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EXECUTIVE OFFICE OF ENERGY & ENVIRONMENTAL AFFAIRS
DEPARTMENT OF ENVIRONMENTAL PROTECTION
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THE OFFICE OF APPEALS AND DISPUTE RESOLUTION

March 25, 2019

In the Matter of
Liatsos, Pinchin, and Southwick

Docket No. WET-2016-005, -006, -007
Mashpee, MA

RECOMMENDED FINAL DECISION AFTER REMAND

INTRODUCTION

These consolidated appeals were brought by 12 residents of Mashpee and the trustees of the New Seabury Condominium Trust 1A, the association of unit owners of the Tidewatch Condominiums located at 94 Shore Drive West, Mashpee (collectively "Petitioners"). The appeals originally challenged the Superseding Orders of Conditions ("SOC") that the Massachusetts Department of Environmental Protection's Southeast Regional Office ("MassDEP") issued to the applicants: Michael and Dawn Southwick; Kenneth Liatsos Trust and Gloria Liatsos Trust; and David and Glenys Pinchin (collectively, "Applicants"). The SOC approved the Applicants' project at their abutting oceanfront properties located at 118, 124, and 126 Shore Drive West, Mashpee ("the Site"). The SOC was issued pursuant to the Wetlands Protection Act, G.L. c. 141 § 30, and the Wetlands Regulations, 310 CMR 10.00. The appeals concern the protected wetlands resource areas of coastal beach and coastal bank. See 310 CMR 10.02, 10.27, 10.30.

Project I. The project that was approved in the original SOC proposed excavation of the coastal bank to decrease its steep slope and to create a void for installation of large sand-filled coir envelopes and fiber rolls ("Project I"). The bank rises at a very steep angle from the beach to a height of approximately 30 feet. Project I was also designed to include 256, 12 foot-diameter, 15 foot-long round wooden pilings installed vertically 10 feet deep into the ground in two horizontal rows parallel to and at the toe of the coastal bank. The coir envelopes and fiber rolls in the coastal bank would be buried with sand nourishment, and regular sand nourishment and planting of vegetation at the top of the new coastal bank would be required pursuant to the SOC.

After holding an adjudicatory hearing, I issued a Recommended Final Decision ("RFD") to vacate the SOC and deny Project I. I found that the project was a coastal engineering structure that was designed to alter wave, tidal, or sediment transport processes to protect a building constructed after 1978 from the effects of those processes, namely coastal erosion. Thus, the project was prohibited by 310 CMR 10.30(3), which bars the installation of such structures for the protection of buildings constructed after 1978. I also recommended denying the project because I found that it failed to comply with the performance standards for coastal bank and coastal beach. In particular, it would remove the natural bank as a regular sediment source and it would cause significant erosion and lowering of the beach. See 310 CMR 10.30(4) and 310 CMR 10.27(3).

As part of his review of the RFD to issue a Final Decision, MassDEP's Commissioner informed the parties that he would treat the RFD as a Tentative Decision pursuant to 310 CMR 1.01(14)(a) and directed the parties to file legal memoranda stating whether he should issue a Final Decision adopting, modifying, or rejecting the RFD. Thereafter, the Applicants and

MassDEP filed legal memoranda urging MassDEP's Commissioner to issue a Final Decision rejecting the RFD. The Petitioners filed a legal memorandum urging MassDEP's Commissioner to adopt the RFD as his Final Decision.

After the MassDEP Commissioner considered the RFD, the administrative record, and the parties' responses to the Tentative Decision, he declined to adopt the RFD as a Final Decision, and instead issued an Interlocutory Remand Decision ("IRD"). In the IRD the Commissioner disagreed that "Project [I] is a prohibited Coastal engineering structure under 310 CMR 10.30(3) (RFD, at pp. 13-40)." He added, however, that "the record does not convince [him] that . . . Project [I] either complies or fails to comply with the Performance Standards for Coastal Bank (310 CMR 10.30(4) and (6) and Coastal Beach (310 CMR 10.27) . . . ."

The Commissioner explained in the IRD that he did not believe that a "project consisting of sand-filled coir rolls and envelopes and fiber rolls combined with beach nourishment as authorized by an Order of Conditions issued by a local Conservation Commission or a Superseding Order of Conditions issued by the Department pursuant to the WPA and the Wetlands Regulations is a prohibited Coastal engineering structure under 310 CMR 10.30(3)." IRD, pp. 4, 10. The IRD explained that coir rolls and envelopes and fiber rolls were a "soft solution" and thus not a coastal engineering structure, as distinguished from "'hard structures' constituting coastal engineering structures such as bulkheads, revetments, seawalls and groins, constructed of rock, concrete, steel or wood . . . ." IRD, p. 4.

The IRD, however, went on to explain that the administrative record, particularly MassDEP's testimony, was ambiguous with respect to whether the project complied with the applicable performance standards for coastal bank and coastal beach. The Commissioner therefore remanded the matter to the "Department and the Presiding Officer for further review of the proposed Project, specifically, for a determination of whether . . . Project [I] either complies or fails to comply with the Performance Standards for Coastal Bank (310 CMR 10.30(4) and (6)) and Coastal Beach (310 CMR 10.27)." IRD, p. 11. Therefore, the Commissioner directed that MassDEP complete further review and issue an amended SOC, "setting forth the Department's findings regarding whether the Project complies or fails to comply with the Performance Standards . . . ." The IRD also directed the Applicants and the Petitioners to file responsive testimony in support of their positions on the amended SOC and that an adjudicatory hearing should be held if necessary.

Project II. On remand, MassDEP's Southeast Regional Office (which previously issued the SOC approving Project I) issued an Amended SOC that denied the timber pile array component of Project I for failing to comply with the performance standards, and replaced that pile array with a significantly different design and components ("Project II"). Mahala PFT[1] (June 26, 2017). The MassDEP Wetlands and Waterways Section Chief for the Southeast Regional Office, James Mahala, testified, based upon his experience and his review of substantial research literature, that the pile array should be replaced with a single row of 4-inch by 4-inch wooden posts, spaced 5 feet apart on center because it would not result in "significant scour of the coastal beach and would meet the performance standards for Coastal Beaches at 310 CMR 10.27(3)." Mahala PFT (June 26, 2017), pp. 10, 13. MassDEP also amended the SOC by increasing the required monitoring and prohibiting the use of the proposed Tensar Geogrid TX190L protective wrap around the coir envelopes because that synthetic wrap would effectively prevent the envelopes from releasing sediment under storm conditions. Mahala PFT (June 26, 2017), p. 12; Mahala PFT (August 17, 2017).

[1] "PFT" is the acronym for "Pre-filed testimony."

The Applicants responded with written expert testimony objecting to the SOC amendments that significantly altered the pile array component of Project I (creating Project II) and an amendment that required removal of the project if it met certain failure criteria. See Applicants' Comments on Department's Amended SOC Findings; Bosma PFT (July 25, 2017). MassDEP responded with testimony rebutting the Applicants' objections to Project II and the Amended SOC. Mahala PFT (September 8, 2017). The Petitioners filed testimony and a brief opposing Project II, asserting that it was still a coastal engineering structure and that it still did not comply with the performance standards. Monroe PFT (July 25, 2017).

Project III. The Applicants and MassDEP then engaged in extended settlement discussions, after requesting and receiving a lengthy stay of the adjudicatory proceedings. MassDEP and the Applicants reached a settlement agreement after MassDEP agreed to the Applicants' proposed alterations to the project, leading to Project III. The settlement was embodied in a proposed Final Order of Conditions and a Monitoring and Maintenance Plan. See MassDEP's Status Report (including attachments) (March 26, 2018). The most significant differences with Project III are the inclusion of: (1) a two-rowed timber pile array that is somewhat modified from the Project I pile array that MassDEP rejected on remand and (2) a more robust monitoring and maintenance plan.

The Petitioners opposed Project III, arguing that it remains a prohibited coastal engineering structure and fails to comply with the performance standards. The Petitioners also pointed out that the IRD did not address whether the pile array component of Project I was a coastal engineering structure. Thus, they asserted that the issue must be addressed on remand. The Applicants and MassDEP responded that the IRD did not specifically direct that the issue be addressed on remand. All parties' positions are correct on this issue. Given this ambiguity; the need to create a complete and thorough administrative record; and the fact that the Project III pile array is different from the Project I pile array, I accepted argument and evidence on whether the pilings in Project III constitute a coastal engineering structure, and I address that issue below, in addition to whether Project III complies with the performance standards.[2] See Order Establishing Schedule for Resolution After Remand (April 6, 2018).

Recommendation. After thoroughly reviewing the administrative record and conducting the adjudicatory hearing on remand, I recommend that MassDEP's Commissioner issue a Final Decision that vacates the original SOC and declines to issue the proposed Final Order of Conditions. The pile array component of Project III is a coastal engineering structure that is clearly prohibited by the Wetlands Regulations. There is no doubt that it is *designed* to alter wave, tidal, or sediment processes to protect the upland buildings from coastal erosion, and thus it is a prohibited coastal engineering structure. Moreover, it is also encompassed by the definitions of three of the enumerated coastal engineering structures: breakwater, bulkhead, and seawall. It has no functional resemblance to any of the natural features of a coastal bank that is a sediment source. Indeed, a preponderance of the evidence demonstrates that it is a hard structure that will not comply with the coastal beach performance standards. To be clear, it is not the pilings themselves that would be in noncompliance with the regulations; rather, it is their proximity to one another (they are too close together) and their unnecessary vertical extension above the beach that are designed to alter wave and tidal forces and which will cause erosion and a lowering of the beach.

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[2] Because the remand directive in the IRD omitted the timber pile array and whether it was a coastal engineering structure, the Applicants filed a motion in limine, assented to by MassDEP, which sought to preclude further evidence, testimony, and rulings on whether the pile array for Project III was a coastal engineering structure. The Petitioners opposed the motion, pointing out, as I did above, that the issue whether the pile array, particularly the one in Project III, was a coastal engineering structure was not addressed by the IRD. I therefore denied the motion in limine argument to prohibit testimony and argument concerning whether the pile array is a coastal engineering structure.

The pile array's frequent interaction with waves, currents, and tidal forces will lead overtime to a general lowering of the beach, despite the provision of nourishment. That is an adverse effect, and one that is not merely negligible; indeed, as the beach lowers, the mean high water line will move even closer to the pile array, causing more interaction between the array and the waves, currents, and tidal forces, resulting in even more scour and lowering of the beach. And, that process will continue until the beach sediment is scoured away, exposing the underlying cobbles and other features; a result that is already occurring at a neighboring beach that is referred to in this decision as Bayswater.

STATUTORY AND REGULATORY FRAMEWORK

The purpose of the Wetlands Act and the Wetlands Regulations is to protect wetlands and to regulate activities affecting wetlands areas in a manner that promotes the following:

(1) protection of public and private water supply;

(2) protection of ground water supply;

(3) flood control;

(4) storm damage prevention;

(5) prevention of pollution;

(6) protection of land containing shellfish;

(7) protection of fisheries; and

(8) protection of wildlife habitat.

G.L. c. 131, § 40; 310 CMR 10.01(2).

The coastal wetlands regulations are "intended to ensure [among other things] that development along the coastline is located, designed, built and maintained in a manner that protects the public interests in the coastal resources listed in M.G.L. c. 131, § 40." 310 CMR

10.21. There are two coastal wetland resource areas at issue in this appeal, coastal beaches and coastal banks. The Wetlands Regulations provide the following with respect to each resource area:

Coastal Beaches. The Coastal Beach consists of "unconsolidated sediment subject to wave, tidal and coastal storm action which forms the gently sloping shore of a body of salt water and includes tidal flats. Coastal beaches extend from the mean low water line landward to the dune line, coastal bank line, or the seaward edge of existing human-made structures, when these structures replace one of the above lines, whichever is closest to the ocean." 310 CMR 10.27(2). The coastal beach in these appeals is significant to storm damage prevention, flood control, and the protection of wildlife habitat. 310 CMR 10.27(1).

The gentle slope, permeability, and granular nature of coastal beaches dissipate wave energy, which permit changes in beach form in response to changes in wave conditions. Coastal beaches serve as a sediment source for dunes and subtidal areas. Steep storm waves cause beach sediment to move offshore, resulting in a gentler beach slope and greater energy dissipation. Less steep waves cause an onshore return of beach sediment, where it will be available to provide protection against future storm waves. Id.

A coastal beach at any point serves as a sediment source for coastal areas down drift from that point. The oblique approach of waves moves beach sediment alongshore in the general direction of wave action. Thus, the coastal beach is a body of sediment which is moving along the shore. Id.

Coastal beaches serve the purposes of storm damage prevention and flood control by dissipating wave energy, by reducing the height of storm waves, and by providing sediment to supply other coastal features, including coastal dunes, land under the ocean and other coastal beaches. Interruptions of these natural processes by human-made structures reduce the ability of the coastal beach to perform these functions. 310 CMR 10.27(1).

Coastal Banks. The Coastal Bank is the seaward face or side of any elevated landform, other than a coastal dune, which lies at the landward edge of a coastal beach, land subject to tidal action, or other wetland. 310 CMR 10.30(2).

A particular coastal bank may serve both as a sediment source and as a buffer, or it may serve only one role. 310 CMR 10.30(1). Coastal banks are likely to be significant to storm damage prevention and flood control. Coastal banks, like the one in these appeals, that supply sediment to coastal beaches, coastal dunes, and barrier beaches are per se significant to storm damage prevention and flood control. 310 CMR 10.30(1). Such banks are composed of unconsolidated sediment and exposed to vigorous wave action, which serves as a major continuous source of sediment for beaches, dunes, and barrier beaches (as well as other land forms caused by coastal processes). The supply of sediment is removed from banks by wave action, and this removal takes place in response to beach and sea conditions. It is a naturally occurring process necessary to the continued existence of coastal beaches, coastal dunes and barrier beaches which, in turn, dissipate storm wave energy, thus protecting structures of coastal wetlands landward of them from storm damage and flooding. 310 CMR 10.30(1).

Coastal banks, because of their height and stability, may act as a buffer or natural wall, which protects upland areas from storm damage and flooding. While erosion caused by wave action is an integral part of shoreline processes and furnishes important sediment to downdrift landforms, erosion of a coastal bank by wind and rain runoff, which plays only a minor role in beach nourishment, should not be increased unnecessarily. Therefore, disturbances to a coastal bank which reduce its natural resistance to wind and rain erosion cause cuts and gullys in the bank, increase the risk of its collapse, increase the danger to structures at the top of the bank and decrease its value as a buffer. 310 CMR 10.30(1).

Bank vegetation tends to stabilize the bank and reduce the rate of erosion due to wind and rain runoff. Pedestrian and vehicular traffic damages the protective vegetation and frequently leads to gully erosion or deep "blowouts" on unconsolidated banks. Therefore, any project permitted by 310 CMR 10.30 should incorporate, when appropriate, elevated walkways. 310 CMR 10.30(1).

When a proposed project involves dredging, removing, filling, or altering a coastal bank, the issuing authority shall presume that the area is significant to storm damage prevention and flood control. This presumption may be overcome only upon a clear showing that a coastal bank does not play a role in storm damage prevention or flood control, and if the issuing authority makes a written determination to that effect. 310 CMR 10.30(1).

When issuing authority determines that a coastal bank is significant to storm damage prevention or flood control because it supplies sediment to coastal beaches, coastal dunes or barrier beaches, the ability of the coastal bank to erode in response to wave action is critical to the protection of that interest(s). 310 CMR 10.30(1).

When the issuing authority determines that a coastal bank is significant to storm damage prevention or flood control because it is a vertical buffer to storm waters, the stability of the bank, i.e., the natural resistance of the bank to erosion caused by wind and rain runoff, is critical to the protection of that interest(s). 310 CMR 10.30(1).

BACKGROUND

The Site consists of three abutting residential lots, each lot equal to approximately one-half acre of land.[3] Each lot contains a residence built between 1994 and 1996. Between the residences and the Atlantic Ocean lie the wetlands resource areas of coastal bank and coastal beach, with the bank rising abruptly approximately 30 feet above the elevation of the beach. 310 CMR 10.30(4) and (6) (coastal bank); 310 CMR 10.27 (coastal beach). Beach access exists via wooden stairs descending from the lots down the steeply pitched bank.

The Tidewatch Petitioners hold a non-exclusive beach easement that is 50 feet wide along the shoreline where the project is to be located for "bathing, swimming, and related recreational uses." The easement dates to 1976. Their condominiums lie just down the shore from the Site, approximately 300 feet to the northeast. Between the Site and the Tidewatch Petitioners' property lies what is referred to in these appeals as the New Seabury Bayswater project. The Bayswater project was another coastal bank project that was installed several years ago in approximately 2012. It includes some aspects that are similar to the project components in these appeals.[4]

The original SOC approved Project I, which was the Applicants' proposal to fortify their 225 linear feet of Coastal Bank against ongoing coastal erosion. Indeed, the bank has eroded and retreated over the last several years. Marden PFT, p. 3. According to the Applicants, the project is designed to "stabilize the eroding coastal bank at" the Site. Marden PFT, p. 4. If the Applicants were to do nothing, the bank would significantly continue to erode. First

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[3] For ease of reference and readability significant portions of this decision duplicate portions of the original RFD.
[4] There are significant differences between the Bayswater project and the project in these appeals, which are discussed later in this decision.

Adjudicatory Hearing Transcript ("Transcript I"), pp. 355-56.[5] There was no evidence, however, that the residential buildings faced imminent danger from coastal erosion.

In general terms, Projects I, II, and III would involve excavating landward approximately 10 feet into the coastal bank and approximately five feet vertically downward into the coastal beach. The excavated void in the bank and the beach would be filled with 6 very large, coir sand-filled envelopes, layered in a terraced or step-wise manner, descending like stairs from near the top of the coastal bank down to the coastal beach.[6] The Applicants' project is designed to reengineer the current steep slope of the bank to a more "stable slope" built upon the terraced coir envelopes and rolls. Marden PFT, p. 8, Exhibits 4-5. The terrace design would be created by stacking each envelope landward by two feet as it is placed on top of the underlying envelope.

The specific component parts of *all* projects that would be installed in the bank are the following:

1. Six (6) biodegradable sand-filled coir envelopes, installed in the coastal bank with one 24" diameter coir fiber roll enclosed within the seaward end of each envelope. Each coir envelope would be filled to capacity with sand, making it approximately 2 feet thick and 6 to 8 feet deep (measured from the seaward edge to the landward edge). The vertical height of all combined stacked envelopes is proposed to be 12 feet.

[5] "Transcript I" is from the first adjudicatory hearing and "Transcript II" is from the second.

[6] Sand filled coir envelopes and fiber rolls are natural products composed of tightly bound coconut fibers. They are typically anchored by themselves into the toe of a slope to help reduce erosion and stabilize the bank. Mahala PFT, p. 5. "Coir is a natural fiber extracted from the husk of coconut and used in products such as floor mats, doormats, brushes, and mattresses. Coir is the fibrous material found between the hard, internal shell and the outer coat of a coconut. Other uses of brown coir (made from ripe coconut) are in upholstery padding, sacking and horticulture. White coir, harvested from unripe coconuts, is used for making finer brushes, string, rope and fishing nets." https://en.wikipedia.org/wiki/Coir

2. Five (5) coir fiber rolls stacked vertically on top of each other to a height of approximately 8 feet above the coir envelopes and anchored into the bank; fiber rolls are generally coconut fibers that are rolled. Transcript I, p. 298. Above the rolls at the top of the bank the area will be vegetated with native plantings to stabilize the uppermost portion of the bank and restore habitat. Marden PFT, p. 8. The remaining top 10 feet of the bank would consist of sediment and planted vegetation.
3. Native vegetation would be planted on the upper bank above the level of the coir envelopes and rolls to restore the natural condition of the bank above the velocity zone.

Project I. Project I was proposed to include two-hundred and fifty six (256) 15 foot long, 12 inch diameter vertical timber piles placed at the toe of the bank, abutting the lowest coir envelop. The piles would be arranged in two alternating rows, with the landward row directly adjacent to and at the seaward edge of the bottom coir envelope. The second row of piles would be set 4 inches seaward of the row abutting the lowest coir envelope. The individual piles in each of the rows would be separated 12 inches from each other. The piles in the two rows would be staggered such that each pile in the most landward row would fill the 12 inch void between the piles in the most seaward row, while maintaining the 4 inch separation between the two rows. With this staggered approach, if one were to view the two rows from the ocean at a perfectly perpendicular angle there would be no space seen between the piles. Each pile is proposed to be driven 10 feet below the elevation of the coastal beach, leaving 5 feet of each pile above the beach surface. There would be a gap of approximately 8 inches between piles when measured diagonally between rows. Marden PFT, Exhibit 6.

Remand to Further Address Vertical Pilings. MassDEP's changing opinions of the pilings and the various project permutations reflect the project's novelty, the variability and unreliability in the scientific literature, and the variability in scour and erosion impacts from pilings. In the first hearing with respect to Project I, "Mahala . . . testified that the pilings will be installed such that they will preserve existing wave and tidal processes affecting the coastal bank." RFD, p. 30. In his "opinion [the spacing between the piles] is more than adequate to permit wave and sediment to pass in between the piles and allow for the exchange of sediment between the coastal bank and the beach." RFD, p. 30.

But other testimony from Mahala at the first hearing stated that "he does not have a high degree of certainty with the impact of this project." RFD, p. 32. He doesn't "have experience in seeing these types of pile arrays in the field and how the shorelines react to it." RFD, p. 32. Generally speaking, he would prefer to see fewer piles that are spaced at greater distances. RFD, p. 32. He testified that the Massachusetts Office of Coastal Zone Managemet ("CZM") was consulted regarding this project and had concerns with it. It would have preferred to see greater space between the pilings.

Mahala admitted that the pile array in Project I would cause wave reflection that causes scour. He testified that the amount of scour will depend on the nature of the vertical surface, how continuous it is, how close it is to the mean high water line, and the frequency of scouring. He also testified that there will be some change in the form of the beach. RFD, pp. 32-33.

Given this conflicting and ambiguous testimony, the Commissioner issued his Interlocutory Remand Decision because the testimony raised questions whether Project I complies with the performance standards. IRD, p. 10. Thus, the appeals were remanded to address whether the vertical pilings for Project I complied with the performance standards for coastal bank and coastal beach. To be clear, it is not the pilings themselves that raised erosion and scouring concerns; instead, it was the close proximity of the pilings to one another and the portion of the pilings that extended above the beach. These are variables—proximity to one another and the vertical height above the beach—the affect the amount of erosion and scour.

Project II. On remand, MassDEP further reviewed the pile array that it approved in Project I, as directed by the IRD. Mahala relied upon his experience, academic research literature, and literature from the U.S. Federal Emergency Management Agency ("FEMA") when he disapproved the pile array in Project I on remand. Mahala PFT (June 26, 2017), pp. 9, 10 Ex. 2 (Umeda, 2011; Mostafa, 2011), Ex. 3 (FEMA). He noted that FEMA literature concluded that localized scour around a *single* pile is generally equal to 1 to 1.5 times the pile diameter; FEMA recommends using a scour depth of 2 times the diameter of the pile, "consistent with the rule of thumb given in the U.S. Army Corps of Engineers' Coastal Engineering Manual (USACE 2008)." He therefore calculated that the local scour around a 12 inch pile would be 2 feet deep. Mahala PFT (June 26, 2017), p. 8, Ex. 3. He also relied upon FEMA to determine scour depth of a pile group, which is 3 times the single pile scour depth, or 6 feet. Id.

Mahala considered that the piles would interact with the waves and currents on a "fairly regular basis" because of the narrowness of the beach and proximity to the mean high water. That proximity increases the potential impact on the beach because of the frequent interaction between the pile array and waves and tidal forces. Mahala PFT (June 26, 2017), p. 9.

Mahala opined based upon FEMA and other literature that the pile array is "likely to lead to the formation of a scour trough under storm conditions" that is several feet deep. Mahala PFT (June 26, 2017), p. 10. He testified that this is even more likely at the Site because of the proximity of the piles to the ocean and the erodible nature of the beach sediments. Id. He concluded that this would lead to an unacceptable impact to the coastal beach that would not meet the performance standards at 310 CMR 10.27(3). Id.

Therefore, Mahala testified based upon his experience, FEMA literature, and other literature that the pile array in Project I should be replaced with the Project II pile array that he designed, consisting of a single row of 4-inch by 4-inch wooden posts, spaced 5 feet apart on center. Mahala amended the SOC to include this new array. He rationalized that this would not result in scour of the beach and would meet the performance standards. Mahala PFT (June 26, 2017), pp. 10, 13. MassDEP also amended the SOC by requiring that the proposed Tensar Geogrid TX190L protective wrap around the coir envelopes be replaced with a biodegradable wrap because the synthetic wrap would effectively prevent the envelopes from releasing sediment under storm conditions. Mahala PFT (June 26, 2017), p. 12; Mahala PFT (August 17, 2017). Under these circumstances, including the nourishment requirement, Mahala concluded that the project would not adversely affect the release of sediment from the bank and thus would comply with the coastal bank performance standard. 310 CMR 10.30(4).

The Applicants responded with rebuttal testimony and comments critical of Project II. Mahala responded with his own rebuttal testimony. Mahala PFT (August 17, 2017), p. 3. The Applicants' rebuttal testimony was critical of Project II and Mahala's reliance on the FEMA literature, arguing that it was inapplicable because it was based upon residential structural pilings in the Gulf of Mexico that were affected mostly by unidirectional currents from hurricanes, as opposed to the circumstance of this case. Mahala rejected that criticism, responding that the FEMA research was analogous because it was based upon observations of "scour [that] were the result of wave action and overwash (the flow of water and sediment across the barrier beach) interacting with pile foundations in a sand dominant barrier beach environment." He concluded that: "At the project site, waves propagating toward and through the pile array would interact with the piles in a *similar manner and would likely exhibit comparable impacts* (scour) to the coastal beach." Mahala PFT (August 17, 2017), p. 5 (emphasis added). Because of these processes, Mahala added it is "generally advisable to avoid and/or minimize the placement of structure(s), such as the proposed pile array, on a coastal beach since they will act as an obstruction to natural flow and will likely induce scour." Mahala PFT (August 17, 2017), p. 6.

Mahala was further critical of Bosma, the Applicants' expert, who testified that one could expect 3.8 inches (depth) of scour for a 1-year storm event and 6.2 inches (depth) of scour for a 5-year storm event. Mahala was critical of him because he did not provide an analysis of any other frequency storms, including the 25, 50, or 100 year storm events. Also, Bosma's analysis "did not include the effects of current flow, including backwash or return flow to the ocean." Mahala PFT (August 17, 2017), p. 6. He was also critical of the fact that Bosma had concluded the combined effects of waves and current at the timber pile array would lead to 7 to 8 inches (depth) of scour around the piles and did not indicate what frequency storm event would cause the calculated scour. Mahala PFT (August 17, 2017), p. 6. Mahala maintained his position that the timber pile array in Project I did not meet the performance standard because it will "cause scour of the coastal beach which will diminish the coastal beach's ability to provide storm damage prevention and flood control." Mahala PFT (August 17, 2017), p. 7.

Mahala was also critical of Bosma's reliance upon the project at Bayswater. The Bayswater project is adjacent to the Site. At Bayswater there is a structure on the bank that is comprised of terraced coir envelopes, similar to what is proposed here. Touching the seaward edge of the bottom envelope is an array of pilings, also similar to what is proposed in this case. The pilings were installed in what appears to be two rows of staggered pilings, like what is proposed in this appeal.[7] The projects differ, however, in that at Bayswater the front side of the landward row appears to be flush with the backside of the seaward row of pilings with approximately one-inch of space between the sides of the pilings in and between the rows. Marden PFT, Exhibit 8, 10.

Mahala was critical of Bosma's reliance on Bayswater because Bosma's purported supporting photographic evidence was almost exclusively from the spring and summer seasons when weather conditions are generally quiescent and favorable for accretion and not conducive to scour and erosion. Mahala PFT (August 17, 2017), p. 7. He also pointed out that Bosma's testimony that Superstorm Sandy in 2012 did not scour the beach is flawed because the observations were made two months after the storm when the site had been nourished with imported sediment. Mahala PFT (August 17, 2017), p. 8. Mahala also pointed out that Bosma's testimony demonstrated that wave energy reaching the bank during 1 and 5 year storm events would be reduced by 7 and 12%, respectively, resulting in less energy to naturally remove sediment from the coastal bank and coir envelopes. And he pointed out that Bosma did not model the wave energy reduction for any other frequency storms, such as the 25, 50, and 100 year storm events. Mahala PFT (August 17, 2017), p. 8. He emphasized: "It is now my opinion, [that] the proposed pile anchors [for Project I] will act to break up and reduce wave energy. That is, the proposed 12 inch timber pile anchors will function to reduce wave energy transmission to the coastal bank, thereby reducing the ability of waves to remove sediment from the coastal bank." Mahala PFT (August 17, 2017), p. 9.

Mahala added that during a storm event once the nourishment is removed and the beach sediment is depleted, in order to meet the performance standards for Coastal Banks, the "coir

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[7] There is no evidence in the administrative record addressing why the Bayswater project was approved by the Conservation Commission and apparently not challenged by MassDEP, the Petitioners in this case, or other parties.

envelopes and rolls need to be able to release additional sediment to replace sediment normally available from the coastal bank." Mahala PFT (August 17, 2017), p. 10. Mahala also opined that during a storm event the nourishment might be depleted but the piles may prevent a sufficient amount of wave energy from reaching the coir envelopes in order to "lose some integrity and release sand in a high energy storm event after surrounding sediments have been depleted." Mahala PFT (August 17, 2017), p. 10.

As a consequence, MassDEP issued the Amended SOC that denied the timber pile portion of Project I for failing to comply with the performance standards for coastal beaches. Mahala PFT (June 26, 2017), pp. 4, 6. The Amended SOC also approved the Project II post array designed by Mahala—a single row of 4-inch by 4-inch posts separated by 5 feet abutting the lowest coir envelope.

Project III. On remand, after the Applicants opposed the Project II single row of posts and Mahala reviewed additional research, MassDEP agreed to changes to the vertical pilings proposed as part of Project I, leading to Project III, which was embodied in a proposed Final Order of Conditions and a Monitoring and Maintenance Plan. See MassDEP's Status Report (including attachments) (March 26, 2018). The primary changes to Project I are the following: The diameter of each pile was reduced from 12 inches to 8 inches. The number of piles was reduced from 256 to 180. The separation between each pile within each row was increased from 2 feet on center to 2.5 feet on center, leaving a 22 inch opening between each pile in each row. However, because the pilings in the rows are staggered, each 22 inch opening is obstructed either by the pile in the row behind it or the pile in front of it. Thus, when both rows are viewed from the ocean on the perpendicular there are 7 inch spaces between each pile in the two rows. The diagonal distance between the piles in the two rows was increased from 8 inches to 11 inches.

The height of the piles above the beach was reduced from 5 feet to 4 feet. The piles will be embedded 10 feet below the surface of the beach. Bosma PFT, p. 18; Mahala PFT (June 1, 2018), pp. 3-4.

The nourishment and monitoring components of all projects included the following:

1. A layer of sand would be placed on top of the coir envelopes and fiber rolls.
2. The project would also include annual and additional as-needed beach nourishment through regular placement of sand on the bank and beach.
3. There would be ongoing maintenance and repair of biodegradable materials.

The proposed Final Order of Conditions and the Monitoring and Maintenance Plan include the following changes:

1. Requiring that the monitoring program be expanded to a quarterly and post-storm survey program, which was changed to more quickly identify potential impacts, provide an opportunity for mitigation to avoid future impacts, and identify impacts that cannot be mitigated.
2. Requiring that the monitoring program also include a beach profile 300 feet to the west to serve as a control point that would not be influence by the project.
3. Requiring "failure criteria" that if met, trigger additional nourishment obligations or actions. The base level annual nourishment amount is 200 cubic yards per property. The plan requires additional nourishment levels, up to a maximum of 800 cubic yards per year per property, as the following different triggering events are met: a primary condition exists when the beach drops 9 inches or more or the cross sectional area of monitoring profile is reduced by 1.4 cubic yards for the specified period of time; a secondary condition exists when the beach elevation

drops 12 inches or more, or the cross sectional area of the monitoring profile is reduced by 2 cubic yards for the specified period of time. There is *no* provision requiring removal of the pile array under any circumstances. Instead, MassDEP would have to initiate an enforcement action.

In addition, the polypropylene covering that was proposed for the coir envelopes (Tensar Geogrid TX190L) was been replaced with biodegradable netting fabricated from the same material as the coir envelopes. Mahala PFT (June 1, 2018), pp. 3-4. That was done because the synthetic wrap would effectively prevent the envelopes from releasing sediment under storm conditions. Mahala PFT (June 26, 2017), p. 12; Mahala PFT (August 17, 2017).

The Petitioners opposed Project III, and accordingly the parties filed pre-filed written testimony and I held an adjudicatory hearing at which the witnesses who filed testimony were cross examined.

WITNESSES

The following witness testified at the adjudicatory hearing on behalf of the Applicants:

Kirk F. Bosma. Bosma is a Senior Coastal Engineer and Team Leader at Woods Hole Group, Inc., an environmental consulting firm located in Falmouth and focused on coastal and oceanic environments. He is a licensed professional engineer. He has more than 20 years of experience in the field of coastal science and engineering. He received BS and MS degrees in civil engineering.

The following witness testified for DEP:

James Mahala. Mahala has been employed in the Wetlands Division of DEP since 1986, working as an environmental analyst. In 2015, he was appointed to serve as Section Chief of the Wetlands and Waterways Program in DEP's

Southeast Regional Office. Mahala has substantial experience relative to coastal geology, especially with respect to Cape Cod. He holds a BS degree in geology and an MS degree in coastal geology.

The following witness testified for the Petitioners:

John S. Ramsey. Ramsey is co-founder and Principal Coastal Engineer with Applied Coastal Research and Engineering, Inc., Mashpee, an engineering and consulting firm focused on developing and implementing solutions to problems in the marine and coastal environments. Ramsey holds a BS degree in civil and environmental engineering and MS degree in civil coastal engineering. He is a licensed professional engineer.[8]

THE BURDEN OF PROOF

As the party challenging the MassDEP's issuance of the Proposed Final Order of Conditions in this *de novo* appeal, the Petitioners have the burden of going forward by producing credible evidence from a competent source in support of their position. 310 CMR 10.03(2); see Matter of Town of Freetown, Docket No. 91-103, Recommended Final Decision (February 14, 2001), adopted by Final Decision (February 26, 2001) ("the Department has consistently placed the burden of going forward in permit appeals on the parties opposing the Department's position."). Specifically, the Petitioners were required to present "credible evidence from a competent source in support of each claim of factual error, including any relevant expert report(s), plan(s), or photograph(s)." 310 CMR 10.05(7)(j)3.c. So long as the initial burden of production or going forward is met, which it was, the ultimate resolution of factual disputes depends on where the preponderance of the evidence lies. Matter of Town of Hamilton, DEP

[8] To a limited extent, I refer in this decision to testimony from witnesses who testified in the first adjudicatory hearing and were identified in the RFD.

Docket Nos. 2003-065 and 068, Recommended Final Decision (January 19, 2006), adopted by Final Decision (March 27, 2006).

"A party in a civil case having the burden of proving a particular fact [by a preponderance of the evidence] does not have to establish the existence of that fact as an absolute certainty. . . . [I]t is sufficient if the party having the burden of proving a particular fact establishes the existence of that fact as the greater likelihood, the greater probability." Massachusetts Jury Instructions, Civil, 1.14(d).

The relevancy, admissibility, and weight of evidence that the parties sought to introduce in the Hearing were governed by G.L. c. 30A, § 11(2) and 310 CMR 1.01(13)(h)(1). Under G.L. c. 30A, § 11(2):

> [u]nless otherwise provided by any law, agencies need not observe the rules of evidence observed by courts, but shall observe the rules of privilege recognized by law. Evidence may be admitted and given probative effect only if it is the kind of evidence on which reasonable persons are accustomed to rely in the conduct of serious affairs. Agencies may exclude unduly repetitious evidence, whether offered on direct examination or cross-examination of witnesses.

Under 310 CMR 1.01(13)(h), "[t]he weight to be attached to any evidence in the record will rest within the sound discretion of the Presiding Officer. . . ."

DISCUSSION

I. The Project Includes A Prohibited Coastal Engineering Structure

When, as here, a coastal bank is determined to be significant to storm damage prevention or flood control because it supplies sediment to coastal beaches, coastal dunes, or barrier beaches, the regulations provide:

> (3) No new bulkhead, revetment, seawall, groin or other coastal engineering structure shall be permitted on such a coastal bank

> except that such a coastal engineering structure shall be permitted when required to prevent storm damage to buildings constructed prior to the effective date of 310 CMR 10.21 through 10.37 or constructed pursuant to a Notice of Intent filed prior to the effective date of 310 CMR 10.21 through 10.37 (August 10, 1978), including reconstructions of such buildings subsequent to the effective date of 310 CMR 10.21 through 10.37, provided that the following requirements are met:
>
> (a) a coastal engineering structure or a modification thereto shall be designed and constructed so as to minimize, using best available measures, adverse effects on adjacent or nearby coastal beaches due to changes in wave action, and
> (b) the applicant demonstrates that no method of protecting the building other than the proposed coastal engineering structure is feasible.
> (c) protective planting designed to reduce erosion may be permitted.
>
> (4) Any project on a coastal bank or within 100 feet landward of the top of a coastal bank, other than a structure permitted by 310 CMR 10.30(3), shall not have an adverse effect due to wave action on the movement of sediment from the coastal bank to coastal beaches or land subject to tidal action.

310 CMR 10.30 (emphasis added).

It is clear that paragraph 3 above was intended to grandfather buildings that were built prior to 1978. In that case, coastal engineering structures are allowed "when required to prevent storm damage to buildings," provided the other requirements are met. See 310 CMR 10.30(3)(a). A Coastal engineering structure is "required" for pre-1978 buildings only if there has been a showing that other measures that are less intrusive than coastal engineering structures (such as moving the building) are not feasible. Matter of Valovcin, Docket No. 97-028, Tentative Final Decision (March 12, 1998), adopted by Final Decision (September 29, 1998); Matter of Scott Glass, Docket No. WET 2009-040, Recommended Final Decision (April 1, 2011), adopted by Final Decision (April 26, 2011); 310 CMR 10.30(3)(a).

For all other coastal properties, such as those in this case where buildings were constructed after 1978 (here, the mid 1990s), the regulation contains an unequivocal prohibition on coastal engineering structures on the coastal bank. If that were not sufficient notice to property owners, the regulations also require that "[t]he Order of Conditions and the Certificate of Compliance for any new building within 100 feet landward of the top of a coastal bank permitted by the issuing authority under [the Wetlands Act] shall contain the specific condition [that] 310 CMR 10.30(3), promulgated under M.G.L. c. 131, § 40, requires that no coastal engineering structure, such as a bulkhead, revetment, or seawall shall be permitted on an eroding bank at any time in the future to protect the project allowed by this Order of Conditions." 310 CMR 10.30(5) (emphasis added).

Here, whether the project for the Applicants' post-1978 residences may be allowed depends on whether the project includes a coastal engineering structure. The regulations provide that coastal engineering structure "means, but is not limited to, any breakwater, bulkhead, groin, jetty, revetment, seawall, weir, riprap or any other structure that is designed to alter wave, tidal or sediment transport processes in order to protect inland or upland structures from the effects of such processes." 310 CMR 10.23 (emphasis added). It is undisputed in these appeals that the "effects of such processes" include the continued erosion of the coastal bank.

The prohibition on post-1978 Coastal engineering structures was enacted in 1978 when the Wetlands Regulations went into effect. Matter of M.J. Kiley, Docket No. 86-15, Final Decision (April 16, 1987). The purpose of the prohibition is to protect coastal banks as a sediment source; to avoid damage caused by erosion from coastal engineering structures; and to put the public on notice that post-1978 coastal construction cannot be protected with coastal engineering structures from the erosive forces of the sea. Transcript I, p. 350.

The regulatory prohibition focuses on the intent of the project, concentrating on whether the project was *designed* to alter wave, tidal, or sediment processes to protect the upland structure from erosion. Indeed, a MassDEP administrative law judge previously interpreted the ban on coastal engineering structures and stated in *dicta* that "banks that are eroding must be left free to erode, and structures that are designed to prevent or minimize erosion are not permitted." Matter of Warner, Docket No. 97-052, Decision on Motion for Partial Summary Decision (October 28, 1997), adopted by Final Decision (July 29, 1998). This clear prohibition should have steered post-1978 coastal development to those areas where the effects of the wave, tidal, or sediment transport processes are compatible with coastal development. In other words, in areas where the coastline is a highly erodible sediment source, the erosive effects of the wave or tidal processes are less likely to be compatible with development. In contrast, in areas where the effects of the wave, tidal, and sediment transport processes do not cause significant erosion, i.e. where the landform is not readily erodible (like sediment and sand), development is more compatible and coastal engineering structures would be unnecessary.

The drafters of the regulations wisely foresaw the problems that would arise from development in erodible coastal areas, particularly with rising sea levels, and they sought to steer and protect the public from building in those areas. Many surely heeded this legal and policy directive, avoiding development in erodible areas and perhaps even foregoing and sacrificing pursuit of development rights because the law barred structures to protect their properties, while others did not. Some that did not are now seeking protection from the sea's erosive forces despite the clear public directive, particularly as the sea rises at an ever increasing rate and coastal storms rage with increased ferocity.

In a recent decision to uphold strict limits on development on coastal dunes (which are not at issue here) DEP recognized the importance of the 1978 regulatory policy decisions and balancing coastal development with the larger public interest of protecting valuable resource areas that serve the public at-large, stating:

> While the impacts of a single pile-supported house seem dwarfed by the impacts of a major coastal storm, the integrity of the primary dune under and around structures may be compromised, diminishing the ability of the dune to serve as the first line of defense against storm damage. By placing limitations on new development, particularly on oceanfront lots with primary dunes, the regulations adopted in 1978 reflect a considered public policy of providing a high level of protection to dunes to preserve their natural functions for the public interests they serve. By restraining overall development along the coast and minimizing associated cumulative adverse effects, the coastal dune regulations avoid increased demands for public services to hazard-prone areas and promote public safety for both coastal and more inland property.

Matter of Peabody, Docket No. 2002-053, Final Decision (January 25, 2006).

In Peabody, DEP's then Commissioner also elaborated on why strict application of the regulations was important:

> In this case where new work is proposed on a currently undeveloped primary dune on a barrier beach, strict application of the regulatory standards is certainly appropriate. . . . The level of protection is established, in part, to take into account the cumulative effects of many similar projects that might otherwise be permitted if the impacts of a single project were considered in isolation. The stringency of the regulations for work on a primary dune on a barrier beach reflect a scientifically and policy based determination that limiting development of these areas serves the public interest by reducing public safety concerns and the economic consequences of storm damage and flooding.

Matter of Peabody, supra.

Standard of Review. My analysis is guided by the standard of review that the courts would apply in reviewing my decision if it were adopted as a Final Decision. In general, regulatory terms, like statutory terms, must be interpreted according to their plain, usual, and ordinary meaning. Language should generally not be implied if it is not present, absent a clear intent to the contrary. Courts generally accord an agency interpretation of its regulations considerable deference. However, courts will "not hesitate to overrule agency interpretations when those interpretations are arbitrary, unreasonable, or inconsistent with the plain terms of the regulation itself." Beverly Port Marina, Inc. v. Commissioner of Department of Environmental Protection, 84 Mass. App. Ct. 612, 620 (2013); accord Water Department of Fairhaven v. Department of Environmental Protection, 455 Mass. 740, 749-50 (2010) (court found agency exceeded statutory and regulatory authority); Warcewicz v. Dep't. of Environmental Protection, 410 Mass. 548, 574 N.E.2d 364, 365-66 (1991) (language should not be implied where it is not present and thus it was improper for agency to import a definition from one regulatory body into another); see also Matter of Sullivan, Docket No. WET 2011-013, Recommended Final Decision (May 31, 2011), adopted by Final Decision (June 22, 2011); Matter of Milton, Docket No. WET 2011-030, Recommended Final Decision (March 29, 2012), adopted by Final Decision (April 6, 2012). When the meaning of a regulation is not plain from its language, I am obligated to consider "the cause of its enactment, the mischief or imperfection to be remedied and the main object to be accomplished, to the end that the purpose of its framers may be effectuated." DiFiore v. American Airlines, Inc., 454 Mass. 486, 490 (2009), quoting Industrial Fin. Corp. v. State Tax Comm'r, 367 Mass. 360, 364 (1975).

The directive to apply the regulations' plain meaning is rooted in the rulemaking process for regulations. It is an elaborate process that is designed to ensure that the agency's regulations are in accord with the public interest and will. The final regulations embody the public sentiment of the Commonwealth on matters of public importance, enabling the agencies to implement and effectuate that public sentiment. The primary duty in interpreting regulations, like statutes, is to effectuate the underlying intent, in accordance with the above interpretative principles. See G.L. c. 30A; Finkelstein v. Board of Registration in Optometry, 370 Mass. 476, 478 (1976). "[O]nce [an agency] exercise[s] its power to promulgate regulations, [it] may not infinitely manipulate or expand their content." Warcewicz, at 552 (citing Finkelstein v. Board of Registration in Optometry, 370 Mass. 476, 478 (1976)).

Applying the Plain Meaning. The Applicants assert that the array of pilings is integral to Project III. Throughout the adjudicatory proceedings the Applicants have denied that the pile array is a coastal engineering structure. Instead, they have asserted that the pilings are designed as an "anchor" for the coir envelopes. The Petitioners have asserted that it is a coastal engineering structure, contending that it falls squarely within the definition of a coastal engineering structure. I agree with the Petitioners. In fact, the pile array in Project III is a coastal engineering structure for three separate and independent reasons.

First, the pile array satisfies the plain meaning of the terms that comprise "coastal engineering structure." I begin with the two most used terms, even though they are further refined in the definition itself—engineering and structure. There is nothing ambiguous about the definitions for these terms as applied here. "Engineer" means to "plan, construct, or manage as an engineer" or "to design or create using techniques or methods of engineering."[9] It is undisputed that the pile array was planned, designed, and created by engineers using engineering methods to re-engineer the bank. The array of pilings thus meets the engineering element.

"Structure" is defined as a "mode of building, construction, or organization" or an "arrangement of parts, elements, or constituents" or "something built or constructed, as a

[9] engineer. Dictionary.com. *Dictionary.com Unabridged.* Random House, Inc.http://www.dictionary.com/browse/engineer (accessed: October 28, 2016).

building, bridge, or dam."[10] See also Munroe PFT, p. 4. Here, the pile array is a relatively complex "arrangement of parts, elements, or constituents" designed by the Applicants' engineers. It is something built or constructed with a specifically engineered design. It is therefore a structure. The project is also located on the coast, specifically the coastal bank as part of a larger project to reengineer the coastal bank. As a consequence, the project is a coastal engineering structure based upon the common meaning of those terms.

Second, the pile array is also a coastal engineering structure because it is at least one of the specifically named examples in the definition ("breakwater, bulkhead, groin, jetty, revetment, seawall, weir, riprap"). It meets the definitions of breakwater, bulkhead, and seawall. These are the types of structures that MassDEP and the Applicants have referred to as unequivocally prohibited "hard structures."

Breakwater is defined as "a barrier that breaks the force of waves, as before a harbor."[11] It is also defined as "An offshore barrier, such as a jetty, that protects a harbor or shore from the full impact of waves."[12] There is no genuine dispute in these appeals that the pile array is a barrier that "breaks the force of waves" and "protects . . . [the] shore from the full impact of waves." In fact, Ramsey persuasively testified that the piles are extended above the beach elevation solely to act as a "breakwater." Ramsey Rebuttal PFT, p. 11. "[T]he intended function of the timber pile array is not to anchor anything but instead to act as a structure to disrupt wave and tidal energy before it reaches the coir envelopes," thus a breakwater. Ramsey PFT, p. 5. Ramsey added, as discussed in detail below, that the Applicants even employed a flawed engineering analysis as "an attempt to justify the use of a dense pile array in front of the project

[10] structure. Dictionary.com. *Dictionary.com Unabridged.* Random House, Inc.http://www.dictionary.com/browse/structure (accessed: October 28, 2016).
[11] Dictionary.com Unabridged Based on the Random House Unabridged Dictionary, © Random House, Inc. 2019
[12] The American Heritage® Science Dictionary Copyright © 2011. Published by Houghton Mifflin Harcourt Publishing Company. All rights reserved.

to serve as a shore protection structure," i.e., a breakwater, bulkhead, or seawall. Ramsey Rebuttal PFT, pp. 15-16. Mahala testified without an explanation that he does not believe the pile array is a breakwater. Transcript II, pp. 253. I do not accept Mahala's conclusory testimony because there was no supporting explanation and because the plain meaning of the term breakwater is controlling.[13]

Bulkhead is defined as "a retaining structure of timber, steel, or reinforced concrete, used for shore protection and in harbor works."[14] The pile array is a wood retaining structure that helps retain the bottommost coir envelope and it protects the shore from the full force of the waves and tides.

Seawall is defined as "a strong wall or embankment to prevent the encroachments of the sea, serve as a breakwater, etc."[15] "Wall" is defined "as any of various permanent upright constructions having a length much greater than the thickness and presenting a continuous surface except where pierced by doors, windows, etc.: used for shelter, protection, or privacy, or to subdivide interior space, to support floors, roofs, or the like, to retain earth, to fence in an area, etc."[16] The pile array is a wall that "prevents the encroachment of the sea, serve[s] as a breakwater, etc." and is "pierced" by uniform spaces to allow the passage of some sediment and seawater.[17]

[13] Conclusory statements, unsupported by a factual basis, lack probative value. See Matter of Cheney, Docket No. 98-096, Final Decision (October 26, 1999); Matter of McNiff, Docket No. 2011-016, Recommended Final Decision (July 25, 2013), adopted by Final Decision (July 31, 2013).

[14] Dictionary.com Unabridged Based on the Random House Unabridged Dictionary, © Random House, Inc. 2019

[15] Dictionary.com Unabridged
Based on the Random House Unabridged Dictionary, © Random House, Inc. 2019

[16] Dictionary.com Unabridged
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[17] Mahala previously provided a conclusory statement that the "proposed project," which included all components of the project, is "not one of the listed structures," without separately analyzing whether the pile array itself is one of the listed structures. Mahala PFT (July 1, 2016), p. 3.

The above three structures have a common thread in their definitions—they are all designed to protect the shore, in one way or another, and to alter the forces of the waves and the sea that threaten and erode the shore. That the regulation provides an absolute prohibition for each of these structures *without* regard to whether they comply with the performance standards evinces an unequivocal regulatory intent to prohibit these structures and those like them, i.e., those that were designed to protect the shore. This dovetails with the last component of the coastal engineering structure definition and the last reason why the pile array is a coastal engineering structure.

Third, the pile array is a coastal engineering structure because it is encompassed within the extremely broad and unequivocal catchall provision of the definition. That is, the definition includes the above examples, and then expounds upon the examples as including, "without limitation," "any other structure that is designed to alter wave, tidal or sediment transport processes in order to protect inland or upland structures from the effects of such processes," i.e., erosion. 310 CMR 10.23 (emphasis added). The regulatory focus on the design, or intent, of the structure is noteworthy. Instead of limiting the definition to specific structures that were used at the time to protect the shore, the drafters foresaw that such structures could evolve or change overtime, and thus the definition would be under-inclusive. Thus, they added the catchall prohibition on any other structure designed for the same reasons as the specifically named structures—namely, to alter the forces of the sea to protect upland areas from coastal erosion. Here, an overwhelming preponderance of the evidence demonstrates that the pile array is designed to alter wave or tidal processes in order to protect the Applicants' upland properties from coastal erosion.

I begin with the relatively obvious definition of "alter," which means: "to make different in some particular, as size, style, course, or the like; modify" or "to change; become different or modified."[18] The remaining analysis turns on whether there is a preponderance of the evidence showing that the structure is "*designed* to alter wave, tidal, or sediment transport processes in order to protect" (emphasis added) the Applicants' residences from the continued erosion of the coastal bank.

There are several reasons why a preponderance of the evidence shows that the pile array is designed to alter wave or tidal processes to protect the properties from erosion. Those reasons are rooted in the Applicants' insistence that the piles be within a certain distance of one another and that the pile height extend a significant distance above the level of the beach—the Project I piles extended five feet above the beach and the Project III piles are proposed to extend four feet above the beach.

The Elevated Pile Height Serves No "Anchoring" Purpose. In the first adjudicatory hearing the Applicants contended that the purpose of the pilings for Project I was to "anchor" the coir envelopes. The Applicants repeated that purported justification for the piles in Project III. That explanation, however, lacks credibility and I attach no weight to it; quite simply, there is no valid explanation, engineering or otherwise, for the "anchors" to be elevated five, or even four, feet above the level of the beach in order to serve as anchors.

The purported "anchoring" function of the piles actually works when they touch the lowest coir envelope and retain, or hold, it in place in the bank. Stated differently, the piles prevent the lowest coir envelope from sliding or slumping seaward. However, the only part of the pilings that touches and thus serves to anchor, or hold in place, the coir envelopes is the very

[18] alter. Dictionary.com. *Dictionary.com Unabridged.* Random House, Inc. http://www.dictionary.com/browse/alter(accessed: November 16, 2016); see also 310 CMR 10.04 (defining alter with respect to wetlands resource areas).

lowest portion of the pilings that is in contact with the lowest coir envelope. That contact point is at or below the beach surface. The remaining length of the pilings rises vertically from the beach, while the proposed coir-envelope bank would be sloped significantly landward away from the vertical pilings, up to the top of the bank. The remaining aboveground portions of the pilings rise above the beach surface with *no* forces from the coir envelopes being exerted on them. Thus, the portion of the pilings above the point of contact with the lowest coir envelope serves no anchoring function for the envelopes.

The Applicants' anchoring argument is further eroded by the fact that it is only the landward row of pilings that would make contact with the bottom coir envelope. The seaward row would make no contact and thus serve no anchoring function.

These findings are fully supported by the administrative record. On remand, the MassDEP witness, Mahala, was critical of the Applicants' asserted anchoring explanation for Project I. He asserted that the seaward row of pilings and the elevated height of the landward row of pilings were *unnecessary* to anchor the system. Mahala PFT (August 17, 2017), p. 10. Thus, he testified that the project could employ only the landward row of pilings and with only a small portion of the pilings exposed above the beach level in order to "anchor the coastal bank stabilization system while *minimizing* wave and current interactions with the pilings." Mahala PFT (August 17, 2017), p. 10, Ex. 1 (emphasis added). Mahala testified that this is the "first time" he has seen an "engineering justification for the necessity of using closely spaced large diameter pilings to hold the toe of a bank stabilization system." Mahala PFT (August 17, 2017), p. 10. He has "reviewed several other sand-filled coir envelope and geotextile coastal bank stabilization projects where pile anchors were not incorporated into the design or small diameter posts were utilized." Mahala PFT (August 17, 2017), p. 10. He testified that the pile array will "act to reduce wave energy transmission such that there may not be sufficient energy to allow the coir envelopes to lose some integrity and release sand in a high energy storm event after surrounding sediments have been depleted." Mahala PFT (August 17, 2017), p. 10.

Mahala also attached several photographs of other projects with coir envelopes installed in the bank, and he noted that in each photograph there were no pilings standing vertically above the beach four or five feet, purportedly to anchor the envelopes. Mahala PFT (August 17, 2017), Ex. 1. Instead, if there were posts deployed as "anchors," they were significantly smaller (4 inch by 4 inch), spaced significantly farther apart (approximately 5 feet), and extended no farther than a few inches above the elevation of the beach. In fact, often no posts are used, and the envelopes are instead held in place by gravity, friction, and cables that are tied into the base of the bank. But to be clear, pilings or posts may be used as anchors as part of a soft solution as long as they are not designed to alter wave, tidal, or sediment transport processes and are appropriately spaced and elevated to actually anchor the envelopes, and they otherwise comply with the performance standards (as discussed below).

Mahala testified at the hearing concerning the Project III pile array that he still questions the anchoring function and does not believe that the portion of the piles above the lowest coir envelope serve any weight bearing function. Transcript II, p. 249, 255, 260. He added that the pilings are a *hard element* in the design and that they are *designed to diminish wave energy*. Transcript II, p. 251-52, 259.[19]

Ramsey, a highly qualified and experienced coastal engineer and licensed professional engineer based on Cape Cod, corroborated Mahala's criticism of the pile height as an "anchor."

[19] Mahala later testified that he does not believe the pilings are a coastal engineering structure because he believes they are spaced far enough apart and thus purportedly comply with the performance standards. Transcript II, pp. 251-52. This perspective of Mahala has no support in the regulations and the unequivocal regulatory prohibition; and, as discussed below, it is not supported by the administrative record—the pilings are not adequately spaced and will not comply with the performance standards.

Similar to Mahala, he testified that if the piles are indeed intended for anchoring, they do not need to extend any higher than the lowest coir envelope, and there is no need for two rows (the seaward row serves absolutely no anchoring function). Ramsey PFT, pp. 5, 14. Ramsey credibly testified that the exposed portions of the piles extending above the beach do not stabilize any portion of the system and are unnecessary to support the system components. Ramsey Rebuttal PFT, pp. 11, 20. As Ramsey persuasively points out, based upon the Applicants' Exhibit 19 showing the angle of repose of the proposed bank, all loads on the bank would be distributed under the ground surface and no structural measures would be necessary to stabilize the bank slope. Ramsey Rebuttal PFT, p. 21. Ramsey has never seen piles used to "anchor" coir envelopes in this manner. Typically cables are used to anchor the system into the bank. Transcript II, pp. 133-35.

Bosma purported to address Ramsey's and Mahala's criticism by performing a loading analysis for the piles in Project III. He testified that his calculations show what is necessary to provide adequate bearing (loading) capacity while minimizing deflection toward the beach. Bosma PFT (May 25, 2018), p. 24. Bosma's response is not persuasive. First, he purported to use a computer program to calculate the load on the pilings, but provided insufficient information regarding the input parameters, making it "impossible to decipher." Ramsey Rebuttal PFT, p. 21. He did not provide "any appropriate description of the various diagrams, input, or output parameters that would allow for review of the information." Ramsey Rebuttal PFT, p. 21.

Second, Ramsey persuasively testified that although Bosma's "calculations included the weight of the sand in the coir envelopes, the weight of the bank above the envelopes, and the weight of sand covering the envelopes, *none* of this weight would act on the above-ground portion of the piles." Ramsey PFT, p. 14 (emphasis added). In fact, it is not physically possible for those loads to exert any force on the aboveground portions of the pilings that have no contact with the coir envelopes. Id.

Ramsey corroborated this position with photographs of the Bayswater site showing nothing but space between the envelopes and the aboveground portion of the pilings. That space (or distance) increases as elevation increases because the bank angles landward, while the piles remain vertical. Ramsey PFT, p. 13, Ex. JR-6; Bosma PFT, Ex. 12.

Bosma's own prior contradictory testimony supports Ramsey's position. Bosma testified on remand that the "anchor spacing and configuration will hold the *toe* of the stabilization system in place ..." Bosma PFT (July 25, 2017), p. 5 (emphasis added). Later, he added that Mahala's proposed anchoring alternatives with 4 inch by 4 inch posts five feet apart were "inadequate to serve the intended anchoring purpose, which is to provide *toe* support at the base of the slope and stabilize the overall project." Bosma PFT (July 25, 2017), p. 16 (emphasis added). Bosma's failure to mention previously anything but the toe as needing support further impeaches his testimony.

Ramsey persuasively concluded that "Bosma's loading analysis provided in his [pre-filed testimony] was simply wrong and was an attempt to justify the use of a dense pile array in front of the project to serve as a shore protection structure." Ramsey PFT, pp. 15-16. Ramsey added based upon sound principles of engineering that: "Mr. Bosma's inability to provide appropriate engineering loading calculations to justify the specifics of 'anchoring' design further demonstrates that the purpose of the pile array is not to 'anchor' the coir envelope system, but rather to serve as a coastal engineering structure that attenuates wave energy." Ramsey PFT, p.

16. Ramsey added that the piles are extended above the beach solely to act as a "breakwater." Ramsey Rebuttal PFT, p. 11.

The Petitioners' prior engineering expert for the first adjudicatory hearing also credibly testified that there is no design supporting how the elevated piles serve as anchors. Munroe Rebuttal PFT, p. 6. In his experience, coir envelopes generally do not have this type of "anchor." The coir envelope assembly is a "gravity design, meaning the weight of the sand filling the coir envelope holds the envelopes in place." Munroe Rebuttal PFT, pp. 6-7.

The Elevated Pile Height Undermines the Applicants' Position. The administrative record contains other information further refuting Bosma's assertions, showing instead that the piles are designed to disrupt and weaken wave and tidal forces to protect upland property from erosion. For example, Bosma's calculations of the appropriate "safety factor" for the piling array have changed over time, as the purported anchoring function of the piles has come under increased scrutiny. The "safety factor" is, generally speaking, a measure in the engineering industry of how strong a structure should be to ensure an adequate margin of safety. That is partially dependent upon the weight of the load being supported and the consequences of failure. Ramsey Rebuttal PFT, p. 22. Here, Ramsey opined that because the elevated portions of the piles above the toe support no load and there are no consequences from their failure, the safety factor for the elevated portions of the pilings is unnecessary.

Bosma's safety factor analysis has varied as the elevated pile height has come under scrutiny. Previously, with respect to Project I Bosma was satisfied with a safety factor of 1.5; that number is the engineering industry's standard safety factor for a "solid pile wall." Ramsey Rebuttal PFT, pp. 21. Subsequently, Bosma's safety factor for Project III increased dramatically to approximately 4.2. It is not entirely clear what caused the safety factor to increase so substantially but it appears that Bosma decided to account for the entire load that the coir envelope bank would purportedly place on the elevated pilings, even though as discussed above, the bank will place no load on the elevated pilings above the point of contact with the lowest coir envelope. Ramsey Rebuttal PFT, pp. 21-22.

As the elevated pile height continued to come under more intense scrutiny with Project III, the Applicants elaborated upon another purported justification for the extended pile height. Bosma asserted for Project III that the piles are designed to be significantly above grade to hold the unconsolidated nourishment in a "similar way as the natural coastal bank (the steep angles of the bank are greater than the natural angle sand is able to maintain) and allow transfer of this nourishment material at a similar rate to the erosion of the natural bank. When nourishment occurs sediment is intended to be filled over the top of the piles . . . ." Bosma PFT, p. 25.

There are a number of reasons why this position lacks merit. First, I find that the Applicants' "anchoring" argument and testimony are so lacking in a supportable evidentiary foundation that the persuasiveness of subsequent positions regarding pile height is seriously impaired.

Second, Bosma provided no analysis or evidentiary foundation supporting his statement that the piles will operate as stated ("similar . . . [to] the natural coastal bank . . . [and] allow transfer of this nourishment material at a similar rate to the erosion of the natural bank"). As Ramsey credibly opined, Bosma's testimony is based on speculation and conjecture; and it is in fact undermined by the Bayswater project. Ramsey Rebuttal PFT, p. 22. Indeed, the Bayswater pilings, which are spaced significantly closer together, retain some nourishment on the bank but only for a brief period of time. Because the mean high tide is relatively high in the area of Bayswater and the Site, high tides frequently interact with the pilings on a regular basis causing the nourishment to leave the bank relatively quickly, and not just during storms. Ramsey Rebuttal PFT, pp. 18-19.

Ramsey demonstrated with photographs of Bayswater that storms rapidly erode the sand off the lower coir envelopes during the initial part of the storm leaving nothing to infill scour and erosion, in contrast to the natural bank. Ramsey Rebuttal PFT, pp. 24, 26, 27-28 (citing Bosma PFT, Ex. 12). After that, the coir envelopes prevent the release of sand from the bank, precluding it from acting as a sediment source. Id. Further, lower energy storm events will be inhibited from reaching the bank by the piles, preventing the release of sediment from the bank and causing waves to reflect off the piles and scour the beach. Ramsey Rebuttal PFT, p. 24.

Third, and more importantly, Bosma's speculation and conjecture is further undermined by the specific design for the Project III pilings. The pilings at Bayswater were improperly installed in roughly a single row with approximately one inch of space between each pile. Given that installation flaw with very small gaps between pilings, it is thus understandable how those pilings retain some nourishment on the bank for at least a limited period of time. In contrast, the Project III pilings are proposed to be in two staggered rows, with four inches separating each row. The most landward row, the one that will supposedly retain nourishment on the steep bank will have a 22 inch opening between each 8-inch diameter pile. The diagonal distance between the piles in the two rows was increased from 8 inches to 11 inches. Because the pilings in the two rows are staggered, each 22 inch opening is obstructed by the pile in the row in front of it. Thus, when both rows are viewed on the perpendicular there are 7 inch spaces between each pile in the two rows.

There is no evidence in the administrative record demonstrating how, if at all, this design will provide *any* retention for nourishment on the bank to be meted out as the waves infiltrate the piling array. In fact, because the spaces between the piles are so large, it is unclear how, if at all, the array will retain the nourishment even without the frequent wave interaction. Although Bosma purported to rely on modelling software, that software is not capable of analyzing the degree to which the piling array is able to withhold (if at all) the sand nourishment when it is initially deposited behind the pilings. Transcript II, pp. 205-207. Instead it measures the degree to which the waves are able to remove sand from the bank itself with and without the piles. Transcript II, pp. 208-213.

At the hearing under cross examination, Bosma, made a number of key concessions that further weakened the Applicants' position. He admitted he has no way of knowing how well the Project III pile array will retain the nourishment on the bank. Transcript II, p. 214. There is no design or evidence to show whether or how it will work; thus, while Bosma may contend the piles are supposed to retain sediment, there's no evidence they were designed for that purpose. Bosma's position is therefore unpersuasive. Further weakening the Applicants' case, Bosma also admitted that the part of the pilings that is elevated above beach serves no purpose other than attempting to have them retain nourishment on the bank, the same purpose for which there is no supporting design. Transcript II, pp. 233-34. Bosma admitted that the forces on the bank are not being applied to the four feet of the pile extending above the beach. Transcript II, pp. 166-67. He also admitted that the piles reduce the wave energy that ultimate reaches the bank, a point for which there is no general dispute in the record. Transcript II, pp. 189-192. And he testified that relative to coir envelopes the piles are a hard structure. Transcript II, pp. 147-48.

What is left then, by Bosma's own preceding admissions and the discussion above, is that the pile array is designed as a hard structure that attenuates wave energy that reaches the bank, landing the array squarely within the definition of a coastal engineering structure.

Bosma's last assertion is that the pile array is not a coastal engineering structure because the piles are all seaward of the toe of the coastal bank and therefore the coastal engineering structure prohibition does not apply. Bosma PFT (May 25, 2018), p. 26. This position lacks merit for several reasons. First, Bosma's position is incorrect. The landward row of piles would be embedded 10 feet into the ground as part of the toe of the bank, touching and supporting that toe, and thus making it a part of the bank. See Matter of Warner, Docket No. 97-052, Decision on Motion for Partial Summary Decision (October 28, 1997), adopted by Final Decision (July 29, 1998) (pilings that were part of a coastal engineering structure touched the bank and thus were part of the bank).[20]

Second, the Applicants have repeatedly asserted that the pilings are an inseparable and integral part of the bank stabilization structure, which includes the coir envelopes. As such, they are part of the proposed coir envelope bank, and thus governed by the prohibition of coastal engineering structures. Ramsey Rebuttal PFT, p. 23.

Third, the definition of coastal beach also evidences that the piling array is part of the bank, and not the beach. It provides that a coastal beach means "unconsolidated sediment subject to wave tidal and coastal storm action which forms the gently sloping shore of a body of salt water and includes tidal flats. Coastal beaches extend from the mean low water line landward to the dune line, coastal bank line or the seaward edge of existing human-made structures, when these structures replace one of the above lines, whichever is closest to the ocean." 310 CMR 10.27(2). The pilings would "replace" the "coastal bank line" creating a point where the beach will terminate because it will no longer be a "gently sloping shore" of

[20] The IRD previously distinguished Warner because it did not address soft solutions and because it resolved whether the applicant was entitled to the pre-1978 exemption to the coastal engineering structure prohibition. IRD, p. 7, n. 3. I, however, rely upon it here because the determination that the structure was part of the bank if a piling touched the bank was necessary to the decision and is relevant to these appeals.

"unconsolidated sediment." Thus, the most seaward edge of the pilings is the landward edge of the beach, and the pilings are thus a part of the bank, not the beach.

For all the above reasons, I find that there is a preponderance of the evidence that the pile array is designed to be elevated four feet above the surface of the beach to alter, diffuse, and attenuate the wave and tidal forces in order to protect the upland properties and the buildings on them from coastal erosion. Although the Applicants endeavored to show that the elevated pile heights were for alternative purposes, those attempts did not stand up to scrutiny; instead, the pilings are designed to alter the sea's erosive forces to protect upland buildings. As such, the pile array constitutes a prohibited coastal engineering structure.[21]

II. <u>The Project Does Not Comply With Performance Standards For Coastal Beach</u>

A. <u>Introduction</u>

The gentle slope, permeability, and granular nature of coastal beaches dissipate wave energy, which permit changes in beach form in response to changes in wave conditions. These functions and characteristics serve the purposes of storm damage prevention and flood control by dissipating wave energy, reducing the height of storm waves, and by providing sediment to supply other coastal features, including coastal dunes, land under the ocean and other coastal beaches. Coastal beaches serve as a sediment source for dunes and subtidal areas. 310 CMR 10.27(1). "Interruptions of these natural processes by human-made structures reduce the ability of the coastal beach to perform these functions." 310 CMR 10.27(1).

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[21] Ramsey also validly testified that "even if the pile array were not a prohibited 'coastal engineering structure,' it would be subject to 310 CMR 10.30(3)(a), which requires a project to 'minimize, using best available measures, adverse effects on adjacent or nearby coastal beaches due to changes in wave action,' and 310 CMR 10.30(3)(b), which requires the applicant to demonstrate 'that no method of protecting the building other than the proposed coastal engineering structure is feasible.'" Ramsey PFT, p. 4. Ramsey concluded that the structure does not use best available measures to minimize adverse effects on the adjacent beach due to changes in wave action and there are feasible methods of protecting the applicants' buildings other than adding this timber pile array to the project.

When, as here, the coastal beach is determined to be significant to storm damage prevention or flood control, the following characteristics are critical to the protection of those interests: "(a) volume (quantity of sediments) and form; and (b) the ability to respond to wave action." 310 CMR 10.27(1). Under these circumstances, the performance standards provide, in relevant part, the following: "(3) Any project on a coastal beach, except any project permitted under 310 CMR 10.30(3)(a), shall not have an adverse effect by increasing erosion, decreasing the volume or changing the form of any such coastal beach or an adjacent or downdrift coastal beach." 310 CMR 10.27(3).

The Petitioners contend that the project will adversely impact the beach when waves and currents deflect from the pilings onto the beach, causing erosion and scour and changing the form and volume of the beach. It is well beyond genuine dispute that there will be substantial deflection and refraction of waves and currents from the pilings onto the beach; the ultimate question, however, is how that will impact the beach. The Petitioners support their position with Ramsey's expert testimony, exhibits, and research literature. MassDEP and the Applicants dispute that the waves deflecting off of the pilings will cause significant erosion, arguing that the performance standard will not be breached because any impacts will be minimal and not arise to an "adverse effect," as defined by the regulations: "Adverse Effect means a greater than negligible change in the resource area or one of its characteristics or factors that diminishes the value of the resource area to one or more of the specific interests of M.G.L. c. 131, § 40, as determined by the issuing authority. Negligible means small enough to be disregarded." 310 CMR 10.23. Like the Petitioners, MassDEP and the Applicants also rely upon research literature, in addition to Mahala's expert testimony and Bosma's expert testimony and forecasting formulas and modelling analyses.

B. **<u>Scour and Erosion Overview, Foundational Principles, and Significant Variability in Effects</u>**

Whenever a hard vertical surface, like an array of large, closely-spaced wood pilings, is introduced into the natural coastal environment, concerns necessarily arise over the increased potential for significant erosion and scour of the surrounding environment. When moving water strikes a hard surface, whether natural or anthropogenic, or is channeled through narrow passages, the resulting increased velocity of the water and its refraction, diffraction, and reflection tend to increase the localized rates of scour and erosion. Bosma PFT, p. 5. Local scour is generally known as the "lowering of the bed in the direct vicinity of a structure due to local accelerations and decelerations of the near bed-velocities and the associated turbulence (vortices) leading to an increase of the local sand transport capacity." Ramsey PFT, Ex. 2 (van Rijn, 2013).

"Scour effects [generally] increase with increasing flow velocity and turbulence, and with increasing soil erodibility. . . . Scour effects are generally localized, ranging from small, shallow conical depressions in the sand around individual piles to larger and deeper depressions around individual piles, to a building sized shallow depression around a *group of piles*, to a large and deep depression around a building foundation."[22] (emphasis added) Some scour effects may be as deep as 6 to 10 feet deep, although, in some instances, underlying concrete slabs or deep grade beams may have contributed to that depth.[23]

The research literature, however, demonstrates that with large wood piles, like those proposed in these appeals, it is generally exceedingly difficult to predict the amount of erosion that will result with any reliable degree of precision. Some erosion and scour will indisputably

[22] Mahala PFT (June 26, 2017), Ex. 4, Erosion, Scour, and Foundation Design, FEMA (January 2009).
[23] <u>Id</u>.

occur; the question is how much? "The controlling factors of scour morphology are *not* fully known because of a lack of comprehensive research on wave-induced scour and the inherent complexity of the problem, including interactions among waves, structures, sediment transport and the seabed." Mahala PFT (June 26, 2017), Ex. 2, S. Umeda, Scour Regime and Scour Depth around a Pile in Waves (2011). There are "significant discrepancies" among the scour research results *even when* the data are obtained in the same laboratory experiment. Id. Scour induced by waves generally leads to significantly different scour results than scour induced by currents. Id. Another problem is that experimental laboratory tests often do not translate well to results in the field. Ramsey Rebuttal PFT, Ex. 1 (Hotta and Mauri).

Other research also suggests that the interaction of waves and currents on pile groups is "highly complex and depends on flow characteristics (depth, velocity, and direction), wave conditions (wave height, period, and direction), structural characteristics (pile diameter and spacing) and soil characteristics."[24] Additional research indicates the main variables are generally pile diameter, water depth, wave characteristics, flow velocity, the Keulegan-Carpenter number, and the gap distance between piles.

It is generally understood, however, that when piles reach a certain minimum distance from each other they tend to act as a single pile equal to the diameter of the two piles together.[25] Scour depth from waves and currents for pile groups generally increases from a single pile as much as two times more than its magnitude for the case of a single pile, depending on the group configuration and gap between piles.[26]

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[24] Mahala PFT (June 26, 2017), Ex. 3, Coastal Construction Manual, Principles and Practices of Planning, Siting, Designing, Constructing, and Maintaining Residential Buildings in Coastal Areas (Fourth Edition), FEMA P-55/Volume II/August 2011 (citing Sumer et al. 2001).
[25] Mahala PFT (June 26, 2017), Ex. 3, Y Mostafa, et al., Scour Around Single Pile and Pile Groups Subject to Waves and Currents (2011).
[26] Id.

Scour may also vary significantly with geography and local conditions. Very significant post-hurricane scour is "widespread" along the Gulf of Mexico shoreline in eastern Texas and southwestern Louisiana but only occasionally along the Gulf shoreline in Alabama and Florida. It has also been observed occasionally on the North Carolina barrier islands and American Samoa. Thus, some "geographic areas are more susceptible than others, but . . . it can occur at any location where there is a confluence of critical soil, flow, and wave conditions."[27] As a consequence, it is difficult to determine whether scouring will occur consistent with a forecasting equation developed from one location or set of conditions to another.[28]

To add another layer of unreliability and complexity onto the above, Bosma, the Applicants' expert, admitted that the research upon which he relied analyzed conditions different from those in these appeals; he testified that because there are no specific case studies of pile anchors at the base of a coastal bank, like Project III, he utilized a variety of studies and calculations. Bosma PFT, p. 6, n. 3. In light of this and the above discussion of unreliability and variability in this subject area, one must be highly skeptical of forecasts or predictions of how the pile array in Project III will impact the surrounding environment.

C. Evidence Concerning the Project

Forecasting Formulas Based On Published Studies. The Applicants' expert witness, Bosma, used empirical data and the resulting forecasting equations from published studies to calculate the maximum potential extent of localized scour around the piles. Bosma PFT (May 25, 2018), pp. 5-7. He stated that his analyses used "site-specific conditions" to evaluate the project's near-bed flow conditions and pile spacing. For the input data he used 8 inch piles, a

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[27] Mahala PFT (June 26, 2017), Ex. 3, Coastal Construction Manual, Principles and Practices of Planning, Siting, Designing, Constructing, and Maintaining Residential Buildings in Coastal Areas (Fourth Edition), FEMA P-55/Volume II/August 2011 (citing Sumer et al. 2001).
[28] Id.

gap ratio of 2.75, and 11 inches spacing on the diagonal. He estimated scour for 1-year, 10-year, and 100-year storm conditions. Bosma PFT (May 25, 2018), pp. 5-7. The gap ratio was calculated by dividing the space between each pile in the row (22 inches) by the pile diameter (8 inches). Based upon that formula the gap ratio of Project III was 2.75, while the gap ratio for Project I was 1. Bosma PFT (May 25, 2018), p. 4. Bosma testified that this increased the overall porosity from 50% to 79%. Porosity was calculated by dividing the total void space of the area by the total area. Bosma PFT, pp. 4, 20. He testified that he used the standard definition of porosity for any medium, which is a measure of void space relative to solid space. Transcript II, p. 194.

Bosma concluded that the estimated scour for the project ranges from .35 feet in a 1 year storm to a maximum of 1.15 feet during a 100 year storm. Bosma PFT (May 25, 2018), p. 7, Ex. 3. He testified that with the project he believed that any scour would be short lived and would not adversely affect the beach. Id. He opined that these calculations likely overestimate the scour and, in fact, scour may not occur at all due to the proximity of the piles to the coastal bank sediment source, and his prediction that nourishment would be released from the bank and fill any scour holes as water returns from the coastal bank with sediment to the sea (assuming the water reaches the coastal bank and there is nourishment on it). Bosma PFT (May 25, 2018), p. 8. In contrast, the piles in the studies were located in areas with similar grades on all sides of the piles, as opposed to having a coastal bank on the landward side. Bosma PFT (May 25, 2018), p. 8.

Ramsey was critical of Bosma's approach to forecasting the amount of resulting erosion, and this testimony persuasively undermines the credibility and weight I attach to Bosma's testimony. First, Ramsey asserts that the research relied upon by Bosma, with the exception of one study (Hotta and Mauri, 1976), was all performed in deep water *outside* of the surf and swash zones on low lying beaches, which is precisely where the project will be located, and where the impact of waves and turbulent water would be expected to lead to more erosion. Ramsey Rebuttal PFT, pp. 16-17, Ex. 1. Indeed, breaking wave conditions, such as those in the surf zone, are highly turbulent. When these waves strike a hard structural bank wave energy increases and will exacerbate scour and erosion. Ramsey PFT, p. 8.

Thus, Ramsey correctly believes that Bosma's conclusions do not account for erosion created by wave reflection or wave-related phenomena associated with the piles being located in those zones during storm conditions and typical energetic high tide conditions. Ramsey PFT, p. 3. Bosma testified that the Hotta and Mauri (1976) study was conducted in the surf zone, but Ramsey justifiably disagrees because the article never states that the experiment was conducted in the surf zone nor describes the characteristics of that zone. Bosma PFT, p. 19; Ramsey Rebuttal PFT, pp. 16-17, Ex. 1. Moreover, even if the Hotta and Mauri study was conducted in the surf zone, the research is not analogous because the piles in the study were spaced approximately 66 feet apart; even then, with that wide pile spacing, the study found that maximum observed scour depths were approximately 2.5 feet. Ramsey Rebuttal PFT, p. 5.

Ramsey discussed one study not relied upon by Bosma which found that scour depths around a pile for non-breaking waves and currents was only about 50% of the maximum scour depth for breaking waves and currents, "indicating that the experiments cited by Bosma that incorporated non-breaking wave conditions substantially underestimate the scour that will occur at the project site." Other studies confirm this. Ramsey Rebuttal PFT, pp. 5-6.

Ramsey also testified that other research not used by Bosma shows the resulting scour depth outside the surf zone can be expected to be in the range of 1 to 1.5 times the pile diameter and the scour impact can be expected to extend approximately 5 to 10 times the pile diameter. Ramsey PFT (May 1, 2018), p. 6. Other research suggests that in the surf zone wave induced velocities and turbulence associated with breaking waves could be expected to increase the scour depth by as much as six times the pile diameter in severe storms. Ramsey PFT, (May 1, 2018), p. 6. Putting aside the influence of the pile array, as opposed to a single pile, that could lead to as much as four feet of scour. Id. Additional research shows waves and current may increase scour depth by as much as 3 times the depth observed outside the surf zone.[29] Here, the scour problem will be exacerbated by the fact that breaking waves at the site will interact with the piles on a frequent basis, as Mahala previously admitted. Supra., pp. 14-15. Ramsey's unrebutted analysis of high tides persuasively concluded that while waves would not interact on a daily basis with the piles, they will interact on a frequent basis. Ramsey Rebuttal PFT, p. 19 (see also videos showing wave interaction with Bayswater piles, Ex. JR-R-2 and JR-R-3); Transcript II, 71-73.

"For piles in the surf zone, wave induced velocities and the influence of turbulence associated with breaking waves cause an increase in potential scour depth. In these cases, the approach used to calculate scour around piles from the FEMA Coastal Construction Manual is appropriate where the Total Localized Scour around vertical piles is equal to six (6) times the pile diameter. Therefore for the proposed piles, the maximum potential scour depth would be 6 times the pile diameter, which could equate to 4 feet of potential scour." Ramsey PFT, p. 18.

Ramsey points out that the maximum scour depth may only be reached during a severe storm, but the potential nevertheless remains. Ramsey PFT, p. 6. The close spacing of the piles in this case allows the scour holes from individual piles to connect. Ramsey PFT, p. 6 (citing

[29] Mahala PFT (June 26, 2017), Ex. 3, Coastal Construction Manual, Principles and Practices of Planning, Siting, Designing, Constructing, and Maintaining Residential Buildings in Coastal Areas (Fourth Edition), FEMA P-55/Volume II/August 2011 (citing Sumer et al. 2001).

van Rijn, 2013). He testified that this will cause significant beach scour that will lead to erosion and a change in form of the fronting coastal beach. It will lower the beach. Ramsey PFT, p. 6.

Second, Ramsey points out that Bosma has not provided underlying information and input parameters that are necessary to analyze the results, something Bosma did previously with his loading analysis. Ramsey correctly asserts that Bosma does not provide information regarding specific storm condition parameters utilized in his analyses, such as wave heights, wave period, and water depths. Ramsey Rebuttal PFT, pp. 4, 9. These are all important variables that can significantly affect the outcome and distinguish Bosma's analysis from the conditions that will occur at the site. Because of the lacking information, Ramsey determined it is "not possible to evaluate the results." Ramsey Rebuttal PFT, p. 4.

Third, Ramsey pointed out that most of the studies relied upon by Bosma evaluated the effect of single piles, not pile arrays, like the array at issue in this matter. Ramsey Rebuttal PFT, p. 5, 6, 7. And, none of the experimental data used arrays of similar spacing to the proposed project. Ramsey Rebuttal PFT, p. 9. In fact, in one of the studies relied upon by Bosma the distance between the piles was substantially greater, approximately 66 feet. Id. In stark contrast, here, when the pile array is viewed from an angle perpendicular to the array there would only be 7 inch spaces (the 22 inch gap less 8 inch pile in the center of the gap) between the outer edges of the pilings in the first and second rows. Ramsey PFT, p. 5.

The studies that include pile arrays (not a single pile) indicate that scour "around closely spaced piles can interfere with each other and lead to greater total scour depths" by linking together. Ramsey Rebuttal PFT, pp. 5, 6, 7, 10. Scour depth for an array can increase as much as twice the scour depth for a single pile. Ramsey Rebuttal PFT, p. 6. Linked scour holes would lead to a large scour area, and thus a lowering of the beach along the entire length of the pile array. Ramsey Rebuttal PFT, p. 7.

Ramsey relied upon academic research (e.g., van Rijn, 2013) stating: "Due to the close spacing of the piles, various researchers agree that scour impact can be expected to extend approximately 5 to 10 times the pile diameter. . . . therefore, connectivity between individual pile scour envelopes can be expected for all 180 piles. Connection of scour envelopes from pile to pile will cause adverse effects to the beach volume and form." Ramsey PFT, p. 12. Ramsey testified that this beach is particularly vulnerable because the pile structure will interact more frequently than other beaches because the beach is narrow and the mean high water is relatively close to the piles. Ramsey PFT, p. 12. There would be near daily interaction with waves for "frequent impacts of wave reflection and scour adjacent to the pile array to lower the beach form." Ramsey PFT, p. 12.

Fourth, Ramsey asserts that Bosma incorrectly calculated the gap ratio because he calculated it for each row, instead of determining the overall gap ratio and total porosity of both rows together, and because he used the maximum distance between the piles (22"), instead of the minimum distance (11"). The minimum distance yields a gap ratio of 1.38, instead of 2.75. Ramsey PFT, p. 2. In contrast, with Bosma's gap ratio the scour calculations "substantially underestimate both the depth and extent of scour" because the higher gap ratio does not reflect that the piles will act as a unified barrier where the piles act together and scour holes link-up. Ramsey Rebuttal PFT, p. 7; Transcript II, pp. 57-60.

For all the above reasons, I attach very little weight to Bosma's use of formulas to forecast the amount of resulting erosion and scour. Quite simply, it is well known that forecasting scour and erosion impacts from pilings is highly unreliable to begin with. That reliability problem is compounded by the specific factors identified above. Combine all of that with Ramsey's position and the underlying literature predicting much greater impacts from closely spaced pile arrays, particularly in the surf zone, and one is left with little confidence in the accuracy of the forecasts. Instead, the greater weight of the evidence shows the range of potential impacts would be significantly greater than what is predicted by Bosma.

Bayswater. Bosma testified that the Bayswater project corroborates his testimony regarding the extent of scour and erosion for Project III. Bosma PFT, p. 8. Although the project here is proposed to have more space between the pilings, both it and Bayswater are nevertheless designed to alter wave and tidal process; they vary only by the degree to which those alterations may occur because of the difference in porosity, i.e., space between the pilings. Transcript, pp. 95-96. As discussed in the RFD, a Massachusetts Office of Coastal Zone Management publication referred to the Bayswater project as an example of how *not* to protect the coastal bank. RFD, p. 24. The publication specifically and "strongly" "discourages" "closely spaced posts," even when installed as anchors for sand bags or as part of a shoreline stabilization project. Munroe PFT, Exhibit DKM-D, p. 5. The publication specifically states: "Although these closely spaced posts have been referred to as fencing, they act as a solid wall, reflecting wave energy and increasing erosion of the beach. Because of their adverse impacts, rows of posts are strongly discouraged."[30] Munroe PFT, Exhibit DKM-D, p. 5. Importantly, Mahala, DEP's expert, agreed with the CZM position. Transcript I, pp. 280-81.

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[30]With regard to the publication on its website, the CZM website states: "Any views or opinions presented in publications prepared for CZM are solely those of the author[s] and do not necessarily represent those of the Massachusetts Office of Coastal Zone Management, the Executive Office of Energy and Environmental Affairs, or the Commonwealth of Massachusetts. Please see our website policies)." Although I recognize that this is not an official publication of CZM, I attach weight to it as a corroborating viewpoint from a CZM author with which Mahala agrees.
http://www.mass.gov/eea/agencies/czm/program-areas/stormsmart-coasts/publications/

The firm at which Bosma is employed, the Woods Hole Group, has been monitoring the Bayswater project since 2012. He testified that "no localized scour has been observed, including during storm events." Bosma PFT, p. 8. And he added that profile data from Bayswater "confirms there has been no long term lowering of the beach or any localized scour other than natural seasonal variations in the overall beach profiles." Bosma PFT, pp. 9, 21.

Bosma's testimony is not persuasive because of the problems with his testimony identified above and because I previously concluded that the Bayswater pile array effectively acted like a solid wall, causing substantial wave deflection and refraction, and ultimately scour to reveal cobbles under the sand in front of the structure. And, more to the point, as I previously found based upon the Petitioners' and the *Applicants' survey data* there has been a general lowering of the beach caused by the pilings.

Contrary to Bosma's statement, individual scour holes would never be observed with the Bayswater project because the piles are very close together, within 1 to 2 inches of each other. That is why Bosma has never observed immediate impacts with the naked eye, absent other indicators like the cobbles that have been frequently revealed in front of the array. Instead, there would be a general lowering of the beach, which, as discussed below, is occurring. Ramsey Rebuttal PFT, p. 26; RFD, pp. 38-39. Indeed, I previously found that "cobbles are not exposed . . . beyond the edge of the Bayswater project, where there are no piles," corroborating fact that the piles were causing erosion and a lowering of the beach. RFD, p. 38.

Mahala was also previously critical of Bosma's reliance upon Bayswater, further undermining the weight of Bosma's testimony. Mahala pointed out that in Bosma's supporting photographs that purportedly do not show scour at Bayswater only 1 of 5 photographs shows the site outside of the spring and summer seasons; during those seasons scour is minimal and sediment is transported back to the beach. Mahala PFT (August 17, 2017), pp. 7-8. He also pointed out that Bosma's photograph that purported to show no scour after Superstorm Sandy was taken two months after the storm and shortly after the site had been nourished with imported sediment. Mahala PFT (August 17, 2017), p. 8.

In addition, and more importantly, I also previously found that the beach elevation data gathered by the Woods Hole Group, the firm for which Bosma is employed, shows that there *has been* a "*net loss* of beach elevation *despite* the provision of substantial nourishment." RFD, p. 39 (emphasis added). I stated: "Data gathered by Marden [the Applicants' other expert from the Woods Hole Group] shows that on October 19, 2010, the mean high water line was approximately 30 feet from the piles, but on November 4, 2015 it was approximately 10 feet from the piles, showing the beach has dropped in elevation. Munroe Rebuttal PFT, p. 7. In addition, data collected by Munroe since 2012 also demonstrate that the beach at Bayswater has dropped in elevation. Munroe Rebuttal PFT, p. 7. At one cross section, the data show that the mean high water was approximately 37 feet from the pilings in May 2012 and approximately 14 feet in March 2016. Munroe Rebuttal PFT, pp. 7, 8; Transcript, pp. 109-110." RFD, p. 39. What perhaps is most telling is that the lowering of the beach is revealed to be approximately the same in both studies—they corroborate each other: mean high water went from approximately 30 to10 and 37 to 14 feet away from the pilings in the two studies.[31] Ramsey also supported his observation that the beach had lowered with photographs. Transcript II, pp. 116-120.

I also found the beach profile data to be biased towards not showing erosion and thus underreported the extent of the beach being lowered, because, in sum, "survey data was only taken once each year and was done at different times in each year – April, September, October,

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[31] The scale of the survey results for the two most recent years, 2015-17, make it impossible to decipher whether the reduction in elevation has continued. The general trend lines, however, appear to indicate that it has. Bosma PFT, Ex. 5.

November. It would be reasonable to expect the fall profiles to be the highest in elevation and the Spring profiles to be the lowest. Interestingly, there is only one Spring profile analysis performed. It was the first data collected after installation and it does show the lowest profile. There is no other Spring profile to compare against. Instead, all of the other profiles are higher but they were all performed in the fall when we would expect to see a higher profile." RFD, pp. 39-40; Ramsey Rebuttal PFT, p. 27. The other problems associated with the beach profile data are that there is insufficient detail, the scale is too small, and the influence of recent nourishment was not accounted for. Ramsey Rebuttal PFT, p. 27. Last, the Bayswater site is also not a reliable indicator of a lack of erosion because the project is relatively new, and thus there have not yet been storm conditions that could lead to the full magnitude of erosion that FEMA predicts for a 100 year storm event. Ramsey PFT and Rebuttal PFT.

In sum, Bayswater does not corroborate Bosma's testimony that there will be no adverse effect from the pilings in Project III. To the contrary, Bayswater shows a lowering of the beach even though the studies and circumstances are biased against showing that and even though substantial nourishment has been added to Bayswater. Despite the biased results, they do show an adverse effect—causing the mean high water line to be just 10 feet away from the piling array and thus interact with the pile array more frequently is undoubtedly more than a negligible change; indeed, one of the variables that predict the rate of scour is the frequency of interaction with waves and currents. The lowering of the beach will increase that rate, which will in-turn increase the rate of erosion and scour, which will continue to feed off of itself leading to more detrimental results over the long-term. As discussed below, the pilings here would be close enough to cause the same or similar results over the long term.

XBeach Modelling. Bosma also employed a software modelling program known as XBeach, which is a "hydrodynamic and sediment transport modeling analysis," to try to simulate the impact of the piles on sediment transport from the bank and the beach itself. It is a modeling program for "wave propagation, long waves and mean flow, sediment transport, and morphological changes of the nearshore area, beaches, dunes, and backbarrier during storms." Bosma PFT, p. 12, n. 12. It is used to simulate numerous coastal processes. Id.

Bosma testified that XBeach was used to predict the amount of wave transmission and sediment movement taking into account "a range of hydrodynamic processes (including short and long wave transformation, wave set-up, unsteady currents, overwash, wave reflection, and inundation) and morphodynamic processes (including sediment bed load and suspended sediment transport)." Bosma PFT, p. 12. He added: "More specifically, [the model] was used to evaluate wave energy transmission through the pile anchors, the mobilization of sediment from the bank behind the pile anchors, the transport of that sediment, and the overall influence of the Project on the beach." Bosma PFT, p. 12.

The XBeach model, however, does not include the ability specifically to represent the pilings that are proposed in this case. Instead, the model predicts impacts based upon Mangrove trees, which can be specified according to varying height, diameter, and density at defined locations along a coastal profile. Bosma used that "feature . . . to represent the Project's timber pile anchor sizes, spacing, and configuration." Bosma PFT, p. 13. He testified that the mangrove variable can be adjusted to simulate a pile by using only the trunk section of the tree. Bosma PFT, p. 13.

Bosma first used XBeach to simulate wave transmission and sediment movement under existing conditions, i.e, without the piles. He compared that to a simulation with the timber pile anchors in place. Both simulations were run with 1, 5, and 10 year storm parameters from the USACE North Atlantic Comprehensive Coastal Study (2015) for the Mashpee, Massachusetts area. Bosma PFT, p. 14. A "steady state storm wave condition" was simulated to identify the amount of energy that would reach the coastal bank. Sediment movement was also quantified. Bosma PFT, p. 14.

"Modeled wave transmission (the percentage of wave energy expected to pass through the pile anchors and thus be capable of activating sediment movement from the bank) varied only minimally with the presence of the anchors." Bosma PFT, p. 14. For the 1, 5, and 10 year storm simulations there was a 1%, 9%, and 12% reduction, respectively, in the amount of wave energy transmitted to the bank through the piles. Bosma concluded, "[i]n all cases, the high level of wave energy transmission is fully capable of moving sediment from the coastal bank to the beach." Bosma PFT, p. 15. The modelling demonstrated that with the piles there was still a transport of sediment from the bank to the nearshore area (between the anchors and the water line) that supplements the elevation of the beach. The beach elevation after the 1 year storm was nearly identical to the elevation without the piles. The 5 and 10 year storm simulations resulted in lowering of the beach by 2.3 inches and 3.6 inches, respectively. Bosma PFT, p. 15. Bosma testified that these changes are insignificant.

Bosma noted that none of the simulations involved the annual nourishment requirement that would be required here: a minimum of 600 cubic yards per year. Modelling with the beach nourishment of 600 cubic yards of sand after two storms in succeeding years demonstrated the beach elevation is approximately 1 to 2 inches higher with the piles and nourishment than without the piles and nourishment. Bosma PFT, p. 16. Bosma testified that the XBeach results demonstrate that the piles will not adversely affect the amount of sediment moving from the bank onto the beach, in compliance with 310 CMR 10.30(4). Bosma PFT, p. 11. He testified that with the required nourishment the project will "increase the total available sediment to the system compared to what is available in the natural bank." Bosma PFT, p. 12. Bosma concluded that the XBeach analysis also demonstrates that the piles will not adversely affect the beach by "increasing erosion, decreasing the volume or changing the form of any beach, in compliance with 310 CMR 10.27(3)."

Ramsey was critical of Bosma's XBeach modelling analysis. Once again, Ramsey correctly pointed out that Bosma failed to show his work that led to his conclusions, including various input parameters or variables, such as wave height, storm hydrograph, sediment characteristics, and pile representation. Ramsey PFT, p. 4. As a consequence, Ramsey testified that it is not possible to review Bosma's modelling analysis. Ramsey Rebuttal PFT, p. 12.

Further, Ramsey testified that the XBeach model cannot be used simulate the full effects of pilings because the vegetation module in the XBeach model can only assess vegetation that is flexible, where wave dissipation through the vegetation from drag caused by friction from the pilings is the only process that occurs. Ramsey PFT, p. 17 (citing Deltares, 2015). That type of vegetation absorbs wave energy through dissipation, which is significantly different from closely spaced rigid wooden piles that cause deflection and refraction of wave and tidal energy, leading to erosion and scour, which XBeach does not capture. Ramsey PFT, p. 17; Transcript II, pp. 110-112, 129-131. He concluded that use of XBeach "represents a misuse of the model, as this application is beyond the limits of its intended use." Ramsey PFT, p. 17. Bosma testified that XBeach does measure wave reflection but he agreed with Ramsey's assessment that it cannot simulate the amount of scour and erosion resulting from wave reflection. Transcript II, pp. 215-216, 227.

This is problematic because for rigid closely spaced piles in the surf zone wave reflection and flow acceleration causing scour and erosion are the dominant processes, but they are not accounted for in the XBeach model. Ramsey Rebuttal PFT, pp. 11-13. Ramsey pointed out that Bosma has not provided any peer reviewed literature to support this use of XBeach under the circumstances of this case. Ramsey Rebuttal PFT, p. 13. The XBeach model also does not include the physics related to sediment transport through the two rows of the pile array. Ramsey Rebuttal PFT, pp. 14-15. Because of the model limitations, Ramsey believes the XBeach model results are invalid. Ramsey Rebuttal PFT, p. 13.

Ramsey also pointed out that Bosma's reliance on the Herbic and Douglas study (1988) as the basis for parameterizing the XBeach model was flawed because the pile array in that study was not similar and did not evaluate the influence of breaking waves, i.e., waves in the surf zone. Ramsey PFT, p. 17.

In sum, the XBeach forecasting model has severe limitations that preclude it from being employed to measure reliably, if at all, the amount of scour and erosion that will result from the proposed pile array.

FEMA Methodology. Ramsey relied, in part, upon FEMA studies of scouring around piles. Mahala also previously relied upon FEMA studies on remand when he criticized and rejected the pile array in Project I, in favor of Project II.

Bosma, in contrast, went so far as to state that FEMA studies are "not applicable" to the site because he believes the FEMA studies are undermined by the "site specific estimations" discussed above (wave conditions, flow characteristics, structural aspects) and the observations of Bayswater. Bosma PFT, pp. 9, 11. And the FEMA forecasting methodology relies on one factor, pile diameter. Bosma PFT, p. 11. Also, Bosma added that the FEMA methodology is derived from post-hurricane storm assessment of houses on piles in the Gulf Coast area that were impacted by storm surges and waves that completely overtop the beach and flow in one direction (unidirectional flow). This is similar to scour observed from unidirectional flow impacting pilings under bridges. Bosma PFT, p. 10. Those results are not applicable, he asserts, because the piles at the site are on the landward side of the beach and will receive flow from the seaward side and the landward side, after water flows back from the bank, causing a "return of wave energy, flow and sediment to the beach." Bosma PFT, p. 9. It is also possible that some scour observed by FEMA was caused by other factors such as concrete slabs and deep beams. Bosma PFT, p. 10, n. 9. And last, Bosma believes that the FEMA methodology is overly conservative because the piles that were studied were generally part of piling structures that supported residences, and thus the conclusions were overly conservative to account for the potential threats to the residences and their occupants. Bosma PFT, pp. 9-11.

Bosma's criticism of FEMA literature holds some validity, but he overstates his case in asserting that it is "not applicable." In fact, when Mahala previously relied upon the FEMA literature in rejecting the array in Project I he correctly recognized there were distinguishing factors, but then nevertheless applied the FEMA analysis because it is undoubtedly "applicable." Indeed, while there are arguable distinguishing factors, there are several reasons why Bosma's testimony should be heavily discounted. First, he errs at the outset by relying upon his own forecasting models and the Bayswater project to counter the FEMA literature; for the reasons discussed above they comprise an unreliable foundation to attack the FEMA literature.

Indeed, Ramsey credibly testified that the FEMA literature is more applicable than the studies relied upon by Bosma because the studies Bosma relied upon are generally performed in deeper water and not in the surf zone. Ramsey PFT, p. 6. Ramsey testified that the FEMA methodology is consistent with peer-reviewed literature and observations of pile scour during *severe* storm events, which have not yet occurred during the short life of the Bayswater project. Ramsey Rebuttal PFT, p. 10. No significant tropical storms have impacted the site since construction of the adjacent pile structure. Ramsey Rebuttal PFT, p. 10. Thus, it is unknown whether the maximum scour of four feet for a 100 year storm event, as noted by Ramsey, would occur. Ramsey Rebuttal PFT, p. 10. The FEMA literature also recognizes the "well understood scientific phenomena that pile groups can act as a single structure and closely spaced pile scour holes can link to each other and create a large cumulative effect." Ramsey Rebuttal PFT, p. 10.

Just as important, the effect of currents studied by FEMA can occur at the site with strong alongshore currents. See Ramsey Rebuttal PFT, p. 10, Ex. JR-R-3 (showing strong alongshore currents at the site). In fact, after the nourishment is washed away, which happens relatively quickly, there is significant space between the pilings and above-grade bank system that is at a similar grade. Transcript II, pp. 182-184. Thus, a strong alongshore current could cause the type of scour noted in the FEMA literature. That also undermines the argument that water returns with sediment and fills in any scour holes. Transcript II, pp. 185-87. In fact, Ramsey believes that the FEMA methodology provides a sound basis for determining maximum potential scour at the Site because it is a low lying beach where wave breaking, wave uprush, and strong alongshore currents occur. Ramsey Rebuttal PFT, p. 11.

While Ramsey's testimony is very credible, he too overstates his case, but not as seriously as Bosma. The fault in Ramsey's testimony is that he does not address the impact of the close proximity of the bank to the pilings. That impact is not known and there is no reliable evidence in the administrative record to further understand it. And, as Ramsey points out elsewhere, initially the bank would provide nourishment, assuming it had been recently nourished. After that, however, the coir envelopes would create another surface off of which the waves would deflect and refract, causing additional erosion and scour, until, perhaps, the envelopes ruptured. Whether they would actually rupture is not known with any reliability because the elevated pilings would continue to seriously dissipate the wave and tidal forces. The envelopes at Bayswater have not ruptured, but they also have never experienced the forces of a serious tropical or 100 year storm. In sum, while there are reasons to arguably distinguish the FEMA literature, to say that it is "not applicable" seriously misrepresents its relevance, just as Mahala previously observed when he relied upon it in rejecting the pile array for Project I.

Mahala Testimony. Mahala's testimony has varied significantly throughout this adjudicatory proceeding, reflecting the novelty of the pile array and the variability and general unreliability of research literature in this area. See supra. at pp. 44-47. Mahala originally approved of the pile array for Project I, issuing the SOC that the Petitioners appealed to commence these proceedings. On remand, however, he relied upon research literature from FEMA and coastal engineering academics to disapprove the same pile array he initially approved, finding it did not comply with the performance standards for coastal beach and coastal bank. He then issued an amended SOC which dramatically altered the pile array to a single row of four-inch by four-inch posts separated on center by five feet. After that, while still on remand, MassDEP and the Applicants entered a settlement agreement which included Mahala's approval of the array in Project III.

When Mahala previously disapproved of the pile array in Project I in reliance upon FEMA and other academic literature, he noted that scour could occur up to 6 feet around pile groups. Mahala PFT (June 1, 2018), p. 7. He noted that the FEMA guidance provided conservative estimates of scour around piles but he correctly believed (as discussed above) that it was still "relevant" because "waves would interact with the piles in a similar manner and would likely exhibit comparable impacts (scour) to the coastal beach." Mahala PFT (August 17, 2017), p. 5. He testified that it is "generally advisable to avoid and/or minimize the placement of structure(s) such as the proposed pile array [in Project I], on a coastal beach since they will act as an obstruction to natural flow and will likely induce scour." Mahala PFT (August 17, 2017), p. 6. He concluded that the piles in Project I will "cause scour of the coastal beach which will diminish the coastal beach's ability to provide storm damage prevention and flood control." Mahala PFT (August 17, 2017), p. 7.

With respect to Project III, Mahala testified that the approved changes in Project III "substantially reduce the anticipated scour around the proposed timber piles and will not inhibit the ability of the waves to remove sediment from the coastal bank under storm conditions." Mahala PFT (June 1, 2018), p. 4. He testified that because of the decrease in pile diameter (12 to 8 inches) and increase in spacing between pilings, the level of scour will be "minimal and significantly less than the previous project." Mahala PFT (June 1, 2018), p. 9.

Mahala's altered view of the impact of the pilings stands on an eroded foundation: Bosma's forecasting analysis that was discredited above. In fact, Mahala testified that he generally did not perform any of his own analysis and instead relied upon Bosma. Transcript II, pp. 248-49. Mahala stated that in reaching this conclusion he has taken into account "the modeling provided by Mr. Bosma that considers site specific information (unlike the FEMA publications), including the fact that the subject beach is backed by a coastal bank, which will mitigate scour by providing sediment to the system and creating multi-directional flow when interacting with wave action." Mahala PFT (June 1, 2018), p. 9. As discussed above, those two factors have no reliable bases in the administrative record.

In approving the Project III pile array, Mahala further distinguished the FEMA guidance, now adopting Bosma's incorrect opinion that the FEMA literature is not applicable. He repeated his prior statement that FEMA guidance was overly conservative because it focused on piling foundations for residential dwellings to ensure that the pilings did not fail. He also repeated the FEMA statement that some geographic areas are more susceptible than others to severe scour, and that he has "not observed scour to the degree predicted by FEMA around individual piles, pile arrays (including the project at the adjacent property) or other projects that [he] has personally inspected throughout [his] career." Mahala PFT (June 1, 2018), p. 7. However, Mahala provides no basis to understand whether the "individual piles" and "other projects" are comparable. Moreover, and more to the point, the pile array that he does rely upon (which is apparently the only one on the Massachusetts coast line), is the Bayswater array, the one on the "adjacent property." And while Mahala states he has not observed scour there, scour would be difficult to observe because it is an array with piles separated by one inch, as Ramsey testified. Instead, what one would see, is a general overall lowering of the beach, which is occurring, as established by the Applicants' and Petitioners' studies. Mahala may be correct that the Massachusetts coastline is less "susceptible to scour compared with areas along the Gulf of Mexico, such as eastern Texas, Louisiana, Alabama, and Florida." Mahala PFT (June 1, 2018), p. 7. But that is not a basis to outright reject the FEMA literature, as Bosma did, an approach that Mahala seems now to adopt outright, without recognizing before that he distinguished it more moderately. Mahala PFT (June 1, 2018), p. 8.

Indeed, when Mahala previously relied upon the FEMA literature in rejecting the pile array in Project I he responded to Bosma's criticism of the literature and accurately defended the FEMA literature, stating that the FEMA guidance provided conservative estimates of scour around piles but he believed that it was still "relevant" because, most importantly: "waves would interact with the piles in a similar manner and would likely exhibit comparable impacts (scour) to the coastal beach." Mahala PFT (August 17, 2017), p. 5 (emphasis added). Mahala's observation that the waves and currents would interact similarly with the piles in Project III remains unchanged, as Ramsey demonstrated: There will be frequent interaction with waves and currents in the surf zone where there will be easily erodible sediment, just as there was in the FEMA studies. The only difference here is that on one side of the landward row of pile will be the terrace of coir envelopes. Mahala adopts Bosma's speculation that this difference will mean that erosion and scouring like that discussed in the FEMA literature will not occur in major storms. However, as Ramsey testified, there is no sound basis for Bosma's conclusion that sediment transport from the bank will prevent the scouring and erosion observed by FEMA. Indeed, the frequent wave interaction with the piles will not lead to scour holes, but it will lead to the general lowering of the beach that has been observed at Bayswater. And in major storms, which Bayswater has not yet experienced, the erosion and scour will be much more serious and any nourishment that may be covering the coir envelopes will quickly dissipate. See infra. at pp. 39-42.

Further, Mahala's position that the piles are sufficiently separated in Project III but they were not sufficiently separated for Project I is undermined by research showing that scour associated with Project I and Project III would be of similar magnitude and lead to a general lowering of the beach. Ramsey Rebuttal PFT, p. 25 (citing van Rijn, 2013). Indeed, research reveals that when the piles are spaced less than 5 to 10 times the diameter of the pile for a single row (here, 40 to 80 inches, or 3.3 to 6.7 feet), scour holes become larger and tend to link together. Ramsey Rebuttal PFT, p. 25, Ex. 1 (van Rijn, 2013). This seems to be roughly accepted as the standard in the industry, as both Mahala and Ramsey have testified that pilings or posts should be *at least* 4 to 5 feet apart, depending upon the diameter of the pile and the number of rows. Transcript I, pp. 342-343, 347 (Mahala testifying to 4 to 5 foot separation for smaller diameter wooden posts for a single row); Transcript II, pp. 134-135 (Ramsey testifying to approximately 4 to 5 feet from outside of posts for a single row; with a double row it gets "confusing" and he is not "quite sure what the purpose [of the pilings in these appeals] is").

Mahala also bases his approval of the pile array in Project III upon an unpersuasive comparison to wind drift fences constructed by 2"x 4" or 2"x 3" wooden components. He opines that he has not seen severe erosion around these structures. His comparison is without merit for a number of reasons. First, wind drift fences by their nature would not be located in a similar environment as the proposed pile array. That is, they would not be located in the surf zone on a low lying beach where they frequently encounter wave and tidal forces. As the CZM Fact Sheet states, that would lead to erosion around the fence and it would likely be destroyed during a storm. Ramsey Rebuttal PFT, p. 28. Second, the project in this case is constructed with two rows of 8 inch diameter piles spaced closer together, and they will be subject to wave action on a routine basis, substantially increasing the likelihood or erosion and scour. Ramsey Rebuttal PFT, p. 28.

Indeed, the CZM Fact Sheet generally provides that: If waves and tides regularly reach the sand fencing, there will be erosion around the fencing and it will likely be destroyed during a storm. If sturdy drift fencing is used, ways to reduce the potential impacts and increase the longevity and effectiveness of the project include installing the fencing far enough landward so that it will not be reached by tides or typical storm waves (i.e., these projects will be affected by severe storms but should not be impacted by regularly occurring storms). Ramsey Rebuttal PFT,

p. 28. Ramsey accurately concluded: "With these standards in mind, there is no similarity between typical drift fences that Mr. Mahala cites in Mahala PFT Ex. 1 and the pile array breakwater constructed of closely spaced 8-inch diameter piles, where it is acknowledged that the structure will be subject to the influence of wave action on a routine basis." Ramsey Rebuttal PFT, p. 28.

In sum, and for the reasons discussed above, a preponderance of the evidence demonstrates that the Applicants' arguments that erosion and scour resulting from the pile array for Project III will be minimal and not amount to an adverse effect are without merit. The Applicants attempted to provide optimistic forecasts, but that was undone by Ramsey's testimony and the literature upon which he relied, showing, among other things, that the Appellants' testimony is unreliable and overlooks a number of factors that would generally lead to more substantial impacts. To be sure, the pile array is unlikely to cause the extreme scour and erosion discussed in some of the literature, particularly the FEMA literature, until it is impacted by a major storm of hurricane strength. But it will also not be the minimal scouring identified by the Applicants in their unreliable forecasts and predictions.

What is more likely is that over time and with exposure to serious storm systems there will be frequent scouring, some very serious, and there will be a general lowering of the beach as a consequence of the pile array. As we are already witnessing at Bayswater, the lowering of the beach will lead to the mean high tide encroaching ever closer to the pilings, resulting in more frequent and intense interactions between the piles and the ocean, as the beach sediment supply decreases and as the beach loses its gradual upward slope. The consequences become more serious as the process feeds upon itself: lowering of the beach, more frequent and severe scour and erosion events, more lowering of the beach, etc.

It is a self-perpetuating cycle that should be avoided, as was so wisely concluded by the drafters of the Wetlands Regulations in 1978, when they planned for the future and astutely and courageously enacted an absolute ban on coastal engineering structures and any other structure, without limitation, that is designed to alter wave and tidal forces to protect buildings after 1978 on upland properties. And while substantial volumes of nourishment will be provided, "the nourishment only temporarily masks the long-term impacts of the pile array breakwater in lowering the form and volume of the coastal beach." Ramsey Rebuttal PFT, p. 9; Ramsey PFT, Ex. 1 (van Rijn, 2013, "impact of a seawall on a beach is a long-term phenomenon").

III. <u>The Project Complies With The Performance Standards For Coastal Bank</u>

When, as here, a coastal bank is significant to storm damage prevention or flood control because it supplies sediment to coastal beaches, coastal dunes or barrier beaches, the ability of the coastal bank to erode in response to wave action is critical to the protection of that interest. Also, when, as here, the coastal bank is significant to storm damage prevention or flood control because it is a vertical buffer to storm waters, the stability of the bank, i.e., the natural resistance of the bank to erosion caused by wind and rain runoff, is critical to the protection of that interest. 310 CMR 10.30(1).

There are two coastal bank performance standards at issue in these appeals. They are 310 CMR 10.30(4) and (6), which provide the following:

> (4) Any project on a coastal bank or within 100 feet landward of the top of a coastal bank, other than a structure permitted by 310 CMR 10.30(3), shall not have an adverse effect due to wave action on the movement of sediment from the coastal bank to coastal beaches or land subject to tidal action. . . .
>
> (6) Any project on such a coastal bank or within 100 feet landward of the top of such coastal bank shall have no adverse effects on the stability of the coastal bank.

There is no genuine dispute that the project will have an adverse effect on the movement of sediment from the natural coastal bank to coastal beaches or land subject to tidal action. Indeed, the project will effectively prevent erosion of the natural bank. That admitted sediment loss would be replaced by annual nourishment required in the proposed Final Order of Conditions. There is, however, no regulatory provision that would allow adverse effects if they were mitigated with nourishment. Instead, there is an absolute prohibition on adverse impacts. In fact, the regulations do not even provide for nourishment from the coastal bank, but they do for the coastal beach. See 310 CMR 10.27(5). In other contexts when a project is allowed to cause adverse effects if they are mitigated the regulations specifically provide for that, but that is not the case here. See e.g. 310 CMR 10.24(7) (limited project provision allowing adverse effect if other requirements including mitigation are required). As a consequence, the project does not appear to comply with the performance standard prohibiting adverse impacts on the movement of sediment from the natural bank.

On the other hand, the provision of nourishment from the coastal bank is a type of soft solution that was sanctioned in the IRD. If compliance with the regulations is measured simply by the amount of sediment that will be removed from the nourishment cover provided on the coir envelope bank behind pile array, it appears the project will be in compliance. There is substantial evidence, including evidence from Bayswater and the mandatory Monitoring and Maintenance Program embodied in the proposed Final Order of Conditions, that the volume of nourishment that will be deposited on the bank and dispersed via wave and tidal forces will be at least equal to the approximate volume that would otherwise be provided by the eroding natural bank. In fact, it may provide more sediment into the system. See Mahala PFT (June 1, 2018), p. 13. Thus, Project III will comply with the standards set forth in the IRD.

The Petitioners, however, have an additional concern with this aspect of the project. They are concerned about the timing of the nourishment. They point out that the nourishment would generally be quickly removed from behind the pile array in even lower level storm conditions. Or, alternatively, the pile array system will effectively prevent the release of sand from behind the piles under conditions where the natural bank would release sediment. The Petitioners' concern is that once the nourishment is dissipated or not reached because of the piles, there will be no sediment provided by the artificial coir envelope bank system until either the nourishment is replenished or the coir envelopes rupture and release sand; the latter is highly unlikely to occur with the pile array system substantially reducing the energy of the wave and tidal forces that ultimately strike the coir envelope system. Ramsey Rebuttal PFT, pp. 24-25, 27; Transcript II, 130-132. Thus, the Petitioners assert that while the end result may be that at some point in time the total annual nourishment equals or exceeds the amount that would be naturally provided, it will not have the same effect as the natural bank because it will be provided intermittently, at different spans of time that have very little correlation to the natural system. I recognize the Petitioners' concerns but they have not introduced any evidence into the administrative record showing how this would result in an adverse effect to the sediment supply needs for the area. Therefore, Project III will comply with the sediment supply component of the performance standards for coastal bank.

Regarding the second component of the performance standard for coastal bank, a preponderance of the evidence demonstrates that there will be no adverse impacts on the stability of the coastal bank if the project were installed. The project would create a more stable slope for the bank and effectively insulate the bank from almost all erosive forces, thereby providing additional stability. Mahala PFT, p. 7; Marden PFT, p. 14.

CONCLUSION

I recommend that MassDEP's Commissioner issue a Final Decision that vacates the original SOC and declines to issue the proposed Final Order of Conditions. The pile array component of Project III is a coastal engineering structure that is clearly prohibited by the Wetlands Regulations. There is no doubt that it is *designed* to alter wave, tidal, or sediment processes to protect the upland buildings from coastal erosion, and thus it is a prohibited coastal engineering structure. Moreover, it is also encompassed by the definitions of three of the enumerated coastal engineering structures: breakwater, bulkhead, and seawall. It has no functional resemblance to any of the natural features of a coastal bank that is a sediment source. Indeed, it is a hard structure that will not comply with the coastal beach performance standards. Its frequent interaction with waves, currents, and tidal forces will overtime lead to a general lowering of the beach, despite the provision of nourishment. That is an adverse effect, and one that is not merely negligible. Indeed, as the beach lowers, the mean high water line will move even closer to the piling array, causing more interaction between the array and the waves, currents, and tidal forces, resulting in even more scour and lowering of the beach. And, that process will continue until the beach sediment is scoured away, exposing the underlying cobbles and other features; a result that is already occurring at a neighboring beach that is referred to in this decision as Bayswater.

NOTICE- RECOMMENDED FINAL DECISION

This decision is a Recommended Final Decision of the Presiding Officer. It has been transmitted to the Commissioner for his Final Decision in this matter. This decision is therefore not a Final Decision subject to reconsideration under 310 CMR 1.01(14)(d), and may not be appealed to Superior Court pursuant to M.G.L. c. 30A. The Commissioner's Final Decision is subject to rights of reconsideration and court appeal and will contain a notice to that effect.

Because this matter has now been transmitted to the Commissioner, no party shall file a motion to renew or reargue this Recommended Final Decision or any part of it, and no party shall communicate with the Commissioner's office regarding this decision unless the Commissioner, in his sole discretion, directs otherwise.

Date: 3/25/19

Timothy M. Jones
Presiding Officer

SERVICE LIST

In The Matters Of:	Kenneth Liatsos Trust and Gloria J. Liatsos Trust David and Glenys Pinchin Michael and Dawn Southwick
Docket Nos. WET-2016-005 WET-2016-006 WET-2016-007	File Nos. SE 43-2787 SE 43-2786 SE 43-2785 Mashpee

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Date: March 25, 2019