Del Mar Bluffs Stabilization Project 5
(Milepost 244.1 to Milepost 245.7)

ALTERNATIVES ANALYSIS REPORT

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1. INTRODUCTION

1.1. BACKGROUND

The San Diego Association of Governments (SANDAG) proposes to implement the Del Mar Bluffs Stabilization Project 5 (Proposed Action) along a portion of the existing North County Transit District (NCTD) right-of-way (ROW) and in the City of Del Mar. The project area is located within the City of Del Mar and extends from rail Milepost (MP) 244.1 near Coast Boulevard south to MP 245.7 at Torrey Pines State Beach. The DMB5 is a maintenance of way project, to maintain the existing track and protect it from erosion and seismic events.

Distinct components include protecting the existing trackbed from erosion, replacing and or enlarging old drainage structures, improving trackside drainage to address the effects of urbanization of the watershed surrounding the tracks, protecting the trackbed from seismic events by stabilizing the bluffs, adding bluff toe protection measures and surface stabilization.

This Alternatives Analysis Report compares and contrasts the alternatives from the perspective of geotechnical evaluation, environmental impact considerations, constructability and phasing, and cost. This report is a preliminary screening document. The purpose of this Alternatives Analysis is to recommend alternatives to carry forward for the purposes of environmental clearance.

1.2. PURPOSE OF THE PROPOSED ACTION

The purpose of the Proposed Action is to maintain a stable trackbed for rail operations, including passenger and freight rail operations. By stabilizing the bluffs, the Proposed Action would increase reliability of existing freight and passenger rail services. This is consistent with key regional and corridor plans, including San Diego Forward: The Regional Plan (SANDAG 2015), the 2016 San Diego regional Transportation Improvement Plan (SANDAG 2016), LOSSAN Corridor wide Strategic Implementation Plan (LOSSAN Corridor Rail Agency 2012), the LOSSAN Program Environmental Impact Report/Environmental Impact Statement (Caltrans and the Federal Railroad Administration 2009), the Infrastructure Development Plan for the LOSSAN Rail Corridor in San Diego County (SANDAG 2013), and the North Coast Corridor Public Works Plan/Transportation and Resources Enhancement Program (NCC PWP/TREP; Caltrans and SANDAG 2016).

1.3. NEED FOR THE PROPOSED ACTION

The coastal bluffs supporting the rail alignment in the project area are subject to coastal erosion over time and have a history of landslides and surficial failures. Ongoing erosion and localized failures of the bluffs have occurred over time causing disruption to rail service. Beginning in the 1990s through 2021, several stabilization projects have been constructed to maintain a stable trackbed. The Del Mar Bluffs 5 Project is needed to ensure the continued reliability of the LOSSAN Corridor. Continued operation over this segment will require protecting the Del Mar Bluffs from erosion and stabilization of areas at risk of slope failure.

2. PROJECT OVERVIEW

2.1. PROJECT LOCATION

As shown on ***Figure 1*** and ***Figure 2,*** the Proposed Action site is located along a 1.6-mile portion of the existing NCTD railroad ROW in the City of Del Mar that extends from rail Milepost (MP) 244.1 near Coast Boulevard south to MP 245.7 at Torrey Pines State Beach. Within this reach, the NCTD rail alignment runs atop the coastal bluffs, which are generally 50 to 70 feet high. Railroad ROW varies between approximately 100 feet and 235 feet in width and, in some places, extends onto the beach below. Portions of the Proposed Action site are also located within Torrey Pines State Beach along the base of the coastal bluffs that support the railroad tracks, and within the City of Del Mar’s right-of-way. The Proposed Action site lies predominantly within NCTD’s right-of-way, in the Coastal Zone.

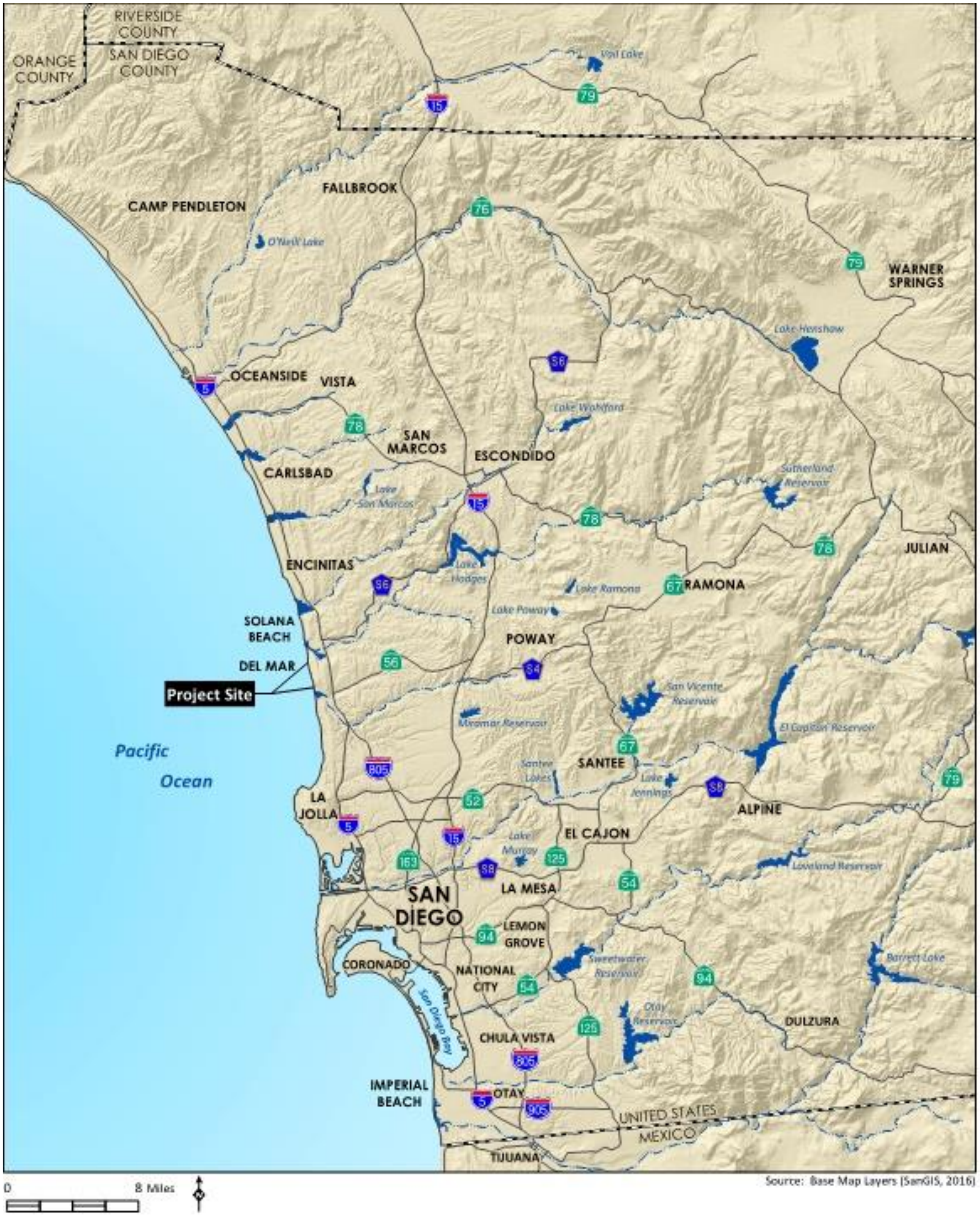

***Figure 1*– Regional Location Map**

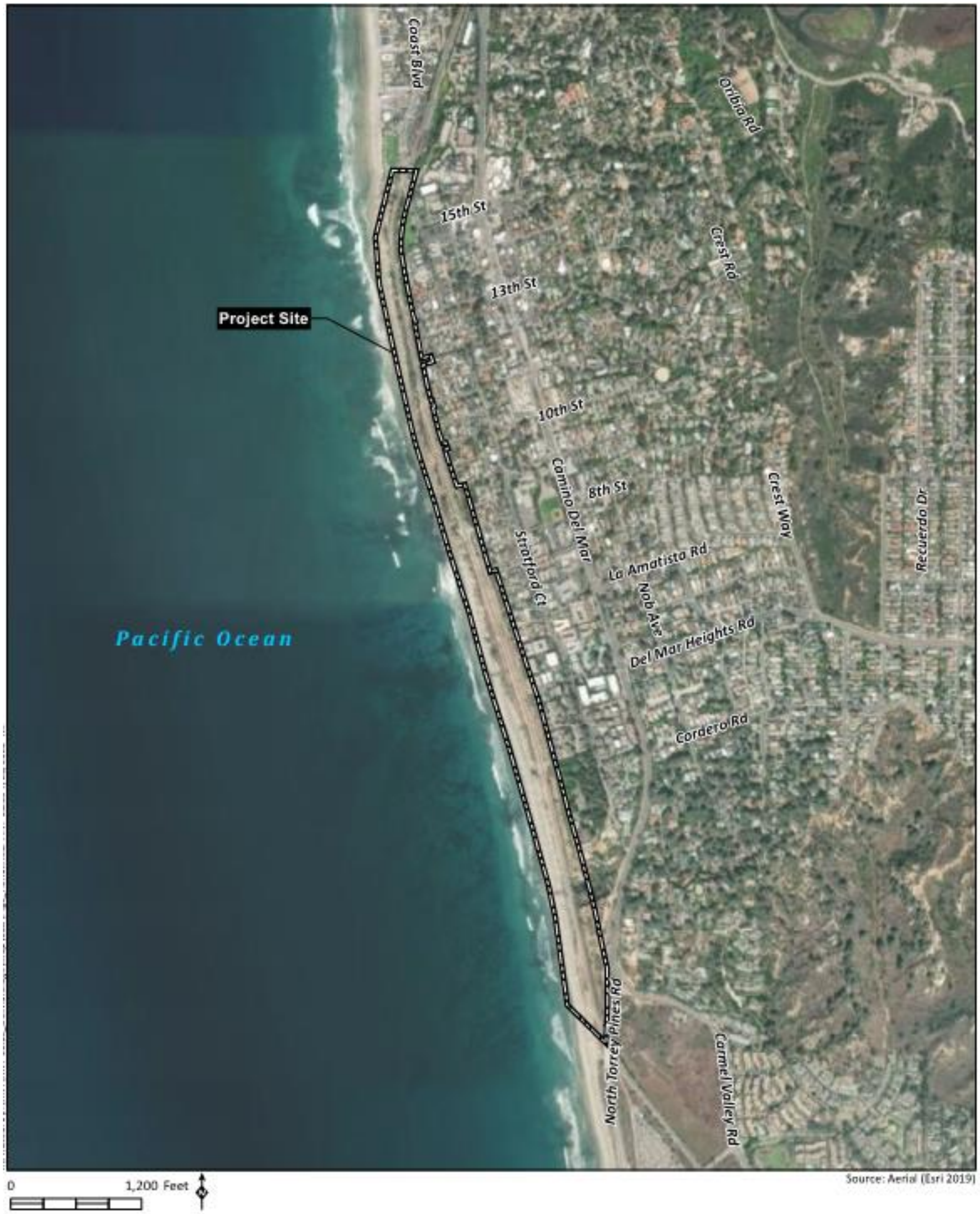

***Figure 2* – Proposed Action Location Map**

2.2. PROJECT DESCRIPTION

The Proposed Action is part of a multi-phase approach to preserving the track bed. To date, extensive field investigations and geotechnical studies have been completed which characterize the nature and cause of bluff erosion, identify and prioritize the areas in need of stabilization, and introduce conceptual stabilization alternatives. The Proposed Action is a continuation of the previous phases of bluff stabilization improvements and includes the design and installation of additional bluff stabilization measures, bluff toe protection measures, surface stabilization and drainage improvements intended to preserve track bed support, using current geotechnical and engineering design standards, including factors of safety for the current condition. The Proposed Action considers the anticipated bluff retreat for the next 30 to 50 years.

2.3. EXISTING CONDITIONS

The coastal bluffs supporting the rail alignment in the project area have a history of landslides and surficial failures. Furthermore, the bluffs are subject to ongoing erosion and failures that could threaten the viability of rail service. It is critical that a means of stabilizing the bluffs and preserving track bed support be implemented in order to maintain the use of the existing railroad track. This track is part of the Los Angeles to San Diego (LOSSAN) rail corridor and represents the only operating rail link to southern San Diego County.

2.4. PREVIOUS STUDIES AND PROJECTS

Several construction projects have been completed as a part of this phased approach. In 1996 a soil cement buttress and new beach outfall were constructed near MP 244.45. An emergency repair project was constructed in late 2001 near the terminus of 8th Street after a failure of the bluff in that area. In 2003, additional surface and subsurface drainage improvements were constructed within the project limits, upper bluff walls were repaired, and a landslide warning system was installed within designated “high-priority” areas. These drainage improvements were part of the first Del Mar Bluffs Stabilization Project. In 2007, SANDAG completed Del Mar Bluffs Stabilization Project 2, which included the installation of Cast-In-Drilled-Holes (CIDH) soldier piles along 1,326 feet of the bluffs in the top priority areas. In 2012, the Del Mar Bluffs Stabilization Project 3 was completed by SANDAG, which included installation of soldier piles at seven additional priority areas along the bluffs that were not completed in previous phases. In 2017, Del Mar Bluffs 4 was initiated to provide urgent repairs to existing drainage systems and lower bluff wood retaining walls. During the course of the project design, additional bluff failures occurred requiring addition of upper bluff stabilization measures below 7th Street and lower bluff stabilization measures below Sea Orbit Lane. In November 2019, wash outs occurred at 13th Street and 15th Street. Repairs were completed for these areas on an emergency basis in November and December 2019 respectively. Del Mar Bluffs 4 construction was initiated in February 2020 and was completed in December 2020. Emergency repairs for a bluff and seawall collapse that occurred in February 2021 are under construction.

3. PROPOSED ACTION - BLUFF STABILIZATION, DRAINAGE AND ACCESS MAINTENANCE

As described in Section 2.2, *Project Description*, the Proposed Action is a continuation of the previous phases of bluff stabilization improvements and includes the design and installation of urgent bluff stabilization measures intended to preserve track bed support for maintenance of railway operations. The bluff stabilization improvements considered include:

1. Proposed trackbed stabilization improvements
2. Trackbed support retrofit improvements
3. Drainage improvements
4. Minor improvements

3.1. DESCRIPTION OF PROPOSED TRACKBED STABILIZATION IMPROVEMENTS

Existing Conditions

The trackbed along the bluff top from MP 244.1 to MP 245.7 is supported by a combination of existing soldier piles and a soil cement buttress as shown on the Permitting Plans in Appendix A. The existing soldier piles were placed 11 to 15 feet seaward of the track centerline. These stabilizations measures were constructed as part of the Del Mar Bluffs Phase 2 Project, Del Mar Bluffs Phase 3 Project and Del Mar Bluffs Phase 4 Project. There are gaps between these existing soldier pile areas that have not been stabilized and per geologic conditions, require measures to preserve the track bed and maintain the viability of rail operations. As discussed in the 2001 Geotechnical Study, average bluff retreat rates in the study area are estimated at a maximum of 0.4 to 0.6 feet per year. This corresponds to an average retreat of approximately 15 to 25 feet over a 30-year to 50-year timeframe assuming that the bluff will retreat at an average rate of 0.5 feet per year.

To summarize the geologic conditions, the site is underlain by sandy permeable materials of the Quaternary-aged Bay Point Formation (i.e. Terrace Deposits or Old Paralic Deposits) which overlie the generally dense sandstones (Tdss) and relatively impermeable siltstones and claystones (Tdcs) of the Eocene-aged Delmar Formation. Within both formations that underlie the right-of-way there are fracture zones that roughly parallel the bluff face. These fracture zones consist of breaks in the bedrock and provide weak zones on which failures can occur and also conduits for ground water migration within the bluff. As a result of this, failures have occurred over the years with an increase in activity over the last several years. In particular, in February 2019, an approximate 60-foot wide section of the lower bluff below Sea Orbit Lane slid, exposing the soil cement buttress between MP 244.4 to MP 244.5. Soil and vegetation moved onto the beach and caused failure of additional sections of the timber lagging found below at the beach level.

Proposed Improvements

As discussed in the 2001 Geotechnical Study, average bluff retreat rates in the study area are estimated at a maximum of 0.4 to 0.6 feet per year. This corresponds to an average retreat of approximately 15 to 25 feet over a 30-year to 50-year timeframe assuming that the bluff will retreat at an average rate of 0.5 feet per year. The actual bluff retreat is episodic with block failures of several feet in depth occurring similar to the slide below Sea Orbit Lane as described above. The actual locations and size of failures cannot be predicted; therefore, the stabilization analysis was based on a total retreat of 25 feet for 50 years, compared to the existing topographic survey prepared as part of the Del Mar Bluffs 5 Project.

Proposed stabilization improvements for most new areas consist of a soldier pile wall at the bluff top to provide track bed support by retaining the earth behind the wall to prevent both local and global slope failures. This type of wall consists of vertical piles placed at 9 to 10 feet on-center with a connecting cast-in-place concrete pile cap or grade beam at the top. The piles would be constructed by drilling a 36-inch to 42-inch diameter hole, placing a steel beam in the hole (W shape) and filling the hole with concrete. If the wall needs to retain soil, the exposed surface between the piles would be in-filled with facing material (lagging) which may be timber, precast concrete planks or shotcrete. For taller walls, tiebacks would be required to anchor the soldier piles into the existing slope. A typical section is shown in ***Figure 3*** below. The soldier piles would be placed 11 feet to 21 feet seaward of the track centerline with the top of the wall about 1 foot below the top of tie. Generally, this would result in a wall that is initially buried; however, due to the natural bluff retreat, the top of the system may become exposed over time.

The specific stabilization areas considered are shown in ***Table 1*** below. The table lists the areas beginning at the north end of the project. A preliminary design has been prepared for each of the stabilization areas to address both static and seismic stability as shown on the attached Permitting Plans in Appendix A. The priority ranking level (i.e., Low, Medium and High) for the new stabilization areas are based on factors of safety, distance from bluff face to center of track, bluff retreat rate, steepness of bluff face, geologic unit, presence of existing failures, field observations, review of survey data, and drone flight videos. Refer to the Appendix B for the detailed ranking matrix evaluation.

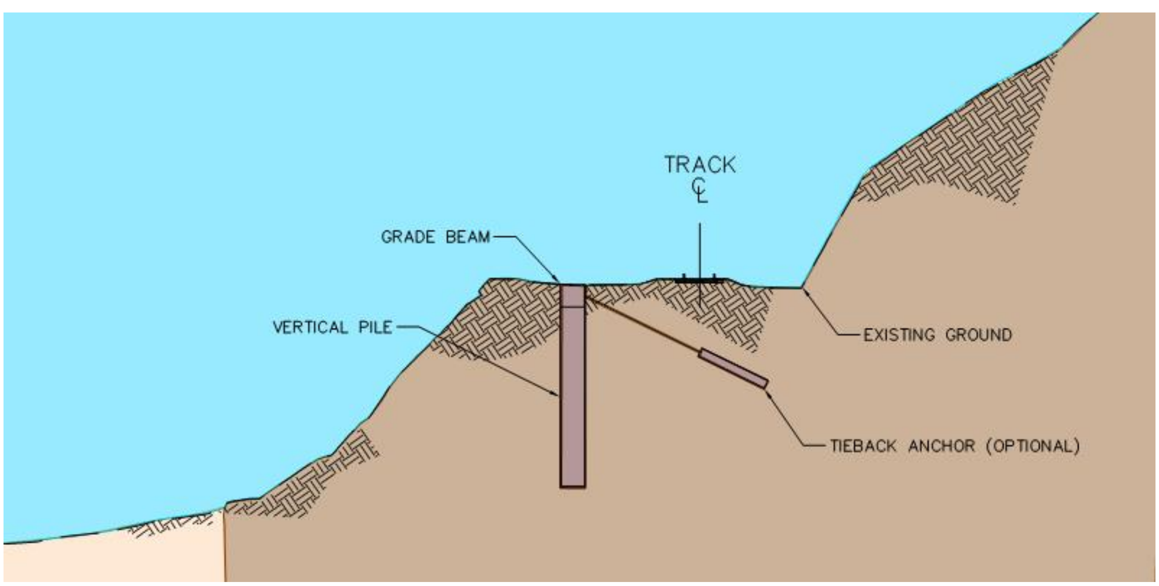

Figure 3 **– Typical Section of Soldier Pile Wall - Trackbed Support Stabilization Areas**

Table 1 – Trackbed Stabilization Areas				
Stabilization Area (SA)	**Ranking**	**Begin Station**	**End Station**	**SA Distance (ft)**
SA16	Low	1544+70	1546+18	150
SA21	High	1539+68	1540+27	59
SA20	High	1535+57	1536+54	97
SA23	Medium	1530+82	1531+34	52
SA24 and SA22*	Medium	1518+85	1528+85	1000
SA3	Low	1516+57	1518+84	227
SA15	High	1512+65	1513+26	61
SA5	High	1511+00	1512+65	165
SA14	Low	1509+50	1511+00	150
SA13	Low	1495+00	1500+00	500
SA6N	Low	1494+09	1494+89	80
SA12	Medium	1485+78	1487+43	165
SA8	High	1481+99	1483+55	155
SA11	High	1480+99	1481+99	100
SA9	High	1479+44	1480+99	156
SA10	Low	1477+94	1479+44	150
*See Section 3.1.4 for description of improvements at SA24 and SA22				

As noted in the 2020 Geotechnical Design Report (30% Design) and the 2021 Memorandum – Update for Geotechnical Design Report (30% Design), an average bluff retreat of 0.5 feet per year is assumed for the design and analysis of the bluff stabilization measures. South of 4th Street, a lesser bluff retreat has been observed; therefore, an average bluff retreat rate of 0.4 feet per year, consistent with the lower end of the accepted range, is assumed for the design and analysis of the bluff stabilization measures in that area.

As described above, north of 4th Street, the bluff retreat is projected to be 25 feet over the project's minimum 50-year design life. Therefore, for design, the bluff face profile has been projected 25 feet inland to represent the future conditions. Furthermore, based on knowledge of the bluff face behavior, a weathered and fractured zone roughly 10 feet in thickness has been assumed parallel to the retreated face. Using these assumptions, a wall design height was calculated for each stabilization area. The wall design height is that portion of the soldier pile wall where active soil pressures, which tend to overturn and or slide the wall laterally are applied. In order to provide stability of the soldier pile wall, the pile must extend below the limits of active pressure. Therefore, the soldier pile length is always greater than the wall design height.

The global stability of the soldier pile walls was verified using the computer program Slope/W (Geo-Slope, 2002). The design was based on a minimum factor of safety of 1.5 for static loads with surcharge and 1.0 for pseudo-static loads (kh=0.28). In many cases the soldier pile embedment length was governed by the global stability calculations. For the local stability analysis of the soldier pile walls, an angle of internal friction (phi angle) of 36 degrees was used for formational materials. The areas within Anderson Canyon are largely comprised of fill material, and therefore a lower phi angle of 32 degrees was used. Preliminary design load cases were based on the American Railway Engineering and Maintenance-of-Way Association (AREMA) Manual of Railway Engineering with provisions for earth, Cooper E 80 and earthquake loads applied to the wall. Preliminary structural calculations were prepared for the cantilever and anchored soldier pile walls to address local stability in accordance with the CALTRANS Trench and Shoring Manual.

A 42-inch diameter CIDH soldier pile, with a W24x229 steel section, was considered for all of the stabilization areas. With the exception of the trench area described above, the use of soldier piles is considered the preferred alternative for all areas. Soldier piles vary in length to extend into the Delmar Formation.

The alternatives considered for trackbed stabilization for the new stabilization areas to protect against 30-year and 50-year bluff retreat included:

1. Improvements at the blufftop only, ie piles, tiebacks and lagging
2. Improvements at the blufftop in conjunction with bluff toe improvements (seawalls) and bluff surface stabilization.

3.1.1. BLUFFTOP IMPROVEMENTS ONLY

Table 2 summarizes the design parameters for the various new stabilization areas within the project, utilizing improvements from the bluff top only.

Table 2 – Stabilization Area Parameters											
Stabilization Area (SA)	Ranking	SA Distance (ft)	Pile Length Sp (ft)	Distance from Pile CL to Top of Bluff 2020 (ft)	# of Piles	30 Year Design Height Dp (ft)	50 Year Design Height Dp (ft)	Total # of Tiebacks (30-year)	Depth of Lagging (ft) (30-year)	Total # of Tiebacks (50-year)	Depth of Lagging (ft) (50-year)
SA16	Low	150	50	34	15	12	27	1	0	2	10
SA21	High	59	60	9	5	30	41	2	15	2	25
SA20	High	97	60	8	9	38	48	2	20	3	35
SA23	Medium	52	60	9	4	7	10	1	5	1	10
SA24*	Medium	812									
SA22*	Medium	188									
SA3	Low	227	60	43	25	7	7	0	0	0	0
SA15	High	61	60	37	6	7	15	1	0	1	5
SA5	High	165	60	25	18	17	27	1	5	1	15
SA14	Low	150	60	47	15	7	7	0	0	0	0
SA13	Low	500	60	48	50	7	7	0	0	0	0
SA6N**	Low	80	60	38	9	7	7	0	0	0	0
SA12	Medium	165	60	18	17	12	22	1	5	1	10
SA8	High	155	60	0	17	16	19	1	15	1	15
SA11	High	100	50	15	10	10	18	1	5	1	10
SA9	High	156	50	18	17	8	21	1	0	1	10
SA10	Low	150	50	21	15	10	24	1	0	1	15

*Proposed stabilization for the trench area (SA24 and SA22) would include excavation and removal of the existing berm, and this is ranked as a medium priority stabilization. The construction of piles in the future is ranked as a very low priority. See Section 3.1.4 for description of improvements at SA24 and SA22.
** Construction of trackbed piles and seawall are underway for a portion of Area 6N due to the February 2021 bluff collapse. 18 piles were constructed at Area 6N as part of the Emergency Repair in 2021. Table shows remaining number of piles required for Area 6N.

Two of the stabilization areas would require a total of two (2) tieback anchors and one of the areas would require a total of three (3) anchors based on predicted 50-year bluff retreat. In addition, four areas would require 20 feet of lagging, one would require 25 feet of lagging and one would require 35 feet of lagging based on predicted 50-year bluff retreat.

An option for larger piles with one tieback was considered for these locations. The pile diameter would be increased to 60 inches with a total of two (2) W24 x 229 steel H Pile sections. The pile length would be the same as shown in ***Table 2*** The single tieback anchor would be constructed as part of the initial project allowing for completion of the primary infrastructure in a single phase. The cost of the larger pile would be nearly three times the cost of the smaller pile with multiple tiebacks. This option was not considered further due to constructability issues stemming from the significantly larger equipment required.

The options considered for lagging panels include wood and concrete lagging panels. Wood lagging and concrete lagging panels could be used for any pile diameter. Lagging options would be the same for all new pile alternatives regardless of pile size.

Lagging options include placement of a shotcrete facing between piles with the shotcrete wall anchored into the existing piles as shown in ***Figure 4*** below. This is consistent with the lagging wall design used on the recent emergency repair at 15th Street. The shotcrete lagging would be finished with a sculpted face similar to the color and texture of the existing bluff. Steel channels would be constructed as part of the initial pile work. With the construction of the channels, wood lagging or concrete lagging could be easily added to the soldier pile system in an initial phase or as needed over time. ***Figure 5*** shows a typical section of the panel lagging concept.

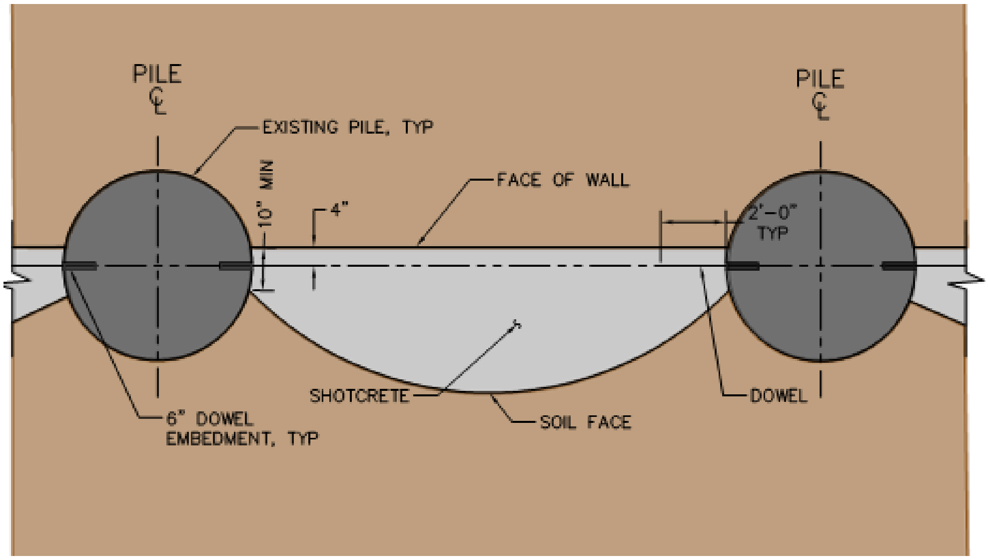

Figure 4 **– Typical Shotcrete Lagging**

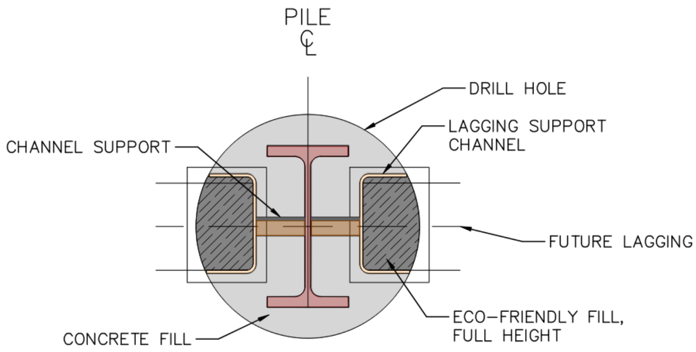

Figure 5 **– Typical Addition of Lagging Panel into Channel**

3.1.2. BLUFFTOP IMPROVEMENTS IN CONJUNCTION WITH BLUFF TOE AND BLUFF FACE STABILIZATION

Toe protection would limit the impacts of rising sea level in the short term and extend the useful life of the current trackbed stabilization. Bluff toe protection is a feasible means of protecting the base of the bluffs from erosion and can be more readily removed if the track is relocated in the future. Toe protection (Seawalls) provides longer term preservation and stability of the bluffs and track structure and can reduce the rate of bluff retreat towards the track. Seawalls are envisaged at locations where piles are installed for trackbed stabilization, to prevent the lower portions of the piles from becoming exposed and destabilized.

In addition to seawalls, the project proposes bluff face surface stabilization, regrading of the slopes at specific locations to a 1.5:1 slope ratio, and slope revegetation to reduce erosion and to improve overall slope stability. Bluff surface stabilization measures are proposed both at locations with existing seawalls and proposed seawalls.

Proposed seawalls consist of a soldier pile wall at the bluff toe with wood lagging panels. Proposed seawalls would be constructed in-line with existing seawalls, where present, to an elevation of 15 feet above MSL. This type of wall consists of vertical piles placed at 6 to 7 feet on-center with wood lagging panels. The pile construction would be similar to the piles placed for trackbed stabilization, except that the piles for the seawall would be smaller in diameter. The space behind the piles would be backfilled, up to the top of the seawall. Cut off walls are proposed in front of proposed and existing seawalls to minimize erosion and undermining of seawalls. Where surface stabilization is recommended, the bluff face would be regraded to a 1.5:1 slope, stabilized with engineered fabric reinforcement, and revegetated.

Surface stability enhancements, and protection of the bluff toe, in conjunction with trackbed stabilization efforts, would extend the life of the track structure and allow for continued utilization of this portion of the LOSSAN corridor for passenger and freight rail services. The addition of the seawall is anticipated to significantly limit ongoing bluff retreat at the toe of the bluff for these locations.

Table 3 summarizes the design parameters for the various new stabilization areas within the project considering blufftop improvements in conjunction with bluff toe and surface stabilization. The Phase I seawalls are prioritized at locations where the seawalls would provide the maximum benefit and stabilize the trackbed for 30-year bluff retreat. The Phase II seawalls are required to extend the service life of trackbed stabilizations beyond 30 years, to protect against 50-year bluff retreat, and would be constructed as a future phase at remaining locations based on priority and funding availability.

Table 3 – Stabilization Area Lagging and Tieback Needs with Bluff Toe and Bluff Face Stabilization											
Stabilization Area (SA)	Trackbed Stabilization Priority Ranking	Existing or Proposed Seawall to Protect Against 30-yr and 50-yr Bluff Retreat	Proposed Surface Stabilization	**Bluff Top Improvements Only**				**Bluff Top Improvements in Conjunction with Bluff Toe and Bluff Face Stabilization**			
				Tiebacks (30 years)	Depth of Lagging (30 years)	Tiebacks (50 years)	Depth of Lagging (50 years)	Tiebacks (30 years)	Depth of Lagging (30 years)	Tiebacks (50 years)	Depth of Lagging (50 years)
SA16	Low	Phase II	X	1	0	2	15	1	0	1	5
SA21	High	Phase I	X	2	15	2	25	1	5	1	5
SA20	High	Phase I	X	2	20	3	35	0	5	0	5
SA23	Med	Ex	X	1	5	1	10	0	5	0	5
SA3	Low	Phase II	-	0	0	0	0	0	0	0	0
SA15	High	Phase II	-	1	0	1	5	1	0	1	0
SA5	High	Phase II	-	1	5	1	15	1	5	1	5
SA14	Low	Phase II	-	0	0	0	0	0	0	0	0
SA13	Low	Phase II	-	0	0	0	0	0	0	0	0
SA6N	Low	Ex*	X	0	0	0	0	0	0	0	5
SA12	Med	Phase I	-	1	5	1	10	1	0	1	5
SA8	High	Repair Ex**	X	1	15	1	15	1	5	1	5
SA11	High	Phase II	-	1	5	1	10	1	5	1	5
SA9	High	Phase II	-	1	0	1	10	1	0	1	5
SA10	Low	Phase II	-	1	0	1	15	1	0	1	5

* Construction of trackbed piles and seawall are underway for a portion of Area 6N due to the February 2021 bluff collapse. 18 piles were constructed at Area 6N as part of the Emergency Repair in 2021. The Emergency repair also includes removal of the existing seawall and construction of 291-foot replacement seawall.

** The 2021 Emergency Repair includes stabilization of the existing seawall at SA8. Options under consideration include a concrete cut off wall or smaller diameter piles in front of the wall.

As noted above, the use of seawalls and surface stabilization limits the number of tiebacks and depth of lagging needed to protect against 30-year and 50-year bluff retreat. None of the stabilization areas would require more than one (1) tieback anchor based on predicted 50-year bluff retreat. In addition, the lagging needs are also significantly reduced.

3.1.3. OTHER ALTERNATIVES CONSIDERED

Consistent with Del Mar Bluffs 2 and 3, the 2020 Geotechnical Design Report (30% Design) identified other alternatives for slope stabilization including a soil cement buttress, and soil nail reinforcement. Not all of these alternatives are viable for each stabilization area. The specific stabilization alternatives considered for each stabilization area are shown in ***Table 4***.

Table 4 – Stabilization Alternatives

Stabilization Area (SA)	Trackbed Stabilization Priority Ranking	Length (ft)	Soldier Pile Wall	Soil Cement Buttress	Soil Nail Reinforcement
SA16	Low	150	X		X
SA21	High	59	X		X
SA20	High	97	X		X
SA23	Med	52	X		
SA22 and SA24	Med	1000	X		
SA3	Low	227	X		X
SA5 and SA15	High	226	X		X
SA14	Low	150	X		X
SA13	Low	500	X		X
SA6N	Low	80	X	X	X
SA12	Med	165	X		X
SA8	High	155	X	X	
SA9 and SA11	High	256	X		X
SA10	Low	150	X		X

Soil Cement Buttress

A soil cement buttress is most viable where the bluffs have previously been graded and fill soils mantle the natural bluff materials. There are two locations within the new stabilization areas that are suitable for use of a soil cement buttress. With this stabilization alternative, the existing slope would be excavated to remove potentially unstable material and replaced with manufactured soil cement. The soil cement could be capped with native soil held in place with pipe and board walls. This would provide a more natural appearance to the bluff face than the manufactured surface and allow for plant growth. At the toe of the slope, a shotcrete facing could be used to control wave erosion. A typical section is shown in ***Figure 6*** below.

In general, the soil cement buttress alternative improves stability of the bluff by creating a strong massive block that resists the driving forces of the earth as noted in the 2010 Geotechnical Evaluation. The preliminary design of the soil cement buttress alternative considered the geometry of the bluff, estimated strength parameters of a soil cement mixture, and anticipated construction equipment and placement practices.

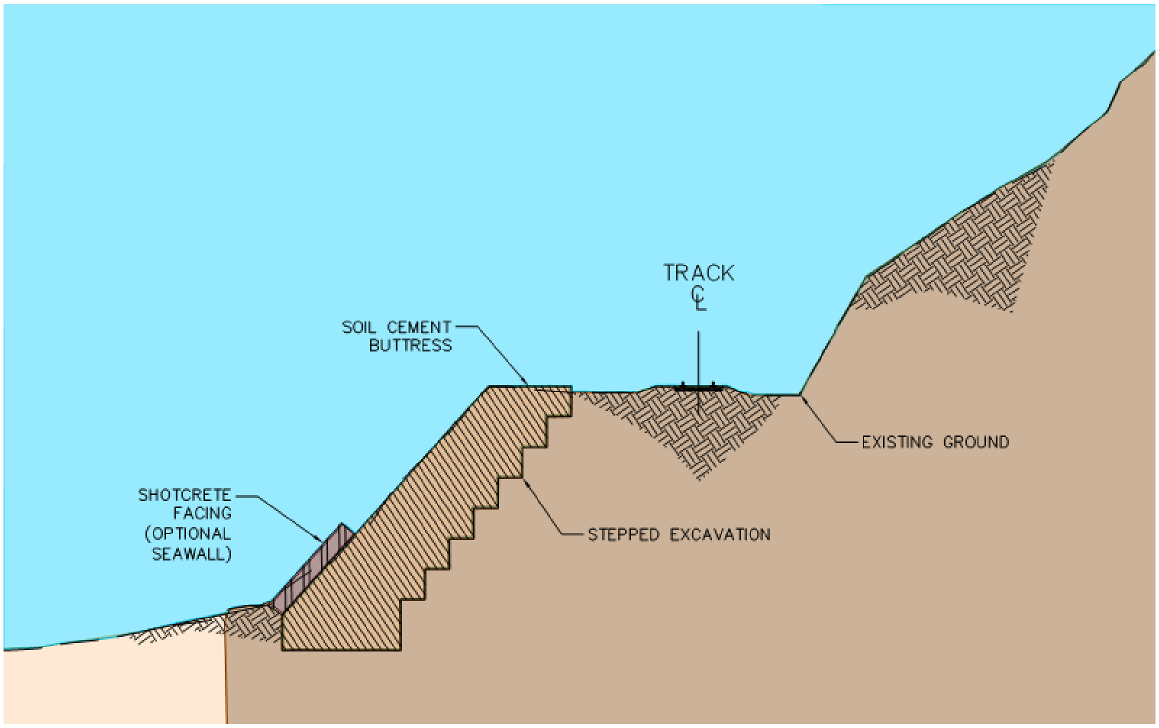

***Figure 6* – Typical Section of Soil Cement Buttress - Trackbed Support Stabilization Areas**

In the preliminary design of the soil cement buttress, an attempt was made to maintain existing top and toe of the bluff and to utilize existing seawalls. The basic components of the soil cement buttress consist of a bottom key up to 18 feet wide embedded at least 5 feet into competent formation or compacted fill, a benched backcut, back drains and a minimum cross section dimension of at least 4 feet. The inclination of finish face slope of the soil cement buttress would vary depending on its location. Typically, two horizontal back drains, an upper and lower drain, would be installed with outlets at an approximate elevation of 15 feet mean sea level (msl) on the finished buttress face. In addition, the use of temporary shoring would also be needed at some locations to support the existing walls and excavation areas. All shoring within the railroad influence should be designed for Cooper E-80 loading.

As noted in the 2010 Geotechnical Evaluation, Slope/W was used to develop the preliminary design with acceptable factors of safety for static surcharge loading and pseudo-static (seismic) conditions. The soil cement mixture or mix design strength parameters used for the preliminary design of the buttresses are assumed to be at least 200 pounds per square inch (psi), a 28-day unconfined compressive strength. These values are typical for soil cement buttress designs. Additional laboratory testing or a treatment study of on-site soils (i.e., various soil and cement mixture ratios) would be required for further analysis and evaluation of final designs.

Soil Nail Reinforcement
Soil nail reinforcement is best suited for areas of dense exposed bedrock where the surface is composed of relatively dense materials. This alternative utilizes steel bars to anchor the bluff face to competent formational material thereby increasing the stability of the slope. The soil nails are

installed by drilling holes approximately 20 to 50 feet deep and grouting a high-strength steel bar in place. A pre-anchor force is not applied to the soil nail (as is done for a tie-back anchor), but test nails must be installed and pull-tested to verify the soil bond stress.

Typically, soil nail reinforcement includes a cast-in-place or shotcrete facing material to stabilize the soil between nails; however, the facing material can be omitted when the surface material is sufficiently dense. In this case, the top of the grouted nail hole would be backfilled with native material. The exposed bluff face is highly variable with localized zones of less stable surface materials. As a result, facing is recommended in conjunction with the soil nail reinforcement at all locations. A typical section is shown in ***Figure 7*** below.

The soil nail alternative improves stability by reinforcing and strengthening the existing bluff through the installation of closely spaced steel bars (nails) embedded in concrete. The preliminary design of the soil nail alternative considered the existing topography of the bluff, estimated bond strength of the soil nails, and anticipated construction installation practices.

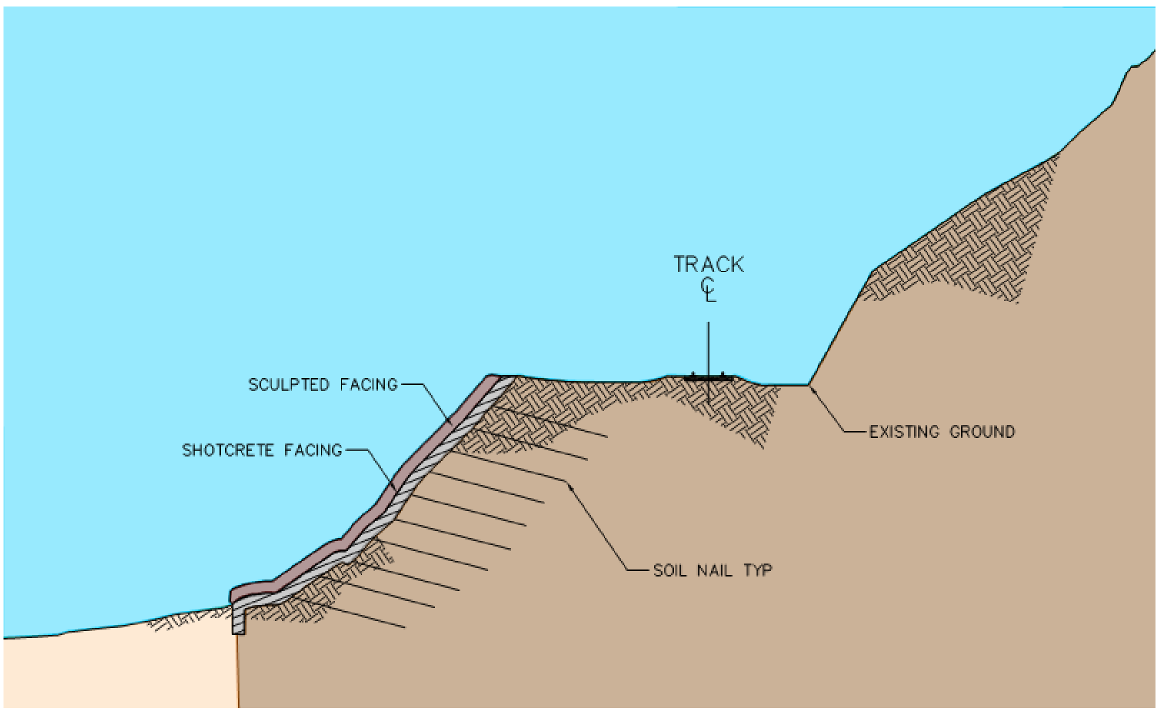

***Figure 7* – Typical Section of Soil Nail Reinforcement - Trackbed Support Stabilization Areas**

Slope/W was used to develop the preliminary design of the soil nail alternative with acceptable factors of safety for static surcharge loading and pseudo-static (seismic) conditions. Refer to the 2010 Geotechnical Evaluation for stability analysis. In summary, the preliminary design consisted of a series of soil nails, approximately 50 feet long, with an approximate vertical and horizontal spacing of 6 feet (i.e., approximately one nail per 36 square feet of bluff face). The first row of soil nails (i.e., lowest row) would begin at an approximate elevation of 14 feet msl. Subsequent rows of soil nails would progress upward to within roughly five to eight feet of the top of the bluff. Preliminary design of the soil nail consisted of at least a 6-inch diameter bored hole, a number 8 steel reinforcement bar, and 3,000 psi concrete. The soil nail was sloped into the bluff at an approximate angle of 15 degrees from horizontal and was assumed to be capable of developing a minimum working resistant load of 18 kips. It should be noted that further analysis and field verification testing of the soil nail bond strength, which is dependent on construction methods and equipment, would be required.

3.1.4. LOCATIONS WITHOUT TRACKBED STABILIZATION

There are two sections which provide a different condition than the other stabilization areas. Based on the evaluation of global slope stability and current factors of safety and the large distance from the track to the edge of bluff, trackbed structural stabilization is not currently proposed at these two locations.

1. From Sta 1518+85 to Sta 1528+85 – This station range includes Stabilization Areas SA22 and SA24 are within the trench area. A typical section is shown in ***Figure 8*** below. The trench area is not currently in jeopardy as a result of bluff retreat, but it does not meet the minimum static and seismic factors of safety. This instability is caused by the added weight of the existing berm, west of the tracks, between the face of the bluff and track. The recommended solution here is to excavate and remove the existing berm, located west of the track, to reduce the weight of the overburden. This stabilization is ranked as a medium priority. As shown in ***Table 5*** below, the grading of the berm on top of the trench will improve current factors of safety to almost the required levels designated in the LOSSAN criteria, but does not quite meet these levels. As a result, a design exception will be required from NCTD/SANDAG.

Table 5 – Current Trench Area Factors of Safety

Station	Without trench grading		With trench grading	
	Static (Min = 1.5)	Pseudo-Static Factor of Safety (EQ, 0.28) (Min = 1)	Static (Min = 1.5)	Pseudo-Static Factor of Safety (EQ, 0.28) (Min = 1)
1520+00	1.79	1.06	1.86	1.11
1520+96	1.37	0.90	1.47	0.96
1524+17	1.35	0.89	1.44	0.93
1526+00	1.40	0.94	1.51	1.03
1527+45	1.36	0.92	1.43	0.94

In addition, the factors of safety could potentially worsen over time based on ongoing bluff retreat. When the anticipated bluff retreat rate is considered across the entire area for the 30 year period, a large section of the trench may not meet the required factors of safety in the future, without additional trackbed stabilization (piles) or bluff toe or bluff face stabilization. However, understanding that bluff retreat is episodic, considering the wide blufftop distance from track to edge of bluff, and that the entire 1000-ft reach is unlikely to retreat at the same design bluff retreat rate, this area is evaluated based on current factors of safety, and not projected 30-year factors of safety.

Alternatives to grading the trench could include approximately 100 piles west of the tracks, spaced 10 feet apart within the 1000-foot-long trench area, or a 1000-ft long seawall at the bluff toe to protect against a deep-seated failure due to a seismic event, and may be needed within the next thirty years. The addition of piles within this area is ranked as a very low priority stabilization, and therefore not included for alternatives assessment within this report. While grading the existing bluff is not generally considered preferable as it relates to impacting the natural bluff face, the added weight of the berm west of the track has contributed to significant failures in recent years. The option of grading and removing the overburden is less expensive and more practical than adding soldier piles or seawalls, and results in less hard infrastructure that would have to be removed in the future. Falling rocks and debris are a hazard to beach goers. Removing the existing material as shown in the figure below would reduce the hazard for rock and mudslide as well as improving the seismic safety of the bluff. Therefore, the grading of the berm is the recommended solution within this section. After the grading of the berm has been completed, ongoing monitoring of this section is recommended to evaluate if additional stabilization needs become necessary before the tracks are moved from the bluffs.

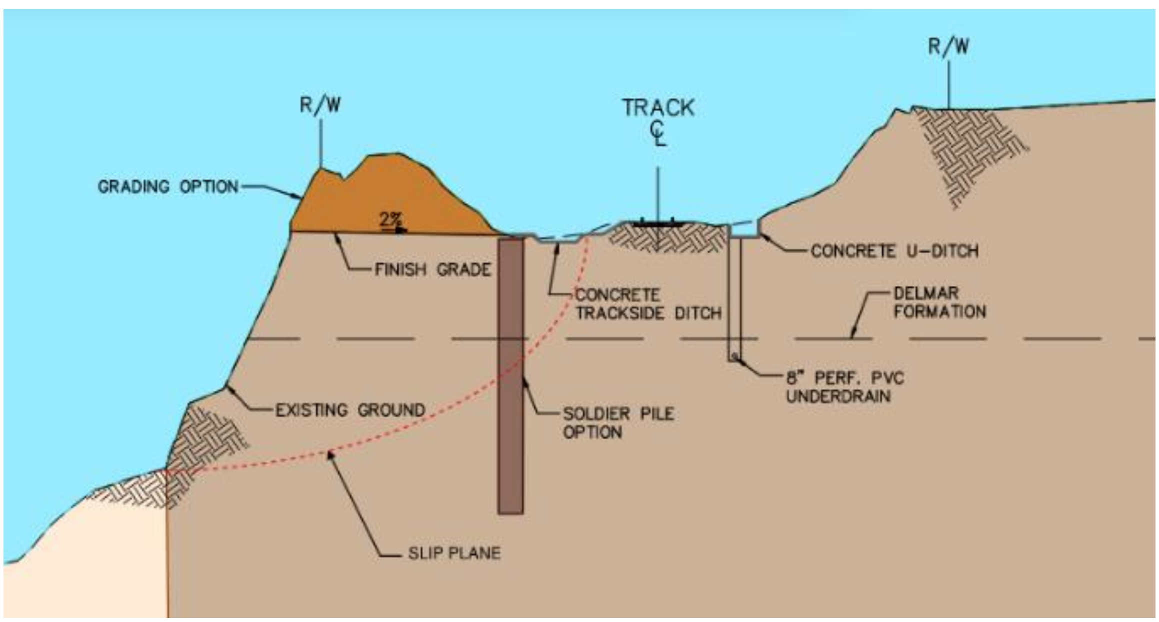

Figure 8 **– Typical Section of Berm at Trench**

2. From Sta 1500 to Sta 1509+50 - This station range extends from south of 4th Street to just north of 6th Street. While the current factors of safety within this reach meet the levels designated in the LOSSAN criteria, the factors of safety could potentially worsen over time based on ongoing bluff retreat. When the anticipated bluff retreat rate is considered across the entire area for the 30 year period, sections of the bluff may not meet the required factors of safety in the future, without additional tracked stabilization (piles) or bluff toe or bluff face stabilization. However, understanding that bluff retreat is episodic, considering

the wide blufftop distance from the track to edge of bluff, and that the entire 950-ft reach is unlikely to retreat at the same design bluff retreat rate, this area is evaluated based on current factors of safety, and not projected 30-year factors of safety. The addition of piles within this area is ranked as a very low priority stabilization, and therefore not included for alternatives assessment within this report. Ongoing monitoring of this section is recommended to evaluate if additional stabilization needs become necessary before the tracks are moved from the bluffs.

3.2. DESCRIPTION OF TRACKBED SUPPORT RETROFIT AREAS

Existing Conditions

As previously mentioned, the trackbed along the upper bluff from MP 244.1 to MP 245.7 is supported by a combination of soldier piles and a soil cement buttress as shown on the attached Permitting Plans. The existing soldier piles were placed 11 to 15 feet seaward of the track centerline. These stabilizations measures were constructed as part of an emergency project in 2001, the Del Mar Bluffs Phase 2 Project in 2008, the Del Mar Bluffs Phase 3 Project in 2012 and Del Mar Bluffs Phase 4 Project in 2020. The Del Mar Bluffs Phase 2 and Del Mar Bluffs Phase 3 projects were constructed with the understanding that lagging could be added over time and that the 20-year service life could be extended by adding tie backs, if necessary. Currently, many of these existing areas have undergone significant erosion and will be nearing their service life. New survey sections were completed to assess existing conditions and evaluate the stability of existing stabilization measures. Based on our analysis and demonstrated by recent bluff failures in the last three years, stabilization measures are urgently needed to support and protect the trackbed. The existing piles were designed for a 20-year service life, over 20 years ago. Therefore, additional stabilization is needed now to protect the trackbed.

Proposed Improvements

As discussed in the 2001 Geotechnical Study, the 2020 Design Report (30% Design), and the 2021 Memorandum – Update for Geotechnical Design Report (30% Design), average bluff retreat rates in the study area are estimated at a maximum of 0.4 to 0.6 feet per year. This corresponds to an average retreat of approximately 15 to 25 feet over a 30 year to 50-year timeframe assuming that the bluff will retreat at an average rate of 0.5 feet per year. South of 4th Street, a lesser bluff retreat has been observed; therefore, an average bluff retreat rate of 0.4 feet per year is assumed for the design and analysis of the bluff stabilization measures in that area, while 0.5 feet per year is used north of 4th Street.

The actual bluff retreat is episodic with block failures of several feet in depth occurring similar to the slide below Sea Orbit Lane as described above. The actual locations and size of failures cannot be predicted, therefore the stabilization analysis was based on a total retreat of 15 feet and 25 feet for a 30-year and 50-year period respectively compared to the existing topographic survey prepared as part of the Del Mar Bluffs 5 Project. Similar to the new stabilization areas, a geotechnical assessment was made of the retrofit areas to predict the wall height and design parameters needed for the predicted bluff retreat for the 30-year and 50-year timeframe.

Table 6 below provides a summary of the existing stabilization areas including the location, size and configuration of the existing piles and the approximate time remaining to reach the existing design service life based on the estimated bluff retreat. Each of the retrofit areas has been ranked in priority of need. The priority ranking level (i.e., Low, Medium and High) for the retrofit areas are based on remaining service life estimated from the design height, distance of the existing pile from bluff face, bluff retreat rate, steepness of bluff face, geologic unit, presence of existing failures, field observations, review of survey data, and drone flight videos. Refer to the Appendix B for the detailed ranking matrix evaluation.

Table 6 – Retrofit Area Parameters

Stabilization Area (SA)	Station	Retrofit Priority Ranking	# of Piles	Design Height (ft)	Pile Length (ft)	# of Existing Tiebacks	Approximate # of years to reach Design Height	Distance from Pile Face to Top of Bluff 2020 (ft)	W shape
DMB2 (SN5) Pile 33 to 38	1544+69	Medium	6	15	45	1	32	28	W18x65
DMB2 (SN5) Pile 24 to 32	1543+50	High	9	15	45	1	6	13.9	W18x65
DMB2 (SN5) Pile 1 to 23	1542+50	High	23	15	45	1	0	0	W18x65
DMB2 (SN7N)	1540+50	Medium	4	20	45	1	20	7.7	W24x84
DMB2 (SN7S)	1539+50	Low	4	10	40	0	28	28.4	W24x76
DMB3 (SP1)	1539+21	Medium	5	18	45	1	12	15	W27x114
DMB2 (SN3) Pile 15 to 19	1538+14	High	5	15	45	1	8	4.7	W18x65
DMB2 (SN3) Pile 1 to 14	1537+82	High	14	18	45	1	8	0.1	W24x76
DMB2 (SN1N)	1536+75	High	4	23	60	1	0	8.4	W24x117
DMB2 (SN1S) Pile 14 to 29	1535+00	Medium	16	15	45	1	12	15.2	W18x65
DMB2 (SN1S) Pile 6 to 13	1533+24	High	8	15	45	1	0	7.5	W18x65
DMB2 (SN1S) Pile 1 to 5	1532+75	High	5	20	45	1	14	3	W24x84
DMB2 (SN2)	1532+25	High	9	23	55	1	0	4.9	W24x117
DMB4 (Pile 1 to 3)	1531+62	Medium	3	34	60	1	30	4	W24x229
DMB3 (SP2) Pile 17 to 23	1530+50	High	7	10	50	0	0	2.5	W27x129
DMB3 (SP2) Pile 6 to 16	1529+70	Medium	11	10	50	0	20	27.8	W27x129
DMB3 (SP2) Pile 1 to 5	1528+79	Low	5	10	50	0	40	36.2	W27x129
DMB2 (SN6) Pile 7 to 10	1516+25	Medium	4	10	40	0	30	27.5	W24x84
DMB2 (SN6) Pile 1 to 6	1516+00	High	6	10	40	0	2	16.6	W24x84
2001 Emergency Repair	1514+63	High	12	30	60	1	0	0	W24x146
DMB3 (SP3) Pile 13	1514+25	Low	1	26.5	65	1	>50	9.9	W24x229
DMB3 (SP3) Pile 5 to 12	1514+08	Low	8	26.5	65	1	>50	11.8	W24x229
DMB3 (SP3) Pile 1 to 4	1513+40	Low	4	26.5	65	1	>50	27.7	W24x229
DMB3 (SP5)	1491+02	Medium	13	8	45	0	22	14.8	W24x84
DMB3 (SP6) Pile 7 to 14	1490+00	Medium	8	8	45	0	16	14.3	W24x84

Table 6 – Retrofit Area Parameters									
Stabilization Area (SA)	Station	Retrofit Priority Ranking	# of Piles	Design Height (ft)	Pile Length (ft)	# of Existing Tiebacks	Approximate # of years to reach Design Height	Distance from Pile Face to Top of Bluff 2020 (ft)	W shape
DMB3 (SP6) Pile 1 to 6	1489+25	High	6	8	45	0	0	7	W24x84
DMB3 (SP7)	1488+73	High	14	8	45	0	0	7.3	W24x84
DMB3 (SP4) Pile 6 to 10	1485+50	Low	5	8	45	0	38	26	W24x84
DMB3 (SP4) Pile 3 to 5	1485+15	Low	3	8	45	0	30	23.4	W24x84
DMB3 (SP4) Pile 1 to 2	1485+00	Low	2	8	45	0	24	23.4	W24x84
DMB2 (SN8) Pile 12 to 13	1484+75	Low	2	10	45	0	30	26.2	W24x84
DMB2 (SN8) Pile 1 to 11	1483+80	Medium	11	10	45	0	10	11.3	W24x84

The alternatives considered for trackbed support retrofit areas, to protect against 30-year and 50-year bluff retreat included:

1. Improvements at the blufftop only, i.e. addition of tiebacks and lagging.
2. Improvements at the blufftop in conjunction with bluff toe improvements (seawalls) and bluff surface stabilization.

3.2.1. BLUFFTOP IMPROVEMENTS ONLY

In general, the existing piles could be retrofitted by addition of lagging and if necessary, addition of tiebacks. The exposed surface between the piles would be in-filled with facing material (lagging) which may be timber, precast concrete planks or shotcrete. Lagging options would include placement of anchors into the existing soldier piles to support the facing. A channel could be attached to support panel lagging. A shotcrete facing would be connected directly to the anchors similar to the emergency repair at 15th Street. The shotcrete lagging would be finished with a sculpted face similar to the color and texture of the existing bluff.

Placing all lagging required for the 30-year bluff retreat in the initial phase of construction would require excavating and backfilling up to the required depth of lagging as shown in the graphic below. The depth of visible lagging is determined both by the extent of predicted bluff retreat, as well as the required excavation for the construction of tieback anchors. Where a second row of tiebacks are proposed, typically 15 feet of the bluff height would require to be exposed and retrofitted with lagging panels. Where a third row of tiebacks is proposed, typically 25 feet of lagging would be required. See ***Figure 9*** below. The excavation would be backfilled with a subdrain added to restore the bluff. Depending on the location and the depth of the replaced fill, the slope at the bluff face would be somewhat weakened with a slightly faster rate of retreat in that zone.

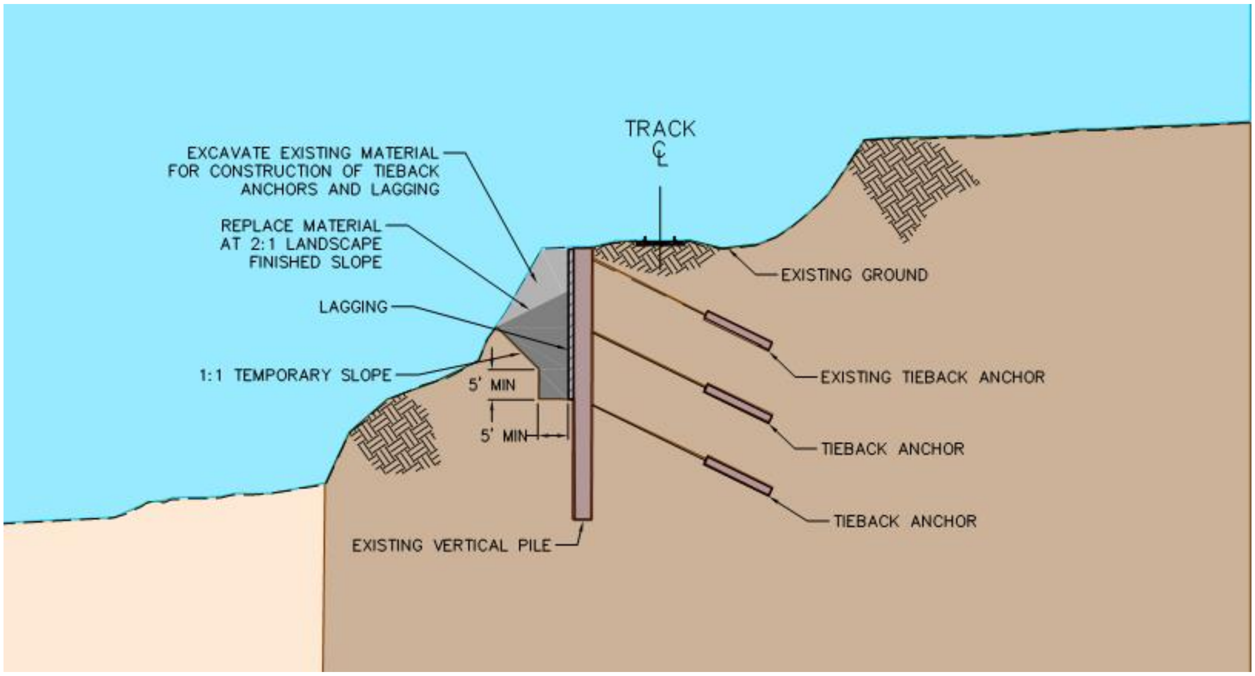

***Figure 9* – Installing Lagging and Tiebacks Needed for 30-year Bluff Retreat (Bluff Top Improvements Only)**

Most of the existing soldier piles would require addition of secondary anchors to extend the service life of the system. Addition of secondary anchors would require construction of a grade beam between the existing piles to support new tieback anchors. The grade beam could be a reinforced concrete beam or steel waler beam encased in shotcrete. Considering the need for adding grade beams to support additional tiebacks, the shotcrete lagging option is considered preferable because it would provide one consistent look for the wall system.

Table 7 provides a summary of the number of tiebacks and depth of lagging needed to retrofit the existing piles for the predicted bluff retreat for the 30-year and 50-year timeframes. Several of the retrofit areas would require two or three additional tieback anchors and 20 to 30 feet of lagging for predicted 50-year bluff retreat. It should be noted that in-line piles are a viable alternative for all areas but are only required for structural requirements in the areas noted in the table below, where 50-year design life is not feasible with the addition of tiebacks and lagging. The in-line pile option provides a stabilization system that does not require construction of lagging over time, however the cost of installation and cost of removal would be substantially greater than the cost adding lagging and tiebacks where feasible. In addition, the removal of the in-line piles in the future would be more impactful to the bluff itself.

Table 7 – Summary of Retrofit Options										
Stabilization Area	Station	Retrofit Priority Ranking	# of Piles	# of Existing Tiebacks	30 yr Design Height (ft)	Total Additional Tiebacks (30 years)	Total Depth of lagging (30 years) (ft)	50 yr Design Height (ft)	Total Additional Tiebacks (50 years)	Total Depth of lagging (50 years) (ft)
DMB2 (SN5) Pile 33 to 38	1544+69	Medium	6	1	13	0	5	32	2	30
DMB2 (SN5) Pile 24 to 32**	1543+50	High	9	1	26	2	30	42	2	30
DMB2 (SN5) Pile 1 to 23**	1542+50	High	23	1	32	2	30	43	2	30
DMB2 (SN7N)	1540+50	Medium	4	1	23	2	30	32	2	30
DMB2 (SN7S)**	1539+50	Low	4	0	14	1	10	37	1	10
DMB3 (SP1)*	1539+21	Medium	5	1	36	1	15	45	1	15
DMB2 (SN3) Pile 15 to 19	1538+14	High	5	1	25	1	15	27	1	20
DMB2 (SN3) Pile 1 to 14	1537+82	High	14	1	24	1	15	27	1	20
DMB2 (SN1N)	1536+75	High	4	1	36	1	25	43	3	40
DMB2 (SN1S) Pile 14 to 29*	1535+00	Medium	16	1	38	1	20	47	1	20
DMB2 (SN1S) Pile 6 to 13	1533+24	High	8	1	25	2	30	29	2	30
DMB2 (SN1S) Pile 1 to 5	1532+75	High	5	1	25	1	15	28	1	20
DMB2 (SN2)	1532+25	High	9	1	31	1	20	34	1	25
DMB4 (Pile 1 to 3)	1531+62	Medium	3	1	34	0	15	39	1	30
DMB3 (SP2) Pile 17 to 23	1530+50	High	7	0	21	1	15	24	1	15
DMB3 (SP2) Pile 6 to 16	1529+70	Medium	11	0	25	1	10	38	3	30
DMB3 (SP2) Pile 1 to 5	1528+79	Low	5	0	0	1	0	25	1	0
DMB2 (SN6) Pile 7 to 10	1516+25	Medium	4	0	10	0	5	27	2	15
DMB2 (SN6) Pile 1 to 6**	1516+00	High	6	0	20	2	15	35	2	15
2001 Emergency Repair	1514+63	High	12	1	30	1	20	38	2	30
DMB3 (SP3) Pile 13	1514+25	Low	1	1	20	0	10	23	0	15
DMB3 (SP3) Pile 5 to 12	1514+08	Low	8	1	18	0	10	24	0	20
DMB3 (SP3) Pile 1 to 4	1513+40	Low	4	1	17	0	5	25	0	15
DMB3 (SP5)	1491+02	Medium	13	0	22	2	20	28	2	25
DMB3 (SP6) Pile 7 to 14	1490+00	Medium	8	0	17	1	10	24	2	20
DMB3 (SP6) Pile 1 to 6	1489+25	High	6	0	24	2	20	28	2	25
DMB3 (SP7)	1488+73	High	14	0	22	1	15	33	3	30
DMB3 (SP4) Pile 6 to 10	1485+50	Low	5	0	5	0	0	20	2	15
DMB3 (SP4) Pile 3 to 5	1485+15	Low	3	0	8	0	0	20	2	15
DMB3 (SP4) Pile 1 to 2	1485+00	Low	2	0	10	0	0	22	2	15
DMB2 (SN8) Pile 12 to 13	1484+75	Low	2	0	10	0	0	20	1	15
DMB2 (SN8) Pile 1 to 11	1483+80	Medium	11	0	21	1	15	31	3	30
* 30 year design life not feasible with addition of lagging and tiebacks. Inline piles/secondary walls needed. ** 50 year design life not feasible with addition of lagging and tiebacks. Secondary walls needed.										

3.2.2. BLUFFTOP IMPROVEMENTS IN CONJUNCTION WITH BLUFF TOE AND BLUFF FACE STABILIZATION

With the addition of seawalls and surface stabilization, where they are recommended, the tiebacks and depth of lagging needed for the 30-year bluff retreat would be significantly reduced. ***Table 8*** summarizes the design parameters for the various retrofit areas within the project considering blufftop improvements in conjunction with bluff toe and surface stabilization. The Phase I seawalls are prioritized at locations where the seawalls would provide the maximum benefit and stabilize the trackbed for 30-year bluff retreat. The Phase II seawalls are required to extend the service life of trackbed stabilizations beyond 30 years, to protect against 50-year bluff retreat, and would be constructed as a future phase at remaining locations based on priority and funding availability.

The ***Figure 10*** below shows the location of the predicted 30-year and 50-year bluff retreat lines with improvements at the blufftop only as shown in lines labeled number 1 and number 2. Where seawalls are proposed, the anticipated bluff retreat lines are drawn holding the toe, and showing retreat at the top of the bluff, as opposed to projecting the retreat of the entire bluff face where there are no seawalls. The predicted 30-year and 50-year bluff retreat lines with the addition of seawalls are labeled as lines number 3 and 4. The difference between the number 3 and number 1 lines shows the extent of the 30-year bluff retreat with and without a seawall. Without a seawall, the entire face of the bluff retreats, resulting in exposure of the pile, requiring a 2nd row of tiebacks, and 15 feet of lagging. The depth of exposure of the pile depends on the steepness of the bluff face, and at some locations this results in over 30 feet of lagging and a 3rd row of tiebacks needed for the projected 30-year bluff retreat. With the seawall, as the bluff retreats, the toe of the bluff face is held at the back of seawall, This results in less material eroding at the face of the bluff, reducing the extent of the visible lagging and need for 2nd row of tiebacks, as shown in the figure below.

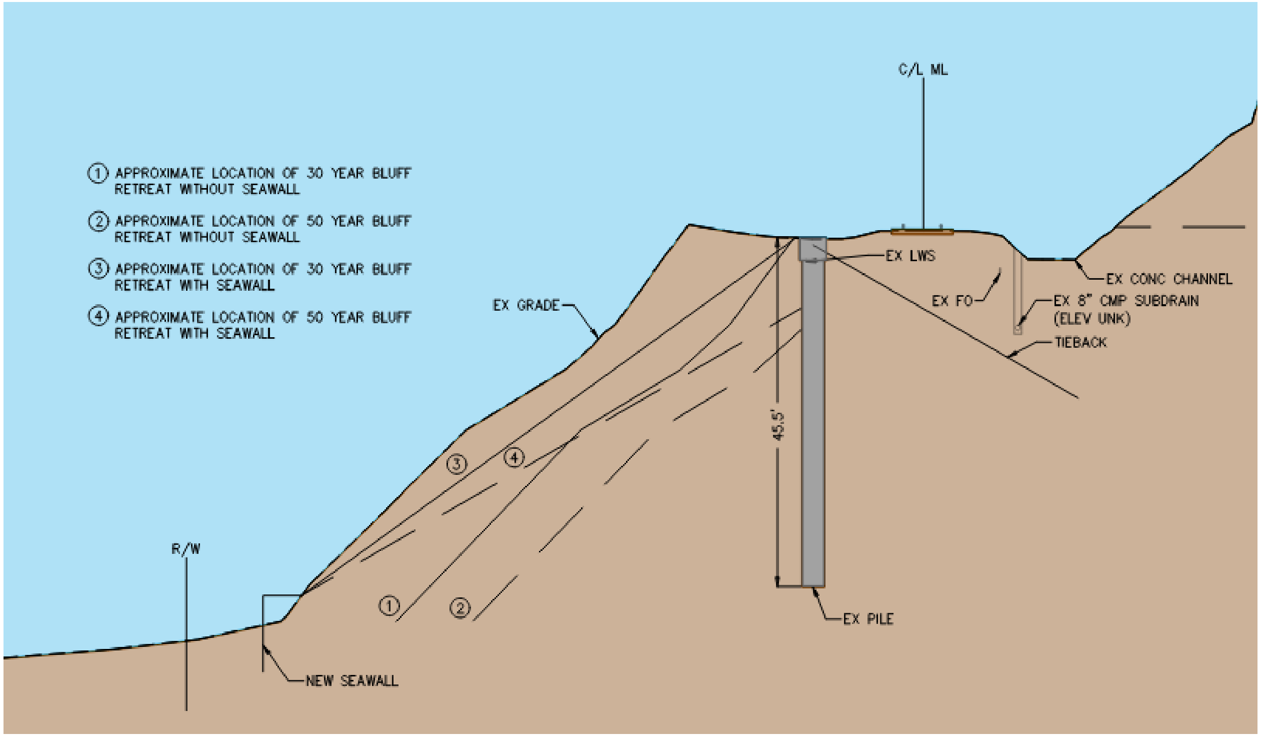

Figure 10 **– Retrofit Areas with Seawalls only**

The location of the predicted 30-year and 50-year bluff retreat lines with improvements at the blufftop only as shown in lines labeled number 1 and number 2 below in ***Figure 11***. The predicted 30-year and 50-year bluff retreat lines with the addition of seawalls only are labeled as lines number 3 and number 4. At some locations, as shown below in ***Figure 11***, due to the steepness of the bluff face, the addition of the seawall does not reduce the predicted bluff retreat to the desired extent to minimize the lagging at the trackbed. At these locations, surface stabilization is proposed in addition to the seawalls. With the addition of surface stabilization, the bluff retreat is arrested, and the bluff does not retreat beyond the graded surface. In addition, the weathered zone is also eliminated. Once the seawall and surface stabilization are in-place, except for ongoing maintenance of the graded and vegetated slope surface, no additional structural retrofit needs are required to extend the service life of the trackbed stabilization to 50 years.

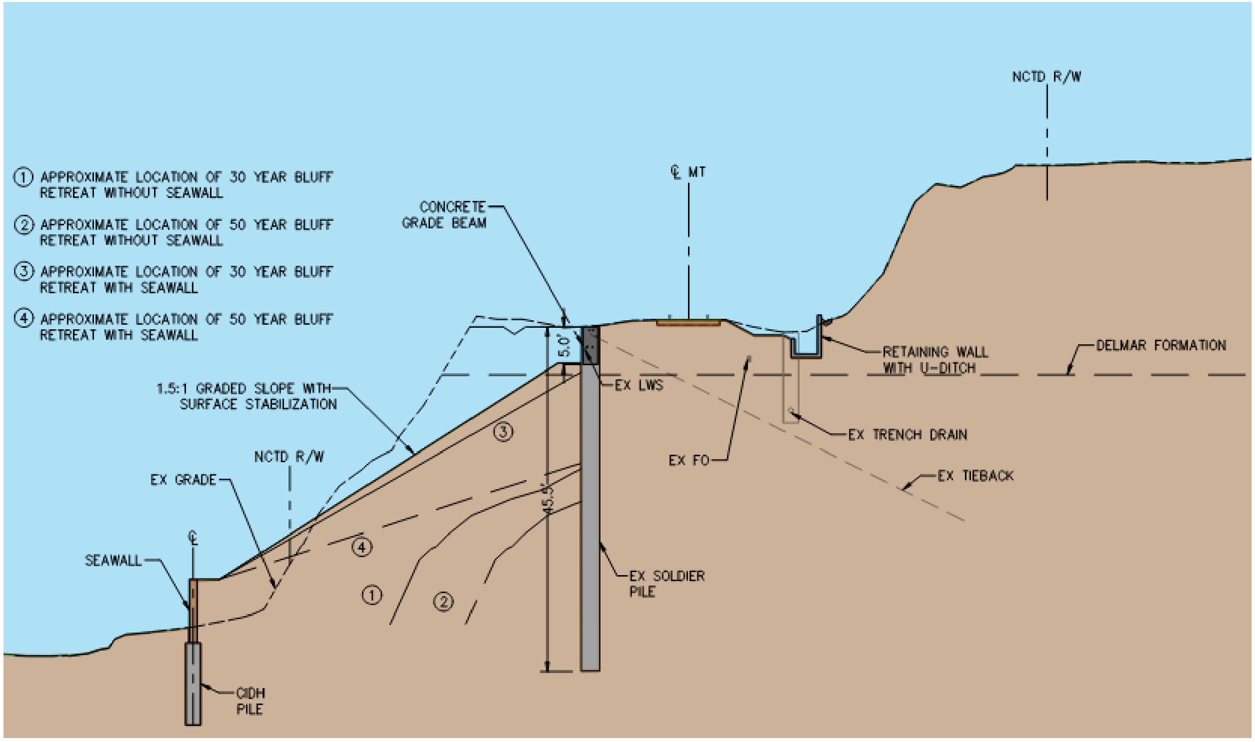

***Figure 11* – Retrofit Areas with Seawalls and Surface Stabilization**

Table 8 – Summary of Retrofit Needs with and without Bluff Toe and Surface Stabilization Improvements											
				Bluff Top Improvements Only				**Bluff Toe and Surface Stabilization in Conjunction with Bluff Top Improvements**			
Retrofit Area	**Retrofit Priority Ranking**	**Existing or Proposed Seawall to Protect Against 30-yr and 50-yr Bluff Retreat**	**Proposed Surface Stabilization**	**Total # of Additional Tiebacks (30-year)**	**Depth of Lagging (30-year) (ft)**	**Total # of Additional Tiebacks (50-year)**	**Depth of Lagging (50-year) (ft)**	**Total # of Additional Tiebacks (30-year)**	**Depth of Lagging (30-year) (ft)**	**Total # of Additional Tiebacks (50-year)**	**Depth of Lagging (50-year) (ft)**
DMB2 (SN5) Pile 33 to 38	Medium	Phase I	X	0	5	2	30	0	5	0	5
DMB2 (SN5) Pile 24 to 32**	High	Phase I	X	2	30	2	30	0	5	0	5
DMB2 (SN5) Pile 1 to 23**	High	Phase I	X	2	30	2	30	0	5	0	5
DMB2 (SN7N)	Medium	Phase I	X	2	30	2	30	0	5	0	5
DMB2 (SN7S)**	Low	Phase I	X	1	10	1	10	1	5	1	5
DMB3 (SP1)*	Medium	Phase I	X	1	15	1	15	0	5	0	5
DMB2 (SN3) Pile 15 to 19	High	Ex	X	1	15	1	20	0	5	0	5
DMB2 (SN3) Pile 1 to 14	High	Ex	X	1	15	1	20	0	5	0	5
DMB2 (SN1N)	High	Phase I	X	1	25	3	40	0	5	0	5
DMB2 (SN1S) Pile 14 to 29*	Medium	Phase I	X	1	20	1	20	0	5	0	5
DMB2 (SN1S) Pile 6 to 13	High	Ex	X	2	30	2	30	0	5	0	5
DMB2 (SN1S) Pile 1 to 5	High	Ex	X	1	15	1	20	0	5	0	5

Table 8 – Summary of Retrofit Needs with and without Bluff Toe and Surface Stabilization Improvements											
Retrofit Area	Retrofit Priority Ranking	Existing or Proposed Seawall to Protect Against 30-yr and 50-yr Bluff Retreat	Proposed Surface Stabilization	Bluff Top Improvements Only				Bluff Toe and Surface Stabilization in Conjunction with Bluff Top Improvements			
				Total # of Additional Tiebacks (30-year)	Depth of Lagging (30-year) (ft)	Total # of Additional Tiebacks (50-year)	Depth of Lagging (50-year) (ft)	Total # of Additional Tiebacks (30-year)	Depth of Lagging (30-year) (ft)	Total # of Additional Tiebacks (50-year)	Depth of Lagging (50-year) (ft)
DMB2 (SN2)	High	Ex	X	1	20	1	25	0	5	0	5
DMB4 (Pile 1 to 3)	Medium	Ex	X	0	15	1	30	0	5	0	5
DMB3 (SP2) Pile 17 to 23	High	Ex	X	1	15	1	15	1	5	1	5
DMB3 (SP2) Pile 6 to 16	Medium	Phase I	X	1	10	3	30	1	5	1	5
DMB3 (SP2) Pile 1 to 5	Low	Phase I	X	1	0	1	0	1	5	1	5
DMB2 (SN6) Pile 7 to 10	Medium	Phase I	X	0	5	2	15	0	0	1	5
DMB2 (SN6) Pile 1 to 6**	High	Phase I	X	2	15	2	15	1	5	1	5
2001 Emergency Repair	High	Phase I	X	1	20	2	30	0	5	0	5
DMB3 (SP3) Pile 13	Low	Ex	X	0	10	0	15	0	5	0	5
DMB3 (SP3) Pile 5 to 12	Low	Ex	X	0	10	0	20	0	5	0	5
DMB3 (SP3) Pile 1 to 4	Low	Phase I	X	0	5	0	15	0	5	0	5
DMB3 (SP5)***	Medium	Phase I	-	2	20	2	25	1	5	2	15
DMB3 (SP6) Pile 7 to 14***	Medium	Phase I	-	1	10	2	20	1	0	2	15
DMB3 (SP6) Pile 1 to 6***	High	Phase I	-	2	20	2	25	1	5	2	15
DMB3 (SP7)***	High	Phase I	-	1	15	3	30	1	5	2	15
DMB3 (SP4) Pile 6 to 10	Low	Phase I	-	0	0	2	15	0	0	1	5
DMB3 (SP4) Pile 3 to 5	Low	Phase I	-	0	0	2	15	0	0	1	5
DMB3 (SP4) Pile 1 to 2	Low	Phase I	-	0	0	2	15	0	0	1	5
DMB2 (SN8) Pile 12 to 13	Low	Phase I	-	0	0	1	15	0	0	1	5
DMB2 (SN8) Pile 1 to 11***	Medium	Phase I	-	1	15	3	30	1	5	2	15

For Bluff Top only Improvements:
* 30 year design life not feasible with addition of lagging and tiebacks, secondary wall/inline piles required
** 50 year design life not feasible with addition of lagging and tiebacks, secondary wall required

For Bluff Toe and Surface Stabilization in Conjunction with Bluff Top Improvements:
*** Phase II (future) surface stabilization would eliminate the need for a second row of tieback anchors and additional depth of lagging to extend the service life of the trackbed stabilization to 50 years.

As noted above, the use of seawalls and surface stabilization limits the number of tiebacks and depth of lagging needed to protect against 30-year and 50-year bluff retreat.

3.2.3. OTHER ALTERNATIVES CONSIDERED

Other retrofit alternatives for areas where the addition of tiebacks and lagging would not adequately extend the service life of the existing stabilization systems include construction of secondary walls or inline piles between existing piles. ***Figure 12*** shows a typical section for a secondary wall. The new wall would be constructed approximately 8 feet west of the existing wall. The new piles would be placed between the existing piles to allow construction of new tieback anchor. Lagging would be added to the new wall to retain the soil between the new wall and existing wall.

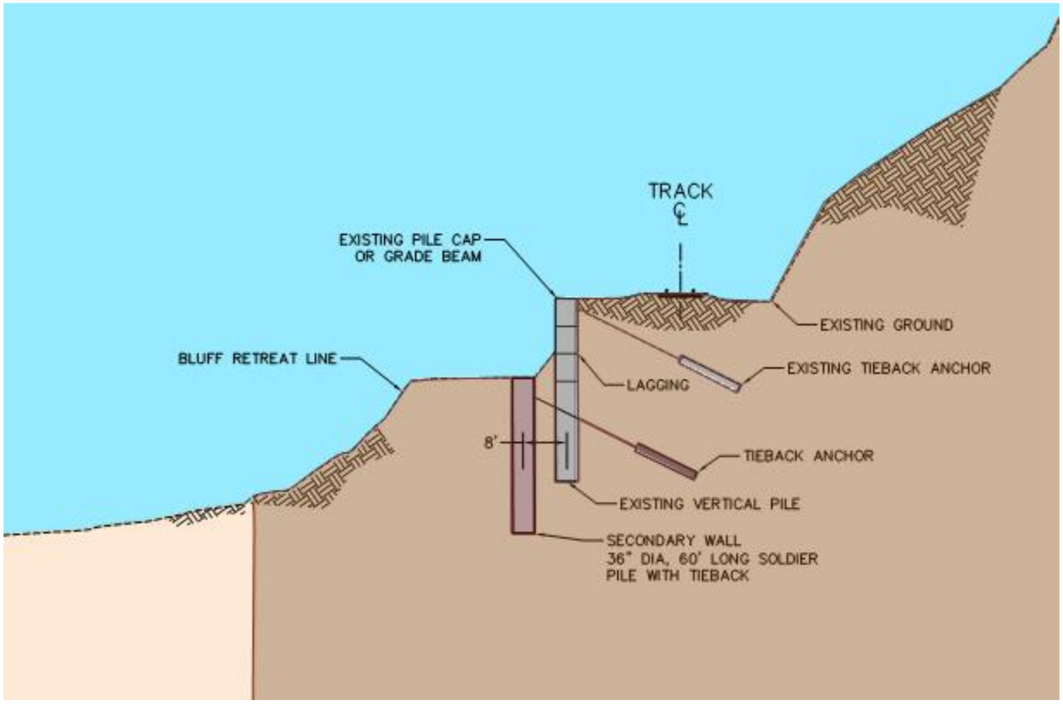

Figure 12 **– Typical Section of Secondary Wall - Trackbed Support Retrofit Areas**

Figure 13 shows a typical section of an inline pile system. Two 36-inch to 42-inch piles would be constructed between the existing piles. One tieback anchor would be constructed to support both piles as shown in ***Figure 14***. The small remaining space between the existing piles would be filled with grout to complete the walls system facing. Lagging would therefore not be needed as part of the inline pile system.

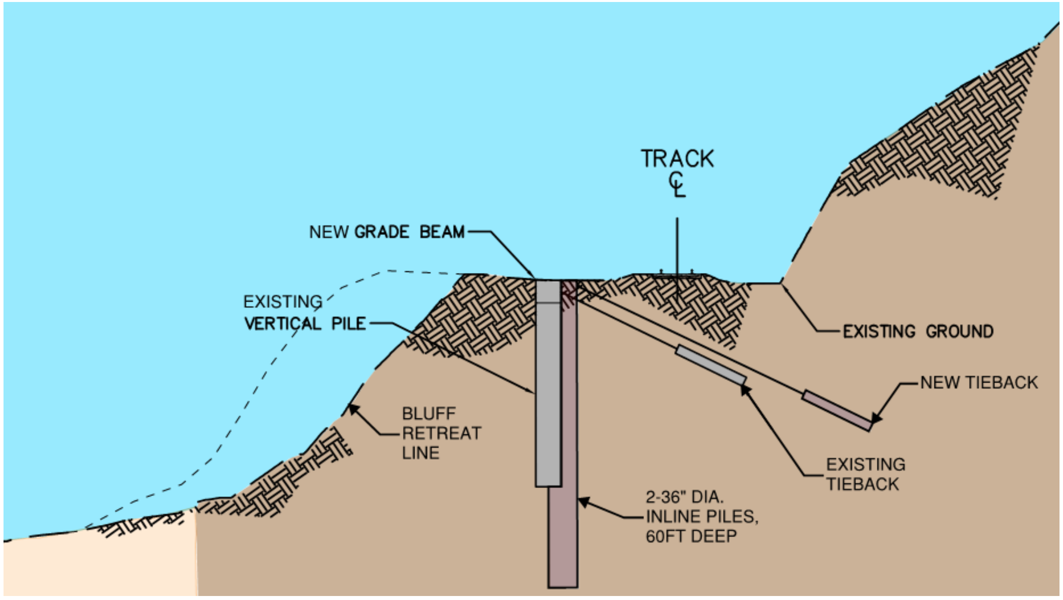

***Figure 13* – Typical Section of Inline Piles - Trackbed Support Retrofit Areas**

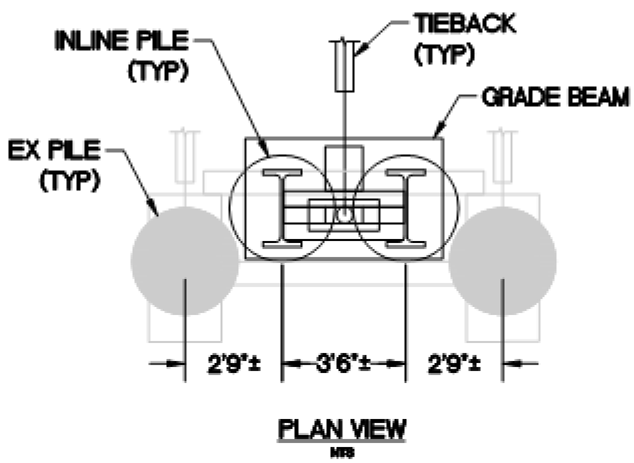

***Figure 14* – Tieback Anchor at Inline Piles - Trackbed Support Retrofit Areas**

The secondary wall option is more effective as part of a phased approach i.e. adding lagging and tiebacks for the predicted 30-year bluff retreat and extending the 30-year system to 50 years by adding the secondary wall. The inline pile solution would be constructed in one phase and would be less visible as one wall compared to two walls. The inline pile system does not work well as part of a phased approach because additional lagging placed in early years would need to be removed before adding the piles. Because of the lesser visual impact and ability to complete the system in one phase, the inline system is the preferred solution for existing soldier pile areas that cannot be extended by addition of lagging and tiebacks alone. The inline pile solution could be used at all of the retrofit locations to provide a single-phase solution rather than adding tiebacks and lagging to the existing piles.

3.3. DESCRIPTION OF PROPOSED DRAINAGE IMPROVEMENTS

The railroad was constructed in the 1880s along what is now Stratford Court, and moved onto the bluffs in 1912, before significant development in the City of Del Mar. Early storm drain systems were provided to convey runoff through the railroad right of way. The City of Del Mar has continued to develop over the years, increasing the area of impervious surfaces and increasing both the peak rate of runoff and total volume of runoff. Much of the City was developed before development standards were recognized. The steep hillside to the east, flows toward the railroad right of way. Existing storm drains in the City of Del Mar are limited by area and by size. In many areas, underground storm drains cross Camino Del Mar and outlet directly to the cross street to the west. Steep streets flow directly into the existing railroad right of way. Many storm drains are undersized, allowing for bypass between basins. In addition, uncontrolled drainage flows between lots and outlets as sheet flow or concentrated surface runoff over unprotected bluffs. The complexity of the existing drainage patterns makes it difficult to control runoff into the railroad right of way. NCTD has continued to evaluate and prioritize drainage improvements needed to protect the railroad right of way since 1992. The program has included improvements to control increased runoff and improvements needed to replace aging infrastructure. While progress has been made in updating and improving drainage facilities, more improvements are still needed. ***Figure 15*** below depicts the existing drainage patterns from Coast Boulevard to Lois Lane.

Figure 15 **– Existing Drainage Patterns from Coast Boulevard to Lois Lane**

Runoff from the City of Del Mar generally flows from east to west concentrating at the streets that dead end into the railroad right of way. Between Sea Orbit Lane and 4th Street, the City runoff is intercepted by concrete channels within the railroad right of way and conveyed to underground storm drain outlets to the beach. The upper bluffs are subject to erosion from natural sources including wind and rain, but the areas where urban runoff sheet flows over the bluffs or is concentrated at the bluffs have more significant erosion. High velocity flows from the local streets often jump the downstream channels, causing erosion and undermining of the concrete channels. Where wider pathways exist west of the existing channels, wind and foot traffic have likely lowered the existing grade causing sheet flow over the top of slope instead of runoff being directed back to the channel. This has caused the formation of erosion gullies that are cutting back to the east through the paths and toward the drainage channels. Several gullies were repaired near 7th Street and 10th Street as part of the Del Mar Bluffs Phase 4 Project, but the bluff continues to erode with deep gullies and undermining of the channels becoming worse. The area showing the most significant damage is located between Sea Orbit Lane and Melanie Way.

The following drainage improvements are needed to maintain and control storm water and protect the railroad from sudden storm-related washouts of the bluffs. Proposed components are described below. For each proposed component, descriptions are provided addressing the existing condition, proposed improvements, and alternatives considered. Details of the proposed improvements are also shown on the attached Permitting Plans, found in Appendix A. A drainage improvement ranking of high, medium, and low has been assigned to each of the proposed drainage areas described in detail below. The ranking of "High" is assigned to improvements needed to protect the railroad from sudden storm-related washouts. These improvements may include replacing undersized storm drainage systems with high peak flows or control of groundwater. The "Medium" ranking is applied to improvements that would improve drainage and maintenance, but a delay in completion would not likely contribute to a catastrophic failure. The ranking of "Low" is applied to improvements that would be needed in the future, but the delay would not have a significant short-term effect. A summary of the drainage ranking is provided in ***Table 9*** below.

Table 9 – Drainage Improvement Ranking

Area	Location	Ranking
1	MP 244.16 – Coast Boulevard	High
2	MP 244.16 to 244.3	High
3	MP 244.3 to 244.4 – 13th Street	High
4	MP 244.4 to 244.43 – 12th Street	High
5	MP 244.45 to 244.61 – Sea Orbit Lane to Melanie Lane	High
6	MP 244.48 to 244.7	High
7	MP 244.64 to 244.71 – 9th Street	Medium
8	MP 244.7 – 8th Street	Medium
9A/9B	MP 244.9	High/Medium
10	MP 244.83 to 245.02 – Sherrie Lane to 4th Street	Medium
11	MP 244.9	Medium
12	MP 244.1 – 4th Street	Medium
13	MP 245.15	Low
14	MP 245.39 to 245.62	Medium
15	MP 245.35 to 245.37	Low

3.3.1. DRAINAGE AREA 1 – COAST BOULEVARD, MP 244.16 TO MP 244.22, WEST OF TRACKS

Existing Conditions

Surface flows from the railroad right of way drain toward Coast Boulevard. An existing 30-inch storm drain system crosses the railroad right of way just south of Coast Boulevard. The storm drain system collects runoff from the City of Del Mar and the railroad right of way. The existing storm drain is significantly undersized by approximately 40% to carry a 100-year flow and undersized by approximately 20% to carry a 25-year flow. Nearly 90% of the runoff flows down Coast Boulevard. Flows that are not captured by the existing storm drain will mostly continue northerly on Coast Boulevard. The remaining 10% of flow sheets into the railroad right of way over the steep unprotected slopes from Sea Grove Park and from the residential development to the south. Less than 1% of the runoff is generated by the railroad right of way. During high flow conditions, flooding will occur at the north end of the railroad right of way inundating the track and overtopping the rail for approximately 200 feet. The railroad right of way slopes northerly at a grade of approximately 1%. Floodwaters will generally flow to Coast Boulevard adding to storm flows in the street until peak flows have reduced consistent with the existing storm drain capacity. Earthen trackside ditches within the railroad right of way convey the runoff from the City to the storm drain system. These trackside ditches do not have capacity to drain even moderate flows. The ditch capacity is further exacerbated by the erosion of the adjacent slopes and debris from City streets. Localized erosion and surficial slides fill the ditches and cause flooding in low peak storms, as well as in major storms. In November 2019, the failures of the drainage features resulted in two major bluff failures north of 13th Street.

Proposed Improvements

Proposed drainage improvements at this location include a new storm drain and outlet to the beach south of the existing City system with construction of approximately 500 feet of new concrete lined trackside ditch west of the existing track as shown in ***Figure 16*** below and further detailed on the plans in Appendix A.

***Figure 16* – Drainage Area 1 Improvements**

The new storm drain would collect flows from the railroad right of way and runoff from Sea Grove Park and adjacent developments. The new system would protect the track from overtopping of floodwaters and relieve the existing pipe that is over capacity. In addition, the new 4-foot wide x 1-foot deep trackside ditch on the west side would collect any additional storm water runoff that backs up from the existing public storm drain system and any additional storm water that overtops the rail and direct flows to the new storm drain system rather than over the bluff top. The capacity of the existing pipe is inadequate; therefore, in order to protect the railroad from sudden storm-related washouts, this area has been ranked as High Priority.

Alternatives Considered

Construction of a new inlet to the existing storm drain system at the south end of Powerhouse Park at MP 244 was considered to collect and discharge overflow waters and lower the overall tributary flow to the existing undersized City system. Collection of the overflow would not result in a significant improvement to the capacity of the City system. High flows in excess of the existing public storm drain capacity would still overtop the bluff near the existing storm drain location; therefore, for protection of the existing bluff, the new storm drain system described above was considered to have greater benefit with less impact to the bluff. Another alternative considered included upsizing the existing pipe at Coast Boulevard, but was rejected as the pipe is located close to the children's playground on the south side of Powerhouse Park.

3.3.2. DRAINAGE AREA 2 – COAST BOULEVARD, MP 244.16 TO MP 244.3, EAST OF TRACKS

Existing Conditions

Surface flows from the railroad right of way drain towards Coast Boulevard. An existing 30-inch storm drain system crosses the railroad right of way just south of Coast Boulevard. The storm drain system collects runoff from the City of Del Mar and the railroad right of way. The existing storm drain is significantly undersized by approximately 50% to carry a 100-year flow and undersized by approximately 20% to carry a 25-year flow. Nearly 90% of the runoff flows down Coast Boulevard. Flows that are not captured by the existing storm drain will mostly continue westerly in Coast Boulevard. The remaining 10% of flow sheets into the railroad right of way over the steep unprotected slopes from Powerhouse Park and from the residential development to the south. Less than 1% of the runoff is generated by the railroad right of way. During high flow conditions, flooding will occur at the north end of the railroad right of way inundating the track and overtopping the rail for approximately 300 feet. The railroad right of way slopes northerly at a grade of approximately 1%. Floodwaters will generally flow to Coast Boulevard adding to storm flows in the street until peak flows have reduced consistent with the existing storm drain capacity. Earthen trackside ditches within the railroad right of way convey the runoff from the City to the storm drain system. These trackside ditches do not have capacity to drain even moderate flows. The ditch capacity is further exacerbated by the erosion of the adjacent slopes and debris from City streets. Localized erosion and surficial slides will fill the ditches and cause flooding in low peak storms as well as in major storms.

From approximately 15th Street to Coast Boulevard, the slopes above the track to Sea Grove Park are generally eroded with large gullies and significant loose material. There are number of large trees and shrubs in the slope. The walkways along the top of the slope skirt the rail right of way and cross over in some locations. A larger plaza area at 1546+00 overhangs significantly into the NCTD right of way.

Proposed Improvements

Proposed stabilization improvements at this location include a new storm drain lateral connected to the new Area 1 storm drain outfall, and construction of approximately 800 feet of concrete lined trackside ditch east of the rail as shown in ***Figure 17*** below and on the plans in Appendix A. The 5-foot wide x 2-foot deep concrete lined trackside U-ditch would provide the additional capacity needed to convey flow to the new storm drain crossing and provide a factor of safety against mudslides. Removal of the large trees on the slopes would likely impact the stability of the top of the slope in the park. Regrading of the slope would require reconstruction of the park plaza area and a significant portion of the walkways. The recommended solution for stabilization of the slope and drainage improvements is to construct a combination U shaped channel and upto a 5-foot high retaining wall. The area behind the wall would be backfilled level with the top of the wall. See ***Figure 18*** below for a cross section of the improvements. The additional flat area will provide room to collect runoff and direct it to the new storm drain system.

South of Station 1545+00, the slope is stable and could be excavated to provide a 1:1 slope, 5 feet west of the right of way line with a brow ditch at the top to control runoff. The 1:1 slope would require a solid shotcrete surface to protect the slope from surficial deteriorations but would impact the existing walkway and other improvements at the top of the slope. Construction of soil nail wall would allow for a steeper 0.5:1 slope and would maintain more of the flat area near the right of way line, preserving the integrity of the private and public improvements above, and is therefore the recommended solution here. See ***Figure 19*** below for a cross section of the improvements.

The railroad right of way slopes northerly at a grade of approximately 1%. The existing underdrain would be extended to the 15th Street storm drain to help control groundwater. This Drainage Area 2, along with Drainage Area 1 has been ranked as High Priority as both systems will work in conjunction to increase the existing capacity and provide a factor of safety against mudslides.

Figure 17 **– Drainage Area 2 Improvements**

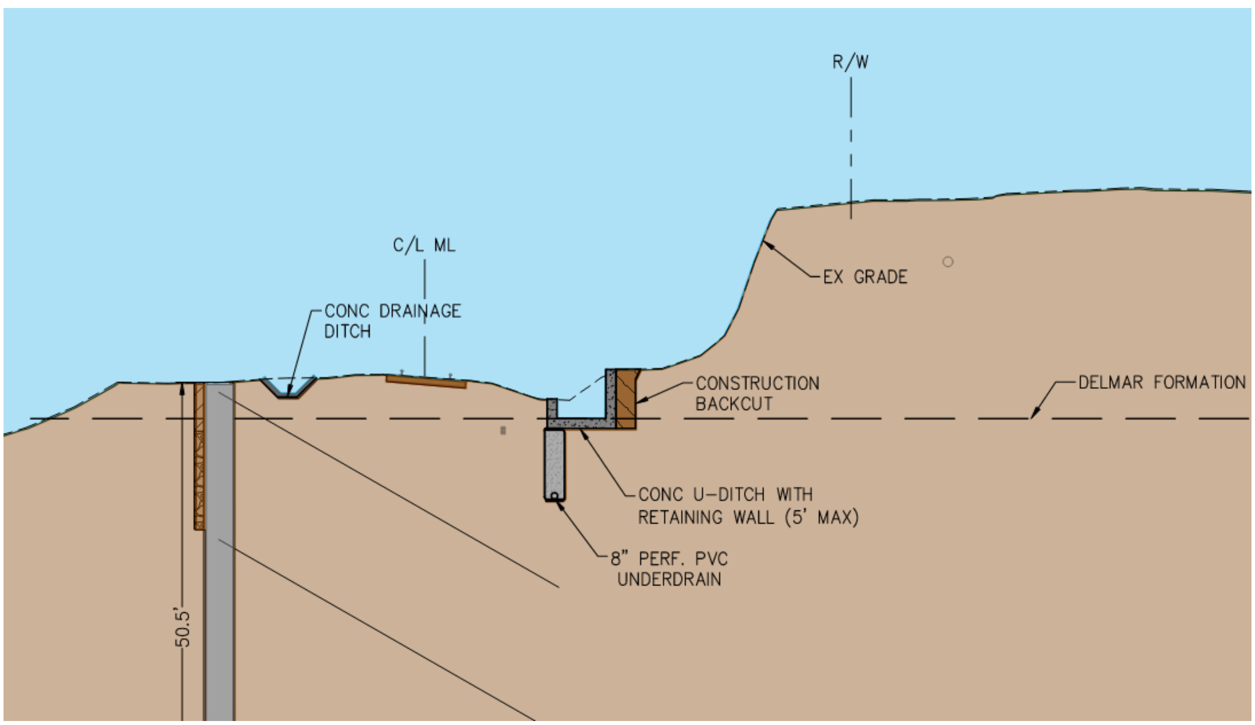

Figure 18 **– Drainage Area 2 Section: Sta 1545+00 – Sta 1548+50**

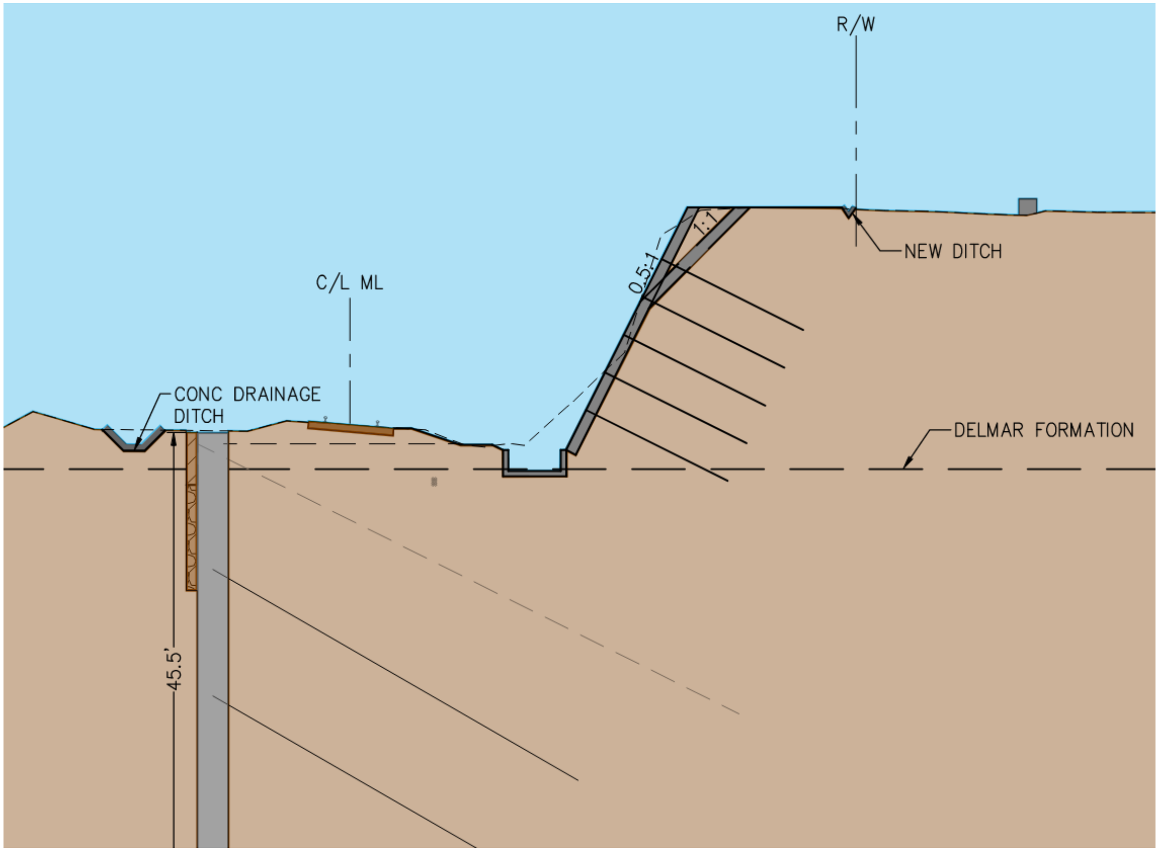

***Figure 19* – Drainage Area 2 Section: Sta 1542+00 – Sta 1545+00**

Alternatives Considered

Construction of a standard 10-foot wide trapezoidal earthen ditch was considered to increase capacity and provide some factor of safety for mud and debris. This option would require construction of significantly more retaining wall with heights exceeding 10 feet in many locations. The new storm drain system was considered to have greater benefit with less grading and visual impact to the bluff.

Erosion of the existing unprotected steep slopes adjacent to the rail is a result of sheet flow over the slopes from the existing development. There are no underground storm drains in the upstream basin south of Coast Boulevard. Sea Grove Park and the majority of development south to 13th Street and west of Camino Del Mar drain directly into the railroad right of way with some concentration occurring in the condominium development west of Coast Boulevard. Current standards do not allow for sheet flow or concentration of surface runoff onto downstream properties. Development of the City has continued over many years and has been in place for many years prior to standards. Therefore, these areas that were developed many years ago, did not require upstream property owners to control runoff in a manner that would not damage downstream properties. Typically, a combination of ditches and storm drains would be required to protect downstream erodible slopes. A combination of small walls and concrete channels with additional underground storm drain in the park was considered to direct storm flows to Coast Boulevard. Controlling the runoff that sheet flows over the existing unprotected slopes would significantly protect the track side ditch from being blocked by debris causing over topping of the trackbed. The existing storm drain system in 15th Street is undersized, however this system would function during the more regular low flow events that have consistently caused damage in the railroad right of way. This work would need to be completed within City owned and private property. Considering the impacts to the existing park and private development as well as the lack of easements, this option was considered infeasible.

3.3.3. DRAINAGE AREA 3 – 13TH STREET, MP 244.3 TO 244.4, EAST OF TRACKS

Existing Conditions

Storm flow tributary to the existing storm drain system includes runoff from 13th Street, Lois Lane and from the development immediately adjacent and east of the railroad right of way. The existing inlet in 13th Street is undersized and the existing ground adjacent to the inlet is lower, allowing significant bypass of uncontrolled surface runoff causing erosion and bypassing the pipe that was intended to act as the conveyance system. Flow from the developed area to the east sheets into the railroad over unprotected slopes causing erosion and mudslides. Earthen trackside ditches within the railroad right of way convey the runoff that is not captured in the 13th Street storm drain, concentrated runoff from Lois Lane and sheet flow from the adjacent development to the east. These trackside ditches do not have capacity to drain even moderate flows. While the peak and regular flows are not high, the erosion, mudslides and debris from City Streets fill the ditches and exacerbate the issue of reduced ditch capacity. Localized erosion and surficial slides fill the ditches and cause flooding in low peak storms as well as in major storm. A major wash out of the bluffs occurred just south of the existing storm drain requiring addition of soldier piles on an emergency basis in 1998. Concentrated runoff at this area has continued to overtop the rail and erode the bluff with the most recent emergencies occurring as a result of storm events in November 2019. The rail was subject to several shutdowns and slow orders while emergency repairs were completed at two separate areas.

Proposed Improvements

Proposed stabilization improvements at this location include construction of inlet improvements at the existing 24-inch pipe crossing at MP 244.3, new inlet in 13th Street, concrete lined trackside ditch from south of Lois Lane to the crossing at MP 244.3, extension of the underdrain from 13th Street to Lois Lane and slope stabilization improvements to prevent debris flows that have previously blocked drainage and caused overtopping of the rail. See ***Figure 20*** below for a plan view of the improvements. The capacity of the existing storm drain system is limited by the inlet structures. A new inlet at the crossing would improve efficiency and allow more flow into the existing 24-inch pipe outlet to the beach. A new 4-foot wide x 2-foot deep concrete trackside ditch would be constructed to collect and convey runoff from Lois Lane to the existing storm drain outlet crossing. The existing 24-inch storm drain lateral that parallels the track is very shallow, has limited capacity and constrains the width and depth available for a new ditch. Reconstructing the pipe at a lower depth would conflict with the existing soldier pile tiebacks and is therefore not feasible. The existing pipe would be removed to allow for a higher capacity open ditch. The existing curb inlet at the end of 13th Street is not functioning to its full capacity because the existing adjacent grades are at a lower elevation than the top of curb allowing flow to bypass the inlet. The grades beyond the cul-de-sac should be raised to avoid bypass flow and a seat wall similar to the existing seat walls at the end of 9th Street would be constructed to avoid overtopping down the graded slope entering the right of way. The existing pipe outlet from 13th Street would be reconnected to the new concrete track side ditch with a splash wall. A paved emergency spillway from 13th Street would be provided to protect the existing slope from erosion in case of bypass flows. Previous failures during rain events in this area have been caused by mud and debris rendering ditches useless.

***Figure 20* – Drainage Area 3 Improvements**

The higher capacity ditches will help alleviate the problem, but the ditch and the storm drain crossing would continue to be subject to blockages. Controlling the mudslide in this area is essential to protecting the bluffs from drainage failures.

Starting 100 feet south of Seagrove Park, the slope east of the tracks is an existing fill slope at a ratio varying from 1.5:1 to 2:1 and is well landscaped and stable. A private path parallels the right of way of just to the east. The project would leave this graded vegetated slope as-is, with the exception of revegetating any disturbed areas

Private improvements encroach more than 20 feet into the right of way north and south of 13th Street making flattening and landscaping the slopes to control erosion infeasible. Retaining walls would be needed to support private encroachments north and south of 13th Street and to provide adequate width for the new ditch and underdrain. A wall type without a footing would be required to avoid conflict with existing soldier pile tiebacks. A soil nail wall is the preferred alternative because it would provide adequate structural stability without conflicting with existing improvements. See ***Figure 21*** below. The soil nail would extend approximately 465 feet with a height ranging from 10 feet to 20 feet. All walls would have an architectural treatment to lessen the visual impact. All disturbed areas would be revegetated.

As previously mentioned, controlling the mudslide in this Drainage Area 3 is essential to protecting the bluffs from drainage failures; therefore, this area has been ranked as *High Priority*.

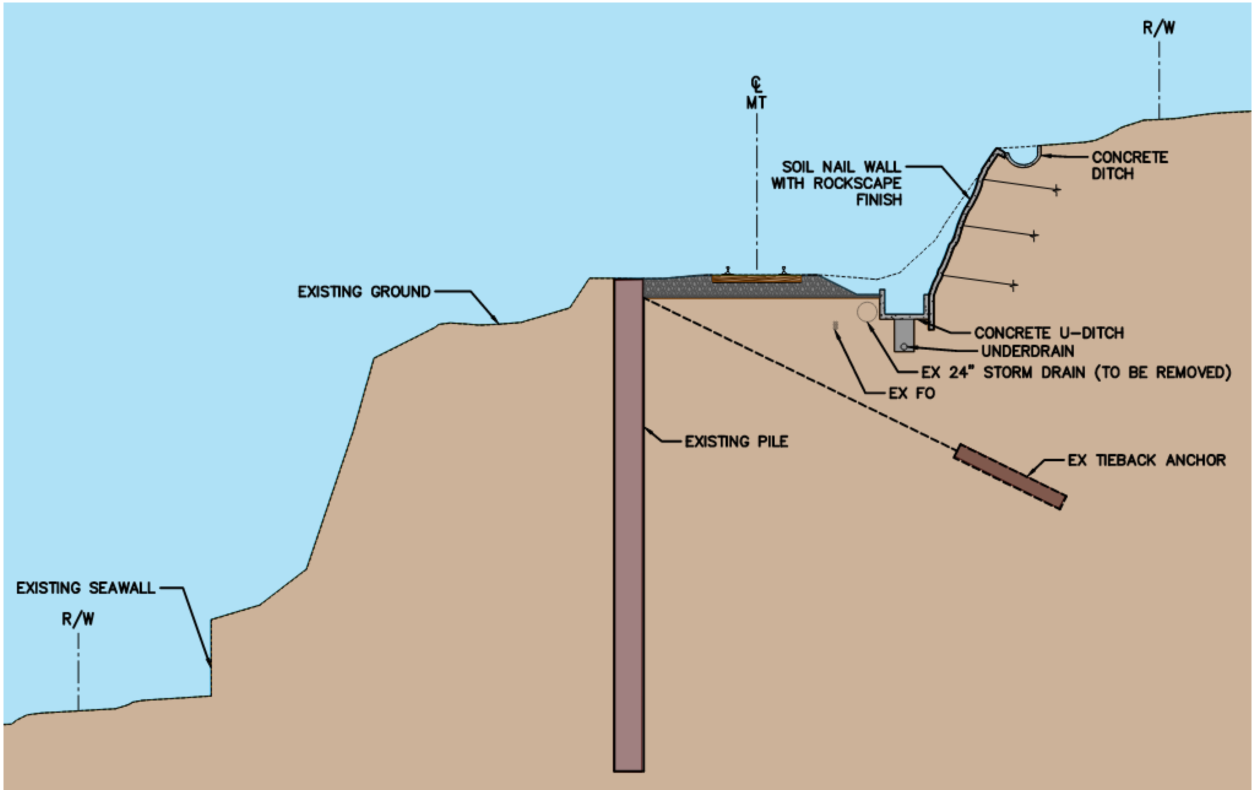

Figure 21 **– Drainage Area 3 Section**

Alternatives Considered

Construction of a new storm drain outlet to the beach at the end of 13th Street was considered to provide additional overflow capacity for blocked ditches. A new system would collect runoff from 13th Street and Sea Orbit Lane. The existing inlets and lateral pipe in 13th Street would be redirected to the new outlet. While a secondary drainage system would provide some redundancy, mudslides would still continue to occur. The volume of runoff would not exceed the capacity of the existing storm drain if the trackside channels were clean. Providing redundancy in the storm systems would not provide the same level of protection as stabilizing the slopes and is therefore not considered a feasible solution.

3.3.4. DRAINAGE AREA 4 – 12TH STREET, MP 244.4 TO 244.45, EAST OF THE TRACKS

Existing Conditions

Storm flow tributary to the existing storm drain system in 12th Street flows to the existing concrete chute to the north. The existing concrete chute was constructed in the early 1900s and is very badly deteriorated. Failure of the chute would result in significant damage due to uncontrolled drainage. In addition, the bowl segment of the chute is very rough with exposed rebar creating a safety concern for beach goers. Several minor repair projects have been completed to extend the service life of the chute, but the structure is well beyond its anticipated service life.

Proposed Improvements

Proposed improvements include construction of a new 42-inch underground storm system directly from 12th Street to the beach, see ***Figure 22*** below. The new storm drain would be constructed using jack and bore method of construction to avoid an open trench cut down to the face of the existing bluff. The jacking pit would be placed in the City right of way between the end of the improved street and the railroad right of way. A row of existing soldier piles with tieback anchors is located on the west side of the track. The new storm drain alignment would be placed between two existing piles. The tie back anchors would be temporarily removed and replaced using a grade beam to connect the new anchors between the existing piles. The new outlet to the beach would be constructed using a U-shaped outlet to dissipate energy similar to the existing outlet at MP 244.45. The new storm drain would be reconnected to the existing storm drain inlets in 12th Street. The landscaped area adjacent to the end of the street would be regraded to direct runoff to the existing inlets. A 4-foot wide x 1-foot deep concrete trackside U-ditch on the east side of the track would be extended south to Sea Orbit Lane to convey runoff to the new storm drain and control erosion in the ditch, see ***Figure 24*** below for a typical cross section. The existing storm drain connection to 12th Street and the existing 48-inch storm drain crossing under the track would be abandoned in place. The old concrete chute and bowl would be removed from the beach. The existing wall adjacent to the chute that runs from Station 1530+25 to Station 1534+00, would also be removed and the area would be regraded. See ***Figure 23*** for a photo of the existing chute. This area has been ranked as High Priority because of the need to protect the railroad from sudden storm-related washouts.

***Figure 22* – Drainage Area 4 Improvements**

Figure 23 **– Existing Chute and Bowl North of 12th Street**

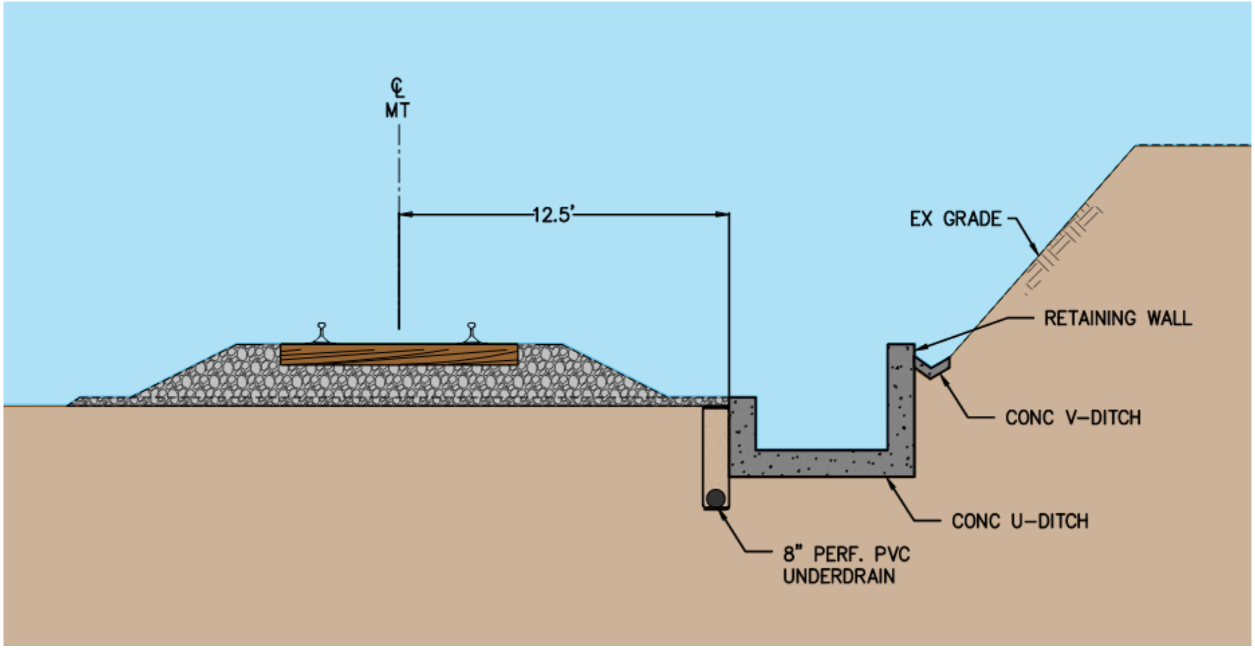

Figure 24 **– Drainage Area 4 Section**

Alternatives Considered

Reconstruction of the new underground storm drain at the chute location was considered. This approach would allow utilization of the existing 48-inch diameter storm drain crossing under the track and maintain the existing connection to 12th Street. An inline replacement would require provisions for temporary bypass of storm water during construction. While not desirable, this risk could be mitigated by requiring construction during the summer months. The existing chute would be removed, and a trench would be excavated into the bluff. Anchors would be needed to hold the new storm drain in place at the steep grade. A new energy dissipating structure would be constructed into the slope. The new pipe trench would be backfilled with concrete and the face of the slope and the outlet would be rockscaped to match the existing bluff face texture and color. While this approach would limit the rework, construction on the bluff face has significant risks and would introduce additional hard surfaces on the bluff face compared to removal of the existing chute.

3.3.5. DRAINAGE AREA 5 – SEA ORBIT LANE, MP 244.45 TO 244.8, EAST OF THE TRACKS

Existing Conditions

The existing storm drain outlet to the beach at Sea Orbit Lane was constructed in 1996. The storm drain inlet consists of a headwall with a vertical grate to prevent debris from entering the pipe inlet. The existing pipe entrance is adequately sized to accept runoff from the upstream basin; however excessive mud and debris have blocked the grated inlet, diminishing capacity and increasing risk of uncontrolled bypass. The pipe accepts flows from Sea Orbit Lane and the concrete channel that collects runoff from 11th Street, Penny Lane, 10th Street and Melanie Way. Flow from Sea Orbit Lane is directed to the headwall inlet via pipe and surface flow from the City Streets are conveyed to the headwall in a concrete channel. The existing concrete channel from Melanie Lane to Sea Orbit Lane varies in width from 9 feet to 12 feet with longitudinal slopes varying from 0.9% to 5%. The channel is located at the top of a steep slope generally exceeding a ratio of 1:1. Much of the existing concrete channel is in poor condition and in need of repair or replacement. Two short segments of soldier pile wall and channel replacement totaling approximately 65 feet have been constructed as part of Del Mar Bluffs Phase 4 Project in the vicinity of 10th Street. The existing channel section is irregular with some shallower sections. In general, the existing channel should provide adequate capacity with the exception of isolated shallow sections. Significant flows at relatively high velocities enter the channel from the intersecting public streets to the west. The momentum of the high velocity lateral flows causes overtopping of the existing channel with excess flows draining over the unprotected steep slopes. The overtopping of the channel results in erosion of the slope, migration of the top of slope closer to the edge of channel, undermining of the channel and deposition of mud and debris on the track below. The over-steepened and eroded slope immediately west of the channel edge would not adequately support a new channel.

Proposed Improvements

Proposed improvements include modifying the existing junction structure at Sea Orbit Lane to include debris control with bypass for floodwaters, replacement of the existing concrete channel with a consistent section sized to convey the peak flows with adequate freeboard consistent with the LOSSAN Design Criteria, and placement of splash walls to control the overflow that occurs at the public street intersections.

The width of the new concrete channel would vary between 11.5 feet and 14 feet depending on the longitudinal slope and the tributary flow from the public streets. The new channel would be similar in width to the existing channel, but the depth will be increased as needed to provide adequate freeboard. The new channel would be shifted to the east where possible to provide separation from the top of the existing slope; however, there is limited flexibility to shift the channel without increasing the height of the easterly channel wall. Because of the location and steepness of the existing slope relative to the top of the new channel, stabilization of the existing slope would be required for the overall stability of the new drainage channel and thus protecting the trackbed.

The proposed stabilization measure includes extending the existing soldier piles north and south of 10th Street and incorporating a concrete channel with integrated wall for about 250 ft south of Sea Orbit Lane. See the Permitting Plans, Appendix A, for the limits of this channel with integrated wall and soldier piles. ***Figure 25*** below shows a plan view of this drainage area. ***Figure 26*** and ***Figure 27*** below, are typical cross sections of the integral channel and soldier pile wall, respectively. Two new segments of soldier pile wall were constructed with concrete lagging, and part of the channel was replaced as part of Del Mar Bluffs 4. However, the remainder of the existing channel continues to deteriorate and is in need of further replacement. A soldier pile wall is the preferred alternative for this area because of access and constructability issues, along with this system providing the necessary support since the area is too close to the edge of the bluff. This type of improvement also provides minimal changes to the existing slope. For consistency of the existing slope protection, a continuation of the soldier pile and lagging system colored to match the bluff is the only practical solution to maintain a consistent visual appearance. Replacement of the existing concrete channel with an adequately sized channel to convey the peak flows is necessary to avoid sudden failure of the bluffs and has been ranked as High Priority.

***Figure 25* – Drainage Area 5 Improvements**

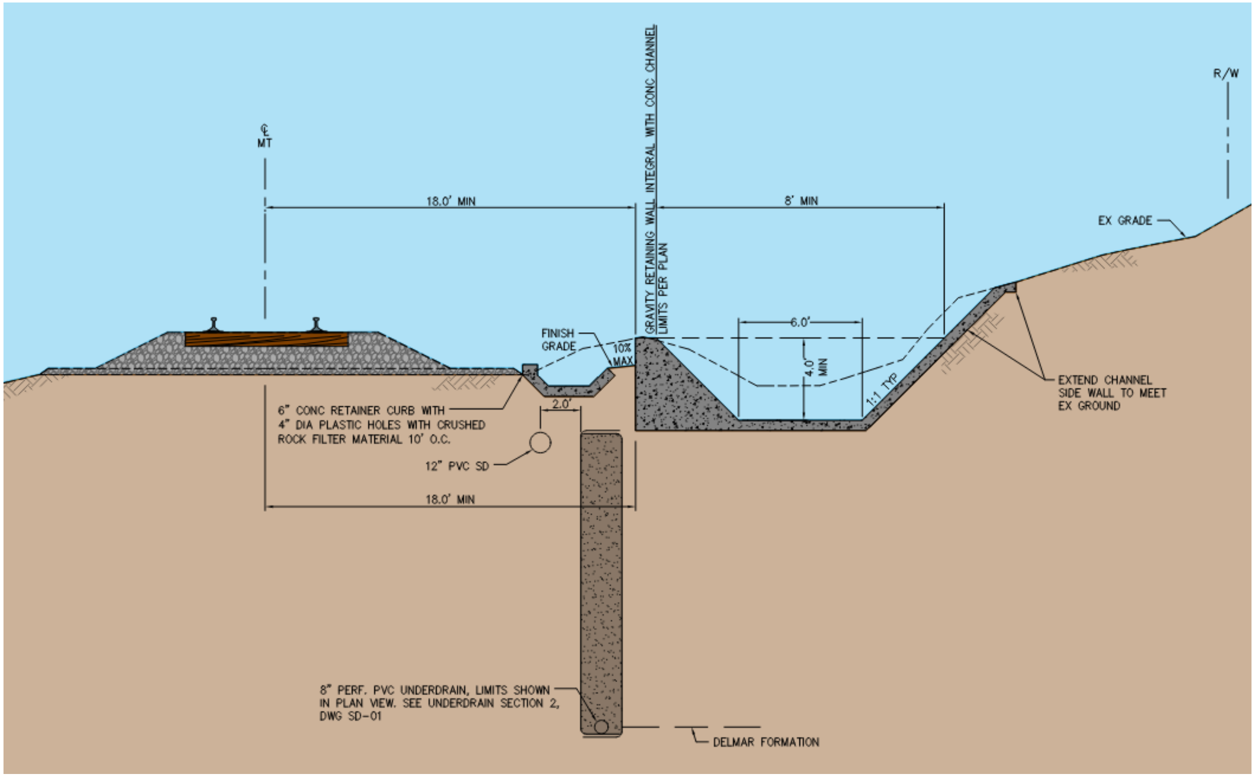

***Figure 26* – Drainage Area 5 Section – Integral Wall**

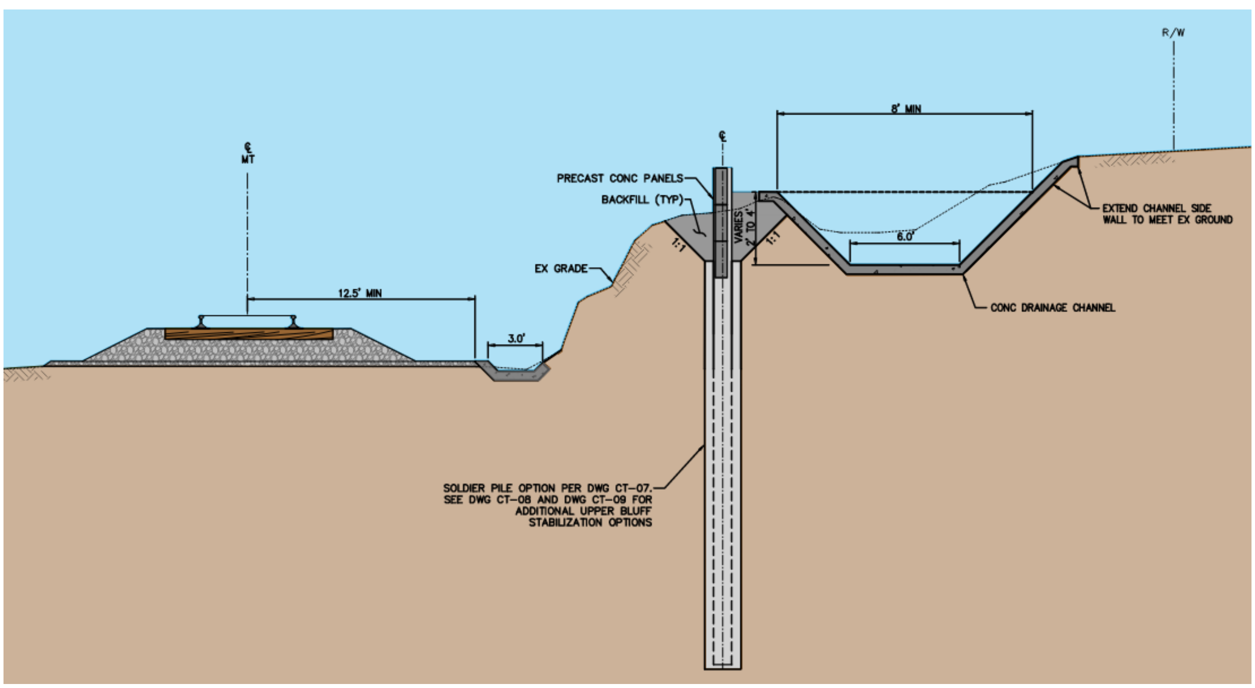

***Figure 27* – Drainage Area 5 Section – Soldier Pile Wall**

Alternatives Considered

Repair of the existing channel was considered as an alternative to complete replacement. However, the existing concrete shows significant signs of deterioration. Increasing capacity of the shallow segments would require raising the channel walls above existing grade. Considering the age of the facility, patching and partial replacement is not considered a feasible approach. In addition, the new configuration allows for lowering the flowline at shallow segments without creating above grade obstructions.

The alternatives considered for the stabilization of the existing slope and new drainage channel are cement slurry buttress, earth buttress, and soil nail reinforcement. These three alternatives are described below, along with the reasoning why the proposed soldier pile wall was preferred.

The cement slurry buttress is best for smaller areas that need to be completely reconstructed. Using this system for continuous support of a long segment would require completely reconstructing the entire slope and changing the color and configuration. For the segment from Sea Orbit Lane to Melanie Way, this is not a viable solution as the bluff continues to erode. It can be used as a temporary fix until a more permanent solution is used. See ***Figure 28*** below for a typical section.

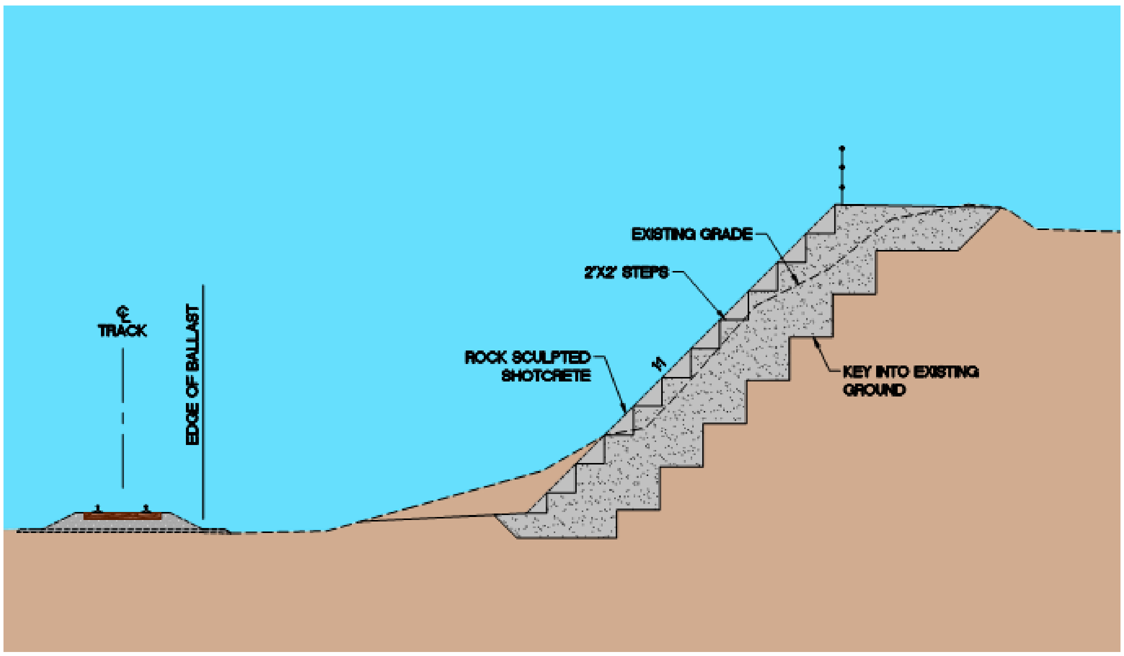

***Figure 28* – Drainage Area 5 - Cement Slurry Buttress Alternative**

The earth buttress requires a 2:1 slope and reconstruction of the existing slope with compacted fill landscaped for erosion control. In this upper bluff stabilization area, the existing slope is steeper than 1:1. The minimum recompacted slope would be 2:1; therefore, there isn't adequate width to replace the slope and have room for the path and drainage channel. Recompacting the existing slope with landscape for erosion control at a 2:1 slope would require a retaining wall at the toe of the slope to provide the horizontal width needed for the path and drainage channel above.

The soil nail reinforcement could be used where the existing slope is intact. Where gullies need to be filled due to the continuous street runoff, the upper portion of the bluff would need a retaining wall with backfill. With this system, the entire length of stabilization would need to be completed and rockscaped, changing the visual appearance for the entire length of the stabilization area. See ***Figure 29*** below for a typical section.

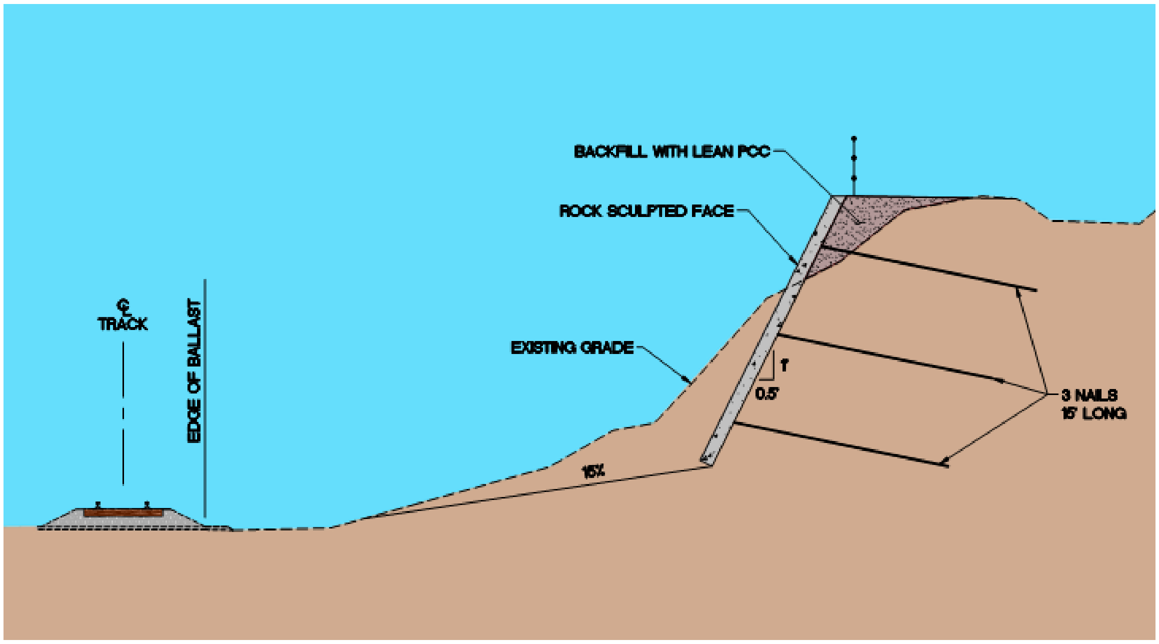

Figure 29 **– Drainage Area 5 - Soil Nail Reinforcement Alternative**

3.3.6. DRAINAGE AREA 6 – 11TH STREET, MP 244.48 TO 244.71, WEST OF THE TRACKS

Existing Conditions

This segment of the railroad corridor is known as the trench because of the existing earthen berm that remains west of the track. Steep, unprotected slopes exist on both sides of the track. Runoff from the slopes flows toward the track from both sides for a length of approximately 1,000 feet. A high point at the mid-point directs flows to the north or south. Longitudinal slopes are less than 0.4%. The unprotected steep slopes are subject to erosion. The eroded material fills the flat ditches and blocks runoff from flowing in either direction. See ***Figure 30*** below for a photo of the existing ponding between the track and beach. A 6-inch diameter pipe and grated inlet were constructed as part of Del Mar Bluffs 1 Project to convey runoff from the trench to the existing storm drain in Sea Orbit Lane. The volume of silt and mud eroded from the adjacent slopes has regularly filled the small pipe rendering it mostly ineffective during even small rainfall events. The area is subject to ponded water that leaches into the ground below. The upper layers of soil consisting of Torrey Sandstone are generally pervious and allow for infiltration of surface water down to the impervious Delmar Formation. Signs of seepage are visible at the face of the bluff. The flow of groundwater serves to increase degradation of the bluffs. In the last few years this area has been one of the most active locations for surficial block failures of the bluff.

***Figure 30* – Photo of Existing Ponding between Track and Beach**

Proposed Improvements

Proposed improvements include construction of concrete lined trackside ditches to convey runoff to the north and south and construction of a new outlet to the beach at the north end, see ***Figure 31*** below. The ponding of water following rainfall events tends to add to the ground water exacerbating the deterioration of the bluff faces as evidenced by the failures that have occurred in recent years following major rainfall events. An 8-foot wide x 1-foot deep concrete lined trapezoidal ditch west of the track and a 4-foot wide x 1-foot deep concrete lined U-ditch east of the track are proposed to direct runoff more efficiently to controlled outlets compared to the existing graded channels and to prevent the ponding of runoff that adds to the groundwater, see ***Figure 32*** below. The existing outlet system to the north has not been functioning adequately; therefore, a new outlet to the beach would be added to convey surface runoff away from trench area. The new concrete trackside ditches draining southerly would continue to be collected by the existing storm drain system and outlet at 8th Street. A new inlet would be constructed on the east side of the track to improve efficiency. Construction of concrete lined trackside ditches would not prevent the continued erosion of the slopes on either side of the track that contribute to blocking the ditches; however the concrete section would provide additional capacity as a factor of safety against blockage, facilitate maintenance of a regular section designed to accept peak flows, and limit ponding that adds to groundwater infiltration, thus this area has been ranked as High Priority.

Figure 31 **– Drainage Area 6 Improvements**

A new underdrain is proposed for the trench area as described in Section 3.3.16. The new underdrain will be in excess of 20 feet deep to collect perched water at the depth of the Delmar formation. The new storm drain outlet to the beach is also needed for connection of the new underdrain.

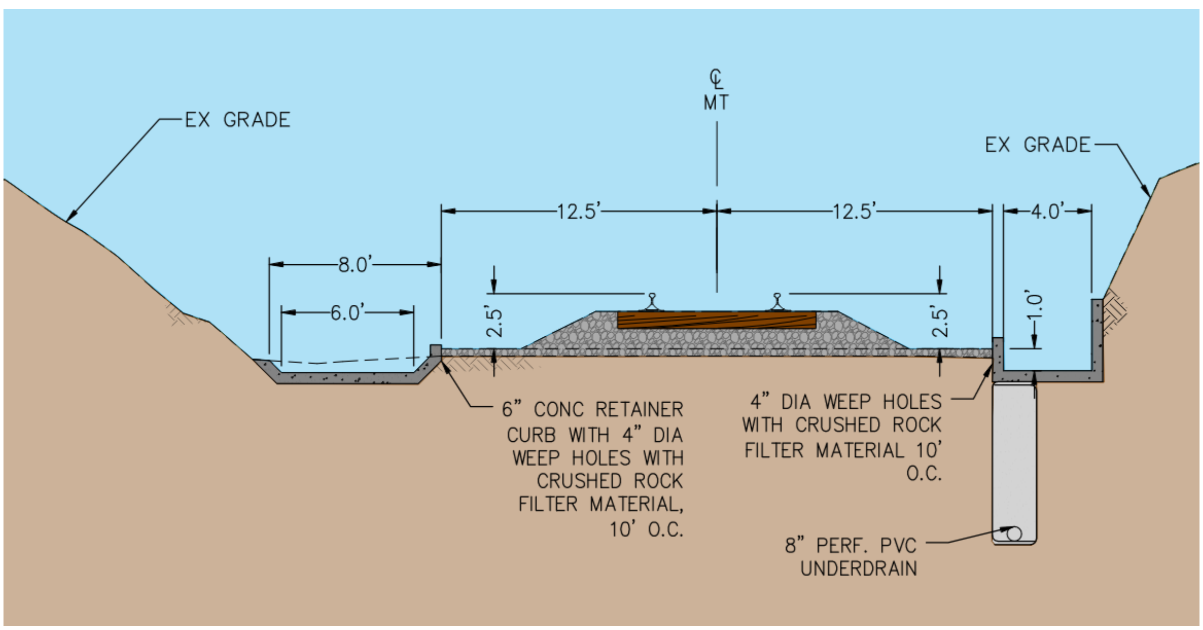

Figure 32 **– Drainage Area 6 Section**

Alternatives Considered

Replacement of the existing 6-inch PVC storm drain with a larger pipe at a steeper slope with an outlet to the existing beach outlet at Sea Orbit Lane was considered. A larger and steeper pipe could convey runoff more efficiently without clogging; however, there is not adequate width on the east side of the track to construct a larger and deeper system without impacting the existing fiber-optic utilities. In addition, the existing storm drain structure east of the track is not deep enough to outlet the proposed underdrain.

3.3.7. DRAINAGE AREA 7 – 9TH STREET, MP 244.64 TO 244.71, EAST OF THE TRACKS

Existing Conditions

Runoff from upstream drainage basins east of Camino Del Mar concentrate in 9th Street and flow toward the railroad right of way. There are no existing underground storm drains. Roadway and gutter flow concentrate along the southerly gutter. The public street narrows near the railroad right of way and sheet flows into a channel that continues southerly toward the 8th Street storm drain system. A rock seat wall was constructed at the end of 9th Street to prevent bypass of flow directly into the railroad right of way, see ***Figure 33*** below. Higher flows pond at the end of the roadway before flowing southerly to the existing channel. Ponding of floodwaters has caused seepage under the rock wall and erosion of the slope to the west. Slope stabilization and pavement repairs were constructed as part of the Del Mar Bluffs 4 Project to restore the existing slope and direct surface runoff behind the wall back to the channel to the south. Continued ponding of surface runoff at the end of 9th Street may cause similar damage in the future.

Figure 33 **– Photo of Existing Rockwall at 9th Street**

Proposed Improvements

Storm flows from 9th Street generally follow the southerly roadway cross slope during low intensity storm events. The existing channel entrance appears to be undersized resulting in a temporary ponding of runoff in the street during major storm events. Proposed improvements include widening and realigning the channel entrance to more efficiently move gutter and surface flows off the street and avoid ponding, see ***Figure 34*** below. The majority of the existing channel between 9th Street and 8th Street is in good condition and has adequate capacity to pass the unconstrained peak flow and will remain in place. Approximately 25 feet of the existing channel approaching the existing 8th Street storm drain inlet is in poor condition and would be replaced. Runoff from Shippey Lane sheet flows over the unprotected slope to the existing concrete channel. A new 4-foot wide by 1.5-foot deep concrete ditch would be constructed to convey the runoff and limit erosion. These drainage improvements would improve drainage and maintenance; however, a delay in completion would not likely contribute to a catastrophic failure; therefore, this area has been ranked as Medium Priority.

Figure 34 **– Drainage Area 7 Improvements**

Alternatives Considered

Addition of an underground storm drain system with inlets upstream from the street end was considered to more efficiently convey runoff and avoid ponding. Addition of an underground system would typically reduce street flow and help limit ponding. However, due to the steepness of the street and spread of flow, standard curb inlets would not provide for complete or efficient catchment of runoff at the end of the street. Improvement of the entrance to the channel was considered a more cost effective and a less impacting solution.

3.3.8. DRAINAGE AREA 8 – 8TH STREET, MP 244.7, EAST OF THE TRACKS

Existing Conditions

A major storm drain outlet to the beach was constructed at the end of 8th Street, MP 244.7, as part of the Del Mar Bluffs 1 Project. The new outlet provided a 36-inch diameter bypass storm drain system. Only very high storm flows are conveyed by the new system, so cleansing velocities do not occur regularly. The existing outlet is often buried by shifting sand and rock. The mid bluff headwall has been damaged by localized erosion. A temporary solution of adding overflow exit points to the existing headwall on the beach were constructed as part of the Del Mar Bluffs 4 Project.

Proposed Improvements

Several repairs to the existing structure are proposed to improve performance of the existing storm drain. The existing weir structure between the 42-inch and 36-inch pipes would be lowered to allow more regular flows and cleansing velocities in the 36-inch pipe. The existing outlet structure would be modified to raise the flowline elevation and allow peak flows to outlet without back up into the existing storm drain. A new outlet pipe would be added to connect the new underdrain from the trench area. The existing mid-bluff headwall from the older system would be repaired and extended to retain loose soil and prevent further erosion. New concrete lined trackside ditches would be constructed to convey runoff from the high point in the trench. A 5-foot wide by 2-foot deep concrete lined trackside U-ditch on the east and a 8-foot wide by 1 deep concrete lined trapezoidal ditch on the west are proposed, see ***Figure 35*** below. These drainage improvements would improve drainage and maintenance; however, a delay in completion would not likely contribute to a catastrophic failure; therefore, this area has been ranked as Medium Priority.

Figure 35 **– Drainage Area 8 Improvements**

Alternatives Considered

The proposed improvements are considered minor repairs that do not significantly change the existing conditions or impact the bluffs; therefore, no alternatives are considered.

3.3.9. DRAINAGE AREA 9 – 6TH STREET, MP 244.8 TO MP 245.1, WEST OF THE TRACKS

Existing Conditions

The segment of rail from Sta 1507+00 to 1513+00 is very flat with a maximum longitudinal slope of approximately 0.25%. The width between the track and top of bluff widens to more than 100 feet. The east side of the track collects flow from the track bed and the upper bluff. Significant storm flows are generated within the right of way and due to the flat longitudinal slope, runoff ponds on the east side of the track and runoff from the west side of the track flows over the top of the bluff to the beach below. Buildup of silt eroded from the upper bluff blocks the existing graded swale on the east side and further exacerbates ponding adjacent to the track. On the west side, deep gullies have formed where flow concentrates at the edge of the bluff. These gullies tend to migrate easterly and accelerate the localized rate of bluff retreat. Graded trackside ditches to the west are flat, fill with silt and become ineffective at controlling flow away from the top of the bluff.

Proposed Improvements – Drainage Area 9A

Proposed improvements include construction of a 5-foot wide by 2-foot deep concrete lined trackside U-ditch on the east to convey runoff and prevent flooding of the track and overtopping of the unprotected bluff. Approximately 650 feet of the easterly ditch would be constructed to flow north to the existing outlet at 8th Street following the existing track grade. Approximately 400 feet of the easterly ditch would be constructed to flow southerly following the existing track grade. See ***Figure 36*** below for the proposed improvements. The flow line of the existing concrete channel at MP 244.9 is above the existing ground elevation and would not be able to accept flow from the new channel. A new underground storm drain would be constructed to collect the ditch flow and convey it to the beach. The new storm drain outlet to the beach would be constructed using jack and bore methods of construction to avoid an open trench cut down to the face of the existing bluff. The jacking pit would be placed in the open area beyond the foul zone of the track. The new outlet to the beach would be constructed using a U-shaped outlet to dissipate energy similar to the existing outlet at MP 244.45. The new headwall would be finished with rockscape facing with texture and color to match the existing bluff. As previously mentioned, preventing flooding of the track and overtopping of the unprotected bluff are essential to protecting the bluffs from drainage failures; therefore, Drainage Area 9A has been ranked as High Priority.

Proposed Improvements – Drainage Area 9B

Proposed improvements include construction a 10-foot wide by 2 deep concrete lined trapezoidal ditch on the west side to convey runoff and prevent flooding of the track and overtopping of the unprotected bluff. Because of the existing width and topography, the westerly ditch alignment would vary relative to the existing track center to provide for steeper slopes with minimum cleansing velocities. The new westerly inlet would be lowered to accept the new ditch westerly flow line elevations. The improvements mentioned above would improve drainage and maintenance; however, a delay in completion would not likely contribute to a catastrophic failure, therefore Drainage Area 9B has been ranked as Medium Priority.

Figure 36 **– Drainage Area 9 Improvements**

Alternatives Considered

Construction of an open gunite down drain channel was considered in place of the underground storm drain outlet to the beach. The down drain would be excavated into the existing bluff. The gunite lining would be colored to match the existing bluff. Anchors would be constructed to secure the steep down drain structure. The down drain structure would blend with the shape and color of the existing bluff and the outlet to the beach would occupy less space than the U-shaped storm drain outlet structure. The concrete down drain would provide a hard surface down the face of the bluff which would be subject to increased erosion in case of overflow. While the underground storm drain would occupy more volume, the jack and bore method of construction allows the existing bluff face to remain intact and is considered the preferred solution. Erosion along the edge of the down drain would occur if the channel is overtopped or is surface flow.

3.3.10. DRAINAGE AREA 10 – SHERRIE LANE, MP 244.83 TO MP 245.02, EAST OF THE TRACKS

Existing Conditions

Existing upper bluff channels convey runoff from 6th Street and Sherrie Lane northerly to the 8th Street storm drain outlet and from 4th Street northerly to the existing down drain at MP 244.9. These existing channels appear to be in good condition and have adequate capacity to carry the tributary peak flows. Overtopping of the existing channels may occur at each of street intersections due to the momentum of intersecting flows. Inlets at 4th Street are undersized.

Proposed Improvements

Proposed improvements include splash walls on the existing channels at the ends of the streets where overtopping of the existing channels is likely to occur, and minor improvements to the surface swales at the street ends to reduce overflow and erosion, see ***Figure 37*** below. The existing inlets on 4th Street do not provide an adequate capacity due to low ground adjacent to the inlet that allows water to overflow into the rail right of way. A new concrete drainage channel will be added to direct overflow from the end of 4th Street to the existing concrete channel that flows norther. The site area withing the railroad right of way will be graded to direct water to the channel and protect the runoff protect against overtopping of unprotected slopes at this location. The improvements mentioned above would improve drainage and maintenance; however, a delay in completion would not likely contribute to a catastrophic failure, thus this Drainage Area 10 has been ranked as Medium Priority.

Figure 37 **– Drainage Area 10 Improvements**

Alternatives Considered

The inlet at the end of 4th Street is 16 feet long; however, it allows for bypass flows to erode the existing slopes during larger storm events due to lower ground on private property adjacent to the road. The existing inlet could be enlarged and lowered but some overflow would likely still occur due to the height of the existing box structure the inlet is connected to. The methods for controlling sheet flow as described above were considered less impacting to the community and therefore considered preferable.

3.3.11. DRAINAGE AREA 11 – 6TH STREET, MP 244.9, EAST OF THE TRACKS

Existing Conditions

The existing down drain structure that connects the upper bluff drainage channels to the lower bluff drainage channel was repaired over 20 years ago as part of the Del Mar Bluffs 1 Project. The original portion of the concrete down drain is showing signs of spalling and in need of repair.

Proposed Improvements

Proposed improvements would replace the down drain with a new concrete down drain structure, see ***Figure 38*** below. Due to the condition of the existing concrete structure, which is deteriorating, this Drainage Area 11 has been ranked as a Medium Priority.

Figure 38 **– Drainage Area 11 Improvements**

Alternatives Considered

This is replacement of an existing facility with a similar structure; therefore, no alternatives are considered.

3.3.12. DRAINAGE AREA 12 – 4TH STREET, MP 244.98 TO MP 245.06, WEST OF THE TRACKS

Existing Conditions

The segment of rail from Sta 1492+00 to 1513+00 is very flat with a longitudinal slope of less than 0.5%. There is an existing concrete lined channel on the east side of the track that collects runoff from the upper bluff and existing storm drain laterals. The existing channel provides adequate capacity for runoff tributary to the east side. The width on the west side from the track to topo of bluff widens to more than 100 feet. Significant storm flows are generated within the right of way and with the flat longitudinal slope, runoff from the west side of the track flows over the top of the bluff to the beach below. On the west side, deep gullies have formed where flow concentrates at the edge of the bluff. These gullies tend to extend easterly and accelerate the localized rate of bluff retreat. Graded trackside ditches to the west are flat, filled with silt and become ineffective at controlling flow away from the top of the bluff.

Proposed Improvements

Proposed improvements include construction of a 4-foot wide ditch, with a 2-foot wide flat bottom and 1 to 1 side slopes on the west side to convey runoff and control overtopping of the unprotected bluff, see ***Figure 39*** below. Because of the existing width and topography, the westerly ditch alignment would vary relative to the existing track center to provide for steeper slopes with minimum cleansing velocities. A new underground storm drain outlet to the beach would be constructed with the inlet elevation lowered to accept the new ditch westerly flow line elevations. The new storm drain outlet would be constructed using jack and bore methods of construction to avoid an open trench cut down to the face of the existing bluff. The jacking pit would be placed in the open area beyond the foul zone of the track. The new outlet to the beach would be constructed using a U-shaped outlet to dissipate energy similar to the existing outlet at MP 244.45. The new headwall would be finished with rockscape facing with texture and color to match the existing bluff.

The improvements described above would improve drainage and maintenance, particularly prevention of gullies along the bluff face; however, a delay in completion would not likely contribute to a catastrophic failure, thus this Drainage Area 12 has been ranked as Medium Priority.

***Figure 39* – Drainage Area 12 Improvements**

Alternatives Considered

Construction of an open gunite down drain channel was considered in place of the underground storm drain outlet to the beach. The down drain would be excavated into the existing bluff. The gunite lining would be colored to match the existing bluff. Anchors would be constructed to secure the steep down drain structure. The down drain structure would blend with the shape and color of the existing bluff and the outlet to the beach would occupy less space than the U-shaped storm drain outlet structure. The concrete down drain would provide a hard surface down the face of the bluff which would be subject to increased erosion in case of overflow. While the underground storm drain would occupy more volume, the jack and bore method of construction allows the existing bluff face to remain intact and is considered the preferred solution. Erosion along the edge of the down drain would occur if the channel is overtopped or is surface flow.

3.3.13. DRAINAGE AREA 13 – SOUTH OF 4TH STREET, MP 245.15, EAST OF THE TRACKS

Existing Conditions
The existing corrugated metal pipe down drain structure that connects the upper bluff drainage channels to the lower bluff drainage channel was repaired over 20 years ago as part of the Del Mar Bluffs 1 Project. The repair included a partial replacement of the existing corrugated metal pipe system. After 20 years the corrugated metal is showing signs of deterioration.

Proposed Improvements
Proposed improvements would replace the existing corrugated metal down drain with a new corrugated ABS material or other non-corrosive material that would provide a lightweight solution with better resistance to the marine environment, see ***Figure 40*** below. This improvement could be delayed until the future and not have any short-term effects; therefore, this Drainage Area 13 has been ranked as Low Priority.

Figure 40 **– Drainage Area 13 Improvements**

Alternatives Considered

Alternatives considered included replacement with a corrugated metal product, similar to existing, with protective coating added to extend service life. While this option would provide a light weight solution, the corrugated metal products would eventually corrode within a marine environment. Another option considered replacement using precast concrete components. While this option has benefits such as requiring only limited access during construction, the corrugated ABS material or similar non-corrosive lighter material would be preferred.

3.3.14. DRAINAGE AREA 14 – SOUTH OF ANDERSON CANYON, MP 245.39 TO 245.62, EAST OF THE TRACKS

Existing Conditions

The existing trackside ditch east of the track collects and conveys significant runoff from the upper bluffs. There is also a significant amount of seepage from the slope above the ditch. The ditch slope is approximately 1%. While the existing ditch slope would accommodate significant flow, erosion and mudslides regularly block the ditch causing ponding and flow over the track.

Proposed Improvements

Proposed improvements include construction of a 6 foot-wide by 1-foot deep trapezoidal ditch to improve capacity and provide additional factor of safety against blockage see ***Figure 41*** below. The channel bottom would be a 2-foot wide open articulated block with a sub drain just below the surface that would convey both storm water and subsurface drainage even if the ditch is blocked by debris. See ***Figure 42*** below. The open articulated block channel bottom width is sized sufficiently to act as a walkway, in order to avoid grading the steep slope or adding a retaining wall. The Delmar Formation is near the surface; therefore, a deep underdrain would not be warranted. The improvements described above would improve drainage and maintenance; however, a delay in completion would not likely contribute to a catastrophic failure, thus this Drainage Area 14 has been ranked as Medium Priority.

Figure 41 **– Drainage Area 14 Improvements**

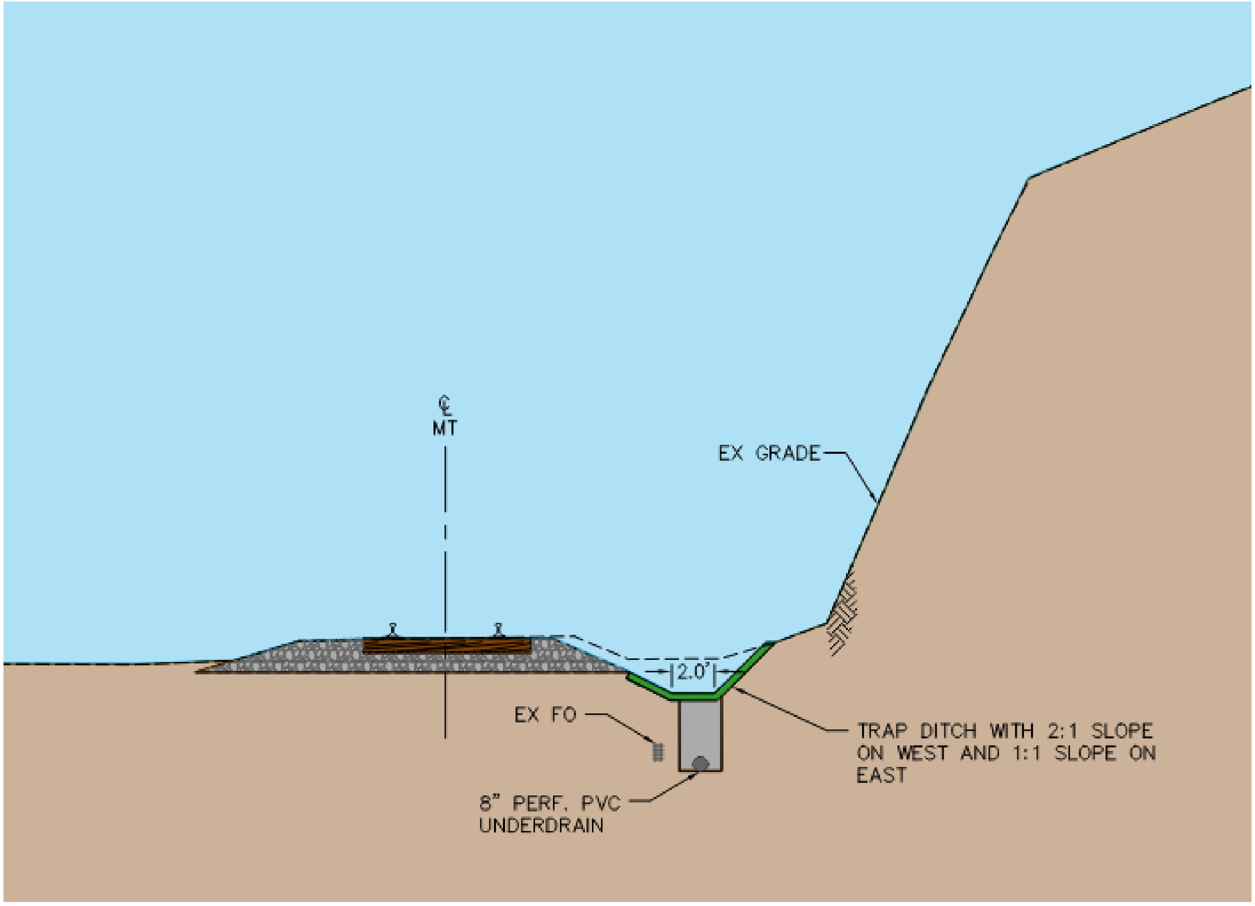

Figure 42**– Drainage Area 14 Section**

Alternatives Considered
Alternatives considered included a solid bottom channel; however, due to the presence of groundwater, the pervious solution is considered as preferred. Another alternative considered a separate walkway with a soft bottom channel, which required a soldier pile wall that would extend approximately 500 feet with an average height of 6 feet.

3.3.15. DRAINAGE AREA 15 – ANDERSON CANYON, MP 245.35 TO 245.37, EAST OF THE TRACKS

Existing Conditions: A concrete arch pipe drains Anderson Canyon from the east to west. The pipe is approximately 4.5 feet wide by 5 feet high. The pipe has significantly more capacity than needed to convey runoff from the upstream basin. The concrete pipe is in good condition; however signs of leakage are visible at the connection to the existing sea wall at the beach level.

Proposed Improvements
Proposed improvements would include repairing the existing arch pipe culvert to create a watertight connection to the existing sea wall at beach level. Repairs are proposed for the Anderson Canyon sea wall that include replacement of the existing fill with a lightweight fill. As part of this construction effort, the existing arch culvert should be inspected where uncovered and additional repairs if needed should be completed concurrently, see ***Figure 43*** below. This improvement could be delayed until the future and not have any short-term effects; therefore, this Drainage Area 15 has been ranked as Low Priority if they were to be completed independently from the Anderson Canyon Sea Wall.

Figure 43 **– Drainage Area 15 Improvements**

Alternatives Considered
These improvements are repairs to the existing system, therefore no alternatives were considered.

3.3.16. UNDERDRAINS

Existing Conditions
The geology of the Del Mar bluffs includes Old Paralic Deposits near the surface underlain by the much harder Delmar Formation. Surface runoff from the upstream development as well as irrigation water flow toward the railroad right of way. Water migrates through the Old Paralic Deposits until it reaches the denser Delmar Formation. Water flows along the contact line between the formations and exits through the face of the bluffs. Evidence of seepage is visible in many locations along the bluffs. Underdrains consisting of a perforated pipe and gravel trench have been constructed over the years to collect ground water and safely direct concentrated flows to a controlled outlet. The Del Mar Bluffs 1 Project constructed new underdrains and replaced underdrains constructed in the 1940s. For the underdrain to be effective the pipe and gravel bed should be constructed at least 6 inches into the Delmar Formation. Additional areas would benefit from construction of underdrains; however, the Delmar Formation is too deep in many areas for feasible construction of underdrains. In addition to depth constraints, utilities including a major fiber-optic backbone owned by Verizon/MCI, as well as the fiber infrastructure supporting positive train control have been constructed just east of the existing track. Conflict with the existing fiber-optic infrastructure limits the feasibility of adding underdrains and increase the associated construction cost.

Proposed Improvements
A total of four areas have been identified for addition of underdrains. ***Table 10*** below provides a summary of the proposed underdrain locations, along with the priority, as well as the trench depth and the outlet location.

Table 10 – Proposed Underdrain Locations

Priority	Begin Station	End Station	Pipe Diameter	Depth	Outlet
High	1544+00	1548+50	8-inch PVC	7 feet	Existing Storm Drain
Medium	1534+50	1537+00	8-inch PVC	15 feet	Existing Storm Drain
High	1518+00	1531+00	8-inch PVC	20 feet	Existing Storm Drain, New Storm Drain on the North and South and intermediate outlets to the beach
High	1469+50	1481+50	8-inch PVC	4 feet	New Surface Energy Dissipator

The three deeper underdrains would require shoring to construct the new systems. These underdrains would collect deep groundwater that is damaging the bluff face and convey it to existing controlled storm drain outlets. The shallow underdrain at the south end would be constructed under a proposed pervious bottom ditch. Significant seepage occurs from the bluffs to the east causing localized erosion and mudslides filling the existing earthen ditch. Because the

Delmar Formation is at or near the surface, the proposed drain would only be 4 feet deep. A pervious bottom ditch would be constructed over the drain to protect it from damage when ditches are cleaned. The underdrain would convey groundwater and surface water should the ditch be blocked by mud slides. These underdrains could be constructed as standalone projects if funding is limited, however for purposes of this assessment, the underdrains would be constructed concurrently with the drainage improvements described in the section above.

Between Station 1518+75 and Station 1528+85, significant groundwater seepage has been observed in the face of the bluff within this area, which is a significant factor influencing slope stability as it accelerates the degradation of the bluff and bluff face erosion. The construction of underdrains and a gravel trench using an open trench construction method would require shoring. The underdrains would consist of a perforated pipe and gravel trench to collect ground water and safely direct concentrated flows to a controlled outlet. For the underdrain to be effective the pipe and gravel bed should be constructed at least 6 inches into the Delmar Formation. Constraints for the construction through an open trench method include depth of the Del Mar formation (20 feet), utilities including a major fiber-optic backbone owned by MCI, as well as the fiber infrastructure supporting positive train control have been constructed just east of the existing track. Conflict with the existing fiber-optic infrastructure limits the feasibility of adding underdrains and increases the associated construction cost. Design options are being further evaluated based on costs, constructability, access, and ease of construction.

Alternatives considered include the construction of a cutoff wall to create an impermeable barrier to retain or stop the flow of groundwater seepage along the Bay Point Formation and Delmar Formation contact, and to provide controlled drainage outlets to the beach. The proposed cutoff wall would be located on the east side of the railroad tracks and constructed using drilled auger cast piles in a secant configuration. The blocked groundwater (i.e., mounding up behind the cutoff wall) will then be drained by several drywells located immediately up gradient of the cutoff wall, and the collected groundwater will be drained to the beach.

Both options listed above for the underdrains located between Station 1518+75 and Station 1528+85 are being further evaluated during the design process.

The existing subdrain outlet around Station 1503+68 which drains to the beach, north of 4th Street, will require stabilization.

3.4. DESCRIPTION OF PROPOSED MINOR IMPROVEMENTS

3.4.1. ACCESS ROADS

Existing Conditions

A series of graded roads provides access to the trackbed for maintenance activities. Many of the access roads show signs of siltation and erosion. A major gulley has bisected the access road near Anderson Canyon. Repair of this gulley was constructed as part of the Del Mar Bluffs 4 Project.

Proposed Conditions

Improvements include regrading the existing access roads at the south end of the corridor as shown on the Permitting Plans in Appendix A. A 6-inch DG surfacing would be added to improve stability while still maintaining the pervious surface.

Alternatives Considered

Repair of the existing access roads is considered a minor improvement to maintain service the already exists, therefore alternatives were not considered.

4. GEOTECHNICAL EVALUATION

This section summarizes the geotechnical studies for the Del Mar Bluffs Stabilization Project 5, prepared by Leighton Consulting, Inc, which includes the following documents:

1. 2020 Geotechnical Design Report (30% Design): This report provides an assessment of the general geotechnical conditions and geologic hazards within the limits of the proposed project site and geotechnical recommendations for the design of the proposed stabilization improvements.
2. 2020 Retrofit Evaluation Report: This report provides an assessment of the geotechnical conditions for the existing Soldier Pile stabilization areas performed under previous projects and geotechnical recommendations for the retrofit design.
3. 2021 Memorandum – Update for Geotechnical Design Report (30% Design): This memorandum provides an updated recommendation for the design bluff retreat (utilizing 0.4 feet/year south of 4th Street), revised ranking matrices for the new stabilization and retrofit areas and recommendations for bluff toe and bluff face stabilization and upper bluff improvements.

4.1. METHODS OF EXPLORATION

4.1.1. SITE RECONNAISSANCE AND AERIAL PHOTO REVIEW

A geotechnical evaluation of the site conditions for the project was performed by Leighton Consulting, Inc. Initial site reconnaissance for Project 5 was made on February 18, 2020, which was followed up by site visits on March 19, 2020, April 4, 2020 and January 19, 2021 to observe specific site areas for the proposed repairs and stabilization measures. To supplement the field reconnaissance, a review of aerial photographs was performed.

4.1.2. SUBSURFACE EXPLORATION

Several phases of field investigations, geologic mapping, and numerous exploratory borings have been incorporated in order to evaluate the site's pertinent soil and geologic conditions and develop the site geotechnical maps (Plates 1 through 7) and geologic cross sections (Plates 8 through 11) used for slope stability analysis. See Appendix B for the Geotechnical Design Report. For previous exploration borings, please refer to the Geotechnical Reports (Leighton, 2002b, 2003 and 2018).

4.1.3. AERIAL DRONE FLIGHTS

Several aerial drone flights were flown from the beach outside of the railroad right-of-way on June 24, 2020 to video document the bluff face. The drone flights ranged in altitude between 100 and 130 feet above mean sea level in order to provide an appropriate field of view angle to the bluff face, and were focused on the top of the bluff, seepage areas and areas of recent movement in the bluff face.

4.2. SITE AND SUBSURFACE CONDITIONS

The following sections present the findings relative to regional and site geology, faulting, bluff retreat and groundwater.

4.2.1. REGIONAL GEOLOGIC SETTING

The site is located in the coastal section of the Peninsular Range Province, a geomorphic province with a long and active geologic history throughout Southern California. The Peninsular Ranges are also traversed by several major active faults. The Whittier-Elsinore, San Jacinto, and the San Andreas faults are major active fault systems located northeast of the site and the Rose Canyon, Newport-Inglewood (offshore), Coronado Bank, and San Diego Trough are active faults located to the west-southwest. Major tectonic activity associated with these and other faults within this regional tectonic framework is right-lateral strike-slip movement. These faults, as well as other faults in the region, have the potential for generating strong ground motions at the project site.

4.2.2. SITE GEOLOGY

The site is underlain by sandy permeable materials of the Quaternary-aged Bay Point Formation (i.e. Old Paralic Deposits as mapped by Kennedy and Tan, 2008) which overlie the generally dense sandstones (Tdss) and relatively impermeable siltstones and claystones (Tdcs) of the Eocene-aged Delmar Formation (see Geotechnical Map – Plates 1 through 7). The Delmar Formation also includes localized permeable zones related to sandy lenses and sandy paleo channel infill deposits, and dense resistant layers. The extent and elevations of these dense layers have been better defined by observations during construction activities of Projects 1, 2, 3 and 4, and the supplemental field mapping activities near the base of the bluff. The Eocene-aged Torrey Sandstone can be observed just east of the track in the southern portion of the site and within Anderson Canyon. This unit is shown on the geologic maps and cross sections but does not underlie the rail alignment.

4.2.3. BLUFF RETREAT

As discussed in the Geotechnical Study (Leighton, 2001a), average bluff retreat rates in the study area are estimated at a maximum of 0.4 to 0.6 feet per year. This average rate of bluff retreat has historically been accepted by the California Coastal Commission as the accepted average rate of bluff retreat for the region. This corresponds to a retreat of approximately 25 feet in the project's 50-year design life (i.e., trackbed stabilization measures), assuming that the bluff will retreat at an average rate of 0.5 feet per year for the next 50 years. Bluff retreat is typically episodic with no retreat for some time and then several feet or more occurring in one event.

Aerial and ground topographic surveys have been complete for the bluffs for all of the major projects. Aerial topographic surveys for the entire site were complete in 1995, 2009 and 2018. Additional field ground surveys were completed for the stabilization area in 2009, 2018 and 2020. A comparison of the survey data over time was reviewed for assessment of the actual bluff retreat along the bluffs. The data is summarized in a Technical Memorandum included in Appendix C.

As expected, the results of the assessment show that the retreat is not uniform along the length of the bluff consistent with the anticipated block failures. Several hundred feet of bluff may show little or no retreat with shorter segments experiencing significant retreat. In general, more significant retreat has occurred in the trench area compared to the northerly and southerly segments of the bluff. The areas of retreat are generally fall within the predicted rates of 0.4 feet to 0.6 feet per year.

4.2.4. SURFACE AND GROUNDWATER

Groundwater is a major factor influencing slope stability as it accelerates the degradation of the bluff and bluff face erosion. The majority of the groundwater is located in a perched horizon at the base of the Bay Point Formation with additional localized zones of groundwater within near-vertical fractures and joints and sandy channel infills of the Delmar Formation. Near-vertical fractures and joints within the Delmar Formation near the bluff face, create potential pathways for migration of groundwater throughout the bluff and the right-of-way. Groundwater can also be observed as numerous localized seeps in the exposed bluff face with additional seepage zones likely masked by dense vegetation or loose surficial soils. Fluctuation in groundwater levels within the near-surface soils and weathered and fractured material near the bluff face is also anticipated after periods of heavy rainfall resulting in additional seepage zones and a temporary increase in seepage.

4.3. SEISMICITY AND GEOLOGIC HAZARDS

4.3.1. FAULTING

The subject site is not located within any State mapped Earthquake Fault Zones. The principal source of seismic activity is movement along northwest-trending regional fault zones such as the San Andreas, San Jacinto and Elsinore Faults Zones, as well as along less active faults, such as the Newport-Inglewood Fault Zone. There are no known major or active faults on or in the immediate vicinity of the site. The nearest known active fault is the Rose Canyon Fault Zone. That fault is oriented north-south and roughly parallels the rail alignment. The fault is located offshore (west) and the distance to the fault alignment varies from 2.3 miles at the southern project end to 2.4 miles at the northern project end.

4.3.2. SEISMIC DESIGN CONSIDERATIONS

The site can be considered to lie within a seismically active region, as can all of Southern California. Ground shaking for consideration in design of railroad facilities and infrastructure should be in accordance with the SANDAG Design Criteria Vol III LOSSAN Corridor in San Diego County (2016). In summary, three levels of seismic ground motion are to be considered in design. The return intervals of the design seismic event correspond to the 93-year, the 320-year, and the 2,190-year seismic events. These events correspond to the bridge performance criteria for the Serviceability, Ultimate, and Survivability Limit States.

4.3.3. SECONDARY SEISMIC HAZARDS

In general, secondary seismic hazards for sites in the region could include soil liquefaction, earthquake-induced settlement, lateral displacement, surface manifestations of liquefaction, landsliding, and seiches and tsunamis. These potential secondary seismic hazards are discussed below.

a. Shallow Ground Rupture -
   No active faults are mapped crossing the site or projecting toward the site, and the site is not located within a mapped Alquist-Priolo Earthquake Fault Zone. Because of the lack of known active faults at the site, the potential for fault surface rupture at the site is considered low.
b. Liquefaction -
   Liquefaction and dynamic settlement of soils can be caused by strong vibratory motion due to earthquakes. Due to the relatively dense nature of the underlying formational materials, the potential for liquefaction and dynamic settlement of the site are considered nil.
c. Tsunamis and Seiches -
   Based on reviews of currently published Tsunami Inundation Maps for Emergency Planning, State of California, County of San Diego, Del Mar Quadrangle, published June 1, 2009, the project site is not subject to hazards associated with a tsunami, excluding the proposed storm drain outlets or headwall structures at the toe of the bluff on the beach.

4.4. **GEOTECHNICAL ANALYSIS AND DESIGN CONSIDERATIONS**

The following section summarizes the analysis of geotechnical conditions influencing the design. Design recommendations developed from the evaluation of the geotechnical considerations are also included in the following sections.

4.4.1. TRACKBED SUPPORT STABILIZATION AREAS

Slope Stability

Twenty (20) idealized models were developed using the proposed cross-section profile, and soil strengths derived from laboratory test results, field observations, and professional judgments. The following minimum factors of safety (FS) were used based on previous established criteria (Leighton, 2003 and 2010):

- Static Analysis with a train surcharge loading: FS = 1.5
- Pseudo-Static (Seismic) Analysis with a seismic coefficient of 0.15: FS = 1.15
- Pseudo-Static (Seismic) Analysis with a seismic coefficient of 0.28: FS = 1.00

The results of this analysis indicate that:

- 7 of the 20 sections analyzed have a factor of safety less than 1.5 for a static condition with a train surcharge load.
- 6 of the 20 cross sections analyzed have a factor of safety less than the minimum acceptable parameter for a seismic coefficient of 0.15 (i.e., FS=1.15), for pseudo static (seismic) conditions
- 11 of the 20 cross sections analyzed were less than the minimum acceptable parameter for a seismic coefficient of 0.28 (i.e., FS=1.00).

For the purposes of prioritizing areas to stabilize, the higher seismic coefficient of 0.28 was used. The cross sections that have one or more factors of safety less than the minimum acceptable parameters defined previously are the areas that should be considered the first priority for stabilization. As previously noted, the impacts of additional bluff retreat were not included in the slope stability analysis.

Stabilization Area Priority

Based on the slope stability analyses, several “Stabilization Areas” were identified. In general, the limits of the stabilization areas were determined based on the slope stability analysis (areas having less than the minimum acceptable parameters or factor of safety) and similar geotechnical and topographic conditions. The Stabilization Areas are numbered with SANDAG’s identification numbers (e.g., SA21). In addition, each area is assigned a priority ranking to assist in prioritizing the areas for construction, based on evaluation of track to top of bluff distances, factors of safety (static and seismic), estimated bluff retreat, exposed geologic units, existing failures, drone flight observations, exposed seepage, and existing improvements. ***Table 11*** provides a summary of the currently recommended prioritization for the stabilization areas and the approximate lengths of the areas. The table also includes the locations of proposed seawalls and surface stabilization. The Phase I seawalls are prioritized at locations where the seawalls would provide the maximum benefit and stabilize the trackbed for 30-year bluff retreat, while the Phase II seawalls are required to extend the service life of trackbed stabilizations beyond 30 years, to protect against 50-year bluff retreat, and would be constructed as a future phase at remaining locations based on priority and funding availability. The priority ranking level (i.e., Low, Medium and High) for the new stabilization areas are based on factors of safety, distance of the existing pile from bluff face, bluff retreat rate, steepness of bluff face, geologic unit, presence of existing failures, field observations, review of survey data, and drone flight videos. The risk matrix for new stabilization area prioritization is provided in Appendix B.

Table 11 – Stabilization Area Priority			
Stabilization Area	**Trackbed Stabilization Priority Ranking**	**Existing or Proposed Seawall to Protect Against 30 year and 50 year Bluff Retreat**	**Proposed Surface Stabilization**
SA16	Low	Phase I	X
SA21	High	Phase I	X
SA20	High	Phase I	X
SA23	Med	Existing	X
SA24	Med	-	-
SA22	Med	-	-
SA3	Low	Phase II	-
SA15	High	Phase II	-
SA5	High	Phase II	-
SA14	Low	Phase II	-
SA13	Low	Phase II	-
SA6N	Low	Existing	X
SA12	Med	Phase I	-
SA8	High	Repair of Existing Seawall	X
SA11	High	Phase II	-
SA9	High	Phase II	-
SA10	Low	Phase II	-

The current total recommended length of stabilization is 3,544 feet. The total length of the study area is 1.6 miles (8,450 feet). For the “Trench” area (SA22 and SA24), slope grading should be considered as part of preserving trackbed support, and to provide public safety along beach. Slope grading would generally consist of removal of upper material from the existing bluff (west of the trackbed) down to a near trackbed elevation.

Stabilization Piles

In general, bluff top stabilization with the installation of a soldier pile wall system within the right-of-way is recommended to preserve trackbed support for new stabilization areas. This stabilization method is consistent with methods used in Projects 2, 3 and 4 (Leighton, 2003, 2010 and 2018). Soldier piles can also incorporate, as needed, tiebacks and grade beams. In addition, if the tops of the soldier piles become exposed over time, lagging can be added to modify the system through the recommended lifetime. Exposed areas can be “rock scaped” as desired to match the surroundings.

Tiebacks

Design anchor bond capacities for tiebacks are between 500psf and 1,000psf, and are provided for consideration by the structural designer in the design process. Actual capacities will likely vary due to materials and construction methods. The specialty contractor responsible for design of the tiebacks should make an independent assessment of the capacity considering soil conditions, material used to construct the tiebacks, and installation methods. The design, construction, testing and inspection of all tiebacks are recommended to conform to the methodology of the Post-Tensioning Institute (PTI). Tie-back anchor strands should be designed such that less than ¼ inch of elongation is required to mobilize the full design resisting load.

Bluff Toe and Bluff Face Stabilization

Bluff toe protection (i.e., Sea Walls with a top elevation of 15 feet) is considered as a feasible means of protecting the base of the bluffs from erosion and can be more readily removed if the track is relocated in the future. In general, toe protection provides longer term preservation and stability of the bluffs and track structure and can reduce the rate of bluff retreat towards the track. Sea walls are envisaged at locations where piles are installed for trackbed stabilization, to prevent the lower portions of the piles from becoming exposed and destabilized. In addition to the sea walls, grading of the bluff face will be performed at some locations, which consists of placing compacted fill soil at a slope ratio of 1.5:1. The surface of the fill slope will be stabilized with engineered fabric reinforcement, and revegetated. The locations of the proposed sea walls are shown in Appendix A.

Pile Installation

All pile installation should be performed under the observation of Leighton Consulting, Inc. and be consistent with standard practice. Where the Delmar Formation is encountered, drilling equipment should be powerful enough to drill through the overlying fill soils and into the dense to very dense formational material to the design penetration depths. Where saturated soil or beach deposits are present, casing should be provided. Once a pile excavation has been started, it should be completed within 8 hours, which includes inspection, placement of the reinforcement, and placement of the concrete. Adjacent piles should not be excavated before sufficient setup of the concrete has been attained.

Localized groundwater as seepage may occur in the pile excavations and if present should be dewatered prior to placing the concrete. If excavations are filled with water or drilling mud, concrete must be placed through a tremie pipe extending to the bottom of the pile excavation. Caving of friable, soft or loose soils may occur where open excavations are made. In addition, the contractor should also be prepared to employ casing or other methods of advancing the drilled pile excavation to mitigate caving, as needed.

4.4.2. TRACKBED SUPPORT RETROFIT AREAS

Thirty-six (36) cross-sections within existing Soldier Pile stabilization areas were geotechnically evaluated for retrofitting. Track to top of bluff distances, year of remaining design life, exposed geologic unit, existing failures, drone flight observations, exposed seepage, and existing improvements were used in prioritizing potential retrofit measures. The cross-sections within existing Soldier Pile stabilizations were assessed with an applied project bluff retreat rate of 0.5 feet per year for a 30-year and 50-year design life (approximately 15 feet and 25 feet, respectively) to further assess and/or selecting potential retrofitting methods. In addition, seawalls and surface stabilization are proposed at locations, where needed, to prevent the lower portions of the existing piles from becoming exposed and destabilized.

Table 12 below presents the priority ranking level (i.e., Low, Medium, High and Very High) for the proposed retrofitting of existing Soldier Pile stabilizations at thirty-two (32) areas. The table also includes the locations of proposed seawalls and surface stabilization. The Phase I seawalls are prioritized at locations where the seawalls would provide the maximum benefit and stabilize the trackbed for 30-year bluff retreat, while the Phase II seawalls are required to extend the service life of trackbed stabilizations beyond 30 years, to protect against 50-year bluff retreat, and would be constructed as a future phase at remaining locations based on priority and funding availability. The priority ranking level (i.e., Low, Medium and High) for the retrofit areas are based on factors of safety, remaining service life, distance of the existing pile from bluff face, bluff retreat rate, steepness of bluff face, geologic unit, presence of existing failures, field observations, review of survey data, and drone flight videos. The risk matrix for retrofit priority evaluation is provided in Appendix B.

Table 12 – Retrofit Area Ranking

Retrofit Area	Trackbed Retrofit Ranking	Existing or Proposed Seawall to Protect Against 30-year and 50-year Bluff Retreat	Proposed Surface Stabilization
DMB2 (SN5) Pile 33 to 38	Medium	Phase I	X
DMB2 (SN5) Pile 24 to 32**	High	Phase I	X
DMB2 (SN5) Pile 1 to 23**	High	Phase I	X
DMB2 (SN7N)	Medium	Phase I	X
DMB2 (SN7S)**	Low	Phase I	X
DMB3 (SP1)*	Medium	Phase I	X
DMB2 (SN3) Pile 15 to 19	High	Ex	X
DMB2 (SN3) Pile 1 to 14	High	Ex	X
DMB2 (SN1N)	High	Phase I	X
DMB2 (SN1S) Pile 14 to 29*	Medium	Phase I	X
DMB2 (SN1S) Pile 6 to 13	High	Ex	X
DMB2 (SN1S) Pile 1 to 5	High	Ex	X
DMB2 (SN2)	High	Ex	X
DMB4 (Pile 1 to 3)	Medium	Ex	X
DMB3 (SP2) Pile 17 to 23	High	Ex	X
DMB3 (SP2) Pile 6 to 16	Medium	Phase I	X
DMB3 (SP2) Pile 1 to 5	Low	Phase I	X
DMB2 (SN6) Pile 7 to 10	Medium	Phase I	X
DMB2 (SN6) Pile 1 to 6**	High	Phase I	X
2001 Emergency Repair	High	Phase I	X
DMB3 (SP3) Pile 13	Low	Ex	X
DMB3 (SP3) Pile 5 to 12	Low	Ex	X

Table 12 – Retrofit Area Ranking			
Retrofit Area	**Trackbed Retrofit Ranking**	**Existing or Proposed Seawall to Protect Against 30-year and 50-year Bluff Retreat**	**Proposed Surface Stabilization**
DMB3 (SP3) Pile 1 to 4	Low	Phase I	X
DMB3 (SP5)	Medium	Phase I	-
DMB3 (SP6) Pile 7 to 14	Medium	Phase I	-
DMB3 (SP6) Pile 1 to 6	High	Phase I	-
DMB3 (SP7)	High	Phase I	-
DMB3 (SP4) Pile 6 to 10	Low	Phase I	-
DMB3 (SP4) Pile 3 to 5	Low	Phase I	-
DMB3 (SP4) Pile 1 to 2	Low	Phase I	-
DMB2 (SN8) Pile 12 to 13	Low	Phase I	-
DMB2 (SN8) Pile 1 to 11	Medium	Phase I	-

5. ENVIRONMENTAL CONSIDERATIONS

Each of the potential bluff stabilization and drainage measures could affect environmental resources along the Del Mar Bluffs with the level of potential effect varying depending on the type of bluff stabilization utilized, drainage improvement proposed and the specific location(s) along the bluff. Consequently, an evaluation of environmental considerations is conducted based on visual resources, noise, prehistoric archaeological and historic resources, paleontological resources, biological resources, recreation and coastal processes because these are environmental resource or issue areas with the potential to either constrain and/or be affected by implementation of potential bluff stabilization measures. The discussion of environmental considerations is followed by a description of environmental regulatory approvals that could be required for the alternative bluff stabilization measures. In order to quantify the evaluation, the following metrics are applied:

- Best or Lowest Potential Impact
- Mid-Level or Moderate Potential Impact
- Worst or Highest Potential Impact

Note that where effects would likely be similar between alternative measures, more than one measure may be rated as best, mid-level or worst within a given category. The evaluation at the end of this section provides a summary of the evaluation results in a tabular format.

5.1. VISUAL RESOURCES

5.1.1. TRACKBED SUPPORT STABILIZATION IMPROVEMENTS

Construction of Improvements at the Bluff Top in Conjunction with Bluff Toe and Bluff Face Stabilization

Trackbed stabilization improvements entail the installation of soldier piles, tiebacks and lagging in areas along the bluffs identified as priority stabilization areas (SA) that were not implemented in previous phases. For soldier pile improvements, the structural elements installed would be almost completely below grade (i.e., underground), with limited surface visibility. In addition, concrete would be colored to help match the color of the existing bluffs, and native material would be used to backfill holes and trenches not filled with concrete, further helping to minimize the visibility of the solider piles and grade beams. The portion of a soldier pile wall that might be visible would be the tops of the piles or the grade beam. In most areas, these would be at or close to the existing ground level, leaving only the very top of the piles or grade beam exposed. In some locations, up to approximately five feet of the concrete grade beam might be exposed on its west side.

Views to the top of the soldier pile wall from inland areas (such as public streets or private yards) would be intermittent. Although the tops of the piles or grade beam could be potentially visible from these areas, they would not draw viewers' attention because the soldier pile wall would be parallel to the existing railroad tracks (which include the rails, ties, and ballast rock) and because most views would be directed toward the beach and/or ocean, not the NCTD ROW. Views to the top of the soldier pile wall from residences/back yards inland of the ROW would, for the most part, be obstructed by intervening topography. Views from these residences/back yards would also primarily be directed toward the ocean, not the railroad ROW.

The tops of piles or the grade beam may be visible by passengers on passing trains (such as Pacific Surfliner or the Coaster), but only for extremely short periods of time (if at all) for any given passenger and probably only for passengers on the trains' lower levels. With regard to beachgoers, the potential for views to soldier pile walls would depend on the specific stabilization site and the bluff topography between that site and the beach. In general, however, views from the beach to the top of the soldier pile wall would be obstructed by topography.

Bluff toe improvements and bluff face stabilization would be included on a site-specific basis. As shown in ***Table 13***, lagging and additional tiebacks needed would be reduced with the addition of bluff toe and bluff face stabilization measures. This approach would minimize the depth of visible lagging. However, this option would change the visual character of the bluff where regrading and revegetation are proposed, and where seawalls are proposed at the bluff toe. Overall, this option would have a mid-level potential visual resources effect.

Table 13 – Summary of Lagging Needs with and without Bluff Toe and Surface Stabilization Improvements for New Stabilization Areas

Stabilization Area (SA)	Trackbed Stabilization Priority Ranking	Existing or Proposed Seawall to Protect Against 30-yr and 50-yr Bluff Retreat	Proposed Surface Stabilization	Bluff Top Improvements Only		Bluff Top Improvements in Conjunction with Bluff Toe and Bluff Face Stabilization	
				Depth of Lagging (30 years) (ft)	Depth of Lagging (50 years) (ft)	Depth of Lagging (30 years) (ft)	Depth of Lagging (50 years) (ft)
SA16	Low	Phase I	X	0	15	0	5
SA21	High	Phase I	X	15	25	5	5
SA20	High	Phase I	X	20	35	5	5
SA23	Med	Ex	X	5	10	5	5
SA3	Low	Phase II	-	0	0	0	0
SA15	High	Phase II	-	0	5	0	0
SA5	High	Phase II	-	5	15	5	5
SA14	Low	Phase II	-	0	0	0	0
SA13	Low	Phase II	-	0	0	0	0
SA6N	Low	Ex	X	0	0	0	5
SA12	Med	Phase I	-	5	10	0	5

Table 13 – Summary of Lagging Needs with and without Bluff Toe and Surface Stabilization Improvements for New Stabilization Areas							
				Bluff Top Improvements Only		**Bluff Top Improvements in Conjunction with Bluff Toe and Bluff Face Stabilization**	
Stabilization Area (SA)	**Trackbed Stabilization Priority Ranking**	**Existing or Proposed Seawall to Protect Against 30-yr and 50-yr Bluff Retreat**	**Proposed Surface Stabilization**	**Depth of Lagging (30 years) (ft)**	**Depth of Lagging (50 years) (ft)**	**Depth of Lagging (30 years) (ft)**	**Depth of Lagging (50 years) (ft)**
SA8	High	Repair Ex Seawall	X	15	15	5	5
SA11	High	Phase II	-	5	10	5	5
SA9	High	Phase II	-	0	10	0	5
SA10	Low	Phase II	-	0	15	0	5

Trench Grading

Proposed stabilization improvements within SA 22 and SA 24 entail removing the existing berm and reduce the hazard for falling rock and mudslide to beach below. Although the views of the bluff could potentially be altered by the removal of the berm, the views would be similar to the existing condition, and a different part of the bluff would be visible. This approach would have some potential disturbance on the bluff face and would therefore have mid-level potential visual resources effect.

Alternatives Considered

Construction of Improvements at the Bluff Top Only

Construction of improvements at the bluff top only, would require disturbing more of the bluff to place the deeper lagging and secondary tiebacks. A subdrain would be added and the excavation would be backfilled to restore the bluff. Depending on the location and the depth of the replaced fill, the slope would be somewhat weakened with a slightly faster rate of retreat in that zone. This approach would have a greater disturbance on the bluff face, and would result in more visible exposure of lagging, and would therefore have the highest potential visual resources effect.

Soil Cement Buttress Alternative

The soil cement buttress would result in a manufactured slope that could be treated or landscaped. For this project, it is assumed that the soil cement buttress would be landscaped with native material using a pipe and board system to retain the topsoil. The extent of visual resource impacts associated with this measure would depend on the specific bluff section being stabilized. Where man-made structures are present and the pre- and post-construction slope profiles are similar, the use of a soil cement buttress may have a minor visual impact. In areas where the slope is steep (e.g., areas of near-vertical exposed sandstone) and few or no man-made features are present, the change to the bluff’s appearance could be considered dramatic. This type of major structural change to the bluff potentially may be found not consistent with California Coastal Act policies calling for development to “minimize the alteration of natural land-forms” (Article 6, Section 30251). Based on the potential for major changes in the appearance of the bluffs, this stabilization method is assessed with having the highest potential visual resources effect.

Soil Nail Reinforcement Alternative

Soil nails and the associated structural facing would alter the appearance of the affected bluff sections. Although treatments can be applied to help the grout around soil nails and associated facing material blend in with the natural surroundings, some (and potentially most) soil nails would still be detectable to viewers on the beach. Views to the soil nails from inland of the tracks would be extremely limited due to the topography of the bluffs. Over time, erosion of the bluffs could lead to soil nails and grout extruding from the bluff and/or the facing material being separated from the bluff by gaps. This would reduce the chances that the soil nails would blend in with the surrounding natural sections of the bluff face. The installation of soil nails and associated facing could potentially conflict with California Coastal Act policies regarding the alteration of natural landforms. Based on these factors, this stabilization method is assessed with having the highest potential visual resources effect.

5.1.2. TRACKBED SUPPORT RETROFIT IMPROVEMENTS

Construction of improvements at the Bluff Top in Conjunction with Bluff Toe and Bluff Face Stabilization

Trackbed support retrofit improvements entail installation of lagging and/or tieback anchors in areas that were previously stabilized as part of Del Mar Bluffs Stabilization 2 and 3 improvements. Tieback anchors are installed completely below the surface and no portions of them would be visible. Lagging on the exposed surface of soldier piles would consist of timber, precast concrete, or shotcrete. Bluff toe improvements and bluff face stabilization would be included on a site-specific basis. As shown in ***Table 14*** lagging and additional tiebacks needed would be reduced with the addition of bluff toe and bluff face stabilization measures. This approach would minimize the depth of visible lagging. However, this option would change the visual character of the bluff where regrading and revegetation are proposed, and where seawalls are proposed at the bluff toe. Overall, this option would have a mid-level potential visual resources effect.

Table 14 – Summary of Lagging Needs with and without Bluff Toe and Surface Stabilization Improvements for Retrofit Areas							
Stabilization Area (SA)	Trackbed Retrofit Priority Ranking	Existing or Proposed Seawall to Protect Against 30-yr and 50-yr Bluff Retreat	Proposed Surface Stabilization	Bluff Top Improvements only		Bluff Toe and Surface Stabilization in Conjunction with Bluff Top Improvements	
				Lagging (30-year) Bluff Retreat (ft)	Lagging (50-yr) Bluff Retreat (ft)	Lagging (30-yr) Bluff Retreat (ft)	Lagging (50-yr) Bluff Retreat (ft)
DMB2 (SN5) Pile 33 to 38	Medium	Phase I	X	5	30	5	5
DMB2 (SN5) Pile 24 to 32**	High	Phase I	X	30	30	5	5
DMB2 (SN5) Pile 1 to 23**	High	Phase I	X	30	30	5	5
DMB2 (SN7N)	Medium	Phase I	X	30	30	5	5
DMB2 (SN7S)**	Low	Phase I	X	10	10	5	5
DMB3 (SP1)*	Medium	Phase I	X	15	15	5	5
DMB2 (SN3) Pile 15 to 19	High	Ex	X	15	20	5	5
DMB2 (SN3) Pile 1 to 14	High	Ex	X	15	20	5	5
DMB2 (SN1N)	High	Phase I	X	25	40	5	5
DMB2 (SN1S) Pile 14 to 29*	Medium	Phase I	X	20	20	5	5
DMB2 (SN1S) Pile 6 to 13	High	Ex	X	30	30	5	5
DMB2 (SN1S) Pile 1 to 5	High	Ex	X	15	20	5	5
DMB2 (SN2)	High	Ex	X	20	25	5	5
DMB4 (Pile 1 to 3)	Medium	Ex	X	15	30	5	5
DMB3 (SP2) Pile 17 to 23	High	Ex	X	15	15	5	5
DMB3 (SP2) Pile 6 to 16	Medium	Phase I	X	10	30	5	5
DMB3 (SP2) Pile 1 to 5	Low	Phase I	X	0	0	5	5
DMB2 (SN6) Pile 7 to 10	Medium	Phase I	X	5	15	0	5
DMB2 (SN6) Pile 1 to 6**	High	Phase I	X	15	15	5	5
2001 Emergency Repair	High	Phase I	X	20	30	5	5
DMB3 (SP3) Pile 13	Low	Ex	X	10	15	5	5
DMB3 (SP3) Pile 5 to 12	Low	Ex	X	10	20	5	5
DMB3 (SP3) Pile 1 to 4	Low	Phase I	X	5	15	5	5
DMB3 (SP5)***	Medium	Phase I	-	20	25	10	15
DMB3 (SP6) Pile 7 to 14***	Medium	Phase I	-	10	20	0	15
DMB3 (SP6) Pile 1 to 6***	High	Phase I	-	20	25	5	15
DMB3 (SP7)***	High	Phase I	-	15	30	5	15
DMB3 (SP4) Pile 6 to 10	Low	Phase I	-	0	15	0	5
DMB3 (SP4) Pile 3 to 5	Low	Phase I	-	0	15	0	5
DMB3 (SP4) Pile 1 to 2	Low	Phase I	-	0	15	0	5
DMB2 (SN8) Pile 12 to 13	Low	Phase I	-	0	15	0	5

Table 14 – Summary of Lagging Needs with and without Bluff Toe and Surface Stabilization Improvements for Retrofit Areas							
				Bluff Top Improvements only		Bluff Toe and Surface Stabilization in Conjunction with Bluff Top Improvements	
Stabilization Area (SA)	Trackbed Retrofit Priority Ranking	Existing or Proposed Seawall to Protect Against 30-yr and 50-yr Bluff Retreat	Proposed Surface Stabilization	Lagging (30-year) Bluff Retreat (ft)	Lagging (50-yr) Bluff Retreat (ft)	Lagging (30-yr) Bluff Retreat (ft)	Lagging (50-yr) Bluff Retreat (ft)
DMB2 (SN8) Pile 1 to 11***	Medium	Phase I	-	15	30	5	15

For Blufftop only improvements
* 30-year design life not feasible with addition of lagging and tiebacks, secondary wall/inline piles required
** 50-year design life not feasible with addition of lagging and tiebacks, secondary wall required
For Bluff Toe and Surface Stabilization in Conjunction with Bluff Top Improvements:
*** Phase II (future) surface stabilization would eliminate the need for a second row of tieback anchors and additional depth of lagging to extend the service life of the trackbed stabilization to 50 years.

Alternatives Considered

Construction of improvements at the Bluff Top Only

Construction of improvements at the bluff top only, would require excavating 20 feet to 30 feet of the bluff to place the deeper lagging and secondary tiebacks. This approach would have a greater disturbance on the bluff face and would result in more visible exposure of lagging and therefore would have a high potential visual resources effect.

Construction of Secondary Walls/In-line Piles

Alternatives to installation of lagging and/or tieback anchors includes the installation of in-line piles or a secondary wall. Based on the limited impact to views due to in-line piles and secondary walls and the variety of measures that would be available to minimize the effects of exposed walls (if necessary), these alternatives are assessed with having low potential visual resources effect.

5.1.3. DRAINAGE IMPROVEMENTS

The Proposed Action includes the construction of a series of drainage improvements within the railroad ROW and at the bluff face on the beach including:

- New storm drain pipelines and outlets to the beach
- Concrete-lined trackside ditches
- Underdrains
- New/modified inlets to existing storm drain systems
- Concrete channels
- Splash walls
- New channel aprons
- New/modified drainage structures

Several of these facilities would be installed at grade (storm drain inlets, channel aprons, weir structures) or below grade (underdrains, storm drain pipelines) and thus, would either not be visible or would be surface features that would not be highly visible from surrounding areas. These improvements would be visually compatible with existing railroad infrastructure as they would not introduce new visual elements within the railroad corridor.

Similarly, the proposed trackside ditches and concrete channels are surface improvements and would not generally involve vertical elements or structures or other highly visual components. Small retaining structures constructed integrally with the channels would be required south of 15th Street and south of 11th Street. While additional concrete surfaces would be introduced, they would be at the ground level and generally adjacent to the railroad tracks and ballast. As such, they would be visually compatible with the existing rail infrastructure and not highly visible from surrounding areas.

Two segments of new concrete channel would require taller retaining structures. An approximately 300-foot long channel section south of 15th Street and an approximately 760-foot long section of channel north and south of 13th Street would require construction of a 10-foot to 20-foot high soil nail wall east of the track to stabilize the slope and provide adequate width for the new channel. Proposed walls could include color or texture treatments to blend in with surrounding elements. While they would be visible within the rail corridor, the proposed soil nail walls would not be visible from adjacent properties or the beach.

Proposed splash and retaining walls would consist of low-profile walls either supporting the downslope side of the channel or supporting a slope above the dich or channel. The height of the walls could be up to approximately 8 feet, with most on the order of two to four feet high. Proposed walls could include color or texture treatments to blend in with surrounding elements. Due to the relatively low height of the walls and the placement of some walls adjacent to the railbed, they would not be highly visible or prominent visual features from both within the rail corridor and adjacent areas.

A total of five new storm drain outlets on the beach are proposed associated with new underground storm drains. Outlet structures would include a headwall at the toe of the existing bluff that would include rock-scaped colored facing. Due to the location at the bottom of the bluffs at the beach, the new storm drain headwalls would primarily be visible from along the beach. The result of these drainage improvements would not impede views along the ocean, and the inclusion of a sculpted facing colored to resemble the existing bluffs would be visually compatible with the character of the area. Overall, the drainage improvements are assessed with having a mid-level potential visual resources effect. Up to five new sub drain outlets may be constructed to drain deep subdrain systems. These outlets would use small pipe diameters on the order of 8-inch with the ends secured with a small rockscaped headwall or outlet through existing sea walls. Due to the very small area of impact, the potential effect on visual resources is considered low.

5.1.4. ACCESS ROAD IMPROVEMENTS

Access road improvements entail re-grading two existing access roads and adding six inches of decomposed granite (DG) surface. These are surface improvements and would not involve vertical elements or structures or other highly visual components. The DG surface would blend into the surrounding areas and would not appear as prominent or contrasting visual features. These improved areas may be noticed by residents, train passengers, and beachgoers; however, these changes are not anticipated to be adverse and these improvements are assessed with having a low potential visual resources effect.

5.2. NOISE

The Proposed Action addressed in this report would generate noise during construction. Once a potential bluff stabilization, drainage measure or access road has been installed, it would not be expected to result in noise generation, with the minor exception of vehicle noise associated periodic maintenance and inspection visits by NCTD staff. The consideration of construction noise in this report focuses on where the noise would occur (would it occur at the bluff top, toe, or both), when the noise would occur (day or night) and the sensitivity of surrounding land uses to noise impacts. There are no applicable policies that specifically set limits on construction noise. This report does not quantify potential construction noise levels for the Proposed Action, but it does identify their potential to affect residents (bluff top) and/or beach visitors (bluff toe).

5.2.1. TRACKBED SUPPORT STABILIZATION

Construction of Improvements at the Bluff Top in Conjunction with Bluff Toe and Bluff Face Stabilization

Because the soldier pile walls would be installed at the top of the bluff at night, construction noise could disturb nearby residents. Although noise might be considered disruptive, this impact would be short term (up to a few months near any given residence). Most construction equipment associated with the construction of the bluff toe protection measures and surface stabilization would operate from the base of the bluff, with the corresponding construction noise affecting visitors to the beach. Due to the amount of excavation required, however, residents at the top of the bluff also would experience construction noise. Based on these factors, this stabilization measure is assessed with having a mid-level potential noise effect.

Trench Grading

Proposed stabilization improvements within SA 22 and SA 24 entail removing the existing berm and reduce the hazard for falling rock and mudslide to beach below. Although the noise from the grading operations might be considered disruptive, this impact would be short term (up to a few months near any given residence). Based on the short-term nature of the construction noise, this stabilization measure is assessed with having a mid-level potential noise effect.

Alternatives Considered

Construction of improvements at the bluff top only – Soldier Piles

Because the soldier pile walls would be installed at the top of the bluff at night, construction noise could disturb nearby residents. Although noise might be considered disruptive, this impact would be short term (up to a few months near any given residence). Based on the short-term nature of the nighttime construction noise, this stabilization measure is assessed with having a mid-level potential noise effect.

Soil Cement Buttress Alternative

Construction noise could be substantial because heavy equipment would be used to remove existing bluff material and replace it with soil cement backfill. Most construction equipment associated with this alternative would operate from the base of the bluff, with the corresponding construction noise affecting visitors to the beach. Due to the amount of excavation required, however, residents at the top of the bluff also would experience construction noise. Based on these factors, this stabilization measure is assessed with having a mid-level potential noise effect.

Soil Nail Reinforcement Alternative

Soil nails would probably be installed through a combination of construction activities at the top of the bluff (at night) and at base of the bluff (during the day). Accordingly, construction noise would have the potential to affect both residents and beach-goers. Because construction noise would be temporary, however, this stabilization measure is assessed with having a mid-level potential noise effect.

5.2.2. TRACKBED SUPPORT RETROFIT IMPROVEMENTS

Construction of Improvements at the Bluff Top in Conjunction with Bluff Toe and Bluff Face Stabilization

Trackbed support retrofit improvements entail installation of lagging and/or tieback anchors in areas that were previously stabilized as part of Del Mar Bluffs Stabilization 2 and 3 improvements. Since lagging and/or tieback anchors would be installed at the top of the bluff at night, construction noise could disturb nearby residents. Although noise might be considered disruptive, this impact would be short term (up to a few months near any given residence). Most construction equipment associated with the construction of the bluff toe protection measures and surface stabilization would operate from the base of the bluff, with the corresponding construction noise affecting visitors to the beach. Due to the amount of excavation required, however, residents at the top of the bluff also would experience construction noise. Based on these factors, this stabilization measure is assessed with having a mid-level potential noise effect.

Alternatives Considered

Construction of Improvements at the Bluff Top Only

These improvements would also be installed at the top of the bluff at night, and construction noise impacts would be similar to the trackbed support stabilization. Although noise might be considered disruptive, this impact would be short term (up to a few months near any given residence). Because construction noise would be temporary, however, this retrofit measure is assessed with having a mid-level potential noise effect.

Construction of Secondary Walls/In-line Piles

Alternatives to installation of lagging and/or tieback anchors includes the installation of in-line piles or a secondary wall. These improvements would also be installed at the top of the bluff at night, and construction noise impacts would be similar to the trackbed support stabilization. Because construction noise would be temporary, however, these retrofit measures are assessed with having a mid-level potential noise effect.

5.2.3. DRAINAGE IMPROVEMENTS

The Proposed Action includes the construction of a series of drainage improvements within the City of Del Mar ROW, railroad ROW and at the bluff face on the beach. These improvements would be installed during the workday, and improvements with the City Street and railroad ROW could disturb nearby residents, while work on the bluff face including installation of headwalls and outlets could disturb beach visitors. Although noise might be considered disruptive, this impact would be short term (up to a few weeks near any given residence or at the beach). Because construction noise would be temporary, however, this measure is assessed with having a mid-level potential noise effect.

5.2.4. ACCESS ROAD IMPROVEMENTS

Access road improvements entail re-grading two existing access roads and adding six inches of DG surface. Although noise might be considered disruptive, this impact would be short term (up to a few weeks near any given residence). Because construction noise would be temporary, however, this measure is assessed with having a mid-level potential noise effect.

5.3. PREHISTORIC ARCHEOLOGICAL AND HISTORIC RESOURCES

A total of 16 known cultural resource sites are located within or adjacent to the area of potential effect (APE) for the Proposed Action. During the current cultural resource survey, four new historical resources were identified and the condition and location of twelve previously recorded resources were updated. Of the updated resources, nine were previously recommended ineligible for listing on the National Register of Historic Places (NRHP) and/or California Register of Historical Resources (CRHR) (Ní Ghabhláin and Pallette 2001; Ní Ghabhláin and Pallette 2002; Mengers 2018a; Mengers 2018b), one has been destroyed and is ineligible for listing, one was unable to be relocated for evaluation and is assumed destroyed, and one has not been evaluated but has protected status and will be avoided. The four newly recorded resources were evaluated for eligibility for listing on the NRHP and all four resources are recommended not eligible for NRHP listing. SANDAG provided documentation to FRA to initiate consultation with the State Historic Preservation Office in accordance with Section 106 of the National Historic Preservation Act requesting concurrence that there are no historic properties within the APE and the undertaking results in No Historic Properties Affected. The Section 106 consultation process is ongoing. The Proposed Action would not impact any previously recorded or newly recorded sites.

5.4. PALEONTOLOGICAL RESOURCES

The proposed soldier piles and tiebacks would extend through the Bay Point Formation into the Delmar Formation. The Bay Point Formation, from the late Pleistocene age, and the Delmar Formation, from the Middle Eocene age, each have been rated as having a “high” paleontological sensitivity (Demere and Walsh 1994). Although the Proposed Action would entail drilling and trenching within these formations, significant impacts to paleontological resources are not anticipated because of (A) the relatively minor amount of formational materials that would be affected by drilling and trenching compared to the overall extent of these formations in the area and (B) the stabilizing effect that the Proposed Action would have on the bluffs. Other proposed drainage and access road improvements would generally occur on the surface and would not extend into these formations. Inadvertent discovery of paleontological resources during construction would be addressed in accordance with applicable laws and regulatory requirements. The Proposed Action is not anticipated to impact paleontological resources.

5.5. BIOLOGICAL RESOURCES

The biological resources letter report prepared for the Proposed Action (HELIX Environmental Planning, Inc. [HELIX] 2021) evaluated potential impacts to biological resources and potential jurisdictional areas (including coastal wetlands and Waters of the U.S.) during construction and operation of the Proposed Action.

5.5.1. TRACKBED SUPPORT STABILIZATION

Construction of Improvements at the Bluff Top in Conjunction with Bluff Toe and Bluff Face Stabilization

The majority of soldier pile wall construction would occur at the top of the bluff, which tends to be dominated by barren, disturbed, and developed habitat types. Similarly, the seawall construction would occur at the toe of the bluff which tends to be barren. Although some sensitive habitat could be affected by construction, intrusions into sensitive habitat would be small and could be offset by restoring disturbed areas (e.g., hydro-seeding with native species) following construction. The surface stabilization requires a 1.5:1 slope and reconstruction of the existing slope with compacted fill landscaped for erosion control. There would be an almost total loss of existing vegetation on the affected section of bluff face. Following the installation of surface stabilization, with imported top soil in place, vegetation could be reestablished. This stabilization measure is assessed with having a mid-level potential biological resources effect.

Trench Grading

Proposed stabilization improvements within SA 22 and SA 24 entail removing the existing berm and reduce the hazard for falling rock and mudslide to beach below. The trench construction would occur at the top of the bluff, which tends to be dominated by barren, disturbed, and developed habitat types. Although some sensitive habitat could be affected by construction, intrusions into sensitive habitat would be small and could be offset by restoring disturbed areas (e.g., hydro-seeding with native species) following construction. This stabilization measure is assessed with having the lowest potential biological resources effect.

Alternatives Considered

Construction of improvements at the bluff top only – Soldier Piles

The majority of soldier pile wall construction would occur at the top of the bluff, which tends to be dominated by barren, disturbed, and developed habitat types. Due to the depth of lagging required, and construction of multiple rows of tiebacks, significant regrading of the bluff face would be required. The potential significance of impacts to habitat would vary depending on the specific location where lagging is installed, as well as the depth of lagging. Based on the potential loss of habitat during construction and the potential constraints on reestablishing vegetation on the affected section of bluff face, this stabilization measure is assessed with having a mid-level potential biological resources effect.

Soil Cement Buttress Alternative

Where soil cement buttresses would be installed, there would be an almost total loss of existing vegetation on the affected section of bluff face. Following the installation of a soil cement buttress, including a pipe and board system to hold imported topsoil in place, vegetation could be reestablished. The potential significance of impacts to habitat would vary depending on the specific location where a soil cement buttress is installed. Based on the near-total loss of habitat that would occur during construction, however, this stabilization measure is assessed with having a high potential biological resources effect as the disturbance footprint would be much larger.

Soil Nail Reinforcement Alternative

Soil nails would affect habitat on the bluff face. The magnitude of this impact would depend on the specific site involved and the extent of facing attached to the soil nails. Areas where facing is attached to the soil nails would not be able to support the reestablishment of vegetation. Based on the potential loss of habitat during construction and the potential constraints on reestablishing vegetation, this stabilization measure is assessed with having a high potential biological resources effect.

5.5.2. TRACKBED SUPPORT RETROFIT IMPROVEMENTS

Construction of Improvements at the Bluff Top in Conjunction with Bluff Toe and Bluff Face Stabilization

Trackbed support retrofit improvements entail installation of lagging and/or tieback anchors in areas that were previously stabilized as part of Del Mar Bluffs Stabilization 2 and 3 improvements. The seawall construction would occur at the toe of the bluff which tends to be barren. Although some sensitive habitat could be affected by construction, intrusions into sensitive habitat would be small and could be offset by restoring disturbed areas (e.g., hydro-seeding with native species) following construction. The surface stabilization requires a 1.5:1 slope and reconstruction of the existing slope with compacted fill landscaped for erosion control. There would be an almost total loss of existing vegetation on the affected section of bluff face. Following the installation of surface stabilization, with imported topsoil in place, vegetation could be reestablished. This stabilization measure is assessed with having a mid-level potential biological resources effect.

Alternatives Considered

Construction of Improvements at the Bluff Top Only

Due to the depth of lagging required, and construction of multiple rows of tiebacks, significant regrading of the bluff face would be required. The potential significance of impacts to habitat would vary depending on the specific location where lagging is installed, as well as the depth of lagging. Based on the potential loss of habitat during construction and the potential constraints on reestablishing vegetation on the affected section of bluff face, this stabilization measure is assessed with having a mid-level potential biological resources effect.

Construction of Secondary Walls/In-line Piles

Alternatives to installation of lagging and/or tieback anchors includes the installation of in-line piles or a secondary wall. Although some sensitive habitat could be affected by construction, intrusions into sensitive habitat would be small and could be offset by restoring disturbed areas (e.g., hydro-seeding with native species) following construction. Based on these factors, these stabilization measures are assessed with having the lowest potential biological resources effect.

5.5.3. DRAINAGE IMPROVEMENTS

The Proposed Action includes the construction of a series of drainage improvements within the railroad ROW and at the bluff face on the beach including:

- New storm drain pipelines and outlets to the beach
- Concrete-lined trackside ditches
- Underdrains
- New/modified inlets to existing storm drain systems
- Concrete channels
- Splash walls
- New channel aprons
- New/modified drainage structures

Several of these facilities would be installed at grade (storm drain inlets, channel aprons, weir structures) or below grade (underdrains, storm drain pipelines). While additional concrete surfaces would be introduced, they would be at the ground level and generally adjacent to the railroad tracks and ballast. Proposed splash and retaining walls would consist of low-profile walls either supporting a slope behind it or extending from a trackside ditch or concrete channel. The height of the soil nail walls would be between 10 feet to 20 feet. The magnitude of this impact to vegetation and sensitive habitat would be relatively limited at each location. Based on the small potential loss of habitat during construction and the potential for reestablishing vegetation upon construction, this stabilization measure is assessed with having a mid-level potential biological resources effect.

5.5.4. ACCESS ROAD IMPROVEMENTS

Access road improvements entail re-grading two existing access roads and adding six inches of decomposed granite (DG) surface. These are surface improvements to existing access roads, and no potential loss of habitat is anticipated. This stabilization measure is assessed with having the lowest potential biological resources effect.

5.6. RECREATION

5.6.1. TRACKBED SUPPORT STABILIZATION

Construction of Improvements at the Bluff Top in Conjunction with Bluff Toe and Bluff Face Stabilization

At any location where a bluff toe protection (seawall) is installed, there would be temporary reduction in usable beach area associated with the construction site, including equipment operating areas, staging/lay down areas and temporary spoil piles. Based on the potential temporary effects to the beach, this stabilization measure is assessed with having a mid-level potential recreation effect.

Alternatives Considered

Construction of Improvements at the Bluff Top Only

The installation of soldier pile walls would occur mostly within an existing ROW and would not directly affect recreational use of the beach. The installation of soldier pile walls would require neither temporary beach access during construction nor result in permanent structures on the beach. Accordingly, this stabilization measure is assessed with having the lowest potential recreation effect.

Soil Cement Buttress Alternative

At any location where a soil cement buttress is installed, there would be temporary reduction in usable beach area associated with the construction site, including equipment operating areas, staging/lay down areas and temporary spoil piles. The soil cement buttresses would not extend beyond the existing bluff toe onto the beach. Based on the potential temporary effects to the beach, this stabilization measure is assessed with having a mid-level potential recreation effect.

Soil Nail Reinforcement Alternative

Soil nail construction would require beach access, but this stabilization measure would not be expected to result in a permanent reduction in usable beach. Based on the potential temporary effects to the beach, this stabilization measure is assessed with having a mid-level potential recreation effect.

5.6.2. TRACKBED SUPPORT RETROFIT IMPROVEMENTS

Construction of Improvements at the Bluff Top in Conjunction with Bluff Toe and Bluff Face Stabilization

At any location where a bluff toe protection (seawall) is installed, there would be temporary reduction in usable beach area associated with the construction site, including equipment operating areas, staging/lay down areas and temporary spoil piles. Based on the potential temporary effects to the beach, this stabilization measure is assessed with having a mid-level potential recreation effect.

Alternatives Considered

Construction of Improvements at the Bluff Top Only

The installation of lagging and tieback anchors would occur mostly within an existing ROW and would not directly affect recreational use of the beach. The installation of lagging and tieback anchors would require neither temporary beach access during construction nor result in permanent structures on the beach. Accordingly, this stabilization measure is assessed with having the lowest potential recreation effect.

Construction of Secondary Walls/In-line Piles

Alternatives to installation of lagging and/or tieback anchors includes the installation of in-line piles or a secondary wall. The installation of these measures would require neither temporary beach access during construction nor result in permanent structures on the beach. Accordingly, these stabilization measures are assessed with having a low potential recreation effect.

5.6.3. DRAINAGE IMPROVEMENTS

The Proposed Action includes the construction of a series of drainage improvements within the City of Del Mar ROW, railroad ROW and at the bluff face on the beach. Work on the bluff face, including installation of headwalls and outlets, would require beach access but would not be expected to result in a permanent reduction in usable beach. Based on the potential temporary effects to the beach, this stabilization measure is assessed with having a mid-level potential recreation effect.

5.6.4. ACCESS ROAD IMPROVEMENTS

Access road improvements entail re-grading two existing access roads and adding six inches of DG surface. These are surface improvements to existing access roads, would not require beach access, and would not be expected to result in a temporary or permanent reduction in usable beach. This stabilization measure is assessed with having the lowest potential recreation effect.

5.7. COASTAL PROCESSES

Implementation of the various bluff stabilization measures currently under consideration for the Proposed Action could impact coastal processes via effects to four primary mechanisms. The four mechanisms are: (1) reduction of the beach width through passive erosion, (2) modification of the near shore wave environment, (3) increase in beach erosion through active erosion, and (4) increase in beach erosion by keeping sand in the bluff from reaching the beach.

The Proposed Action would involve several bluff stabilization improvements that are necessary to protect the integrity of existing LOSSAN Rail Corridor railroad infrastructure along the blufftops, as well as to protect public beaches below the bluffs from erosion-related effects.

5.7.1. TRACKBED SUPPORT STABILIZATION

Construction of Improvements at the Bluff Top in Conjunction with Bluff Toe and Bluff Face Stabilization

Construction of soldier piles, tiebacks, and lagging would not affect the bluff face and thus, wave-induced erosion of the bluff would continue as a natural process. While the soldier piles would increase the geotechnical stability of the bluffs, which would tend to reduce the overall rate of bluff erosion, the bluffs would likely continue to erode at a rate similar to or less than the rate that would occur in the absence of a bluff stabilization project. Although the improved stability of the bluff would tend to reduce the long-term erosion rate, thereby reducing the volume of sand supplied to the beach, this contribution is likely to be very small given that the greatest contribution to overall bluff erosion is wave-induced erosion of the bluff toe. Additionally, only a relatively small amount of “sandy material” would be excavated during soldier pile installation. Roughly the top 10 to 15 feet of each soldier pile would be within the Bay Point Formation.

In April 2021, eighteen (18) representative soil samples from the bluff exposure within the area of the proposed seawalls were collected for sampling. In addition, a limited field exploration was performed in January and February 2021 to obtain soil samples from the upper Bay Point Formation and the beach sand below between 9th Street and 11th Street. The results of the sieve analyses were used to evaluate the compatibility of the Del Mar Bluff soils based on SANDAG’s Sand Compatibility and Opportunistic Use Program (SCOUP). The SCOUP program defines “Optimum Beach Fill Material” as soil containing less than 15 percent fines. “Less-Than-Optimum Beach Fill Material” is defined as soil containing between 15 and 45 percent fines. Typically, dry beach sediments range from 0 to 5 percent fines which is consistent with the fines of the Beach Deposits tested in this study. Based on the results of the sieve analysis testing, the Bay Point Formational materials at the upper bluffs are within the range defined by the SCOUP program as being “Less-Than-Optimum Beach Fill Material”. The Del Mar Formational Materials along the base of the bluffs are also primarily classified as being “Less-Than-Optimum Beach Fill Material”; however, six samples tested contain too many fines to meet this definition (i.e., defined as “Not Optimum Beach Fill Material” within this evaluation). In general, the soils within the bluffs and potential sea wall locations are not “optimum” for providing beach replenishment. Material consisting of more than 10 percent fines typically is not considered suitable for beach nourishment, and materials with more than 20 percent would rarely be used for beach nourishment.

Soil tests conducted for Del Mar Bluffs Stabilization Project 2 indicated that approximately 22 to 26 percent of this material consists of fine-grained sediment, or “fines” (soils passing through a number 200 sieve). The remaining approximately 70 percent of the material excavated from the soldier pile holes (i.e., below 10 to 15 feet) would consist of the silts and clays that form the Delmar Formation, which would not be suitable for any kind of beach nourishment.

Construction of the toe protection and bluff stabilization measures would increase the resistance of the bluff face material, thereby reducing wave-induced erosion of the bluff relative to existing conditions. The toe protection and bluff stabilization would also increase the overall stability of the bluff decreasing the potential for erosion attributed to geotechnical instability (e.g., slope failure). Therefore, implementation of the toe protection and bluff stabilization would tend to reduce bluff erosion over the project life by a substantial to marginal level. The position of the shoreline would be partially fixed due to the toe protection and bluff stabilization so some passive erosion effects could occur depending on the relative contribution of beach sand from bluff erosion versus stream inputs. The near shore wave environment could be impacted due to toe protection and bluff stabilization since the resistance of the bluff face would be increased; however, this impact would be minor given that the change in material properties would be relatively small and the alignment of the bluff face would be similar to the existing condition. The reduction of bluff erosion would decrease the volume of sand supplied to the beach. Although this contribution is likely to be very small given that the greatest contribution to beach sand supply is from stream inputs, the Coastal Commission typically requires a sand mitigation fee as mitigation for this impact. Therefore, this alternative would likely have a mid-level potential impact.

Trench Grading

SA22 and SA24 are within the trench area which provides a different condition than the other stabilization areas. The trench area is not currently in jeopardy due to bluff retreat, but there is a low factor of safety against a seismic event. This instability is caused by the added weight of the existing berm on the west side of the tracks that exists between the face of the bluff and track. The solution proposed here is to excavate and remove the berm to reduce the weight of the overburden. While removing the existing berm would increase the geotechnical stability of the bluffs, which would tend to reduce the overall rate of bluff erosion, the bluffs would likely continue to erode at a rate similar to or less than the rate that would occur in the absence this component.

Soil tests conducted in January 2021 along the outer bluff between 9th Street and 11th Street indicated that approximately 18 to 24 percent of this material consists of fine-grained sediment, or “fines”. Per the SCOUP report, less than optimum beach fill (15%-45% fines) are to be placed in the surf zone or nearshore, dependent on conditions and fines content.

The improved stability of the bluff would tend to reduce the long-term erosion rate, thereby reducing the volume of sand supplied to the beach. This contribution is likely to be very small given that the greatest contribution to beach sand supply is from stream inputs. The Coastal

Commission typically requires a sand mitigation fee as mitigation for this impact. Therefore, this approach is assessed with having a low potential effect.

Alternatives Considered

Construction of Improvements at the Bluff Top Only

As described above, construction of soldier piles, tiebacks, and lagging would not affect the bluff face and thus, wave-induced erosion of the bluff would continue as a natural process. While the soldier piles would increase the geotechnical stability of the bluffs, which would tend to reduce the overall rate of bluff erosion, the bluffs would likely continue to erode at a rate similar to or less than the rate that would occur in the absence of a bluff stabilization project. Although the improved stability of the bluff would tend to reduce the long-term erosion rate, thereby reducing the volume of sand supplied to the beach, this contribution is likely to be very small given that the greatest contribution to overall bluff erosion is wave-induced erosion of the bluff toe. Therefore, this approach is assessed with having a low potential effect.

Soil Cement Buttress Alternative

Since construction of the soil cement buttress wall would increase the resistance of the bluff face material, wave-induced erosion of the bluff would be reduced relative to existing conditions. In addition, the soil cement buttress wall would increase the overall stability of the bluff. Therefore, implementation of the soil cement buttress wall could substantially reduce bluff erosion over the project life.

The position of the shoreline would be partially fixed under the soil cement buttress wall so some passive erosion effects could occur depending on the relative contribution of beach sand from bluff erosion versus stream inputs. The near shore wave environment could be impacted under the soil cement buttress wall since the resistance of the bluff face would be increased; however, this impact would be insignificant given that the change in material properties would be relatively minor and the alignment of the soil cement buttress wall would be similar to the alignment of the existing bluff face. Likewise, impacts attributed to active erosion could also occur under this alternative since the erosion processes could be adversely impacted by the soil cement buttress. However, this impact also would be expected to be minor given that the alignment of the soil cement buttress wall would be similar to the alignment of the existing bluff face and the change in bluff material properties would be minor. The reduction of bluff erosion would decrease the volume of sand supplied to the beach. This contribution is likely to be very small given that the greatest contribution to beach sand supply is from stream inputs. Therefore, the soil cement buttress wall would likely have mid-level potential impact.

Soil Nail Reinforcement Alternative

Construction of the soil nail alternative would increase the resistance of the bluff face material, thereby reducing wave-induced erosion of the bluff relative to existing conditions. The soil nails would also increase the overall stability of the bluff decreasing the potential for erosion attributed to geotechnical instability (e.g., slope failure). Therefore, implementation of the soil nail alternative would tend to reduce bluff erosion over the project life by a substantial to marginal level. The level of reduction is dependent on whether shotcrete is used on the facing of the bluff. Using shotcrete on the bluff face would substantially reduce the wave-induced erosion rate while implementation of the soil nail alternative without shotcrete would only tend to marginally reduce wave-induced erosion. The discussion below is based on the use of shotcrete to treat the bluff face since this option would yield the greatest potential impact to coastal processes. The position of the shoreline would be partially fixed under the soil nail alternative so some passive erosion effects could occur depending on the relative contribution of beach sand from bluff erosion versus stream inputs. The near shore wave environment could be impacted under the soil nail alternative since the resistance of the bluff face would be increased; however, this impact would be minor given that the change in material properties would be relatively small and the alignment of the soil nail alternative would be similar to the alignment of the existing bluff face. Likewise, impacts attributed to active erosion could also occur under this alternative since the erosion processes could be adversely impacted by the soil nail alternative. However, this impact would also be expected to be minor given that the alignment of the soil nail alternative would be similar to the alignment of the existing bluff face and the change in bluff material properties would be small. The reduction of bluff erosion would decrease the volume of sand supplied to the beach. Although this contribution is likely to be very small given that the greatest contribution to beach sand supply is from stream inputs, the Coastal Commission typically requires a sand mitigation fee as mitigation for this potentially substantial impact. Therefore, the soil nail alternative would likely have a mid-level potential impact.

5.7.2. TRACKBED SUPPORT RETROFIT IMPROVEMENTS

Construction of Improvements at the Bluff Top in Conjunction with Bluff Toe and Bluff Face Stabilization

The installation of lagging and tieback anchors would not affect the bluff face and thus, wave-induced erosion of the bluff would continue as a natural process. As described in the section on trackbed stabilization measures, construction of bluff toe and bluff face stabilization improvements would result in this alternative having a mid-level potential effect.

Alternatives Considered

Construction of Improvements at the Bluff Top Only

The installation of lagging and tieback anchors would not affect the bluff face and thus, wave-induced erosion of the bluff would continue as a natural process. Therefore, this alternative would likely have a low potential impact.

Construction of Secondary Walls/In-line Piles

Alternatives to installation of lagging and/or tieback anchors includes the installation of in-line piles or a secondary wall. These would be similar to the soldier piles and as described in the section on upper bluff stabilization measures, these retrofit measures are assessed with having the lowest potential impact.

5.7.3. DRAINAGE IMPROVEMENTS

The City of Del Mar has continued to develop over the years, increasing the number of impervious surfaces and increasing both the peak rate of runoff and total volume of runoff. The proposed drainage improvements are needed to adequately handle this increased runoff, as well as protect the railroad and mitigate the potential for sudden bluff failure that could result from a failed drainage system. The project will include construction of the following drainage features:

- New underground storm drains with the NCTD right-of-way with new outlets with headwall structures at the toe of the bluff on the beach.
- Trackside ditches, east and west of the tracks at different locations within the project footprint.
- Surface drainage improvements east of the railroad tracks, including modifications to existing inlets within the City streets, construction and replacement of channels, construction of splash walls at the end of the City streets and replacement of down drains.

The construction of an approximately 300-foot long channel section south of 15th Street and an approximately 760-foot long section of channel north and south of 13th Street would require construction of a 10-foot to 20-foot high soil nail wall east of the track to stabilize the slope and provide adequate width for the new channel. These walls limit the erosion and sand contribution to the beach, but their construction is necessary as the volume of silt during rain events is exacerbated by the volume and velocity of uncontrolled runoff from the City. The silt overwhelms the track side ditches causing overtopping of the track, failure of the bluff and ultimately undermining of the track. The slope stabilization in these areas is critical to control siltation and clogging of the drainage systems, but the walls will reduce the sediment to the beach

The improvements within NCTD and City right-of-way would function in the same manner as existing in-kind facilities, with no resultant increase in localized erosion, additional armoring of the bluffs, or change in the potential for sand replenishment. The proposed drainage improvements, such as new concrete-lined trackside channels and new storm drain outlets/headwalls on the beach, would involve some additional minor armoring of the bluffs, but not at a magnitude to alter the natural shoreline process. While construction of the new outlets and headwalls would increase the geotechnical stability of the bluffs by reducing the potential for failure of a system and falling debris, which would tend to reduce the overall rate of bluff erosion, the bluffs would likely continue to erode at a rate similar to or less than the rate that would occur in the absence these improvements. A relatively small amount of "sandy material" would be excavated during construction of these features. The excavated material would be tested and utilized for sand replenishment to the beach if it meets the material specifications for sand replenishment. These improvements are assessed with having a mid-level potential impact.

5.7.4. ACCESS ROAD IMPROVEMENTS

The new surfacing on the regraded access roads would help prevent localized areas of accelerated erosion and damage to the bluff. The surfacing would not result in additional armoring of the existing bluff or prevent the natural retreat of the bluff. This measure is assessed with having the lowest potential impact.

5.8. REGULATORY APPROVALS

Potential regulatory approvals (including legal requirements associated with federal funding through the Department of Transportation's FRA) are described below.

5.8.1. NEPA

The Federal Railroad Administration (FRA) serves as the federal lead agency for the Proposed Action under the National Environmental Policy Act (NEPA; 42 United States Code [U.S.C.] 4321 et seq.). The Proposed Action meets the criteria for one of the class of actions that is categorically excluded from NEPA pursuant to Title 23 CFR 771.116(c)(20) and (22), which include:

> (20) Environmental restoration, remediation, pollution prevention, and mitigation activities conducted in conformance with applicable laws, regulations and permit requirements, including activities such as noise mitigation, landscaping, natural resource management activities, replacement or improvement to storm water oil/water separators, installation of pollution containment systems, slope stabilization, and contaminated soil removal or remediation activities.
>
> (22) Track and track structure maintenance and improvements when carried out predominantly within the existing right-of-way that do not cause a substantial increase in rail traffic beyond existing or historic levels, such as stabilizing embankments, installing or reinstalling track, re-grading, replacing rails, ties, slabs, and ballast, installing, maintaining, or restoring drainage ditches, cleaning ballast, constructing minor curve realignments, improving or replacing interlockings, and the installation or maintenance of ancillary equipment.

A portion of the Proposed Action is being funded by the FRA and the Federal Transit Administration (FTA).

5.8.2. FEDERAL COASTAL ZONE MANAGEMENT ACT

The proposed bluff stabilization would occur entirely within the California coastal zone, as established by the California Coastal Act (California Public Resources Code Sections 30000 et seq.). Because of its location within the coastal zone, the Proposed Action can only receive federal funding if it is consistent with the coastal resources planning and management policies contained in Chapter 3 of the California Coastal Act. This requirement, described below, stems from the Federal Coastal Zone Management Act (33 United States Code Sections 1451 et seq.), as amended through Public Law 104-150 (the Coastal Zone Protection Act of 1996).

The Federal Coastal Zone Management Act (Section 1456(d)) mandates that:

> State and local governments submitting applications for Federal assistance under other Federal programs, in or outside of the coastal zone, affecting any land or water use of natural resource of the coastal zone shall indicate the views of the appropriate state or local agency as to the relationship of such activities to the approved management program for the coastal zone. Such applications shall be submitted and coordinated in accordance with the provisions of section 6506 of title 31. Federal agencies shall not approve proposed projects that are inconsistent with the enforceable policies of a coastal state's management program, except upon a finding by the Secretary that such project is consistent with the purposes of this chapter or necessary in the interest of national security.

In California, the referenced "enforceable policies" are contained in Chapter 3 of the California Coastal Act. The Chapter 3 policies address public access, recreation, marine environment, land resources, development and industrial facilities (many of these policies would not be applicable to a project involving preservation of trackbed support). As applicable, these policies are considered in the assessment of visual resources, noise, prehistoric archeological and historic resources, paleontological resources, biological resources, recreation, and coastal processes.

5.8.3. DEPARTMENT OF TRANSPORTATION 4(F) REQUIREMENTS

Bluff stabilization measures that would affect the public beach at the base of the bluffs would be subject to consideration under Department of Transportation Section 4(f) analysis. In part, Section 4(f) states that:

> [T]he Secretary [of the Department of Transportation] shall not approve any program or project which requires the use of any publicly owned land from a public park, recreation area, or wildlife and waterfowl refuge of national, State, or local significance as determined by the Federal, State, or local officials having jurisdiction thereof, or any land from an historic site of national, State, or local significance as so determined by such officials unless (1) there is no feasible and prudent alternative to the use of such land, and (2) such program includes all possible planning to minimize harm to such park, recreation areas, wildlife and waterfowl refuge, or historic sites resulting from such use….

The reference to "Section 4(f)" reflects that these requirements originally were contained in Section 4(f) of the Department of Transportation Act of 1966. They since have been codified in Title 49, United States Code (U.S.C.), Section 1653(f). Similar requirements for Federal-Aid Highway projects also are contained in Title 23 U.S.C. Section 138. For purposes of this report (and following convention), the codified requirements are still referred to as "Section 4(f)" requirements.

The public beach at the base of the Del Mar bluffs qualifies as a public recreation area of state or local significance. If a bluff stabilization measure would trigger Section 4(f) requirements due to beach use, that measure could only be implemented if there is no feasible and prudent alternative that would not require use of the beach. An alternative may be rejected as not being feasible and prudent for any of the following reasons:

1. Not meeting the project purpose and need;
2. Excessive cost of construction;
3. Severe operational or safety problems;
4. Unacceptable adverse social, economic or environmental impacts;
5. Serious community disruption; or
6. An accumulation of lesser magnitude of the foregoing types of factors.

In practice, documenting that an alternative is not reasonable and prudent can be difficult. If there is a reasonable and prudent alternative to the use of the beach (or any other 4(f)-protected resource), the FRA must select that alternative. If there are no reasonable and prudent alternatives that would avoid impacts to the beach, FRA must select the alternative that would cause it "least harm."

Section 4(f) does not apply to a temporary occupancy (including those resulting from a right-of-entry, construction, and other temporary easements and other short-term arrangements) of publicly owned recreation areas where there is documentation that the officials having jurisdiction over the protected resource agree that the temporary occupancy would:

1. Be of short duration and less than the time needed for construction of the project;
2. Not change the ownership or result in the retention of long-term or indefinite interests in the land for transportation purposes;
3. Not result in any temporary or permanent adverse change to the activities, features, or attributes which are important to the purposes or functions that qualify the resource for protection under Section 4(f); and
4. Include only a minor amount of land.

5.8.4. CLEAN WATER SECTION ACT 404 AND 401 PERMITS

The biological resources letter report prepared for the Proposed Action (HELIX 2021) evaluated potential impacts to biological resources, including Waters of the U.S. (WUS), during construction and operation of the Proposed Action. Impacts to WUS would require a Clean Water Act Section 404 Permit from the USACE and a Clean Water Act Section 401 Water Quality Certification from the RWQCB. It is recommended that these agencies be contacted to confirm the limits of their jurisdiction within the proposed project area.

5.8.5. RIVERS AND HARBORS ACT PERMIT

Section 10 of the Rivers and Harbors Act, administered by the USACE, requires permits for all structures and activities in navigable waters of the U.S.

5.8.6. TRACKBED SUPPORT STABILIZATION

Construction of Improvements at the Bluff Top in Conjunction with Bluff Toe and Bluff Face Stabilization

No conflicts with required regulatory approvals have been identified for the installation of soldier pile walls, lagging and tieback anchors, as well as the bluff toe protection measures (seawalls) and bluff surface stabilization. The installation of these features would be consistent with the planning and management policies contained in Chapter 3 of the California Coastal Act. This assessment regarding California Coastal Act consistency would require concurrence from the California Coastal Commission, as would any of the California Coastal Act consistency determinations presented in this report. (It should be noted that the soldier pile walls installed for Del Mar Bluffs Stabilization Projects 2 and 3 were found by the Coastal Commission to be consistent with Chapter 3 of the California Coastal Act.) This alternative would not have conflicts with required regulatory approvals. Construction on the beach would be subject to the 4(f) requirements, including the requirement for coordination with, and specific findings by, the local government or state agency having jurisdiction over the affected section of beach.

Trench Grading

Proposed stabilization improvements within SA 22 and SA 24 entail removing the existing berm and reduce the hazard for falling rock and mudslide to beach below. The trench grading would be consistent with the planning and management policies contained in Chapter 3 of the California Coastal Act. The trench grading would not have conflicts with required regulatory approvals.

Alternatives Considered

Construction of Improvements at the Bluff Top Only

As described in the section above, no conflicts with required regulatory approvals have been identified for the installation of soldier piles.

Soil Cement Buttress Alternative

No conflicts with required regulatory approvals have been identified for the installation of the soil cement buttress. The installation of the soil cement buttress would be consistent with the planning and management policies contained in Chapter 3 of the California Coastal Act. Construction on the beach would be subject to the 4(f) requirements, including the requirement for coordination with, and specific findings by, the local government or state agency having jurisdiction over the affected section of beach.

Soil Nail Reinforcement Alternative

No conflicts with required regulatory approvals have been identified for the installation of the soil nail wall. The installation of the soil nail wall would be consistent with the planning and management policies contained in Chapter 3 of the California Coastal Act. Construction on the beach would be subject to the 4(f) requirements, including the requirement for coordination with, and specific findings by, the local government or state agency having jurisdiction over the affected section of beach.

5.8.7. TRACKBED SUPPORT RETROFIT IMPROVEMENTS

Construction of Improvements at the Bluff Top in Conjunction with Bluff Toe and Bluff Face Stabilization

The installation of retrofit lagging and tieback anchors in conjunction with toe protection and surface stabilization would be similar to the trackbed stabilization measures. No conflicts with required regulatory approvals have been identified for the installation of proposed stabilization measures. Construction on the beach would be subject to the 4(f) requirements, including the requirement for coordination with, and specific findings by, the local government or state agency having jurisdiction over the affected section of beach.

Alternatives Considered

Construction of Improvements at the Bluff Top Only

As described in the section above, no conflicts with required regulatory approvals have been identified for the installation of lagging and tieback anchors

Construction of Secondary Walls/In-line Piles

Alternatives to installation of lagging and/or tieback anchors includes the installation of in-line piles or a secondary wall. These would be similar to the soldier piles, and no conflicts with required regulatory approvals have been identified.

5.8.8. DRAINAGE IMPROVEMENTS

The Proposed Action includes the construction of a series of drainage improvements within the City of Del Mar ROW, railroad ROW and at the bluff face on the beach. No conflicts with required regulatory approvals have been identified for the installation of proposed drainage improvements. Construction on the beach would be subject to the 4(f) requirements, including the requirement for coordination with, and specific findings by, the local government or state agency having jurisdiction over the affected section of beach.

5.8.9. ACCESS ROAD IMPROVEMENTS

No conflicts with required regulatory approvals have been identified for the surfacing on the regraded access roads which would help prevent localized areas of accelerated erosion and damage to the bluff.

5.9. SUMMARY OF ENVIRONMENTAL IMPACTS

Table 15 presents the summary of environmental considerations conducted based on visual resources, noise, biological resources, recreation and coastal processes and potential conflicts with regulatory approvals, along with an overall ranking. There are no anticipated impacts to prehistoric archeological and historic resources and paleontological resources and are therefore not included in the table below.

Table 15 – Summary of Environmental Impacts							
Alternative	**Visual Resources**	**Noise**	**Biological Resources**	**Recreation**	**Coastal Processes**	**Potential Conflicts with Regulatory Approvals**	**Overall Ranking**
TRACKBED SUPPORT STABILIZATION							
Bluff top and bluff toe improvements, with bluff face stabilization	Mid-level	Mid-level	Mid-level	Mid-level	Mid-level	No	Mid-level
Trench Grading	Mid-level	Mid-level	Low	Low	Low	No	Best
Bluff top Improvements only	High	Mid-level	Mid-level	Low	Low	No	Best
Soil Cement Buttress	High	Mid-level	High	Mid-level	Mid-level	No	Worst
Soil nail reinforcement	High	Mid-level	High	Mid-level	Mid-level	No	Worst
TRACKBED SUPPORT RETROFIT							
Bluff top and bluff toe improvements, with bluff face stabilization	Mid-level	Mid-level	Mid-level	Mid-level	Mid-level	No	Mid-level
Bluff top Improvements only	High	Mid-level	Mid-level	Low	Low	No	Best
Secondary wall/In-line piles	Low	Mid-level	Low	Low	Low	No	Best
DRAINAGE IMPROVEMENTS							
Drainage Improvements	Mid-level	Mid-level	Mid-level	Mid-level	Mid-level	No	NA
MISCELLANEOUS							
Access Road Improvements	Low	Mid-level	Low	Low	Low	No	NA

6. CONSTRUCTABILITY

6.1. CONSTRUCTION ACCESS AND STAGING

Potential construction entrance areas would be located near the northern project limits at Coast Boulevard, at the termini of 8th and 7th Streets, and near the southern project limits at Torrey Pines State Beach. These entrances would provide construction access along the east and west sides of the railroad tracks within the project limits using existing NCTD maintenance access roads. A temporary rail crossing would also be provided at 7th Street to allow construction vehicles to cross the tracks to access improvement areas and staging locations. Potential construction staging areas within the railroad right-of-way could be located at the following locations:

- Staging Area 1 - Adjacent to the Coast Boulevard construction entrance west of the tracks
- Staging Area 2 - Terminus of 12th Street east of the tracks
- Staging Area 3A - West of the 8th Street construction entrance west of the tracks
- Staging Area 3B - Adjacent to the 8th Street construction entrance east of the tracks
- Staging Areas 4 - Near MP 245.2 4th west of the tracks
- Staging Area 5A and 5B - Adjacent to the southern construction entrance near MP 245.7

Potential construction entrances for access to work areas on the beach include the west end of 18th Street and 17th Street next to the lifeguard station at the north end of the project, and through the Torrey Pines State Beach, access road at the south end of the project as shown on the Staging Area and Access Exhibits attached. The approximate limit of access along the beach at the toe of bluff is shown on the access exhibits. Use of the beach access would subject to tidal influences.

In addition to the construction staging and laydown areas within the railroad right-of-way, portions of the Torrey Pines State Beach parking lot, City owned lot at the end of 18th Street and City Streets could be used for additional staging and laydown subject to permits from the City of Del Mar and/or State Parks.

6.2. CONSTRUCTION METHODS

6.2.1. TRACKBED SUPPORT STABILIZATION

Construction of Improvements at the Bluff Top in Conjunction with Bluff Toe and Bluff Face Stabilization

Construction of bluff top improvements, i.e., soldier piles would require access from existing City of Del Mar street ends (e.g., 8th Street) and Torrey Pines State Beach parking lot. No access from the beach would be necessary. The construction work area would be contained entirely within the NCTD right-of-way that generally extends at least 50 feet west of the current track centerline. Staging and lay-down areas are available on the flat portions of the bluff top near 4th Street, 6th Street and 8th Street, and at the southern end near Torrey Pines State Beach parking lot. The work area would most likely be limited to one stabilization area at a time with multiple drill rigs, limited earth moving equipment, and construction crews.

The center of the soldier pile wall would be located approximately 11 to 21 feet seaward of the centerline of the track, and the top of the wall would be about 1 foot below the top of tie elevation. The selection of this wall location is based on LOSSAN maintenance access standards, the requirement to meet CPUC clearances, and previous soldier pile installation projects as noted below:

- The California Public Utilities Commission (CPUC) under General Order No. 26-D specifies an 8-foot, 6-inch minimum horizontal clearance (9-feet, 6-inches on curved alignment) to structures above the top of rail. Soldier pile walls constructed below the track elevation are outside of the minimum permanent clearance envelope and, therefore, this criterion does not affect the horizontal wall location. The CPUC also requires a minimum 2-foot-wide level maintenance walkway on each side of the tracks beyond the ballast.
- The design criteria for the LOSSAN Corridor in San Diego County specifies that the exposed vertical face of a retaining wall supporting tracks shall not be placed closer than 12 feet from the centerline of the nearest track. The exposed vertical face of retaining walls not supporting tracks adjacent to the tracks are required provide a minimum clearance of 12 feet from the front face of the wall to the centerline of the nearest track, per LOSSAN Clearance Standards ESD2101. This exceeds the CPUC minimum and allows for a minimum 3-foot-wide (3 feet, 11 inches preferred) level maintenance walkway alongside of the ballast. Placement of the soldier pile wall grade beam one foot below the top of tie elevation allows a portion of the top of the grade beam to support the maintenance walkway. With a 3-foot, 6-inch-wide grade beam centered at a minimum of 11 feet from the track center, the LOSSAN minimum clearance can be achieved.

Construction of the soldier piles requires a drill rig and crane located on or just east of the track and the piles should be located within reach of conventional drilling equipment. Several CIDH pile construction projects have been completed in the last 20 years including the 8th Street emergency repair, Del Mar Bluffs Project 2, 3 and 4. The most recent project constructed 3 – 42-inch dimeter piles at 65 feet in length. A Soilmec SR-75 track mounted rotary drill rig was used together with a Link-Belt TCC 750 crane and CAT TL 1055 telescopic forklift. While other drilling equipment exists with longer reach capabilities, an 11- to 15-foot dimension was selected as a baseline for this project. The pile offset may be increased to approximately 21 feet where the existing width of the bluff can accommodate the equipment. Where tieback anchors are needed, drilling of the bore hole for the tiebacks would be accomplished from the top of the bluff by using a flight auger attached to the boom of an excavator (i.e., CAT 330 or equivalent). In addition to the drilling equipment, a delivery truck would be needed to transport the steel H piles and a ready-mix concrete truck and pump would be needed at each site for placement of concrete.

The soldier pile construction has the potential to impact rail operations. Most of the soldier pile drilling and placing operation would require equipment on or immediately adjacent to the track. This must be addressed through specified work windows and possibly with temporary shoring placed between the track bed and the work area.

Construction of the grade beam or lagging between existing piles would not typically require shoring because of the arching that occurs between the piles so long as construction is completed in a timely manner and staging of work limits concurrent open segments. Slower train speeds can be implemented on a temporary basis to further limit the need for shoring. If excessive erosion has occurred due to rainfall or other influences, shoring may be required. Temporary shoring requirements following the AREMA guidelines for previous projects on the Del Mar Bluffs were based on an envelope starting 2 feet horizontally from the bottom of the tie and extending outward at a 1H:1V slope. A grade beam up to 3 feet, 6 inches wide and 3 feet deep located 13 feet from the track centerline and 1 foot below the top of tie is outside of this temporary clearance envelope and therefore, would not likely require temporary shoring. When the wall is located closer to the track or where the existing slope geometry requires a lower grade beam, shoring may be required.

Night work would be required for the soldier pile construction. During the day, the frequency of rail traffic does not allow for any major construction activities along the right-of-way. The nighttime work window would be determined during the final design phase but normally runs between the last passenger train in the evening and the first passenger train in the morning with an approximate five-hour operation. For Del Mar Bluffs 3 in 2012, passengers from the last two trains of the day were bussed around this location allowing for an eight-hour nighttime work window. Lighting would be required for work done at night and should be aimed at the work area away from the bluff toe and private property.

Several weekend work windows are typically scheduled throughout the year to accommodate construction projects on the corridor. The number of soldier piles proposed is greater than what could be completed during 3 or 4 weekend work windows but use of the weekend work windows would reduce the number of nighttime work windows needed.

Many successful soldier pile construction projects have been completed along the Del Mar Bluffs area. The methodology is well understood within the construction industry and is not highly susceptible to unforeseen site conditions. The primary concern is the potential of encountering a buried object during the drilling for the piles or for the tieback anchors. This is typically handled by drilling or coring through the obstruction but maintaining the planned pile or anchor location. Perched groundwater may be encountered. This is not typically a major concern because pile construction is completed in one work shift. If a pile excavation were to remain exposed and groundwater collected, the groundwater would need to be pumped prior to placement of concrete.

Construction of bluff toe stabilization improvements (seawall) and surface stabilization would require access from both the beach and the bluff top. It would require a large quantity of earthwork to remove unsuitable soil and replace the topsoil, as well as placement of the anchored engineered mat to stabilize the surface.

The construction work area would extend outside of the NCTD right-of-way and would require establishing a temporary processing plant (i.e., pugmill), stockpile areas, and haul routes with possible temporary subgrade improvements. For efficiency, large sections of bluff would be excavated and stabilized in a single stage.

Given the extensive earthmoving equipment necessary, staging areas at the bluff top and at the bluff toe (beach) would be required. It should be noted that construction activities associated with this alternative, especially those near the bluff toe, would be affected by high tides, waves, and storm surf. There are several existing seawalls with fill placed above them within the project vicinity.

With the addition of seawalls and surface stabilization, the number of tiebacks and depth of lagging needed would be reduced, minimizing some of the impacts to rail operations, and construction within a constrained rail corridor. From a constructability standpoint, this alternative is rated as the best solution.

Construction of Improvements at the Bluff Top Only

As described above, construction of a soldier piles would be completed from the bluff top and would require access from existing City of Del Mar street ends (e.g., 8th Street) and Torrey Pines State Beach parking lot. No access from the beach would be necessary. Due to the additional tiebacks and depth of lagging required, which would need to be constructed from the blufftop within the constrained rail corridor, this alternative is rated as a mid-level solution from a constructability standpoint.

Soil Cement Buttress

Construction of a soil cement buttress would require access from both the beach and the bluff top. It would require a large quantity of earthwork to remove unsuitable soil and provide the necessary minimum width of buttress and must be benched into the existing slope.

The construction work area would extend outside of the NCTD right-of-way and would require establishing a temporary processing plant (i.e., pugmill), stockpile areas, and haul routes with possible temporary subgrade improvements. For efficiency, large sections of bluff would be excavated and backfilled in a single stage.

Given the extensive earthmoving equipment necessary, staging areas at the bluff top and at the bluff toe (beach) would be required. It should be noted that construction activities associated with this alternative, especially those near the bluff toe, would be affected by high tides, waves, and storm surf.

At the bluff top, this work would likely result in excavations within the temporary railroad clearance envelope and require the grading to be done in short segments with temporary shoring to avoid major disruptions to rail service. Work from the top for grading and soil cement placement would likely be accomplished at night when the rail traffic is reduced or during weekend absolute work windows.

There has been one soil cement placement project in the lower bluff area. This earthmoving construction technique is very common in the industry, but it is susceptible to unforeseen soil conditions. Typically, this is handled by increasing the extent of the excavation work based on on-site observations and recommendations by the project geotechnical engineer.

From a constructability standpoint, the soil cement buttress alternative is rated as the most difficult solutions.

Soil Nail Reinforcement

Construction of the soil nail reinforcement includes drilling, installation and grouting of soil nails. At a minimum, the lower portion of the bluff face would be covered with a shotcrete facing that is placed using air-blown mortar over a reinforced wire mesh.

Drilling of the bore hole for the soil-nails could be accomplished from the toe or top of the bluff by using a flight auger attached to the boom of an excavator (i.e., CAT 330 or equivalent). Man-lifts and small cranes would also be needed to install the steel reinforcement and grout, and to perform quality control and assurance testing on the selected soil nails. Access to the construction areas is expected to be from the beach and the top of the bluff depending on the activity and location. The work area would most likely be limited to one section of the bluff. Construction activities near the bluff toe would be affected by high tides, waves, and storm surf.

Without an extended period of beach access, it is anticipated that the equipment required to construct soil nails would impact rail operations forcing night-time construction work and busing traffic around the work. With extended accessibility from the beach, the impact to rail operations would be significantly reduced but would still require some work to be done at night.

Soil nail reinforcement construction can be staged from the bluff top using the staging areas identified for the soldier pile alternative. The potential for unforeseen conditions is similar to the soldier pile alternative during the nail drilling operation. In addition, the work at the bluff face can cause localized sloughing and erosion depending on the condition of the natural bluff face.

From a constructability standpoint, the soil nail reinforcement alternative is rated as a mid-level solution.

6.2.2. TRACKBED SUPPORT RETROFIT AREAS

Construction of Improvements at the Bluff Top in Conjunction with Bluff Toe and Bluff Face Stabilization

Lagging would be added to the existing piles to prevent migration of material in the upper elevations. Lagging is expected to be placed in increments varying from 3 feet in height to 10 feet in height. Construction of lagging and tiebacks would be completed from the bluff top and would require access from existing City of Del Mar street ends (e.g., 8th Street) or Torrey Pines State Beach parking lot. No access from the beach would be necessary.

Existing soldier piles have been constructed at approximately 10 feet on center with offsets from track centerline varying between 11 feet and 15 feet. Lagging would consist of a reinforced shotcrete wall placed between the existing soldier piles. Similar to the lagging added below 15th Street in December 2019. Reinforcing dowels would be placed into the existing concrete piles and attached to a rebar cage the width and height of the lagging wall, with a prefabricated drainboard placed against the exposed earth surface. Shotcrete would be placed to a thickness of approximately 18 to 24 inches. The outer face of the wall would be colored and sculpted similar to the existing rock face. Required equipment would include a small excavator and two manlifts to remove material and support workers placing steel and concrete. The shotcrete operation would require a ready-mix truck and concrete pump. Delivery trucks and a bobcat would be needed for delivering and moving materials to and within the site.

When the soldier pile walls have exceeded their design height, additional tiebacks would be needed. Most piles have one tieback at the top of the existing pile. Where piles have been constructed without tiebacks, one tieback can be added at the top of the existing pile. The piles constructed as part of Del Mar Bluffs 3 have an empty steel tieback pocket designed to accept a future tieback. The existing concrete cap and filler material would be removed to expose the steel pocket for use. Piles constructed as part of Del Mar Bluffs 2 do not have an empty tieback pocket. A new steel beam waler would be constructed as part of the grade beam / lagging to support the new tieback. The bore hole for the tiebacks in both cases would be drilled into the slope from the top of the bluff using a flight auger attached to the boom of an excavator (i.e., CAT 330 or equivalent).

Placement of lagging has the potential to impact rail operations. Most of the lagging construction would require equipment on or immediately adjacent to the tracks. This must be addressed through specified work windows and possibly with temporary shoring placed between the track bed and the work area.

Construction of the lagging/grade beam requires temporary excavation 5 feet minimum (6 feet from the top of tie). Temporary shoring requirements for previous projects on the Del Mar Bluffs were based on an envelope starting 2 feet horizontally from the bottom of the tie and extending outward at a 1H:1V slope. A grade beam 18 inches wide and 5 feet deep located 15 feet from the track centerline and 1 foot below the top of tie is outside of this temporary clearance envelope. Shoring may be required for piles located less than 15 from track centerline, lagging in excess of 5 feet in height or where the existing slope geometry requires a deeper lagging wall.

Night work would be required for the construction of lagging and tiebacks. During the day, the frequency of rail traffic does not allow for any major construction activities along the right-of-way. The nighttime work window would be determined during the final design phase but normally runs between the last passenger train in the evening and the first passenger train in the morning with an approximate five-hour operation. For Del Mar Bluffs 3, the passengers from the last two trains of the day were bused around this location allowing for an eight-hour nighttime work window. Lighting would be required for work done at night and should be aimed at the work area away from the bluff toe and private property.

Construction of a bluff toe stabilization improvements (seawall) and surface stabilization would be similar to the work described under trackbed support stabilization above. With the addition of seawalls and surface stabilization, the number of tiebacks and depth of lagging needed would be reduced, minimizing some of the impacts to rail operations, and construction within a constrained rail corridor. From a constructability standpoint, this alternative is rated as the best solution.

Construction of Improvements at the Bluff Top Only

For the alternative with improvements at the bluff top only, additional tiebacks, including a second and third row of tiebacks could be needed at some locations where the bluff retreat exceeds the soldier pile design height. For the second row of tiebacks, a grade beam (waler) would be added to support and connect the tiebacks. Once the tiebacks have been installed, a steel waler would be placed over the anchors and attached to the pile. The waler would be designed to distribute the anchor load evenly across the piles and provide a point of attachment for the tie-back. The equipment and construction methods for the second row of tiebacks would be similar to the construction of the first row of tiebacks. A second row of tiebacks would be located 10 to 15 feet below the top of pile. At some locations, a third row of tiebacks may be required at 20 to 30 feet below the top of pile. Larger equipment would be needed to complete a third row of tiebacks from the bluff top.

The construction work area would be contained entirely within the NCTD right-of-way that generally extends at least 50 feet west of the current track centerline. Staging and lay-down areas are available on the flat portions of the bluff top near 4th Street, 6th Street and 8th Street. The work area would most likely be limited to one stabilization area at a time, with multiple drill rigs, limited earth moving equipment and construction crews. Construction of the lagging would require the use of pickup trucks, loaders, excavators, forklifts, and fall protection equipment.

Due to the additional tiebacks and depth of lagging required, which would need to be constructed from the blufftop within the constrained rail corridor, this alternative is rated as a mid-level solution from a constructability standpoint

Addition of In-line and Secondary Piles

When the soldier pile walls have exceeded their design height, secondary or in-line piles could be added. Where used, two 36-inch piles, would be constructed in between the existing piles constructed by Del Mar Bluffs Phase 2 and Phase 3 projects. Construction of the in-line soldier piles would be similar to the soldier pile construction described above. Construction would require a drill rig and crane located on or just east of the tracks and the piles should be located within reach of conventional drilling equipment. Several CIDH pile construction projects have been completed in the last 15 years including the 8th Street emergency repair, Del Mar Bluffs Project 2, 3 and 4. The most recent project constructed a total of three – 42-inch dimeter piles at 65 feet in length. A Soilmec SR-75 track mounted rotary drill rig was used together with a Link-Belt TCC 750 crane and CAT TL 1055 telescopic forklift. Where tieback anchors would be needed, drilling of the bore hole for the tiebacks would be accomplished from the top of the bluff by using a flight auger attached to the boom of an excavator (i.e., CAT 330 or equivalent). In addition to the drilling equipment, a delivery truck would be needed to transport the steel H piles and a ready-mix concrete truck and pump would be needed at each site for placement of concrete.

The soldier pile construction has the potential to impact rail operations. Most of the soldier pile drilling and placing operation would require equipment on or immediately adjacent to the tracks. This must be addressed through specified work windows and with temporary shoring placed between the trackbed and the work area.

Secondary piles would include the construction of a second set of piles located west from the existing piles and would include tiebacks as necessary. Where used, the piles would be constructed about 8-feet west of the existing piles constructed by Del Mar Bluffs Phase 2 and Phase 3 projects. Construction of the secondary soldier piles would be similar to the soldier pile construction described above, but larger equipment may be required for the construction of the piles from the top, adjacent the tracks, since these secondary piles would be further away.

Many successful soldier pile construction projects have been completed along the Del Mar Bluffs area. The methodology is well understood within the construction industry and is not highly susceptible to unforeseen site conditions. The primary concern is the potential of encountering a buried object during the drilling for the piles or for the tieback anchors. This is typically handled by drilling or coring through the obstruction but maintaining the planned pile or anchor location.

From a constructability standpoint, the addition of inline piles or a secondary wall (soldier piles) is rated as a mid-level solution.

6.2.3. DRAINAGE IMPROVEMENTS

The project will include construction of the following drainage features:

- New underground storm drains with the NCTD right-of-way with new outlets with headwall structures at the toe of the bluff on the beach.
- Trackside ditches, east and west of the tracks at different locations within the project footprint.
- Surface drainage improvements east of the railroad tracks, including modifications to existing inlets within the City streets, construction and replacement of channels, construction of splash walls at the end of the City streets and replacement of down drains.

The drainage improvements are mostly repairs of existing facilities, and while alternatives were considered at some locations along with the descriptions in Section 3.2, they were not evaluated for constructability separately.

Underground Storm Drain Systems in the NCTD Right-of-Way
The new underground storm drains within the NCTD right-of-way, and the corresponding outlets to the beach would be constructed using a combination of cut and cover and pipe jacking

technology. The storm drainpipe would be constructed using cut and cover methods during a railroad Absolute Work Window. The westerly segment of the pipe to the beach would be constructed using a jack and bore method to avoid trenching through the existing bluff face. The jacking pit would typically be placed in the City right of way between the end of the street and the railroad right of way, or in an open area beyond the foul zone of the track, if within the railroad right of way.

Construction of Outlets and Headwall Structures at the Toe of Bluff

This work would require access by pickup trucks, flatbed trucks, dump trucks, excavator, a small backhoe, a drill rig and loader, and concrete ready-mix trucks and pump. Work on the beach would be necessary to complete the new headwall and remove the debris of existing broken pipe, headwalls, or chutes being replaced. Headwalls in the natural bluff face (Areas 1, 6, 9, 12 and 15) would use a soil nail wall to avoid over-excavation of native material. Construction of the new headwalls would require excavation at the toe of the slope using an excavator. A drill rig would be used for construction of the tie backs. Once in place, the front face of the wall would be formed, and concrete would be pumped to complete the headwall structure. Texturing would be sprayed onto the face of the wall and sculpted by hand to provide a rock appearance. The headwall for Area 4 at the end of 12th Street is in previously disturbed fill and would be constructed as standard cast in place concrete headwall. The concrete would be colored similar the headwall at MP 244.45 west of Sea Orbit Lane.

Drainage Channels and Trackside Ditches within NCTD Right-of-Way

This work would require access by pickup trucks, flatbed trucks, dump trucks, a small backhoe, excavator and concrete ready-mix trucks with pumps. The storm drainage channels and trackside ditches within the railroad foul zone would be constructed during regular working hours with flagger protection under Form B or with Track and Time as approved by NCTD. The new channel bed or trackside ditch would be cleaned and prepared using a backhoe and compactor. Reinforcing would be placed, and shotcrete would be sprayed and shaped to the channel or ditch section.

Improvements within and Adjacent the City Right-of-Way

Repair of channel entrances at the end of the City Street, repair of existing inlets and addition of inlets with the roadway, minor re-grading, and construction of splash walls at the ends of the City Streets, repair and replacement of down drains, would include access from the City Street. Removal of the existing concrete, asphalt or other hard surfaces would be completed using a backhoe, loader and dump truck. Debris would be disposed of off-site. The new channels would be cleaned and prepared using a backhoe and compactor. Cast in place foundations for splash walls, retaining walls and inlets would be excavated. Forming and reinforcing would be placed by hand and additional forming would be placed for splash walls. Placement of concrete would require ready mix trucks and pumps. Shotcrete would be sprayed and shaped to the channel section. Concrete would be pumped for the splash walls, inlet structures and surface improvements. Hot mix asphalt paving would require delivery trucks and compaction rollers. This work would be completed during regular daytime working hours and would not generally require flagging protection. All work within the City right of way would be subject to City approval and encroachment permits.

6.3. CONSTRUCTION TIMING AND SCHEDULE

6.3.1. TRACKBED SUPPORT STABILIZATION AND RETROFIT CONSTRUCTION

The timing of construction activities would depend in large part on which activities can be conducted during periods of active rail use (during the day) and which activities can only be conducted when no trains are operating (late night/early morning). SANDAG is investigating the potential for daytime installation (construction) of the soldier piles; however, this may require the use of specialized construction equipment that (A) does not currently exist, (B) may not be feasible to build and/or (C) could be prohibitively costly. It is assumed that with the exception of a few tasks such as site clean-up, fabricating metal reinforcement cages, and stressing tiebacks, installation during active rail use is not feasible.

If installation of the soldier piles cannot happen when the rails are in active use, most construction activities would occur at night/early morning when train traffic is much lower than during the day. In order to avoid rail traffic, installation would occur between 12:00 a.m. and 5:30 a.m. each weekday morning. If NCTD busses evening passengers around the Del Mar Bluffs, installation could start much earlier, extending from approximately 9:30p.m. until 5:30 a.m. the following morning (with some minor interruptions for nighttime freight trains). Currently, it is anticipated that if bussing is used, it would occur on Monday, Wednesday, and Thursday evenings.

SANDAG estimates that up to three drill crews may be operating concurrently. It is projected that each drill crew could install at least one soldier pile per 5½-hour shift and at least two piles per 8-hour shift. For safety and constructability reasons, soldier pile holes would be filled each night (i.e., soldier pile holes would not be left open during the day). The progress of soldier pile installation could be affected by several factors such as subsurface geologic conditions, weather, equipment maintenance and repair requirements, and rail traffic levels.

Based on the above-noted projections, pile installation is projected to require up to approximately 24 months, depending on whether bussing is used to allow up to three 8-hour shifts per week. Up to one additional month of mobilization (e.g., bringing supplies and equipment to the site, setting up a construction trailer, placing temporary rubber track crossing panels across the railroad track) and up to one additional month of demobilization (e.g., site cleanup, removing equipment) may be required.

6.3.2. BLUFF TOE AND BUFF FACE STABILIZATION IMPROVEMENTS

Proposed seawalls consist of a soldier pile wall at the bluff toe with wood or concrete lagging panels. It should be noted that activities associated with construction the bluff toe would be affected by high tides, waves, and storm surf. Construction of improvements on the beach could be completed independent of train operations, but access will be governed by tidal cycles.

Installation of the soldier piles at the bluff toe can occur during the day. SANDAG estimates that up to three drill crews may be operating concurrently. It is projected that each drill crew could install at least two piles per 8-hour shift. For safety and constructability reasons, soldier pile holes would be filled after each shift. The progress of soldier pile installation could be affected by several factors such as subsurface geologic conditions, weather, equipment maintenance and repair requirements, and tidal cycles.

Based on the above-noted projections, seawall installation is projected to require up to approximately 24 months. Up to one additional month of mobilization and up to one additional month of demobilization (e.g., site cleanup, removing equipment) may be required. In addition, the project proposes bluff face stabilization through regrading of the slopes to a 1.5:1 ratio, stabilizing the surface with engineered reinforced mat, placing fill on top the mat, and then revegetating the slope to reduce erosion and improve lower slope stability.

Accordingly, the overall construction schedule is estimated at up to approximately 36 months. This represents SANDAG's best estimate, and it may take the selected contractor slightly more or less time to construct the bluff top, bluff toe and bluff face improvements. The construction schedule does not include plant establishment and revegetation which could take an additional two to three years.

6.3.3. DRAINAGE IMPROVEMENTS

A total of 15 areas of proposed drainage improvements have been defined. Each are could be completed independently with multiple crews completing work simultaneously in multiple areas. Smaller work areas could be completed sequentially. It is anticipated that similar types of work would be scheduled to utilized specialty equipment (i.e. jack and bore equipment and drill rigs) efficiently rather than mobilize such equipment for each area.

There is a total of 5 underground storm drains with outlets to the beach. All will require jack and bore methods of construction. Jacking pits would be constructed during regular working hours. Pipe jacking operations would be completed during daytime hours with flagging protection. Construction of components on the beach could be completed during regular day time hours independent of train operations Replacement of the existing storm drain at 12th Street should not be done during the rainy season. Construction of the drainage outlets and headwalls could be done concurrently with multiple crews, or sequentially with one move on of equipment. Use of two crews is considered more likely with an estimated construction time of 9 months.

Construction of components within the City right-of-way could be completed during regular day time hours independent of train operations. Construction of the drainage inlets, channels, splash walls, down drain replacement and other repairs could be done concurrently with multiple crews, or sequentially with one move on of equipment. Excavation and placement of the new splash walls would take approximately 4 weeks. Excavation and placement of channels, inlets, down drain replacements, and other improvements would take approximately 6 weeks. With mobilization and cleanup of 6 weeks these components could take up to 12 months to complete all components.

Work within the foul zone of the railroad could be completed during regular working hours with flagger protection. This work would include construction of trackside ditches and channels, underdrains and access roads. The remaining work outside the foul zone could be completed during regular daylight working hours. Work to complete these drainage and miscellaneous improvements could be partially overlapping or sequential and would take approximately 8 weeks with an additional mobilization and demobilization of 4 weeks, for a total of 12 months to complete all areas.

6.4. DESIGN CRITERIA

New Soldier Piles and Existing Soldier Pile Retrofit Systems

Previous projects have considered soldier pile design criteria as providing a 20-year service life with lagging added over time as needed. Addition of lagging was intended to be based on field review of existing conditions. As pile caps became exposed, addition of lagging was to be considered. While the retreat of the bluffs has been monitored over the last 20 years, the general approach of considering exposed piles has not resulted in addition of lagging. The only lagging added was done in response to emergency failures at 15th Street and 13th Street after prolonged rainfall.

The 20-year service life criteria was established as the time frame necessary to support the bluffs during planning and construction of a tunnel that would allow for removal of the track from the bluffs. While the Regional Transportation Plan still identifies the need for a tunnel, the cost of the tunnel project and lack of funding make the time frame uncertain. It is critical to the region that the trackbed on the bluffs be safely supported until an alternative track alignment is in service. The design criteria for Del Mar Bluffs 5 must provide improvements for an adequate time frame to accomplish removal of the track from the bluffs, flexibility if relocation of the track is delayed, a safety factor against sudden failures that interrupt service, minimize maintenance and consider removal of structures once they are no longer needed.

The design for the trackbed support stabilization and retrofit include the construction of improvements at the bluff top in conjunction with bluff toe and bluff face stabilization, to protect against predicted 30-year and 50-year bluff retreat. Installing seawalls will slow the rate of bluff retreat, and therefore increase the service life of the track bed support without adding more infrastructure at the top of the bluff. Use of toe protection (sea walls) and surface stabilization above existing walls could extend the service life of the soldier pile system and limit the height of exposed soldier pile walls.

Designing for a 30-year predicted bluff retreat would provide adequate time for removing the train from the bluff provided funding is available. The 50-year bluff retreat can be accommodated by using the 30-year design as the initial phase and adding additional improvements if needed to extend the service to 50 years.

6.4.1. TRACKBED SUPPORT STABILIZATION AREAS

Deterioration of the coastal bluffs including block failures of the bluffs onto the beach is a challenge along the entire coast, not just the Del Mar Bluffs. A working group representing members from the coastal cities has been established to work with the California Coastal Commission on solutions to improve safety and manage bluff failures. Discussions with the California Coastal Commission at monthly coordination meetings have included possible use of toe protection (i.e., sea walls) and regrading and landscaping along portions of the bluff to eliminate sudden failures and improve overall safety. The potential benefit of placing a sea wall at the toe of priority areas together with restoring the slope above a sea wall could manage the anticipated bluff retreat to a level that would ensure the function of the 30-year service life design for as long as needed to relocate the train off the bluffs. In addition, placement of a sea wall would limit the height of exposed piles along the bluff with most of the piles remaining completely buried.

Maintaining uninterrupted train service along the bluff is critical to the entire region. While the track may be relocated in the next 30 years, the funding and time frame are uncertain. Constructing the main infrastructure to support the trackbed is essential to safe operations. The preferred approach is therefore the option that includes bluff toe and bluff face stabilization at prioritized areas, in addition to trackbed piles, as this provides lesser depth of exposed lagging and number of tiebacks, lesser grading at the bluff face, a more viable solution that minimizes permanent structures at the trackbed. The seawalls and other retrofit needs required for the 50-year bluff retreat could be constructed in a future phase.

Bluff Top Improvements in Conjunction with Bluff Toe and Bluff Face Stabilization
The bluff toe improvements (seawalls) would slow the rate of bluff retreat. In addition, placement of a sea wall and regrading/landscaping the slope would lessen the need for lagging. As shown in ***Table 16***, the depth of lagging and number of tiebacks needed to protect against 30-year and 50-year bluff retreat are significantly reduced with the addition of seawalls and surface stabilization.

Table 16 – Stabilization Area Lagging and Tieback Needs with Bluff Toe and Bluff Face Stabilization											
				Bluff Top Improvements Only				**Bluff Top Improvements in Conjunction with Bluff Toe and Bluff Face Stabilization**			
Stabilization Area (SA)	**Trackbed Stabilization Priority Ranking**	**Existing or Proposed Seawall to Protect Against 30-yr and 50-yr Bluff Retreat**	**Proposed Surface Stabilization**	**Tiebacks (30 years)**	**Depth of Lagging (30 years)**	**Tiebacks (50 years)**	**Depth of Lagging (50 years)**	**Tiebacks (30 years)**	**Depth of Lagging (30 years)**	**Tiebacks (50 years)**	**Depth of Lagging (50 years)**
SA16	Low	Phase II	X	1	0	2	15	1	0	1	5
SA21	High	Phase I	X	2	15	2	25	1	5	1	5
SA20	High	Phase I	X	2	20	3	35	0	5	0	5
SA23	Med	Ex	X	1	5	1	10	0	5	0	5
SA3	Low	Phase II	-	0	0	0	0	0	0	0	0
SA15	High	Phase II	-	1	0	1	5	1	0	1	0
SA5	High	Phase II	-	1	5	1	15	1	5	1	5
SA14	Low	Phase II	-	0	0	0	0	0	0	0	0
SA13	Low	Phase II	-	0	0	0	0	0	0	0	0
SA6N*	Low	Ex	X	0	0	0	0	0	0	0	5
SA12	Med	Phase I	-	1	5	1	10	1	0	1	5
SA8**	High	Ex	X	1	15	1	15	1	5	1	5
SA11	High	Phase II	-	1	5	1	10	1	5	1	5
SA9	High	Phase II	-	1	0	1	10	1	0	1	5
SA10	Low	Phase II	-	1	0	1	15	1	0	1	5

* Construction of trackbed piles and seawall are underway for a portion of Area 6N due to the February 2021 bluff collapse. 18 piles were constructed at Area 6N as part of the Emergency Repair in 2021. The Emergency repair also includes removal of the existing seawall and construction of 291-foot replacement seawall.

** The 2021 Emergency Repair includes stabilization of the existing seawall at SA8. Options under consideration include a concrete cut off wall or smaller diameter piles in front of the wall.

6.4.2. TRACKBED SUPPORT RETROFIT AREAS

The stabilization systems constructed in previous phases of the project were designed for a 20-year service life and that service life has been achieved. Several of the retrofit locations, particularly the high priority locations, have minimal service life remaining. In order to extend the service life by another 30 to 50 years, a hybrid solution that combines seawalls and surface stabilization with minimal lagging is proposed.

Blufftop Improvements in Conjunction with Bluff Toe and Bluff Face Stabilization
The bluff toe improvements (seawalls) would slow the rate of bluff retreat. In addition, placement of a sea wall and regrading/landscaping the slope would lessen the need for lagging. ***Table 16*** shows the depth of lagging and number of tiebacks needed for 30-years and 50-years for the trackbed support stabilization locations, with and without the bluff toe and surface stabilization improvements. As shown in ***Table 17***, the depth of lagging and number of tiebacks needed to protect against 30-year and 50-year bluff retreat are significantly reduced with the addition of seawalls and surface stabilization.

Table 17 – Summary of Retrofit Needs with and without Bluff Toe and Surface Stabilization Improvements

Retrofit Area	Retrofit Priority Ranking	Existing or Proposed Seawall to Protect Against 30-yr and 50-yr Bluff Retreat	Proposed Surface Stabilization	Bluff Top Improvements Only				Bluff Toe and Surface Stabilization in Conjunction with Bluff Top Improvements			
				Total # of Additional Tiebacks (30-year)	Depth of Lagging (30-year) (ft)	Total # of Additional Tiebacks (50-year)	Depth of Lagging (50-year) (ft)	Total # of Additional Tiebacks (30-year)	Depth of Lagging (30-year) (ft)	Total # of Additional Tiebacks (50-year)	Depth of Lagging (50-year) (ft)
DMB2 (SN5) Pile 33 to 38	Medium	Phase I	X	0	5	2	30	0	5	0	5
DMB2 (SN5) Pile 24 to 32**	High	Phase I	X	2	30	2	30	0	5	0	5
DMB2 (SN5) Pile 1 to 23**	High	Phase I	X	2	30	2	30	0	5	0	5
DMB2 (SN7N)	Medium	Phase I	X	2	30	2	30	0	5	0	5
DMB2 (SN7S)**	Low	Phase I	X	1	10	1	10	1	5	1	5
DMB3 (SP1)*	Medium	Phase I	X	1	15	1	15	0	5	0	5
DMB2 (SN3) Pile 15 to 19	High	Ex	X	1	15	1	20	0	5	0	5
DMB2 (SN3) Pile 1 to 14	High	Ex	X	1	15	1	20	0	5	0	5
DMB2 (SN1N)	High	Phase I	X	1	25	3	40	0	5	0	5
DMB2 (SN1S) Pile 14 to 29*	Medium	Phase I	X	1	20	1	20	0	5	0	5
DMB2 (SN1S) Pile 6 to 13	High	Ex	X	2	30	2	30	0	5	0	5
DMB2 (SN1S) Pile 1 to 5	High	Ex	X	1	15	1	20	0	5	0	5
DMB2 (SN2)	High	Ex	X	1	20	1	25	0	5	0	5
DMB4 (Pile 1 to 3)	Medium	Ex	X	0	15	1	30	0	5	0	5
DMB3 (SP2) Pile 17 to 23	High	Ex	X	1	15	1	15	1	5	1	5
DMB3 (SP2) Pile 6 to 16	Medium	Phase I	X	1	10	3	30	1	5	1	5
DMB3 (SP2) Pile 1 to 5	Low	Phase I	X	1	0	1	0	1	5	1	5
DMB2 (SN6) Pile 7 to 10	Medium	Phase I	X	0	5	2	15	0	0	1	5
DMB2 (SN6) Pile 1 to 6**	High	Phase I	X	2	15	2	15	1	5	1	5

Table 17 – Summary of Retrofit Needs with and without Bluff Toe and Surface Stabilization Improvements

Retrofit Area	Retrofit Priority Ranking	Existing or Proposed Seawall to Protect Against 30-yr and 50-yr Bluff Retreat	Proposed Surface Stabilization	Bluff Top Improvements Only				Bluff Toe and Surface Stabilization in Conjunction with Bluff Top Improvements			
				Total # of Additional Tiebacks (30-year)	Depth of Lagging (30-year) (ft)	Total # of Additional Tiebacks (50-year)	Depth of Lagging (50-year) (ft)	Total # of Additional Tiebacks (30-year)	Depth of Lagging (30-year) (ft)	Total # of Additional Tiebacks (50-year)	Depth of Lagging (50-year) (ft)
2001 Emergency Repair	High	Phase I	X	1	20	2	30	0	5	0	5
DMB3 (SP3) Pile 13	Low	Ex	X	0	10	0	15	0	5	0	5
DMB3 (SP3) Pile 5 to 12	Low	Ex	X	0	10	0	20	0	5	0	5
DMB3 (SP3) Pile 1 to 4	Low	Phase I	X	0	5	0	15	0	5	0	5
DMB3 (SP5)***	Medium	Phase I	-	2	20	2	25	1	5	2	15
DMB3 (SP6) Pile 7 to 14***	Medium	Phase I	-	1	10	2	20	1	0	2	15
DMB3 (SP6) Pile 1 to 6***	High	Phase I	-	2	20	2	25	1	5	2	15
DMB3 (SP7)***	High	Phase I	-	1	15	3	30	1	5	2	15
DMB3 (SP4) Pile 6 to 10	Low	Phase I	-	0	0	2	15	0	0	1	5
DMB3 (SP4) Pile 3 to 5	Low	Phase I	-	0	0	2	15	0	0	1	5
DMB3 (SP4) Pile 1 to 2	Low	Phase I	-	0	0	2	15	0	0	1	5
DMB2 (SN8) Pile 12 to 13	Low	Phase I	-	0	0	1	15	0	0	1	5
DMB2 (SN8) Pile 1 to 11***	Medium	Phase I	-	1	15	3	30	1	5	2	15

For Bluff Top only Improvements:
* 30 year design life not feasible with addition of lagging and tiebacks, secondary wall/inline piles required
** 50 year design life not feasible with addition of lagging and tiebacks, secondary wall required

For Bluff Toe and Surface Stabilization in Conjunction with Bluff Top Improvements:
*** Phase II (future) surface stabilization would eliminate the need for a second row of tieback anchors and additional depth of lagging to extend the service life of the trackbed stabilization to 50 years.

6.5. MAINTENANCE

Ongoing maintenance will be reduced as a result of the project; however, monitoring and some maintenance would be required.

7. COSTS

7.1. TRACKBED SUPPORT STABILIZATION AREAS

The cost of Phase I improvements are based on prioritized locations to stabilize the trackbed for 30-year bluff retreat, while the Phase II improvements would be constructed as a future phase based on priority and funding availability to stabilize the trackbed for 50-year bluff retreat. ***Table 18*** below provides a summary of preliminary construction costs at each of the new stabilization areas for the following with and without bluff toe and bluff face stabilization.

Table 18 – Trackbed Stabilization Area Costs with and without Bluff Toe and Bluff Face Stabilization

Stabilization Area (SA)	Ranking	Cost of Bluff Top Improvements in Conjunction with Bluff Toe and Bluff Face Stabilization		Cost of Bluff Top Improvements Only	
		Phase I	Phase II	Phase I	Phase II
SA16	Low	$930,000	$41,000	$930,000	$293,000
SA21	High	$377,000	$0	$472,000	$25,000
SA20	High	$685,000	$0	$996,000	$284,000
SA23	Medium	$275,000	$0	$303,000	$11,000
SA3	Low	$1,650,000	$0	$1,650,000	$0
SA15	High	$438,000	$0	$438,000	$17,000
SA5	High	$1,283,000	$0	$1,283,000	$84,000
SA14	Low	$990,000	$0	$990,000	$0
SA13	Low	$3,300,000	$0	$3,300,000	$0
SA6N	Low	$594,000	$25,000	$594,000	0
SA12	Medium	$1,168,000	$40,000	$1,208,000	$40,000
SA8	High	$1,283,000	$0	$1,367,000	$0
SA11	High	$648,000	$0	$648,000	$28,000
SA9	High	$992,000	$40,000	$992,000	$79,000
SA10	Low	$930,000	$41,000	$930,000	$124,000
	TOTAL	**$15,543,000**	**$187,000**	**$16,101,000**	**$985,000**

*Costs shown are preliminary construction costs only, and do not include items such as escalation, mobilization, contingency, construction and site management, etc.

Within each stabilization area, the stabilization alternatives were analyzed in sufficient detail in order to determine site-specific geometric issues, challenges and preliminary construction costs. As mentioned in Sections 3.1.1, not all of the alternatives described in this report are viable or practical for each stabilization area. As discussed in Section 3.1.1, soldier piles are the preferred option for the new trackbed stabilization areas. Other alternatives such as soil cement buttress and soil nail viable are viable or practical only at certain locations. Only the costs for the applicable alternatives are shown in the table below.

Table 19 below provides a summary of preliminary construction costs at each of the new stabilization areas for the following scenarios:

a. Construction of improvements at the bluff top in conjunction with bluff toe and bluff face stabilization (total Phase I and II)
b. Construction of improvements at the bluff top only (total Phase I and II)
c. Soil Cement Buttress, where feasible
d. Soil Nail Wall, where feasible

Table 19 – Cost Comparison of Trackbed Support Stabilization Alternatives

Stabilization Area (SA)	Ranking	Bluff Top Improvements in Conjunction with Bluff Toe and Bluff Face Stabilization (Total Phase I and II)	Bluff Top Improvements Only (Total Phase I and II)	Soil Cement Buttress	Soil Nail Reinforcement
SA16	Low	$971,000	$1,223,000	-	$1,425,000
SA21	High	$377,000	$497,000	-	$513,000
SA20	High	$685,000	$1,280,000	-	$855,000
SA23	Medium	$275,000	$314,000	-	-
SA3	High	$1,650,000	$1,650,000	-	$2,375,000
SA15	Low	$438,000	$455,000	-	$570,000
SA5	Low	$1,283,000	$1,367,000	-	$1,045,000
SA14	Low	$990,000	$990,000	-	$1,425,000
SA13	Medium	$3,300,000	$3,300,000	-	$4,750,000
SA6N	High	$619,000	$594,000	$2,590,000	$1,995,000
SA12	High	$1,208,000	$1,248,000	-	$1,539,000
SA8	High	$1,283,000	$1,367,000	$1,071,000	-
SA11	Low	$648,000	$676,000	-	$950,000
SA9	Low	$1,032,000	$1,071,000	-	$1,776,500
SA10	High	$971,000	$1,054,000	-	$1,425,000
	TOTAL	**$15,730,000**	**$17,086,000**	**$3,661,000**	**$20,643,500**

*Costs shown are preliminary construction costs only, and do not include items such as escalation, mobilization, contingency, construction and site management, etc.
**The preliminary construction cost for over excavation within the trench area (SA22 and SA24) is $775,000.

While the costs differences between the options with and without bluff toe and bluff face improvements is less than 10% for the new stabilization areas, the savings are more substantial when considered along with the retrofit stabilization areas. The soil cement buttress is only feasible at two locations, and therefore not comparable. The soil nail walls are feasible at all locations except SA23 and SA8, however they are significantly more expensive than the soldier pile alternatives.

7.2. TRACKBED SUPPORT RETROFIT AREAS

The cost of Phase I improvements are based on prioritized locations to stabilize the trackbed for 30-year bluff retreat, while the Phase II improvements would be constructed as a future phase based on priority and funding availability to stabilize the trackbed for 50-year bluff retreat. ***Table 20*** below provides a summary of preliminary construction costs at each of the retrofit areas for the following scenarios:

a. Construction of improvements at the bluff top in conjunction with bluff toe and bluff face stabilization (Phase I and Phase II)
b. Construction of improvements at the bluff top only (Phase I and Phase II)
c. Cost of in-line piles. Costs for secondary walls are assumed to be similar to in-line and were not evaluated separately.

Table 20 – Cost Comparison of Trackbed Retrofit Support Stabilization Alternatives

Stabilization Area	Ranking	Cost of Bluff Top Improvements in Conjunction with Bluff Toe and Bluff Face Stabilization		Cost Bluff Top Improvements Only		Cost of Inline Piles
		Phase I	Phase II	Phase I	Phase II	
DMB2 (SN5) Pile 33 to 38	Medium	$17,000	$-	$17,000	$350,000	$720,000
DMB2 (SN5) Pile 24 to 32	High	$25,000	$-	$556,000	$960,000	$960,000
DMB2 (SN5) Pile 1 to 23	High	$63,000	$-	$1,421,000	$2,760,000	$2,760,000
DMB2 (SN7N)	Medium	$11,000	$-	$247,000	$-	$600,000
DMB2 (SN7S)	Low	$72,000	$-	$83,000	$360,000	$360,000
DMB3 (SP1)	Medium	$14,000	$-	$863,000	$-	$720,000
DMB2 (SN3) Pile 15 to 19	High	$14,000	$-	$143,000	$14,000	$480,000
DMB2 (SN3) Pile 1 to 14	High	$39,000	$-	$401,000	$39,000	$1,680,000
DMB2 (SN1N)	High	$11,000	$-	$152,000	$196,000	$480,000
DMB2 (SN1S) Pile 14 to 29	Medium	$44,000	$-	$2,470,000	$-	$1,920,000
DMB2 (SN1S) Pile 6 to 13	High	$22,000	$-	$494,000	$-	$840,000
DMB2 (SN1S) Pile 1 to 5	High	$14,000	$-	$143,000	$14,000	$600,000
DMB2 (SN2)	High	$25,000	$-	$310,000	$25,000	$1,080,000
DMB4 Pile 1 to 3	Medium	$11,000	$-	$33,000	$115,000	$360,000
DMB3 (SP2) Pile 17 to 23	High	$68,000	$-	$107,000	$-	$840,000
DMB3 (SP2) Pile 6 to 16	Medium	$107,000	$-	$138,000	$603,000	$1,200,000
DMB3 (SP2) Pile 1 to 5	Low	$49,000	$-	$35,000	$-	$600,000
DMB2 (SN6 Pile 7 to 10	Medium	$-	$72,000	$11,000	$164,000	$360,000

Table 20 – Cost Comparison of Trackbed Retrofit Support Stabilization Alternatives						
Stabilization Area	**Ranking**	**Cost of Bluff Top Improvements in Conjunction with Bluff Toe and Bluff Face Stabilization**		**Cost Bluff Top Improvements Only**		**Cost of Inline Piles**
		Phase I	**Phase II**	**Phase I**	**Phase II**	
DMB2 (SN6) Pile 1 to 6	High	$108,000	$-	$263,000	$720,000	$720,000
2001 Emergency Repair	High	$33,000	$-	$413,000	$311,000	$1,440,000
DMB3 (SP3) Pile 13	Low	$3,000	$-	$6,000	$3,000	$120,000
DMB3 (SP3) Pile 5 to 12	Low	$22,000	$-	$44,000	$44,000	$840,000
DMB3 (SP3) Pile 1 to 4	Low	$11,000	$-	$11,000	$22,000	$480,000
DMB3 (SP5)	Medium	$163,000	$301,000	$538,000	$36,000	$1,560,000
DMB3 (SP6) Pile 7 to 14	Medium	$56,000	$229,000	$100,000	$207,000	$840,000
DMB3 (SP6) Pile 1 to 6	High	$59,000	$155,000	$248,000	$17,000	$720,000
DMB3 (SP7)	High	$137,000	$363,000	$214,000	$687,000	$1,560,000
DMB3 (SP4) Pile 6 to 10	Low	$-	$49,000	$-	$178,000	$600,000
DMB3 (SP4) Pile 3 to 5	Low	$-	$29,000	$-	$107,000	$240,000
DMB3 (SP4) Pile 1 to 2	Low	$-	$20,000	$-	$71,000	$240,000
DMB2 (SN8) Pile 12 to 13	Low	$-	$36,000	$-	$47,000	$120,000
DMB2 (SN8) Pile 1 to 11	Medium	$197,000	$285,000	$258,000	$540,000	$1,320,000
TOTAL		**$1,395,000**	**$1,539,000**	**$9,719,000**	**$8,590,200**	**$27,360,000**

*Costs shown are preliminary construction costs only, and do not include items such as escalation, mobilization, contingency, construction and site management, etc. For the retrofit areas there is a substantial savings in the cost of retrofit improvements when considered in conjunction with bluff toe and bluff face stabilization.

7.3. BLUFF TOE AND BLUFF FACE STABILIZATION

Table 21 below provides a summary of preliminary construction costs for the bluff toe and bluff surface stabilizations. These include the cost of the piles and lagging for the construction of the seawall, backfill behind the seawall, surface stabilization anchors, engineered mat, and revegetation costs. The Phase I seawalls are prioritized at locations where the seawalls would provide the maximum benefit and stabilize the trackbed for 30-year bluff retreat, while the Phase II seawalls would be constructed as a future phase at remaining locations based on priority and funding availability.

Table 21 – Cost of Bluff Toe and Bluff Face Stabilization Improvements (All costs in 2021 dollars)	
Proposed Improvements	**Cost of Proposed Improvements**
Phase I Seawalls and Surface Stabilization	$9,799,000
Phase II Seawalls	$4,005,000

Table 22 – Summary of Proposed Trackbed Stabilization and Retrofit Costs with and without Bluff Toe and Bluff Face Stabilization Improvements (All costs in 2021 dollars)				
	Bluff Top Improvements in Conjunction with Bluff Toe and Bluff Face Stabilization		**Bluff Top Improvements Only**	
Proposed Improvements	**Phase I**	**Phase II**	**Phase I**	**Phase II**
Proposed Trackbed Stabilization	$15,543,000	$187,000	$16,101,000	$985,000
Retrofit Support Stabilization	$1,395,000	$1,539,000	$9,719,000	$8,590,000
Seawall and Surface Stabilization	$9,799,000	$4,005,000	0	0
TOTAL	**$26,737,000**	**$5,731,000**	**$25,820,000**	**$9,575,000**

*Costs shown are preliminary construction costs only, and do not include items such as escalation, mobilization, construction and site management, etc.

When comparing the costs of retrofit improvements, the option utilizing bluff toe and bluff surface stabilization is significantly less expensive than the option considering blufftop improvements, considering the overall cost of the 30 year and 50 year needs.

7.4. DRAINAGE IMPROVEMENTS

Preliminary construction costs for the drainage improvements are listed in ***Table 23*** below. As the proposed drainage improvements are repairs of existing drainage features, and relatively minor in cost, costs for the alternatives considered are not shown.

Table 23 – Cost of Drainage Improvements *(All costs in 2021 dollars)*		
Ranking	**Location**	**Cost of Proposed Improvements**
High	Drainage Area 1 – Coast Boulevard, MP244.16 – MP 244.22, West of Tracks	$672,000
High	Drainage Area 2 - Coast Boulevard, MP244.16 – MP 244.3, East of Tracks	$1,375,000
High	Drainage Area 3 – MP 244.3 – MP 244.4	$1,940,000
High	Drainage Area 4 – MP 244.4 – MP 244.45	$660,000
High	Drainage Area 5- MP 244.45– MP 244.8	$1,160,000
High	Drainage Area 6 – MP 244.48– MP 244.71	$230,000
Medium	Drainage Area 7– MP 244.64– MP 244.71	$60,000
Medium	Drainage Area 8– MP 244.7	$130,000
High	Drainage Area 9 - MP 244.8– MP 245.14	$740,000
Medium	Drainage Area 10 - MP 244.83– MP 245.02	$90,000
Medium	Drainage Area 11- MP 244.9	$20,000
Medium	Drainage Area 12 - MP 245.1– MP 245.06	$210,000
Low	Drainage Area 13 - MP 245.05	$20,000
Medium	Drainage Area 14 – MP 245.39-245.62	$340,000
Low	Drainage Area 15 – MP 245.35-245.37	$100,000
	Underdrains	$1,650,000
	TOTAL	**$9,397,000**

*Costs shown are preliminary construction costs only, and do not include items such as escalation, mobilization, construction and site management, etc.

7.5. ACCESS ROAD IMPROVEMENTS

The preliminary construction cost for regrading the access road (roughly 13,000 square feet) is $100,000.

8. ALTERNATIVES ASSESSMENT

As described earlier, the project consists of three distinct components:

- Bluff Stabilizations, including trackbed support stabilization, retrofit, toe protection and bluff face stabilization.
- Drainage Improvements.
- Miscellaneous Improvements, such as access roads.

This assessment is used to assist in the selection of the most appropriate alternative for the bluff stabilizations. Most of the drainage improvements are repairs of existing facilities. The evaluation for the drainage alternatives, where alternatives were considered, is included in Section 3.2 and an alternatives assessment is not performed here. Access road improvements consist of regrading existing facilities and alternatives were not considered. The three categories selected for the assessment of bluff stabilization improvements are:

1. Constructability - Section 6 summarizes the constructability for this project, including the ability to build within access limitations, with commonly available construction equipment, and with minimal impact to rail operations.
2. Construction Cost - The construction cost for each stabilization alternative and stabilization area is estimated based on preliminary engineering and is reported in Section 7. Since the estimated cost includes provisions for the type and complexity of the work, the costs can be directly compared for each area and alternative.
3. Environmental Considerations - ***Table 15*** in Section 5 presents the summary of environmental considerations conducted based on visual resources, noise, biological resources, recreation and coastal processes and potential conflicts with regulatory approvals, along with an overall ranking. The figures below show visual simulations of the project, north of 11th Street, comparing improvements needed to protect against 30-year bluff retreat, when constructed at the bluff top only versus improvements at the bluff top in conjunction with bluff toe and bluff face stabilization.

***Figure 44* - Existing Conditions**

***Figure 45* – Construction of improvements at the bluff top only**

Figure 46 **– Construction of improvements at the bluff top in conjunction with bluff toe and bluff face stabilization**

8.1. TRACKBED SUPPORT STABILIZATION

The following stabilization alternatives were evaluated for their relative suitability for lower bluff stabilization:

a. Construction of improvements at the bluff top in conjunction with bluff toe and bluff face stabilization
b. Construction of improvements at the bluff top only
c. Soil Cement Buttress, where feasible
d. Soil Nail Wall, where feasible

As noted in ***Table 24***, the preferred approach is therefore the option that includes bluff toe and bluff face stabilization at prioritized areas to protect against 30-year bluff retreat, in addition to trackbed piles, as this provides lesser depth of exposed lagging and number of tiebacks, lesser grading at the bluff face, a more viable solution that minimizes permanent structures at the trackbed. This hybrid solution includes seawalls to reduce bluff retreat and mitigate for Sea Level Rise, while minimizing exposed lagging and large vertical walls at the bluff face. The seawalls and other retrofit needs required to extend the design life of stabilization features beyond 30 years, i.e., for the 50-year bluff retreat, could be constructed in a future phase. The trench grading is the preferred solution within SA22 and SA24, and alternatives were not evaluated, and therefore trench grading is not included in the table below. The soil cement buttress is only feasible at two locations, and therefore not comparable. The soil nail walls are feasible at all locations except SA23 and SA8, however the cost of the preferred approach would still be significantly less than the cost of soil nail walls. Since the preferred approach of bluff top improvements with bluff toe and bluff face stabilization was rated "best" for constructability and construction cost, it is also rated "best" overall solution.

Table 24 – Summary of Trackbed Support Stabilization Alternative Evaluation				
	Constructability	**Construction Cost**	**Environmental Considerations**	**Overall Rating**
Bluff Top and Bluff Toe Improvements, with Bluff Face Stabilization	Best	Best	Mid-level	Best
Bluff Top Improvements Only	Mid-level	Mid-level	Best	Mid-level
Soil Cement Buttress	Worst	N/A	Worst	Worst
Soil Nail Reinforcement	Mid-level	Worst	Worst	Worst

8.2. TRACKBED SUPPORT RETROFIT

The following stabilization alternatives were evaluated for their relative suitability for trackbed support retrofit:

a. Construction of improvements at the bluff top in conjunction with bluff toe and bluff face stabilization
b. Construction of improvements at the bluff top only
c. Cost of in-line piles. Costs for secondary walls are assumed to be similar to in-line and were not evaluated separately.

Table 25 – Summary of Trackbed Support Retrofit Alternative Evaluation				
	Constructability	**Construction Cost**	**Environmental Considerations**	**Overall Rating**
Bluff Top and Bluff Toe Improvements with Bluff Face Stabilization	Best	Best	Mid-level	Best
Bluff Top Improvements Only	Mid-level	Mid-level	Best	Mid-level
Inline Piles	Mid-level	Worst	Best	Mid-level

As noted in ***Table 25***, and ***Figure 10*** and ***Figure 11*** in Section 3.2, the preferred approach is therefore the option that includes bluff toe and bluff face stabilization at prioritized areas to protect against 30-year bluff retreat, as this provides lesser depth of exposed lagging and number of tiebacks, lesser grading at the bluff face, a more viable solution that minimizes permanent structures at the trackbed. This hybrid solution includes seawalls to reduce bluff retreat and mitigate for Sea Level Rise, while minimizing exposed lagging and large vertical walls at the bluff face. The seawalls and other retrofit needs required to extend the design life of stabilization features beyond 30 years, i.e., for the 50-year bluff retreat could be constructed in a future phase. Since the preferred approach bluff top retrofit improvements with bluff toe and bluff face stabilization was rated "best" for constructability and construction cost, it is also rated "best" overall solution.

9. CONCLUSIONS

Trackbed Support Stabilization and Retrofit: Based on the detailed geotechnical evaluation, environmental considerations, construction costs, future removability and constructability, construction of improvements at the bluff top in conjunction with bluff toe and bluff face stabilization is the preferred alternative for the trackbed support stabilization and retrofit for this project. The alternative with improvements at the blufftop only would require much more significant lagging, in the order of 25 to 35 feet at several locations and multiple rows of tiebacks to be constructed now to protect against 30-year bluff retreat, with major impacts to the bluff face. These improvements would also be harder to remove in the future when the tracks are moved from the bluffs. Therefore, construction of improvements at the bluff top in conjunction with bluff toe and bluff face stabilization is the recommended stabilization and retrofit method for lower bluff stabilization areas. Based on our analysis and demonstrated by recent bluff failures in the last three years, stabilization measures are urgently needed to support and protect the trackbed. Therefore, the recommended stabilization and retrofit improvements need to be constructed as soon as possible, prioritizing the locations from high to low, based on available funding.

Drainage and Access Road Improvements: The proposed drainage improvements are needed to protect the railroad and mitigate the potential for sudden bluff failure that could result from a failed drainage system. Regrading of the existing access roads is required for ongoing maintenance purposes.

Table 26 lists the total project costs for the Proposed Action to preserve track bed support and extend the service life by an additional 30 to 50 years (Phase I and Phase II improvements).

Table 26 – Project Costs *(All costs in 2021 dollars)*

Component	**Phase I**	**Phase II**	**TOTAL**
Trackbed support stabilization	$ 15,543,000	$ 187,000	$ 15,730,000
Trench Grading	$ 775,000	$ -	$ 775,000
Trackbed support retrofit	$ 1,395,000	$ 1,539,000	$ 2,934,000
Bluff Toe and Bluff Face Stabilizations	$ 9,799,000	$ 4,005,000	$ 13,804,000
Drainage improvements	$ 9,397,000	$ -	$ 9,397,000
Access road improvements	$ 100,000	$ -	$ 100,000
BASE CONSTRUCTION ESTIMATE (BCE)	**$ 37,009,000**	**$ 5,731,000**	**$ 42,740,000**
SWPPP and Temporary Erosion Control (6%)	$ 2,221,000	$ 344,000	$ 2,565,000
Mobilization and Demobilization (10%)	$ 3,701,000	$ 573,000	$ 4,274,000
Contingency (27%)	$ 9,992,000	$ 1,547,000	$ 11,539,000
CONSTRUCTION COST ESTIMATE (CCE)	**$ 52,923,000**	**$ 8,195,000**	**$ 61,118,000**
Ancillary Construction and Design costs	$ 26,991,000	$ 4,179,000	$ 31,170,000
Right of Way Costs	$ 700,000	$ -	$ 700,000
PROJECT COST ESTIMATE	**$ 80,614,000**	**$ 12,374,000**	**$ 92,988,000**

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