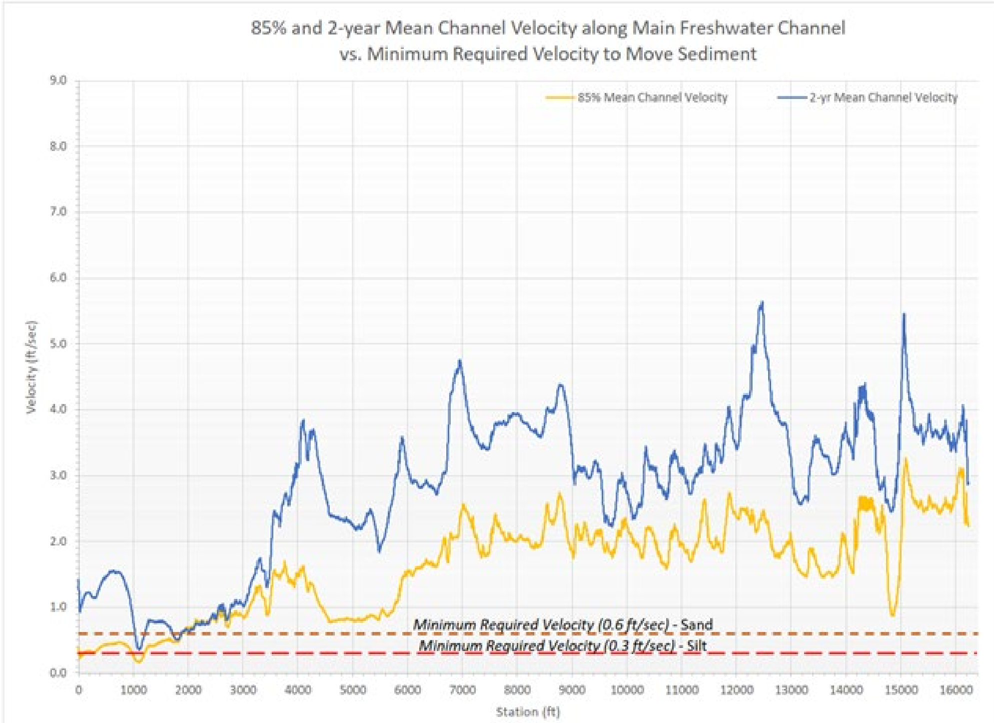

Figure 2-10: Minimum Velocities - Primary Freshwater Channel

The segment that falls below the minimum velocity occurs between Stations 1+000 to 55+00. As shown on Figure 2-11, this segment is within the salt marsh restoration area, just upstream of the pinch point. The area is graded lower to increase the extent and frequency of tidal influence that is important to the establishment and sustainability of the salt marsh restoration. The channel elevation in this area is therefore an important component of the design and was not refined based on this sedimentation analysis. results.

Figure 2-11: Velocity Gradients for 85th Percentile Storm Event

2.8 Maintenance

Establishment of vegetation on the channel banks and adjacent grading areas through native planting, seedbed preparation, and temporary irrigation is intended to stabilize the areas of the freshwater channels and drainageways. The use of rounded cobble is planned on the channel bottom to help stabilize sections of the freshwater channel bed that exceed the threshold for channel scouring for a 2-year storm event. The selected use of cobble will likely reduce maintenance that may be required to address scouring.

Vegetation is expected to establish in the freshwater channels that can impact the capacity of these channels to convey dry weather and more frequent storm flows. A key design goal is to reduce the impact of freshwater dry weather flows and ponded storm flows on non-tidal and tidal salt marsh restoration areas. Maintenance is anticipated during the Adaptive Management period to maintain channel capacity within segments where the overall marsh plain is constrained and therefore the capacity of the channel and marsh plain to convey freshwater flows. These segments include the primary and secondary channels within the Coastal Conservancy parcel and the channel segment between the low flow channel and the railroad embankment.

Monitoring the appropriate growth of plants and preventing the overgrowth of certain plant species for these segments that have maintenance access will be part of maintaining the design intent and improving the chances of a successful restoration. Various access points have been provided in the 90% to the freshwater channels within the Coastal Conservancy parcel, as well as along the low flow diversion feature further downstream along the freshwater channel and salt marsh restoration area.

It is expected that during the 5-year Adaptative Management period, vegetation in and along the full length of the freshwater channels will require maintenance on an annual basis. The maintenance may consist of selective removal or treatment of non-native plant species, cutting back woody vegetation to improve the establishment of other beneficial species, or potentially additional planting or re-seeding of areas. The maintenance will complement the goal of creating a natural, stabilized channel bank and adjacent floodway at the end of the Adaptive Management period, with the vegetation established in the designed range of roughness and velocity, to promote a healthy morphology of the stream beyond the maintenance period.

Maintenance may be required periodically during the 5-year Adaptive Management period to remove accumulated sediment from sections of the freshwater channel. The design team has used the sediment transport modeling results to focus sediment deposition to certain segments of the channel to reduce temporary impacts and extent of maintenance. Depositions are predicted to take place outside of the channels where the velocities are lower as shown in the modeling. Specifically, these identified locations are directly downstream of Flood Plain Enhancement 2 and along the low flow diversion feature. The 90% design further refined the design to reduce sedimentation in these areas and focus it to the channel and channel benches that may require periodic maintenance.

Given the analysis to date, a potential recommendation for maintenance inspections of the freshwater channels may be to schedule semi-annual inspection events and inspection events after storms with a magnitude greater than or equal to the 85th percentile storm (potentially two or more additional inspection events per year). Maintenance planning and budgeting for the freshwater channels has been finalized in the 90% design cost estimate and provides estimated levels of effort for vegetation establishment, sediment removal, and scour repair.

Maintenance is not planned along the freshwater channel between the Coastal Conservancy parcel and the low flow diversion feature. The intent for this unmaintained area is that flows over the 85^{th} percentile storm will overtop and connect to other freshwater channels to allow for a braided system to develop.