

MILWAUKEE COUNTY COASTLINE MANAGEMENT GUIDELINES

Section 3

COASTLINE MANAGEMENT GUIDELINES

OVERVIEW

This section sets forth goals, guidelines, and proposal requirements designed to enable Milwaukee County to manage/evaluate potential coastline impacts to County-owned assets.¹ The guidelines offer a framework for promoting bluff slope stability within County-owned lands along the Lake Michigan coastline. The guidelines will serve as a reference tool as the County considers conducting work or evaluates proposals from individual property owners, Friends Groups and other groups, or municipalities interested in conducting work that may impact bluff slope stability within County-owned lands along the Lake Michigan coastline.

Property owners, groups, and municipalities interested in conducting such work should prepare and submit to the County a scope of work as laid out in this Section. Applicable work may include—but is not limited to—development, such as the construction of infrastructure, occupiable buildings, and other facilities; landscape management, such as the removal of invasive species; maintenance of existing infrastructure; and shore protection modifications and structures. Proposal requirements set forth herein would be supplementary to the application that such property owners, groups, and municipalities would need to complete for a proposed bluff project.² While the guidelines and requirements set forth in this Section are

¹ *County-owned assets include lands and facilities that are adjacent to the waters of Lake Michigan.*

² *A Parks Improvement Project Form is required for all proposed park improvements. Information on project considerations that should be addressed by community project requests and on the project request review process are set forth in the County's Community Project Request Guide.*

to serve as a tool by which the County can evaluate a scope of work, the County may adjust the guidelines and requirements presented in this report as necessary.

A critical component of coastline management as set forth in this report is the Coastline Management Zone (CMZ).³ The CMZ incorporates a stable bluff slope and an appropriate site-specific distance from the existing bluff crest for development. As depicted in Figure 3.1, the CMZ encompasses the projected 60-year bluff recession distance from the current bluff toe, future stable slope distance, an additional distance of 100 feet, and any features lakeside from the bluff toe. The future stable slope distance is calculated from the existing bluff toe to the future stable bluff crest using the ratio of a one-foot vertical rise to a 2.5-foot horizontal run.⁴ The projected 60-year bluff recession distance⁵ is calculated using a minimum recession rate of one foot per year—unless information revealed during the site analysis necessitates using a greater recession rate per year. The additional 100-foot distance provides for uncertainties related to future recession rates, stable slope angles, the effect of nearby shore protection structures, fluctuations in Lake Michigan water levels, and other factors.

Once the CMZ is established in relation to a proposal, the Milwaukee County Coastal Resources Inventory,⁶ which sets forth the vulnerability and value of County-owned assets in the Lake Michigan Coastline Management Zone, may be used to prioritize implementation activities and help the County conduct long-range capital planning. Additional information on implementation is presented in Section 4.

This report uses a study area that encompasses the full extent of the Lake Michigan coastline in Milwaukee County and includes the County-owned land adjacent to the waters of Lake Michigan outlined on Map 3.1 [*under preparation*]. While this report and its guidelines and requirements apply only to County-owned facilities and land within the study area, local municipalities are encouraged to consider the addition of similar goals and guidelines for applicable local proposals within their own jurisdictions.

³ *The Coastal Management Setback is based on recommendations for bluff setbacks published by the University of Wisconsin Sea Grant Institute in 2008. Established to provide bluff setbacks for new development and redevelopment along Lake Michigan, the Coastal Management Setback is intended to protect structures and properties from slope erosion and failure without reliance on shore protection measures.*

⁴ *The stable slope of 2.5 to 1 is an average estimate that will vary depending on bluff geology, including soil types, and other conditions.*

⁵ *The 60-year bluff recession distance is designed to accommodate bluff recession over a time period that is twice that of a typical home mortgage loan.*

⁶ *Milwaukee County was in the process of publishing the coastline asset inventory as this report was being prepared.*

COASTLINE MANAGEMENT GOALS

- Protect Milwaukee County's financial investment in County-owned assets within the Lake Michigan Coastline Management Zone.
- Protect the ecology, resources, and natural character of County-owned lands within the Lake Michigan Coastline Management Zone.
- Provide efficiency and consistency when reviewing proposals for a scope of work to be completed within the Lake Michigan Coastline Management Zone.

COASTLINE MANAGEMENT GUIDELINES

General Guidelines/Objectives

Milwaukee County will seek to attain the following as part of long-term management of the Lake Michigan Coastline Management Zone:

- ▶ Ensure appropriate public access to and recreational opportunities within the Lake Michigan Coastline Management Zone without compromising the stability of the Lake Michigan bluff slope or the integrity of the Lake Michigan shoreline.
- ▶ Ensure access for the maintenance of stormwater facilities within the Lake Michigan Coastline Management Zone.
- ▶ Limit land-disturbing activities within the Lake Michigan Coastline Management Zone that adversely impact natural functions of the land.⁷
- ▶ Prevent erosion and sedimentation that would be detrimental to or increase the area of the natural drainage system.
- ▶ Assess bluff conditions around existing facilities and infrastructure within the Lake Michigan Coastline Management Zone in order to identify both short- and long-term detrimental impacts.
- ▶ Severely limit actions that may detrimentally alter natural and ecologically stable conditions characteristic of the Lake Michigan coastline.
- ▶ Protect the natural character and aesthetic values of the Lake Michigan viewshed in a sustainable way.

⁷ Land disturbing activities may include—but are not limited to—landscape management, the removal of invasive species, accessing stormwater infrastructure, and constructing permanent structures or other facilities.

- ▶ Preserve undeveloped areas within the Lake Michigan Coastline Management Zone that contain a unique or sensitive resources.

Goals for Proposed Development within the Lake Michigan Coastline Management Zone

For work involving the construction of infrastructure, occupiable buildings, and other facilities within the Lake Michigan Coastline Management Zone, the following guidelines should apply:

- ▶ A proposal prepared by a Professional Engineer (P.E.) or Registered Architect (R.A.) licensed in the State of Wisconsin should be submitted to assess compliance with these guidelines and requirements. Any proposal for infrastructure and/or buildings shall adequately assess surface and subsurface soil conditions to address the proposed design.
- ▶ Stormwater management within the Lake Michigan Coastline Management Zone should meet the following requirements:
 1. Stormwater produced on-site should be directed away from the bluff, potentially landward, and stormwater discharges to groundwater should be limited;
 2. Low-impact development (LID) stormwater management practices⁸ should be properly modified for the bluff top or constructed as far from the bluff crest as possible; and
 3. Maintain existing stormwater drainage patterns to and protect tributary ravines.

Goals for Proposed Landscape Management

- ▶ A proposal for a scope of work for landscape management within the Lake Michigan Coastline Management Zone, including but not limited to the removal of invasive species, should be prepared by a landscape architect licensed within the State of Wisconsin and shall include a landscape management plan that meets the following requirements:
 1. Inventory the existing vegetation, including the variances in heights of existing low groundcovers; size, species, and health of shrubs and trees, specifying any proposed alterations to existing vegetation;⁹ and
 2. Describe the vegetation that is to be removed and the means by which the vegetation will be removed, which should be in a manner that does not displace or remove existing forest litter or decrease bluff stability, and identify replacement vegetation to be

⁸ Including but not limited to rain barrels, rain gardens, and porous pavements.

⁹ The use of mulch material is discouraged.

planted in place of the vegetation proposed to be removed, including the rationale used in selecting the proposed replacement vegetation.¹⁰

- ▶ Landscape management proposals related to watershed management within the Lake Michigan Coastline Management Zone should account for the need to retain and maintain bluff vegetation in a variety of heights to promote bluff stability.¹¹ Soil types and vegetation establishment periods shall be prioritized. Appropriate vegetation for bluff stabilization that takes into account height at maturity, soil type and moisture, sun/shade tolerance, and other characteristics is presented in Appendix C.¹²

Goals for a Proposed Shore Protection Modifications and Structures¹³

- ▶ Prioritize non-structural shore protection measures¹⁴ for existing assets within the Lake Michigan Coastline Management Zone that are vulnerable to damage from coastal hazards.¹⁵
- ▶ Enhance, restore, and create coastline wetlands and other appropriate aquatic ecosystem resources where feasible.
- ▶ Limit the construction of shore protection structures within the Lake Michigan Coastline Management Zone to areas where non-structural shore protection measures would be ineffective at protecting the value of County-owned land and structural assets. Shore protection structure designs should include the following:

1. A site investigation of slope stability, lakeshore erosion, and near-shore bathymetry;

¹⁰ Essential information on appropriate vegetation to promote bluff stability is presented in a reference guide, A Property Owner's Guide to Protecting Your Bluff, which was under development by the Wisconsin Coastal Management Program as this report was being prepared.

¹¹ Soil stability can be improved by incorporating a variety of vegetation of different type, heights, and with varying root characteristics. Combinations of trees and shrubs, many of which have deep roots that can serve as vertical anchors, with low-growing herbaceous plants, whose roots tend to prevent lateral shear, can create an interlocked root system to mitigate the impact of both groundwater and surface water runoff. In addition, incorporating evergreen vegetation ensures moisture can be extracted from the soil over longer durations than may be accomplished by strictly deciduous vegetation.

¹² Vegetation for bluff stabilization is taken from a publication under preparation by the University of Wisconsin Sea Grant Institute and the Southeastern Wisconsin Regional Planning Commission, A Property Owner's Guide to Protecting Your Bluff as this report was being prepared.

¹³ All shore protection modifications and structures are regulated by the Wisconsin Department of Natural Resources (WDNR) and the U.S. Army Corps of Engineers (ACOE).

¹⁴ Examples of which include bluff top stormwater and wastewater management, maintaining and enhancing vegetation along shoreline and on bluff slopes, and beach enhancement.

¹⁵ Coastal hazards may include bluff toe erosion, bluff slumping or sliding, or damage related to groundwater seepage or lakebed erosion.

2. A plan for ensuring adequate quality control of materials used in the designed structure; and
3. Adequate monitoring and maintenance plans, as determined by Milwaukee County.

Submittal Requirements for Proposed Projects within the Lake Michigan Coastline

Management Zone¹⁶

- ▶ A proposal for a scope of work for any bluff or shoreline modification¹⁷ within the Lake Michigan Coastline Management Zone should be submitted for review by and approval of the Milwaukee County Parks Planning & Development and Environmental Services Divisions prior to work being performed. The proposed work should be performed under the supervision of a Professional Engineer (P.E.) with a minimum of 10 years of experience involving geotechnical investigation and/or engineering and shoreline slope stability evaluation. A proposal for a scope of work should include the following:
 1. A slope stability analysis¹⁸ that meets the following requirements:
 - Calculations are based upon the highest groundwater conditions that can occur at the site—not the elevation of the groundwater on the day of the analysis;
 - An appropriate safety factor¹⁹ should be used to account for the intensity of the planned use (see Table 3.1);
 - The analysis shall evaluate existing surface and subsurface conditions. Collection of soil data is the responsibility of the applicant, and all work must be permitted through a Parks right-of-entry permit from Milwaukee County.

¹⁶ *Proposals for a scope of work are required for all construction-related land-disturbing activities within the Lake Michigan Coastline Management Zone. Per Chapter NR 152 Appendix A of the Wisconsin Administrative Code, land-disturbing construction activity is defined as “any man-made alteration of the land surface resulting in a change in the topography or existing vegetative or non-vegetative soil cover that may result in runoff and lead to an increase in soil erosion and movement of sediment into waters of the state,” including clearing and grubbing, demolition, excavating, pit trench dewatering, filling, and grading activities.*

¹⁷ *Bluff or shoreline modifications may include—but are not limited to—the construction of shoreline protection structures, such as beach nourishment; the installation of bulkhead, groin, jetty, revetment, or rip rap, or the establishment of wetlands; and development or landscape management within the Coastline Management Zone.*

¹⁸ *Detailed components of the required slope stability analysis are described in Section 4 of this report.*

¹⁹ *An engineer’s assessment utilizing a safety factor of 1.0 would identify the point at which a bluff would fail; the P.E. should use a safety factor greater than 1.0 to account for the intensity of the planned use, which would result in development being subjected to a greater setback from the existing bluff toe.*

2. A no adverse impacts (NAI)²⁰ analysis stamped by a Professional Engineer (P.E.) with a minimum of 10 years of experience involving geotechnical investigation and/or engineering and shoreline slope stability evaluation that meets the following requirements:
 - Accounts for the stability of bluffs and structures;
 - Accounts for the conditions of the shoreline;
 - Accounts for the stormwater managed and produced on-site and for the site's natural drainage system;
 3. A landscape management plan describing the practices and materials, including replacement vegetation, that would be used to implement the plan and maintain the landscape;²¹
 4. Adequate monitoring and maintenance plans as determined by Milwaukee County; and
 5. A statement from the P.E. establishing that the proposed scope of work will not decrease the stability of the bluff area.
- ▶ Milwaukee County will determine the veracity and appropriateness of the proposal.

Application of the Coastline Management Guidelines

When considering the County's Coastline Management Guidelines, Milwaukee County will recognize and protect Milwaukee County's broad public interest via the following:

- ▶ Solicit input from individuals and groups representative of local public interests.
- ▶ Consider the County's duty to preserve natural resources, provide recreational opportunities, maintain public infrastructure, and address coastline impacts/bluff stability risks, in a balanced and sustainable fashion.
- ▶ Take into account the policies, programs, and recommendations of municipalities within the County.

²⁰ Established by the Association of State Floodplain Managers (ASFPM), NAI is a managing principle under which the actions of a property owner to manage water on that property are not allowed to adversely affect the rights of other property owners.

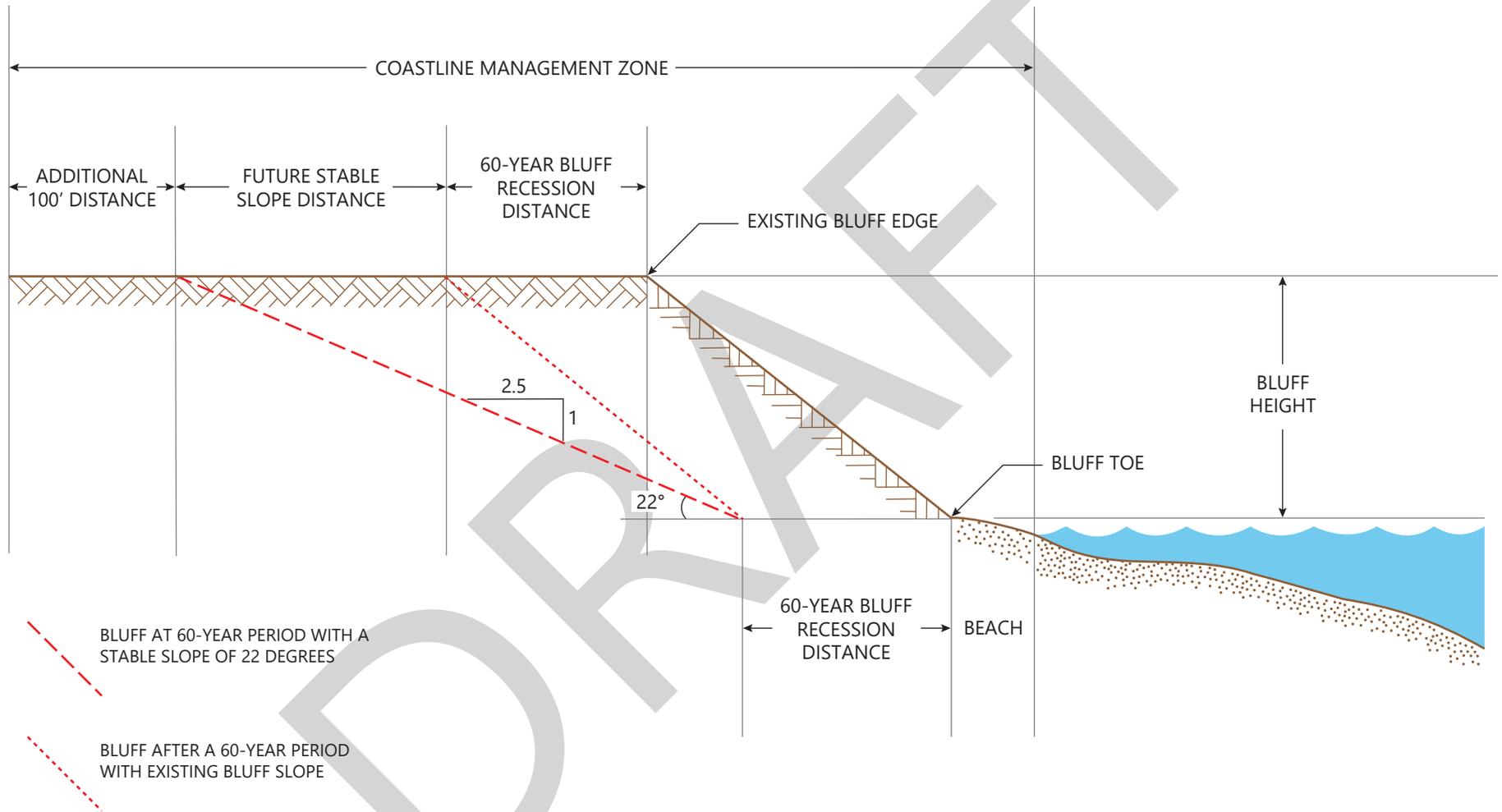
²¹ Detailed components of the required landscape management plan are described in Appendix B of this report.

- ▶ Solicit information and recommendations from individuals with expertise in technical areas pertinent to the proposed project, such as ecology, geology, hydrology, limnology, aquaculture and other scientific fields pertinent to shoreline management.
- ▶ Consider more up-to-date information from pertinent State and Federal coastline management guidelines, policies, and best management practices.

Determinations regarding project proposals shall be made by licensed Professional Engineers and Landscape Architects working for Milwaukee County.

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Figure 3.1
Coastline Management Zone: 2020



Source: University of Wisconsin Sea Grant Program and SEWRPC

Table 3.1
Minimum Design Safety Factors for Coastline Slope Stability Analyses by Intensity of Use

| Intensity of Use | Applicable Activities/Facilities | Minimum Design Safety Factor^a |
|-----------------------------|--|---|
| Low (Passive) ^b | Agricultural or open space use; primary and secondary environmental corridors; and woodlands | 1.1 |
| Light/Moderate ^c | Park and recreational uses; ^d barn/garage/shed; small buried utilities; and tile beds | 1.1-1.2 |
| Heavy/Active | Infrastructure; ^e occupiable buildings and structures; retaining walls; and storage | 1.3-1.5 |

^a These minimum design safety factors exemplify those that engineers may use to find the bluff edge setback appropriate to the associated land use intensity.

^b No buildings.

^c No occupiable buildings.

^d Including golf courses and swimming pools.

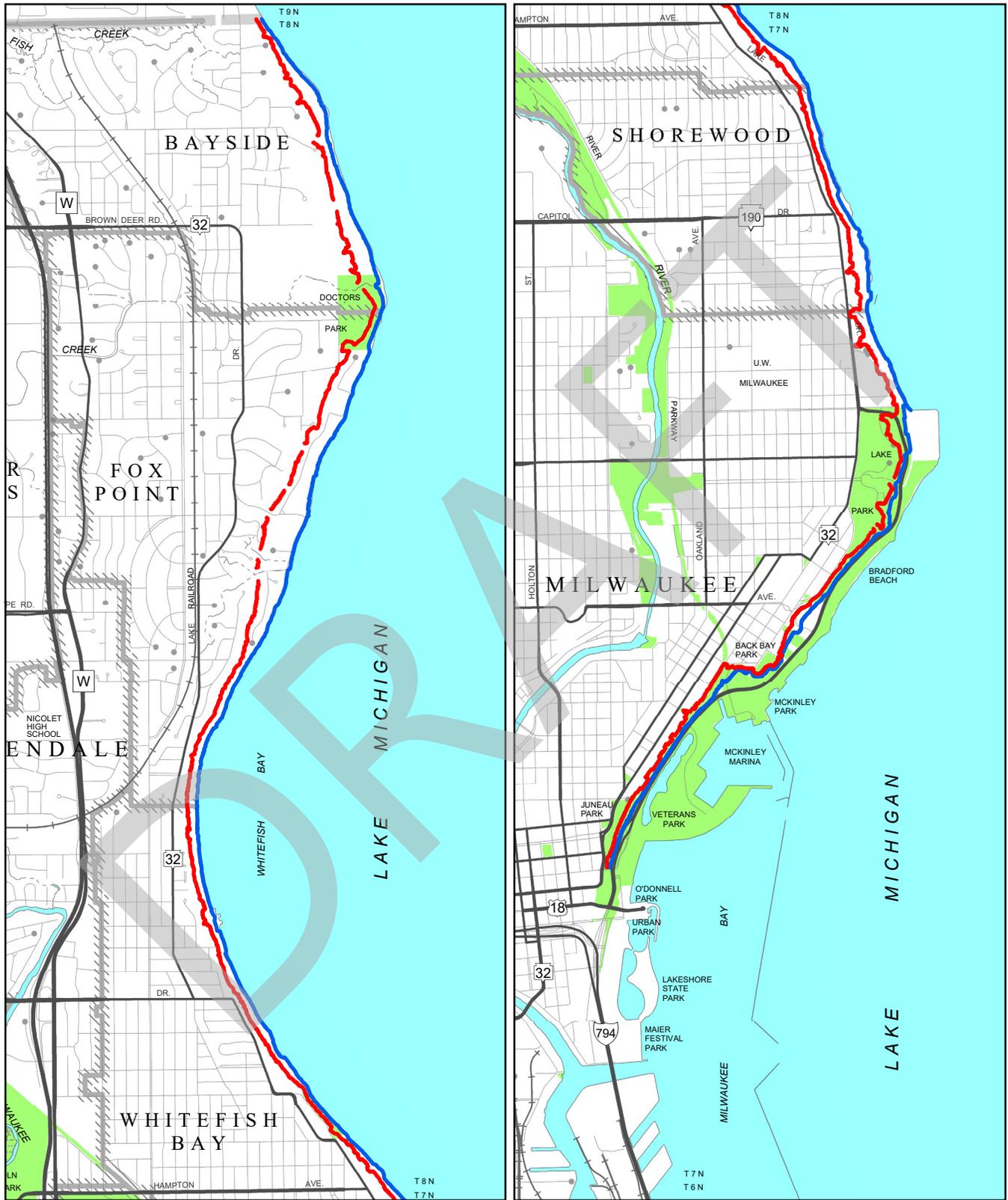
^e Including bridges and high-risk utilities.

Source: Ontario Ministry of Natural Resources and SEWRPC



Map 2.x
Bluff Crest and Bluff Toe Along the Milwaukee County Coastline

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- BLUFF CREST
- BLUFF TOE

Note: (Based on 2015 Lidar Topo but aligned in various locations to data provided to SEWRPC by Wisconsin Coastal Management Program)

■ MILWAUKEE COUNTY OWNED PROPERTY



Source: Wisconsin Coastal Management Program and SEWRPC

Map 2.x
Bluff Crest and Bluff Toe Along the Milwaukee County Coastline

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- BLUFF CREST
- BLUFF TOE

MILWAUKEE COUNTY OWNED PROPERTY

Note: (Based on 2015 Lidar Topo but aligned in various locations to data provided to SEWRPC by Wisconsin Coastal Management Program)



Source: Wisconsin Coastal Management Program and SEWRPC

Appendix C Vegetation for Bluff Stabilization^a

| Herbaceous Plants | | | | | | | |
|--|---|---|-------------------------|--|---|--|---|
| Common Name(s) | Scientific Name(s) | Typical Mature Height | Soil Type | Moisture | Sun/Shade Tolerance | Root Type | Usage Area |
| Asters | <i>Symphotrichum</i> <i>Eurybia spp.</i> | 1-4' | Any | Wet to dry, depending on species | Full sun to shade, depending on species | Fibrous, some species spreading by rhizomes | Table, ravine, bluff face, toe |
| Bergamot | <i>Monarda fistulosa</i> | 3-4' | Any | Moist to somewhat dry | Full sun to partial shade | Deep branched roots and shallow rhizomes | Table, face, toe |
| Blue Vervain | <i>Verbena hastata</i> | 3-5' | Any | Wet to moist | Full sun | Fibrous | Table, toe |
| Common Milkweed | <i>Asclepias syriaca</i> | 2-6' | Any | Moist to dry | Full sun to partial shade | Fibrous, spreading rhizomes | Table, bluff face, toe |
| Foxglove Beardtongue | <i>Penstemon digitalis</i> | 2-3' | Loamy, but adaptable | Moist to medium | Full sun to partial shade | Fibrous | Table, face, toe |
| Goldenrods | <i>Solidago</i> and <i>Euthamia spp.</i> | 2-6' | Any | Wet to dry, depending on species | Full sun to shade, depending on species | Fibrous, some species spreading by rhizomes | Table, ravine, bluff face, toe |
| Great Blue Lobelia | <i>Lobelia siphilitica</i> | 2-4' | Any | Moist to medium | Full sun to light shade | Fibrous, shallow | Table, ravine, toe |
| Mountain Mint | <i>Pycnanthemum virginianum</i> | 2-3' | Any | Moist to medium | Full sun to partial shade | Fibrous with shallow rhizomes | Table, face, toe |
| Sedges | <i>Carex spp.</i> and <i>Scirpus spp.</i> | 0.5-3' | Any | Wet to dry, depending on species | Full sun to shade, depending on species | Fibrous, some species spreading by rhizomes | Table, face, ravine, toe |
| Tall Boneset | <i>Eupatorium altissimum</i> | 3-4' | Any | Medium to dry | Full sun to partial shade | Fibrous | Table, face, toe |
| Virginia Creeper/ Woodbine | <i>Parthenocissus quiquefolia</i> and <i>P. inserta</i> | 1' (on the ground), 30-50' in trees | Any | Moist to somewhat dry | Full sun to shade | Extensive woody root system | Table, face, ravine, toe |
| Warm-season grasses (Switchgrass, Big Bluestem, Little Bluestem, Indiangrass, Rough Dropseed, etc.) | <i>Panicum virgatum</i> , <i>Andropogon gerardii</i> , <i>Schizachyrium scoparium</i> , <i>Sorghastrum nutans</i> , <i>Sporobolus compositus</i> , etc. | 2-8' | Any | Moist to dry, depending on species | Full Sun | Fibrous, deeply penetrating root systems, some species spreading by rhizomes (esp. switchgrass) | Table, face, toe, help prevent erosion |

Herbaceous Plants

| Common Name(s) | Scientific Name(s) | Typical Mature Height | Soil Type | Moisture | Sun/Shade Tolerance | Root Type | Usage Area |
|-------------------|----------------------------|-----------------------|-----------|------------------------------------|---|-------------------------------|--|
| White Snakeroot | <i>Ageratina altissima</i> | 1-3' | Any | Moist to somewhat dry | Partial sun to shade | Fibrous with shallow rhizomes | Table, ravine, toe |
| Wild Ryes | <i>Elymus spp.</i> | 3-5' | Any | Moist to dry, depending on species | Full sun to shade, depending on species | Fibrous | Table, face, ravine, toe, quick to establish |
| Yellow Coneflower | <i>Ratibida pinnata</i> | 3-5' | Any | Medium to dry | Full sun | Fibrous | Table, face, toe |

Shrubs

| Common Name(s) | Scientific Name(s) | Typical Mature Height | Soil Type | Moisture | Sun/Shade Tolerance | Root Type | Usage Area |
|--|--|--|-----------|--------------------------------|------------------------------|---|--------------------------|
| American Highbush Cranberry Viburnum | <i>Viburnum trilobum</i> | 8-15' | Any | Moist | Full sun to light shade | Spreading, suckering | Table, ravine, toe |
| Blackhaw Viburnum | <i>Viburnum prunifolium</i> | 10-15' | Any | Somewhat moist to somewhat dry | Full sun to light shade | Branching, woody, suckering | Table, ravine |
| Chokecherry | <i>Prunus virginiana</i> | 5-30' (shortest in sunny, exposed locations) | Any | Moist to somewhat dry | Full sun to full shade | Spreading, suckering | Table, ravine, toe |
| Common Elderberry | <i>Sambucus nigra ssp. canadensis</i> | 5-12' | Any | Moist to somewhat dry | Full sun to partial shade | Extensive, suckering | Table, ravine, toe |
| Common Ninebark | <i>Physocarpus opulifolius</i> | 5-10' | Any | Moist to somewhat dry | Full sun to partial shade | Spreading, fibrous, extensive, suckering | Table, ravine, face, toe |
| Common Snowberry | <i>Symphoricarpos albus</i> | 2-5' | Any | Moist to dry | Full sun to light shade | Spreading, suckering | Table, ravine |
| Hop Tree | <i>Ptelea trifoliata</i> | 10-20' | Any | Medium to dry | Full sun to partial shade | Extensive, but does not sucker from roots or rhizomes | Table, bluff face, toe |
| Nannyberry Viburnum | <i>Viburnum lentago</i> | 14-25' | Any | Moist to medium | Full sun to light shade | Spreading, fibrous, suckering | Table, ravine, toe |
| Pussy Willow, Missouri River Willow, and Bebb's Willow | <i>Salix discolor, Salix eriocephala, Salix bebbiana</i> | 6-20' | Any | Wet to moist | Full sun to partial shade | Extensive, Fibrous, suckering | Table, ravine, face, toe |
| Red Elderberry | <i>Sambucus racemosa</i> | 8-14' | Any | Moist to medium | Partial shade to light shade | Spreading, suckering | Table, ravine, toe |

Shrubs

| Common Name(s) | Scientific Name(s) | Typical Mature Height | Soil Type | Moisture | Sun/Shade Tolerance | Root Type | Usage Area |
|--|---|------------------------------|---------------------|---|----------------------------|--|--|
| Red-Osier Dogwood, Gray Dogwood, and Silky Dogwood | <i>Cornus sericea</i> , <i>Cornus racemosa</i> , and <i>Cornus amomum</i> | 6-15' | Any | Wet to medium, depending on the species | Full sun to partial shade | Deep, extensive, suckering | Table, ravine, face, toe |
| Round-leaved Dogwood | <i>Cornus rugosa</i> | 10-15' | Any | Medium to somewhat dry | Partial sun to light shade | Deep, extensive, suckering | Table, ravine, toe |
| Sandbar Willow | <i>Salix interior</i> | 8-20' | Sands and loams | Wet to moist | Full sun to partial shade | Extensive, Fibrous, suckering to form large colonies | Table, ravine, face, toe |
| Soapberry | <i>Shepherdia canadensis</i> | 3-9' | Neutral to Alkaline | Moist to dry | Full sun to partial shade | Spreading, suckering | Bluff face, toe (naturally occurs most often on exposed bluff headlands) |
| Staghorn Sumac and Smooth Sumac | <i>Rhus typhina</i> and <i>Rhus glabra</i> | 15-25' | Any | Medium to dry | Full sun | Spreading, suckering to form large colonies | Table, ravine, bluff face, toe |
| American Highbush Cranberry Viburnum | <i>Viburnum trilobum</i> | 8-15' | Any | Moist | Full sun to light shade | Spreading, suckering | Table, ravine, toe |

| Trees | | | | | | | |
|--|--|-----------------------|----------------------------|-------------------------------------|---|---|---|
| Common Name(s) | Scientific Name(s) | Typical Mature Height | Soil Type | Moisture | Sun/Shade Tolerance | Root Type | Usage Area |
| Alternate-leaved Dogwood | <i>Cornus alternifolia</i> | 15-25' | Loamy | Well drained, moist to medium | Full sun to light shade (understory tree) | Shallow, spreading root system benefits from leaf litter | Table, ravine |
| Basswood | <i>Tilia americana</i> | 50-100' | Any | Moist to somewhat dry | Full sun to partial shade | Mostly lateral roots, can form adventitious roots when base is buried | Table, ravine, toe |
| Black Cherry | <i>Prunus serotina</i> | 45-80' | Any | Medium to dry | Full sun to partial shade | Tap root with shallow spreading roots, some roots up to four feet deep | Table, ravine, bluff face, toe |
| Black Walnut | <i>Juglans nigra</i> | 80-120' | Prefers loam but adaptable | Moist to somewhat dry | Full sun | Tap root, produces compound that inhibits growth in some other plants | Table, ravine |
| Black Willow | <i>Salix nigra</i> | 30-60' | Any | Wet to moist | Full sun | Dense, shallow roots, forms adventitious roots when base is buried | Table, ravine, bluff face, toe |
| Eastern Arborvitae | <i>Thuja occidentalis</i> | 40-60' | Loams and clays | Moist to medium | Full sun to partial shade | Shallow, spreading root system | Table, ravine, bluff face |
| Eastern Cottonwood | <i>Populus deltoides</i> | 60-120' | Any | Moist to somewhat dry | Full sun | Roots are shallow and spreading, suckers when top-killed | Bluff face, ravine, toe |
| Hawthorn | <i>Crataegus spp.</i> | 15-35' | Any | Moist to somewhat dry | Full sun to partial shade | Spreading, shallow to medium depths. | Table, ravine, face, toe |
| Hophornbeam | <i>Ostrya virginiana</i> | 25-50' | Any | Well drained, moist to somewhat dry | Full sun to light shade (understory tree) | Variable, shallow in heavy soils | Table, ravine |
| Oaks (esp. Bur Oak and Chinquapin Oak) | <i>Quercus spp.</i> (esp. <i>Quercus macrocarpa</i> and <i>Quercus muehlenbergii</i>) | 40-120' | Any | wet to dry, depending on species | Full sun | Deep and wide-spreading roots, will re-sprout from stump or crown if top-killed | Table, ravine (where relatively stable) |
| Paper Birch | <i>Betula papyrifera</i> | 50-70' | Any | Moist to somewhat dry | Full sun | Shallow, spreading root system, good for stabilization | Table, ravine, bluff face, toe |

| Trees | | | | | | | |
|---------------------|----------------------------|-----------------------|---------------------------------------|-----------------|---------------------------|--|---|
| Common Name(s) | Scientific Name(s) | Typical Mature Height | Soil Type | Moisture | Sun/Shade Tolerance | Root Type | Usage Area |
| Peach-leaved Willow | <i>Salix amygdaloides</i> | 35-70' | Any | Wet to moist | Full sun | Dense, shallow roots, forms adventitious roots when base is buried | Table, ravine (especially along waterways), bluff face, toe |
| Quaking Aspen | <i>Populus tremuloides</i> | 30-60' | Any | Moist to dry | Full sun | Extensive roots to 2-3 feet, with a few roots to at least 5 feet, suckering to form large colonies | Bluff face, ravine, toe |
| Red Maple | <i>Acer rubrum</i> | 50-80' | All but the most high pH (>7.4) soils | Moist to medium | Full sun to partial shade | Shallow roots | Table, ravine, bluff face, toe |
| Wild Plum | <i>Prunus americana</i> | 15-25' | Any | Medium to dry | Full sun | Spreading, shallow to medium depths. | Table, ravine, bluff face, toe |

^a As identified in *A Property Owner's Guide to Protecting Your Bluff*, a publication under preparation by the University of Wisconsin Sea Grant Institute and the Southeastern Wisconsin Regional Planning Commission as this report was being prepared.

Source: University of Wisconsin Sea Grant Institute, and SEWRPC.

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 LKH/RMB
 11/5/2020