



Morro Bay, CA.

INSPECTION AND ASSESSMENT OF REVTMENTS AND SEAWALLS MORRO BAY, CA



January 23, 2025

Prepared by:

BRADY

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January 23, 2025

City of Morro Bay
1275 Embarcadero
Morro Bay, CA 93442

Attention: Ms. Cindy Cecil, PE
City Engineer

Subject: Inspection and Assessment of Revetments and Seawalls, Morro Bay, CA

Dear Cindy,

In accordance with the contract Scope of Work, an above water routine inspection of revetments and seawalls has been conducted. BRADY performed the above water inspection of the revetments and seawalls between June 19th and June 21st, 2024, to observe the overall condition of the structures. The structural and geotechnical observations are also included within this report. The report includes budgetary cost estimates and the top prioritized repair/replacement recommendations.

We greatly appreciate the opportunity to provide this inspection, assessment services, and estimates. Should you have any questions regarding the findings or recommendations, please do not hesitate to contact me.

Respectfully Submitted:



Amanda Del Bello P.E.

BRADY

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1. EXECUTIVE SUMMARY

Background – The City of Morro Bay (“City”) requested technical proposals from qualified and experienced consultant firms to conduct a detailed and thorough inspection and assessment of the revetments and seawalls in and around the Harbor of the City of Morro Bay. Three seawalls and 12 sections of revetment were identified by the City.

This report will convey the condition of the structures, discuss repair options along with prioritized repairs, and rough cost estimates for conceptual recommendations to support the City’s planning and budgeting for the improvements.

Condition Assessment Findings and Recommendations – To assist the City in understanding the condition of its existing seawalls and revetments, an assessment was performed by BRADY. Results are in Chapter 3 – Findings.

A routine above water inspection was performed on visible portions of the structure(s) by walking, and at times, utilizing a small boat as needed for access. This inspection was used to form a general understanding of the condition of the twelve (12) revetments and three (3) seawalls with the purpose of identifying and prioritizing repairs. The pictures in Appendix A and recorded data in Appendix B should be referenced, along with the discussion presented herein, to identify the location and extents of all items noted.

Additional technical studies performed include a Revetment and Seawall survey by eTrac, a geophysical study using Ground Penetrating Radar by GeoVision, and Conceptual Geotechnical recommendations by ENGEO. The results of these studies informed the overall condition of the revetments and seawalls and are included throughout the report and in the conclusions.

Geophysical and Geotechnical Assessment – The existing condition of the revetment locations and seawalls range from needing minor maintenance to complete failure. General conceptual geotechnical recommendations are summarized in the following sections for each revetment location and seawall. Recommendations for each 100 ft station are provided at the start and end of each revetment location and seawall. Stationing is shown in the survey and report by eTrac (Appendix C).

Common recommendations include controlling surface drainage, adding rock, revetment refurbishment, and revetment rebuilding. Controlling surface drainage may include grading ditches, swales, or berms; drains; concrete, metal, or plastic structures; or other methods designed by a civil engineer. As shown in the attached figures, revetment refurbishment should consist of stockpiling of the existing riprap, excavation of a keyway for replacement of the riprap, smoothing of the existing subgrade, placement of filter fabric, placement of a protection layer consisting of quarry fines, and then placement of the riprap, carefully seating each stone. Rebuilding the revetment includes excavating a larger keyway and rebuilding the slope face with engineered fill in addition to the steps identified in refurbishing.

Additional exploration such as borings and/or test pits should be performed for the design of new seawalls or refurbishment or rebuilding of revetment locations.

Given the above studies and recommendations, BRADY concludes and recommends that further geotechnical investigations be planned and conducted as driven by the design decisions for the improvements that are contemplated after review of the results of this report.

Conceptual Recommendations – This report provides findings and recommendations broken down by each seawall and revetment. Recommendations in Chapter 5 are assigned a repair prioritization by priority; short-term, mid-term, or long-term so that a repair approach and work plan can be developed.

The following summary of conceptual recommendations is listed below considering priority and condition. Reference Section 5 of this report to see all the recommendations.

A summary table is below:

Structure	Conceptual Recommendations	Condition	Priority
Seawall 1	Further investigation of seawall and wharf. Refurbish revetment in front of seawall.	Fair	Short
Seawall 2	Replace in-kind or build revetment	Critical	Mid
Seawall 3	Replace in-kind or build revetment	Critical	Mid
Revetment 1	Add Rock and Refurbish	Fair	Long
Revetment 2	Add Rock, Refurbish, Rebuild	Poor	Mid
Revetment 3	Rebuild	Serious	Short
Revetment 4	Refurbish and Rebuild	Serious	Short
Revetment 5	Add Rock and Refurbish	Fair	Long
Revetment 6	Refurbish	Fair	Long
Revetment 7	Refurbish	Poor	Mid
Revetment 8	Refurbish	Poor	Mid
Revetment 9	Refurbish and Rebuild	Critical	Priority
Revetment 10	Rebuild	Serious	Short
Revetment 11	Refurbish	Poor	Mid
Revetment 12	Add Rock and Refurbish	Fair	Long

Long-Term Improvement Plan – A long-term improvement plan is recommended to be developed and implemented. The recommendations made in this report are conceptual and need to be supported by further investigations. Once further investigation is performed, a more detailed cost estimate could be developed. Additionally, a financial analysis could be developed in that plan in pursuit of potential grants or sources of funding.

The long-term plan must consider the City and Harbor's Organization, Leaseholders and their repair responsibilities, current and future uses, Coastal Commission review and input, and the City's Local Coastal Plan. These considerations are presented in Section 6 of this report.

Compliance, Permitting, & Environmental – The work, which is anticipated, will need to comply with several requirements including the California Coastal Act of 1976 (California Coastal Commission (CCC)), California Environmental Quality Act (CEQA), US Army Corps of Engineers (USACE) and others. It is not within the scope of this project to perform a complete analysis or plan for compliance with these regulations; however, a summary is given in this report. As with all permitting, sufficient time should be allowed for permit application submittal and approval.

Cost Estimates – Cost estimates are included in Appendix F and is accompanied by a discussion in Section 8 of this report. The cost estimates are based on current prices and escalation is not included. Estimates are developed using costs based on direct experience and knowledge, recent bid history of similar items and projects, vendor or contractor quotes, and other historical cost information.

Costs have been estimated for the recommended improvements and are shown in Appendix F. The estimates generally include the following cost categories.

- **General Conditions for Construction**
- **Mobilization/Demobilization**
- **Seawall Rebuild versus Replacement with Revetment**
- **Revetment Refurbishment construction**
- **Revetment Rebuild construction**
- **Geotechnical Investigation**
- **Engineering**
- **Compliance, Permitting, & Environmental Studies**
- **Contractor Overhead & Profit**
- **Construction Support**
- **Construction Management**

Limitations - This scope of work did not include assessment for seismic resiliency and would likely require significant improvements to address common seismic stability criteria. Seismic resiliency will need to be considered for future repair and refurbishment work that is undertaken. Seismic resiliency will be considered during the geotechnical study and during the design phase, which are included in the cost estimates. However, the findings may result in increased costs of construction to address seismic improvements.

SUMMARY CONCLUSIONS

The major conclusions of this report are as follows:

- Presently, several deficiencies and issues exist with the seawalls and revetments at the City of Morro Bay such that the current conditions do not meet recommended standards.
- Many of these deficiencies and conditions should be addressed immediately. The Conceptual Recommendations Section discusses the recommended prioritization for repairs and refurbishment.
- A Long-Term Improvement Plan should be developed and updated annually.
- Candidates for funding avenues should be researched to determine feasibility of monetary assistance and factored into the overall repair plan.

2. INTRODUCTION

BRADY conducted a detailed inspection and assessment of the revetments and seawalls around the waterfront for the City of Morro Bay. This assessment will be utilized to prioritize capital improvements and maintenance requirements as well as documentation in pursuit of potential grants for the rehabilitation and replacement of these facilities.

Three seawalls and 12 sections of revetment were identified by the City with approximately 384 total lineal feet of seawall and 6,239 total lineal feet of revetment. Morro Bay's waterfront is vital to the community, industries, and tourism of the City and maintaining the City's revetments and seawalls is essential. Visual inspection of the revetments and seawalls is an important first step towards understanding the condition of these facilities.

This report will convey the structure's condition, discuss repair options along with prioritized repairs, and provide rough cost estimates for conceptual recommendations to support the City's planning and budgeting for the improvements; and the waterfront can serve the community for many years to come.

BACKGROUND AND DESCRIPTION

BRADY's inspection of the City's 12 revetments and 3 seawalls was conducted between June 19th through the 22nd. The seawalls and revetments are located along Coleman Drive and the Embarcadero with the exception of Revetment 1 located on the oceanside to the north of Coleman Drive and Seawall 3, behind the hotel at 60 State Park Road, see Figure A and Figure B for Location and Vicinity Maps.

The waterfront from Morro Rock to Tidelands Park was man-made. The natural harbor was (and still is) protected to the west by the sand peninsula and was open to the north (now Coleman Drive) making Morro Rock an island (Photo 1). In 1935 the waterfront was transformed by placing rock taken from Morro Rock to connect the rock to shore at Coleman Beach (Photo 2 and Photo 3). During the Second World War, the US Navy initiated major development of the Harbor including building the north and south harbor entrance breakwaters, the two T-Piers, and dredged and filled behind the rock placed between Morro Rock and Coleman Beach and dredged and filled behind the inner harbor revetment creating the current Embarcadero Road on what was previously tidal flats. It is understood there has been little to no maintenance performed on these facilities since their construction.

Seawall Structures. Seawalls are designed to protect against large wave forces. The three seawalls in Morro Bay are designed primarily to retain the soil behind a vertical wall in locations with less wave action. Record documents were not available for review to determine the age and design of the seawalls. Each seawall is constructed differently. Seawall 1 appears to be a retaining wall with shotcrete placed over it and rock placed on a slope in front of it. The shotcrete covering the wall makes it difficult to understand the construction. Seawall 2 is a concrete retaining wall that may have had some tie backs however the wall has failed. Seawall 3 is a timber sheet pile wall, wale and steel tie back system, which has failed. See Section 3, Item 1 of this report for more detail on each seawall.

Revetment Structures. A revetment is a sloped surface of stone or other material used to protect an embankment, natural coast, or shoreline against erosion. Large rock or armor stone units are placed on the outer surface to hold the underlying material in place. Revetments must have an adequate filter to

prevent fines or the in-situ soils from washing through the voids of the structure. The filter can be either layers of stone or cloth. The material in each layer is carefully increased in size over the underlying material to prevent loss of the smaller size material.

A well-designed and constructed rubble-mound revetment can protect embankments from waves. The underlying philosophy of the rubble-mound is that a pile of stones is efficient at absorbing wave energy and robust in design in that damage is often not catastrophic.

The design of the revetments around Morro Bay is unknown. The City of Morro Bay provided a section of what is believed to be a typical section of the revetment around Morro Bay, however its origins are unknown, see Figure C. The section indicates there is a 2:1 slope, the rock is placed up to elevation +10 ft (datum unknown) and that 4' Class "C" Stone was used.

Based upon review of historical data, Revetment 2 was initially constructed in 1936 and the remaining revetments were constructed during WWII. A 1937 aerial image is seen in Photo 4 which demonstrates the land along what is now Coleman Road has been filled and the downtown areas embarcadero has not been built. In Photo 5 a 1949 aerial image shows the waterfront was dredged and filled creating the Embarcadero Road and revetment. See Section 3, Item 2, of this report for more detail on each revetment.

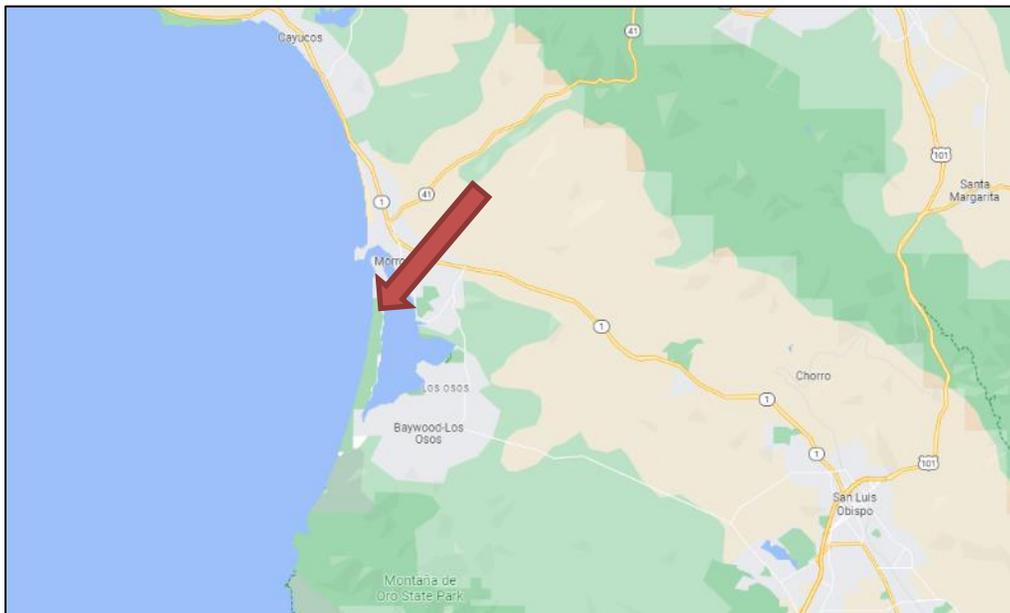


Figure A. Location Map.



Figure B. Vicinity Map.

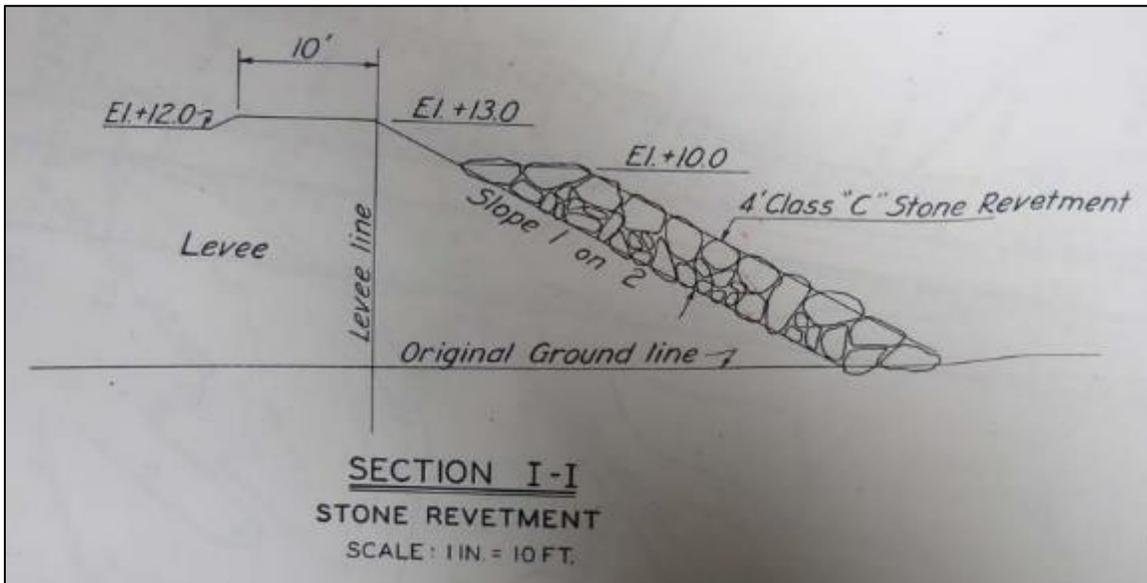


Figure C. 1941 Stone Revetment Detail, provided by the City of Morro Bay.



Photo 1. Aerial image from 1912 taken before the breakwater and revetments were constructed (oldmorrobay.com).

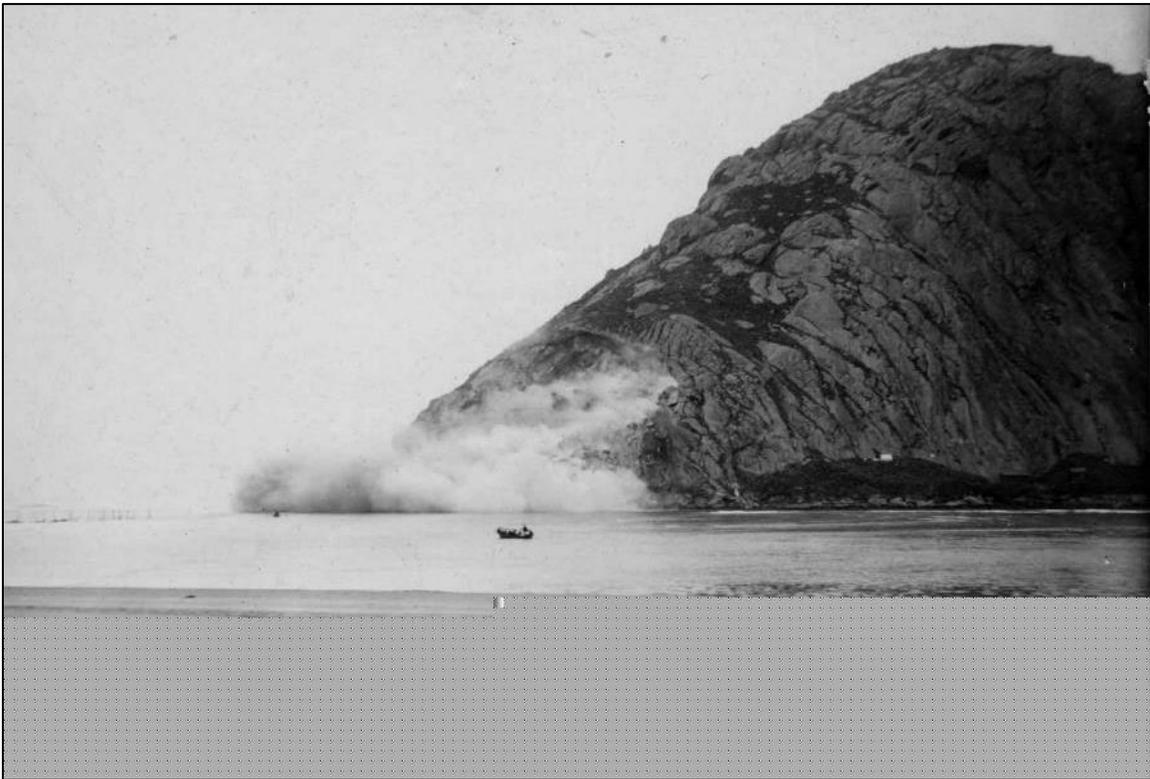


Photo 2. Blasting of the east face of Morro Rock in the early 1890's to source building material (Gaines-Birkhead).

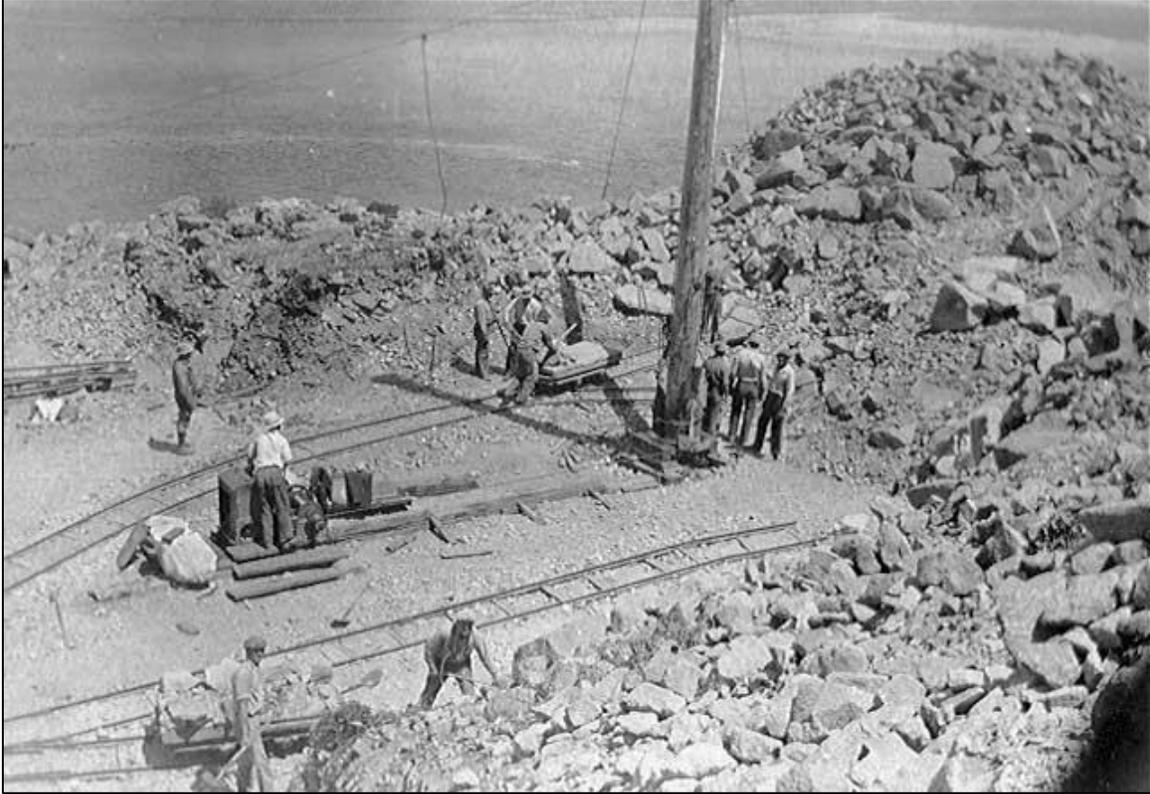


Photo 3. Construction of the causeway to and from Morro Rock in 1936 (oldmorrobay.com).



Photo 4. 1937 Aerial Image (UCSB Library).



Photo 5. 1949 Aerial Image (UCSB Library).



Photo 6. Typical rock revetment, looking west at Revetment 2.

INSPECTION SCOPE OF WORK

An above and below water routine inspection was performed on the pier's structural components and utility systems. A review of the pier's current condition was conducted to support the development of a very rough order of magnitude cost estimate and schedule for the top prioritized repairs or replacement.

The services provided consist of the following:

1. **Project Management, Planning, and Setup:** BRADY

- a. *Work with City staff and subconsultants to devise inspection and reporting plan that is clear and meets the project needs.*
- b. *Review existing engineering documentation; meet with City personnel to gather record documents and first-hand knowledge and experience of the facilities.*
- c. *Prepare aerial plan of facilities with stationing.*
- d. *Attend kickoff meeting, present inspection plan schedule, and prepare meeting minutes.*

2. **Structural Observation:** BRADY

- a. *To be completed in accordance with ASCE Manual No. 130 "Waterfront Facilities Inspection and Assessment".*
- b. *Inspect above water revetment and record data.*
- c. *Inspect seawall structure and areas behind the seawall for subsidence.*
 - i. *Inspect the lower portion of the wall at a minus tide, walk, wade in water, or utilize a small boat as needed for access and close-up inspection.*

2.2 **Survey:** eTrac

A survey will be conducted at all the revetments using a high-resolution multibeam sonar-based condition survey of the revetment below water and a lidar survey above water. The survey data will be processed and present plot maps with cross sections which will help develop detailed repair quantities and associated cost estimates.

3. **Geotechnical Observation:** ENGEO and GEO Vision

- a. *ENGEO will oversee the areas recommended for GPR and provide observations.*
 - i. *If anomalies are recommended to be further explored, perform soil borings. Two borings are included with this scope of work and fee, if more borings are recommended, additional fees will apply.*
- b. *Review BRADY's visual and tactile inspection data and findings.*
- c. *Provide Geotechnical recommendations.*

4. **Reporting and Deliverables:** BRADY

- a. *Compile findings from the above tasks into a draft report as described in the Detailed Work Approach and Methodology section.*
- b. *Perform cross-disciplinary QA/QC review.*
- c. *Present one PDF file of the Draft Report to the City of Morro Bay.*
- d. *Conduct virtual meeting to review draft report and allow for three weeks of City Review.*
- e. *After draft report has been reviewed, cost estimates will be produced based on feedback from this meeting. A very rough order of magnitude cost will be provided for repairing or replacing the revetment, and one repair alternative per seawall, or replacement cost. Repair quantities*

- for the revetment will be developed with the survey data provided by the Lidar and MBES survey data.*
- f. Prepare Final Report and perform final internal QA/QC process.*
 - g. Conduct virtual meeting to review final report.*
 - h. Submit three hard copies of the final report and one PDF version.*

5. Presentation of Findings to City Stakeholders and Decision-Making Bodies: BRADY & ENGEO

Prepare a PowerPoint presentation of findings to be presented to City staff during a virtual meeting. Allow City to review and comment. ENGEO will provide assistance and/or input in development of the slide deck.

INSPECTION METHODOLOGY

BRADY performed a routine inspection in accordance with American Society of Civil Engineers (ASCE) Manual No. 130 "Waterfront Facilities Inspection and Assessment".

Visual Inspection - Observations and defects were recorded for the seawall and revetment structures. The above water inspection included a visual inspection of all structures above water at various tides. An effort was made to visually inspect all of the revetments during a lower tide, however photographs were collected during various tides from approximately -1 ft MLLW to +4 ft MLLW. All elevations in this report are relative to Mean Lower Low Water (MLLW). Datums from the nearest station, Port San Luis, is provided in Figure 4. It should be noted that NAVD88 = 0.08 ft MLLW and is therefore considered elevation in NAVD88 is equal to elevation relative to MLLW.

Echosound and LIDAR - To understand the slope of the revetments above and below water, a multibeam echosounder and LiDAR survey was conducted by eTrac between May 21 and May 23. The vertical datum for the survey data is with respect to NAVD88. A survey report and profiles are provided in Appendix C.

Geotechnical Field Visit - A cursory inspection was conducted by ENGEO and BRADY on June 26th to obtain a geotechnical perspective of the condition of the revetments. A report is provided in Appendix D and discussed in Section 4 of this report.

Ground Penetrating Radar - Part of this investigation involved a geophysical investigation to help identify subsurface voids by using Ground Penetrating Radar (GPR), which was conducted between July 15 and 19th by GEOVision. Not all locations were planned for GPR investigation due to obstructions, for example where concrete and composite sidewalks exist, it was anticipated the GPR would not be able to image through and these areas were excluded. Results of the geophysical investigation are presented in Appendix E and discussed in more detail in Section 4 of this report.

A subsurface exploration at various locations was conducted based on anomalies identified during the GPR investigation. Hand augers and potholing were performed on September 30, 2024 and October 3, 2024. The results of this investigation are presented in Appendix D and Section 4 of this report.

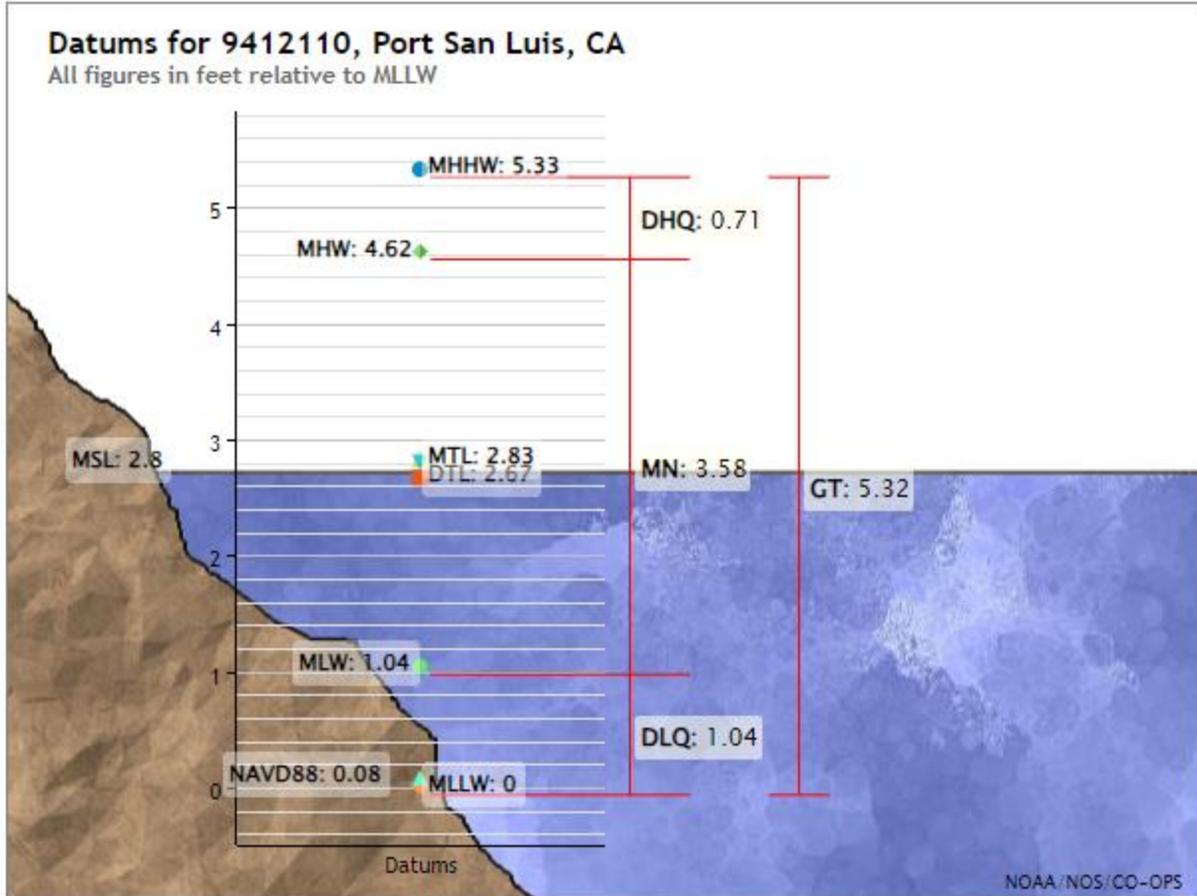


Figure 4. Vertical Datums at Port San Luis with respect to MLLW, provided by NOAA.

CONDITION ASSESSMENT RATINGS

The American Society of Civil Engineers (ASCE Manual of Practice 130) has developed an overall condition rating system that provides standard condition rating classifications for all waterfront facilities. In the use of this system, each facility is given an overall rating based on the observed conditions. The six terms used to describe the conditions of a structure are described below and will be used in describing structural elements in this report.

- **“Good”** – No problems or only minor problems noted. Structural elements may show some very minor deterioration, but no overstressing observed.
- **“Satisfactory”** – Minor to moderate defects and deterioration observed, but no overstressing observed.
- **“Fair”** – All primary structural elements are sound, but minor to moderate defects and deterioration observed. Localized areas of moderate to advanced deterioration may be present but do not significantly reduce the load-bearing capacity of the structure.
- **“Poor”** – Advanced deterioration or overstressing observed on widespread portions of the structure.
- **“Serious”** – Advanced deterioration, overstressing, or breakage may have significantly affected the load-bearing capacity of primary structural components. Local failures are possible.

- **“Critical”** – Very advanced deterioration, overstressing, or breakage has resulted in localized failure(s) of primary structural components. More widespread failures are possible or likely to occur.

To assess the damage of a revetment the following table from the US Army Corps of Engineers (USACE) is used.

Table 1. Descriptive rating guidance for armor loss (based on USACE, 2003)

Structural rating (typical associated maintenance)	Description
Minor or no damage (no action)	<p>At most, slight movement of armourstones in a few isolated spots</p> <p>Movement has left a depression no larger than $\frac{1}{4}$ of one armour stone (or unit) diameter</p> <p>Armourstone movement has caused some waviness along the slope surface with depressions less than $\frac{3}{4}$ of the armour layer thickness</p> <p>Any bridging is over a void less than $\frac{1}{2}$ of the armourstone diameter. Underlayer may be seen in places, but no material has been lost</p>
Moderate damage (repair)	<p>Some loss of armourstone in spots, leaving voids or depressions about the size of an armour unit; units surrounding the void may be rocking or gradually moving out of place</p> <p>Underlayer or core might be seen at these spots, but armourstone position still prevents loss of this material</p> <p>Bridging to a diameter of an armour stone may be visible in several places</p> <p>Armour units have been lost or displaced in some portions of the reach length</p> <p>Voids are just large enough to allow loss of underlayer</p>
Major damage (rehabilitation)	<p>Armour units have been fully displaced or lost</p> <p>Voids are large enough to allow underlayer and core loss with ease</p> <p>Armour units have been fully displaced or lost</p> <p>Loss of underlayer material is evident</p> <p>Armour units are gone or fully displaced. Structure is unravelling</p>

3. CONDITION ASSESSMENT FINDINGS & RECOMMENDATIONS

This section will discuss and show typical conditions and notable defects of the seawalls and revetments. Reference is made to the photos, which provide a general depiction of findings discovered during the investigation. As part of the investigation, photos and observed conditions were recorded every 100 ft or at the beginning and end of each structure. Reference Appendix A for the photos and Appendix B for the recorded observations and site-specific recommendations. General written recommendations are provided in this section.

ITEM 1 – SEAWALLS

Three (3) seawalls were included in the inspection for condition and current configuration and detailed results are presented below. Pictures illustrate condition and typical defects.

The linear extent of each existing seawall was provided to BRADY by the City in a PDF document. A field survey was not conducted to verify the beginning and end of the City's seawalls, so dimensions are based upon the information provided. For the purposes of this report and the visual inspection and survey, the stationing was assumed based upon the PDF provided and there was some variation found in length of seawalls.

Seawall 1

Seawall 1 starts at the south side of the North-T Pier, following Revetment 3, and continues 87 feet under Tognazzini's Dockside wharf which supports a building and outdoor dining area. The seawall continues to the south; however is a private leasehold. Record drawings were not available for review and the construction is unknown. The seawall was inspected from below deck and above deck and the components that were observed include a retaining wall with shotcrete placed over it and rock placed on a slope in front of it, see Photo 7 and Photo 8. Above deck and behind the wall, the pavement was inspected for subsidence or evidence of ponding. From what can be observed, the wall is in *fair* condition.

The shotcrete was sounded with a hammer to listen for hollow sections. The shotcrete was observed to be in fair condition with isolated areas of hollow sounds and minor cracks. The shotcrete extends over the rock slope to approximately +3 ft MLLW and where it ends, areas of undermining were observed. An example is seen in Photo 9 where a void extending 3 ft horizontally under the shotcrete was recorded.

Above deck, a v-ditch for diverting runoff is installed behind the wall, see Photo 10. Some cracking in the concrete behind the wall was noted, however there did not appear to be significant ponding or subsidence. The GPR data identifies linear features evenly spaced behind the wall which suggests the wall has a tieback system.

Over the wall there is a timber 14-in high cap beam that extends the length of the wall which supports timber and steel stringers that span west over two rows of pile caps and timber piles. It is understood this portion of the structure is the leaseholder's responsibility and was not inspected as part of this investigation; however, it was noted that several timber piles exhibit damage due to marine borers and in some cases have up to 100% section loss (Photo 11). In one instance the pile was missing altogether (Photo 12). It was also noted that the timber cap beam over the seawall exhibited severe decay and section loss due to marine borers, reducing the strength of the wood. Areas of the cap beam were easily

penetrated by the hammer revealing the deterioration of the internal cross section (Photo 13). In at least one instance overstressing was observed where the member was crushed which will likely result in deflection of the wharf deck.

Recommendations

While beyond the scope of this report an above and below water complete inspection is recommended for the timber and steel wharf and its utilities to determine the extent and severity of defects. If more than one pile in a row has 100% section loss, failure could occur. The cap beam should be repaired, and all defective piles replaced or structurally repaired.

Although the seawall is in *fair* condition, its condition is not able to be properly assigned without further investigation. It is likely the seawall was constructed in the 1940's and is approximately 80 years old and has exceeded its service life. Due to its age, it is strongly recommended that a long-term solution be considered that would be in line with the life expectancy of the current surrounding developments, which would likely be to replace the seawall entirely. **A comprehensive repair or replacement approach should be developed once the wharf is thoroughly assessed so wharf and seawall improvements can be coordinated. Geotechnical and coastal engineering considerations should be included in the investigation.**



Photo 7. STA 0+00 Looking South at the revetment placed in front of the seawall.



Photo 8. STA 0+45 Looking Southeast at shotcrete placed over the wall and revetment.



Photo 9. Seawall 1 STA 0+43 Shotcrete undermined up to 3 ft deep.



Photo 10. STA 0+00 from above deck looking south. The red dashed line indicates the location of the seawall below the interface of the concrete and timber deck.



Photo 11. STA 00+43 Pile with 100% section loss (out of scope).

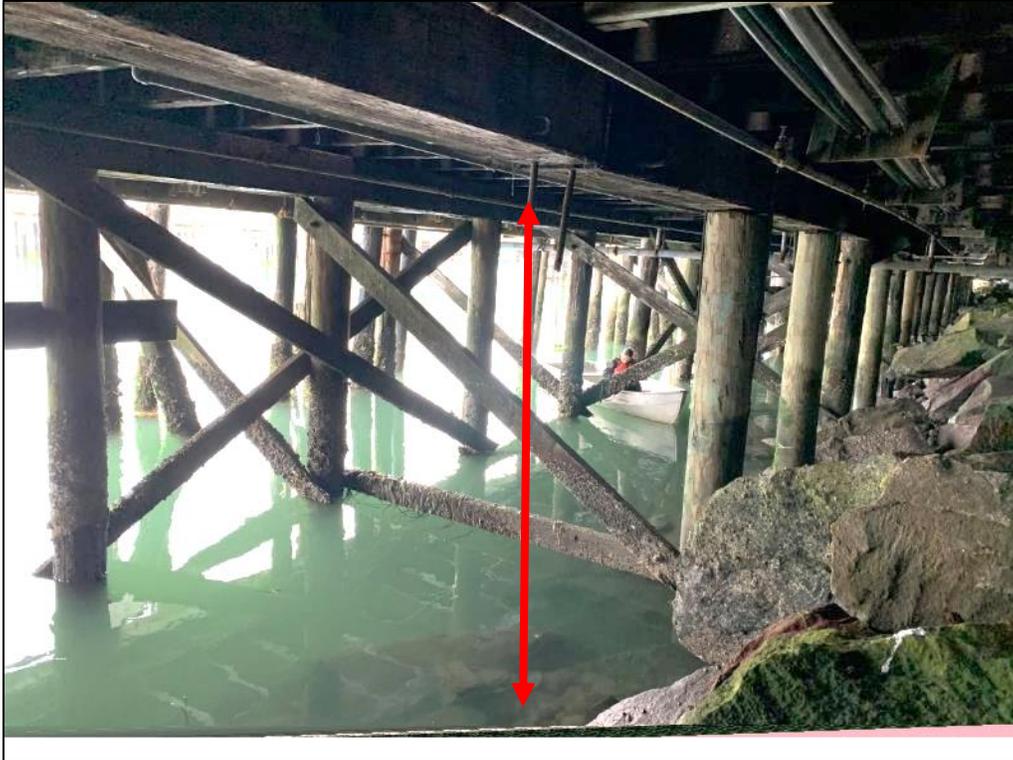


Photo 12. Seawall 1 STA 1+44 Missing pile (out of scope).



Photo 13. STA 1+00 Deteriorated timber cap (out of scope).

Seawall 2

Seawall 2, as seen in Photo 14, is a concrete structure located immediately after Revetment 12 at the southern end of the parking lot for the public boat launch, extending 84 feet. To the south, the wall transitions to a private property consisting of rock with concrete placed on top. Record drawings were not available for review and the age of the structure is unknown.

Seawall 2 is in *critical* condition with “overstressing and breakage resulting in localized failure(s) of primary structural components”. The wall has various stages of construction, the original wall has failed, and the various types of repairs have also failed. What appears to be the original concrete wall is 1 ft thick and extends from approximately 5 ft to 1 ft MLLW and was likely cast over rock and mud. Large concrete sections have failed and are laying in front of the wall (Photo 15 and Photo 16). The wall is undermined (Photo 17), settlement has occurred, and rotation seaward was observed.

It appears the wall may have been tied back originally or to the wall placed behind the original wall since portions of tie backs were observed and are not functioning. Behind the wall areas of concrete were placed and a concrete masonry unit (CMU) wall stacked above it. This added wall appears to rely on the outer wall to hold it in place, and as the outer wall continues to fail, this wall will also fail.

Recommendations

The wall is beyond repair and the entire extent (84 ft) should be removed and replaced. The wall could be replaced in kind with a cast-in-place concrete retaining wall designed to comply with new code conditions. Alternatively, replacing the wall with a rock revetment could be explored and could be more economical. Both options would require input from CCC.



Photo 14. Overall view of the wall where settlement is obvious, and the CMU wall added behind (red arrow) is seen.



Photo 15. Overall photo of Seawall 2 looking east from STA 0+00.



Photo 16. STA 0+10 where the wall section has failed, and various sections of concrete have been placed in the void to attempt to retain the soil.



Photo 17. STA 0+06 where undermining up to 2-foot-deep is recorded.

Seawall 3

Seawall 3 is located behind the Inn at Morro Bay extending the length of the parking lot and is 213 ft long. Record drawings were not available for review and therefore the specifics and details of construction are unknown. Review of historical aerial images suggest the wall was built between 1963 and 1969, see Photo 18. The wall is constructed of timber sheet piles, a timber wale and steel tie back system, with round timber piles placed in front of the wale, see Photo 19.

Seawall 3 is in *critical* condition with “overstressing and breakage resulting in localized failure(s) of primary structural components”. Decay and marine borer damage has degraded the lower portion of the sheet piles resulting in voids and the retained soil migrating through the wall, see Photo 20 and Photo 21. Due to its location at the bottom of a hill, the wall is subject to significant runoff during rain events. The combination of the wall’s inability to retain soil and erosion due to runoff has resulted in substantial voids behind the wall, exposing the tie back system, and failure of the AC paving, see Photo 22. A fence has been installed to mitigate public access from this hazard, see Photo 23. Over time the soil behind the wall will continue to erode and the failed area will continue to grow further into the existing parking lot.

Recommendations

The wall is beyond repair and the entire wall should be removed and replaced. The sheet pile wall could be replaced with a rock revetment, which is a more economical solution. However, if it is desirable to replace in-kind so that vessels can access the structure again, a new concrete sheet pile wall and tie back system is recommended. Drainage improvements such as capture, detention, or channelization would be

required to eliminate damage to the new wall from stormwater runoff. Dredging would be required to reclaim the material lost through the failed wall and allow vessels to berth. Both options would require input from CCC.



Photo 18. Aerial image from 1969 shows a recently constructed wall and parking lot (UCSB Library).



Photo 19. Overall photo of Seawall 3 looking southeast.

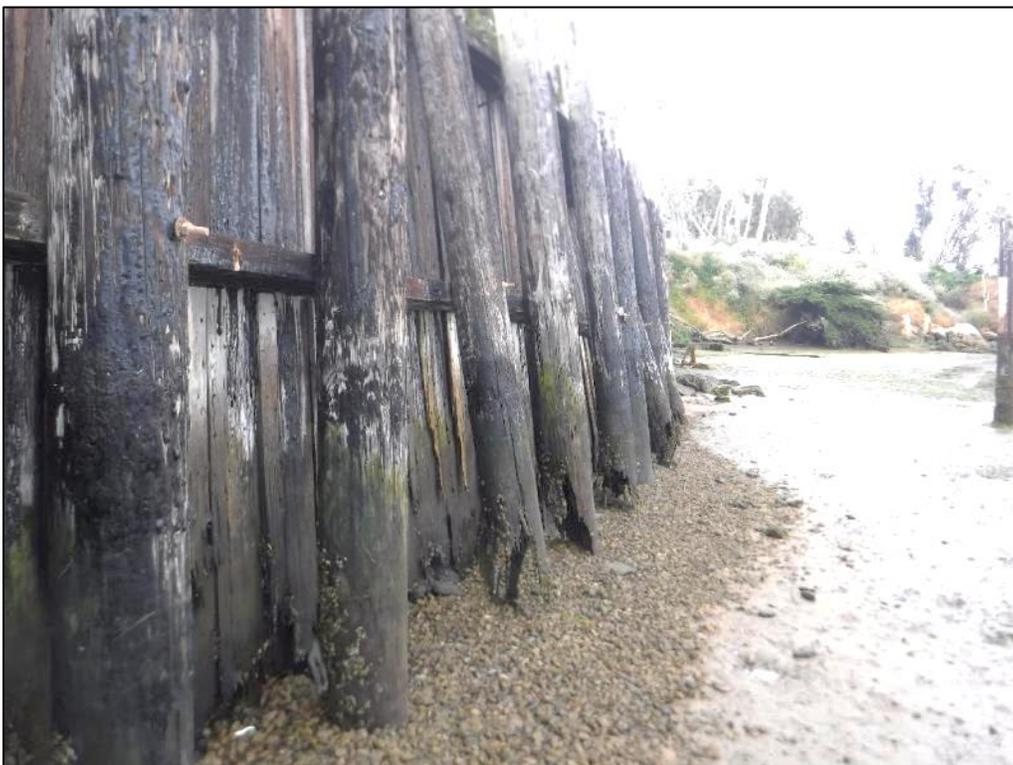


Photo 20. STA 1+00 looking south.



Photo 21. STA 0+20 Close up of degraded timber sheet piles.



Photo 22. STA 1+73 Loss of material behind the wall and exposed tie backs.



Photo 23. Looking west where a fence has been installed to restrict access to the failed wall.

ITEM 2 – REVETMENTS

Twelve (12) revetments were included in the inspection for condition and current configuration; findings and general recommendations are presented below. The descriptive terminology used is consistent with the USACE and presented from the Rock Manual in Appendix B. The linear extent of each existing revetment was provided to BRADY by the City in a PDF document. A field survey was not conducted to verify the beginning and end of the City's revetment. For the purposes of this report and the visual inspection and survey, the stationing was assumed based upon the PDF provided and there is some variation in length of revetments between what was provided and what was recorded during this survey.

It should be noted that a key factor to determining the condition of the existing revetment is the amount of slope of the existing rock compared with its original as-built slope and elevation of the crown. Since there is no record of the historical slope, elevation at the crown, or toe of revetment, there is no basis upon which to assess the performance of the revetment on. While defects are noted, it is not possible to determine if the revetment was constructed properly and if the slope has changed significantly or significant defects have developed over time. Engineering judgement is used to determine damage based on experience and damage ratings provided by the USACE, as described in Table 1 in the Condition Assessment Ratings section of this report.

During visual inspection, notes and photos were recorded every 100 ft and where defects were found. A geotechnical review also provided comments at these locations. The survey provided profiles every 100 ft or at the beginning and end of each revetment. Findings at these locations are presented in Appendix A and B and profiles are in Appendix C.

The following sections discuss notable findings at each revetment based on the visual observations and data collected during this investigation. Photos are presented to illustrate typical and notable defects. Considering all the data collected, general recommendations are provided in Appendix B by station and after each revetment. Overall recommendations are provided in the Recommendations section of this report.

Revetment 1

Revetment 1 is located to the northeast of Morro Rock, starting adjacent to the outfall and extending east 740 ft along the length of the Morro Rock Beach parking lot. This revetment is exposed to the ocean to the north/northwest and protects an unpaved dirt parking lot to the south. Between the parking area and the revetment are concrete fire pits and benches. Access to Morro Rock Beach is provided at the east end between the revetment and the sand dunes.

Revetment 1 is in *fair* condition with areas of *minor* to *moderate* damage (Photo 24) and isolated areas of *major* damage recorded. The revetment armor stone generally consists of the minimum recommended size rock, 4-ton rock (4.5 ft diameter), however there are numerous 1/4-ton (18-in to 24-in diameter) rock mixed in. While site specific historical slope or elevation data is not available to compare the crown elevation and slope to, the first 300 ft of revetment has evidence of erosion from runoff and/or wave overtopping at the top and possible elongation of the slope and settlement of rock at the top. *Major* damage is observed in areas between Station 4+00 to 8+00, where the armor layer has significant voids, or the rock is missing altogether thereby exposing the subgrade (Photo 25 and Photo 26).

Erosion due to run off or from wave overtopping is evident throughout the structure. The armor layer is not protecting the top of the slope which could be a result of rock migrating down the slope or it was originally constructed this way.

Recommendations

See Appendix B for recommendations by station. Because of exposure to ocean waves, 4-ton armor stone should be added in areas where rocks were missing and up to the top of the slope. Improvements to surface drainage are necessary to mitigate long-term effects of runoff. Sections of the revetment where *moderate* damage was recorded should be refurbished, see Section 5 for more detail.



Photo 24. Revetment 1 STA 5+00 Loss of rock throughout, erosion and voids at top. The tape measure identifies a large void.



Photo 25. STA 7+00 The top of the slope is not protected. Erosion of fine material is seen at the top, large voids, and missing rock is noted.



Photo 26. Revetment 1 STA 7+40 Looking west where large voids and missing armor stone is recorded.

Revetment 2

Revetment 2 begins near the "Fisherman's Family Sculpture" and extends 2,414 ft northeast to the end of Coleman Park, ending at the old PG&E intake structure building. The revetment protects the shoreline along the north side of the channel entrance and the north end of Morro Bay. The first 600 ft of revetment protects an unpaved parking area, a paved road, concrete benches, and a sculpture. Behind the remaining revetment there is a concrete sidewalk, viewing platform, benches, and a paved road.

Revetment 2 is in *poor* condition with widespread areas of *moderate* to *major* damage recorded. The revetment generally consisted of ¼-ton rock (18 to 24-in diameter). In the first 600 ft of revetment erosion was seen at the top of the slope. This was evident where undermining was recorded, for example at Station 1+60 under the trashcan slab and at Station 2+00 under the park bench (Photo 27). Erosion due to runoff was also noted and was significant at Station 5+60 (Photo 28) where the revetment has major damage where loss of fine material behind the revetment resulted in the slope spreading, the crown collapsing, major loss of rock, and the subgrade exposed. The revetment is not functioning in this area.

From approximately Station 6+00 to Station 19+50 the concrete walkway is located behind the top of the slope, see Photo 29. This section of revetment is steeper, with an average slope of 1.5:1 typically recorded. Typical observations include loss of fine materials at the top due to erosion, and limited areas of migration of rock down the slope. Undermining of the sidewalk was observed in several places, for example at Station 8+00 and 14+66 where up to 13-in was recorded, see Photo 30 and Photo 31.

Around Station 19+50 and at the intersection of Coleman Drive and the Embarcadero the revetment turns to the south and there is a viewing platform at this corner. The revetment then transitions to a sand

shoreline with some rock and vegetation. In this area the revetment is no longer protecting the shore and erosion is seen at the top and rock is missing or has migrated down the slope. As a result, the shoreline is receding. This is apparent at the viewing platform where the slab has been undermined up to 2 ft deep due to the loss of fine material, see Photo 32 and Photo 33.

Recommendations

Reference the table in Appendix B for the recommendations pertaining to this section. In general, there are areas with *major* damage that need to be rebuilt, as described in Section 5. The steep sections should have additional rock added. Improvements to surface drainage are necessary to mitigate long-term effects of runoff. This area needs to be addressed to protect the shoreline and the public walkway.



Photo 27. Revetment 2 STA 2+00 Concrete bench is undermined by 4-in.



Photo 28. Revetment 2 STA 5+60 Loss of fine material due to runoff has resulted in the crown failing, slope spreading, loss of rock, voids, and exposed subgrade.



Photo 29. Revetment 2 STA 20+00 Looking west.



Photo 30. Revetment 2 STA 8+00 Approximately 5-in of lost material due to erosion.



Photo 31. Revetment 2 STA 14+66 Up to 13-in of material is lost resulting in undermining of the sidewalk.



Photo 32. Revetment 2 STA 20+00 Missing rock revetment, erosion, and undermined observation deck footing.



Photo 33. Revetment 2 STA 20+00 Undermined observation deck footing up to 2 ft deep.

Revetment 3

Revetment 3 starts south of the Morro Bay Oyster Company and extends 136 ft to the south side of the North T-Pier. Behind the revetment is a paved road and the US Coast Guard Station and Morro Bay Harbor Department Office.

Revetment 3 is in *serious* condition with widespread areas of *moderate* to *major* damage recorded. The revetment generally consisted of some ¼-ton rock (18-24 in diameter), concrete debris, and mostly smaller than ¼-ton rock, with concrete placed over the crown, see Photo 34 and Photo 35. Where the concrete ends, significant voids were recorded, up to 6 ft deep, as depicted in Photo 36 through Photo 38.

Erosion due to runoff was evident at the top as seen in Photo 39 where the curb and AC Paving has been washed away.

Recommendations

Recommendations for this revetment are included in Appendix B. Due to the observed slope, significant voids, migration of rock, and exposed underlayer, the revetment should be rebuilt. Alternatively, a sheet pile wall or tie back wall could be explored as a potential solution for protecting the shoreline in this area. Improvements to surface drainage are necessary to mitigate long-term effects of runoff.



Photo 34. Revetment 3 STA 0+30 Looking north.



Photo 35. Revetment 3 STA 0+70 Revetment consists of concrete debris and concrete placed at the top of the slope.



Photo 36. Revetment 3 STA 0+70 Location of a 6-ft deep void.



Photo 37. Revetment 3 STA 1+36 A 6 ft long area of undermined concrete at +4 ft MLLW.

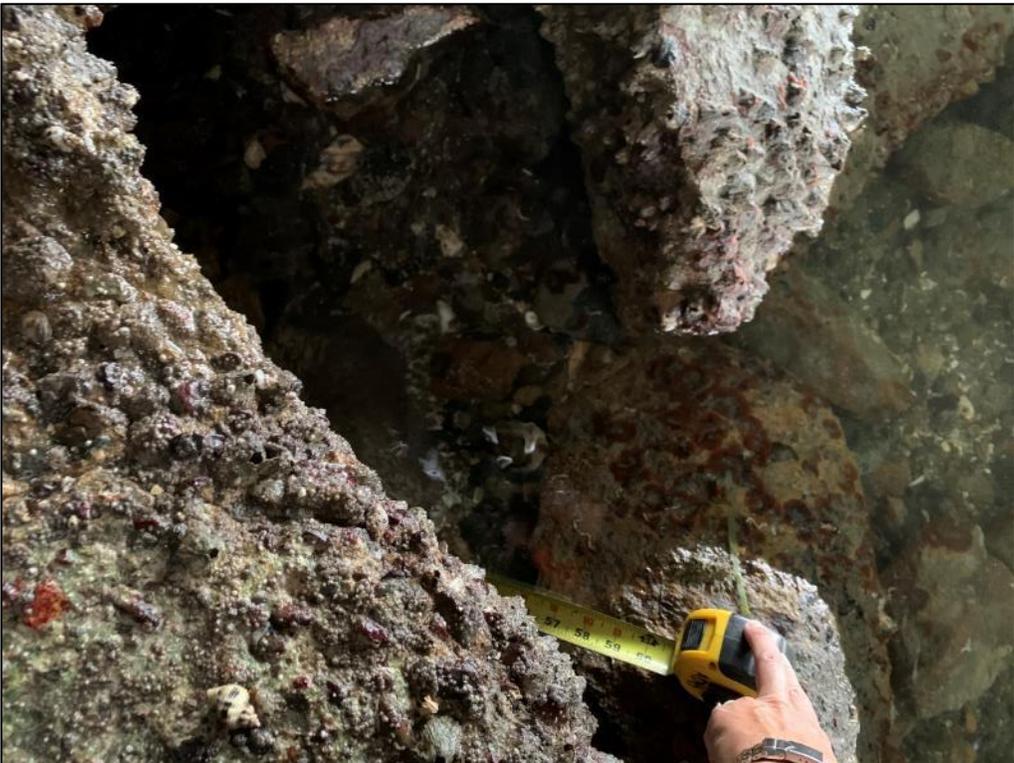


Photo 38. Revetment 3 STA 1+36 A close up showing the void extends 6 ft deep.



Photo 39. Revetment 3 STA 0+00 Missing curb and erosion.

Revetment 4

Revetment 4 begins to the south of the Great American Fish Company, extending 518 ft under the South-T Pier to the northern boundary of DeGarimore’s Marine leasehold. Behind the revetment is a fence and a concrete walkway, paved parking and the Embarcadero.

Revetment 4 is in *satisfactory* condition for this first 80 ft, see the foreground of Photo 40. It appears this section, which is in the vicinity of the South T-Pier, has been rehabilitated with ¼-ton rock at a 2:1 slope. The remaining 438 ft is in *serious* condition with *major* and *moderate* damage noted. This section of revetment consists of some ¼-ton rock and smaller, concrete debris, and concrete placed at the top of the slope in various areas.

Erosion and subsidence at the top of the slope was widespread although not always visible due to the presence of vegetation. In one instance the concrete walkway was observed to be undermined up to 8-in deep where rock was not present at the top and the subgrade of soil and gravel was exposed, see Photo 41.

The top third to half of the slope was typically steeper and rock had migrated down the slope exposing the underlayer of soil and gravel, see Photo 42. This also resulted in voids found below the top third of the slope, for example in Photo 43 where a 4 ft deep void was recorded. Typically all areas where concrete was placed over the top of the slope, voids were recorded under the concrete, for example in Photo 44 and Photo 45, a void 15 ft long by 6 ft deep and 2 ft high was documented. In this condition, the slope is

unstable and failure of the top third of the slope is possible which would likely result in undermining and failure of the sidewalk.

Near Station 3+00 there is a concrete ramp providing access to floating docks. The footing of the ramp is undermined up to 2 ft, see Photo 46.

Widespread portions of the revetment do not appear to be protected by a filter layer and are subject to increase erosion from runoff, current, and waves. There are widespread areas with voids recorded below the added concrete and rock migrating down the slope. Erosion is evident at the top of the slope where subsidence and undermining of the concrete walkway were observed. Erosion is evident below the concrete footing at the ramp access to the floating docks. The revetment protecting the footing is not present in this area.

Recommendations

Reference Appendix B for recommendations at this revetment. In general, the revetment to the north and in front of the concrete ramp access should be refurbished and to the south should be rebuilt to protect the public walkway and ramp access.



Photo 40. Revetment 4 Looking south from the South T-Pier where the rehabilitated section of revetment transitions to a steeper slope with inconsistent rock sizes and concrete debris.



Photo 41. Revetment 4 STA 1+55 Sidewalk footing undermined up to 8-in deep.



Photo 42. Revetment 4 STA 1+22 Sections of concrete debris mixed with 20-in and smaller rock. Missing rocks exposing subgrade, heavy vegetation, and potential undermined of walkway at top.



Photo 43. Revetment 4 STA 2+06 Large rock on the top 3rd of the revetment is undermined by 4 ft.



Photo 44. Revetment 4 STA 5+00 The voids below the added concrete at elevation +8 ft MLLW is greater than 6ft deep.



Photo 45. Revetment 4 STA 5+00 A Void at elevation +8 ft MLLW was up to 2 ft high and extended 15 ft along the revetment.



Photo 46. Revetment 4 STA 2+60 Footing undermined up to 2 ft deep.

Revetment 5

Revetment 5 begins to the south of DeGarimore’s Marine leasehold and extends to the south end of Anchor Memorial Park, covering 223 feet. The revetment protects a paved parking area, the Embarcadero, and a concrete walkway. There is gangway access to floating docks near the north and south ends of the revetment and a public access pier in the middle.

Revetment 5 is in *fair* condition with *minor* to *moderate* damage recorded. The revetment is steeper than desired (1.6:1), consisting of ¼-ton rock with a lot of smaller 12-in rock and concrete debris mixed in. There is a section where concrete was placed on the top of the slope which is perhaps an indication of a larger problem. There are areas of heavy vegetation and loss of rock protection at the top. Large rock has migrated down the slope leaving voids in the middle of the slope exposing the subgrade of soil and gravel, see Photo 47.

At the public access pier, undermining was observed at the abutment and the concrete foundation for the first pier bent, see Photo 48 and Photo 49.

Recommendations

The table in Appendix B recommends that areas with *minor* damage have rock added and areas with *moderate* damage be refurbished. The revetment around the public access pier should be refurbished and at this time the abutment and bent foundation should be repaired.



Photo 47. Revetment 5 STA 1+86 Looking west. Missing armour stone exposes the subgrade.



Photo 48. Revetment 5 STA 1+00 The abutment (blue arrow) and first bent (red arrow) of the public access pier. The bent foundation was undermined however the size of void was not recorded. A previous foundation is seen to the left of the pier where minor undermining was observed.



Photo 49. The pier abutment, shown in Photo 48, is undermined up to 2 ft deep and 1 ft high.

Revetment 6

Revetment 6 is 49 feet long, starting at the south boundary of the Harbor Center, LLC, and ending at the north boundary of the Anderson Inn. There is a timber pile supported public access pier and gangway to a floating dock at this location. Behind the revetment is a paved parking area.

Revetment 6 is in *fair* condition with *minor to moderate* damage noted. The revetment is steeper than desired (1.6:1), consisting of some ¼-ton rock with a lot of 12-in and smaller rock mixed in. The rock protection does not extend to the top of the slope and there is vegetation at the top.

The first pile bent for the public access pier, consisting of three timber piles, holds some of the larger rocks back while smaller rocks migrate down the slope. This results in a steep drop off to the waterside of the piles, see Photo 50. The piles are not designed to resist this loading. Large rock has migrated down the slope leaving voids in the middle of the slope exposing the subgrade of soil and gravel. Photo 51 is taken where rock was missing, there was a 2 ft high void, and the gravel subgrade was exposed.

Recommendations

The table in Appendix B recommends that the revetment be refurbished. This effort will need to be coordinated with repairs to the public access pier. Ideally the revetment should be deconstructed, new piles at Bent 1 driven, the filter layer placed, and the rocks restacked. Improvements to surface drainage are necessary to mitigate long-term effects of runoff.



Photo 50. Revetment 6 STA 0+33 Looking north at Bent 1 of the public access pier and the revetment behind it.



Photo 51. Revetment 6 STA 0+40 Rock and section of slope is missing resulting in a vertical drop and unsupported rock.

Revetment 7

Revetment 7 is located at the intersection of Embarcadero and Front Street, between the old Libertine Pub and Rose’s Bar and Grill and is 56 feet long. There is a timber pile supported public access pier and gangway to a floating dock at this location. Behind the revetment is a railing and a paved parking area.

Revetment 6 is in *poor* condition with *major to moderate* damage noted. The revetment consists of ¼-ton rock with a lot of 12-in and smaller and some larger rock mixed in. The rock protection does not extend to the top of the slope and there is vegetation at the top.

The first pile bent for the public access pier consists of three timber piles and cross bracing. This bent is restraining some of the larger rocks on the uphill side resulting in a steep drop off to the waterside of the piles, see Photo 52. The piles are not designed to resist this loading. Large rock has migrated down the slope leaving voids in the middle of the slope exposing the subgrade of soil and gravel. In some places the top section is left unsupported. In Photo 53 a large void was noted below the drainpipe leaving it unsupported and exposing the gravel sublayer.

On the south end of the revetment there is a public walkway providing access around the waterside of the building. The portion of the walkway extending west is supported by a timber pile placed on top of rock revetment and concrete. This section of the revetment is undermined, see Photo 54.

Recommendations

Reference Appendix B for recommendations. The revetment should be refurbished. This effort will need to be coordinated with repairs to the public access pier and the public access walkway to the south. Ideally the revetment should be deconstructed, new piles at bent 1 driven, the filter layer placed, and the rocks restacked. Improvements to surface drainage are necessary to mitigate long-term effects of runoff.



Photo 52. Revetment 7 STA 0+40 Looking north.



Photo 53. Revetment 7 STA 0+14 Large voids in the middle of the slope leaving upper section of rock and the drain pipe unsupported.



Photo 54. Revetment 7 STA 0+56 Split timber pile supporting deck for Rose's Bar and Grill leashhold site.

Revetment 8

Revetment 8 is located between Dutchman’s Seafood House and extends 68 ft to the Morro Bay Marina, near the intersection of Embarcadero and Pacific Street. At the south end there is a gangway providing access to floating docks. Behind the revetment is a railing and paved parking area.

Revetment 8 is in *poor* condition with *major* to *moderate* damage noted. The revetment consists of ¼-ton rock with some 12-in and smaller and some larger rock mixed in, see Photo 55. There is vegetation at the top and it did not appear that the rock extends to the top of the slope.

The top third of the slope is very steep and large rock has migrated down the slope leaving voids in the middle of the slope. This is evident at the concrete drainage ditch placed over the rock at Station 0+00 where the rock has separated from the concrete resulting in inadequate support and cracks in the concrete. Areas of large voids exposing the subgrade were recorded, see Photo 56 and Photo 57. In this condition, the slope is unstable and failure of the top third of the slope is possible which would likely result in undermining and failure of the sidewalk.

Settlement and cracking in the concrete sidewalk behind the revetment suggest there is loss of fine material through the revetment, see Photo 58.

Recommendations

Reference Appendix B for recommendations at this revetment. The revetment should be refurbished to protect the sidewalk and gangway abutment. Improvements to surface drainage are necessary to mitigate long-term effects of runoff.



Photo 55. Revetment 8 STA 0+00 Looking west.



Photo 56. Revetment 8 STA 0+53 Subgrade soil and gravel exposed.



Photo 57. Revetment 8 STA 0+63 Rock missing and migrating down the slope. A 12-in unsupported drain pipe, erosion, and loss of material is shown.



Photo 58. Revetment 8 STA 0+54 Crack (red circle) and settlement of the concrete sidewalk indicates potential settlement.

Revetment 9

Revetment 9 is located between the Morro Bay Marina and extends 93 ft to the Three Stacks and a Rock Brewing Company, near the intersection of Embarcadero and Marina Street. There is a timber pile supported public access pier extending from the middle of the revetment, see Photo 59. Behind the revetment is a paved parking area and concrete sidewalk.

Revetment 9 is in *critical* condition with *major to moderate* damage recorded. The revetment is steeper than desired (1.5:1), consisting of 4-ton rock to ¼-ton rock and smaller 12-in rock on the northern portion. To the south of the pier, the revetment transitions to a wall consisting of miscellaneous pieces of concrete and timber debris, and cast-in-place concrete which is piled above the revetment. The makeshift wall supports the sidewalk and parking area behind the revetment.

On the north side of the revetment, rocks are migrating down the slope and there is loss of rock protection on top exposing the soil subgrade, see Photo 60. A concrete drainage ditch is placed over the rocks, the ditch is undermined and there is a steep drop off at the end of the ditch where rock protection is missing. In this condition, the slope is unstable and failure of the top third of the slope is possible which would likely result in undermining and failure of the sidewalk. At the pier's abutment, there is evidence of erosion and the foundation is beginning to be undermined.

To the south of the pier, the slope is very steep and large rock is not present at the top, see Photo 61. The makeshift wall is undermined up to 3.5 ft deep and up to 2 ft high in one area (Photo 62) and 20-in deep

by 16-in high along the remainder of the wall. On the bottom half below the wall, there is rock protection missing and erosion is evident. To the south of the makeshift wall placed at the top of the slope of the revetment 9, the shore protection transitions to the leasehold which consists of mostly 1-ft and smaller rock placed with concrete, Photo 63. This section is unstable and at risk of failure which will result in undermining and failure of the sidewalk and parking area behind it.

Recommendations

Reference Appendix B for recommendations at this revetment. The portion of the revetment to the north of the pier can be refurbished while the portion to the south of the pier should be rebuilt. Repairs will have to be coordinated with the leasehold to the south. Improvements to surface drainage are necessary to mitigate long-term effects of runoff.



Photo 59. Revetment 9 Looking east.



Photo 60. Revetment 9 STA 0+00 Looking south.



Photo 61. Revetment 9 STA 0+60 Looking east at makeshift concrete wall.



Photo 62. Revetment 9 STA 0+60 Makeshift concrete wall undermined by 3.5 ft.



Photo 63. Revetment 9 STA 0+60 Erosion and loss of material below the wall. To the south, the leasehold wall consists of rocks stacked with concrete on a very steep slope.

Revetment 10

Revetment 10 is located between 551 Embarcadero and the Morro Bay Yacht Club and is 81 ft long. Behind the revetment is a paved parking area and concrete sidewalk with a railing.

Revetment 10 is in *serious* condition with *major* damage recorded. The revetment is steeper than desired (1.6:1) and consists of mostly ¼-ton rock with larger 4-ton rock migrating down the slope. There is one area where there is concrete placed on top.

Settlement is observed at the sidewalk and the sidewalk and railing appear to be rotated towards the water, see Photo 64. The top of the slope is covered by heavy vegetation (ice plant seen in Photo 65) and erosion of fine material is evident at the top of the slope. It does not appear that the rock extends to the top of the slope under the ice plant.

Loss of rock and significant voids were observed at the middle section of slope. Voids and loss of rock protection were also observed on the bottom half of slope. Sections of rock are missing exposing the soil subgrade and leaving the slope unprotected, see Photo 66.

Where the revetment transitions to the leasehold to the south there are sections of concrete that are undermined and rock is migrating down the slope.

Recommendations

Reference Appendix B for recommendations at this revetment. Revetment 10 should be rebuilt. Construction will need to be coordinated with the surrounding leaseholds.

In the meantime, the ice plant should be removed since it has shallow roots, which are not effective in stabilizing steep or deep slopes. Since it appears the top of the slope is missing its rock protection, the ice plant could contribute to erosion by sliding down the slope and taking large portions of soil with it. Improvements to surface drainage are necessary to mitigate long-term effects of runoff.



Photo 64. Revetment 10 STA 0+00 Looking south.



Photo 65. Revetment 10 STA 0+00 Covered by vegetation.



Photo 66. Revetment 10 STA 0+50 Missing revetment and large voids.



Photo 67. Revetment 10 STA 0+81 Looking at the leasehold to the south where the concrete placed over the revetment has cracked due to loss of rock support.

Revetment 11

Revetment 11 begins south of the Estero Inn and continues 51 ft to the north of Associated Pacific Constructors Inc. There is a timber pile supported public access pier, gangway, and floating dock. Behind the revetment is a concrete sidewalk and public park area.

Revetment 11 is in *poor* condition with *major* to *moderate* damage recorded. The revetment consists of ¼-ton rock with miscellaneous concrete debris mixed in, see Photo 68. Rock is not visible at the top of the slope with heavy vegetation and exposed soil. A section of steep slope was recorded near the top and rock is migrating down the slope. Sections of concrete are placed over the rock. Concrete sections and large rocks are migrating down the slope, see Photo 69.

Recommendations

Reference Appendix B for recommendations at this revetment. Revetment 11 should be refurbished. Construction will need to be coordinated with the surrounding leaseholds. Improvements to surface drainage are necessary to mitigate long-term effects of runoff.



Photo 68. Revetment 11 STA 0+00 Looking east between the northern leasehold and the public access gangway. Miscellaneous sections of concrete are seen.



Photo 69. Revetment 11 STA 0+35 Looking west between the public access pier and the south leasehold. The top of slope is not protected, large rocks and concrete are sliding down the slope and voids are noted.

Revetment 12

Revetment 12 starts adjacent to the property on 471 Embarcadero and extends 1,810 ft to the end of the public launch ramp parking lot south of Tidelands Park. The revetment protects the Embarcadero paved road on the north section, tidelands park and a concrete sidewalk in the middle section, and a viewing platform and paved parking area on the south section.

Revetment 12 is in *fair* condition with *minor* to *major* damage recorded. The revetment consists of ¼-ton rock and some 4-ton rock.

The first 600 ft does not have rock protection extending to the top of the slope, exposed soil and erosion was evident, and undermining was observed at the tree (Photo 70 at Station 2+00) and of the concrete sidewalk (Photo 71).

Around Station 6+40 there is a concrete ramp and stairs providing access to floating docks. There is loss of rock protection in front of the concrete structure and the soil and gravel subgrade is exposed, see Photo 72. The concrete footing for this structure was undermined up to 12-in deep, see Photo 73.

At Station 8+00 rock does not appear to be present at the top of the slope, is covered by heavy vegetation, and erosion from runoff is evident. Loss of material has resulted in the sidewalk being undermined and the foundation for the light exposed, see Photo 74. Where vegetation ends on the slope (around +11 ft MLLW), the slope steepens dramatically (from +11 to +7 ft MLLW). Between Station 8+00 to Station 14+00,

the slope is very steep, with the steepest section at Station 11+00 where 1.1:1 was the calculated average. There was heavy vegetation in this area obstructing the inspection however an area of near vertical slope was observed in Photo 75. In this condition, the slope is unstable and failure of the top third of the slope is possible.

Between Station 13+00 and 14+00 there is a timber pile supported viewing platform. To the north of this structure, erosion is evident as the sidewalk is undermined, see Photo 76. To the south of the structure there is a 20 ft long undermined section of concrete sidewalk, see Photo 77. Erosion is seen below the pile support platform where the footing is exposed in Photo 78.

To the north of the boat ramp erosion from runoff was observed where the AC paving had failed, see Photo 79. To the south of the boat ramp there is a timber brow providing access to a gangway and floating docks. Below the concrete abutment, loss of rock and undermining is observed (Photo 80) leaving the abutment not adequately supported.

Recommendations

Reference Appendix B for recommendations at this revetment. The revetment should be refurbished.

There are several areas where undermining and erosion is observed, suggesting the rock slope is not adequately retaining the soil behind the revetment. Erosion from runoff and tidal activity will continue to erode these areas. Where the top third of the slope is steeper than 1.5:1, the slope is unstable, and failure could occur. Improvements to surface drainage are necessary to mitigate long-term effects of runoff.



Photo 70. Revetment 12 STA 2+00 Erosion and Undermining below the tree.



Photo 71. Revetment 12 STA 4+25 Undermined concrete sidewalk, cracked concrete, and evidence of erosion.



Photo 72. Revetment 12 STA 6+38 Erosion of fine material.



Photo 73. Revetment 12 STA 6+38 A close up of the concrete ramp seen in Photo 72 undermined 1 ft deep.



Photo 74. Revetment 12 STA 8+00 Concrete sidewalk undermined 4-in deep.



Photo 75. Revetment 12 STA 11+00 Erosion, undermining, and loss of large rock material resulting in a very steep section at the top of the slope.



Photo 76. Revetment 12 STA 13+40 Erosion in front of the concrete sidewalk results in a 3-in high void.



Photo 77. Revetment 12 STA 14+00 A 20 ft long section of sidewalk is undermined.



Photo 78. Revetment 12 STA 14+00 The footing for public access platform is exposed.



Photo 79. Revetment 12 STA 16+00 Erosion and failed AC paving.



Photo 80. Revetment 12 STA 17+40 Brow abutment inadequately supported, migration of rock material down slope.

4. GEOPHYSICAL AND GEOTECHNICAL ASSESSMENT

GeoVision performed a geophysical investigation using the Ground Penetrating Radar (GPR) method to identify subsurface voids at Seawall 1 and Revetments 3 and 5 through 12. Revetment 1 was not included in the survey because of the location of the revetment and lack of improvements at the top of the slope and Revetments 2 and 4 were not included because the existing Harbor Walk boardwalk would not allow subsurface measurements by the GPR equipment. The full GeoVision study is included as Appendix E.

Geotechnical Review

ENGEO reviewed the GeoVision report and data provided by BRADY and provided the following conclusions and recommendations.

- The City indicated it is unaware of any documentation regarding the construction of the revetment and seawalls and thus ENGEO was limited to the data collected by BRADY, eTrac, and GeoVision.
- ENGEO generally understands that Morro Bay was improved to support the World War II effort by the United States military. Rock for the revetment was generally harvested from Morro Rock. Historical aerial photographs show the portion of Revetment 2 between the beach and Morro Rock being constructed in the 1930s prior to the other revetment and seawalls.
- According to geologic mapping by Wigers (2021), Revetments 1 through 4 are in mapped areas of eolian deposits and young alluvial valley deposits. Revetments 5 through 12 are in mapped areas of old eolian deposits and artificial fill adjacent to the bay. ENGEO anticipates the young alluvial valley deposits and artificial fill to consist of sand like the eolian deposits.
- Since there is a lack of documentation on how the revetments were constructed, ENGEO recommends a minimum of three sections be deconstructed to observe the cross-section of the revetment and underlying subgrade. This work will help better understand the existing condition of the revetments and provide suitable recommendations for maintenance, rehabilitation, and repair. ENGEO recommends exploring both Revetments 2 and 12 and performing the third exploration within Revetments 5 through 10.
- According to guidelines by the United States Army Corps of Engineers Shore Protection Manual, stone for Revetment 1 should consist of 4-ton riprap (4.5-ft diameter) due to being in the surf zone and stone within the harbor for Revetments 2 through 12 should consist of ¼-ton riprap (1.8-foot-diameter) due to tidal flow and proximately to pedestrians. The riprap should extend to the top of the slope to account for future sea level rise.
- As shown by eTrac (Appendix C), many sections of revetment are inclined steeper than a 2:1 (horizontal:vertical). Riprap may be placed as steep as 1½:1 with proper benching and special care during rock placement; however, it is generally recommended that riprap be placed at 2:1 or flatter.
- The geophysical survey by GeoVision was generally performed within 20 ft of the top of the slope at Revetments 3 and 5 through 12 and Seawall 1. The maximum depth of the survey was about 7

to 10 feet except for the area near the boat ramp of Revetment 12 where the maximum depth was about 1½ feet. GeoVision identified several high-amplitude anomalies at each seawall and revetment location surveyed; however, they concluded that the “depth below the ground surface of these anomalies is between 0.5 and 3 ft below the ground surface and their vertical extent is probably less than 6-in. A high amplitude anomaly is generated when the electromagnetic signal transitions from soil to air. A subsurface exploration at various locations was conducted based on anomalies identified during the GPR investigation.

- The conclusions from the pothole exploration were as follows:
 - Significant voids below the concrete or asphalt pavement were not observed which generally confirms the conclusions by GeoVision.
 - The tilted railing and observed movement in the sidewalk at Revetment 10 may be caused by slope movement due to the very loose sand and loss of revetment which provides bracing of the slope.

Summary Conclusions & Recommendations

Based on the data provided by BRADY, ENGEO concluded that the existing condition of the revetment locations and seawalls range from minor maintenance to complete failure. General conceptual geotechnical recommendations are summarized in the following sections for each revetment location and seawall. Recommendations for each 100-foot station are provided at the start and end of each revetment location and seawall. Stationing is shown in the survey and report by eTrac (Appendix C). BRADY also provided photographs and field notes for notable features between 100-ft stations.

- Common recommendations include controlling surface drainage, revetment refurbishment, and slope and revetment reconstruction. **Controlling surface drainage may include grading ditches or berms; drains; concrete, metal, or plastic structures; or other methods designed by a civil engineer.** Additional riprap should be imported to provide the minimum section thicknesses. Rebuilding of the slope and revetment includes excavating a larger keyway and rebuilding the slope face with engineered fill. Rebuilding is generally recommended where instability of the slope was observed.
- For the design of new seawalls or refurbishment or rebuilding of revetment locations, additional exploration such as borings and/or test pits should be performed.

Given the above studies and recommendations, BRADY concludes and recommends that additional geotechnical studies be planned and conducted. The geotechnical studies should be driven by the design decisions for the improvements that are contemplated after review of this report.

5. CONCEPTUAL RECOMMENDATIONS

Data collected from the field combined with our experience from similar assessments were used to present the overall repair or replacement recommendations provided below. Recommendations are prioritized considering severity of the damage. Recommendations are associated with the following repair prioritizations:

1. Priority Repairs – Structure should be repaired or replaced immediately/within one year. Or further investigation is needed.
2. Short-term Repairs – Structure should be repaired or replaced within 2 to 4 years.
3. Mid-term Repairs – Structure should be repaired or replaced within 5 to 7 years.
4. Long-term Repairs – Structure should be repaired or replaced within 8 to 10 years.

General Recommendations

Reference Appendix B for site specific recommendations. Appendix B contains a Summary Table which displays the Repair Priority and Condition organized by Seawall and Revetment. The second table, Seawall and Revetment Inspection Record and Recommendations shows the field observations, damage rating, and Conceptual Recommendation organized by revetment and Station. A summary by structure type is provided in this section along with design considerations.

Structure	Conceptual Recommendations	Condition	Priority
Seawall 1	Further investigation of seawall and wharf. Refurbish revetment in front of seawall.	Fair	Short
Seawall 2	Replace in-kind or build revetment	Critical	Mid
Seawall 3	Replace in-kind or build revetment	Critical	Mid
Revetment 1	Add Rock and Refurbish	Fair	Long
Revetment 2	Add Rock, Refurbish, Rebuild	Poor	Mid
Revetment 3	Rebuild	Serious	Short
Revetment 4	Refurbish and Rebuild	Serious	Short
Revetment 5	Add Rock and Refurbish	Fair	Long
Revetment 6	Refurbish	Fair	Long
Revetment 7	Refurbish	Poor	Mid
Revetment 8	Refurbish	Poor	Mid
Revetment 9	Refurbish and Rebuild	Critical	Priority
Revetment 10	Rebuild	Serious	Short
Revetment 11	Refurbish	Poor	Mid
Revetment 12	Add Rock and Refurbish	Fair	Long

Further Discussion

Seawalls

- Further investigation is recommended at Seawall 1 to determine the condition of the seawall which was not visible during the visual and tactile inspection. The wharf along the seawall is not an independent structure and relies on the seawall for vertical support. This structure was not part of this inspection and was seen to have critical defects. A future investigation should be performed on a priority basis. It is strongly recommended that a long-term solution be considered that would be in line with the life expectancy of the current surrounding developments, which would likely be to replace the wall entirely.
- Seawalls 2 and 3 are beyond repair and should be replaced. These walls could be replaced in-kind or a rock revetment could be constructed instead.

Revetments

- Further investigation is recommended to determine the construction of the riprap and the extent of recommended repairs. During the recommended study, an area of the riprap could be excavated to determine its construction. Three sections should be deconstructed to observe the cross-section of the revetment and underlying subgrade. An underwater inspection may be warranted at this time. This will help guide recommendations for maintenance, rehabilitation, and repair.
- Until repairs can be implemented, the revetments should be monitored by routinely checking the slope and the elevation of the crown, particularly in areas where elongation and instability of the slope were recorded.
- Surface runoff should be controlled behind the revetment to reduce the erosion occurring at the top of the slope. Engineered drainage solutions and Best Management Practices (BMPs) should be included when the revetments are repaired to mitigate future erosion and potential destabilization of the riprap. Until permanent repairs can be implemented, routine maintenance is recommended to keep existing drain piles and v-ditches clear and to remove problematic vegetation.
- Recommendations include adding rock, refurbishing, and rebuilding the revetments.
 - Add Rock: This can be an economical solution if it is limited to isolated areas where armor stone is missing, the filter layer is intact, the slope is stable, and the toe is constructed properly. Rock can also be added at the top of the slope where these design parameters are met. The toe and the filter layer would need to be investigated during the recommended further investigation to deconstruct and inspect the revetment to verify its suitability for adding more rock.
 - If widespread armor layer damage occurs that causes large sections of armor to be displaced or to slump, it may be feasible to repair the structure by adding an overlay consisting of similar or dissimilar units.

- If the revetment was not originally constructed properly, adding rock is not a viable or economical solution.
- **Refurbish:** Consists of stockpiling the existing rock, excavation of a keyway for replacement of the rock, smoothing the existing subgrade to a desired slope, placement of filter fabric, placement of protective layer consisting of quarry fines, then placement of the riprap carefully seating each stone. Import additional riprap to meet desired slope and minimum section thickness.
 - This solution is viable in places where the slope is stable, it is not too steep, and there has not been significant erosion or voids behind the revetment.
- **Rebuild:** Similar to refurbishing, however, includes excavating a larger keyway and rebuilding the slope face with engineered fill.
 - Rebuilding is recommended where slope instability was observed.
- Address undermined abutments, ramp and access stair foundations. These structures will need further evaluation to determine if they need to be replaced or can be repaired during repairs to the revetments. If repairs to the revetment are not scheduled for the short term, these areas should be temporarily addressed. If these areas are not addressed the public walkway and concrete access ramp could be at risk.

Design Considerations

Filter Layer. For the riprap to function properly the two principal requirements for a satisfactory filter are that it must be more pervious than the protected soil so that it can drain, and that it must be fine enough to prevent particles of the protected soil from washing into its voids. Modern construction requirements would incorporate the use of a filter fabric. However, in the 1940s when the riprap was presumed to have been constructed, synthetic filter fabric did not exist. Instead, a properly designed filter would have been layers of varying gradations of rock or gravel and sand. If constructed properly, the filter layer would have performed well in a protected harbor for many years. If a properly graded filter layer was installed, and is found during further investigation, this will help justify areas where only adding rock is recommended.

For areas to be refurbished or rebuilt, a filter cloth geotextile or composite geotextile/geogrid between the rocks and the underlying soil is recommended. A geotextile that provides rapid transfer of water through the material while holding soil particles and is strong enough to survive the construction process without puncturing by the overlying rocks is recommended. The modern use of a plastic grid integrally welded to the geotextile can provide some additional strength to bridge soft underlying soils. The geotextile should be designed to not allow the rocks to slide down the surface. The use of an underlayer of stones between the armor layer and the geotextile/grid, as shown in ENGEO Figure 1 of Appendix D, is common.

Crest Detail. The rock protection was constructed after the slopes and in most cases, did not extend to the top of the slope. The rock protection should be detailed to extend to the top of the slope. If further investigation confirms the presence of a filter layer and toe keyway, rock can be added to the top of the

slope. In some cases, adding rock is not a viable solution and the revetment will need to be refurbished or rebuilt in order to extend the rock protection to the top of the slope.

Slope. A typical riprap slope in a protected marina can be designed at an inclination of 1.5:1 provided it is constructed properly and each rock is carefully seated, however this is not good practice for modern design and an inclination of 2:1 is preferred. Revetment structure slopes greater than 1½:1 (horizontal:vertical) are not recommended (USACE 1984). There are several areas that were surveyed with a slope steeper than 2:1. In many cases, it could be observed that the rock layer was not constructed properly and contained various debris, rock smaller than ¼-ton, and other anomalies. Therefore, it can be assumed that these sections were not constructed properly, and all repairs should be detailed with a slope of 2:1 maximum inclination.

Rock Size. Within a protected bay such as Morro Bay, which has a limited wind fetch and hence, a maximum wave height can be predicted, the required minimum stone size according to the USACE Shore Protection Manual would be less than ¼-ton. However, within most harbor districts, a minimum rock size of ¼-ton is specified to ensure stability of the rock to prevent its movement and possible injury to the public. At Revetment 1, where the structure faces the ocean, 4-ton rock is recommended by USACE.

Wave and Geotechnical Analysis. The design of structural features such as armor stone, underlayers, toe, slope and other features depend on design wave conditions, consequences of the waves exceeding design values, and the availability of construction equipment and materials. A geotechnical report is required to describe the soil conditions over which the structure will be placed. Including borings, seismic profiling, and materials identification. This would be used to design the structure foundation, toe and slope as well as the interior of the structure.

Sea Level Rise. Design would need to consider Sea Level Rise. Considering Sea Level Rise for the riprap will present challenges for some of the adjacent roadways which are projected to be below water in a 50-year life scenario.

6. LONG-TERM IMPROVEMENT PLAN

The useful life of similar facilities is directly attributable to the maintenance and upkeep spent on the facility during its operational life. In the case of the Morro Bay Seawalls and Revetments, it does not appear that significant maintenance or repairs have been made or done since construction.

The common definition of service life used in reference to an engineering structure - "Service life – the length of time during which a structure, or facility, can be used economically before emergent damage causes increasing interruptions in facility operations or becomes a threat to public health and safety." In this context, the seawalls and revetments have exceeded their service life. Minor maintenance and repair activities have improved some isolated areas in working order, however additional significant capital improvements are now perhaps overdue.

If the recommended overall plan is not developed, the areas identified will likely require a greater effort and replacement of widespread portions at a greater cost. In the absence of such planning, the default position is to continue using temporary repairs, until such time as an inevitable event forces a decision for substantial repair or replacement.

Plan Considerations

The following considerations should be included in the plan.

Capital Improvement Budget. Long term planning should be part of the routine City budgeting process and include development of a capital budget for improvements, and operations budgets for operations and maintenance.

A general cost estimate for restoring or replacing the seawalls and revetments will be included with the final report. However, the recommendations made in this report are conceptual and need to be supported by further investigations. Once further investigation is performed, a more detailed cost estimate could be developed which can also consider the availability of funding.

Financial Analysis. A financial analysis could be developed in the plan to explore options for funding. The analysis could consider additional revenue sources, such as charging for parking, explore existing revenue sources to determine if there are options for improvement, and grant funding opportunities.

City and Harbor Organization. The long-term plan must take into account the organization of the City, which currently the Harbor Department is responsible for the waterfront leaseholds and the City is responsible for public waterfront access. This organization should be recognized during the development of the plan.

Leaseholders. The long-term plan should consider the leaseholders and their responsibility to maintain their waterfront improvements. Coordination with leaseholders will need to be considered when planning and prioritizing repairs. A combination of field survey and records research will be required to properly show what is the City's versus the leaseholder's responsibility.

Current and Future Uses. There are several potential opportunities for enhancing the City's ability to encourage future projects. For example, the harbor is the only protected harbor with USCG facilities from San Francisco to Santa Barbara and the only large, protected harbor from San Francisco to Long Beach.

The USACE maintains the channel entrance and breakwaters. Since the USACE routinely maintains the channel entrance, there is an opportunity to perform repair work with their routine work. This could save on mobilization and demobilization and could use a similar approval process for compliance and permitting.

Coastal Commission Input and Review. The long-term plan will need to have input from the CCC so replacement and repair options can be selected and deemed to be acceptable with the Coastal Act.

Local Coastal Plan (LCP). The requirements contained in the City's current available Local Coastal Plan (May 2021) should be considered during development of any long-term plans. The LCP recommends a Shoreline Management Plan be prepared for approval by the CCC as an amendment to the LCP. This plan is intended to help implement coastal protections, maximize public access, and protect coastal resources along the City's shoreline. The plan is to be coordinated with relevant local, regional, and/or state agencies for the purpose of protecting coastal resources and infrastructure. If the LCP is currently being developed, this could support the Long-Term Improvement Plan.

7. COMPLIANCE, PERMITTING & ENVIRONMENTAL DISCUSSION

Future work will need to follow several requirements from various jurisdictions, including the Coastal Act (California Coastal Commission), California Environmental Quality Act (CEQA), US Army Corps of Engineers (USACE) and others. It is not in the scope of this study to perform a complete analysis or plan for compliance with these regulations, however a brief summary is given in this section.

California Coastal Act

1. Permit
2. Schedule

CEQA

1. Biological Resources Assessment
2. Cultural Resources Assessment
3. Hydroacoustic Biological Assessment
4. City of Morro Bay Categorical Exemption or Initial Study / Mitigated Negative Declaration

Federal

1. USACE Department of the Army Permit (Clean Water Act and Rivers & Harbors Act)
2. Endangered Species Act
3. Marine Mammal Protection Act
4. Magnuson-Stevens Fishery Conservation and Management Act consultations (between USACE and National Marine Fisheries Service) National Historic Preservation Act (between USACE and State Historic Preservation Officer)
5. US Dept of Fish and Game

California State

- RWQCB Water Quality Certification (Clean Water Act)
- Local Basin Plan
- California State Dept of Fish and Wildlife (CDFW)

Local/County

- Local MS4
- Local Land Use

For the purposes of this report, it is assumed that permit requirements would be the same for any Southern California waterfront project, with the project limits extending into the State of California's jurisdiction. The State Lands Commission (SLC) is responsible for the state's sovereign tidelands, i.e., those extending below the Mean High Tide Line (MHTL), which is also the jurisdictional boundary for the CCC. Projects that extend below the MHTL also require permits from the U.S. Army Corps of Engineers (USACE),

likely a Nationwide Permit, along with a Clean Water Act Section 401 Water Quality Certification to be provided by the local Regional Water Quality Control Board.

It is not clear at this time which Nationwide Permit the USACE would utilize. It is anticipated it would be a Nationwide Permit 3, which authorizes maintenance of any authorized structure or fill.

Eelgrass beds are known to be present within Morro Bay, which is a federally protected resource and will likely result in the requirement of both pre-construction and post-construction eelgrass surveys. Eelgrass monitoring will likely be performed as required by the USACE through consultation with NOAA Fisheries during permitting. NOAA Fisheries will require adherence to the California Eelgrass Mitigation Policy (CEMP), which includes pre- and post-construction eelgrass monitoring for projects where work occurs over or adjacent to eelgrass resources. It is also possible for the City of Morro Bay to require adherence to the CEMP as a condition for a right-of-entry permit to complete the construction.

The project will require a Coastal Development Permit and possibly an SLC Protective Structure Lease. However, the CCC will require that the SLC weigh in on whether the SLC asserts jurisdiction and what will be required by the SLC, along with any special condition requirements from the CCC.

The USACE will also issue a permit, basically addressing federal compliance requirements.

8. COST ESTIMATES

Included in Appendix F: Cost Estimate, is a very rough order of magnitude cost estimate broken down by revetment and seawalls, based on the conceptual recommendations provided in this report. The cost estimates are based on current prices and escalation is not included. Estimates are developed using costs based on direct experience and knowledge, recent bid history of similar items and projects, vendor or contractor quotes, and other historical cost information.

Included for each structure is estimated costs for engineering, environmental compliance and permitting, geotechnical engineering, engineering support during construction, construction management, and contractors' overhead and profit. The estimated range of probable project cost (-30% to +50%) is between \$25.5 million and \$54.6 million.

Seawall versus Revetment. Also included are alternatives for Seawall 2 and 3 to be replaced with a revetment instead of reconstructing a seawall. These alternatives were not explored for permitting and CCC and therefore may not be a viable option.

For Seawall 1, as noted in the general recommendations section of this report, further investigation is recommended. The approximate cost for further investigation is included in the estimate to help determine the condition of the seawall, which was not exposed during the visual and tactile inspection. Further investigation should include excavation behind the wall to observe the wall and tie back system and an underwater inspection of the wharf structure in front of the wall.

Seawall 2 is assumed to be replaced with a cast-in-place concrete retaining wall, similar to the existing. If it is found that the geotechnical exploration and conclusions do not support this type of construction, a sheet pile wall may be required and would likely result in higher costs.

Geotechnical Study. Further exploration is recommended to determine the existing construction of the riprap and the extent of recommended repairs. The estimated cost of this recommended study is included in the cost estimate. The exploration would include excavating an area of the riprap at three locations along the bay to observe the cross-section of the revetments and underlying subgrade and help determining the original construction. The study is important to support the conceptual recommendations made for maintenance, rehabilitation, and repair.

At this time, the cost estimates include different lengths of revetment to receive new rock, be refurbished, or be entirely rebuilt. The construction alternative of simple retrieving dislodged stones and placing additional rock will be considerably less cost than rebuilding or refurbishing.

To begin repairs for refurbishing and rebuilding, it is necessary to remove the armor stone and temporarily stockpile the material. Grading the slope to suit design parameters also presents challenges. Embedding and securing a new armor slope toe can be more difficult and not as secure as new construction. In this instance, rebuilding is recommended. In this report, assumptions have been made based on visual observations where rock can simply be added, however this has not been verified by the geotechnical study. If larger sections of the revetment will require refurbishing or rebuilding than simply adding rock, the estimated cost will increase.

Environmental Compliance. Methods of construction may be dictated by environmental and social impacts, which could greatly affect the total cost of the project. For example, the stockpiling of rock may be restricted, the ability to transport material by road may be prohibited or it may be critical to prevent losses of fines into the air or water during placement of quarried rock. An environmental study and beginning the process of environmental compliance with regulatory agencies is critical step in the planning process and should be considered a priority.

Phasing. Considering the limited funding available, the cost estimates include engineering, environmental and permitting, mobilization, and demobilization for each revetment and seawall such that, as funding becomes available, priority revetments can be repaired first. Considerable savings could be realized if revetment repairs were all completed within the same project. Alternatively, as funding becomes available, revetments could be grouped together to implement priority and short-term repairs, then mid- and long-term repairs.

Estimated costs do not include the replacement of the timber piles for the public access piers, which should be planned to occur at the same time as revetment repairs. It is imperative that future repairs are coordinated cohesively for the proper use of funds. Development and implementation of a long-term plan for improvement and maintenance will reduce even greater repair efforts and replacement of widespread portions of the structure(s), which will be at a much larger cost in the future.

Sourcing Materials and Access. To the extent possible, existing materials should be reused, and new materials sourced locally. The estimates assume that rock will be stockpiled and reused where refurbishing and rebuilding is recommended. The price of rock is based on current prices from a quarry in Cambria, including delivery to the site.

BRADY explored the option of sourcing the material from a quarry in Catalina, shipping it with a tugboat and barge, and placing it with a crane mounted barge. The shipping of rock from Catalina and placement was comparable in price to sourcing it from Cambria and working from land if several revetments could

be repaired concurrently. There is a much higher mobilization cost resulting from working from the barge but can be spread over multiple revetments if done in parallel.

Construction from a barge can take twice as long as construction from the landside; however, there are limitations regarding access for both options. Working from shore requires ample working space and protecting existing shoreside structures from construction equipment and activities. Working from the waterside would require suitable depth for the barge and tugboat to access the revetment with the crane. Generally, construction would be more impacted by tides and weather conditions. At this time, it was assumed construction would be from shore, and rock would be shipped by truck from Cambria. Once the bathymetry is confirmed, the advantages and disadvantages of working from shore or the water can be weighed out.