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Illinois Coastal Management Program
Issue Paper

Coastal Erosion along the Illinois Coastal Zone

Introduction

Coastal erosion simply defined is the landward movement of the shoreline caused by the erosion of sand or other geologic materials along beaches, bluffs and/or lakebed. Coastal erosion has always been an issue along the Illinois coast. The Illinois coastal zone contains some of the highest valued real estate in the State of Illinois as well as in the entire Great Lakes region. Thus any loss of coastal land because of erosion carries a very high cost. As a result, Illinois also has one of the most intensely engineered coastlines within the Great Lakes region. Erosion-control structures along some segments of the Illinois coast have minimized and even eliminated local bluffline and shoreline recession. However, renewed coastal erosion is a potential threat if these structures are not properly maintained.

Effective coastal management is necessary to provide needed erosion protection balanced by the need to protect the remaining natural coastal processes and systems. Because the Illinois coastline has been substantially modified by coastal engineering, the issue of coastal erosion must be considered within the context of a highly altered, engineered shore with few remaining natural areas.

The purpose of this issue paper is to provide an overview of coastal erosion along the Illinois coast first from a historical perspective and then from the perspective of present-day erosion issues. This issue paper provides suggestions for the management of coastal erosion along the Illinois coast and suggestions for the types of erosion studies that could benefit from Illinois Coastal Management Program (ICMP) funding.

The Natural Setting

In its predevelopment setting in the mid 1800s, erosion dominated much of the Illinois coastline (Chrzastowski, Thompson and Trask 1994). A considerable volume of sand moved naturally along the shore by the process of wave-induced littoral transport, but at any given location the long-term trend was a landward shift of the shoreline consistent with net erosion (U.S. Army Corps of Engineers 1953; Illinois Division of Waterways 1958). The one exception was an approximate four-mile reach of shore at Waukegan and North Chicago where there was a continuing gain of coastal sand and a trend of net lakeward shift in shoreline position. This southern end of the Zion beach-ridge plain was gaining coastal sand related to the ongoing southward migration of this coastal landform. Other than this reach, net coastal erosion dominated along the remaining Illinois coast.

The dominance of net erosion along the Illinois coast was related to a combination of factors. The coast is exposed to considerable wave energy during times of northerly waves. The glacial and coastal sediments along the coast can be readily eroded and transported by wave action. In addition, the coast was (and is) still adjusting in configuration to the modern lake levels of Lake Michigan which began about 2,500 years B.P. (Before Present). Wide fluctuations in lake level had previously occurred since about 14,000 years B.P. resulting in shoreline positions being up to several miles farther inland or lakeward compared to the modern coast. However, beginning about 2,500 years B.P. the lake levels were similar to current and historical lake levels. In response to this trend of lake level remaining within a well-defined range, wave erosion began to modify the Illinois coastline toward a configuration in

equilibrium with that lake level. Through historical time the trend in coastal change, where unimpeded, is for the coast to erode inland. The result has been erosion and a net loss of sediment from the coast, and a net recession of shoreline and bluff line.

Human Influence on Coastal Erosion

Historical Perspectives

Although erosion was the natural and predominant trend along the Illinois coast in the natural setting, human activity along the coast has altered coastal processes and accelerated coastal erosion due to the introduction of shore structures that interrupted the natural southward net transport of littoral sand. The earliest human influence on coastal erosion related to the interruption of littoral sand passing the mouth of the Chicago River. Jetties built in the 1830s at the river mouth resulted in the trapping of sand on the north (updrift) side of the river mouth and a deprivation of sand along the shore on the south (downdrift) side of the river mouth (Chrzastowski 1991; Rosenbaum 1981). By the 1850s, shore protection was needed to prevent shoreline recession from threatening Michigan Avenue along what is now the west side of Grant Park. The stage was set for the eventual lake filling to construct Grant Park. With time, the sand deprivation and resulting shore erosion was felt farther southward. This erosion and its threat to the Illinois Central Railroad was one factor contributing to the lake filling for constructing Burnham Park.

Coastal erosion related to the artificial blockage of littoral sediment has also occurred on the northern part of the Illinois coast resulting from the construction of the harbor jetties at Waukegan Harbor and the breakwaters for the U.S. Navy's Great Lakes Harbor. The history of harbor construction at Waukegan dates from the 1880s, but the harbor jetties did not attain their present configuration until 1906. Subsequent downdrift shore erosion can be attributed to the sand blockage, but the major erosional response has been the reduction of sand cover across the lake bottom south of the harbor where several feet of sand loss has been documented (Chrzastowski and Trask 1995). The breakwaters for Great Lakes Harbor were completed in 1923. Since that time, sand has been trapped against the north breakwater as well as inside the northern half of the harbor by storm waves transporting sand over the low crest of the north breakwater. The sand deprivation to the shore south of the Great Lakes Harbor has been a major factor in erosion along the shore of Lake Bluff and to a lesser extent along the shore farther south (Chrzastowski and Trask 1995).

The entrance area of Waukegan Harbor is a place of persistent lake-bottom sand accretion that requires routine dredging to maintain desired water depths for navigation. Since 1982 sand dredged from the harbor entrance channel has been placed in shallow water either south of the harbor or north of the harbor along the North Unit of Illinois Beach State Park. Thus, this sand has been maintained within the littoral system. However, prior to 1982, sand captured in this dredging was disposed into deep water 2.5 miles offshore. This former practice of permanent removal of sand from the coastal system was a serious detriment to the coastal sand budget. Between 1889 and 1982 approximately 2.5 million cubic yards of sand was removed from the Illinois shore in this manner (Chrzastowski and Trask 1995).

Present-day Perspectives

The process of coastal erosion along the Illinois coast has been largely transformed from one of eroding bluff faces and receding shorelines to one with relatively stable bluffs and fixed shoreline positions. Much of the coastline has been altered to protect property threatened by coastal erosion and to maintain commercial navigation. These alterations include the construction of large structures to protect harbors and adjacent commercial infrastructure, dredging of channels to maintain commercial and recreational navigation, and the emplacement of erosion-control structures to protect both private and public property.

The net effect of this engineering has been to alter the natural coastal processes that create and maintain the beaches, dunes, and bluffs that once existed in a natural state along the Illinois coastline. For example, shore protection structures, such as jetties, bulkheads, breakwaters, groins, and revetments, produce a measurable impact on the shoreline that extends for many times their length (*e.g.*, Dean and Work 1993, Kraus 1988, Komar 1976, O'Brien and Johnson 1980, Shabica and Pranschke 1994, Nairn and Parson 1995, Parson, Morang and Nairn 1996, Nairn and Willis 2002). Structures built to reduce bluff recession can typically succeed in that role, but over the long-term, the structures may lead to the reduction or elimination of beaches, the loss of nearshore sand substrates, and an increase in lakebed erosion which leads to increased water depths in nearshore areas.

If shore-normal structures such as groins or jetties are allowed to trap and accumulate littoral sediments on their updrift side, the structure thereby eliminates those sediments from the active littoral system. Water depths become shallower updrift of these structures and eventually littoral sand may be diverted offshore into deeper water. The downdrift reduction in available sediment supply results in a loss of protective sand cover, accelerates nearshore lakebed erosion, increases nearshore water depth and incident wave energy impinging on the shoreline. Downdrift beaches become thinner and narrower, and rates of bluff-recession increase. These effects are initially local, but long-term permanent reductions in littoral sediment supplies can impact much of the downdrift shore.

Since the 1980s in Illinois, the State (IDNR) and Federal (U.S. Army Corps of Engineers) permitting of any structures or shore facility having the potential to trap littoral sand requires a calculation of the sand retention by a structure and a pre-mitigation emplacement of this sand volume plus an additional 20 percent as an uncertainty factor. This permit requirement minimizes the potential negative downdrift impacts of shore structures. Thus, the potential for entrapment of littoral sand and adverse downdrift impact is no longer unmitigated as it was prior to this permit requirement.

Along the bluff coast from Waukegan south to Glencoe (and to a lesser extent southward to north Evanston) shore-parallel structures such as revetments, bulkheads and seawalls have been built along the toe of the bluffs to prevent bluff erosion. By preventing bluff erosion, these structures contribute to reduced availability of sand and gravel that would otherwise help to nourish and maintain the beaches. In the natural setting, bluff erosion was the primary supply of new sand to the coastal system (Colman and Foster 1994).

The property investment that has been made along the North Shore makes it unrealistic that we can ever return to a setting of unimpeded eroding coastal bluffs. However, the elimination of sediment supply from bluff erosion has contributed to reduced sand volume along the North Shore. Simply said, there has been a trade-off of halting bluff erosion but accelerating beach erosion.

Multi-decade comparisons of beach and nearshore profiles and measurement of sand thickness have documented a long-term trend of sand loss resulting in the beach and nearshore consisting of a thinner and narrower lens of sand (Shabica and Pranschke 1994). Shore-parallel structures may also locally concentrate wave energy in the nearshore zone (through reflection and/or refraction) thereby promoting the loss of sand cover and accelerating nearshore lakebed erosion. Field data in other Great Lakes states has shown that a loss of sand cover will typically result in a thin lag deposit of coarse sand, gravel, and cobble-size material over an indurated cohesive clay or bedrock substrate (Nairn and Willis 2002, Meadows *et al.* 2005).

One of the seasonal factors of coastal erosion is ice. A nearshore ice complex can protect the shore from direct wave impact during winter storms. However, when the ice is broken into blocks and chunks, wave-thrusted ice can act as battering rams and damage shore structures. When the lakeward edge of a nearshore ice complex is impacted by waves, some of the wave energy is directed downward which can

cause erosion on the lake bottom. The wave turbulence can cause sand to be thrown up onto the ice to become part of the ice complex. As the ice breaks up, this incorporated sand can be rafted away and permanently lost from the nearshore area where it originated (Barnes *et al.* 1994).

Geographic Variance of Illinois Coastal Erosion

Coastal erosion along the Illinois coast does not have a single nature but instead has different facets related to setting. This relates to varying degrees of coastal engineering in the different coastal settings as well as to coastal geology. The following discussion of coastal erosion is divided as follows progressing from north to south.

1) Illinois Beach State Park
2) Waukegan and North Chicago
3) Great Lakes Naval Training Center
4) High bluff coast (Lake Bluff to Glencoe)
5) Low bluff coast (Glencoe to Wilmette)
6) Chicago and Evanston coast
7) Nearshore lake bottom

Illinois Beach State Park

Nowhere along the Illinois coast is the potential for shoreline recession greater than along the unarmored segments of shoreline at Illinois Beach State Park. The most severe long-term shoreline recession along the Illinois coast is documented in the state park North Unit averaging 10 feet per year (Jennings 1990). The erosion process at the park relates to the long-term southward migration of this coastal sand plain by erosion along its northern reach and accretion along its southern reach. Shore erosion along the North Unit of the park provides a littoral sand supply that nourishes the beach along the South Unit. If all North Unit erosion was halted, the South Unit shore would be deprived of sand supply and would begin to experience net erosion.

The erosion issues at the park are thoroughly discussed in a separate Issue Paper addressing this as an area of particular concern. The uniqueness of the park setting, the habitat that the park provides and the popularity of the park are all factors that demand effective stewardship of the park (Illinois Department of Natural Resources 2001). Coastal erosion is a primary coastal management issue at the park. The erosion issue is more immediate and long-term than any other location along the Illinois coast.

Waukegan and North Chicago

The Waukegan shore north of Waukegan Harbor has the benefit of sand retention by the north jetty and north breakwater of Waukegan Harbor as well as the abundant sand supply from the north caused by erosion along the state park shore. Maintenance dredging occurs at the entrance to Waukegan Harbor as well as in the cooling water channel at the Midwest Generation Waukegan Generating Station. If sand dredged from these locations is not returned to the littoral stream, this results in a permanent reduction in littoral sand volume in the Illinois coastal system. How the sand is managed from these two dredge sites are critical coastal management issues.

The shore south of Waukegan Marina and continuing south for approximately two miles is primarily an armored shore of rubble-mound revetment with no beach. This is a narrow, southern appendage of the Zion beach-ridge plain and was the leading edge of the southward advancing plain prior to the construction of Waukegan Harbor. Armoring of this shore is essential for erosion control. Foss Park in North Chicago includes a high bluff that requires sound management practices to minimize erosion or

instability. The potential for bluff erosion is most severe at the north end of the park lakeshore where the beach is narrowest. The majority of the park lakeshore has the advantage of a broad beach that is retained by a headland formed by a water plant to the south of the park.

Great Lakes Naval Training Center

All federal land and coastal area that is part of the Great Lakes Naval Training Center is exempt from the ICMP. However, at the discretion of the U.S. Navy, land management at the Naval Training Center could be done such that it is compatible and beneficial to coastal management along the Illinois coast. Sand that has historically been trapped by Great Lakes Harbor is a potential sand resource that could mitigate beach and nearshore erosional trends along the North Shore coast to the south (downdrift) of the harbor. Sand that is dredged and meets necessary environmental parameters could be reintroduced to the littoral transport.

High Bluff Coast (Lake Bluff to Glencoe)

The bluffs of the Illinois coast were essentially all in an erosional state in the late 1800s and early 1900s. As land continued to be developed above the bluff slopes, it became necessary to armor the bluffs to arrest erosion and prevent loss of land and the threat of property damage. By the late 1900s, nearly all of the bluff erosion along the Illinois coast had been contained. For example, many segments of the high bluffs that had serious erosion as recently as the 1970s are now stable and vegetated. Where beaches have been adequately protected and/or engineered with groins, headlands or breakwaters as a means to retain beach sand, times of high lake levels may have the lower beach submerged causing reduced beach width, but as lake level declines the beach width can be restored and there may be minimal net change to the beach profile.

A key factor in containing the bluff erosion has been to eliminate wave action intercepting the bluff toe and contributing to undermining of the bluff face, which can ultimately lead to failure along the bluff slope. Stopping the bluff erosion along the Illinois coast has been achieved by constructing bulkheads, revetments, or seawalls along the toe of the bluffs, or building groins or other beach-retention structures to hold beaches that prevent or diminish wave impact along the bluff toe. The North Shore coast is dominated by a variety of shore-protection structures along the bluff toe. There is also a nearly continuous array of various design groins and other shore-perpendicular structures that are intended to hold beach sand (Keefe 2002; Shabica *et. al* 2004). This coastal infrastructure serves a purpose in erosion defense. However, there is variance in the effectiveness, usefulness, durability, and aesthetics of these structures. Some are well designed and functioning properly, some are less well designed, and some have deteriorated to the point of being of minimal use. A continuing issue for coastal stewardship is the maintenance, update and renewal of this shore-protection infrastructure.

Breakwater-contained beaches at the municipal lakeshore parks in Lake Bluff (Sunrise Beach) and Lake Forest (Forest Park Beach) provide models of beach design that provide shore protection, allow bypass of littoral sand, and create a recreational beach where a beach may otherwise be limited in extent or may not exist. These engineered beach systems are well suited for erosion defense along this bluff coast. Maintenance dredging at the boat launch facilities at Forest Park Beach and at Central Street Beach in Highland Park needs to return sand to the littoral transport.

Low Bluff Coast (Glencoe to Wilmette)

Erosion defense at the toe of the low bluffs from Glencoe south to Wilmette is necessary to arrest bluff recession as along the high bluffs to the north. Erosion defense can be with shore-parallel structures (revetments, bulkheads) along the bluff toe, or by maintaining beaches held by groins or breakwaters. As

along the high bluffs, maintenance, updates and replacement of the shore-protection infrastructure are a continuing coastal stewardship issue.

The entrance to Wilmette Harbor is a trap for littoral sand and requires maintenance dredging. Dredged sand that meets environmental parameters needs to be returned to the littoral transport. The prominent change in shoreline orientation that occurs in the vicinity of the Wilmette Harbor entrance makes it imperative that no action is taken that might contribute to a deflection of littoral sand to the offshore area. Such a deflection would compromise the benefit of the sand for erosion defense or mitigation.

Evanston and Chicago Coast

The Evanston coast north of Northwestern University has low-bluffs and has needs for erosion defense along the bluff toe comparable to the Wilmette shore to the north. Maintenance, updates and replacement of the shore-protection infrastructure are important for sound coastal stewardship.

South of Northwestern University, and continuing south along the Chicago lakeshore to the Illinois-Indiana state line, the upland has a gentle slope to the lakeshore without any coastal bluffs. This bluff-free reach is divisible into two different coastal settings. The Evanston and far north Chicago lakeshore (north of Ardmore - Hollywood Avenue Beach) has a shoreline at or near the pre-development location. South of Hollywood Avenue the shore has been substantially altered by lakefilling.

Along the northern, non-fill lakeshore, shore-parallel structures are locally important to protect the upland from wave impact and wave-induced erosion during times of high lake level. Rubble-mound revetments along most of the Evanston lakeshore parks provide such erosion protection. Shore-parallel structures along the far north Chicago lakeshore consist of a variety of design bulkheads and revetments. Groin-held beaches provide additional shore protection for the Evanston and Chicago far north lakeshore, as well as provide recreational beaches. Erosion defense is critical along this reach in order to protect the nearby arterial and secondary streets, neighborhood lakeshore parks, and the high-density lakeshore residential properties. Emergency erosion defense was necessary during the record high lake level of 1986 resulting in the construction of rubble-mound breakwaters to protect the Chicago beaches at Fargo Avenue Park, Jarvis Avenue Park and Lane Park.

Chicago's lakefill coast begins at Ardmore-Hollywood Avenue Beach and is essentially continuous to the Indiana state line with the exception of a short reach on Chicago's south lakeshore between 71st and 75th Streets. The made land of the Chicago lakeshore resulted from filling between the shoreline that existed in pre-development time and a designed shoreline position that is hundreds to thousands of feet lakeward. At Montrose and Wilson Avenues on Chicago's north lakeshore, the present shoreline is nearly three quarters of a mile lakeward of the natural shoreline position. Along much of the made land the water depth is in the range of six to 10 feet, but depths as much as 18 to 20 feet occur along the east end of the lakefill land at Montrose Avenue.

Revetments and bulkheads protect the lakeward edge of the filled land of the Chicago lakeshore. Stone placed as toe protection along the lake-bottom edge of these structures protect the lake bottom from erosion that would otherwise occur by the downward-deflected energy of incoming waves. The coastal erosion that can occur along the made land of the Chicago lakeshore has several variations.

1) Revetment Deterioration: Wave impact, ice impact, changing lake levels and freeze-thaw action can all contribute to a deterioration of the revetments and bulkheads along the Chicago lakefront. A first generation of timber and stone revetments, most built between 1920 and 1940, were seriously deteriorated by the late 1980s (Chicago Shoreline Protection Commission 1988). This led to the construction of a second generation of revetments built with steel sheetpile and formed-

in-place concrete. Maintenance and updating of the Chicago revetments are a necessary commitment in order to safeguard the made land that these structures hold and protect.

2) Erosion by Revetment Overtopping: Storm events during times of above-average lake level can result in waves breaking over the revetments and impacting the adjacent parkland. Damage to upland infrastructure (walkways, signage, *etc.*) can occur. Subsequent erosion mitigation may involve filling, regrading, and replanting vegetation.

3) Beach Erosion: All Chicago beaches have been built with some type of structure to retain beach sand such as groins (Hollywood Avenue or Montrose Avenue Beach), groins combined with submerged breakwaters (North Avenue or 31st Street Beach), or simply a submerged breakwater (12th Street Beach). The potential exists for sand loss during times of above average lake level. Beach nourishment may be a necessary mitigation over time.

The importance of maintaining the edge of the Chicago lakeshore filled land is critical for the erosion defense of the fill. The fill material is predominantly sand but includes clay (clayey till) (Chrzastowski 1991). This fill material can be readily eroded if subject to wave action. The edge of this filled lakeshore is the line of erosion defense for the diverse infrastructure of roadways, walkways, parkland and the varied public venues that occupy the made land.

Nearshore Lake Bottom (Lakebed Erosion)

The nearshore is defined as the zone between the shoreline and an indefinite distance offshore beyond the surf zone. Along the Illinois coast, wave action and sediment transport can alter the bottom profile to a depth of about 18 feet. Thus the 18 foot depth is used as the limit of the nearshore zone. Because of lake-level changes, the location of this depth contour is subject to change.

The process of lakebed erosion refers to the erosion of cohesive clays (glacial till) that forms the lakebed of the nearshore. These clays are typically overlain by sand that forms the lens of sand that extends from the beach and into the nearshore. If the sand cover is depleted, wave action can directly erode the till. Alternatively, wave action can move a thin layer of sand across the till and the abrasion can cause erosion. This erosion lowers the nearshore profile and thus creates deeper water closer to shore. This deeper water and steeper profile in turn makes the shore more vulnerable to wave attack and erosion. Lakebed erosion can also contribute to the undermining of shore structures.

Lakebed erosion is irreversible and, once it occurs, substantial volumes of material (sand and gravel) are needed to restore the lakebed profile to a pre-erosion profile. When lake levels rise, deeper water in the nearshore zone increases wave energy and accelerates erosion of beaches and adjacent bluff areas. The only effective way to manage lakebed erosion without resuming bluff erosion is to artificially maintain adequate supplies of protective littoral sediment within the nearshore zone, and/or armor the lakebed with cobbles or boulders to prevent erosion of the underlying cohesive clays.

Impact of Shore Protection on Nearshore Habitats

Erosion-control and navigation structures alter the coastal processes that create and maintain the pattern and distribution of nearshore aquatic habitats. Loss of sand and gravel substrates can reduce potential spawning, nursery, and migratory fish habitats in nearshore areas (Goodyear *et al*. 1982). These structures also alter nearshore bathymetry and water circulation patterns, which may in turn affect water temperature, turbidity, productivity and prey availability, and the distribution of larval and juvenile fish.

Research is needed regarding the status of the nearshore habitat along the Illinois coast south of Waukegan, as well as research addressing the issue as to how human activity along this reach has potentially altered the once natural habitat. Extensive coastal engineering and loss of littoral sand suggests that the adjacent nearshore habitats are now much more coarse-grained and heterogeneous than would have naturally been present. One of the impacts of these changes in substrate is the rapid colonization and spread of aquatic invasive species (such as *dreissenids*) that have adversely impacted food web-dynamics and the Great Lakes ecosystem. It is only now recognized that many of the physical changes that have occurred in the nearshore zones of the Great Lakes have provided the opportunity for massive expansion of these invasive species along with significant associated ecological impacts (*e.g.*, Janssen, Berg and Lozano 2004; Meadows *et al.* 2005).

Perspectives on the Management of Illinois Coastal Erosion

The high value of real estate will continue to be a prime reason why this shore will be defended. The ICMP provides an opportunity to do the needed evaluation, monitoring and planning related to the diverse erosion issues along the Illinois coast. The following series of focus items provide perspectives on how the management of Illinois coastal erosion can be perceived and addressed.

1) Erosion and Its Relationship to Lake Level: Coastal erosion along the Illinois coast occurs at all lake levels. Although high lake levels are times when erosion is perceived as most problematic, the erosion processes also continue during times of low lake levels. The focus of erosion simply shifts lakeward and impacts the nearshore lake bottom. Coastal erosion monitoring and mitigation should be ongoing management issues regardless of lake level.

2) Appreciation of the Erosional Natural State: Erosion dominated along the Illinois coastline in the natural state. Although some human activity has contributed to shore erosion, coastal engineering has also eliminated erosional trends such as bluff recession along the North Shore and long-term shoreline recession along nearly the entire Illinois coast except at Illinois Beach State Park. Because of the natural erosional trends along the Illinois coast, this coast will be perpetually dependent on coastal structures and/or artificial beach nourishment. However, wherever possible, both hard (structural) and soft (nourishment) solutions should be done in such ways to maintain or enhance habitat.

3) The Need for Erosion Defense: Prevention and remediation of shore erosion is a necessary management practice along the Illinois coast if the present shoreline is to be maintained. Both hard remedies (structures such as revetments, breakwaters, bulkheads, *etc.*) and soft remedies (beach nourishment) have a role in this erosion management. Shore-protection structures are an integral component of the Illinois coast and these need to be maintained, repaired, updated and augmented as needed.

4) Planning and Design of Shore Protection: To the greatest degree possible, new shore-protection structures built along the public lakeshore should be designed and built with maximum consideration of durability, public access, recreational applications and aesthetics. The Chicago lakeshore provides numerous examples of shore-protection structures that are functional, user friendly and a compliment to the lakeshore scenery. Shore-protection structures that are most desirable are ones that provide the needed shore protection while minimizing impacts to natural coastal processes, enhancing nearshore and coastal-margin habitat, and providing access to the water's edge. Shore-protection structures that are built along private property but extend onto the public-trust lake bottom need to clearly satisfy their purpose of erosion protection.

5) Priority Erosion Concern: Shore erosion at Illinois Beach State Park should be the long-term priority for coastal-erosion management along the Illinois coast. The need for this focus relates to the intrinsic value of this unique coastal setting and habitat, the potential for sustained shore erosion along this state park shore, and the need to protect this public landscape for the enjoyment of future generations. Beach nourishment is the preferred erosion defense; use of structural measures should be minimized in order to preserve as much as possible a shore that is open, free and clear of shore structures.

6) Management of Dredged Sand: Sand dredged from harbor entrances or other areas where undesirable sand accretion occurs should be sand that is maintained within the littoral system. This can involve either placing the sand along the beaches or nearshore downdrift of the dredge area or, if conditions and management needs warrant, returning the sand to the beach or nearshore in the updrift direction and thus recycle the sand along a specific reach of shore.

7) Limited Reliance on Littoral Transport: Only Illinois Beach State Park should be a coastal reach along which erosion protection is dependent on a sustained supply and transport of littoral sand. This is needed to preserve the setting of this state park shore. This sand supply can be from beach nourishment and a sand recycling program of returning beach sand to the north end of the park after being captured at the south end of the park. The diminishing resource of littoral sand along the North Shore and the northern Chicago lakeshore requires that any location along this reach not be dependent on a sustained supply of littoral sand from the north.

8) Recognition of Chicago's Unique Coastal Setting: The maintenance and improvements to beaches and shore-protection structures along the lakeshore parkland in Chicago has special significance. This shoreline infrastructure provides erosion protection of made land, which in some locations can be readily lost to wave erosion if not protected. This shoreline infrastructure is also an urban recreational and aesthetic asset that annually benefits millions of users.

9) Lakebed Erosion: Lakebed erosion is an important coastal management issue that presents unique challenges. It occurs below water and thus it cannot be visibly evaluated and monitored. In addition, the erosion process may not be apparent until after adverse impacts occur. Maintaining a lakebed mapping and monitoring program would provide needed data to determine the extent, rate and trends of lakebed erosion along the Illinois coast and may also be a basis for mitigation.

10) Bluff Erosion: In order to stabilize the bluff slopes, erosion across the bluff face should be prevented or mitigated by using vegetation, appropriate grading, and proper management of surface water runoff. The natural erosional state of the bluff face prevented any extensive vegetation cover. Thus, there is no "native" bluff-face vegetation that can be employed, but plants best suited for the slope and soil conditions should be selected. Opportunities should be pursued that provide a vegetation stabilization of the slopes as well as provide habitat. A well-vegetated bluff slope is effective erosion prevention. Also effective is a bluff toe having a well-designed and maintained revetment and/or a wide beach. Both high bluffs and low bluffs need protection along the bluff toe. Although erosion along the high bluffs can be visually impressive, the low bluffs can have a greater potential recession rate because less material needs to be removed per unit of bluffline recession (Jibson, Odum and Staude 1994).

11) Shore Erosion along Inland Waters: Coastal erosion management will primarily be concerned with the open-water Lake Michigan coast of Illinois, but there are other areas within the Illinois coastal management zone that also have potential issues related to shore erosion. These are the

land areas bordering the Inland Waterways, Chicago's small-boat harbors, the Calumet River, Lake Calumet, Wolf Lake and Powder Horn Lake.

12) Coastal Sand as a Limited Commodity: There are essentially no new sand supplies being provided to the Illinois coast. The once primary source of sand supply from bluff erosion has been eliminated; the volume of littoral sand coming south across the Illinois-Wisconsin state line has been substantially reduced. The need exists for conserving, recycling and enhancing the existing coastal sand resource.

Application of Coastal Management Program Funding

The ICMP can assist in funding for erosion monitoring and evaluation that will provide the data needed for effective coastal zone planning and management. Five areas of coastal erosion study are particularly worthy of funding:

- From annual monitoring of physical characteristics along the entire Illinois coast, maintain a database of profile data, sand-thickness measurements and distribution maps, nearshore bathymetry, and coastal photography. Such a database will be a valuable planning tool for coastal management.

- Conduct annual monitoring of physical characteristics specifically focused on the coastal area of Illinois Beach State Park/North Point Marina and the neighboring coast southward to Waukegan Harbor. This coastal reach includes the most severe beach erosion along the Illinois coast and has the greatest need for the management of coastal sand.

- Establish and maintain a mapping program specifically to monitor lakebed erosion. This is primarily a North Shore issue, but can include the lake bottom off North Chicago and Waukegan south of Waukegan Harbor, and Chicago's north lakeshore north of Hollywood Avenue. Lakebed erosion has the potential of being the future, long-term erosion issue along the Illinois coast.

- Support research to better understand the role of nearshore ice in Illinois coastal erosion. Previous studies of the dynamics of coastal ice along the Illinois coast have demonstrated that nearshore ice can contribute to erosion (Barnes *et. al* 1994). Ice can also contribute to the damage and deterioration of shore structures.

- Support periodic inventory of all shore-protection structures along the Illinois coast (public and private) to document structural integrity and effectiveness in erosion defense or in retaining beach sand.

Summary

The Illinois coast was predominantly an erosional coast in its natural setting. Since the late 1800s, various types of shore-protection structures (revetments, breakwaters, bulkheads, and groins) have reduced the degree and extent of coastal erosion. Shore-protection structures have an important role in erosion control along the Illinois coast. The planning, design and maintenance of these structures are critical to assure that they are effective and do not contribute to detrimental impacts.

Lakebed erosion is a process that can contribute to detrimental impacts along much of the northern half of the Illinois coast. Routine monitoring of lakebed erosion, monitoring of beach and shoreline

characteristics, and inventories of shore-protection structures are all important planning and management tools for the stewardship of the Illinois coast.

The most severe shoreline recession along the Illinois coast occurs in the North Unit of Illinois Beach State Park. The South Unit of the state park has the potential of comparable severe erosion if this shore does not receive a supply of littoral sand from the north. Erosion management at the park should be the highest priority for Illinois coastal erosion management, and this will remain a high priority as long as it is desirable to maintain a shore with minimal or no shore-protection structures. In particular, the South Unit is the last remaining natural and near-natural coastal landscape along the Illinois coastline. This is a fragile and priceless coastal landscape that needs to be preserved for the benefit of future generations.

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