

**MEMORANDUM – COASTAL ENGINEERING REVIEW
SLBE SLEEPING BEAR DUNES NATIONAL LAKESHORE GEOTUBE
SHORELINE PROTECTION INSTALLATION
TAR 19877**

15 July 2021

Project Background

A park inholder has proposed the installation of a geotube shoreline protection system on private lands (located at 9060 Bar Road) of the Lake Michigan shoreline within the Sleeping Bear Dunes National Lakeshore (SLBE) park. NPS has requested a review of the proposed geotube shoreline protection installation and analysis of potential impacts on the park shoreline along with suggested mitigations for landowners and the park.

The private landowner plans to install a geotube that will be buried by sand to stabilize the bluff and allow beach access while restoring the natural dune landscape (example geotube shown in Figure 1). The homeowner relocated their house away from the bluff edge in 2020. The homeowner has stated that if the geotube is not buried by sand and the water continues to recede, then it could be removed at the request of NPS. The landowner additionally proposes to level off the top of the bluff, approximately 20 feet above the lake water level, to align with the elevation along the southern side of the property. If Lake water recedes, then the proposed action would be to grade the area to remove the ridge at the edge of the bluff.



Figure 1. Geotube example at beach bluff (Admir Technologies 2016)

During geotube installation, the landowner proposes to modify the angle of the bluff, from the existing approximately 55 degrees to an average of 45 degrees, to facilitate installation of a staircase and removal of the top few feet of bluff. The landowner states that this would make the site appear more naturally graded and will allow installation of the staircase without switchbacks or landings, thus minimizing the

impact of the proposed action. Finally, the area at the top of the bluff to the house will be planted with dune grass approved by the Department of Environment, Great Lakes and Energy (EGLE).

This memorandum presents comments regarding the evaluation of the proposed geotube shoreline protection at 9060 Bar Road located within SLBE and discusses the potential impacts to the surrounding areas. This analysis was completed using design drawings provided by the landowner (Jillson Architects). Based upon this limited information review, EA provides within this memo initial technical observations as follows:

Proposed Geotube Armoring System

[TenCate Geotube® geocontainment technology](#) was developed in conjunction with the US Army Corps of Engineers (USACE) as a coastal protection solution to prevent coastline erosion and retreat in order to preserve natural landscapes, protect housing, and provide safety for onshore infrastructure. This technology has become a common alternative to hard structures for shoreline stabilization and is marketed as cost-effective due to its durability, custom designs, easy installation, and high flexibility. Geotubes such as the proposed armoring system consist of a very large geotextile bag, made with unique, tough, yet flexible fabric structures that are hydraulically filled with a “slurry” of sand and water to facilitate placement.

Rate of Erosion

The homeowner’s surveys show significant erosion on the site, approximately 24 feet of the upper lawn space has been lost since the homeowner started the house relocation (August 2019) compared to the most recent survey (May 2021). A comparison of sequential aerial photographs available through Google Earth reveals progressive erosion over the last five years. The timescale between photographs ranges from several months to over a year, therefore minor accretion events are not necessarily captured. It should be noted that the high rate of erosion observed between August 2019 and May 2021 may overstate the average erosion rate at the site because of the observation period used. Typical weather patterns would indicate a slightly higher erosion pattern observable during early spring (i.e., pre-May), with accretion occurring over summer months (i.e., pre-August) due to ice melt patterns and winter storms.

Sediment Transport

EA previously outlined the state of science regarding Great Lakes mean circulation for the TAR 15529 regarding an adjacent homeowner’s riprap armoring project(s). To summarize, it is understood that the dominant mean circulation pattern is from south to north along the SLBE shoreline, while individual storm events may cause localized erosion drift north to south temporarily. It was determined that the riprap armoring project in TAR 15529 would likely have little impact on SLBE assets due to the relatively small distance being armored and the significant distance between the armored shoreline section and park lands serving as a buffer.

The potential impacts of hardening a section of land located within the park itself are more immediate. As has been observed in numerous park facilities and shorelines generally, hardening one area of high erosion will typically shift the erosion hotspot along the shoreline in the direction of mean circulation. Theoretically, this would mean the proposed shoreline hardening would cause the observed erosion to shift north. A certain level of accretion would be expected to occur immediately south of the hardened shoreline segment, as the hardened shoreline edge would stand to potentially trap sediment and prevent the natural sediment transfer past this particular spot.

This typical pattern of erosion migration is based upon several factors, including the length of protection, the upstream material available to be moved along the shore, and the energy which is moving the sediment. Without site specific data available, the general magnitude of these factors can be estimated to approximate the anticipated level of impact. The overall length of the proposed armoring is quite small relative to the length of shoreline experiencing severe erosion, and with the erosion occurring so rapidly, the energy moving the sediment is considered significant. No modeling was conducted for the site, but this desktop review reveals these two factors could combine to provide a very narrow window for the suspended sediment to drop out of the water column due to the disruption by the armoring. This combination of the small site size and high energy environment could lead to the unusual scenario of the protection system causing almost no change to the erosion pattern upstream or downstream of the property. It should be noted that this analysis is relevant only to a single area of armoring and only at this particular site. The cumulative impacts of potentially replicating such a design at multiple locations along the SLBE shoreline, for example if desired by other private landowners, are difficult to estimate without reviewing the actual proposed design layout and proximity to one another.

Projected Lake Water Levels

USACE produces reports and analyses of Great Lake water level data (https://www.lre.usace.army.mil/Missions/Great-Lakes-Information/Great-Lakes-Information.aspx#ICG_ETH_22302). Lake Michigan's mean monthly water level in April 2021 was the lowest the Lake level has been at any point over the past two years; 14 inches below the water level recorded in April 2020. However, it should be noted that in recent years, the water levels in Lake Michigan have been historically high; the 2020 elevations from January through August set new record high elevations in the Lake (Figure 2).

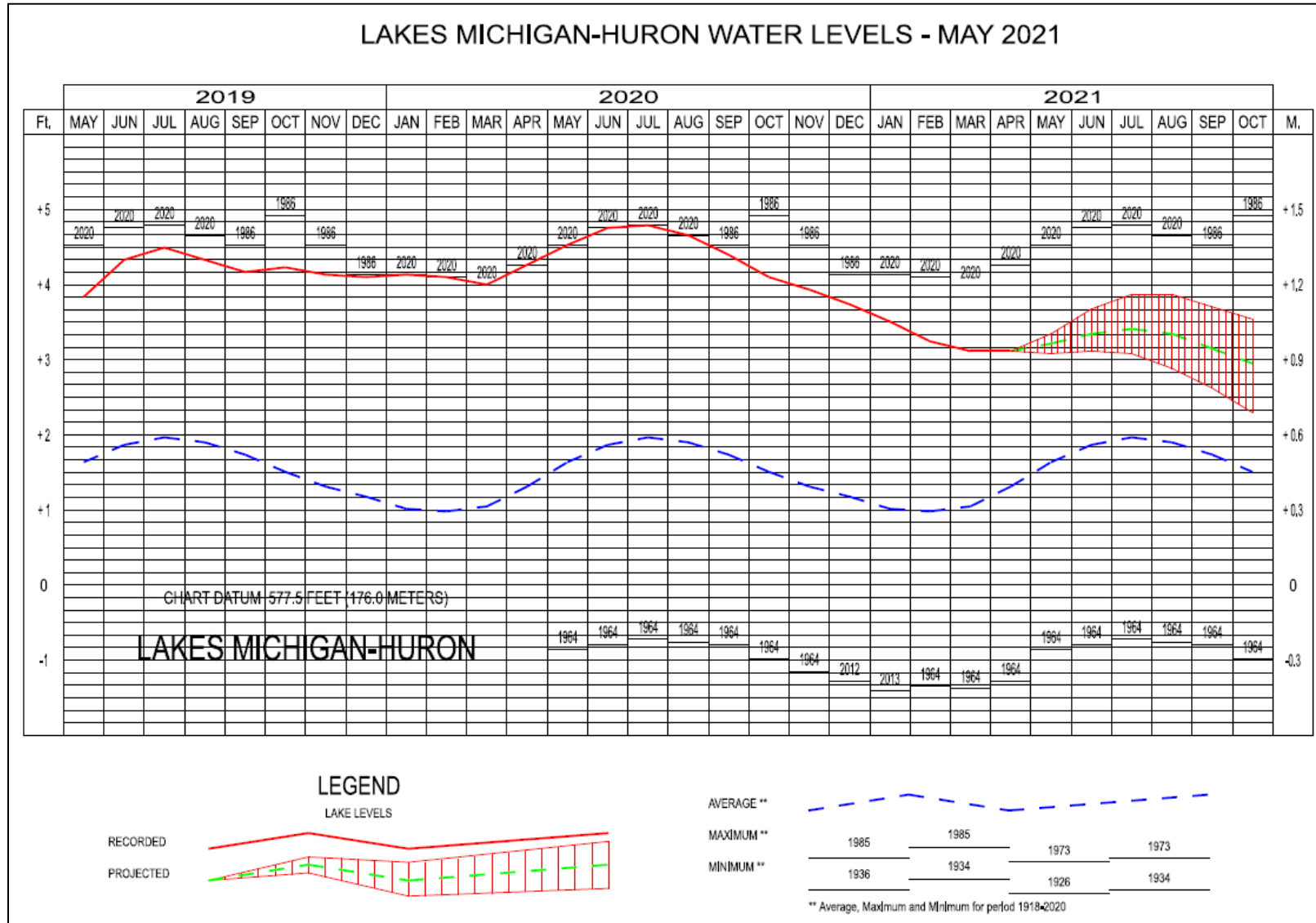


Figure 2. Lake Michigan and Lake Huron Water Levels (USACE)

Discussion

Based on a preliminary review of available information as described above, it is not likely that hardening the shoreline with geotextile tubes to prevent erosion as shown on the design drawings will lead to the erosion shifting north and impacting NPS assets. However the proposed design – a hybrid of armoring the historical high water elevations of 2020 with geotextile tubes while regrading and stabilizing the bluff with native grasses – is neither guaranteed to mitigate the erosion mechanisms observable at the precise site in question. Some potential pitfalls of the design are outlined here.

First, natural plantings are understood to be a preferable natural erosion prevention system and the homeowner is planning to utilize this method along the top of the bluff to stabilize sand there. However, the Lake is the primary cause of erosion of the bluff, with wave and current action undercutting the bluff face, causing scarp and collapse of the upper layers of sediment into the Lake. Native grass plantings along the top of the bluff would not have sufficient root structure to reach down the 20 feet to stabilize the sediments along the waterline, and would therefore be ineffective in stabilizing against this type of erosion.

Second, for the erosion to have caused a loss of approximately 24 feet in 21 months as shown on the plans, there are significant forces that are impacting the base of the bluff. These force calculations are not provided with the submitted plans and should be generated and reviewed by the homeowner's design team and shared with NPS to determine if the geotextile tubes would survive these forces. In the case of a geotextile tube failure, the slurry fill may no longer be contained, and could become a type of "beach fill" that enters the Lake and park sediment systems. It is recommended that any selection of slurry fill follow the NPS Beach Nourishment Guidance issued in 2012 regarding sediment grain size.

Third, the proposed design will likely not mitigate erosion occurring immediately adjacent to the geotextile tube installation. While the small size of the proposed protection scheme suggests that longshore sediment transport patterns will not change, the erosive forces addressed by the scheme will continue to influence adjacent areas of beach and bluff. Therefore the proposed armoring may protect the homeowner's property, but the loss of land will continue to occur both updrift and downdrift, leading to the eventual flanking of the geotextile tube as the adjacent shorelines continue to erode. Once the adjacent land erosion exceeds the width of the proposed geotextile tube, the land behind the armoring will likely start to erode again. If it could be interpolated that another erosion cycle of 10 or more feet per year were to occur, flanking could possibly begin by the year 2024.

Finally, with the erosion observed between August 2019 and May 2021 coinciding with the historic high levels of the Lake, the design team should examine both the extreme erosion protection needs and more likely scenarios. Similar to using a recurrence interval for the storm events, a recurrence analysis for the Lake water levels would provide significant insight, and potential impact reductions, for the final protection system design.

Summary

1. Water levels in Lake Michigan have been highly variable in recent years. The drawing depicts approximately 24 feet of erosion between August 2019 and May 2021, which coincides with record setting high Lake water elevations between January and August of 2020. In April 2021, the mean monthly Lake water level was the lowest it has been at any point over the past two years; 14 inches below the water level recorded in April 2020.

2. The landowner proposes to use 100 linear feet of geotextile tubes filled with a “slurry” of sand and water that harden when dry, to provide protection at the toe of the Bluff, by reducing a wave’s energy before it impacts the shore, which slows erosion. This may not be adequate to resist natural forces and should be verified with a coastal engineering analysis and shared with NPS prior to NPS providing a final opinion.
3. The landowner proposes to plant EGLE approved dune grass from the top of the bluff towards the house which will create root systems and help prevent erosion by keeping sand/soil in place 20 feet above the historic Lake water elevation. However, this will not prevent future Lake-driven erosion events.
4. The 2 single page drawings (1 plan, 1 cross-section) of the proposed work by the architect proposes no integration into the park space on either side.
5. The proposed geotextile armoring system may provide some temporary relief of erosion at the property but is so small relative to the overall shoreline and energy involved that it is not believed to provide any lasting impacts to local or global erosion patterns, this should be reviewed by a coastal engineer once the design is updated, and those findings shared with NPS prior to NPS providing a final opinion.
6. The overall design of the proposed hardening system does not account for the potential of flanking.

Conclusions

Based on our initial review, EA recommends that NPS request a more detailed basis of design for the proposed hardening option, which would detail:

1. Design forces which the filled geotextile tube will withstand.
2. Safeguards against flanking of the geotextile tube system.
3. Source of slurry fill material in case of failure and loss into SLBE assets.

References

TenCate Geosynthetics Amer. 2021. *Coastal Protection*. Available at: <https://www.tencategeo.us/en-us/markets/water-infrastructure/coastal-protection>. Accessed online April 2021.

USACE. *Great Lakes Information*. Available at: https://www.lre.usace.army.mil/Missions/Great-Lakes-Information/Great-Lakes-Information.aspx#ICG_ETH_22302. Accessed online April 2021.