Broad Beach Restoration Project

Addendum #1 to the
Coastal Engineering Report
Exhibit L to CDP Application 4-12-043

PREPARED FOR:

BROAD BEACH GEOLOGIC HAZARD ABATEMENT DISTRICT

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Response to CCC Comments by Ensitu Engineering, Inc. February 2014

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Exhibit F-A1	Design Drawings for Additional Alternatives

1. INTRODUCTION

This addendum to the Broad Beach Restoration Project Coastal Engineering Report (CER) was prepared in response to comments on the *Alternatives Analysis* provided by the California Coastal Commission (CCC) under item 3 of its letter dated December 20, 2013 and in subsequent discussions between the Broad Beach Geological Hazard Abatement District (BBGHAD) project team and CCC staff.

Six additional project alternatives were developed and analyzed to cover "all feasible alternatives to the proposed project that would serve to minimize adverse impacts to coastal resources" as requested in the December 20, 2013 CCC letter. The additional alternatives account for the following considerations:

1. A third scenario for upgrades to existing onsite wastewater treatment systems (OWTSs) which assumes alternative treatment systems are installed permitting a higher leach field loading rate and future expansion areas are not required. The design of upgraded OWTSs is summarized in the Ensitu Engineering, Inc report provided in Appendix 7-A1.
2. Partial removal of the temporary emergency revetment along East Broad Beach where sufficient setback exists between the baseline wave uprush line and primary structures
3. Feasibility of reduced beach nourishment volume at the west end of Broad Beach to reduce the potential for impacts to intertidal habitat near Point Lechuza.

Based on these considerations the additional alternatives described in Table 1-1 were analyzed following the same methodology applied to alternatives presented in the CER (M&N, 2013). A summary of the engineering analysis and potential impacts of each alternative are provided in the following sections of this report.

Table 1-1. List of Additional Alternatives

Alternative	Title and Description
3C	**Landward-located Seawall Along Upgraded Leach Fields (Ensitu-Scenario 3) with Beach Nourishment and Dune Restoration:** The temporary emergency revetment would be removed and a vertical seawall would be constructed following a stringline along the Scenario 3 upgraded leach fields. Beach nourishment & dune restoration would be similar to the proposed project.
6C	**Relocation of Improved Revetment Along Upgraded Leach Fields (ENSITU - Scenario 3) with Beach Nourishment & Dune Restoration:** Where feasible, the temporary emergency revetment would be removed and an improved revetment would be constructed following a stringline along the Scenario3 upgraded leach fields. Beach nourishment & dune restoration would be similar to the proposed project.
7A	**Removal of Existing Temporary Revetment East of 30970 Broad Beach Road with Beach Nourishment & Dune Restoration:** The temporary emergency revetment would be removed at the eastern end of Broad Beach where more than a 15 foot buffer exists between the existing leach fields and the baseline wave uprush line. About 1,130 feet of revetment would be removed under this alternative. Beach nourishment & dune restoration would be similar to the proposed project design.
7B	**Removal of Existing Temporary Revetment East of 31034 Broad Beach Road with Beach Nourishment & Dune Restoration:** The temporary emergency revetment would be removed at the eastern end of Broad Beach where more than a 15 foot buffer exists between the upgraded (ENSITU-Scenario 3) leach fields and the baseline wave uprush line. About 1,600 feet of revetment would be removed under this alternative. Beach nourishment & dune restoration would be similar to the proposed project design.
8	**No Beach Nourishment at West Broad Beach with Revetment at Current Location:** No beach nourishment or dune restoration would occur west of 31346 Broad Beach Road (west end of temporary revetment) to avoid and minimize impacts to intertidal habitat near Point Lechuza. East of this location the revetment, beach nourishment and dune restoration are the same as proposed for the project. The total volume of nourishment and dune restoration would be reduced to about 460,000 cy.
9	**Reduced Beach Nourishment at West Broad Beach with Revetment at Current Location:** Beach nourishment west of 31346 Broad Beach Road (west end of temporary revetment) would be limited to about 60,000 cy to minimize impacts to intertidal habitat near Point Lechuza. No restored dune is proposed west of 31346 Broad Beach Road. East of this location the revetment, beach nourishment and dune restoration are the same as proposed for the project. The total volume of nourishment and dune restoration would be reduced to about 520,000 cy.

2. ALTERNATIVE 3C, LANDWARD-LOCATED SEAWALL ALONG UPGRADED LEACH FIELDS (ENSITU-SCENARIO 3) WITH BEACH NOURISHMENT AND DUNE RESTORATION

This alternative specifies the replacement of the current temporary revetment with a seawall of sufficient size and strength to protect the 78 homes landward of the current revetment and the voluntary replacement of existing septic systems with alternative onsite wastewater treatment systems (AOWTSs) to achieve the CCC's requested most landward possible alignment and location of such improvements. This alternative represents the most landward feasible alignment of a vertical seawall that follows a stringline no less than 6 feet from the upgraded leach fields based on Scenario 3 evaluated by Ensitu Engineering Inc. (EEI, 2014). Current codes allow a seawall to be located within six feet of the seaward edge of a leach field (EEI, 2013). By definition, a seawall is constructed high enough to preclude direct wave overtopping, hence the much closer proximity allowed. The stringline along the leach fields was drawn in such a manner that it would closely represent the alignment of a shoreline protective device (SPD), i.e., relatively smooth alignment without abrupt or jagged discontinuities.

EEI evaluated a third scenario for potential upgrades Onsite Wastewater Treatment Systems (OWTSs) based on comments from California Coastal Commission (CCC) staff provided in their letter dated December 20th 2013. The layout of upgraded leach fields for Scenario 3 is based on the following assumptions:

1. Existing septic & leach fields systems are replaced with alternative onsite wastewater treatment systems (AOWTSs)
2. Allowance for future leach fields is not provided.
3. A loading rate of 2 gallons/square foot/day is used to determine the minimum leach field area requirements.

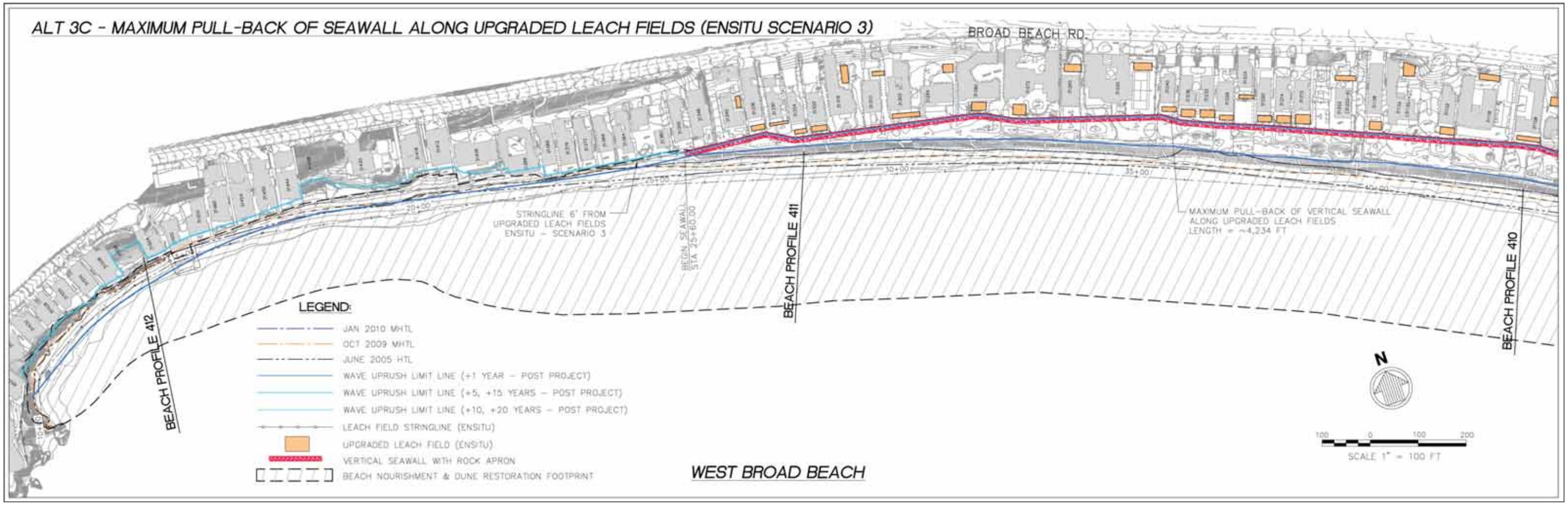
These assumptions result in upgraded leach fields with smaller footprints than existing leach fields and reflect the landward most feasible relocation of AOWTS infrastructure regardless of existing auxiliary buildings, landscape, and hardscape. The design calculations and layout of upgraded AOWTS infrastructure for Scenario 3 are provided in the EEI, 2014 report (Appendix 7-A1).

2.1 SEAWALL DESIGN

Seawall construction could consist of a range of alternative designs, including steel sheetpile with a concrete cap, or cast-in-place concrete seawall. A sheetpile seawall would be preferred due to the smaller construction footprint and close proximity of existing OWTS leach fields. A

cast-in-place concrete wall may not be feasible due to the wider construction footprint and impacts to the existing leach fields. This analysis assumes a sheetpile wall and concrete cap are installed with a crest elevation of +20 feet MLLW. The wall would be encased in concrete down to about 0 feet MLLW with a rock apron (10 feet wide) installed for scour protection.

A plan view and representative section of this alternative and the corresponding wave uprush lines are shown in Figure 2-1 and Figure 2-2. Detailed drawings of this alternative are provided in Exhibit F-A1. The landward most relocation of AOWTS infrastructure results in a seawall alignment further landward than the temporary emergency revetment for its entire length of about 4,700 feet. The Alternative 3C seawall has an average setback distance of 75 feet from the toe of the temporary emergency revetment and a maximum setback of about 130 feet.



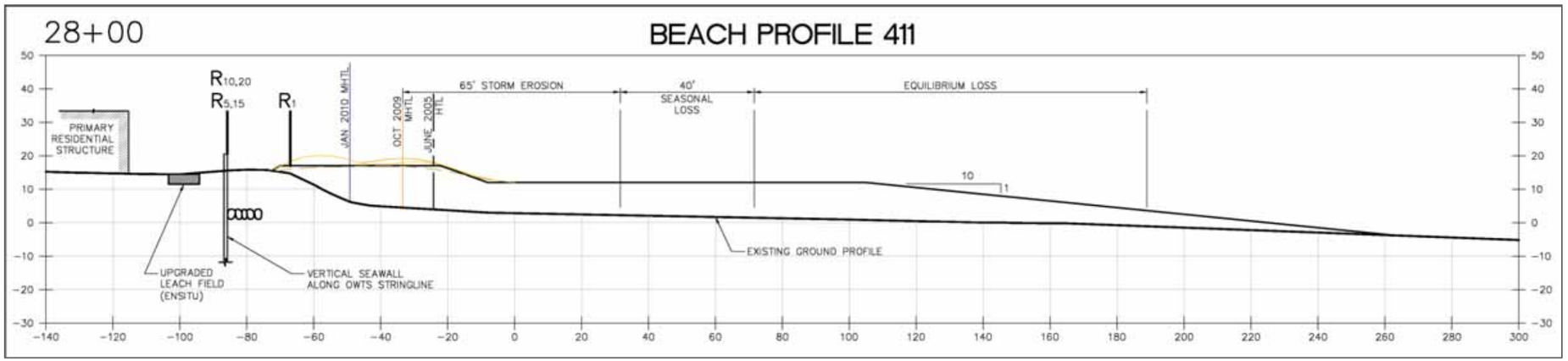
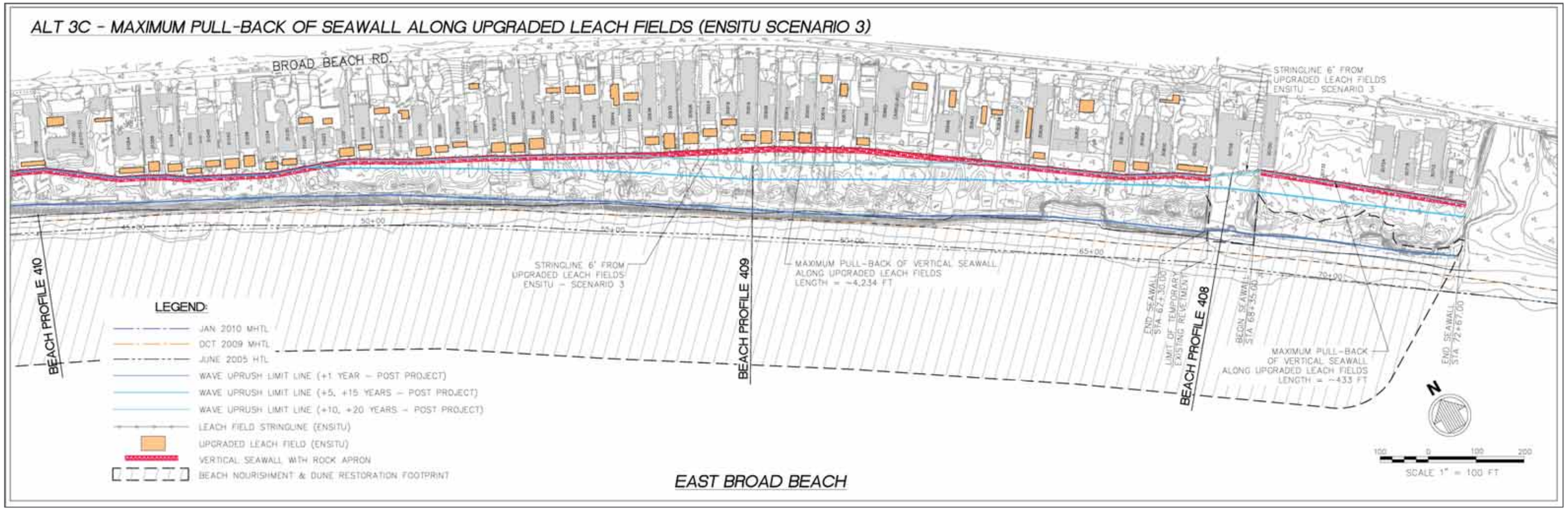


Figure 2-1. Alternative 3C– West Broad Beach



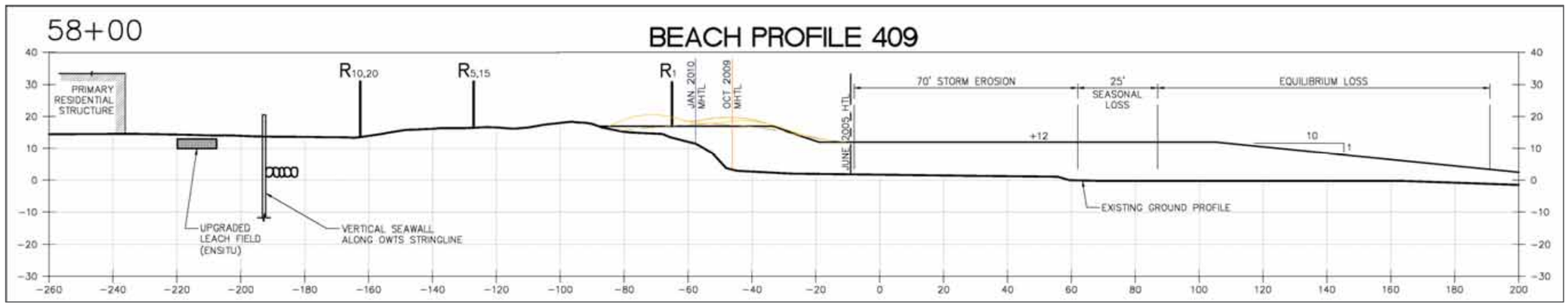


Figure 2-2. Alternative 3C– East Broad Beach

2.2 EXISTING DEVELOPMENT

A wave uprush analysis of Alternative 3C was performed following methodology applied for the proposed project and presented in Section 9.6 of the Coastal Engineering Report (CER) (M&N, 2013). The results indicate that all existing development (residential structures and leach fields) along Broad Beach will be outside of the 100-year wave uprush limit over the project's 20-year time horizon. The vertical seawall with a crest elevation of +20 feet MLLW would significantly reduce the potential for overtopping and the wave uprush limit line would remain seaward of the wall throughout the duration of the project. Relative to the baseline condition, the Alternative 3C project would substantially reduce the risk of coastal erosion and flood damage to existing development along Broad Beach. However, implementation of this alternative would also double the cost of the project without a funding source or authorization to do so. The seawall required by this alternative would also block views from each of the protected homes to the beach. A comparison of existing development at risk for the baseline condition and Alternative 3C is provided below.

In order to realign the seawall in accordance with the Ensitu Scenario 3 AOWTS implementation, all of the 78 residences will require system upgrades. Assuming the minimum upgrade cost estimate by EEI of $101,000, the added cost to the property owners to implement only the septic system upgrade aspect associated with this alternative is $7.9 million. Other aspects, such as demolition and reconstruction of backyards of the affected parcels would present additional cost.

Table 2-1. Alternative 3C – Risk to Existing Development Relative to Baseline Condition

Time Horizon	Baseline Conditions (2005)		Alternative 3C	
	Leach Fields at Risk	Residential Buildings at Risk	Leach Fields at Risk	Residential Buildings at Risk
West Broad Beach - Point Lechuza to Transect 411				
Present Time	2	8	0	0
+10 Years	3	24	0	0
+20 Years	3	32	0	0
Central Broad Beach – Transect 411 to Transect 410				
Present Time	7	3	0	0
+10 Years	10	17	0	0
+20 Years	10	23	0	0
East Broad Beach – Transect 410 to Transect 408				
Present Time	5	0	0	0
+10 Years	20	5	0	0
+20 Years	33	27	0	0
Totals (+20 years)	**46**	**82**	**0**	**0**

2.3 LITTORAL PROCESSES

Relative to the baseline conditions, the added protection for this alternative is achieved by an increased beach width in combination with a vertical seawall to act as a last line of defense. The beach nourishment and dune restoration template for this alternative is the same as for the proposed project. Please refer to Sections 9.2 through 9.4 of the CER (M&N, 2013) for engineering analysis and discussion of the proposed beach nourishment and dune restoration. Section 9.7 of the CER evaluates potential impacts due to the proposed beach nourishment and dune restoration. Analysis of seasonal & inter-annual profile changes was performed assuming a slower placement rate based on trucking sand from an inland source. The proposed nourishment volume will be placed over 8 months and would result in more sand loss during construction to long-shore and cross-shore transport during construction. Although the maximum beach widths are less than predicted for shorter placement durations, the overall profile changes along Broad Beach are similar to results of the proposed project beach fill analysis presented in Section 9.7 of the CER (M&N, 2013). Results of the seasonal and inter-

annual beach profile changes are provided in Appendix 5-A1. The analysis of potential impacts for Alternative 3C is summarized in Table 2-2.

The landward relocation of a vertical seawall will reduce the potential exposure of the structure during the proposed project and delay exposure of the seawall after cessation of nourishment activities. Based on an average setback distance of 75 feet from the temporary emergency revetment, the additional sand volume available for littoral transport is about 195,000 cubic yards. Assuming a continued sand loss rate of 53,000 cyy (based on 2009-2013 surveyed profiles), this alternative alignment provides an additional 3.5+ years' worth of sand to the littoral system. This additional volume of sand will temporarily delay exposure of the seawall by offsetting the effects of a long-term sediment deficit along Broad Beach. According to the average annual sand loss rate, this temporary benefit will last for about 3.5 years. The exposure of the seawall is heavily dependent on the magnitude of seasonal changes, storm related erosion, and the ability of the beach to recover after significant storm events. As illustrated by the wave uprush analysis, large seasonal beach loss coupled with a 100-year storm event occurring mid-cycle (5 year post nourishment) could result in exposure of about 2,300 feet of seawall. Large seasonal beach loss coupled with an extreme storm event at the end of a nourishment cycle would result in almost complete exposure of the seawall.

Over the project duration, landward relocation of a vertical seawall would not substantially influence coastal processes. When the seawall is fronted by a sandy beach, which can be expected over the majority of the proposed project, there are no impacts of the structure on coastal processes. Should the seawall become partially exposed, the wave reflection from the vertical seawall may increase local erosion of sand in front of the exposed seawall. After the project, in the event nourishment activities are discontinued, the seawall alignment of Alternative 3C would provide a temporary benefit by delaying exposure of the structure and allowing additional sand to enter the littoral system over a period of about 3.5 years.

Historic shoreline erosion trends are expected to continue and will eventually expose the seawall. At this point, the impact on coastal processes for this alternative would become significant. Vertical walls are rigid and impermeable structures that reflect all wave energy and may contribute to erosion of sand in front of the structure. In comparison, wave reflection for a stone revetment is much less due to the energy dissipation provided by large voids in the structure. Although revetments may result in passive erosion due to the sand volume retained behind the structure, the active erosion due to wave reflection is typically not a concern.

2.4 STRUCTURAL INTEGRITY OF SHORE PROTECTION DEVICE

The purpose of a vertical seawall or bulkhead is to support, stabilize, and protect the property behind the device. Although typically more costly than a stone revetment, a vertical wall reduces the lateral encroachment onto the beach, which can be a major issue on most coastal

projects, particularly where public access is an issue. In contrast to a stone revetment, vertical walls are inflexible structures and failures can be catastrophic, expensive and difficult to repair. Maintenance is needed relatively infrequently, but, when necessary, it can be expensive. The recent repair histories of vertical seawalls (for example, in 2011, four contiguous neighbors spent in excess of $800,000 to repair a seawall protecting the homes from 31372 to 31360 Broad Beach Road) along West Broad Beach typify this issue.

These vertical wall structures will, in most cases, transmit hydrodynamic forces produced by waves to the soil behind them. The soil must therefore be compacted and retained. Most seawall and bulkhead failures in Southern California have occurred because the backfill material was lost and the wall failed in shear or inward bending moments. Seawall failures are less likely to occur when the backfill is properly placed, compacted and retained.

A landward located seawall would also eliminate protection of the restored dunes against coastal erosion. This has two distinct impacts: 1) an impact to terrestrial biological resources, should the restored dune habitat be lost to erosion; and 2) a loss of coastal protection provided by the elevated dunes against wave runup and overtopping. As the dune system erodes, the protective barrier is reduced and the primary structures would be more susceptible to flood damage from overtopping.

2.5 PUBLIC ACCESS AND AESTHETICS

In order to provide overtopping protection, the crest of the seawall would be designed at +20 MLLW or higher. This is about 5 to 8 feet above the existing ground along the proposed alignment. In addition to the aesthetic impacts of such a structure, a wall of this height would create a significant obstruction to vertical beach access and to property owners landward of the seawall.

The primary reason why vertical seawalls are currently preferred in general over rock revetment by the resource agencies is the reduced footprint, resulting in lesser impact on the public beach, which is a diminishing resource in Southern California. However, given the fact that this alternative includes the beach nourishment and dune restoration elements, the project intent remains to keep the shoreline protective device – seawall in this alternative case – completely buried. Therefore, the significantly greater cost of constructing a buried seawall, coupled with the visual obstruction issues, in relation to a buried revetment is unwarranted.

Given the fact that this project is completely funded by the BBGHAD, and the BBGHAD's existing assessment limits cannot be increased without a vote by the property owners within the GHAD in accordance with California law, the very high cost of constructing a seawall[1] would most likely result in the need to reduce or even eliminate the beach nourishment and dune reconstruction elements, thereby significantly reducing the public benefit and environmental benefit components of the project.

[1] Assuming a typical seawall cost of $3,500 per linear foot and a 4,700 foot project length, the cost of the seawall element alone would be on the order of $16.5 million, thereby nearly doubling the cost of the project and likely eliminating the ability to nourish the beach or create dune habitat.

Table 2-2. Alternative 3C – Summary of Potential Impacts

Category	Summary of Impacts
Existing Development	• All existing development (residential structures and existing leach fields) will be outside of 100-year wave uprush line over project duration (20 years). • Adds $7.9 million minimum in septic system upgrade costs.
Sand Supply	• Increased sand supply after initial 600,000 cy nourishment will reduce adverse impacts of sediment deficit. • Up to 195,000 cy of additional sand supply provided by landward relocation of SPD.
Beach Profile	• Seasonal profile changes (depth of sand cover) will temporarily increase in magnitude. • Inter-annual profile changes will not be impacted. Long-term trend of erosion is expected to continue. • Coarse grained nourishment may temporarily steepen upper profile after nourishment or backpassing.
Extreme Storm Erosion	• Added beach width will improve resistance to extreme storm erosion up to 5 years after initial nourishment. • After 5 years, majority of storm protection will be provided by the SPD. • Restored dune system will be seaward of the relocated seawall and susceptible to storm erosion.
Shore Protection Device (SPD) - Stability	• Reduced potential for overtopping due to structure type and crest elevation (+20 feet MLLW) • Less susceptible to adverse impacts associated with short-term SLR. • Maintenance needs are infrequent, but expensive. • Wave reflection may increase nearshore erosion and loss of sand to downcoast beaches.
SPD Alignment	• Relocated SPD will delay exposure of seawall by up to 3.5 years. • Relocated SPD may increase sand available to littoral processes.
Adaptive Management	• Increased potential for backpassing due to relocation of SPD. • Re-nourishment to occur as planned for proposed project.
Public Access	• Public access to dry beach will be significantly improved after nourishment for about 7 years. • From 7-10 years public access would be limited by dune habitat and seawall. • Vertical access limited if seawall becomes exposed between nourishment cycles (probable at west end). • Extended public access benefits due to relocated SPD (Up to 3.5 years after cessation of nourishment).
Aesthetics	• Beach aesthetics will be improved with a widened sandy beach and restored dune system. • Less potential for seawall exposure would improve aesthetics. • Erosion of dune system may adversely impact aesthetics.

3. ALTERNATIVE 6C, LANDWARD RELOCATION OF MORE ROBUST REVETMENT ALONG THE UPGRADED LEACH FIELDS (ENSITU-SCENARIO 3) WITH BEACH NOURISHMENT AND DUNE RESTORATION

This alternative specifies the replacement of the current temporary revetment with a more robust revetment of sufficient size and strength to protect the 78 homes landward of the current revetment and the voluntary replacement of existing septic systems with alternative onsite wastewater treatment systems (AOWTSs) to achieve the CCC's requested most landward possible alignment and location of such improvements. This alternative evaluates the options for pulling back a more robust revetment design as far landward as feasible following a stringline along the upgraded OWTSs based on Scenario 3 evaluated in the EEI Study (2014). As discussed in the Ensitu Engineering, Inc. (EEI) (2013) report, current codes require that a revetment be located such that the maximum wave uprush limit landward of the revetment be no closer than 15 feet of the seaward edge of leach field. The stringline along the leach fields was drawn in such a manner that it would closely represent the alignment of a shoreline protective device (SPD), i.e., relatively smooth alignment without abrupt or jagged discontinuities.

EEI evaluated a third scenario for potential upgrades Onsite Wastewater Treatment Systems (OWTSs) based on comments from California Coastal Commission (CCC) staff provided in their letter dated December 20th 2013. The layout of upgraded leach fields for Scenario 3 is based on the following assumptions:

1. Existing septic & leach fields systems are replaced with alternative onsite wastewater treatment systems (AOWTSs)
2. Allowance for future leach fields is not provided.
3. A loading rate of 2 gallons/square foot/day is used to determine the minimum leach field area requirements.

These assumptions result in upgraded leach fields with smaller footprints than existing leach fields and reflect the landward most feasible relocation of AOWTS infrastructure regardless of existing auxiliary buildings, landscape, and hardscape. The design calculations and layout of upgraded AOWTS infrastructure for Scenario 3 are provided in the EEI, 2014 report (Appendix 7-A1).

3.1 REVETMENT DESIGN

Regarding the elements of a more robust design, the existing revetment was constructed under emergency conditions during the El Niño winter of 2009/2010 using an armor stone size and shallower toe elevation to allow for faster construction. The intent of this alternative is to

replace the temporary emergency revetment with a more stable "permanent" revetment design in accordance with current design standards, following an alignment as far landward as feasible. This alternative would augment the emergency revetment with one additional outer layer of properly sized armor stone (3- to 5-ton) to represent a more permanent and stable design. All the armor stone used to construct the temporary revetment will be used as underlayer for the reconstructed revetment; new geotextile fabric will be required.

The foundation of the structure would also be improved by constructing a deeper toe and/or keying armor stone into bedrock. The modified revetment would become permanent and beach nourishment activities would take place directly over and seaward of the revetment. The rock would become buried below the restored dune and provide a last line of defense should the beach experience excessive sand loss during large storms or a series of storms. A typical cross section is illustrated in Figure 3-1.

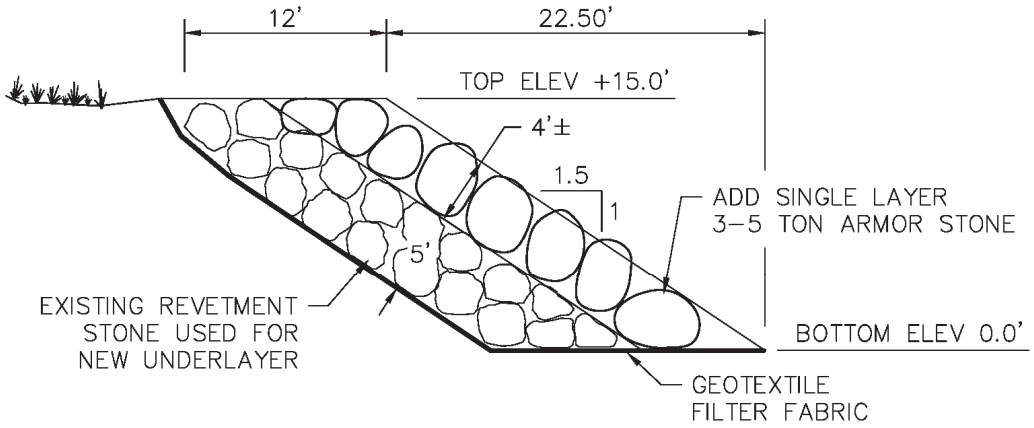
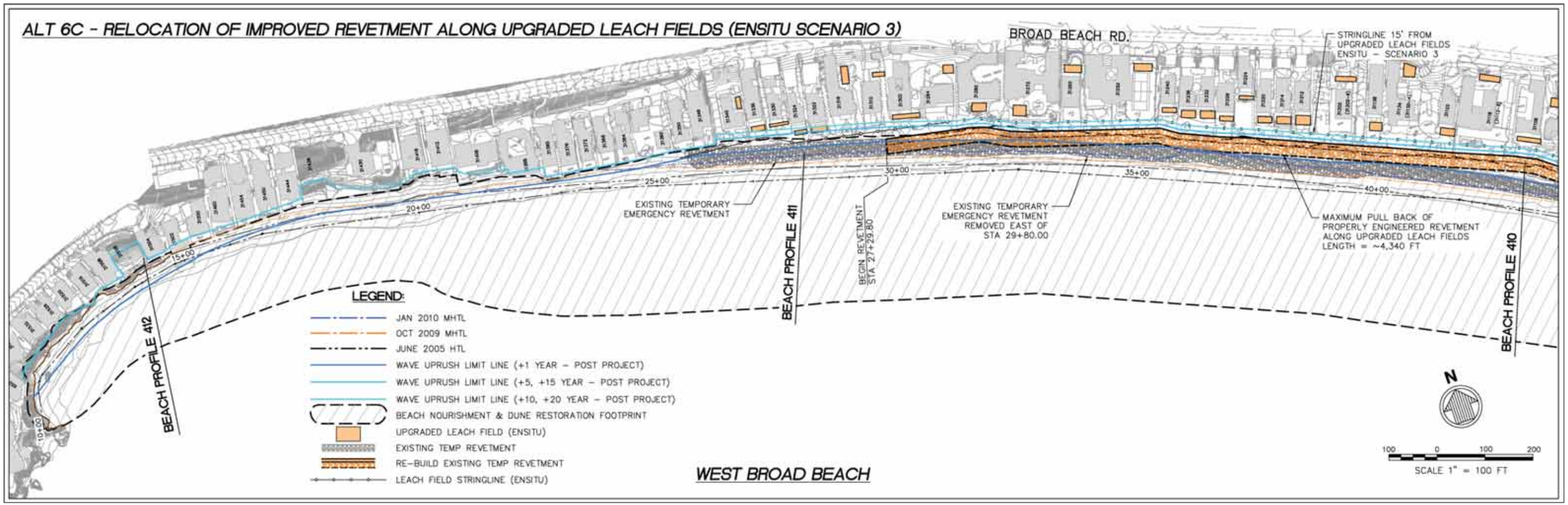


Figure 3-1. Typical Cross Section of Relocated Revetment

A plan view and representative section of this alternative and the corresponding wave uprush lines are shown in Figure 3-2 and Figure 3-3. Detailed drawings of this alternative are provided in Exhibit F-A1. Landward relocation of the western end of the temporary emergency revetment is constrained by the close proximity to the upgraded leach fields. For properties between 31346 and 31310 Broad Beach Road, revetment relocation was not feasible since the required 15 foot buffer from the wave uprush line to the upgraded leach field could not be met. Where landward relocation was not feasible the temporary emergency revetment would remain in its current location. The western end of the temporary emergency revetment has an average crest elevation of about +15 feet MLLW.

Relocation of the revetment was feasible within the parameters presented by the CCC for all properties east of 31310 Broad Beach Road for a total length of about 4,340 feet. The relocated revetment has an average setback of about 54 feet from the temporary emergency revetment and a maximum pullback of about 105 feet. The maximum wave uprush limit line for the relocated and improved revetment is about 25 feet landward of the revetment crest under current conditions, and about 30 feet landward with the inclusion of SLR.



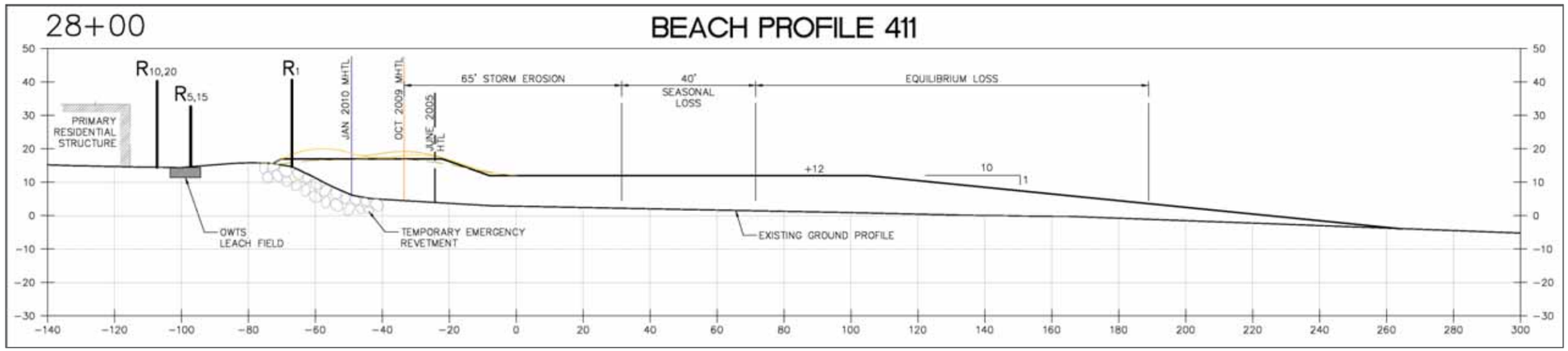
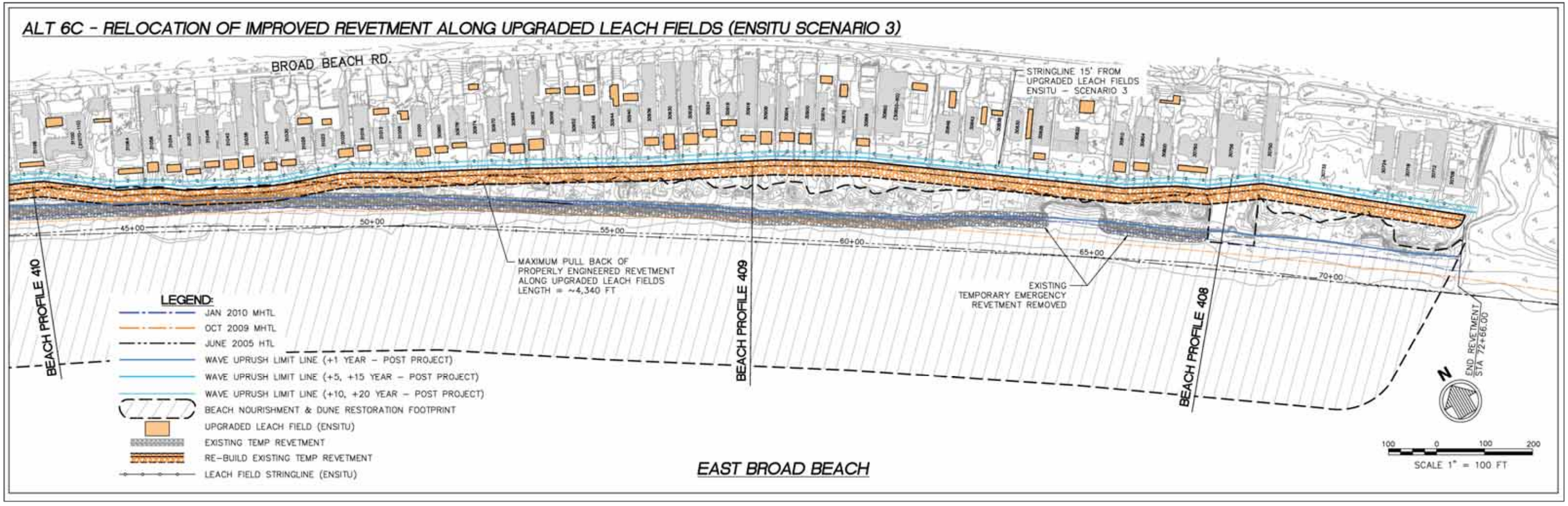


Figure 3-2. Alternative 6C– West Broad Beach



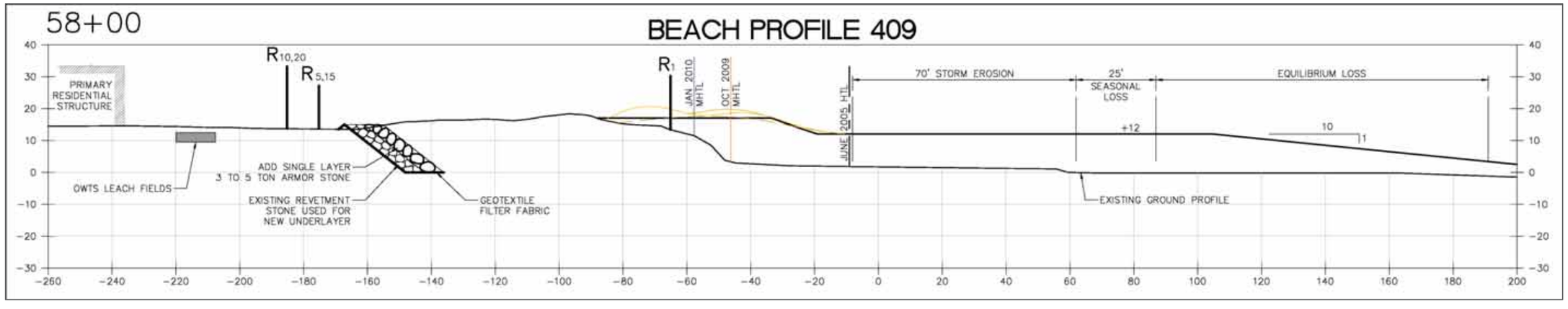


Figure 3-3. Alternative 6C – East Broad Beach

3.2 EXISTING DEVELOPMENT

A wave uprush analysis of Alternative 6C was performed following the methodology presented in Section 9.6 of the CER (M&N, 2013) for the proposed project. The results indicate that all residential structures along Broad Beach will be outside of the 100-year wave uprush limit over the project's 20-year time horizon, but some of the upgraded leach fields behind the west end of the revetment would remain at risk of damage from an extreme storm event at the end of a nourishment cycle. Relative to the baseline condition, the Alternative 6C project would substantially reduce the risk of coastal erosion and flood damage to existing development along Broad Beach, but such risk reduction would come at a cost significantly higher than the current project budget and relocation of existing septic systems. A comparison of existing development at risk for the baseline condition and Alternative 6C is provided below.

In order to realign the revetment in accordance with the Ensitu Scenario 3 AOWTS implementation, all of the 78 residences will require system upgrades. Assuming the minimum upgrade cost estimate by EEI of $101,000, the added cost to the property owners to implement only the septic system upgrade aspect of this alternative is $7.9 million. Other aspects, such as demolition and reconstruction of backyards of the affected parcels would present additional cost.

Table 3-1. Alternative 6C – Risk to Existing Development Relative to Baseline Condition

Time Horizon	Baseline Conditions (2005)		Alternative 6C	
	Existing Leach Fields at Risk	Residential Buildings at Risk	Upgraded Leach Fields at Risk	Residential Buildings at Risk
West Broad Beach - Point Lechuza to Transect 411				
Present Time	2	8	0	0
+10 Years	3	24	2	0
+20 Years	3	32	2	0
Central Broad Beach – Transect 411 to Transect 410				
Present Time	7	3	0	0
+10 Years	10	17	0	0
+20 Years	10	23	0	0
East Broad Beach – Transect 410 to Transect 408				
Present Time	5	0	0	0
+10 Years	20	5	0	0
+20 Years	33	27	0	0
Totals (+20 years)	**46**	**82**	**2**	**0**

3.3 LITTORAL PROCESSES

Relative to the baseline conditions, the added protection for this alternative is achieved by an increased beach width in combination with a rock revetment to act as a last line of defense. The beach nourishment and dune restoration template for this alternative is the same as for the proposed project. Please refer to Sections 9.2 through 9.4 of the CER (M&N, 2013) for engineering analysis and discussion of the proposed beach nourishment and dune restoration. Section 9.7 evaluates potential impacts due to the proposed beach nourishment and dune restoration. Analysis of seasonal & inter-annual profile changes was performed assuming a slower placement rate based on trucking sand from an inland source. The proposed nourishment volume will be placed over 8 months which will result in more sand loss during construction to long-shore and cross-shore transport during construction. Although the maximum beach widths are less than predicted for shorter placement durations, the overall profile changes along Broad Beach are similar to results of the proposed project beach fill analysis presented in Section 9.7 of the CER (M&N, 2013). Results of the seasonal and inter-annual beach profile changes are provided in Appendix 5-A1. The analysis of potential impacts for Alternative 6C is summarized in Table 3-2.

The relocation of 4,340 feet of revetment will reduce the potential exposure of a portion of revetment during the proposed project and delay exposure of the revetment after cessation of nourishment activities. Based on an average setback distance of 54 feet from the temporary emergency revetment, the additional sand volume available for littoral transport is about 130,000 cy. Assuming a continued sand loss rate of 53,000 cyy (based on 2009-2013 surveyed profiles), this alternative alignment provides an additional 2.5 years' worth of sand to the littoral system. This additional volume of sand will temporarily delay exposure of the revetment by offsetting the effects of a long-term sediment deficit along Broad Beach. Assuming the average annual sand loss rate continues unchanged, this temporary benefit will last for about 2.5 years. The exposure of the revetment is heavily dependent on the magnitude of seasonal changes, storm related erosion, and the ability of the beach to recover after significant storm events. As illustrated by the wave uprush analysis, large seasonal beach loss coupled with a 100-year storm event could result in exposure of the relocated revetment within the first several years of the proposed project.

Over the project duration, relocation of the downcoast portion of revetment with a properly engineered revetment would not substantially influence coastal processes. When the revetment is buried, there are no impacts of the structure on coastal processes. Should the revetment become exposed, there may be incremental increases in wave reflection and a slight reduction of littoral sand volume retained landward of the revetment.

3.4 STRUCTURAL INTEGRITY OF SHORE PROTECTION DEVICE

The deeper revetment toe and larger armor stone of the improved revetment will provide added resistance to geological hazards such as liquefaction and wave impacts. Complete failure due to liquefaction or wave impacts is unlikely for both the temporary emergency revetment and the improved revetment due to the flexible nature of a rock revetment and its ability to accommodate settling and displacement. The risk of wave runup and overtopping would also be lower for the improved revetment but would remain a concern.

The design wave height calculated for the critical design condition of extreme tide, scour and SLR is about 9.6 feet (M&N, 2013). The armor stone required to meet the 0 to 5 percent damage criteria for the design wave height is 3 to 4 tons in weight based on the Hudson formula (CEM, 2003). These results indicate the improved revetment and western portion of the temporary emergency revetment can withstand these design wave heights with minimal damage. Armor stone for the remainder of the temporary emergency revetment is under-sized and greater than 5 percent damage can be expected during the design wave event.

A relocated revetment as proposed for Alternative 6C would significantly reduce erosion protection of the restored dunes. This has two distinct impacts. One is an impact to terrestrial biological resources due to erosion of restored dune habitat. The second is a loss of coastal protection provided by the elevated dunes against wave runup and overtopping. If the entire restored dune system erodes, the maximum crest elevation of the protective barrier is reduced from about +20 feet MLLW to +15 feet MLLW, and the primary structures would be more susceptible to flood damage from overtopping.

3.5 PUBLIC ACCESS AND AESTHETICS

The impacts of this alternative on public access and aesthetics will be positive for most of the project duration. After an extreme storm event, partial or complete exposure of the revetment could potentially impact public access and aesthetics temporarily. During calmer post-storm conditions, the beach would recover some of the sand lost and help restore public access opportunity and aesthetics.

Landward relocation of the revetment would provide temporary public access and aesthetic benefits by delaying exposure of the relocated revetment. The exposure of the pulled back revetment would be delayed by about 2.5 years based on the average annual sand loss rate. Even with a pulled back revetment, the amount of dry beach width will be narrow or non-existent at the end of each nourishment cycle impacting public access and aesthetics until the next beach nourishment project. This impact would be temporary and similar to conditions between 2010 and 2013 when a narrow and seasonal beach existed along the temporary emergency revetment.

Table 3-2. Alternative 6C – Summary of Potential Impacts

Category	Summary of Impacts
Existing Development	• All residential structures will be outside of 100-year wave uprush line over project duration (20 years). • Approximately 2 leach fields remain at risk of damage from wave uprush at the end of each nourishment cycle. • Adds $7.9 million minimum in septic system upgrade costs.
Sand Supply	• Increased sand supply after initial 600,000 cy nourishment will reduce adverse impacts of sediment deficit. • Up to 130,000 cy of additional sand supply provided by relocation of SPD.
Beach Profile	• Seasonal profile changes (depth of sand cover) will temporarily increase in magnitude. • Inter-annual profile changes will not be impacted. Long-term trend of erosion is expected to continue. • Coarse grained nourishment may temporarily steepen upper profile after nourishment or backpassing.
Extreme Storm Erosion	• Added beach width will improve resistance to extreme storm erosion up to 5 years after initial nourishment. • After 5 years, majority of storm protection will be provided by the SPD and restored dune system. • Restored dune system will be mostly seaward of the relocated revetment and susceptible to storm erosion.
Shore Protection Device (SPD) - Stability	• Improved revetment (4,340 feet) less susceptible to damage (< 5%) during design storm event. • Less maintenance after extreme storm events compared to proposed project. • Maximum uprush line (with SLR) estimated to extend 30 feet landward of improved revetment. • Improved revetment less susceptible to adverse impacts associated with SLR.
SPD Alignment	• Relocated SPD may delay exposure of revetment by about 2.5 years. • Relocated SPD may increase sand available to littoral processes. • Relocated SPD reduces level of protection provided by restored dunes.
Adaptive Management	• Increased potential for backpassing due to relocation of SPD. • Re-nourishment to occur as planned for proposed project.
Public Access	• Public access to dry beach will be significantly improved after nourishment for about 7 years. • From 7-10 years public access will be similar to beach conditions between 2010 and 2013.
Aesthetics	• Beach aesthetics will be improved with a widened sandy beach and restored dune system. • Duration of revetment exposure would be lessened by about 2.5 years along relocated portion of SPD.

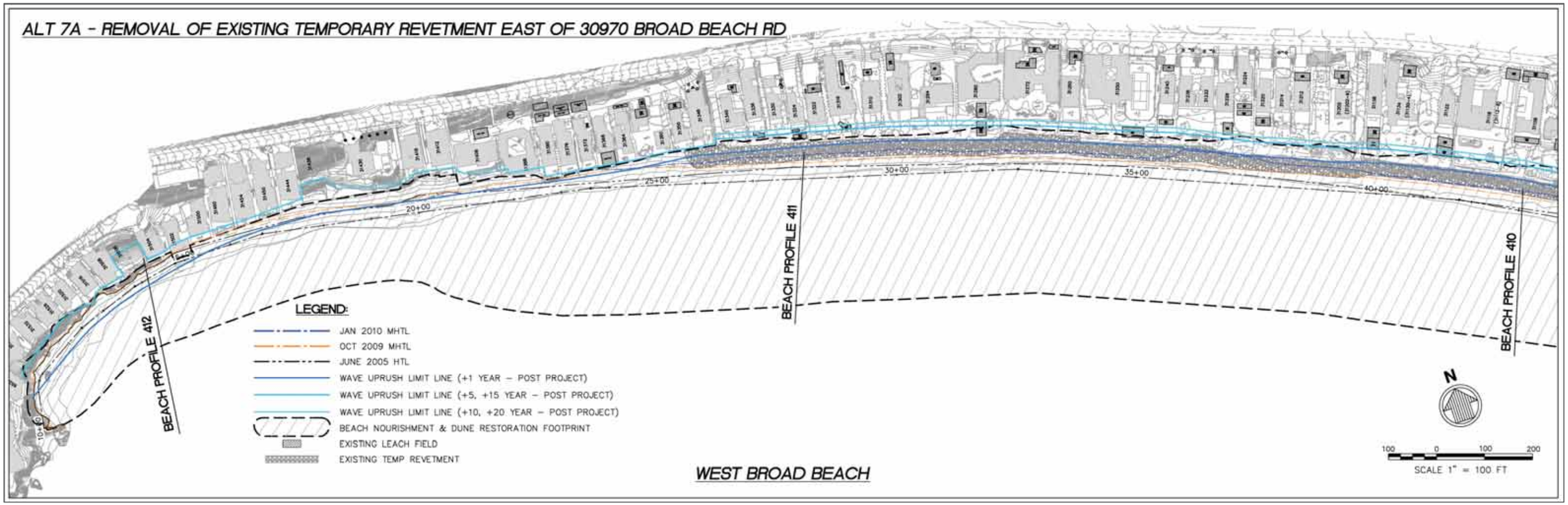
4. ALTERNATIVE 7A, REMOVAL OF TEMPORARY EXISTING REVETMENT EAST OF 30970 BROAD BEACH ROAD WITH BEACH NOURISHMENT AND DUNE RESTORATION

This alternative assumes the eastern portion of the temporary emergency revetment is removed east of 30970 Broad Beach Road. The length of revetment removed was based on the location of the existing leach fields relative to the pre-project "baseline" wave uprush line. If there was less than a 15 foot buffer between the baseline wave uprush line and the existing leach fields the revetment will remain in place to protect these primary structures. If there was a 15 foot or greater buffer from the baseline wave uprush line to the existing leach fields, which is the case for properties east of 30970 Broad Beach Road, the revetment would be removed. Based on this criterion, about 1,130 feet of revetment would be removed. The beach nourishment and dune restoration footprint for this alternative is the same as the proposed project.

The pre-project "baseline" wave uprush line was estimated relative to the 2005 shoreline assuming no shoreline protection structures were in place. Between June 2005 and January 2010 (when the temporary emergency revetment was constructed) the shoreline continued to recede by over 40 feet in some locations. Due to significant shoreline retreat between 2005 and 2010 the baseline wave uprush line under-predicts the current threat to existing infrastructure.

4.1 EXISTING DEVELOPMENT

A wave uprush analysis of Alternative 7A was performed following the methodology presented in Section 9.6 of the CER (M&N, 2013) for the proposed project. West of 30970 Broad Beach Road wave uprush during an extreme storm event is limited by the temporary emergency revetment which would remain in its current location with an average crest elevation of about +13 feet MLLW. The maximum wave uprush limit line along the temporary emergency revetment is about 35 feet landward of the revetment crest under current conditions, and about 40 feet landward with the inclusion of SLR. East of 30970 Broad Beach Road, where the temporary emergency revetment would be removed, the wave uprush line is not limited by a SPD and is dependent on a restored beach and dune system for storm protection. A plan view and representative section of this alternative and the corresponding wave uprush lines are shown in Figure 4-1 and Figure 4-2. Detailed drawings of this alternative are provided in Exhibit F-A1.



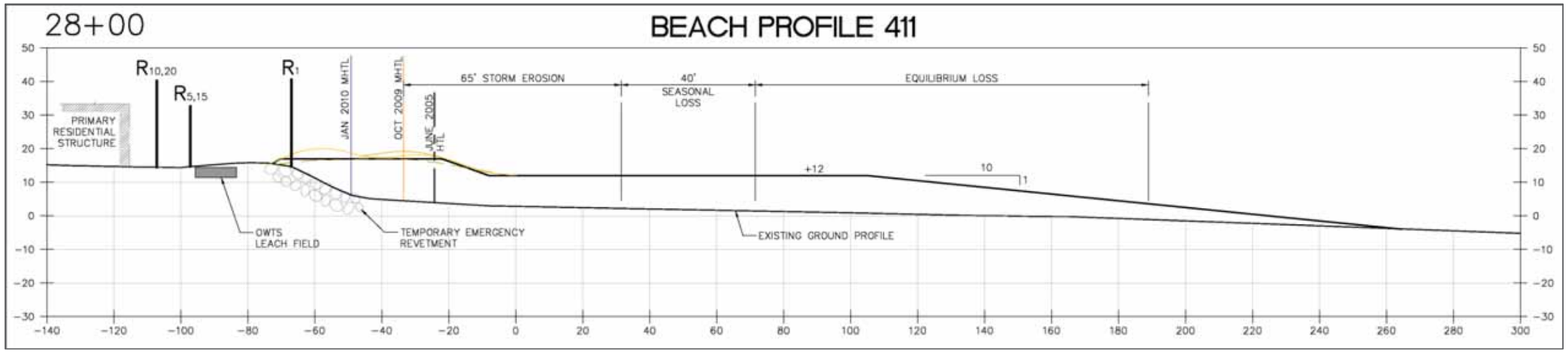
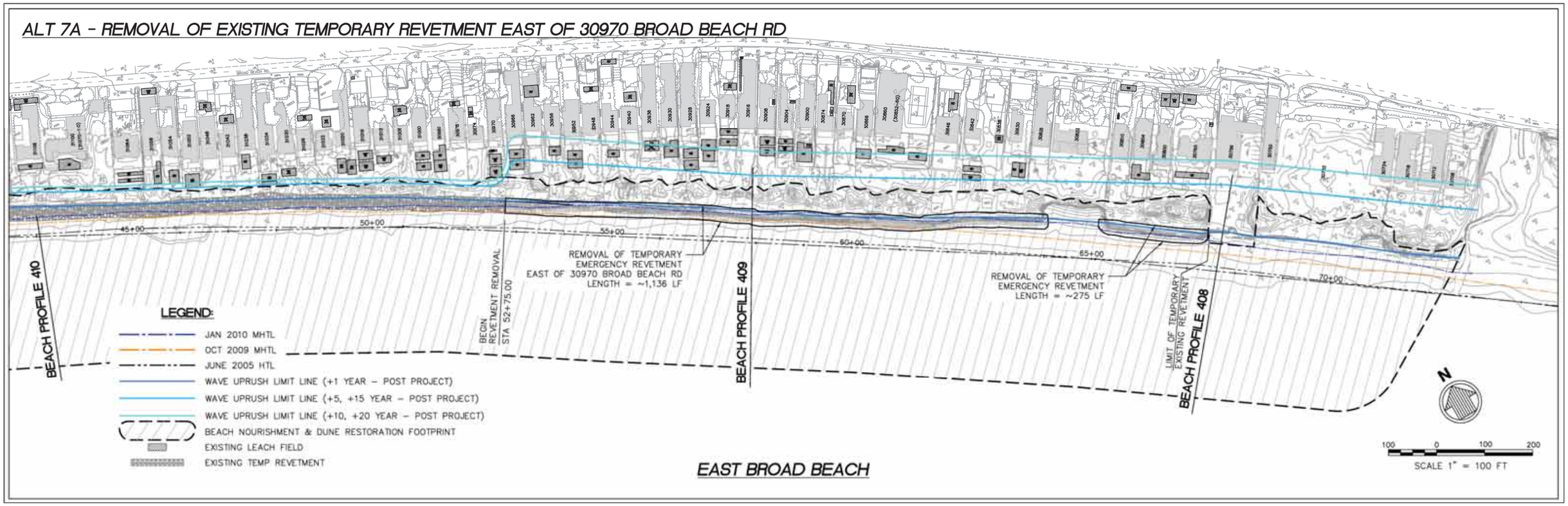


Figure 4-1. Alternative 7A– West Broad Beach



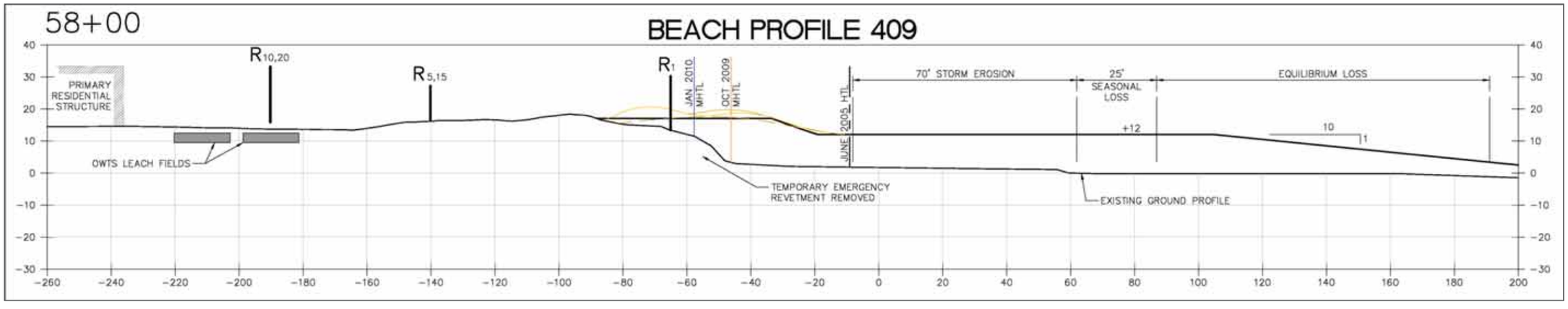


Figure 4-2. Alternative 7A – East Broad Beach

The wave uprush results indicate that all residential structures along Broad Beach protected by a seawall or revetment in combination with beach nourishment and dune restoration will be outside of the 100-year wave uprush limit over the project's 20-year time horizon. Along east Broad Beach residential structures without a revetment would be at risk of damage from an extreme storm event at the end of each nourishment cycle. Existing leach fields in close proximity to the temporary emergency revetment would be at risk of damage from wave overtopping at the middle to end of each nourishment cycle. Existing leach fields without structural shore protection would be at greater risk of damage since shoreline erosion has the potential to reach existing leach fields at the end of each nourishment cycle.

Relative to the baseline condition, the Alternative 7A project would reduce the risk of coastal erosion and flood damage to most existing development along Broad Beach. However, primary structures without shore protection would be at risk at the end of each nourishment cycle. It is important to note that residences at the eastern end of the project area east of 30756 Pacific Coast Highway (parcels from 30750 Pacific Coast Highway to 30708 Pacific Coast Highway) do not have a temporary revetment seaward of their residences. While these residences appear to be well set-back and protected under the baseline shoreline condition, this portion of the project area has lost approximately 80' of beach between the residences and the ocean since 2011. A comparison of existing development at risk for the baseline condition and Alternative 7A is provided below.

Table 4-1. Alternative 7A – Risk to Existing Development Relative to Baseline Condition

Time Horizon	Baseline Conditions (2005)		Alternative 7A	
	Existing Leach Fields at Risk	Residential Buildings at Risk	Existing Leach Fields at Risk	Residential Buildings at Risk
West Broad Beach - Point Lechuza to Transect 411				
Present Time	2	8	0	0
+10 Years	3	24	2	0
+20 Years	3	32	2	0
Central Broad Beach – Transect 411 to Transect 410				
Present Time	7	3	0	0
+10 Years	10	17	6	0
+20 Years	10	23	6	0
East Broad Beach – Transect 410 to Transect 408				
Present Time	5	0	0	0
+10 Years	20	5	23	11
+20 Years	33	27	23	11
Totals (+20 years)	**46**	**82**	**31**	**11**

4.2 LITTORAL PROCESSES

Relative to the baseline conditions, the added protection for this alternative is achieved by an increased beach width and restored dune in combination with a rock revetment to act as a last line of defense. The beach nourishment and dune restoration template for this alternative is the same as for the proposed project. Please refer to Sections 9.2 through 9.4 of the CER (M&N, 2013) for engineering analysis and discussion of the proposed beach nourishment and dune restoration. Section 9.7 evaluates potential impacts due to the proposed beach nourishment and dune restoration.

Analysis of seasonal and inter-annual profile changes was performed assuming a slower placement rate based on trucking sand from an inland source. The proposed nourishment volume will be placed over 8 months which will result in more sand loss during construction to long-shore and cross-shore transport during construction. Although the maximum beach widths are less than predicted for shorter placement durations, the overall profile changes along Broad Beach are similar to results of the proposed project beach fill analysis presented in Section 9.7 of the CER (M&N, 2013). Results of the seasonal and inter-annual beach profile changes are provided in Appendix 5-A1.

Over the project duration, the temporary existing revetment would not substantially influence coastal processes. When the revetment is buried, there are no impacts of the structure on coastal processes. Should the revetment become exposed, there may be incremental increases in wave reflection and a slight reduction of littoral sand volume retained landward of the revetment. GENESIS results for Alternative 7A, shown in Figure 4-3, indicate the remaining portion of the revetment will be exposed about 7 years after nourishment.

Removal of the downcoast portion of the temporary emergency revetment will allow additional sand to be available for littoral transport. The volume of sand between the temporary emergency revetment and existing leach fields along this reach is about 85,000 cy. The benefit of this is additional sand entering the littoral system, equivalent to about 1.5 times the annual sand loss rate of 53,000 cy. This will provide a short-term benefit to littoral processes but comes at the cost of damage to the upgraded leach fields and residential structures in an extreme storm event and an increased rate of sand loss for the project area over the course of the project.

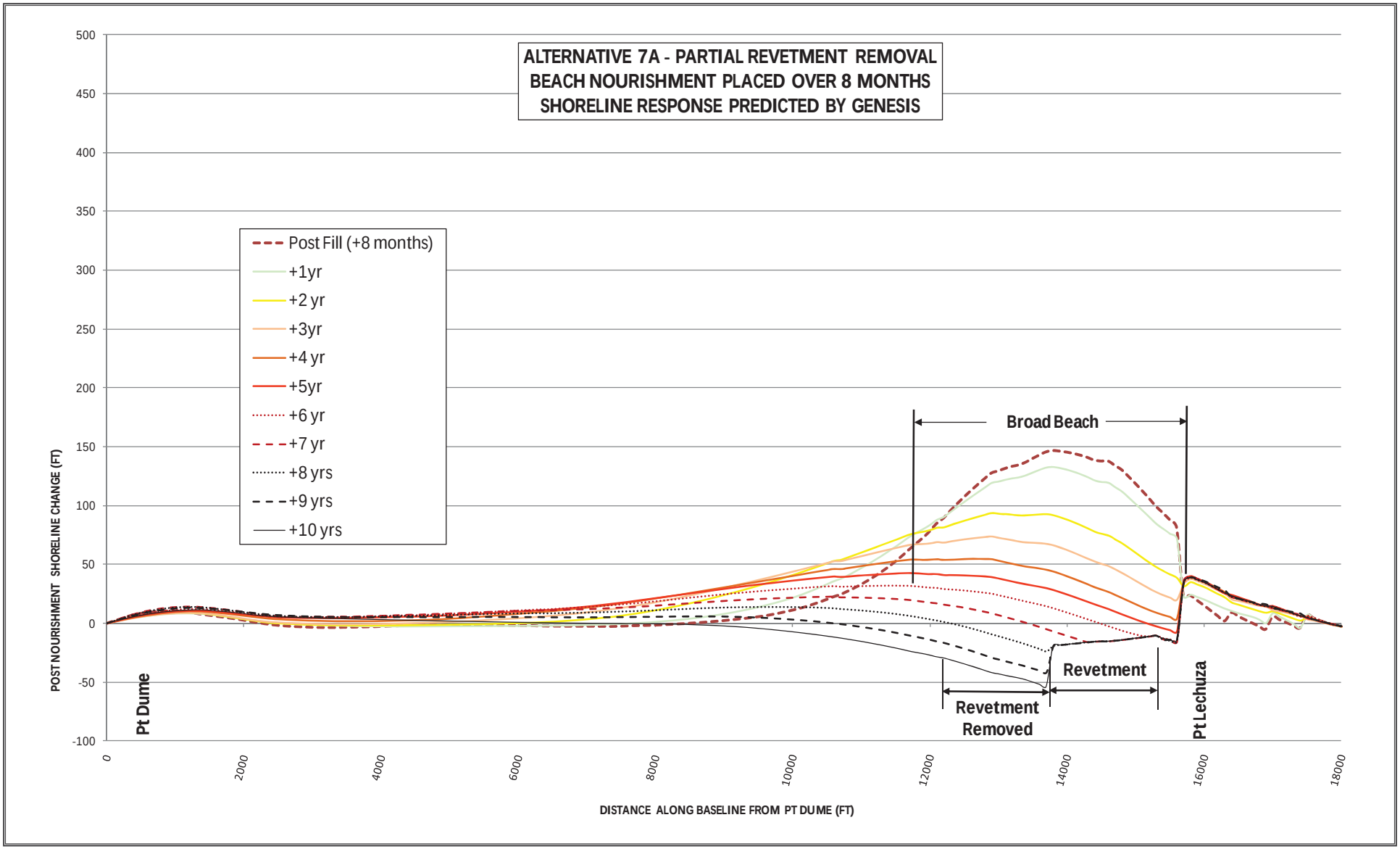


Figure 4-3. Alternative 7A – GENESIS Results

4.3 STRUCTURAL INTEGRITY OF SHORE PROTECTION DEVICE

The temporary emergency revetment will remain in its current location west of 30970 Broad Beach Road to provide a last line of defense behind the nourished beach. The general alignment of the revetment follows the foredune boundary of the baseline 2005 condition. Please refer to Section 9.1 for a discussion of the stability and integrity of this type of revetment. A discussion of impacts associated with the revetment is provided in Section9.8. The analysis of potential impacts for Alternative 7A is summarized in Table 4-2.

4.4 PUBLIC ACCESS AND AESTHETICS

The impacts of this alternative on public access and aesthetics will be positive for most of the project duration. After an extreme storm event, partial or complete exposure of the revetment could potentially impact public access and aesthetics temporarily. During calmer post-storm conditions, the beach would recover some of the sand lost and help restore public access opportunity and aesthetics.

At the end of each nourishment cycle the amount of dry beach width will be narrow or non-existent, impacting public access and aesthetics until the next re-nourishment project. This impact would be temporary and similar to conditions between 2010 and 2013 when a narrow and seasonal beach existed along the temporary emergency revetment. With removal of the downcoast portion of revetment, the impact of an exposed revetment on public access will be reduced. However, this alternative carries a higher potential for damage to existing development due to extreme storm erosion that would adversely impact public access and aesthetics.

Table 4-2. Alternative 7A – Summary of Potential Impacts

Category	Summary of Impacts
Existing Development	• Residential structures protected by an SPD along with nourishment and dune restoration will be outside of 100-year wave uprush line over project duration (20 years). • Residential structures without a revetment would be at risk of damage from an extreme storm event at the end of each nourishment cycle. • Approximately 32 existing leach fields (most along East Broad Beach) are at risk of damage from wave uprush at the end of each nourishment cycle.
Sand Supply	• Increased sand supply after initial 600,000 cy nourishment will reduce adverse impacts of sediment deficit. • Up to 85,000 cy of additional littoral sediment supply between removed SPD and existing leach fields.
Beach Profile	• Seasonal profile changes (depth of sand cover) will temporarily increase in magnitude. • Inter-annual profile changes will not be impacted. Long-term trend of erosion is expected to continue. • Coarse grained nourishment may temporarily steepen upper profile after nourishment or backpassing.
Extreme Storm Erosion	• Added beach width will improve resistance to extreme storm erosion up to 5 years after initial nourishment. • After 5 years, majority of storm protection will be provided by the SPD and restored dune system. • Inadequate extreme storm protection for East Broad Beach properties without an SPD.
Shore Protection Device (SPD) - Stability	• Temporary emergency revetment (remaining 2,970 feet) would be susceptible to damage > 5%. • Some maintenance probably required after an extreme storm event near end of nourishment cycle. • Maximum uprush line (with SLR) estimated to extend 40 feet landward of revetment crest. • Revetment could be adapted with an increased crest elevation if SLR exceeds projections over the project duration.
SPD Alignment	• Exposure of SPD is expected at the end of each nourishment cycle. • About 35,000 cy of sand is retained between the revetment and existing leach fields. • Alignment provides a stable foundation for restored dunes constructed over and landward of revetment.
Adaptive Management	• Regular backpassing from east to west will occur as planned for the proposed project. • Re-nourishment to occur as planned for proposed project.
Public Access	• Public access to dry beach will be significantly improved after nourishment for about 7 years.

	• From 7-10 years public access will be similar to beach conditions between 2010 and 2013.
Aesthetics	• Beach aesthetics will be improved with a widened sandy beach and restored dune system. • Aesthetic & public access impacts temporarily reduced at the end of a nourishment cycle where SPD was removed.

5. ALTERNATIVE 7B, REMOVAL OF TEMPORARY EXISTING REVETMENT EAST OF 31034 BROAD BEACH ROAD WITH UPGRADED LEACH FIELDS (ENSITU – SCENARIO 3), BEACH NOURISHMENT AND DUNE RESTORATION

This alternative assumes the temporary emergency revetment is removed east of 31034 Broad Beach Road and OWTS infrastructure is upgraded along Broad Beach based on Scenario 3 evaluated by Ensitu Engineering Inc (EEI). In order to realign the revetment in accordance with the Ensitu Scenario 3 AOWTS implementation, all of the 78 residences will require system upgrades. Assuming the minimum upgrade cost estimate by EEI of $101,000, the added cost to the property owners to implement only the septic system upgrade aspect of this alternative is $7.9 million. Other aspects, such as demolition and reconstruction of backyards of the affected parcels would present additional cost.

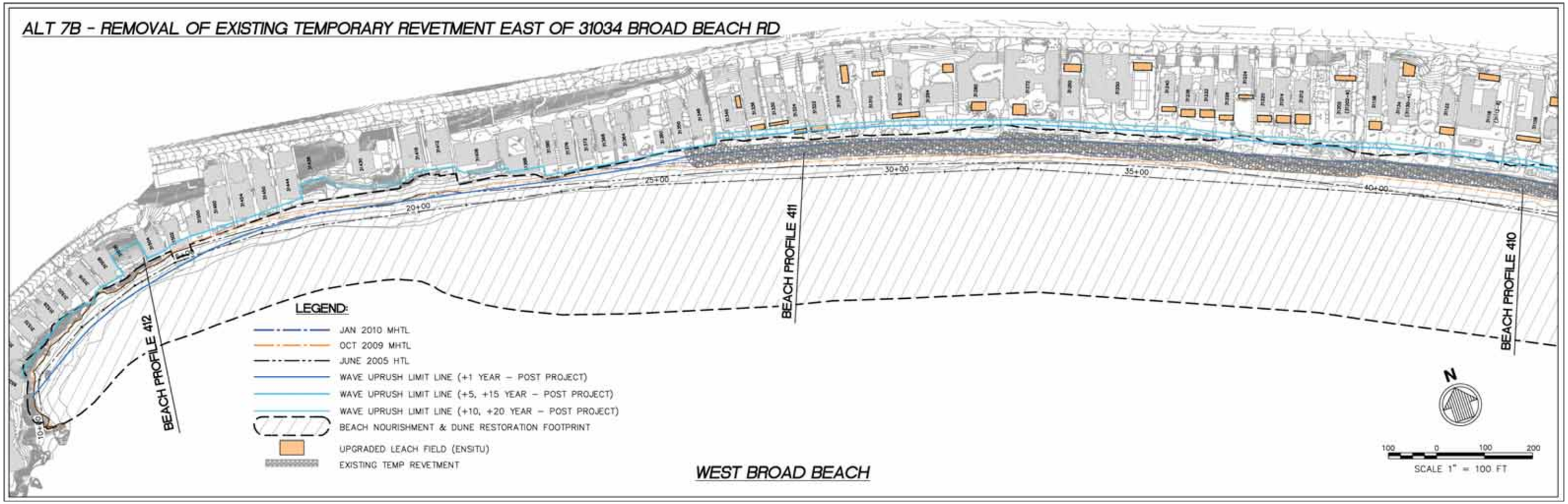
The length of revetment removed was based on the location of the upgraded leach fields (Scenario 3) relative to the pre-project "baseline" wave uprush line. If there was less than a 15 foot buffer between the baseline wave uprush line and the upgraded leach fields the revetment would remain in place to protect these primary structures. If there was a 15 foot or greater buffer from the baseline wave uprush line to the upgraded leach fields, which is the case for properties east of 31034 Broad Beach Road, the revetment would be removed. Based on this criterion, about 1,600 feet of revetment would be removed. The beach nourishment and dune restoration footprint for this alternative is the same as the proposed project.

The pre-project "baseline" wave uprush line was estimated relative to the 2005 shoreline assuming no shoreline protection structures were in place. Between June 2005 and January 2010 (when the temporary emergency revetment was constructed) the shoreline continued to recede by over 40 feet in some locations. Due to significant shoreline retreat between 2005 and 2010 the baseline wave uprush line under-predicts the current threat to existing infrastructure. Present day shoreline conditions exhibit up to 80 feet of shoreline retreat beyond the eastern terminus of the existing temporary revetment.

5.1 EXISTING DEVELOPMENT

A wave uprush analysis of Alternative 7B was performed following the methodology presented in Section 9.6 of the CER (M&N, 2013) for the proposed project. The wave uprush during an extreme storm event is limited by the temporary emergency revetment west of 31034 Broad Beach Road. With an average crest elevation of about +13 feet MLLW the maximum wave uprush limit line is about 35 feet landward of the revetment crest under current conditions, and about 40 feet landward with the inclusion of SLR. East of 31034 Broad Beach Road, where the temporary emergency revetment would be removed, the wave uprush line is not limited by a SPD and is dependent solely on a restored beach and dune system for storm protection. A plan

view and representative section of this alternative and the corresponding wave uprush lines are shown in Figure 4-1 and Figure 4-2. Detailed drawings of this alternative are provided in Exhibit F-A1.



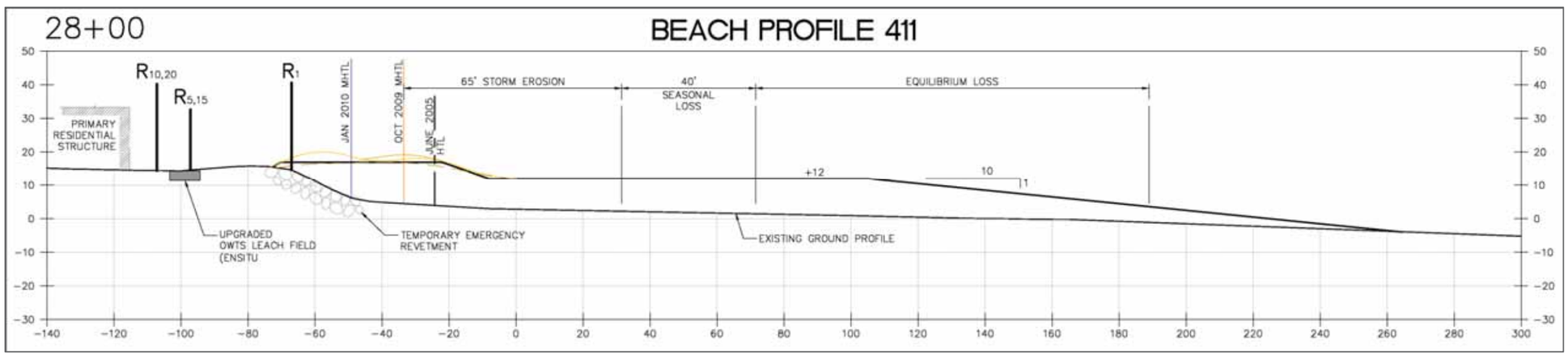
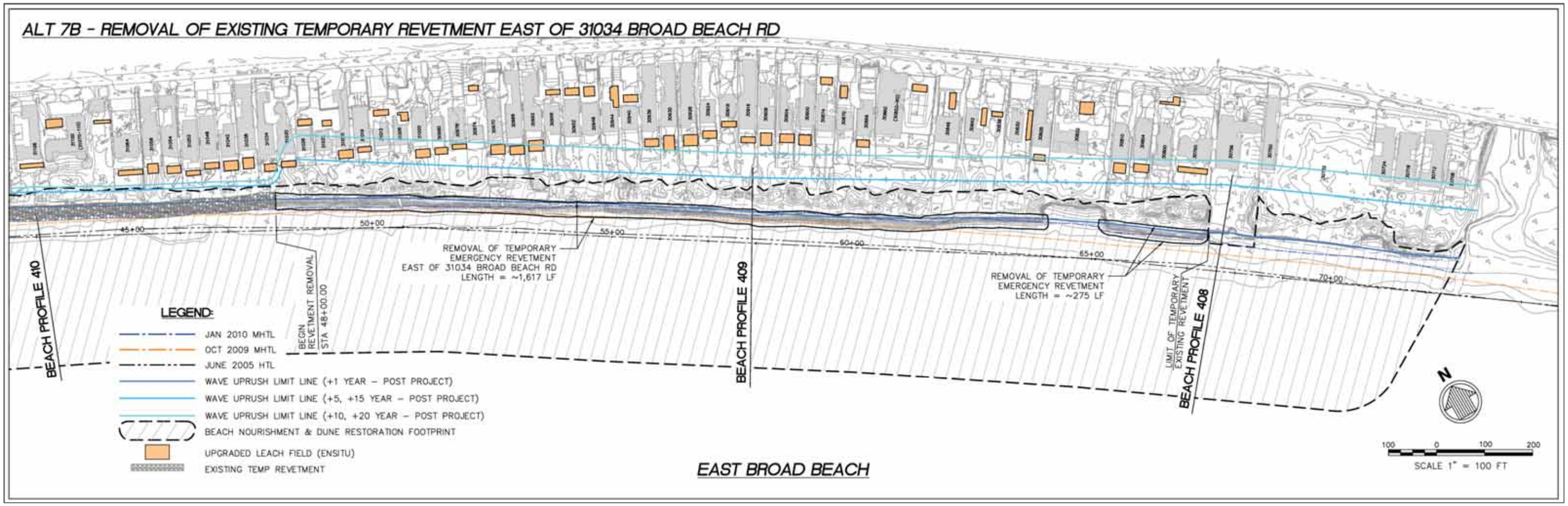


Figure 5-1. Alternative 7B– West Broad Beach



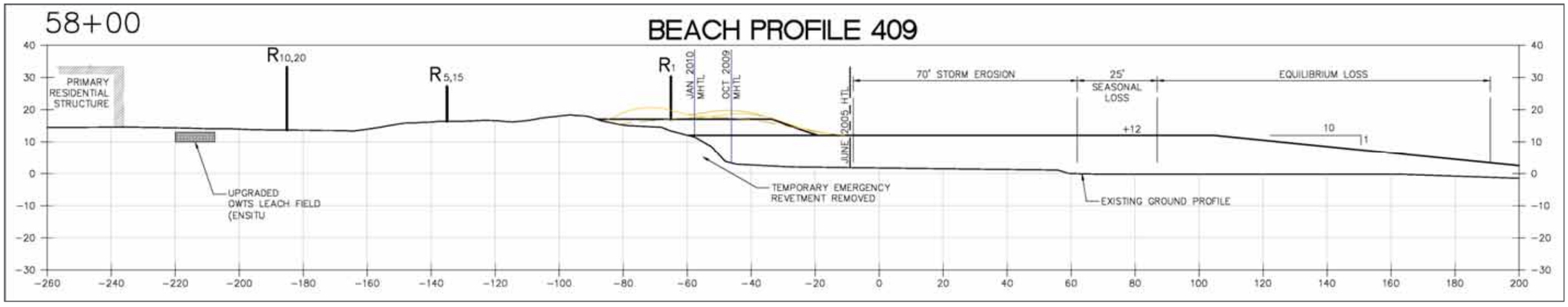


Figure 5-2. Alternative 7B – East Broad Beach

The wave uprush results indicate that all residential structures along Broad Beach protected by a seawall or revetment in combination with beach nourishment and dune restoration will be outside of the 100-year wave uprush limit over the project's 20-year time horizon. Along east Broad Beach residential structures without a revetment would be at risk of damage from an extreme storm event at the end of each nourishment cycle. Several upgraded leach fields at the west end of the temporary emergency revetment would also be at risk of damage from wave overtopping at the middle to end of each nourishment cycle. Upgraded leach fields without structural shore protection would be at greater risk of damage since storm erosion could reach upgraded leach fields at the end of each nourishment cycle.

Relative to the baseline condition, the Alternative 7B project would reduce the risk of coastal erosion and flood damage to most existing development along Broad Beach. However, primary structures without shore protection would be at risk of damage during an extreme storm event at the end of each nourishment cycle. A comparison of existing development at risk for the baseline condition and Alternative 7B is provided below.

In order to remove the eastern portion of the revetment in accordance with the Ensitu Scenario 3 AOWTS implementation, 43 residences will require system upgrades. Assuming the minimum upgrade cost estimate by EEI of $101,000, the added cost to the property owners to implement only septic system upgrades specified by this alternative is $4.3 million.

Table 5-1. Alternative 7B – Risk to Existing Development Relative to Baseline Condition

Time Horizon	Baseline Conditions (2005)		Alternative 7B	
	Existing Leach Fields at Risk	Residential Buildings at Risk	Upgraded Leach Fields at Risk	Residential Buildings at Risk
West Broad Beach - Point Lechuza to Transect 411				
Present Time	2	8	0	0
+10 Years	3	24	2	0
+20 Years	3	32	2	0
Central Broad Beach – Transect 411 to Transect 410				
Present Time	7	3	0	0
+10 Years	10	17	1	0
+20 Years	10	23	1	0
East Broad Beach – Transect 410 to Transect 408				
Present Time	5	0	0	0
+10 Years	20	5	14	20
+20 Years	33	27	14	20
Totals (+20 years)	**46**	**82**	**17**	**20**

5.2 LITTORAL PROCESSES

Relative to the baseline conditions, the added protection for this alternative is achieved by an increased beach width and restored dune in combination with a rock revetment to act as a last line of defense. The beach nourishment and dune restoration template for this alternative is the same as for the proposed project. Please refer to Sections 9.2 through 9.4 of the CER (M&N, 2013) for engineering analysis and discussion of the proposed beach nourishment and dune restoration. Section 9.7 evaluates potential impacts due to the proposed beach nourishment and dune restoration.

Analysis of seasonal and inter-annual profile changes was performed assuming a slower placement rate based on trucking sand from an inland source. The proposed nourishment volume will be placed over 8 months which will result in more sand loss during construction to long-shore and cross-shore transport during construction. Although the maximum beach widths are less than predicted for shorter placement durations, the overall profile changes along Broad Beach are similar to results of the proposed project beach fill analysis presented in Section 9.7 of the CER (M&N, 2013). Results of the seasonal and inter-annual beach profile changes are provided in Appendix 5-A1.

Over the project duration, the temporary existing revetment would not substantially influence coastal processes. When the revetment is buried, there are no impacts of the structure on coastal processes. Should the revetment become exposed, there may be incremental increases in wave reflection and a slight reduction of littoral sand volume retained landward of the revetment. GENESIS results for Alternative 7B, shown in Figure 4-3, indicate the remaining portion of the revetment will be exposed about 7 years after nourishment.

Removal of the downcoast portion of the temporary emergency revetment will allow additional sand to be available for littoral transport and off of the project area. The volume of sand between the temporary emergency revetment and existing leach fields along this reach is about 130,000 cy. The benefit of this is additional sand entering the littoral system, equivalent to about 2.5 times the annual sand loss rate of 53,000 cy. This will provide a short-term benefit to littoral processes but comes at the cost of damage to the upgraded leach fields and residential structures in an extreme storm event.

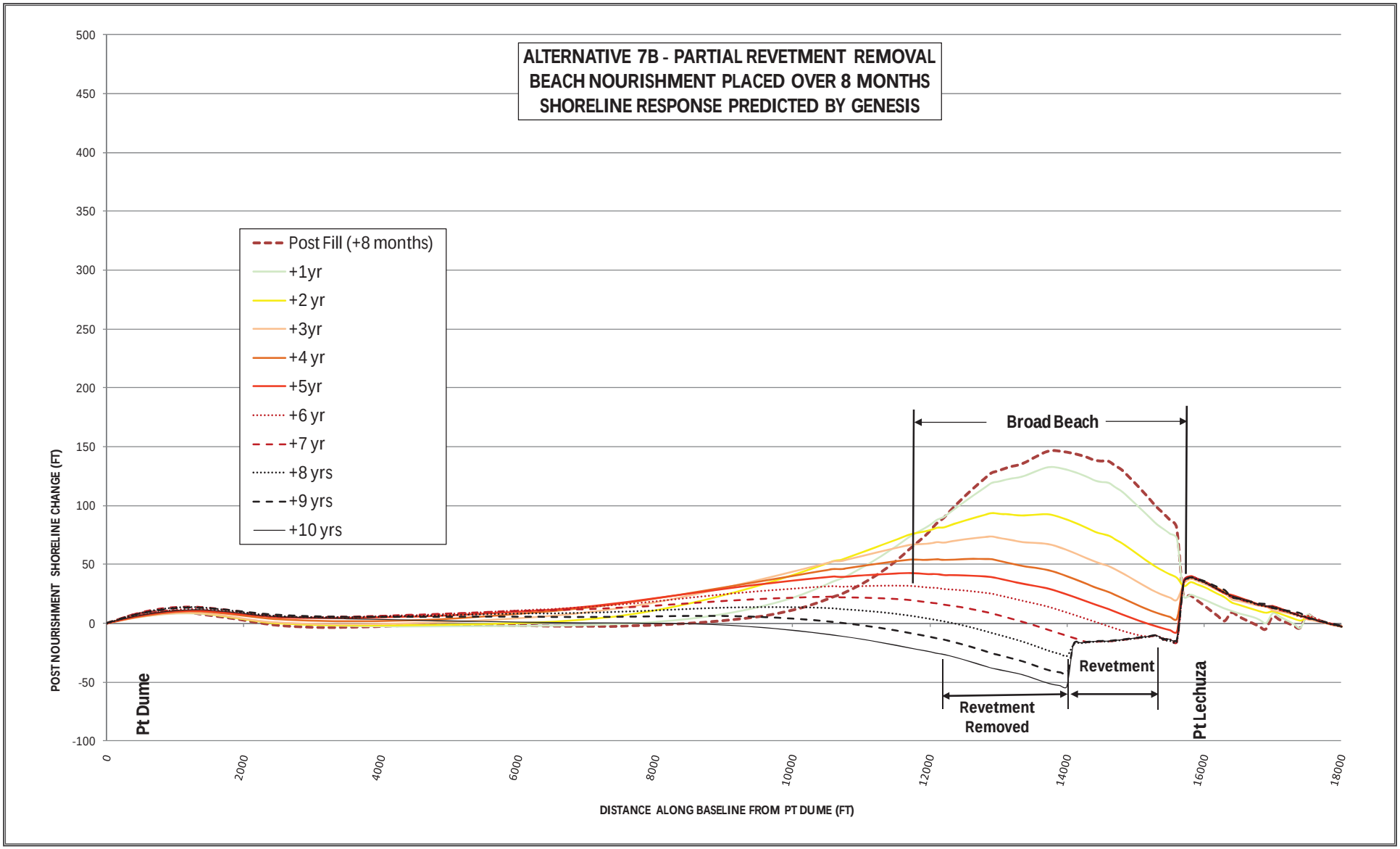


Figure 5-3. Alternative 7B – GENESIS Results

5.3 STRUCTURAL INTEGRITY OF SHORE PROTECTION DEVICE

The temporary emergency revetment will remain in its current location west of 31034 Broad Beach Road to provide a last line of defense behind the nourished beach. The general alignment of the revetment follows the foredune boundary of the baseline 2005 condition. Please refer to Section 9.1 for a discussion of the stability and integrity of this type of revetment. A discussion of impacts associated with the revetment is provided in Section9.8. The analysis of potential impacts for Alternative 7B is summarized in Table 4-2.

5.4 PUBLIC ACCESS AND AESTHETICS

The impacts of this alternative on public access and aesthetics will be positive for most of the project duration. After an extreme storm event, partial or complete exposure of the revetment could potentially impact public access and aesthetics temporarily. During calmer post-storm conditions, the beach would recover some of the sand lost and help restore public access opportunity and aesthetics.

At the end of each nourishment cycle the amount of dry beach width will be narrow or non-existent, impacting public access and aesthetics until the next re-nourishment project. This impact would be temporary and similar to conditions between 2010 and 2013 when a narrow and seasonal beach existed along the temporary emergency revetment. With removal of the downcoast portion of revetment, the impact of an exposed revetment on public access will be reduced. However, this alternative carries a higher potential for damage to existing development due to extreme storm erosion that would adversely impact public access and aesthetics.

Table 5-2. Alternative 7B – Summary of Potential Impacts

Category	Summary of Impacts
Existing Development	• Residential structures protected by an SPD along with nourishment and dune restoration will be outside of 100-year wave uprush line over project duration (20 years). • Residential structures along East Broad Beach without a revetment would be at risk of damage from an extreme storm event at the end of each nourishment cycle. • Approximately 17 upgraded leach fields (most along East Broad Beach) are at risk of damage from wave uprush at the end of each nourishment cycle. • Adds $4.3 million minimum in septic system upgrade costs.
Sand Supply	• Increased sand supply after initial 600,000 cy nourishment will reduce adverse impacts of sediment deficit. • Up to 130,000 cy of additional littoral sediment supply between removed SPD and upgraded leach fields.
Beach Profile	• Seasonal profile changes (depth of sand cover) will temporarily increase in magnitude. • Inter-annual profile changes will not be impacted. Long-term trend of erosion is expected to continue. • Coarse grained nourishment may temporarily steepen upper profile after nourishment or backpassing.
Extreme Storm Erosion	• Added beach width will improve resistance to extreme storm erosion up to 5 years after initial nourishment. • After 5 years, majority of storm protection will be provided by the SPD and restored dune system. • In-adequate extreme storm protection for East Broad Beach properties without an SPD.
Shore Protection Device (SPD) - Stability	• Temporary emergency revetment (remaining 2,500 feet) would be susceptible to damage > 5%. • Some maintenance probably required after an extreme storm event near end of nourishment cycle. • Maximum uprush line (with SLR) estimated to extend 40 feet landward of revetment crest. • Revetment could be adapted with an increased crest elevation if SLR exceeds projections over the project duration.
SPD Alignment	• Exposure of SPD is expected at the end of each nourishment cycle. • About 46,000 cy of sand is retained between the revetment and upgraded leach fields. • Alignment provides a stable foundation for restored dunes constructed over and landward of revetment.
Adaptive Management	• Regular backpassing from east to west will occur as planned for the proposed project. • Re-nourishment to occur as planned for proposed project.

Public Access	• Public access to dry beach will be significantly improved after nourishment for about 7 years. • From 7-10 years public access will be similar to beach conditions between 2010 and 2013.
Aesthetics	• Beach aesthetics will be improved with a widened sandy beach and restored dune system. • Aesthetic & public access impacts temporarily reduced at the end of a nourishment cycle where SPD was removed.

6. ALTERNATIVE 8 - NO BEACH NOURISHMENT AT WEST BROAD BEACH WITH REVETMENT AT CURRENT LOCATION

This alternative includes a reduced beach nourishment and dune restoration volume of 460,000 cy within a placement footprint that terminates at 31346 Broad Beach Road (western end of temporary revetment) to avoid and minimize impacts to intertidal habitat near Point Lechuza. This volume is based on keeping the same beach nourishment and dune restoration design, but over a reduced project length. The temporary revetment will remain in its current location (occupying a footprint of 3.01 acres) with dune restoration and beach nourishment burying the revetment. No new or modified structures are proposed under this alternative.

A re-nourishment volume of 460,000 cy is proposed at a 10 year frequency with this alternative. The re-nourishment volume is equivalent to the initial volume because it is expected that most of the initial nourishment to be transported downcoast after 10 years. The timing and quantities of re-nourishment may vary depending on results of the intensive monitoring plan.

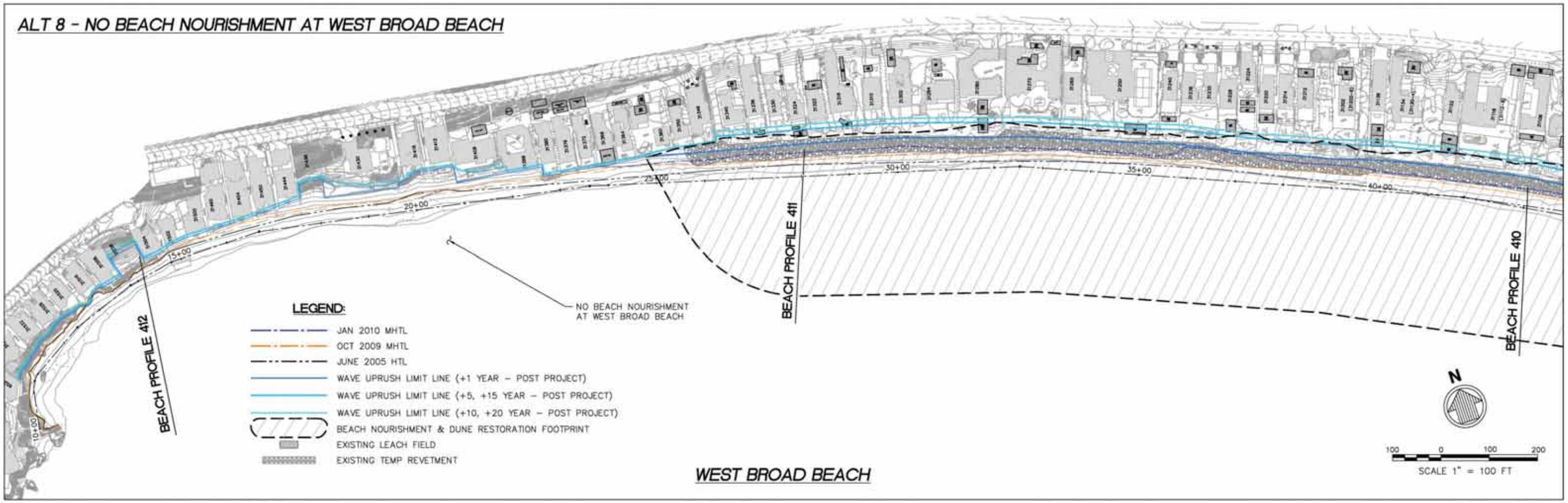
6.1 EXISTING DEVELOPMENT

A wave uprush analysis of Alternative 8 was performed following the methodology presented in Section 9.6 of the CER (M&N, 2013) which accounted for seasonal beach loss, waves from a 100-yr storm event, projected SLR and predicted erosion of the beach fill to determine the landward limit of wave uprush for this alternative.

Without nourishment at the west end there will be only a relatively narrow beach for a short duration after the project. During an extreme storm event the wave uprush line will be limited by the performance of existing shore protection devices (SPDs) and the natural bluff. The exposed height of many structures increased by 4 to 5 feet from 2002 to 2004 due to lower sand levels along west Broad Beach (Griggs, 2008). As the exposure height increases, the wave energy impacting these structures will also increase and could eventually compromise the stability of the structures.

East of 31346 Broad Beach Road wave uprush during an extreme storm event is limited by the temporary emergency revetment which would remain in its current location with an average crest elevation of about +13 feet MLLW. The maximum wave uprush limit line along the temporary emergency revetment is about 35 feet landward of the revetment crest under current conditions, and about 40 feet landward with the inclusion of SLR.

A plan view and representative section of this alternative and the corresponding wave uprush lines are shown in Figure 6-1 and Figure 6-2. Detailed drawings of this alternative are provided in Exhibit F-A1.



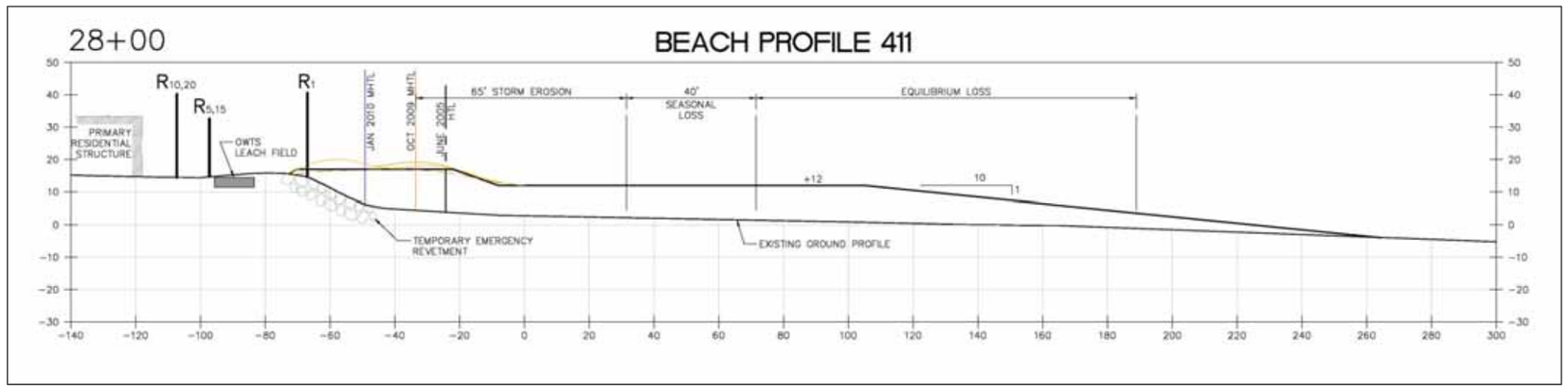
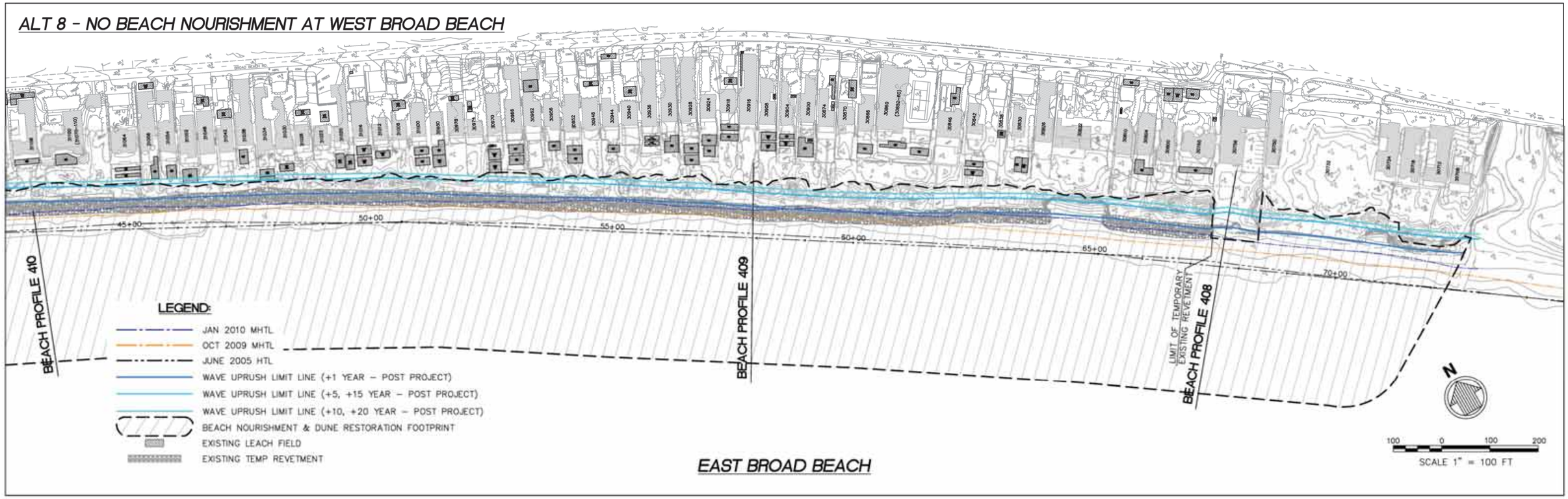


Figure 6-1. Alternative 8 – West Broad Beach



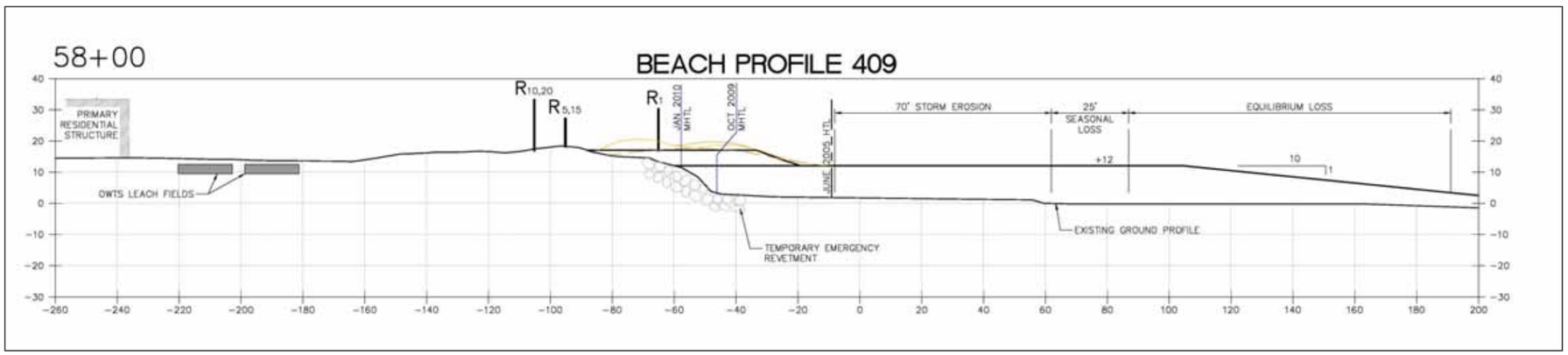


Figure 6-2. Alternative 8 – East Broad Beach

The wave uprush analysis indicates that residential structures along Central and East Broad Beach will be protected from coastal erosion and flooding over the project's 20-year time horizon. However, residential structures in West Broad Beach would be at risk. Similarly, leach fields at risk of damage would be reduced in the 20-year horizon for Central and East Broad Beach as compared to the baseline condition; however, no additional protection would be provided for primary structures along West Broad Beach.

Relative to the baseline (no-project) condition, the Alternative 8 project would reduce the risk of coastal erosion and flood damage to existing development along Central and East Broad Beach. Based on results of the wave uprush analysis, a comparison of existing development at risk for the baseline condition and Alternative 8 is provided in Table 6-1.

Table 6-1. Alternative 8 – Risk to Existing Development Relative to Baseline Condition

Time Horizon	Baseline Conditions (2005)		Alternative 8	
	Leach Fields at Risk	Residential Buildings at Risk	Existing Leach Fields at Risk	Residential Buildings at Risk
West Broad Beach - Point Lechuza to Transect 411				
Present Time	2	8	0	15
+10 Years	3	24	3	15
+20 Years	3	32	3	15
Central Broad Beach – Transect 411 to Transect 410				
Present Time	7	3	0	0
+10 Years	10	17	6	0
+20 Years	10	23	6	0
East Broad Beach – Transect 410 to Transect 408				
Present Time	5	0	0	0
+10 Years	20	5	4	0
+20 Years	33	27	4	0
Totals (+20 years)	**46**	**82**	**13**	**15**

6.2 LITTORAL PROCESSES

This alternative would result in less dry beach width remaining after equilibrium compared to the larger initial nourishment of the proposed project. The result is a reduced buffer against background erosion, seasonal fluctuations, and storm related erosion. A moderate to extreme storm event even early in the nourishment cycle could result in damage to primary structures along West Broad Beach and would likely expose the revetment.

GENESIS results for this alternative, as shown in Figure 6-3, simulate the shoreline response with reduced fill volumes for a 10-year time horizon. The reduced fill volume and proposed 10-year re-nourishment schedule has the potential to increase the extent and duration of revetment exposure over the life of the project. Based on GENESIS results, the western end of the revetment is exposed in Year 5. By Year 8 the entire revetment is exposed. These results indicate the revetment will be exposed at least 1 year longer than expected for the proposed project.

Despite no direct placement of sand along West Broad Beach minimal added beach width is expected from westward diffusion of the downcoast fill. GENESIS predicted beach width results for beach profiles 412 are shown in Table 6-2. The analysis predicts that the beaches in this area will experience temporary increases in beach width up to 50 feet from the beach fill being transported to the west; however, no beach fill remained at the west end transects after Year 3.5.

Table 6-2. GENESIS Predicted Beach Width Post-Nourishment for Profiles 412

Time after Start of Fill (Years)	Alternative 8 Beach Width Added-GENESIS
0.33	17
0.67	47
1	49
1.5	37
2	25
2.5	17
3	9
3.5	2
4	-5

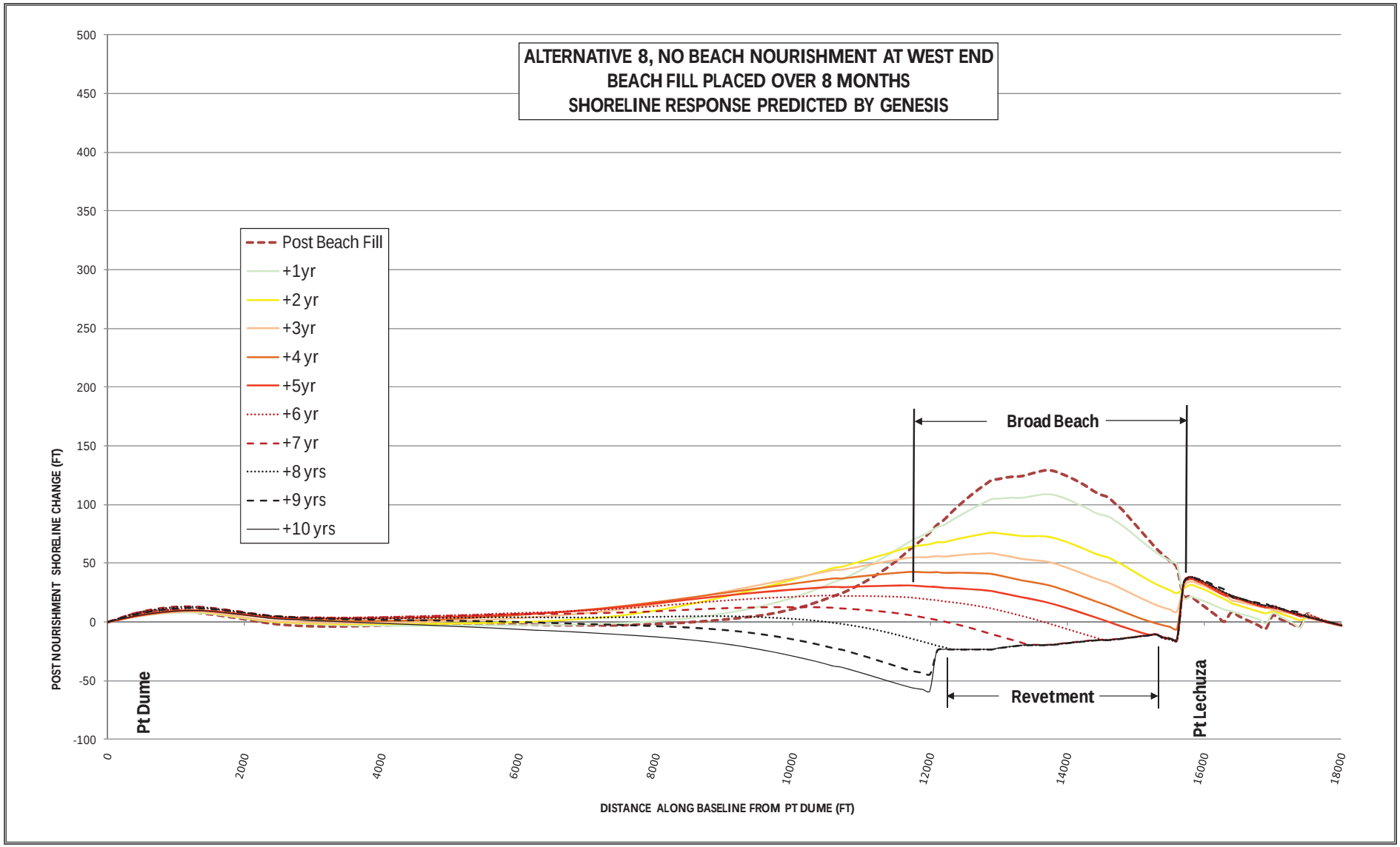


Figure 6-3. Alternative 8 – GENESIS Results

A predicted beach width and depth of cover analysis was conducted for this alternative to understand the impacts to intertidal habitat near Point Lechuza. Methodology was identical that that described in Section 9.7.2 of the CER (M&N, 2013). The reduced nourishment volume will result in similar beach profile changes expected for the proposed project except on a smaller scale and over a shorter duration, especially at the west end.

As the nourished profile approaches equilibrium, sand will be distributed in along-shore and cross-shore directions, increasing the magnitude of seasonal changes in sand movement. Transect 412 is a representative section along West Broad Beach. Based on profiles measured since 2009 the "natural" seasonal depth of sand cover ranges from 1 to 2.5 feet in depth at transect 412. Despite no direct placement of sand in this location a wider beach is expected as some material from the downcoast nourishment will be transported toward Point Lechuza. Additional sand cover may result from ponding in the west end of Broad Beach at the confluence of eastward transport of natural littoral drift around Point Lechuza, mixing with westward transport of the new beach nourishment material via diffusion (Everts Coastal, 2014).

During placement of the initial nourishment volume of 460,000 cy and for about 1 year after placement, the "natural" seasonal depth of cover may increase by 1 to 2 feet in depth at transect 412 (Figure 6-4 and Figure 6-5). By the second year after nourishment, the increase in seasonal depth of cover is less than 1 foot in depth (Figure 6-6). Complete results of seasonal and inter-annual depth of cover analysis at each transect are provided in Appendix 5-A1.

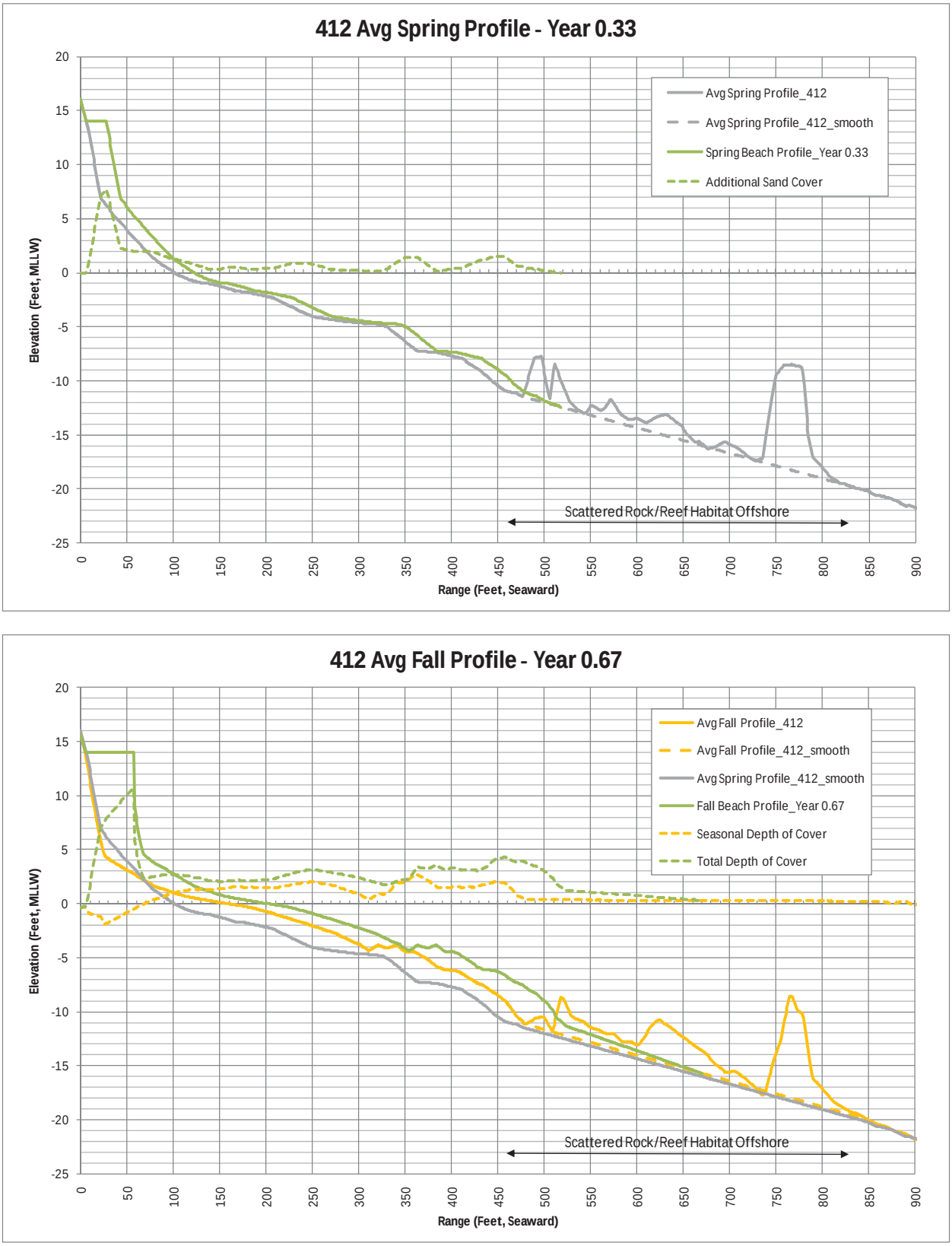


Figure 6-4. Alternative 8 – Depth of Cover Results During 8 Month Placement

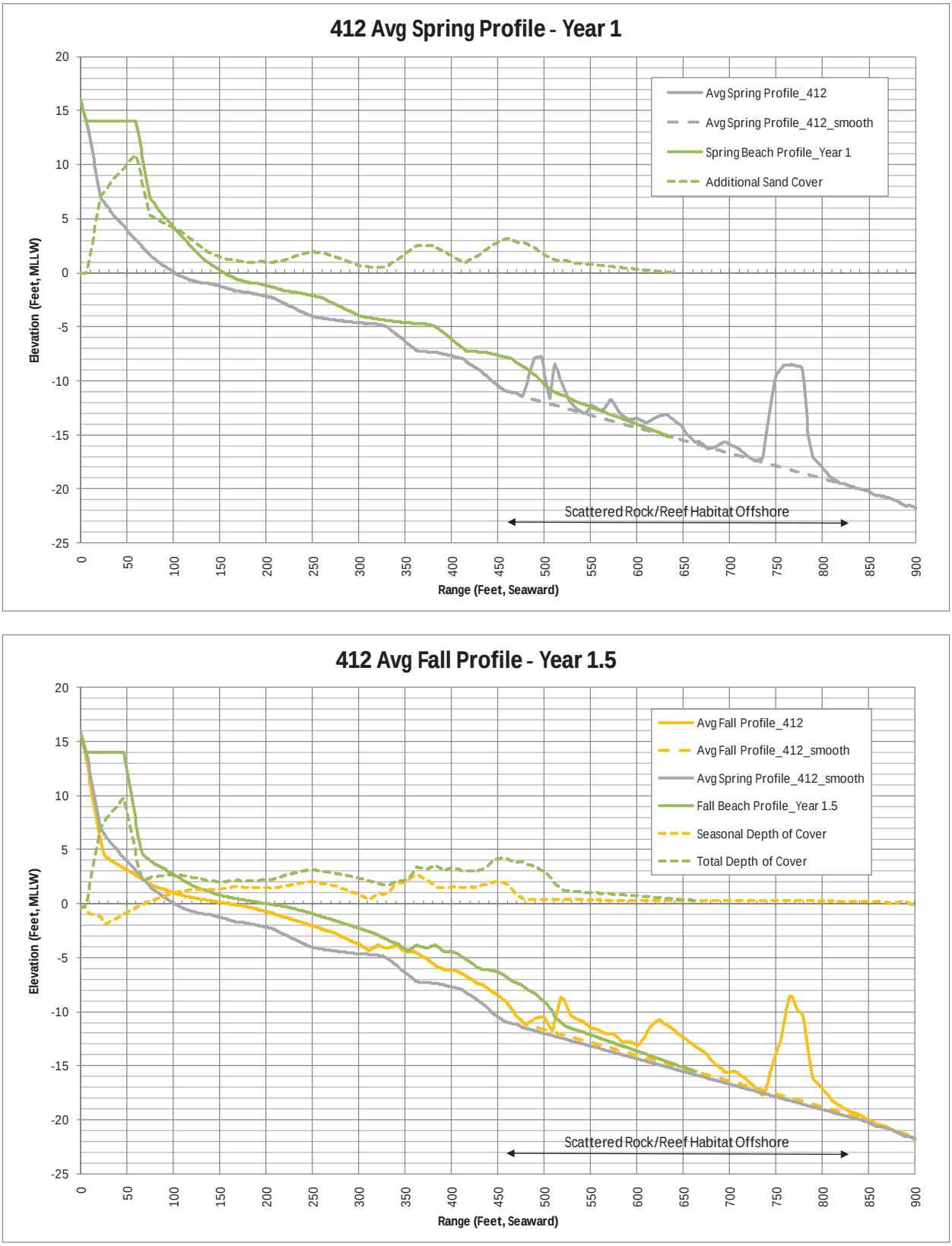


Figure 6-5. Alternative 8 – Depth of Cover Results at Year 1

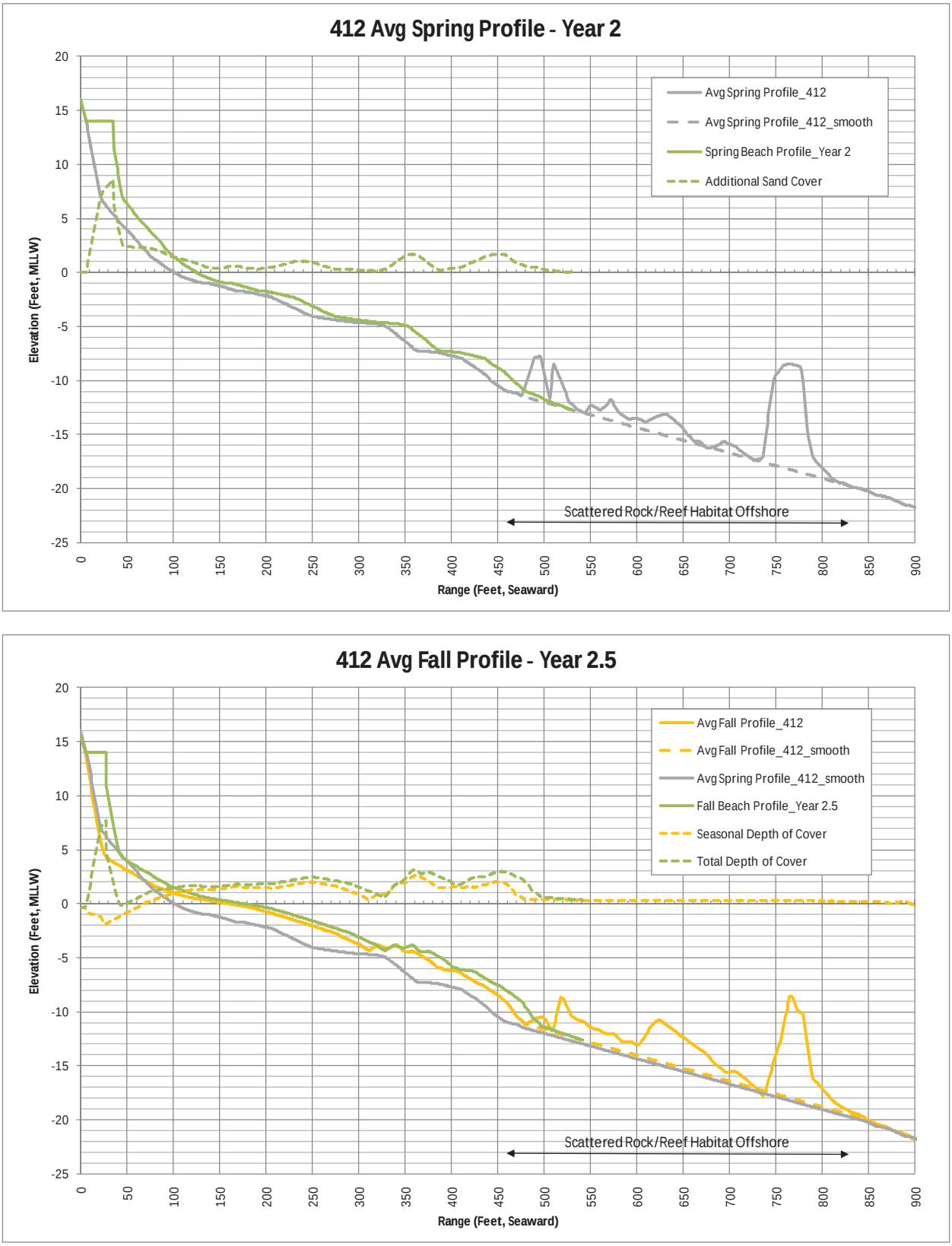


Figure 6-6. Alternative 8 – Depth of Cover Results at Year 2

6.3 STRUCTURAL INTEGRITY OF SHORE PROTECTION DEVICE

The temporary emergency revetment will remain in its current location to provide a last line of defense behind the nourished beach. The general alignment of the revetment follows the foredune boundary of the baseline 2005 condition. Please refer to Section 9.1 for a discussion of the stability and integrity of this type of revetment. A discussion of impacts associated with the revetment is provided in Section 9.8. The analysis of potential impacts for Alternative 8 is summarized in Table 6-3.

6.4 PUBLIC ACCESS AND AESTHETICS

The impacts of this alternative on public access and aesthetics will be positive for Central and East Broad Beach for most of the project duration. Western Broad Beach would experience a temporary improvement over the existing condition. After an extreme storm event, partial or complete exposure of the revetment could potentially impact public access and aesthetics temporarily. During calmer post-storm conditions, the beach would recover some of the sand lost and help restore public access opportunity and aesthetics.

At the end of each nourishment cycle the amount of dry beach width will be narrow or non-existent, impacting public access and aesthetics until the next re-nourishment project. This impact would be temporary and similar to conditions between 2010 and 2013 when a narrow and seasonal beach existed along the temporary emergency revetment.

6.5 GEOLOGIC HAZARD ABATEMENT DISTRICT (GHAD) REQUIREMENTS

This alternative provides a significant benefit to Central and Eastern portions of Broad Beach; but little or no benefit in terms of added shoreline protection along West Broad Beach. There may be legal implications for reducing or eliminating benefits within a GHAD since the formation of the Broad Beach GHAD was based upon the requirement that a near equal benefit is provided to all properties. California law requires “substantial equivalent benefit” for all GHAD property owners within the GHAD (Cal. Pub. Resources Code § 26534). This means that each property owner within the BBGHAD must receive roughly equal benefit from the BBGHAD Project.

See also, http://www.lao.ca.gov/1996/120196_prop_218/understanding_prop218_1296.hhtml

Table 6-3. Alternative 8 – Summary of Potential Impacts

Category	Summary of Impacts
Existing Development	• All residential structures within Central and Eastern Broad Beach will be outside of 100-year wave uprush line over project duration (20 years). • Primary structures along Western Broad Beach at risk of damage from an extreme storm event. • Approximately 13 leach fields are at risk of damage from wave uprush at the end of each nourishment cycle.
Sand Supply	• Increased sand supply after initial nourishment will reduce adverse impacts (shoreline erosion) of sediment deficit.
Beach Profile	• Increase in seasonal profile changes (depth of sand cover) reduced in duration and magnitude at West Broad Beach. • Inter-annual profile changes will not be impacted. Long-term trend of erosion is expected to continue. • Coarse grained nourishment may temporarily steepen upper profile after nourishment or backpassing.
Extreme Storm Erosion	• This alternative provides limited shoreline protection for West Broad Beach. • Added beach width will improve resistance to storm erosion but would not withstand 100-year storm erosion. • Majority of extreme storm protection will be provided by the SPD and restored dune system. • Restored dune system will be mostly protected by revetment and will improve resistance to overtopping.
Shore Protection Device (SPD) - Stability	• SPDs at west end will be subject to increased exposure to wave attack over the project duration. • Revetment susceptible to >5% damage during design storm event due to displacement or settling of smaller armor stone. • Maximum uprush line (with SLR) estimated to extend 40 feet landward of revetment crest. • Revetment could be adapted with an increased crest elevation if SLR exceeds projections over the project duration.
SPD Alignment	• Partial exposure of SPD is expected at Year 5. Complete exposure is anticipated by Year 8. • About 75,000 cy of sand is retained landward of the structure and seaward of the leach fields. • Alignment offers protection to restored dunes constructed over and landward of revetment.
Adaptive Management	• Re-nourishment volume and frequency to occur as planned for the proposed project. • Opportunities for backpassing from east to west will be limited with reduced nourishment volumes.

Public Access and Aesthetics	• Public access & aesthetics significantly improved along Central and Eastern segments of Broad Beach. • Limited and temporary access and aesthetic improvements for West Broad Beach. • Reduced sand volume increases duration of revetment exposure by about 1 year compared to the proposed project. • At the end of each 10-year nourishment cycle, public access will be similar to beach conditions between 2009 and 2013.
BBGHAD	• There may be legal implications for the GHAD if near equal benefits are not provided for all properties.

7. ALTERNATIVE 9 – REDUCED BEACH NOURISHMENT AT WEST BROAD BEACH WITH REVETMENT AT CURRENT LOCATION

This alternative includes a reduced beach nourishment and dune restoration volume of 520,000 cy due to a reduced placement footprint and quantity west of 31346 Broad Beach Road (western end of temporary revetment). The objective of this alternative is to avoid and minimize impacts to intertidal habitat near Point Lechuza while providing some benefits of beach nourishment to properties along West Broad Beach. About 60,000 cy of sand would be placed west of the temporary emergency revetment along a tapered footprint toward Point Lechuza. The temporary revetment will remain in its current location (occupying a footprint of 3.01 acres) with dune restoration and beach nourishment burying the revetment. East of 31346 Broad Beach Road the beach nourishment and dune restoration would be the same as the proposed project. No new or modified structures are proposed under this alternative.

A re-nourishment volume of 520,000 cy is proposed at a 10 year frequency with this alternative. The re-nourishment volume is equivalent to the initial volume because we expect most of the initial nourishment would be transported downcoast after 10 years. The timing and quantities of re-nourishment may vary depending on results of the intensive monitoring plan.

7.1 EXISTING DEVELOPMENT

A wave uprush analysis of Alternative 9 was performed following the methodology presented in Section 9.6 of the CER (M&N, 2013) which accounted for seasonal beach loss, waves from a 100-yr storm event, projected SLR and predicted erosion of the beach fill to determine the landward limit of wave uprush for this alternative.

A reduced nourishment volume at the west end will only temporarily provide the shoreline protection benefits of a widened beach. The added beach width will improve resistance to storm erosion but would not withstand 100-year storm erosion. During an extreme storm event the wave uprush line will be limited by the performance of existing shore protection devices (SPDs) and the natural bluff. The risk to existing development along West Broad Beach will be greater near the end of each nourishment cycle when there is less opportunity for backpassing to maintain a dry beach width. As beach width at the west end decreases, the wave energy impacting the natural bluff and SPDs will increase and could eventually compromise the stability of the bluff or structures.

East of 31346 Broad Beach Road wave uprush during an extreme storm event is limited by the temporary emergency revetment which would remain in its current location with an average crest elevation of about +13 feet MLLW. The maximum wave uprush limit line along the

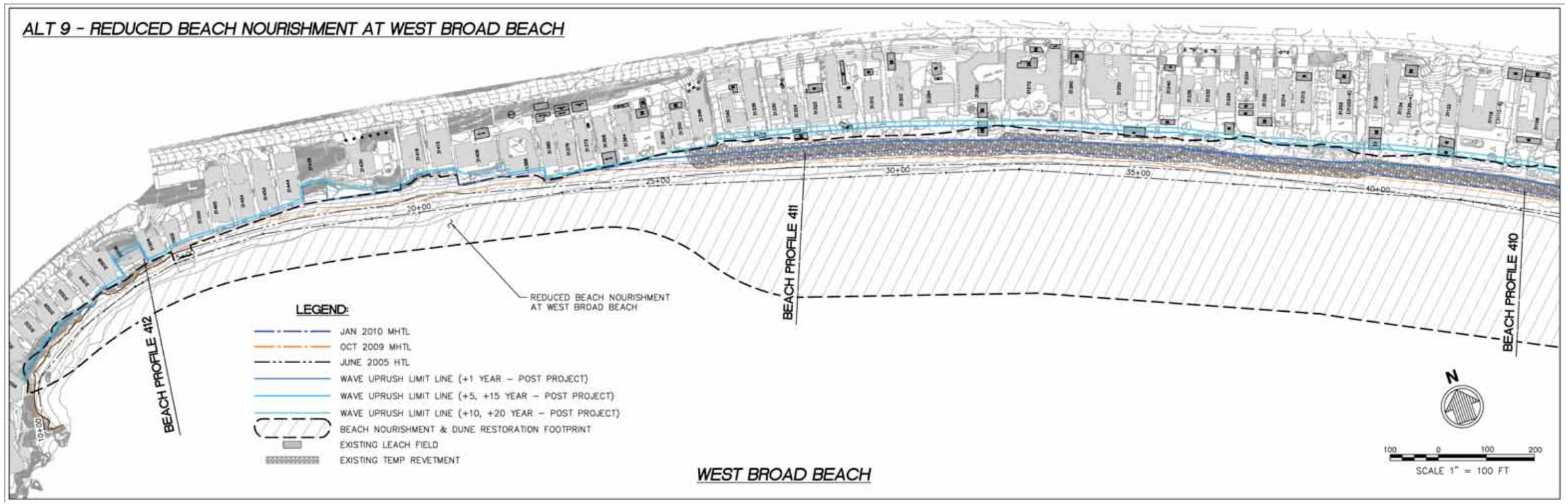
temporary emergency revetment is about 35 feet landward of the revetment crest under current conditions, and about 40 feet landward with the inclusion of SLR.

The wave uprush analysis indicates that residential structures along Central and East Broad Beach will be protected from coastal erosion and flooding over the project's 20-year time horizon. However, residential structures in West Broad Beach would be at risk of damage near the middle to end of each nourishment cycle. Similarly, leach fields at risk of damage would be reduced in the 20-year horizon for Central and East Broad Beach as compared to the baseline condition. Based on results of the wave uprush analysis, a comparison of existing development at risk for the baseline condition and Alternative 9 is provided in Table 7-1.

A plan view and representative section of this alternative and the corresponding wave uprush lines are shown in Figure 7-1 and Figure 7-2. Detailed drawings of this alternative are provided in Exhibit F-A1.

Table 7-1. Alternative 9 – Risk to Existing Development Relative to Baseline Condition

Time Horizon	Baseline Conditions (2005)		Alternative 9	
	Leach Fields at Risk	Residential Buildings at Risk	Existing Leach Fields at Risk	Residential Buildings at Risk
West Broad Beach - Point Lechuza to Transect 411				
Present Time	2	8	0	0
+10 Years	3	24	3	15
+20 Years	3	32	3	15
Central Broad Beach – Transect 411 to Transect 410				
Present Time	7	3	0	0
+10 Years	10	17	6	0
+20 Years	10	23	6	0
East Broad Beach – Transect 410 to Transect 408				
Present Time	5	0	0	0
+10 Years	20	5	4	0
+20 Years	33	27	4	0
Totals (+20 years)	**46**	**82**	**13**	**15**



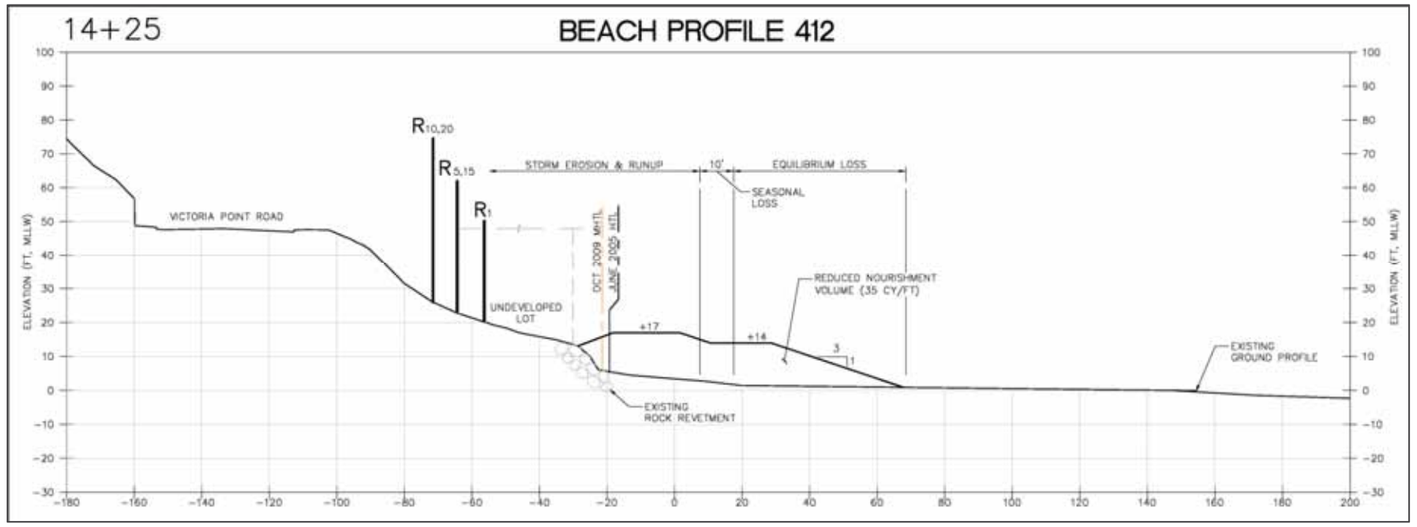
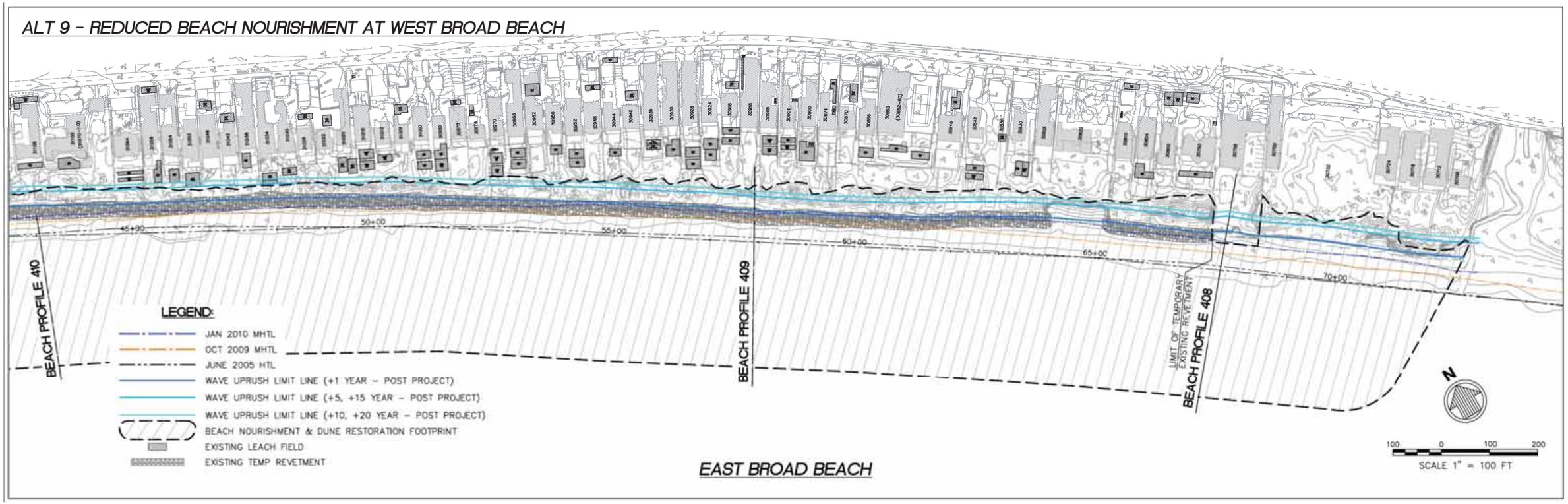


Figure 7-1. Alternative 9 – West Broad Beach



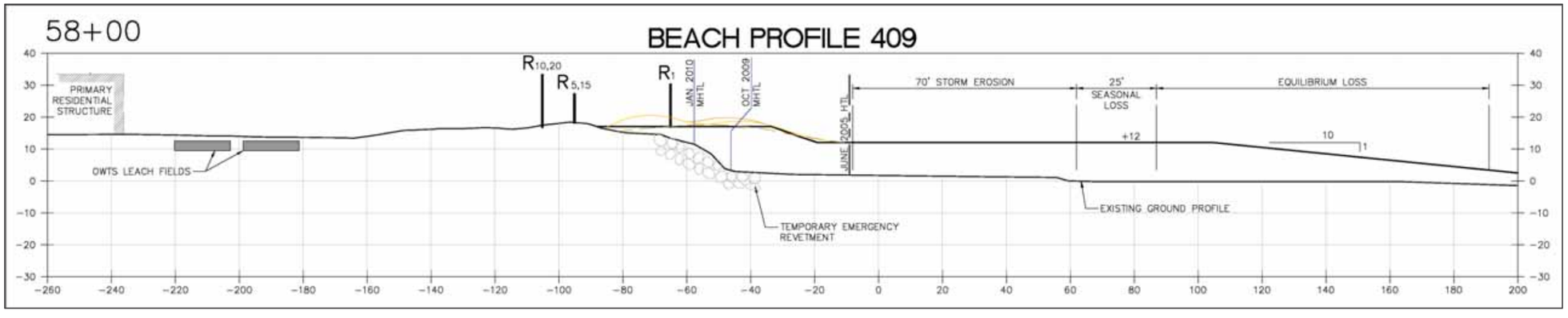


Figure 7-2. Alternative 9 – East Broad Beach

7.2 LITTORAL PROCESSES

This alternative would result in less dry beach width remaining after equilibrium compared to the larger initial nourishment of the proposed project. The result is a reduced buffer against background erosion, seasonal fluctuations, and storm related erosion. A moderate to extreme storm event during the latter half of each nourishment cycle could result in damage to primary structures along West Broad Beach and would likely expose the revetment along Central and East Broad Beach.

GENESIS results for this alternative, as shown in Table 7-2, simulate the shoreline response with reduced fill volumes for a 10-year time horizon. The reduced fill volume and proposed 10-year re-nourishment schedule could potentially increase the extent and duration of revetment exposure near the end of the project. Based on GENESIS results, the western end of the revetment is exposed in Year 6 and the entire revetment is exposed by Year 9. These results indicate the revetment will be exposed about 0.5 years longer than expected for the proposed project.

The volume of material placed at the west end for Alternative 9 (60,000 cy) is about equal to the predicted volume of westward transport via diffusion predicted for the Alternative 8 nourishment plan. The Alternative 9 nourishment plan basically pre-fills material at the west end with the intent of balancing the benefits of additional nourishment while reducing the potential for impacts to intertidal habitat. The resulting beach widths predicted by GENESIS are slightly greater than for Alternative 8 as shown in Table 7-2 at transect 412. The analysis predicts that the beaches in this area will experience temporary increases in beach width up to 70 feet at the end of the initial beach fill.

Table 7-2. GENESIS Predicted Beach Width Post-Nourishment for Profile 412

Time after Start of Fill (Years)	Alternative 8 Beach Width Added-GENESIS (ft)	Alternative 9 Beach Width Added-GENESIS (ft)
0.33	17	39
0.67	47	72
1	49	69
1.5	37	55
2	25	41
2.5	17	33
3	9	24
3.5	2	17
4	-5	9

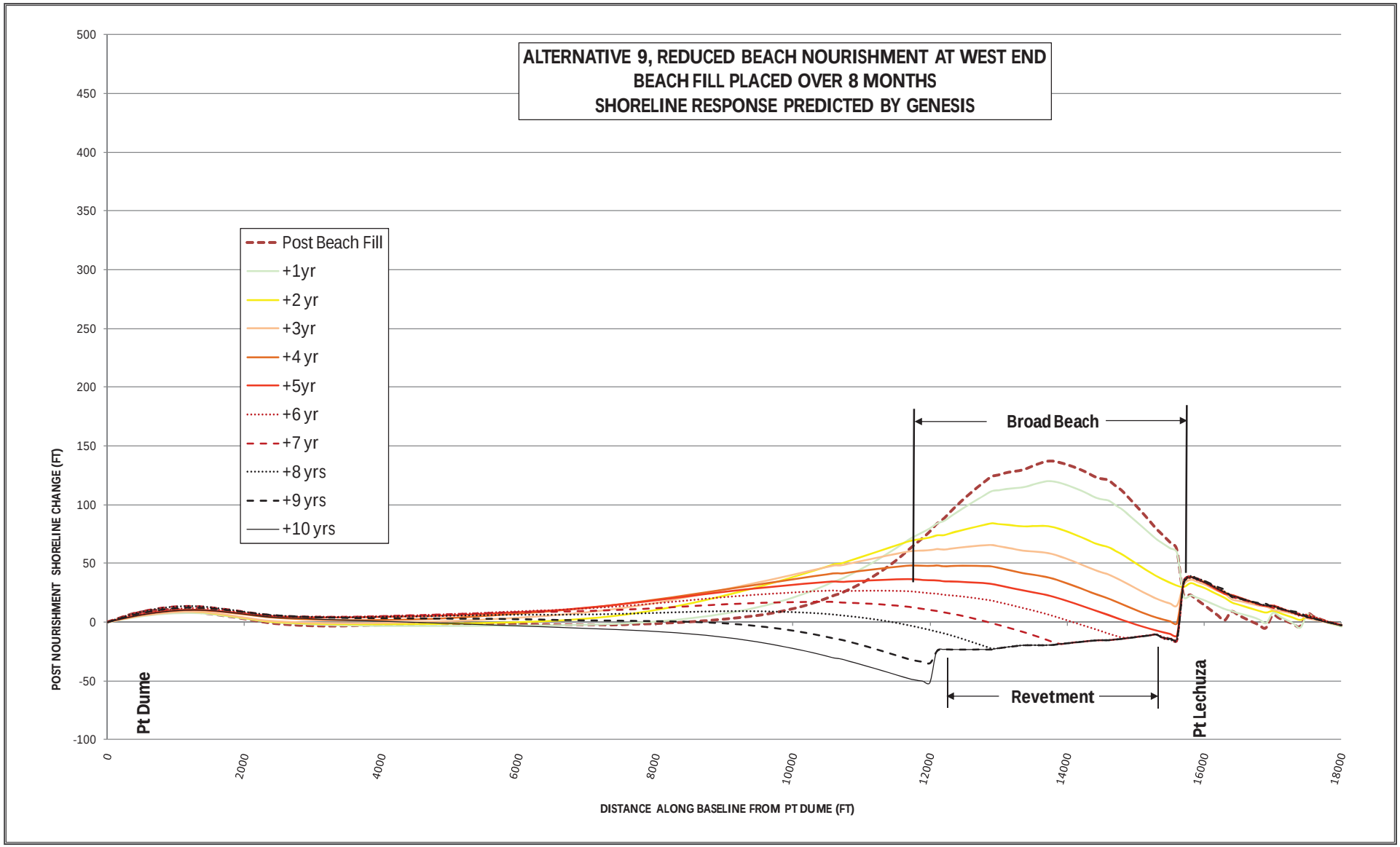
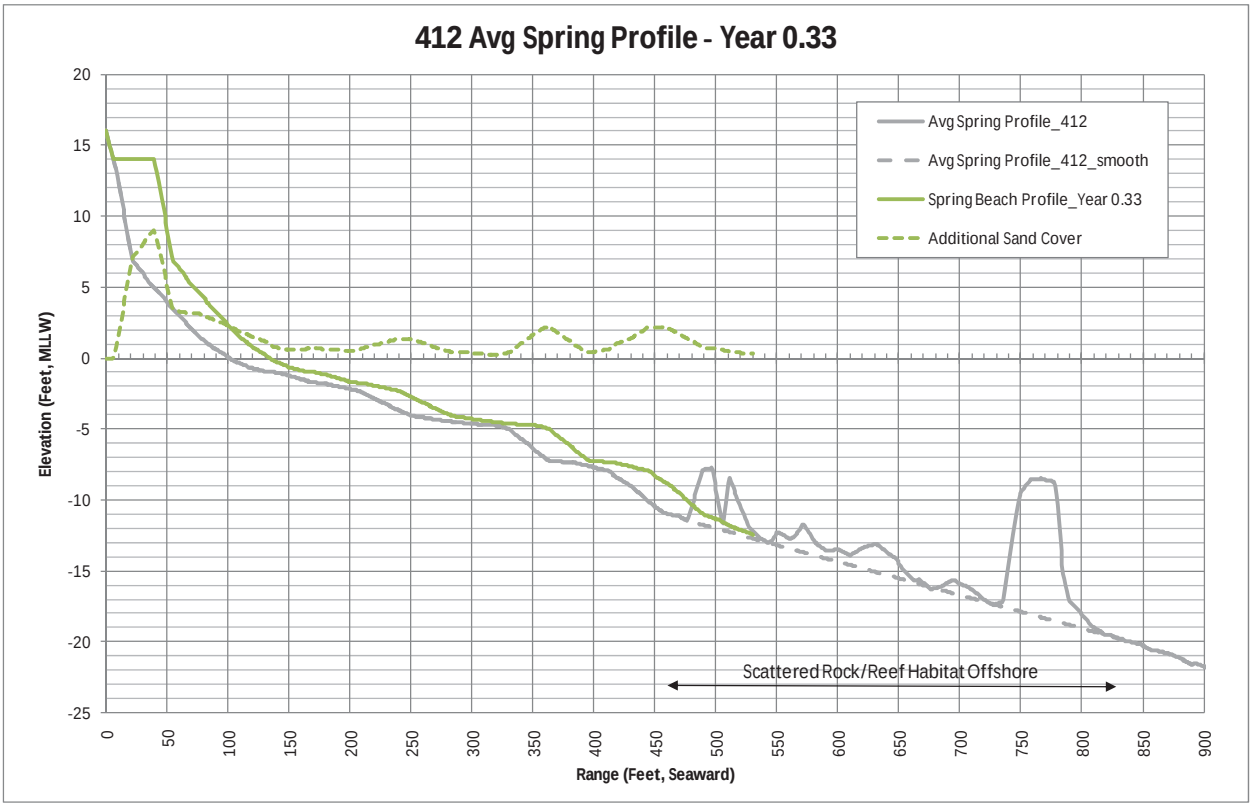


Figure 7-3. Alternative 9 – GENESIS Results

A predicted beach width and depth of cover analysis was conducted for this alternative to understand the impacts to intertidal habitat near Point Lechuza. Methodology was identical that that described in Section 9.7.2 of the CER (M&N, 2013). The reduced nourishment volume will result in similar beach profile changes expected for the proposed project except on a smaller scale and over a shorter duration, especially at the west end.

As the nourished profile approaches equilibrium, sand will be distributed in along-shore and cross-shore directions, increasing the magnitude of seasonal changes in sand movement. Transect 412 is a representative section along West Broad Beach. Based on profiles measured since 2009 the "natural" seasonal depth of sand cover ranges from 1 to 2.5 feet in depth at transect 412. Relative to Alternative 8 the tapered nourishment footprint of Alternative 9 would reduce the ponding effects and sediment accumulation at the confluence of eastward transport of natural littoral drift around Point Lechuza, mixing with westward transport of the new beach nourishment material via diffusion (Everts Coastal, 2014).

During placement of the initial nourishment volume of 520,000 cy and for about 1 year after placement, the "natural" seasonal depth of cover may increase by 1 to 3 feet in depth at transect 412 (Figure 7-4 and Figure 7-5). By the second year after nourishment, the increase in seasonal depth of cover is less than 1 foot in depth (Figure 7-6). Complete results of seasonal and inter-annual depth of cover analysis at each transect are provided in Appendix 5-A1.



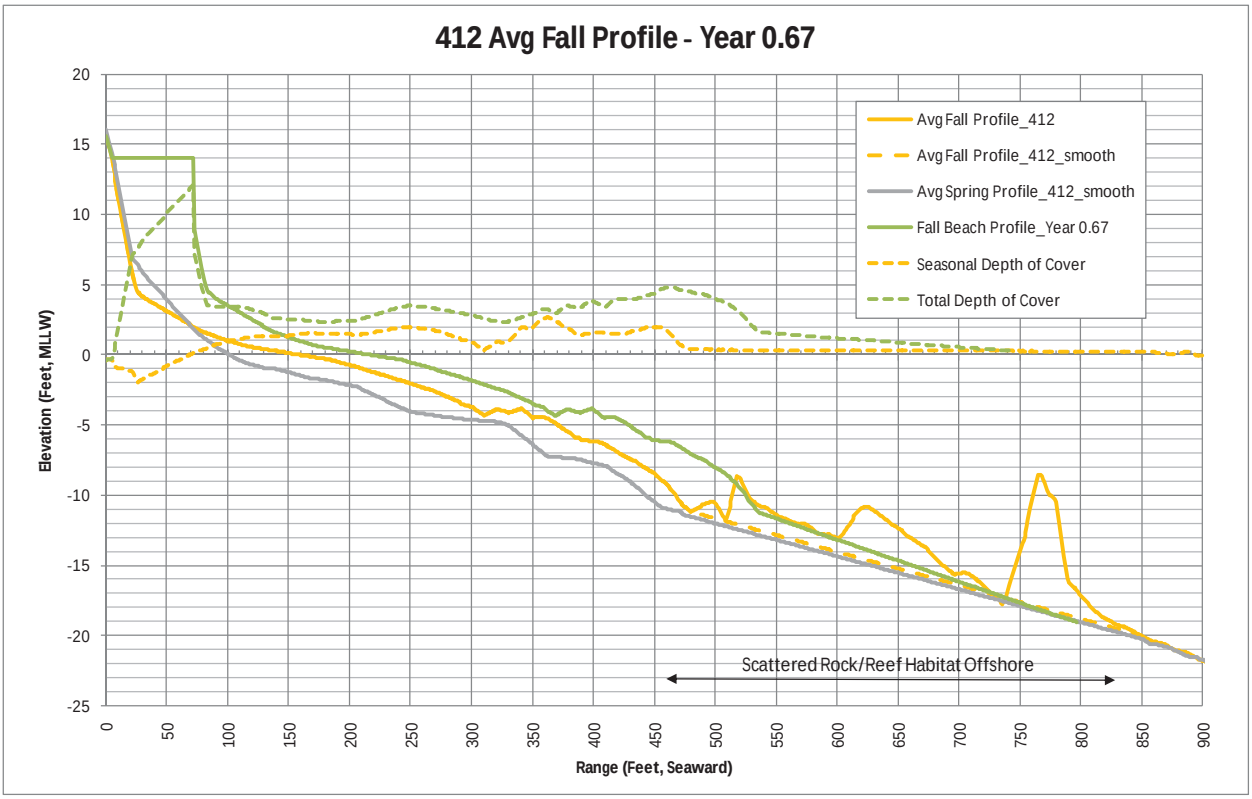
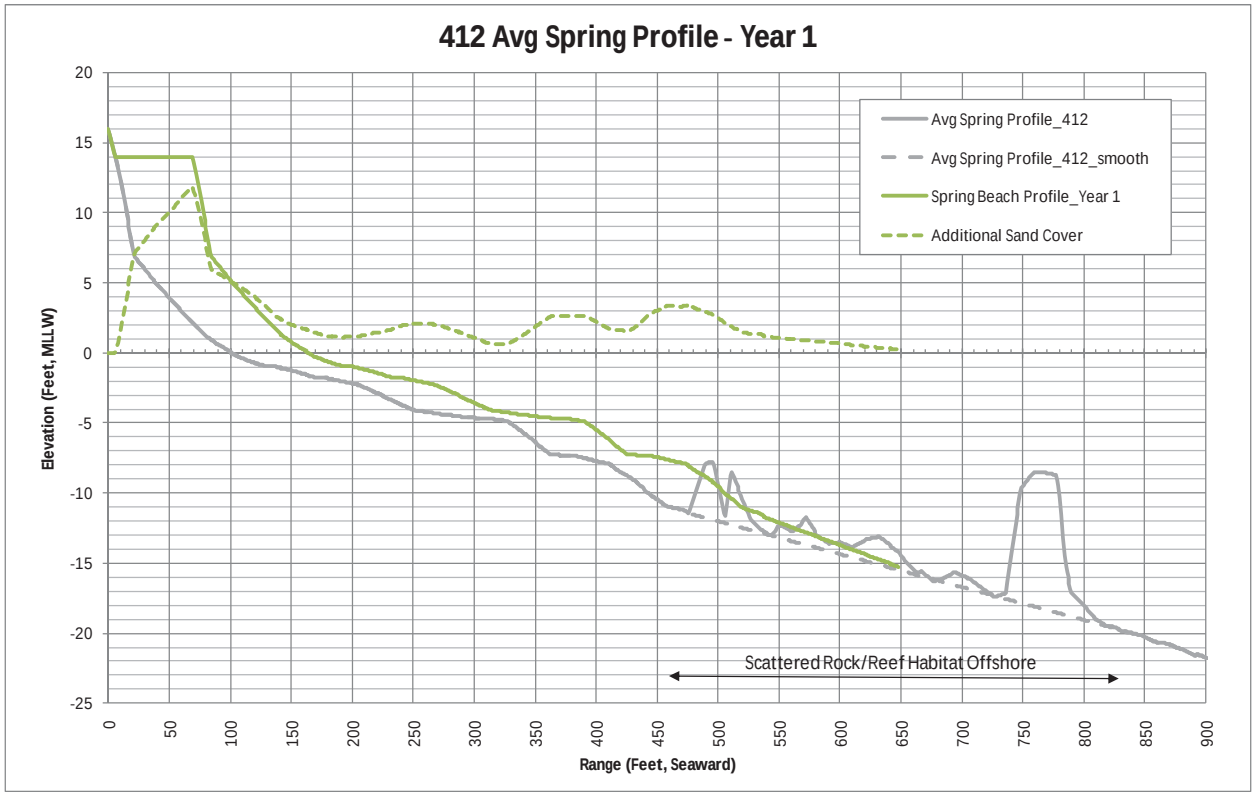


Figure 7-4. Alternative 9 – Depth of Cover Results During 8 Month Placement



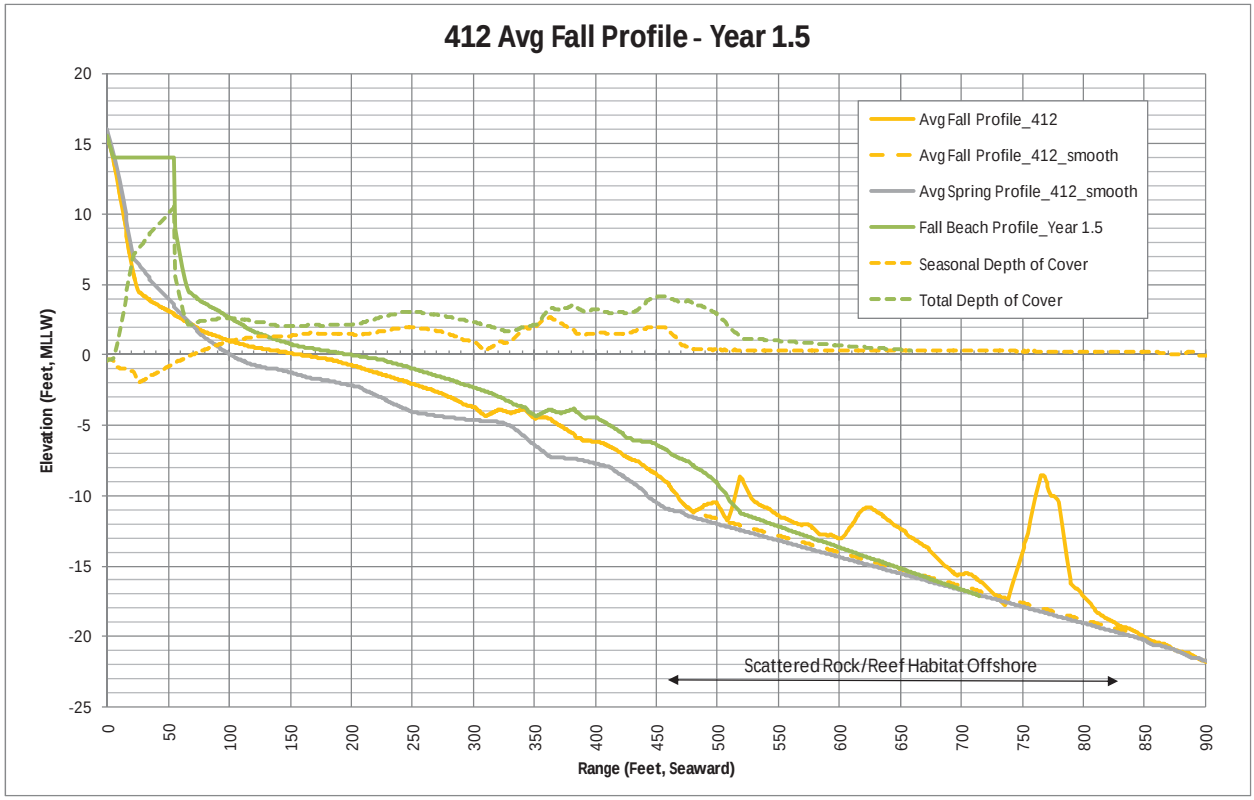
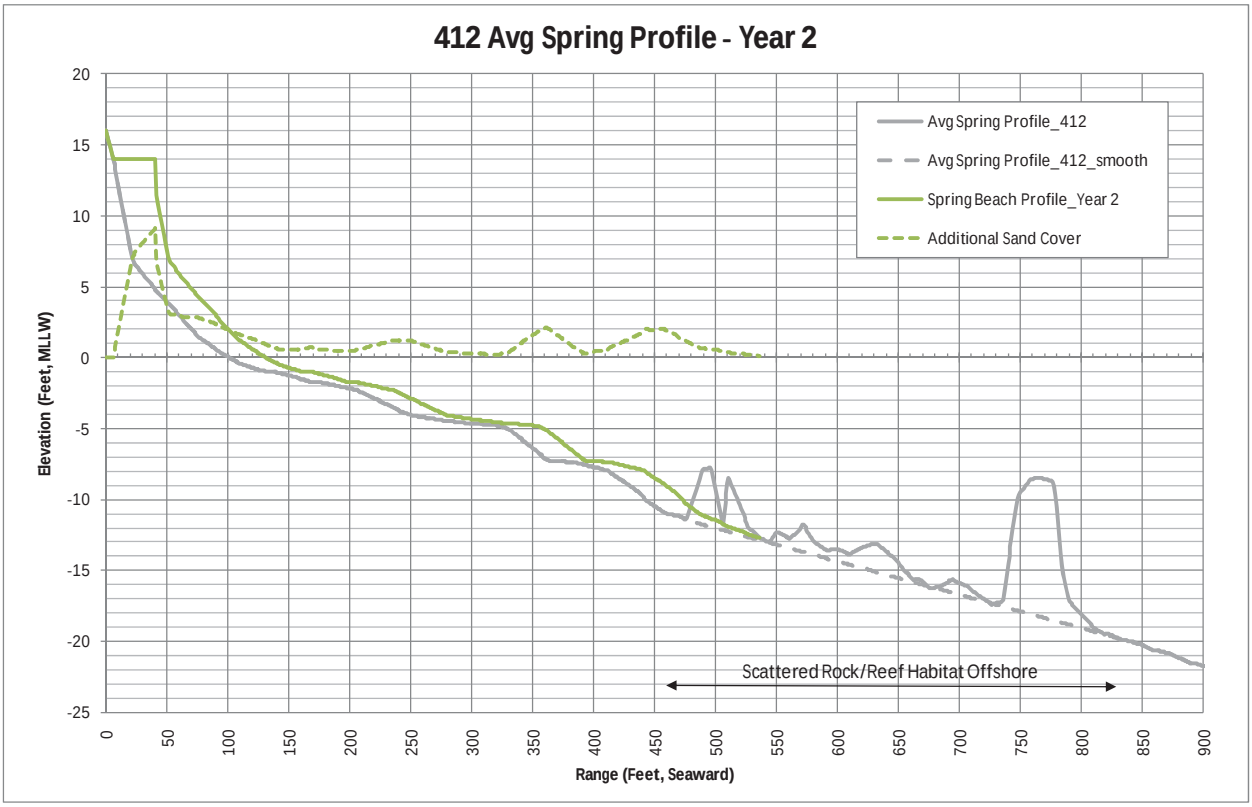


Figure 7-5. Alternative 9 – Depth of Cover Results at Year 1



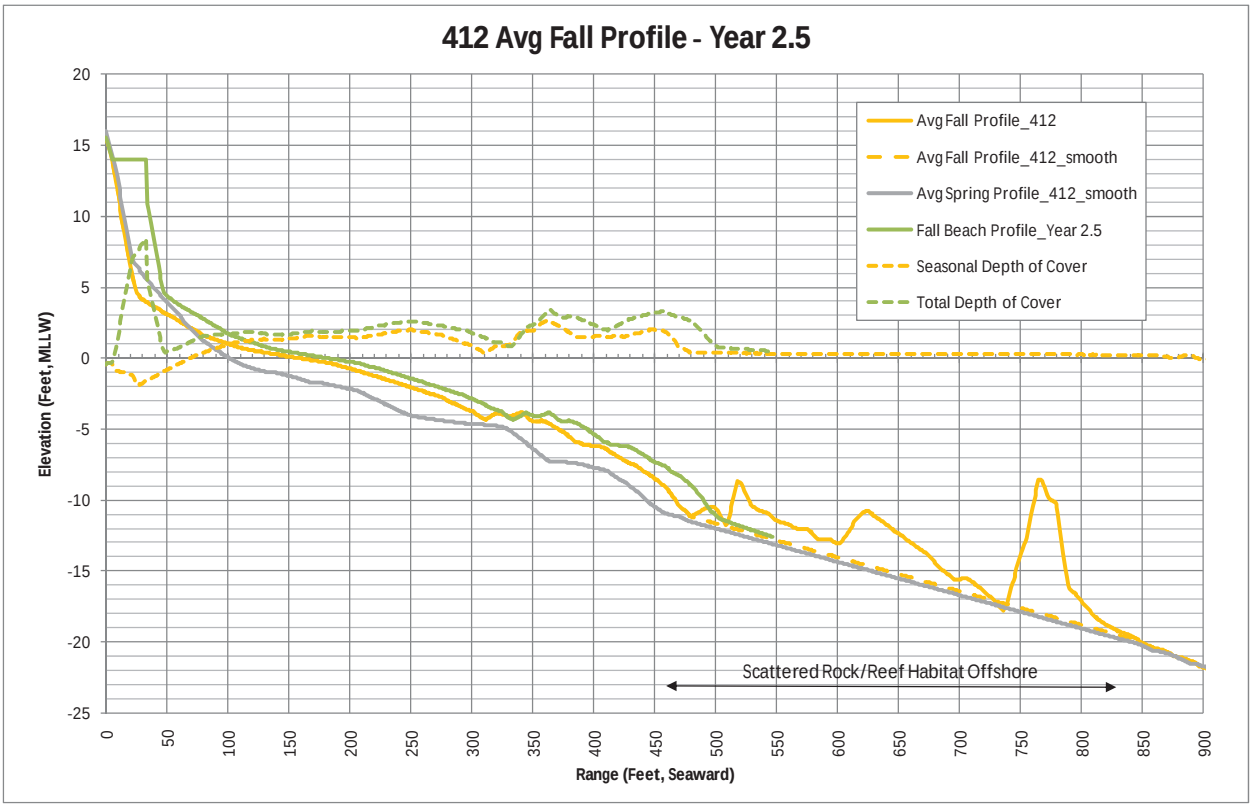


Figure 7-6. Alternative 9 – Depth of Cover Results at Year 2

7.3 STRUCTURAL INTEGRITY OF SHORE PROTECTION DEVICE

The temporary emergency revetment will remain in its current location to provide a last line of defense behind the nourished beach. The general alignment of the revetment follows the foredune boundary of the baseline 2005 condition. Please refer to Section 9.1 for a discussion of the stability and integrity of this type of revetment. A discussion of impacts associated with the revetment is provided in Section9.8. The analysis of potential impacts for Alternative 9 is summarized in Table 7-3.

7.4 PUBLIC ACCESS AND AESTHETICS

The impacts of this alternative on public access and aesthetics will be positive for Central and East Broad Beach for most of the project duration. Western Broad Beach would experience a temporary improvement over the existing condition. After an extreme storm event, partial or complete exposure of the revetment could potentially impact public access and aesthetics temporarily. During calmer post-storm conditions, the beach would recover some of the sand lost and help restore public access opportunity and aesthetics.

At the end of each nourishment cycle the amount of dry beach width will be narrow or non-existent, impacting public access and aesthetics until the next re-nourishment project. This impact would be temporary and similar to conditions between 2010 and 2013 when a narrow and seasonal beach existed along the temporary emergency revetment.

7.5 GEOLOGIC HAZARD ABATEMENT DISTRICT (GHAD) REQUIREMENTS

This alternative provides a significant benefit to Central and Eastern portions of Broad Beach; but shoreline protection benefits along West Broad Beach could be reduced. There may be legal implications for reducing or eliminating benefits within a GHAD since the formation of the Broad Beach GHAD was based upon the requirement that a near equal benefit is provided to all properties.

Table 7-3. Alternative 9 – Summary of Potential Impacts

Category	Summary of Impacts
Existing Development	• All residential structures within Central and Eastern Broad Beach will be outside of 100-year wave uprush line over project duration (20 years). • Primary structures along West Broad Beach at risk of storm damage at the end of a nourishment cycle. • Approximately 13 leach fields are at risk of damage from wave uprush at the end of each nourishment cycle.
Sand Supply	• Increased sand supply after initial nourishment will reduce adverse impacts (shoreline erosion) of sediment deficit.
Beach Profile	• Increase in seasonal profile changes (depth of sand cover) reduced in duration and magnitude at West Broad Beach. • Inter-annual profile changes will not be impacted. Long-term trend of erosion is expected to continue. • Coarse grained nourishment may temporarily steepen upper profile after nourishment or backpassing.
Extreme Storm Erosion	• Reduced shoreline protection for West Broad Beach. • Added beach width will improve resistance to storm erosion but would not withstand 100-year storm erosion. • Majority of extreme storm protection will be provided by the SPD and restored dune system. • Restored dune system will be mostly protected by revetment and will improve resistance to overtopping.
Shore Protection Device (SPD) - Stability	• SPDs at west end will be subject to increased wave attack near the end of each nourishment cycle. • Revetment susceptible to >5% damage during design storm event due to displacement or settling of smaller armor stone. • Maximum uprush line (with SLR) estimated to extend 40 feet landward of revetment crest. • Revetment could be adapted with an increased crest elevation if SLR exceeds projections over the project duration.
SPD Alignment	• Partial exposure of SPD is expected at Year 6. Complete exposure is anticipated by Year 9. • About 75,000 cy of sand is retained landward of the structure and seaward of the leach fields. • Alignment offers protection to restored dunes constructed over and landward of revetment.
Adaptive Management	• Re-nourishment volume and frequency to occur as planned for the proposed project. • Opportunities for backpassing from east to west will be limited with reduced nourishment volumes.

Public Access and Aesthetics	• Public access & aesthetics significantly improved along Central and Eastern segments of Broad Beach. • Limited and temporary access and aesthetic improvements along West Broad Beach. • Reduced sand volume increases duration of revetment exposure by about 0.5 years compared to the proposed project. • At the end of each nourishment cycle, access & aesthetics would be similar to beach conditions between 2009 and 2013.
BBGHAD	• There may be legal implications for the GHAD if near equal benefits are not provided for all properties.

8. REFERENCES

Ensitu Engineering Inc, 2013. Broad Beach Restoration Onsite Wastewater Feasibility Study. Prepared for the Broad Beach Geological Hazard Abatement District. October, 2013.

Everts Coastal, 2014. Estimates of Beach Fill Loss Rates and Thoughts on Optimizing Placement Timing and Locations: Broad Beach, Malibu, California. Prepared for Moffatt & Nichol. February 2014.

Moffatt & Nichol, 2013. Broad Beach Restoration Project Coastal Engineering Report (CER), prepared for the Broad Beach Geological Hazard Abatement District as Exhibit L to CDP Application 4-12-043. October 2013.

Appendix 2-A1

Coastal Geomorphology Study by Everts Coastal

2D - Estimates of Beach Fill Loss Rates and Thoughts on Optimizing Placement Timing and Locations: Broad Beach, Malibu, California. February 2014.

Appendix 5-A1

Seasonal & Inter-annual Beach Profiles Changes

5A – Beach nourishment for Alternatives 3C, 6C, 7A, and 7B are similar to the proposed project. Profile analysis was performed assuming a slower placement rate (8 months total placement)

Appendix 5-A1

Seasonal & Inter-annual Beach Profiles Changes

5B – Profile analysis based on beach nourishment proposed for Alternative 8

Appendix 5-A1

Seasonal & Inter-annual Beach Profiles Changes

5C – Profile analysis based on beach nourishment proposed for Alternative 9

Appendix 7-A1

OWTS Feasibility Study by Ensitu Engineering, Inc.

Response to CCC Comments by Ensitu Engineering, Inc. February 2014