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TECHNICAL MEMORANDUM (DRAFT)

To: Jennifer Blackman, General Manager
Bolinas Community Public Utility District
P.O. Box 390
Bolinas, California 94924

From: William Millhone, PE
Drew Kennedy, PG, CEG

Date: August 15, 2023

Re: **Coastal Bluff Evaluation and Alternatives Analysis – Update**
Surfer's Overlook on Terrace Avenue
Bolinas, California
Gannett Fleming Project No. 075063

In accordance with the agreement between Gannett Fleming, Inc. and Bolinas Community Public Utility District (BCPUD), dated April 6, we are pleased to submit this technical memorandum that serves as a supplemental update to the Coastal Bluff Evaluation and Alternatives Analysis for Surfer's Overlook on Terrace Avenue (Ref. 1), submitted to BCPUD in August 2011. This update is intended to be read in conjunction with the 2011 report and includes figures and photos from the 2011 report by reference. We present herein a brief site description and summary of the original report's findings; a summary our observations during a site visit in April 2023; and a discussion of implications/changes in regards to the original conclusions and recommendations as they relate to the existing beach-level bluff protection wall (sea wall) and apparent stability of the coastal bluff at Surfer's Overlook.

The 2011 report was prepared by Sanders & Associates Geostructural Engineering, Inc. (SAGE), who rebranded as SAGE Engineers, Inc. in May 2013, and then was acquired by Gannett Fleming in March 2019. The authors of the 2011 report are the same authors of this technical memorandum.

SITE DESCRIPTION & BACKGROUND

Surfer's Overlook comprises an approximately 200-foot length of coastal bluff, up to 60 feet in height. Terrace Avenue traverses the top of the bluff on the western part of the site, with the outboard edge of roadway supported by an anchored, steel pile-and-lagging retaining wall. The base of the bluff is partly buttressed by an approximately 135-foot-long, timber pile-and-lagging seawall, which closely abuts a concrete sea wall/platform to the west and generally follows the natural beach embayment to the east before terminating near the property line between Parcels 193-142-11 and 193-142-10.

The approximately 65 feet of bluff between the east end of the sea wall and the residence at 100 Brighton Avenue is currently unprotected, with no buttresses or structures immediately in front of the bluff face. A timber bulkhead and groins had existed in this area at one time, but the bulkhead failed in the early 1980s, leading to the loss of a residence behind it (locally known as the Frenetta residence) in the early 1990s. Remnants of the groins, comprising deteriorating driven timber piles and lagging locally project above the beach by two to three feet.

The conditions at the site, and past stabilization/remediation efforts have been documented and photographed in varying detail since the late 1800s. A moderately detailed history of the documented site conditions, modifications, and improvements may be found in the 2011 report. We offer an abbreviated summary of that history below:

- 1890s: Photos show timber pile-and-lagging bulkheads present along the toe of the bluff in the area of Surfer's Overlook and adjacent portions of Brighton Beach. These bulkheads were reportedly severely damaged during the winter of 1912-1913, but were subsequently repaired and maintained until the 1930s.

- 1942-43: The timber bulkheads at the toe of the bluff were again severely damaged, and one residence was partially undermined, eventually requiring demolition. This loss of protection precipitated increased erosion and retreat of the bluff face for several years thereafter, approaching within an estimated 16 feet or so of Terrace Avenue, and prompting the installation of three timber pile and lagging retaining walls along the outboard edge of Terrace Avenue.

- 1947: A concrete groin was installed near the mouth of Bolinas Lagoon, which helped restore/retain sand at Brighton Beach well into the 1960s. Prior to 1967 a timber bulkhead was constructed at the beach level in front of the Frenetta residence, offset from the bluff toe. Two timber groins (the remnants of which are mentioned above) were also installed at the beach level.

- 1967: Marin County installed the current timber pile and lagging sea wall, offset approximately 6 feet from the toe of the bluff, extending from the concrete platform on the west end, to the timber bulkhead protecting the Frenetta residence on the east end. The timber sea wall was constructed with an exposed height of approximately 7 feet. Sometime prior to 1972, lagging was added to face of the seawall, extending up to 7 feet below beach level. Rip rap was also placed below grade against the face of the wall, and above grade behind the wall against the face of the bluff.

- 1981-1983: A portion of the road wall adjacent to Terrace Avenue was damaged by a landslide and subsequently repaired. Winter storms in 1982-83 also severely damaged the bulkhead protecting the Frenetta residence, eventually leading to the loss of the residence in the early 1990s.

- 1988: The deteriorating concrete groin installed at the mouth of Bolinas Lagoon in 1947 was replaced in order to restore and maintain sand retention at Brighton Beach.

- 2008: BCPUD performed an assessment of the timber sea wall, documenting at least two breaches in the wall and several piles that were deteriorating and/or out of plumb. Numerous undocumented repairs to the sea wall lagging were performed by unknown parties subsequent to this assessment.

In 2010, in response to continued deterioration of the timber sea wall and continued retreat/erosion of the upper bluff adjacent to Terrace Avenue at Surfer's Overlook, BCPUD retained SAGE to perform visual, structural evaluations of the sea wall and the road wall supporting Terrace Avenue at the time, and a

geologic evaluation of the coastal bluff and beach at Surfer's Overlook. In addition, BCPUD requested that SAGE develop concepts for the long term stabilization/protection of the bluff – motivated largely by the desire to preserve Terrace Avenue as the sole means of emergency vehicle access to 41 private residences, as well as the utilities buried beneath the roadway.

Pursuant to BCPUD's request, SAGE conducted a site visit on November 30, 2010 to perform visual observations of the sea wall, road walls, and bluff face, both from the ground level and from an articulating manlift basket suspended above portions of the slope; additionally, a seismic refraction survey was conducted at the beach below Surfer's Overlook in order to help estimate the depth of sand overlying the Merced Formation platform below the toe of the bluff at the time. After completing its evaluation SAGE submitted a report to BDPUD in August 2011, presenting its findings and recommendations, which are briefly summarized below:

- The bluff at Surfer's Overlook consists of nearly vertical, weakly-cemented siltstone and clayey sandstone (comprising upper Pliocene to Pleistocene Merced Formation marine sedimentary deposits), overlain by approximately 12 feet of native soil and fill inclined at approximately 1:1 (horizontal:vertical). Published, bluff erosion rates for the site vicinity were estimated to average 6 to 20 inches per year over the long term, attributable to a combination of wind and runoff on the face of the bluff, occasional failures of tabular blocks along defined joint sets and bedding planes, and periodic, progressive bluff collapse caused by undercutting at the toe of the bluff due to wave action; although this rate was assumed to have slowed significantly where the toe of bluff is protected by the sea wall.

- The sea wall exhibited significant weathering/deterioration, including loss of core wood within some of its timber piles, and extensive rotting of some lagging, particularly in the lower lagging elements. However, the piles were found to be generally plumb, and exhibited little necking of the outer diameter, and much of the lagging appeared relatively solid, with little bowing; thus, the wall was found to be generally serviceable at the time of inspection. Based on the history of powerful winter storms and periodic bluff collapses at the site, the 2011 report estimated that the sea wall might have as little as 5 years of useful life remaining.

- The three road walls adjacent to Terrace Avenue, totaling a combined 156 feet in length and retaining up to 7 feet of soil, comprised 12-inch diameter timber piles anchored with steel cables attached to timber "deadman" piles buried within the retained fill. Earth retention between the piles was provided by 2x12 timber lagging spanning between horizontally between the piles. Each of the road walls exhibited multiple signs of distress, including deteriorating/failing lagging, undermining of lagging and piles, loss of lateral cover at the toe of the wall, missing piles, excessive deflections, and corroded anchor cables. The walls were found to be in incipient and/or active failure, and were estimated to be susceptible to catastrophic failure within 1-3 years if remedial measures were not taken. At the time of inspection, however, the roadway did not exhibit significant signs of settlement or cracking consistent with lateral movement.

Based on these findings and observations, the 2011 report recommended that the most reliable way to stabilize the Surfer's Overlook site on a long-term basis would be to construct a full-height bluff protection wall – the most feasible (and least obtrusive) type being a soil nail wall, comprising a reinforced shotcrete facing, anchored to the bluff face with regularly-spaced ground anchors. However, it was generally acknowledged by all parties that obtaining approval from the California Coastal Commission for such construction would be a difficult and time-consuming process, at best. In light of this fact, SAGE suggested

that the stability of the bluff could be significantly improved via discrete, "in-kind" repairs of the road walls at the top of the bluff, and timber sea wall at the toe, with the road wall repairs being the most time-critical, due to their incipient failure. Indeed, subsequent to the report being issued, Marin County replaced the road wall along Terrace Avenue. To our knowledge, no official repairs were conducted on the sea wall.

SCOPE OF CURRENT STUDY

In 2021, noting that it had been approximately 10 years since the original evaluation was issued, BCPUD contacted the original authors of the 2011 report at Gannett Fleming to inquire about a supplemental/follow-up evaluation of Surfer's Overlook, specifically to document any significant changes to the extents, orientation, or condition of the coastal bluff; and to provide updated opinions about the serviceability of the sea wall and the feasibility of in-kind repairs to the wall.

On April 13, 2023, Drew Kennedy (Chief Engineering Geologist) and William Millhone (Principal Engineer), who conducted the original evaluation in 2011, performed a visit to Surfer's Overlook to visually observe the site conditions from the ground, take hand measurements of the coastal bluff and sea wall, and photo-document the site. Based on these observations and measurements, we present below our findings and conclusions regarding:

- Significant or material changes to the location, orientation, or conditions of the local bluff;
- Changes in the apparent condition of the sea wall since the 2011 evaluation, including condition of timber elements and fasteners, and the exposed height, extents, orientation, and inclination of the wall; and,
- An updated estimate of the serviceability and remaining service life of the sea wall and opinions regarding the feasibility of an in-kind repair/replacement of the wall.

SUPPLEMENTAL EVALUATION

Below we document the observations and measurements made during our site visit.

Sea Wall Conditions

The timber sea wall is approximately 135 feet long, with an exposed (retained) height up to about 7 feet. The wall intersects the east end of the existing concrete platform at 47 Terrace Avenue and continues in a north-south orientation for approximately 30 feet before turning to a roughly east-west orientation offset approximately 6 feet from the toe of the bluff until ultimately terminating at the remains of the failed timber bulkhead at the property line of lot 193-142-10 (the former site of the Frenetta residence). The wall comprises 12-inch-diameter timber piles on approximately 6-foot centers, reportedly embedded 11 to 12 feet below grade, with 2x12 timber lagging affixed to the backs of the piles within the exposed height of the wall, and affixed to the fronts of the piles from existing grade to about 8 feet below grade. The backfill material reportedly comprises dumped rip rap and is overlain with material that has sloughed off of the bluff face, inclined at approximately 1:1 or steeper. Portions of the sloughed material have become oversteepened and spilled over the wall face, forming piles of earthen material at the face of the wall in numerous locations. Rip rap was also reportedly placed below grade in front of the wall and is exposed at the beach surface in some places.

The sea wall conditions observed in 2023 represent a significant deterioration relative to our observations in 2010, with multiple piles exhibiting severe splitting and out-of-plumb orientations (see Photos 1-3).

Similarly, a significant number of the lagging boards behind the piles exhibit severe bowing or are completely ruptured (see Photos 4 & 5). Little is visible in the way of fasteners/hardware on the wall, except that in a few locations, steel bands appear to have been placed around some piles, in what is assumed to have been an attempt to resist splitting of the piles; however, in these cases the bands appear to have failed.

In general, the sea wall distress becomes increasingly severe moving from west to east. Indeed, the piles and lagging within about 60 feet of the concrete platform at 47 Terrace Avenue appear to have remained in generally serviceable condition. This is likely due to several factors, including that the west end of the sea wall is in a relatively oblique orientation to the direction of typical wave runup at Surfer's Overlook. Additionally, the western end of the wall is in the "shadow" of the wave attack, being somewhat sheltered by the eastern corner of the concrete platform at 47 Terrace Avenue. Another factor may be that the western end of the sea wall is not as heavily loaded by sloughed debris as the other portions of the wall. However, the eastern half of the sea wall is in an advanced state of disintegration, with many elements appearing to have little structural value. The most severely deteriorated piles appear incapable of carrying any significant load and may be on the verge of imminent collapse. It is possible that the rip rap buried within the backfill behind the wall is reducing the active pressures on the lagging, thereby delaying such collapse. In any event, it is our opinion that the eastern half of sea wall should not be relied upon to provide continued protection of the toe of the bluff.

Bluff Conditions

The bluff at Surfer's Overlook has continued to experience erosion and retreat in the approximately 12 years that have passed since the previous evaluation. While some of the retreat has occurred in the weakly-cemented siltstone/sandstone in the lower portion and toe of the bluff, the majority of material loss within this formation appears to have been primarily due to typical wind/waterborne processes, and the occasional loss of tabular blocks along existing joint sets and bedding planes. We did not, however, observe evidence of significant retreat due to progressive/cyclical wave undercutting, followed by collapse of the bluff face, which is typically the primary mechanism of bluff retreat in similar formations in California. Whereas published average retreat rates for the area would have predicted anywhere from 6 to 20 feet of bluff retreat, we estimate that the unprotected toe of the bluff to the east of the sea wall has retreated less than 5 feet, with few signs of significant outflanking of the property at 100 Brighton Avenue (see Photo 6). Also, although it is in very poor condition, the timber seawall has obviously provided significant protection to the bluff, where present.

This slower-than-anticipated retreat at the unprotected toe of the bluff may be attributable to several factors. First, while the remnants of the timber groin that once fronted the Frenetta residence are in a state of advanced disrepair, they do still pose some impediment to wave attack on the bluff, both by deflecting/slowing wave runup, and intercepting some waveborne debris that can exacerbate the undercutting effects of wave attack (see Photo 7). Second, the continued presence of the concrete groin at the mouth of Bolinas Lagoon likely contributes to more sand retention at Surfer's Overlook, which can increase wave runup distances and help dissipate wave energy. Also, it should be borne in mind that bluff retreat rates are based on long term trends, and a period of time on the order of a decade in which bluff retreat was less than the long-term average is not especially unusual.

In contrast to the lower bluff, the upper portion of the bluff, comprising deeply-weathered Merced Formation materials, organic soils, and artificial fill, has experienced more significant erosion and retreat. This is evidenced by significant piles of sloughed debris that have accumulated on and in front of the sea wall (see Photos 8 & 9), as well as evidence of continued soil loss on the upper slope itself (see Photo 10).

If the more competent materials in the lower bluff can be protected from significant retreat, the erosion of the upper bluff could be expected to slow over time as they become shallower and approach a more stable slope configuration. However, the length of time required for the slope to achieve a more stable configuration, and what the inclination of the slope would be under those conditions, are difficult to predict. Based on our observations, it is plausible that the upper slope will continue to shallow to an extent that threatens to undermine the rebuilt road wall along the outboard edge of Terrace Avenue. Based on our observations, however, there is no evidence that the road wall is destabilized. Obviously, as the protection of the lower bluff continues to degrade over time, the toe of the bluff will become more susceptible to undercutting and collapse, which would certainly expedite the loss of upper bluff materials as well.

FEASIBILITY OF IN-KIND SEA WALL REPLACEMENT/REPAIRS

The 2011 report noted the following in regards to the prospect of in-kind repairs to the sea wall:

> *Maintaining the seawall at the base of the bluff would require considerable effort, and would fall under the permitting jurisdiction of the [California Coastal Commission]. While the sea wall is not restrained with anchors, a significant portion of the wall (on the order of 12 feet) is reportedly buried below the typical sand level at the beach, and is therefore difficult to access. In addition, as-built drawings indicate that the toe of the seawall may be buttressed by a rip rap berm. Consequently, while replacing the above grade timber lagging would require relatively little effort, replacing below-grade lagging, or wall piles, would likely involve significant excavation within the beach sand and/or rip rap, and could require temporary shoring of the wall to effect repairs. As with the road walls, it is our opinion that major repairs to the seawall would rival the cost of constructing an entirely new seawall of similar extents, but would likely have less than half the service life of a modern structure. However, since the seawall is generally in better condition than the road walls at the top of the bluff, such repairs might not be required for 5 years or more.*

In our opinion, this assessment remains largely accurate, with the obvious exception that the useful life of the sea wall now appears to be at an end. The existing timber wall has clearly been very effective to date in protecting the toe of the bluff on the western side of Surfer's Overlook. In considering a full replacement of the wall, we note that the materials used to treat the timbers installed in 1967 are likely unavailable today, and replacement piles and lagging treated with alternative materials may not perform as well or last as long as the original structure. That said, depending on how much deviation would be permitted in regards to the materials and/or wall type, replacement of the wall in its current configuration is worth exploring. While full demolition and replacement of the wall may be relatively expensive and require considerable logistical planning to install, the design would be relatively straightforward from an engineering standpoint.

As an alternative to full replacement, it is our opinion that more economical in-kind repair may be possible. If the pile deterioration has not progressed too far below grade, we feel that it may be feasible to splice new pile sections atop the embedded portions of the piles using a steel (or similar) "sleeve," filled with grout or epoxy, to join the two sections (see Figure 1). With this approach, we anticipate that the lagging would be stabilized by hand-placed rakers (i.e., "kickers") braced in front of the wall while the deteriorated pile top was removed and replaced with a new pile section, and could be removed once the splice was cured/secured.

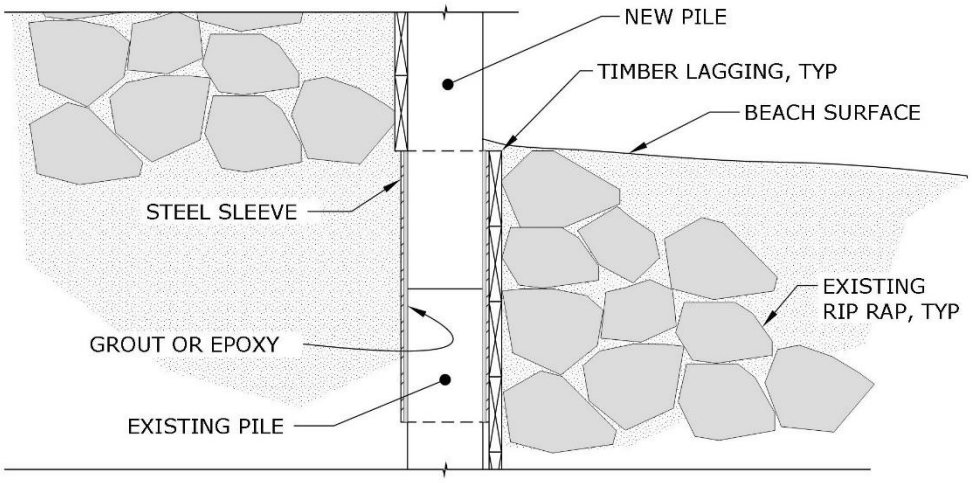

Figure 1: Conceptual detail depicting a below-grade splice of a sea wall pile.

In order to investigate the feasibility of this approach, the depth to sound wood in candidate piles would need to be determined by exhuming the upper embedment of candidate piles and inspecting each pile, possibly by driving a small probe into the pile or collecting a small core of wood. These inspections could be performed largely with hand tools, although a mini excavator might be necessary to remove some rip rap blocks from the face of the pile. If sound wood were found below existing grade that was reasonably accessible without extensive excavation, stockpiling, etc., we feel that this method of repair could be considered for rehabilitation of the wall.

We see several potential advantages to this approach, including:

- The repairs could be accomplished with hand tools and/or relatively small equipment, such as a mini excavator, and would require a relatively small footprint during construction;
- This technique is scalable, and may be performed in discrete wall locations on an as-needed basis, or across multiple piles at once.
- Lagging within the retained height could be replaced individually on an as-needed basis after splicing of the pile.

Gannett Fleming would be happy to work with BCPUD in devising a small investigation plan to determine the feasibility of the pile splicing approach upon request.

SUMMARY

Based on our follow-up evaluation of the coastal bluff and sea wall, we have the following opinions:

- The lower portion of the bluff at the east end of Surfer's Overlook has experienced less retreat than would be predicted by published, long-term retreat rates for the Bolinas area, which may be attributable in part to the presence of the remnants of the timber groins in the area and/or the concrete groin farther to the east near Bolinas Lagoon. The upper section of the bluff has continued to erode at a faster rate, and has lost significant material over time. While this might be expected

to eventually threaten the stability of the road wall along Terrace Avenue, we observed no evidence of any such instability during our visit.

- The toe of the bluff has been substantially protected from erosion and undercutting where fronted by the sea wall. However, the sea wall appears to be at the end of its useful life, with some areas experiencing incipient failure, and cannot be relied upon to continue to provide continued protection without remediation in the near term.

- While a wholesale replacement of the sea wall could be expected to be a major undertaking with significant costs, it is possible that discrete, in-kind repairs, entailing splicing of the timber piles, and as-needed replacement of timber lagging, may be feasible as a means of maintaining the current wall. The feasibility of this approach would have to be determined via a limited-depth excavation at one or more piles in order to determine the integrity of the piles below grade.

LIMITATIONS

This technical memorandum has been prepared for the sole use of Bolinas Community Public Utility District, and its agents, and is based on available and relevant documents contained our files and our observations during a site visit at Surfer's Overlook on April 13, 2023. Gannett Fleming is not responsible for the data presented by others. Adverse conditions may exist that were not visible at the time of the site visit, and changes in the condition of the bluff, seawall, and road wall can occur with the passage of time, whether due to natural processes or the works of man. In addition, changes in applicable standard of practice can occur, whether from legislation or the broadening of knowledge. Accordingly, the information provided in this technical memorandum may be invalidated, wholly or partially, by changes outside of our control. Should changes occur that might affect the evaluation presented herein, Gannett Fleming should be notified to evaluate the validity of this report to those changes.

References:

1. *Final Technical Report, Coastal Bluff Evaluation & Stabilization Alternative Analysis, Surfer's Overlook on Terrace Avenue, Bolinas, California*, SAGE Project No. 10-009.00 Phase 1/ Task 2, prepared by Sanders & Associates Geostructural Engineering, Inc., dated August 31, 2011

Photo 1: Severely split/failing sea wall piles. Note broken steel band at mid-height. Photo: IMG_3296.jpg Date: 4/13/23

Photo 2: Debris and vegetation accumulation within void of split pile. Note missing bottom lagging at lower left. Photo: IMG_3297.jpg Date: 4/13/23

Photo 3: Vegetation growing from within void of split pile. Note sloughed slope debris around pile. Photo: IMG_3298.jpg Date: 4/13/23

Photo 4: Severely bowing/failing timber lagging. Photo: IMG_3309.jpg Date: 4/13/23

Photo 5: Severely bowing/failing timber lagging. Photo: IMG_3310.jpg Date: 4/13/23

Photo 6: Unprotected bluff face adjacent to 100 Brighton Avenue. Photo: IMG_0382.jpg Date: 4/13/23

Photo 7: Remnants of timber groins to the east of the sea wall. Photo: IMG_0376.jpg Date: 4/13/23

Photo 8: Sloughed material from upper bluff. Photo: IMG_0370.jpg Date: 4/13/23

Photo 9: Sloughed material from upper bluff. Photo: IMG_0371.jpg Date: 4/13/23

Photo 10: Undermined fence post on the upper bluff. Photo: IMG_0371.jpg Date: 4/13/23