

Guide to the Geology of Illinois Beach State Park and the Zion Beach-Ridge Plain, Lake County, Illinois

Michael J. Chrzastowski and Wayne T. Frankie



Field Trip Guidebook 2000C
Field Trip Guidebook 2000D

September 23, 2000
October 28, 2000

Department of Natural Resources
ILLINOIS STATE GEOLOGICAL SURVEY



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Department of Natural Resources
George H. Ryan, Governor
ILLINOIS STATE GEOLOGICAL SURVEY
Natural Resource Building
615 East Peabody Drive
Champaign, IL 61820-6964
Homepage: <http://www.isgs.uiuc.edu>

Cover photo View from the southeast across the shore of the South Unit at Illinois Beach State Park. The South Unit preserves the last remaining reach of Lake Michigan shoreline in Illinois that is free of shore-protection structures. The South Unit also preserves the natural landscape of the Zion beach-ridge plain with its extensive dunes, beach ridges, and coastal wetlands (photo by J. Dexter, Illinois State Geological Survey, May 2000).

Geological Science Field Trips The Geoscience Education and Outreach Unit of the Illinois State Geological Survey (ISGS) conducts four free tours each year to acquaint the public with the rocks, mineral resources, and landscapes of various regions of the state and the geological processes that have led to their origin. Each trip is an all-day excursion through one or more Illinois counties. Frequent stops are made to explore interesting phenomena, explain the processes that shape our environment, discuss principles of earth science, and collect rocks and fossils. People of all ages and interests are welcome. The trips are especially helpful to teachers who prepare earth science units. Grade school students are welcome, but each must be accompanied by a parent or guardian. High school science classes should be supervised by at least one adult for each ten students.

A list of guidebooks of earlier field trips for planning class tours and private outings may be obtained by contacting the Geoscience Education and Outreach Unit, Illinois State Geological Survey, Natural Resources Building, 615 East Peabody Drive, Champaign, IL 61820-6964. Telephone: (217) 244-2427 or 333-4747. This information is on the ISGS home page: <http://www.isgs.uiuc.edu>

Two USGS 7.5-Minute Quadrangle maps (Waukegan and Zion) provide coverage for this field trip area.

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Era	Period or System and Thickness	Epoch	Age (years ago)	General Types of Rocks	
CENOZOIC "Recent Life"	Quaternary 0-500'	Holocene	10,000	Recent—alluvium in river valleys and sediments along Lake Michigan shore	
		Pleistocene Glacial Age		Glacial till, glacial outwash, gravel, sand, silt, lake deposits of clay and silt, loess and sand dunes; covers nearly all of state except north-west corner and southern tip	
	Tertiary 0-500'	Pliocene	1.6 m	Chert gravel, present in northern, southern and western Illinois	
		Eocene	5.3 m	Mostly micaceous sand with some silt and clay; presently only in southern Illinois	
			36.6 m		
	Paleocene	57.8 m	Mostly clay, little sand; present only in southern Illinois		
MESOZOIC "Middle Life"	Cretaceous 0-300'		66.4 m	Mostly sand, some thin beds of clay, and, locally, gravel, present only in southern Illinois	
PALEOZOIC "Ancient Life"	Pennsylvanian 0-3,000' ("Coal Measures")		144 m	Largely shale and sandstone with beds of coal, limestone, and clay	
			286 m		
	Mississippian 0-3,500'		320 m	Black and gray shale at base, middle zone of thick limestone that grades to siltstone chert, and shale; upper zone of interbedded sandstone, shale, and limestone	
	Devonian 0-1,500'		360 m	Thick limestone, minor sandstones and shales; largely chert and cherty limestone in southern Illinois; black shale at top	
	Age of Invertebrates	Silurian 0-1,000'		408 m	Principally dolomite and limestone
		Ordovician 500-2,000'		438 m	Largely dolomite and limestone but contains sandstone, shale, and siltstone formations
				505 m	
		Cambrian 1,500-3,000'		570 m	Chiefly sandstones with some dolomite and shale; exposed only in small areas in north-central Illinois
		Precambrian			Igneous and metamorphic rocks; known in Illinois only from deep wells

Generalized geologic column showing succession of rocks in Illinois. The sediments of Illinois Beach State Park and Zion beach-ridge plain are of the Holocene Epoch (less than 10,000 years in age).

Illinois Beach State Park and Zion Beach-Ridge Plain

The Illinois coast of Lake Michigan extends 60 miles along the southernmost part of the western shore of the lake (fig. 1). This coast borders the most densely populated area in the Great Lakes region, and includes some of the most engineered and altered coastal settings in the region. Unique along the Illinois coast is its far northern segment that includes Illinois Beach State Park. This park preserves the last remaining segments of Lake Michigan shoreline in the state that are free of any coastal engineering, and the last remaining expanse of coastal dunes and wetlands. Illinois Beach State Park is part of a distinct coastal landform called the Zion *beach-ridge plain*.^{*} This young, dynamic, and migratory landform results in this state park being in a setting, and having ongoing geologic processes, unlike any other park in Illinois. The unique geological setting of the park is a habitat for many rare and endangered plant species.

The Illinois Department of Natural Resources (DNR) has the role of stewardship for the state park and the adjoining North Point Marina (fig. 2). Together the park and marina facilities occupy 6.5 miles of the 9.7-mile shore between the Wisconsin–Illinois state line and Waukegan Harbor. This segment of the Illinois coast presents some of the state’s most challenging issues regarding coastal management. The coastal geology and dynamics of this setting produce both deficits and surpluses of coastal sand from place to place. The Department of Natural Resources spends approximately half a million dollars a year to place sand along the shore of the state park to reduce, but not eliminate, the erosional threat. To the south of the state park, a surplus of coastal sand requires maintenance dredging every one to two years to keep channels open for power plant cooling water at the Waukegan Generating Station and navigation into Waukegan Harbor. Nowhere else on the Illinois coast is the management and conservation of coastal sand resources as important as along this reach. Other issues at stake, such as recreational amenities, aesthetics, commerce and industry, and preservation of natural areas, are current topics that frequently appear in the news.

This field trip provides the opportunity to observe how natural processes along the coast and human activity interact to produce both beneficial and detrimental results. The stops were selected to examine erosion hot spots along this shore, state-of-the-art coastal engineering to halt shore erosion, beach nourishment to counteract erosion, and coastal challenges that occur where there is an overabundance of coastal sand. The management and conservation issues will be examined in the context of the geological processes that led to the formation of this unique coastal landform and the ongoing processes of coastal change that continue to modify this coast. Understanding the coastal geology and coastal evolution provides a critical framework for understanding the challenges in coastal management of this unique setting.

HISTORY OF ILLINOIS BEACH STATE PARK †

Illinois Beach was legally designated as a state park on July 13, 1953, and thus the fiftieth anniversary of this park will occur in 2003. Prior to the park designation, the land now occupied by the park had a diverse history and saw a variety of land uses. The initial designation as a park was for what is now the South Unit. The North Unit has existed for only about 30 years and resulted from land acquisitions in the 1970s.

^{*} Italicized terms are defined in the glossary at the end of the guidebook.

[†] This section was adapted from the DNR park brochure and Bannon-Nilles (in preparation).

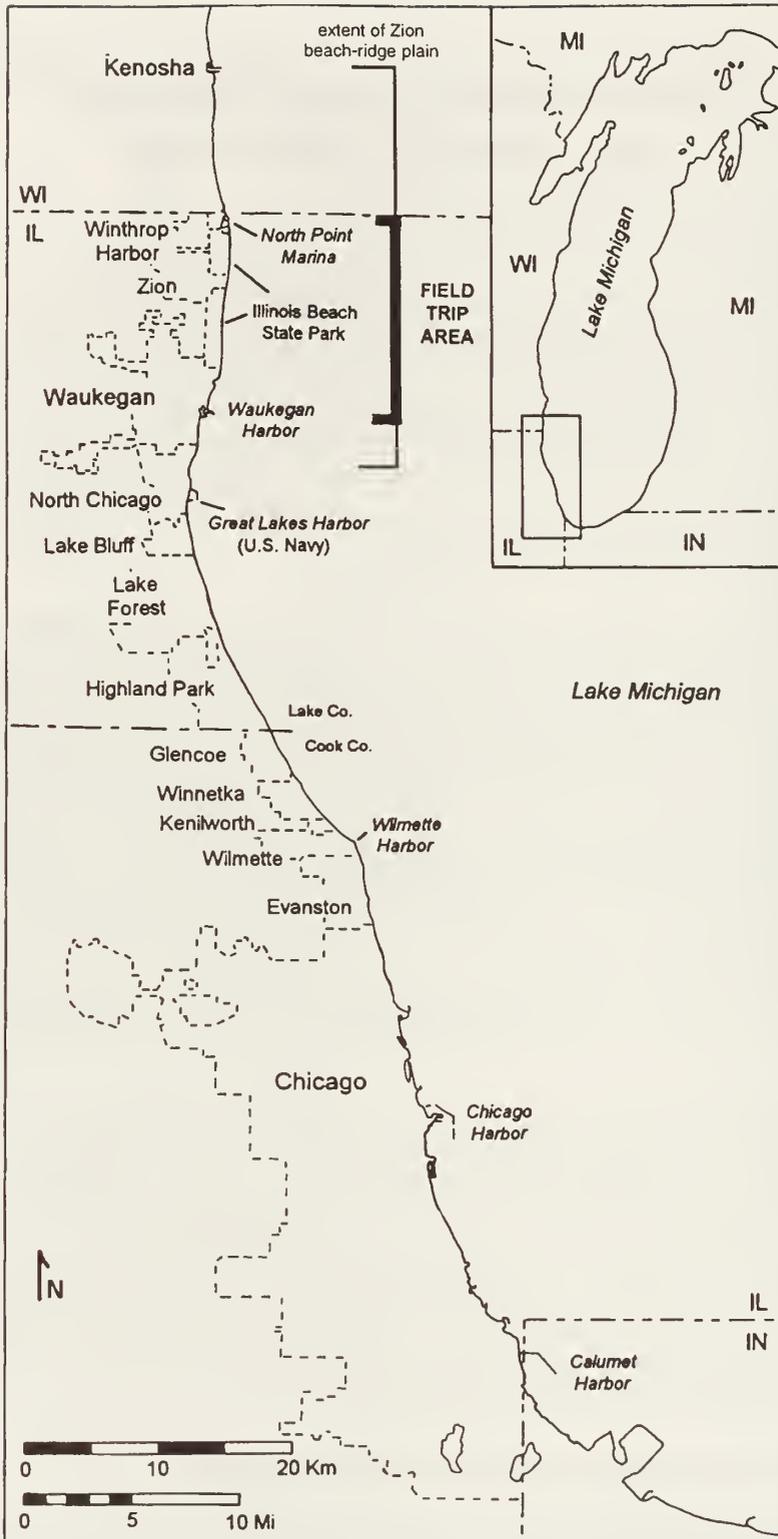


Figure 1 Illinois coast of Lake Michigan with location of the field trip.

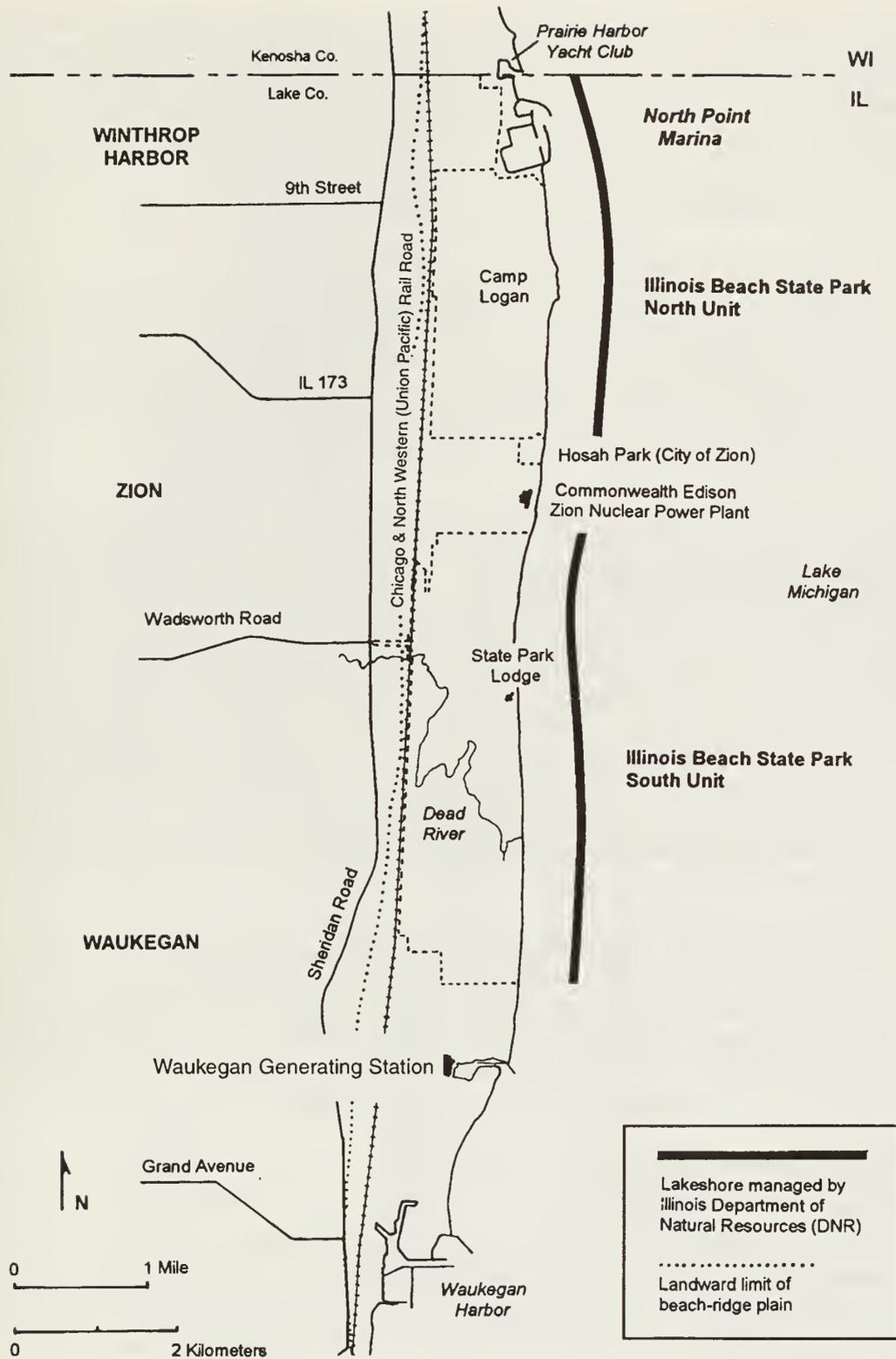


Figure 2 Limits of the North and South Units of Illinois Beach State Park, local place names and geographic features, and the extent of shoreline managed by the Illinois Department of Natural Resources.

The land that makes up the South Unit never saw any widespread development, but documents indicate that a community (called Mayville) was once platted for land along Dead River. About 1902 a railroad track had been built across the ridges and swales to a point along the shore just north of Dead River. Along the beach vast quantities of sand and gravel were then being mined and hauled away by rail car. The remains of the abandoned tracks can still be found in some places. The scenery of what is now the South Unit led to using the area for the filming of several westerns beginning in 1914 and continuing into the 1920s.

The northward advance of the Waukegan industrial developments along the lakeshore prompted the Illinois Dunes Park Association to lease some land in the present South Unit area in the 1930s. The association hired caretakers and charged visitors fees. Then in 1943 the Illinois General Assembly approved the purchase of 450 acres (182 hectares) of land for park use, but following the purchase, the land was turned over to the U.S. Army for temporary use during World War II. After the war, the land reverted to the State, which then purchased another 623 acres (252 hectares). Land acquisition in the South Unit continued into the 1950s.

The North Unit of the park occupies land that has had a much more intense and extensive history of development than the South Unit. The Camp Logan area of the North Unit was a prisoner of war camp during the Civil War. This installation went on to serve as a U.S. Army basic training camp through World Wars I and II; in the late 1940s, it was turned over to the Illinois National Guard. Land here has seen tank maneuvers, gun and artillery ranges, and the varied buildings and infrastructure of an army base. To the north and south of Camp Logan, residential housing developments existed in the 1950s and 1960s. Many homes built near the shore later suffered severely from shore erosion. Some structures actually fell into the lake. The closing of Camp Logan and the erosion problems along this reach allowed the State to acquire the land in the 1970s. What is now the North Unit of the state park formally became part of the park between 1971 and 1982. The North Unit originally extended along the shore to the Wisconsin–Illinois state line. Construction of North Point Marina resulted in a separate parcel of lakeshore land that is managed by DNR separately from the state park.

The combined North and South Units give Illinois Beach State Park a total land area of 4,160 acres (1,683 hectares). This ranks as the fifth largest state park in Illinois. On May 9, 2000, the North Point Marina and Illinois Beach State Park were formally dedicated as the Cullerton Complex in honor of William J. Cullerton, Sr. A decorated World War II hero, a Chicago-area radio personality, and a highly successful sporting goods businessman, Bill Cullerton has been a long-time advocate of Lake Michigan conservation, fishing, and boating.

GEOLOGIC FRAMEWORK

The Zion Beach-Ridge Plain

Illinois Beach State Park occupies a prominent coastal feature called a *beach-ridge plain*. This type of coastal landform occurs worldwide along sandy coasts. Beach-ridge plains consist of linear, generally coast-parallel mounds of sand and/or gravel (adjacent to each other) that have been built up by wave action to extend the coast outward into the adjacent ocean or lake. Excellent examples of beach-ridge plains along ocean coasts occur along the Nayarit coast in Mexico and on St. Vincent Island, Florida. The Zion beach-ridge plain extends along the Lake Michigan shore for nearly 18 miles (29 km) from Kenosha, Wisconsin, to North Chicago, Illinois (fig. 1). The plain has a maximum width of about 1 mile (1.6 km) opposite Zion, Illinois, and has thus been named after this city. The plain defines one of the three different coastal/geomorphic zones along the Illinois coast (fig. 3) and has a geologic history very different from the rest of the Illinois coast.

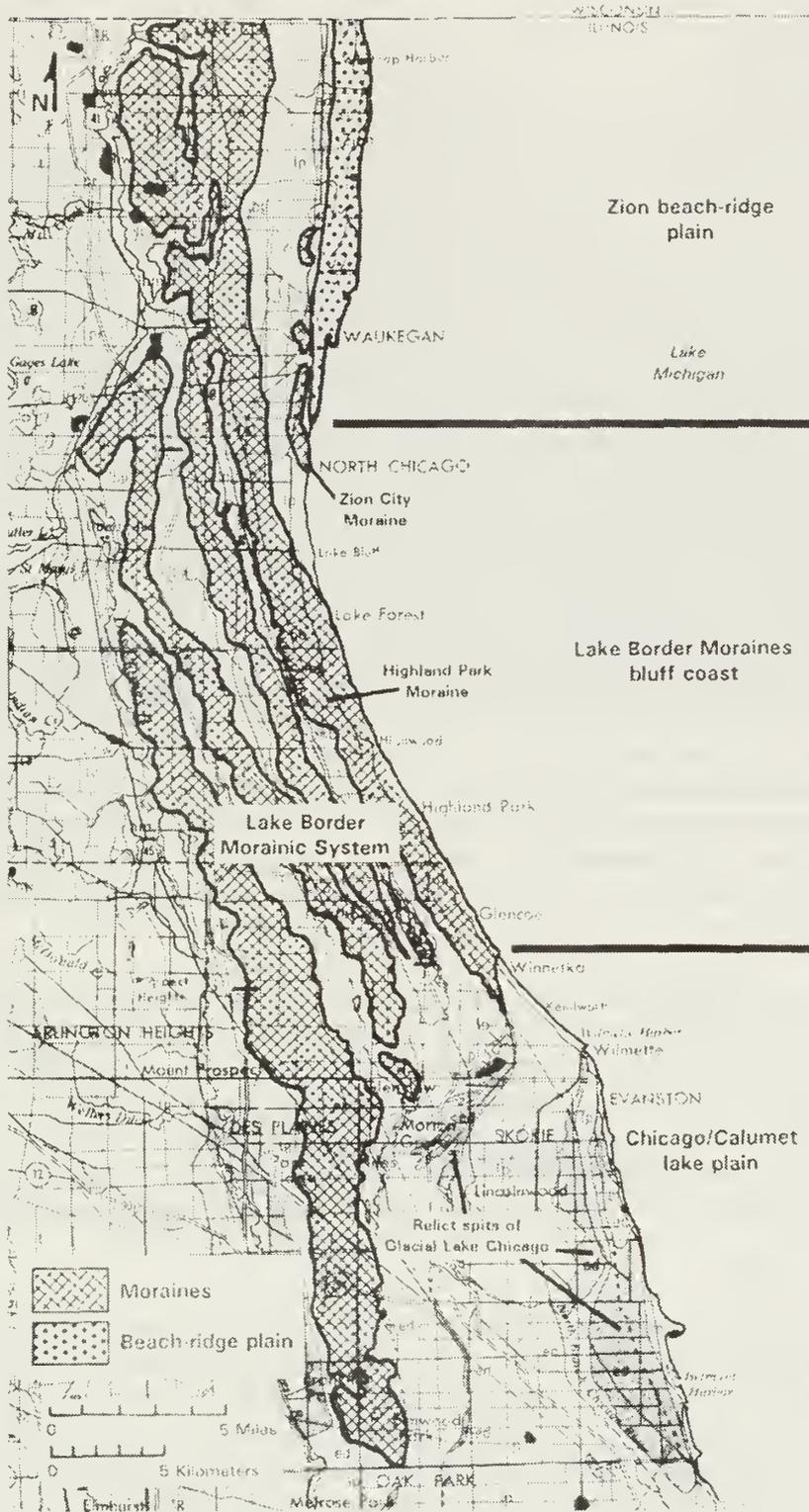


Figure 3 Three coastal geomorphic divisions along the Illinois coast of Lake Michigan (from Chrzastowski and Trask 1995; modified from Willman and Lineback 1970).

A characteristic of a beach-ridge plain is a “washboard” topography of sub-parallel ridges separated by low areas called *swales*. The ridges and swales of the Zion beach-ridge plain are best seen in the South Unit of the state park, and best viewed from the air (fig. 4). The difference in elevation between the ridges and swales in the state park is generally no more than 10 feet (3 m), except where sand dunes built atop the ridges add to their height. The ridges are typically formed by storm waves that have enough energy to move large volumes of sediment and deposit sediment in a mound (i.e., ridge) that can have a lateral continuity for great distances along the shore. Although the topography consists of multiple ridges and swales, this type of coastal landform is called a plain because the elevation difference between tops of the ridges and bottom of the swales is minor compared to the length and breadth of the overall landform.

The Beach-Ridge Plain in Three Dimensions

Considerable amounts of geologic data, collected from drill-hole data on land and seismic-reflection surveys across the nearshore, provide a three-dimensional understanding of the Zion beach-ridge plain. Aiding in mapping this three-dimensional geometry is the marked contrast between the sands, gravels, and organic deposits that make up the beach-ridge plain and the underlying compact glacial clays (and tills).

Figure 5-A shows that in cross section the plain consists of a lenticular body of sands and gravels that is thickest near the present shoreline and thins both landward (west) and lakeward (east). The maximum thickness ranges from 30 to 35 feet (9.1 to 10.6 m) (Fraser and Hester 1974). On the landward margin, the sediments of the plain pinch out at the toe of the change in slope that marks the base of the upland bluffs. This zone is where sediments of the beach-ridge plain are lapped against former beach deposits laid down when this was a bluff coast, prior to the formation of the beach-ridge plain. From the water’s edge, the beach-ridge sediments extend more than 5,000 feet (1,525 m) offshore and thin to a veneer that becomes indistinguishable from the veneer of sand and gravel that blankets the lake floor.

To compare the 3-D geometry of the beach-ridge plain with the beaches that occur to the south, figure 5-B shows a representative cross section of the beach and nearshore deposits at the Highwood Waterworks, which is located about 8.5 miles (13.7 km) south of the southern limit of the beach-ridge plain. All the beach and nearshore deposits along the Illinois bluff coast are typically thin (less than 10 ft [3 m] thick) and narrow (less than 3,000 ft [915 m] wide). Similar thin and narrow beach and nearshore deposits existed along a bluff coast at the site of the present beach-ridge plain prior to the plain advancing southward and superimposing its deposits.

Drainage Area

Because the Zion beach-ridge plain is lower in elevation than the adjacent upland to the west, and because the upland slopes toward the lake, the beach-ridge plain is the focus of a rather large drainage area (or watershed). This drainage area has an elongate, north–south trend that generally parallels the shore and reaches to just under 3 miles (4.8 km) inland from the shore (fig. 6). The westward limit of this watershed approximately corresponds to the route of Green Bay Road, which generally follows the high ground along the crest of one of the lake-border moraines (fig. 3). The drainage divide formed by this moraine separates drainage directed east, across the Zion beach-ridge plain, and into Lake Michigan from drainage directed west and then south by way of the Des Plaines River. This is a segment of the major eastern continental divide that separates drainage directed through the Great Lakes to the Gulf of St Lawrence and drainage directed through the Mississippi River basin to the Gulf of Mexico.



Figure 4 Aerial view of the South Unit of Illinois Beach State Park looking southwest past Dead River. The major ridges and swales are distinguished by differences in vegetation adapted to the higher and lower elevations. The arc pattern of the ridges and swales records the southward advance of the beach-ridge plain as successive beach ridges were added (photo by M. Chrzastowski, May 2000).

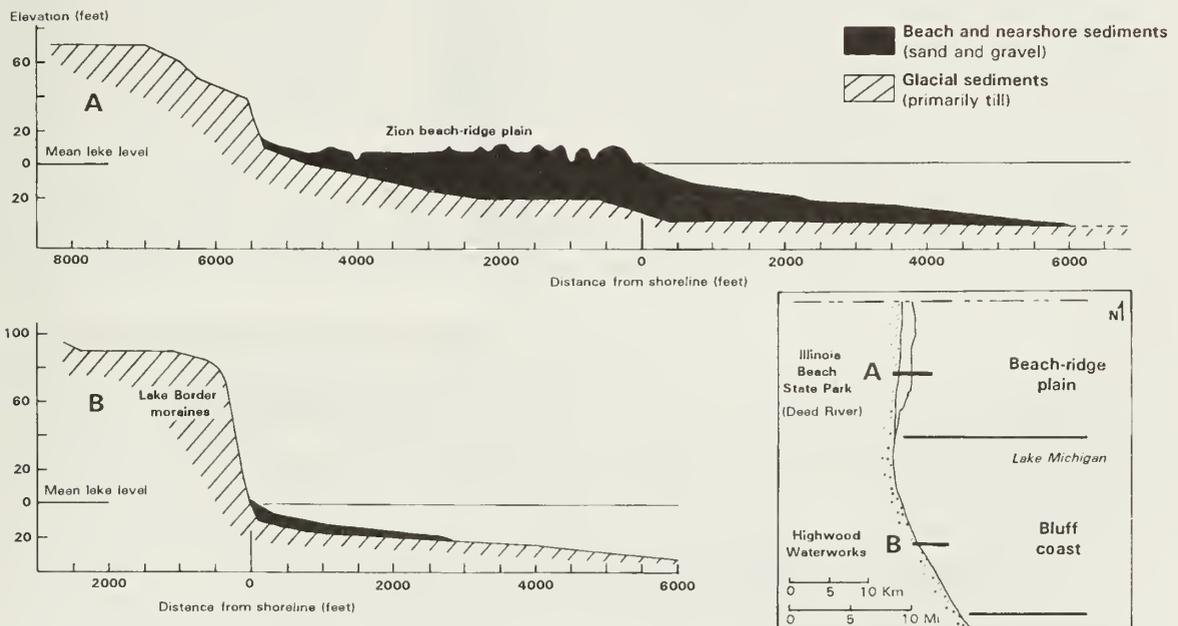


Figure 5 Cross sections of the beach and nearshore sediments along the Illinois coast comparing the thickness and breadth of deposits at the Zion beach-ridge plain near Dead River (A) and along the bluff coast at Highwood Waterworks (B) (from Chrzastowski and Trask 1995).

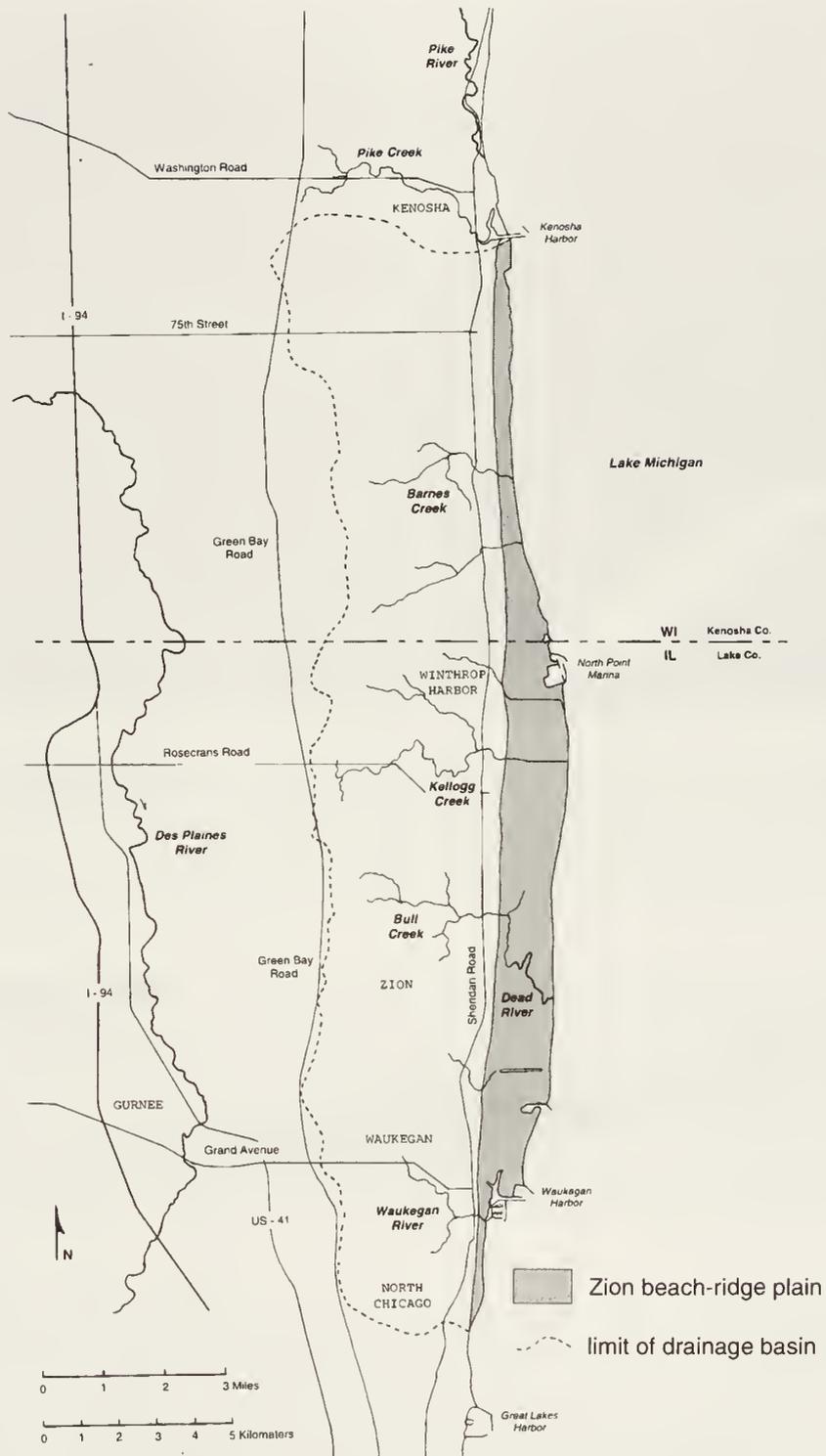


Figure 6 Drainage area of the Zion beach-ridge plain.

The total drainage area west of the beach-ridge plain is about 37 square miles (96 sq km) with 46 percent of the area in Wisconsin and 54 percent in Illinois. West of the beach-ridge plain, the streams flow through a dendritic pattern of V-shaped ravines incised into the glacial sediments. The geologic history of these ravines has yet to be fully studied, but they likely formed during the Chippewa phase of Lake Michigan's lake-level history. This phase lasted from about 10,000 to 5,500 years B.P. (before present) when lake levels were tens to hundreds of feet lower than today. In response to the lower lake levels, erosion occurred along the river and stream channels draining to the lake (see Geologic Evolution section).

Sediment Characteristics

The surficial sediments of the Zion beach-ridge plain consist of a broad range of materials that include organic-rich sand, silt, and clay in the marsh deposits of the swales, well-sorted medium sands in the dunes, and localized deposits of concentrated coarse sand, pebbles, and cobbles along the beach. The differences in surficial sediments reflect the differences in transport and sorting by either waves or wind. In the subsurface, the sediments are dominated by those deposited below or at lake level as the beach-ridge plain advanced along the coast (fig. 7). The deepest deposits are fine to medium sands with shell material. These sediments, which generally overlie glacial till, accumulated offshore in water as much as 20 feet (6 m) deep or more and mark the underwater leading margin of the plain. These are overlain by medium to coarse sand and gravel that accumulated in the nearshore and eventually across the beach. These are deposits laid down in shallower water, where the wave energy was greater, and represent the advancement of the nearshore and subaerial parts of the plain along the coast. The subsurface, vertical sequence of offshore, nearshore, and beach deposits mimics the surficial lateral succession of deposits one encounters in traversing from the beach to the offshore area across the lake bottom.

The pebbles and cobbles that are distributed across the beach and shallow nearshore are noteworthy for their interesting shapes and the variety of rock types represented. The pebbles and cobbles are well rounded, in part due to their transport by wave processes along the coast. However, as discussed in the Geologic Evolution section, the entire suite of particles found along the beach began as deposits in a glacier-fed river, and much of the rounding of these pebbles and cobbles would have occurred during this river transport. The composition of these pebbles and cobbles represents the variety of rock types that occur in northern Wisconsin, northern Michigan, and southern Ontario, Canada. They were removed from these areas and transported into the Lake Michigan region by a lobe of the continental ice sheet that spread across the Great Lakes region during the last glacial episode of the Great Ice Age.

COASTAL PROCESSES

The Zion beach-ridge plain is a geologic feature that owes its origin and evolution to coastal processes. These processes include wave dynamics, the movement of sediment by wave action, short- and long-term changes in lake level, and the influence of coastal ice. The areal extent and configuration of Lake Michigan provides a setting in which many of the coastal processes operating along the shore of the Zion beach-ridge plain are comparable to coastal processes operating along many ocean coasts. In contrast to most ocean coasts, this Great Lakes setting can have rapid changes in mean water level due to wind and pressure disturbances across the confined water area of the lake. This Great Lakes coast also experiences the dynamics of coastal ice, a phenomena that only occurs along arctic and near-arctic reaches of ocean coasts.

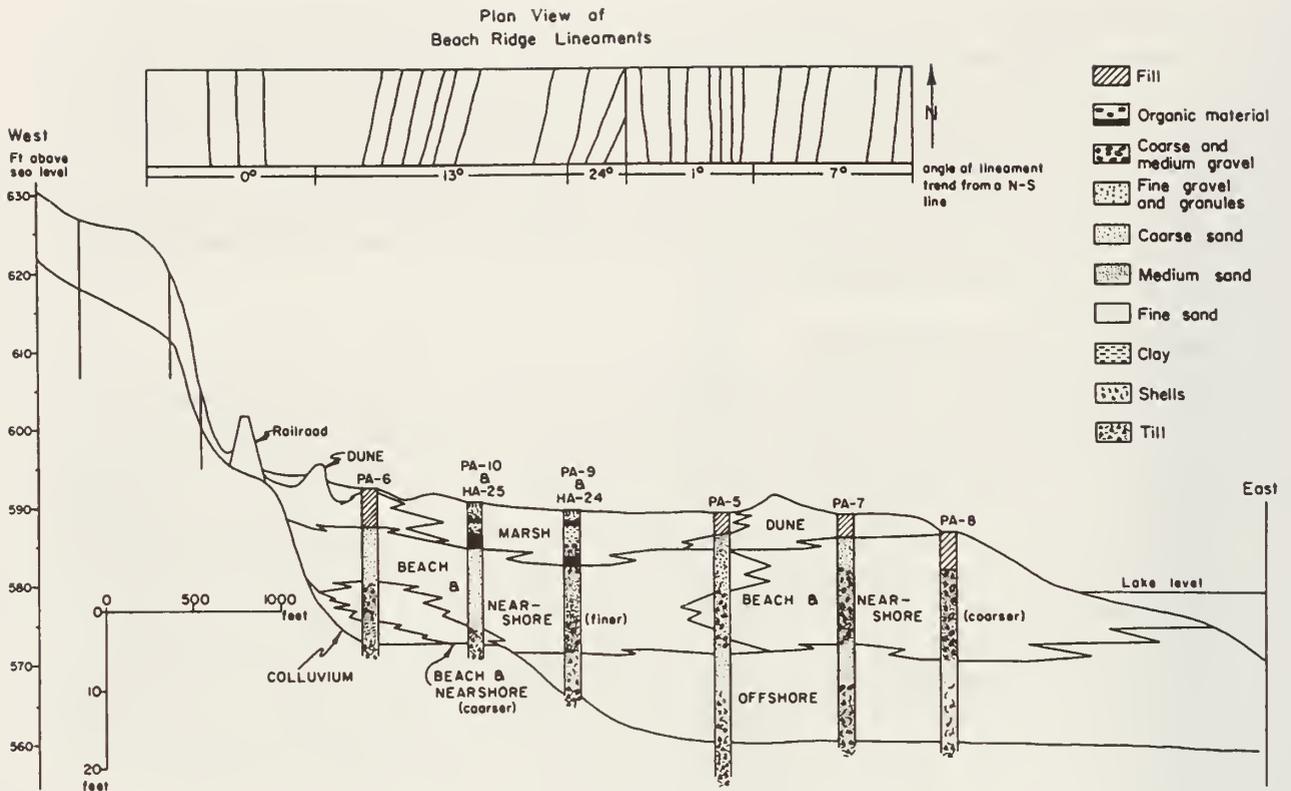


Figure 7 Cross section of subsurface sediments and depositional environments. Compiled from drill holes taken along a west–east line from the state park entrance to the parking lot near the main swimming beach (from Hester and Fraser 1973).

Waves

Wave action is the most important force influencing the Zion beach-ridge plain. Generated by winds blowing across Lake Michigan, waves (1) provide the energy for the erosion, transport, and deposition of sediment, (2) produce the directional forces that influence the shape of the nearshore lake bottom and beach, and (3) play a role in the location and configuration of the shoreline. As further discussed in the Geologic History section, waves are responsible for the very formation and evolution of the beach-ridge plain.

The beach-ridge plain parallels the north–south orientation of the western shore of the lake, which is exposed to waves approaching from the northeast, east, or southeast sectors. Wave generation is dependent on the wind’s speed and direction, the length of time it blows in a given direction, and fetch (the distance over water that the wind can blow). Because of the shape of Lake Michigan and the geographic position of the Zion beach-ridge plain, the greatest distance of open water from the shore of the Zion beach-ridge plain is to the northeast (fig. 1, inset map).

Wave data for the shore at Illinois Beach State Park have been evaluated based on a 32-year history of observations along the Lake Michigan shore (Hubertz et al. 1991, Booth 1994). The average wave along this shore has a height of 2.3 feet (0.7 m) and a period (time between the passage of wave crests) of 3.7 seconds. Compared to the average waves intercepting most ocean coasts, these are relatively small waves. During storms, however, waves along this coast can exceed 10 feet (3 m), a height equivalent to storm waves along some ocean coasts.

The frequency of waves approaching the Illinois Beach State Park shore from the three east compass sectors is given in figure 8. Considering the occurrence of all waves approaching this shore regardless of height, most waves (46%) approach from a southerly direction (fig. 8-A). When wave frequency is considered according to wave height, waves from a northerly direction dominate. The northerly direction accounts for half the waves that equal or exceed about 3 feet (1 m) in height (fig. 8-B), nearly three-fourths of the waves that equal or exceed about 7 feet (2m) (fig. 8-C), and 90 percent of the waves that equal or exceed about 10 feet (3m) (fig. 8-D). The important points here are that the most common winds and waves along this shore are southerly, but the very long northerly fetch causes waves from this direction generally to have the greatest height, the greatest energy, and thus the greatest net effects along this coast.

Those who infrequently visit the shore at Illinois Beach State Park are likely to see the lake calm or near calm, since northerly waves approach the shore less than half the time. During calm or near-calm conditions, it can be difficult to imagine the wave heights of 10 feet (3 m) or more that occur in storm events. Such storms typically occur in the fall, winter, and spring. Because storm systems usually drift rapidly eastward out of the region, the high waves they generate rarely last more than a few days. It is during these infrequent and short-lived events that the effect of waves along the coast is greatest, the greatest volumes of coastal sediment are transported, and most of the annual coastal change occurs.

Littoral Transport

Littoral transport refers to the movement of sediment along beaches and in the nearshore (littoral) zone under the influence of wave action and wave-induced currents. The sediment moved in this process is referred to as *littoral drift*.

Waves approaching the shore at an angle provide the driving force for littoral transport (fig. 9). If waves approach from a direction perfectly perpendicular to the shoreline, sediment will be moved onshore and offshore, but not in one direction along the shore. As the angle between the approaching waves and the shoreline becomes greater, potential for wave action to transport sediment along the shore increases. In the nearshore, sediment is moved along the lake floor by a current generated by the incoming waves. As the waves break along the beach, sediment is moved across the beach surface by the swash and backwash.

Littoral transport was responsible for the formation of the Zion beach-ridge plain and is the key factor in its continuing coastal evolution. The littoral transport along this shore can be directed either northward or southward depending on the wave approach at any time. As noted previously, waves usually approach the state park shore from a southerly direction; thus, the littoral transport is usually northward. However, the largest and most energetic waves usually approach from the northerly direction, and the transport capability of these waves greatly exceeds that of their southerly counterparts. Thus, although sediment moves both northward and southward along the state park shore (called “gross transport”), the greater energy of storm waves causes the *net* transport to be southward.

Because of the net southward transport along this shore, transport in the northward direction along this shore is referred to as *updrift*, and in the southward direction as *downdrift*. This terminology is also used in referring to the updrift (north) and downdrift (south) side of structures that extend across the beach and into the nearshore. Such structures can act as barriers to the littoral transport, trapping littoral sediment on the updrift side and depriving littoral sediment supply to the

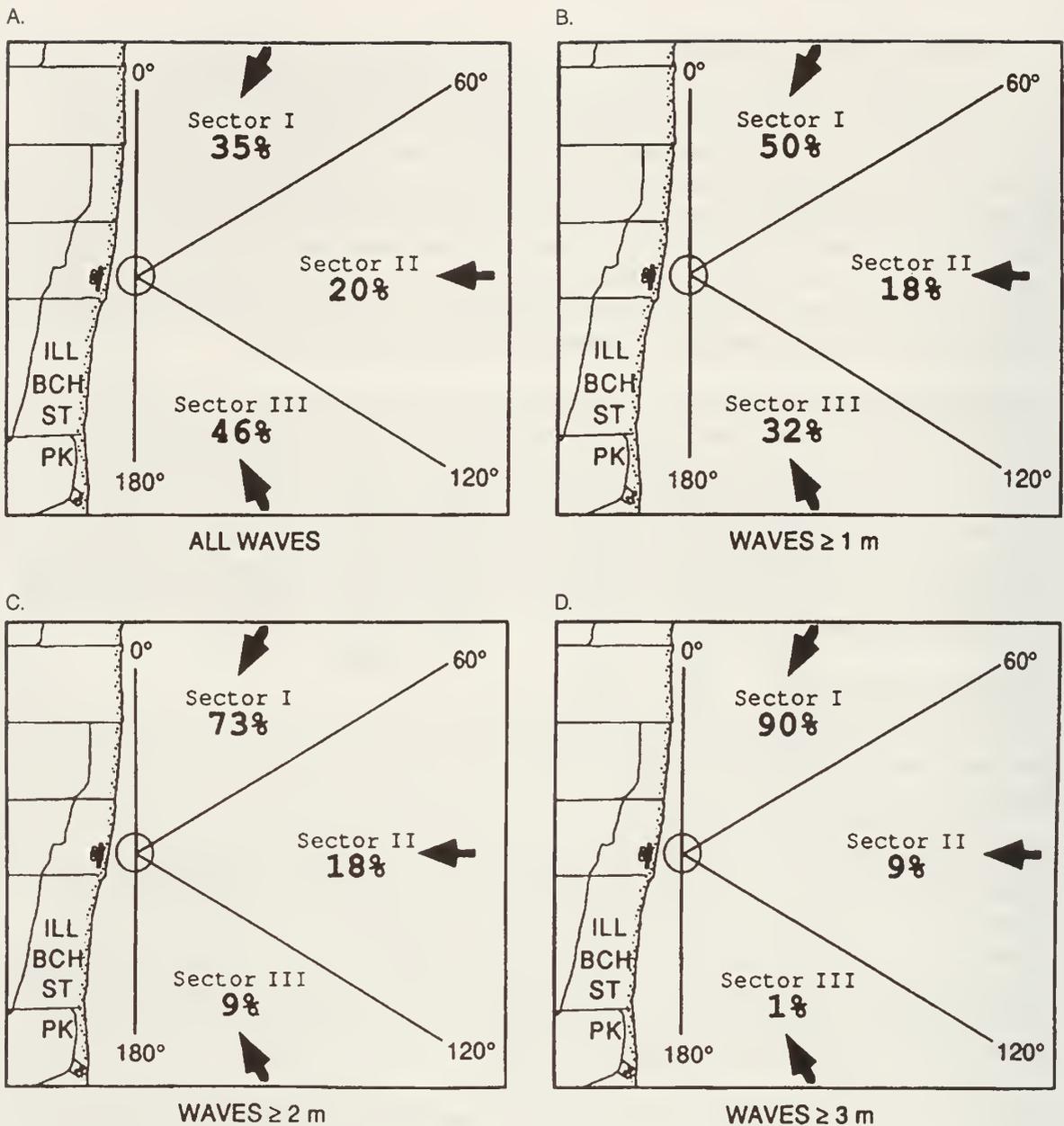


Figure 8 Relative frequency of waves of different heights approaching the shore at Illinois Beach State Park from the northerly, easterly, and southerly sectors (from Booth 1994).

downdrift side. Examples of such littoral sediment entrapment against shore structures include the higher and wider beaches on the updrift (north) side of shore structures at Camp Logan, which we will visit at Stop 2.

Littoral Transport Volumes

The volume of sediment moving along the shore each year in littoral transport is a very important factor to the geologists, engineers, and managers who work on the coast and who are concerned with erosion and accretion issues. This volume can vary significantly from year to year because of differences in storm-wave frequency and intensity, lake-level changes, changes in sediment supply, and the influence of human activity in aiding or interrupting the littoral transport. The long-term

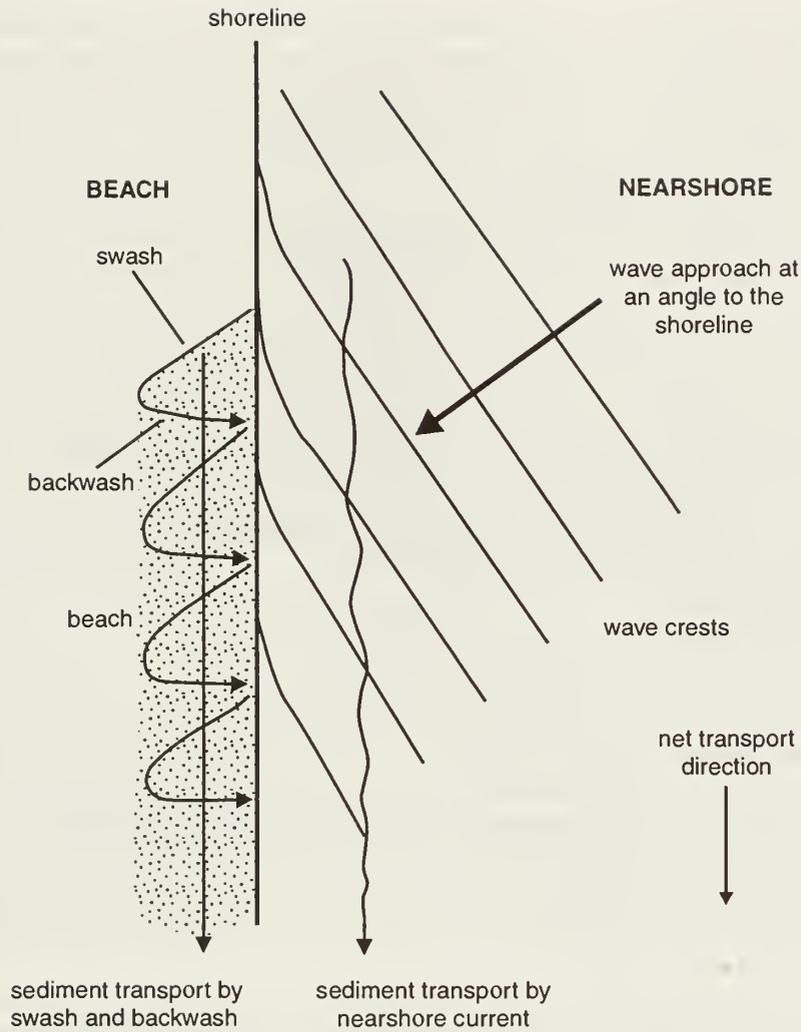


Figure 9 Dynamic components that contribute to littoral transport. Sediment can be moved in either direction along the shore at different times depending on the wave approach. One of the two directions is the net transport direction, which is the most important direction in the evolution of the coast.

record of littoral transport provides a means to compute an average annual rate. Methods of measuring sediment volumes typically have relied on a comparison of repetitive profile data and/or bathymetric mapping, records of the volume of sand added as beach nourishment and its rate of dispersal, and records from dredging in channels that can trap the flow of littoral sediment. For example, computing the state park transport volumes is aided by the long-term records of dredging at the cooling-water channels for the Waukegan Generating Station and the entrance channel to Waukegan Harbor (fig. 2). Summation of the average annual volume of sediment dredged from these two sites offers a good approximation of the annual transport volume along much of the state park because the net southward littoral transport must pass the southern end of the state park before reaching these two dredge sites.

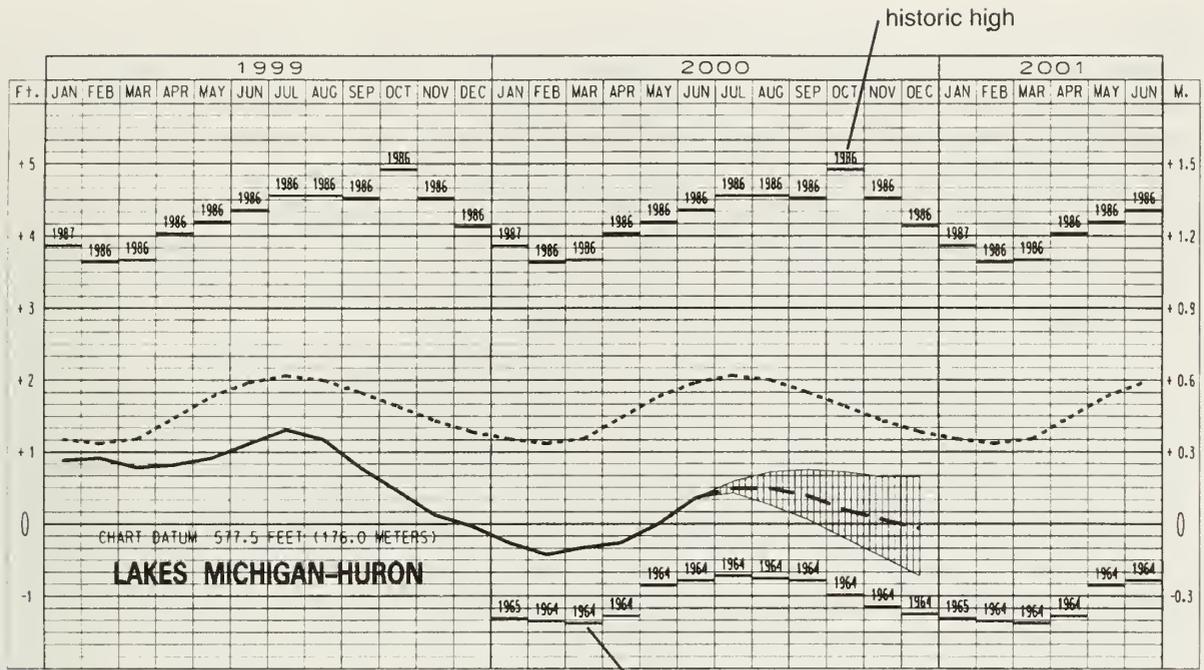
Volume estimates for the net southward littoral transport passing the state park generally range between 73,000 and 95,000 cubic yards per year (U.S. Army Corps of Engineers 1953, Tetra Tech 1978, Foyle et al. 1998). A volume of 80,000 cubic yards per year is generally used as the representative or average value. The available data suggest that the long-term average transport rate has not changed much over historical time. What has changed is the contribution to this supply that reaches the Illinois coast from the Wisconsin shore. Prior to human modification of the southern Wisconsin shore, erosion and transport along this reach could contribute several tens of thousands of cubic yards per year to the littoral transport. The combination of shore defense along much of the shore south of Kenosha, and the capture, dredging, and removal of littoral sand at the entrances to Kenosha Harbor and Prairie Harbor Marina on the Wisconsin side of the state line have drastically reduced the quantity of littoral sediment reaching the Illinois shore. The estimated volume of littoral transport crossing the state line is only slightly more than 10,000 cubic yards per year (Foyle et al. 1998). Thus, most of the littoral sediment that is in transport past the southern end of the state park comes from erosion of the beach and nearshore in the northern reach of the state park. This erosion and its mitigation is a major coastal management issue that is further discussed in the description on page 39 for Stop 1 of the field trip.

Lake-Level Changes

The level of Lake Michigan varies annually, seasonally, daily, and hourly. On an annual basis, lake level generally varies by about 1 foot (0.3 m), with high water in summer and low water in winter (fig. 10). The seasonal and multi-year fluctuations in lake level result from long-term changes in the overall water budget of the Great Lakes system. Short-term changes, on the order of days or hours, result from the lake surface responding to winds pushing water toward or away from the shore, or differences in atmospheric pressure across the lake basin. Since the beginning of official lake-level records for Lake Michigan, which began in 1860, the extreme range of monthly mean elevations has been 6.3 feet (1.9 m) between the historical low water in March 1964 and the historical high water in October 1986

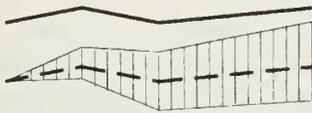
Much of the beach along Illinois Beach State Park and the nearby shore has a rather gradual slope, and therefore changes in lake level can result in rather substantial changes in beach width. Higher lake levels will drown the lower beach; lower lake levels will expose the lower beach and possibly the shallow nearshore. Two areas between the state line and Waukegan Harbor are particularly prone to such shoreline changes. Both are extremely low-slope areas where there has been beach and nearshore sand accretion against large shore structures. One is North Beach, located on the north side of the north breakwater at North Point Marina; and the other is the city of Waukegan Beach, which has segments on the north sides of both the breakwater and the north jetty at Waukegan Harbor.

Times of high lake levels have caused severe erosion at Illinois Beach State Park, and in some cases have required emergency shore-protection measures. A common misconception is that coastal erosion is not a problem at lower lake levels. Although lower lake levels do make it more difficult for storm waves to reach sufficiently landward to erode the upper beach and the foredunes, erosional processes remain active at lower lake levels. The focus of erosion just shifts downward and lakeward across the nearshore lake bottom. Here nearshore sand bars that formed at the higher lake level will be destroyed or translated farther lakeward. Erosion can also be more focused around the toes of shore structures such as breakwaters or groins that otherwise would be submerged by deeper water and thus have greater protection from wave action.



LAKE LEVELS

recorded



projected

average

(1918-1998)



maximum

1985	1985	1973	1973
------	------	------	------

minimum

1936	1934	1926	1934
------	------	------	------

Figure 10 Lake-level fluctuations for Lakes Michigan and Huron for 1999 and the first half of 2000 (solid line). During 1999 and into 2000, lake level has remained below the long-term average (dashed line) (from U.S. Army Corps of Engineers, Monthly Bulletin of Lake Levels for the Great Lakes, July 2000).

Storm setup Setup refers to a temporary rise in lake level caused by winds pushing water toward the shore. Factors that determine the height of the setup include the strength and duration of the wind, the location along the shore, and fetch. The elongate north-south orientation of Lake Michigan and the strength of northerly storm winds make the southern shore of the lake susceptible to storm setup. Maximum potential setup along the Indiana shore is 1.7 feet (0.5 m). The potential setup diminishes northward along the Illinois shore according to the decrease in fetch. At Milwaukee, Wisconsin, the setup is 1.2 feet (0.3 m) (U.S. Army Corps of Engineers 1978). Based on the intermediate location of Illinois Beach State Park relative to the Indiana and Milwaukee locations, maximum setup along the state park shore would be expected to be about 1.4 feet (0.4 m).

Setup can contribute to accelerated shore erosion because the higher lake level allows the swash of waves to reach higher up the beach. A benefit of storm setup is that it can increase the water exchange in marinas and harbors such as North Point Marina. Setup brings water into the marina through the entrance channel, and then water returns to the lake as the setup diminishes. At North Point Marina, strong currents from these water-level adjustments can often be seen in the entrance channel, sometimes persisting a day or more after the storm event that caused the setup.

Ice

Winter development of ice along the Lake Michigan coast is a key factor that distinguishes the coastal dynamics here from most ocean coasts. The role of ice in the dynamics of this coast was often ignored or misunderstood in years past, but recent research efforts along the Illinois coast by the U.S. Geological Survey and other researchers have shed new light on the role that ice plays in shaping the lake bottom and redistributing coastal sediments. Often thought to be a process that “locks up” the shore and prevents erosion, it has now been documented that ice induces nearshore erosion and commonly contributes to the permanent loss of sand from the nearshore littoral transport system.

Conditions can be favorable for the development of ice along the shore at Illinois Beach State Park from December into March, but the ice history from year to year can be quite variable. Whether or not ice forms, and how long any ice development persists, depends on the duration of air temperatures at or below freezing, the lake-water temperature, and the duration and strength of wave activity. Some winters may have only minimal ice, while other winters have extensive ice development that can extend tens of feet offshore. Most winters have multiple events of ice formation, breakup, and redevelopment. Wave action is responsible for the break up. Rarely is the breakup a result of ice melting during the winter months.

Figure 11 is a diagram of the typical components of the coastal ice that can form along the state park shore. The entire ice feature is called a “nearshore ice complex.” The process of formation begins on the beach, which freezes and forms the “ice foot.” As waves break against the ice foot, the wave splash can freeze and build up an ice ridge. The ice complex then grows lakeward as sequential, shore-parallel ice ridges form against one another (or as a sequential ridge sometimes forms a short distance lakeward of its predecessor) and the ridges are separated a short distance by a shore-parallel segment of congealed, low-relief ice called an “ice lagoon.” “Ice volcanoes” are common along the ice ridges, and the ridge crests and volcano summits can rise as high as 6.5 feet (2 m) above the lake level (figs. 12 and 13).

When the ice ridge is present along the shore, waves intercepting this ridge behave like waves impacting a bulkhead or breakwater, and as occurs at those types of engineered structures, some of the wave energy is directed downward and causes lake-bottom erosion. Profile data and diver observations have documented that on the Illinois coast an erosional trough as deep as 1.6 feet (0.5 m) and as wide as 6.5 to 9.8 feet (2 to 3 m) develops lakeward of the ice. Some of the eroded sediment is moved alongshore, but some is caught in the wave turbulence to be thrown up and incorporated into the ice ridge. As a result, sand-ridden ice, or “dirty ice,” is a common feature along the ice ridges (Barnes et al. 1994, Kempema 1998).

Incorporation of this sediment into the ice becomes an important factor in beach and nearshore sediment dynamics. Breakup of the ice allows the sediment to be rafted away under the influence of winds and currents. Along the Illinois shore, observations have shown that most of this ice-rafted sediment moves southward. However, some ice-rafted sediment also moves offshore. Sediment cores from the deep central basin of Lake Michigan include sands derived from beaches and nearshore settings. Ice rafting is the most likely transport agent to have brought these sands so far offshore and released the sediment as ice melting occurred. To specifically track ice rafting, specially designed, weighted disks (ice drifters) were placed in ice that formed along the Illinois shore at Wilmette. Several of these disks were recovered along the eastern Indiana shore. One disk was recovered along the Michigan shore, which indicates an ice-rafted transport across the entire width of the lake (Kempema et al. 1992).

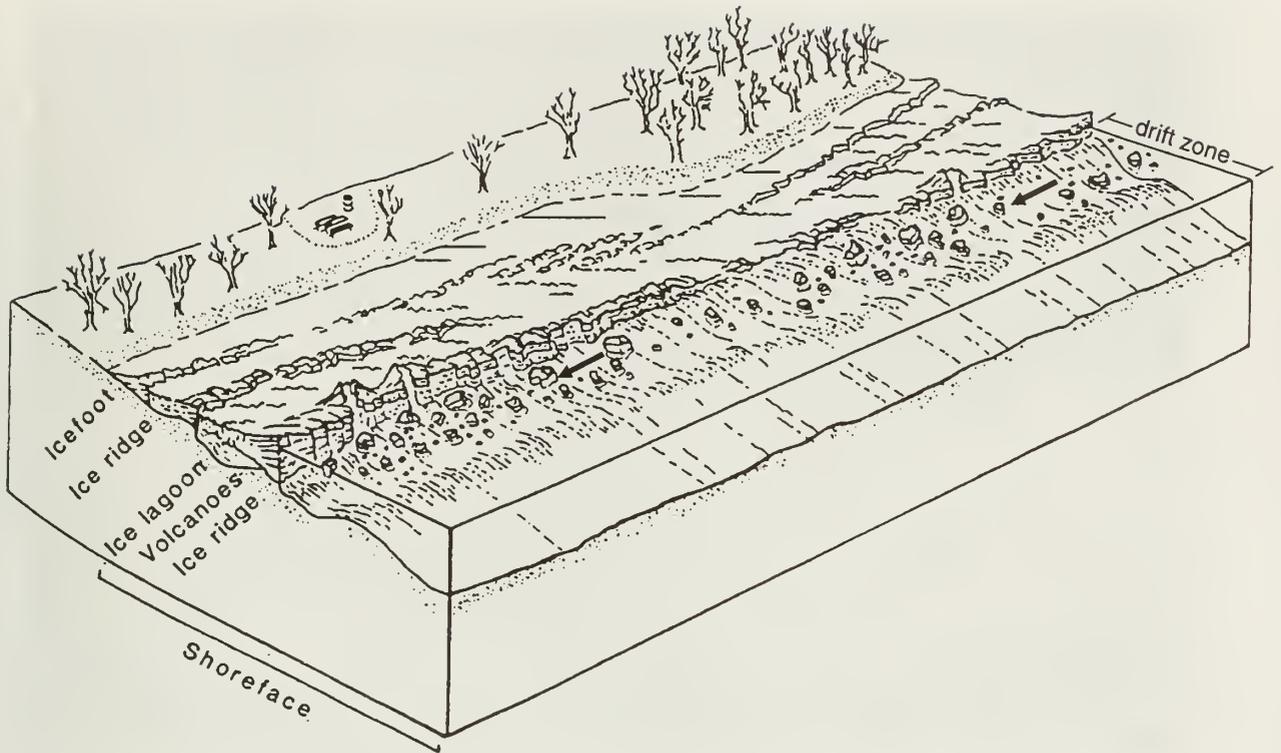


Figure 11 Diagram of a well-developed nearshore ice complex such as often forms along the shore at Illinois Beach State Park. The complex includes an ice foot, which is the attachment to the shore, multiple ridges and lagoons, ice volcanoes, and a zone of drifting brash and slush ice (from Barnes et al. 1994).

Does ice rafting account for any sizable transport and loss of sediment from the beach and nearshore at Illinois Beach State Park? Data specific for the state park are lacking, but an extrapolation based on ice studies at Wilmette suggest that the annual volume of sediment that could be rafted from the state park coast could be as great as 3,000 cubic yards per mile of beach (Kempema 1998). For the approximate 5.5 miles (8.8 km) of beach in the North and South Units of the state park, this process annually could permanently remove 16,500 cubic yards of beach and nearshore sediment.

GEOLOGIC EVOLUTION

The Zion beach-ridge plain is a product of geologic processes that have occurred since the late phases of the last glaciation. About 14,500 years B.P. (before present), the Lake Michigan lobe of ice was receding northward and forming a pro-glacial lake in the southern Lake Michigan basin. Once the ice margin receded to a position just north of Racine, Wisconsin, the shore to the south was never again covered by ice. The shore began to be transformed by coastal processes that led to the formation of the Zion beach-ridge plain and have continued to the present in a multi-phase evolution. The water level of Lake Michigan fluctuated widely during much of this time, and that history of lake-level change played a key role in the evolution of the beach-ridge plain. Much geologic work is needed to fully reconstruct the geologic evolution of the Zion beach-ridge plain, but what is known about this evolution indicates that this is a unique coastal landform in southern Lake Michigan. The coastal evolution outlined here is based on ongoing and unpublished research by the Coastal Geology Section of the Illinois State Geological Survey.



Figure 12 An “eruptive” event in the development of an ice volcano. Wave surge under the nearshore ice complex forces water up through breaks or gaps in the ice, and the freezing of this water results in development of an ice volcano (photo by M. Chrzastowski, January 2000).



Figure 13 Two well-developed ice volcanos. The ice volcano in the foreground has an excellent example of a summit crater (photo by M. Chrzastowski, January 2000).

Lake-Level History

Beginning about 14,500 years B.P., the northward recession of the ice lobe that occupied the Lake Michigan basin resulted in an open-water area in the southern part of the basin. The ice, however, blocked a northward outlet for this pro-glacial lake, and moraines ringing the southern margin of the lake basin acted as a dam to hold the lake water at levels tens of feet higher than at present. Between about 14,500 and 10,000 years B.P., as the ice sheet fluctuated and ultimately receded from the Great Lakes basins, wide fluctuations in lake level occurred as movement of the ice margin opened and closed different outlets and as outlet channels eroded downward (Hansel et al. 1985, Hansel and Mickelson 1988, Chrzastowski and Thompson 1992, 1994). During the Glenwood phases (14,500 to 12,200 years B.P.), the ancestral Lake Michigan lake level was as much as 60 feet (18 m) higher than today; during the Calumet phase (11,800 to 11,200 years B.P.), lake level was about 40 feet (12 m) higher than today (fig. 14). During these two phases, the shoreline in the vicinity of present-day Zion, Illinois, was located in what is now the upland areas near or west of Sheridan Road (fig. 6). The processes that would eventually lead to the formation of the beach-ridge plain were then occurring along the ancestral Lake Michigan shoreline near present-day Racine, Wisconsin, 16 miles (26 km) north of the Wisconsin–Illinois state line.

Glenwood phases – The Root River delta The Glenwood phases of high lake level, the first of the high lake events, occurred between about 14,500 and 12,200 years B.P. Evidence for a short-lived event of lower lake level divides the Glenwood into two events (Glenwood I and II). The maximum Glenwood lake levels were as much as 60 feet (18 m) above the historical mean lake level. This placed the shoreline as high as the 640-foot (195 m) contour (above MSL) along the present uplands. A gradual decline in lake level was probably occurring during the Glenwood phases (Chrzastowski and Thompson 1992).

Between Kenosha, Wisconsin, and North Chicago, Illinois, ancient shoreline features associated with this time of extreme high lake level are preserved in the uplands between the 640- and 630-foot (195 and 192 m) elevation contours. At Racine, the present-day coast is dominated by coastal bluffs, and atop these bluffs is a series of arc-shaped topographic features that occur above the 640-foot (195 m) elevation contours, and are suggestive of a grouping of ancient barrier islands. The nearby Root River presently occupies an incised channel, but at the time of the Glenwood lake levels, the river would have entered the lake at Racine at about the 640- to 630-foot elevations. At that time Root River was a major glacial meltwater stream, deriving meltwater and sediment from much of the ice margin in southeastern Wisconsin, and transporting and dumping this sediment-laden water into ancestral Lake Michigan at Racine. The result was the building of an extensive delta of glacial outwash sediments (sand and well-rounded gravel) (fig. 15, map 1). South of Racine, and all the way to the Indiana shore, no other river that emptied into the lake was responsible for such a large sediment discharge to the lake.

Nearly all of this ancient delta has been eroded, and all that remains is its more landward parts. The coastal bluffs at Racine provide a cross-sectional exposure of these glacial delta deposits, and a remnant of the sloping underwater surface of this delta is preserved across the upland south of Racine. During the formation of the delta, a prime factor in preventing the river-supplied sediments from being dispersed southward along the coast was the glacial ice to the north that prevented any significant fetch from this direction. The open water of southern Lake Michigan only provided a long fetch for wave action from southeasterly waves.

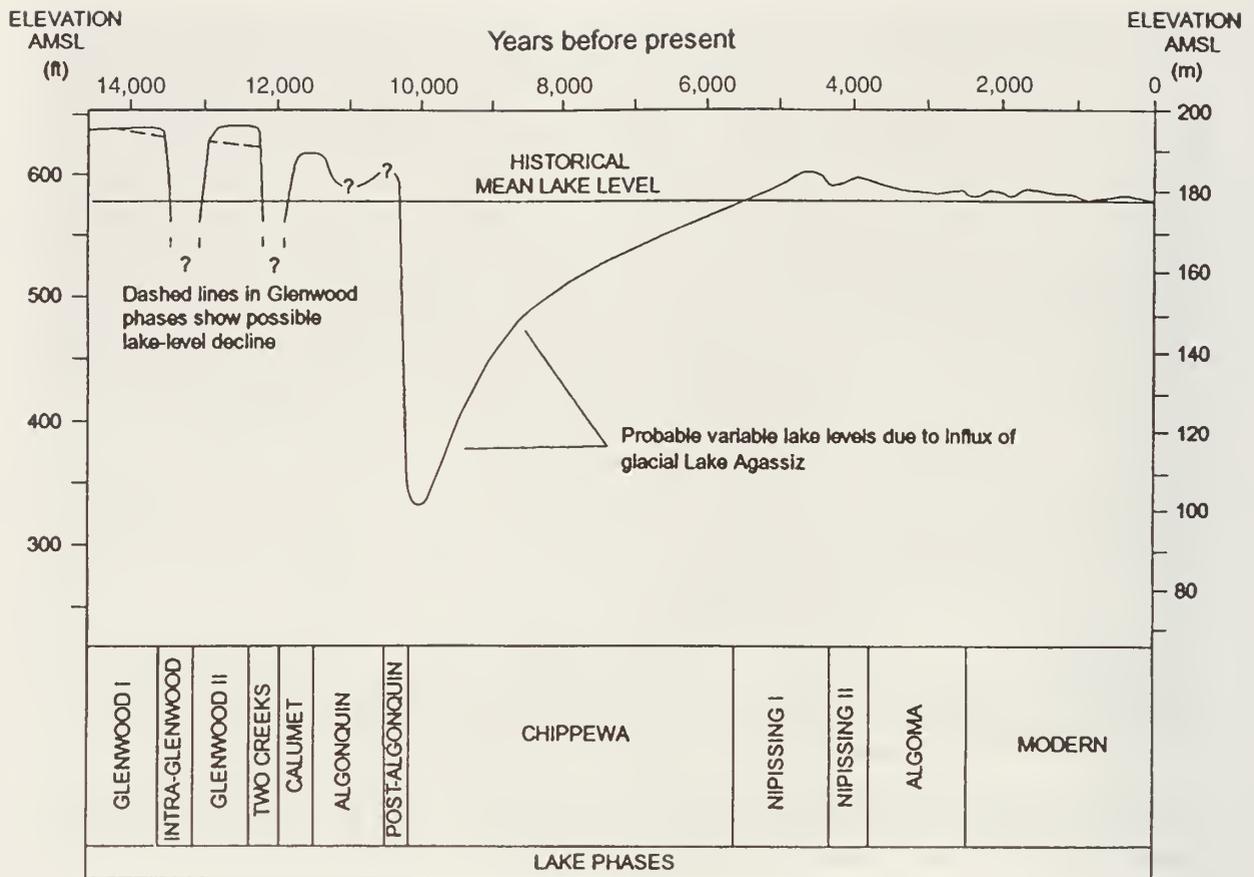


Figure 14 Generalized lake-level curve for southern Lake Michigan since 14,500 years B.P. Elevations are above mean sea level (MSL). The historical mean lake level is 580 feet (177 m) above MSL (after Hansel et al. 1985; modified from Chrzastowski and Thompson 1992).

Calumet phase – Erosion, transport, and spit development The Calumet phase occurred between about 11,800 and 11,200 years B.P. Lake level was as high as 40 feet (12 m) above the historical mean level. The ice margin was north of the limits of the Root River drainage basin, so no additional meltwater discharge flowed along this river to the lake. The ice margin across Lake Michigan was sufficiently far enough north to allow an open-water area to exist north of Racine, which set the stage for the coast at Racine to be influenced by northerly waves. The relict Root River delta would have been a readily erodible source of sand and gravel, and these sediments were transported southward. The process of erosion and transport removed much of the former delta sediment and redeposited it along a more elongate coastal depositional feature (fig. 15, map 2).

The surficial appearance of this elongate depositional feature would not have been greatly different from the southern part of the present-day beach-ridge plain. But unlike the beach-ridge plain, this coastal feature had an open-water area on three of its sides (west, east, and south), and therefore it would be classified as a *spit*. A remnant of this spit is the elongate sand deposit that formed along the coast at the Calumet phase at lake-level elevation (620 ft [189 m], above MSL) along the coast from south of Racine to north of Kenosha. The spit partially enclosed an embayment that today is a low area of land crossed by the Pike River. The southward-deflected course of this river as it approaches Kenosha indicates the influence that the spit has had on the local topography and drainage. During this Calumet phase, what is now the downtown area of Kenosha was

submerged; Kenosha is just south of the distal end of the relict spit. Farther south, along the extent of the present beach-ridge plain, the shoreline was at the 620-foot (189 m) elevation, which is generally along the top of the bluffs along the western margin of the plain.

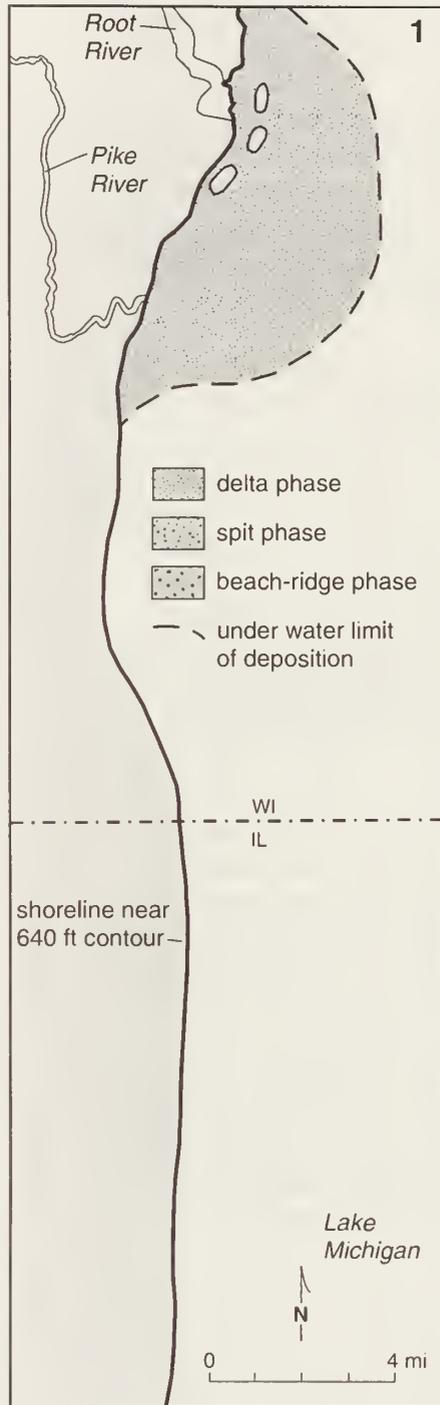
The Calumet phase was important in setting the stage for the eventual development of the beach-ridge plain. The wave erosion, transport, and deposition transferred large volumes of sediment from the immediate vicinity of Racine to a location just north of Kenosha. The sediment redistribution formed a “spit platform,” which is a broad submerged mound atop which the emergent part of a spit forms. This spit platform probably would have extended well south of Kenosha and formed the slightly elevated lake-bottom surface atop which the beach-ridge plain later began to form.

Chippewa phase – An abandoned coast and ravine erosion Lake level fell to as much as 260 feet (80 m) lower than present about 10,000 years B.P. (Colman et al. 1994), when the ice margin had receded northward enough to allow ancestral Lake Michigan to drain through a low-level outlet that had been depressed to this elevation by the weight of the former overlying ice sheet. This began the Chippewa phase of lake history (fig. 14). For the next 4,500 years, lake level gradually rose as “rebound” of the land raised the outlet elevation. Through the entire Chippewa phase, the sand and gravel deposits of the former delta and spit between Racine and Kenosha were abandoned coastal features, left high and dry by the lower lake level, and distant from the lake shoreline. This time of lowered lake levels set the stage for erosion of the ravines carved into the upland to the west of the beach-ridge plain. The ravines were formed as the streams cut downward into the glacial deposits in order to adjust their gradients to the lower average lake level.

Nipissing phases – Early formation of the beach-ridge plain By about 5,500 years B.P., the lake level had risen to again reach the historical mean lake level, and this began the Nipissing phases of lake history (figs. 14 and 15, map 3). Lake level in the Nipissing phases ultimately rose to about 20 feet (6 m) above present-day, and then declined. This lake level rise brought a resurgence of wave erosion, transport, and deposition along the shore of the relict delta and spit. Storms caused pulses of sand and gravel moving southward in the littoral drift to be deposited in elongate ridges, and this marked the beginning of the growth of the Zion beach-ridge plain. The crests of these earliest beach ridges, which formed just south of what is now the downtown area of Kenosha, are some of the highest on the beach-ridge plain because many of them formed at the highest lake levels of the Nipissing phases. While these first beach ridges were forming, all of the coast to the south was a bluff coast with waves washing against and eroding into the glacial tills in the upland. The remaining Illinois portion of this bluff coast is marked by the abrupt change in relief along the western margin of the beach-ridge plain, just west of the Chicago and North Western/ Union Pacific railroad tracks.

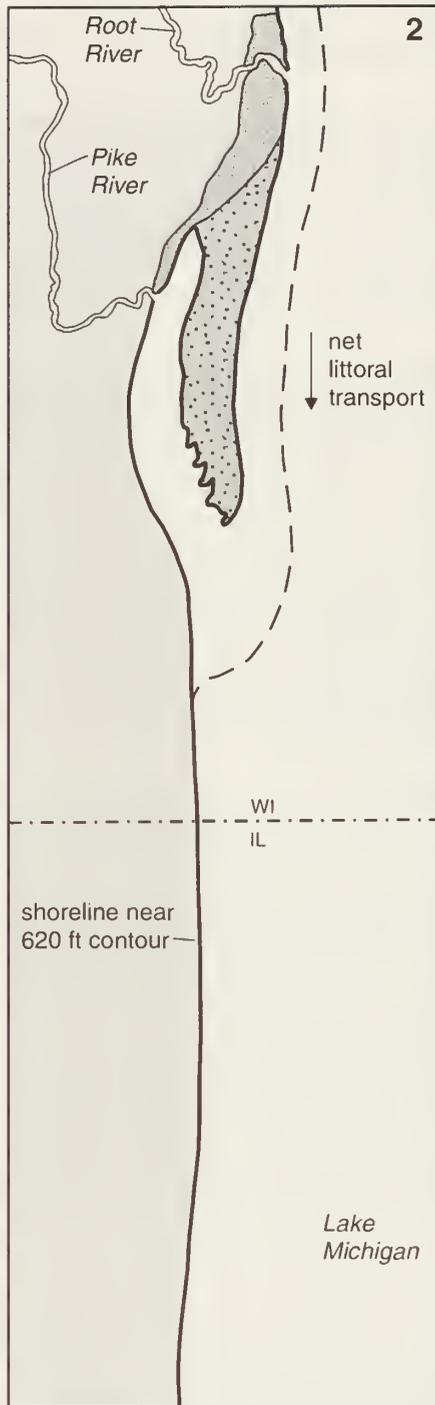
Algoma and Modern phases – Early migration of the beach-ridge plain The last 3,800 years of lake history encompass the Algoma and Modern phases. During this time, there has been continued erosion of the relict glacial delta at Racine and the relict spit north of Kenosha. Southward transport and deposition of these sediments continued to form the southward-advancing beach-ridge plain. Radiocarbon dating of the organic material in the marsh deposits at the base of the *swales* between successive ridges provides a means to determine exactly when different beach ridges were forming along the plain. Because the first migration of beach ridges across the Wisconsin–Illinois state line occurred 3,700 years B.P. (Larsen 1985) (fig. 15, map 4), the entire Illinois portion of the beach-ridge plain is less than about 3,700 years old. Illinois Beach State Park thus occupies some of the youngest land anywhere in Illinois.

-12,500 years before present (B.P.)



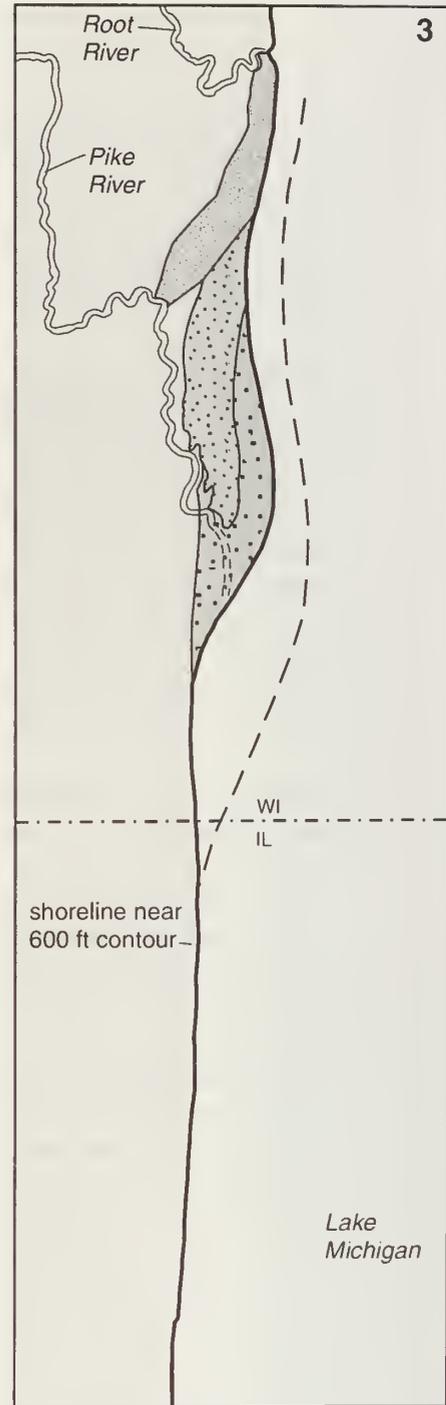
Glenwood II phase
lake level 60 ft (18 m)
above historical mean

-11,500 years B.P.



Calumet phase
lake level 40 ft (12 m)
above historical mean

-4,500 years B.P.



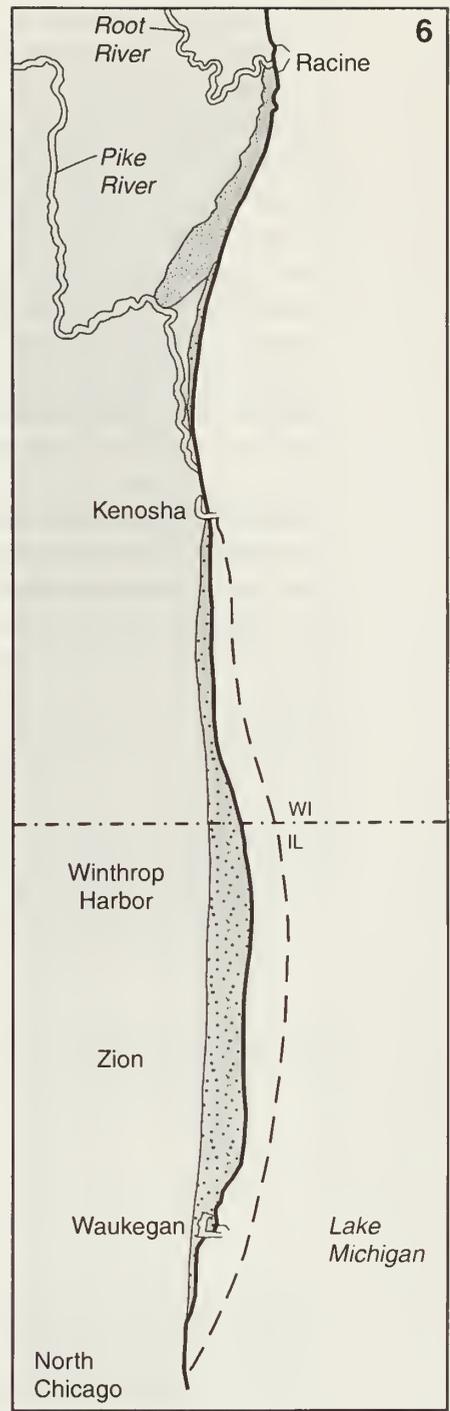
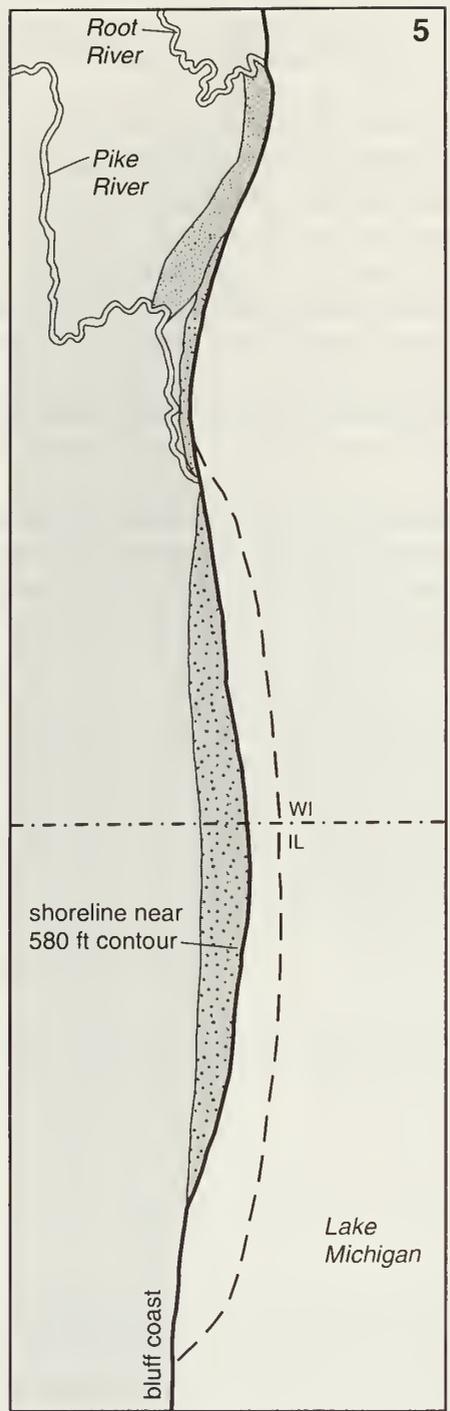
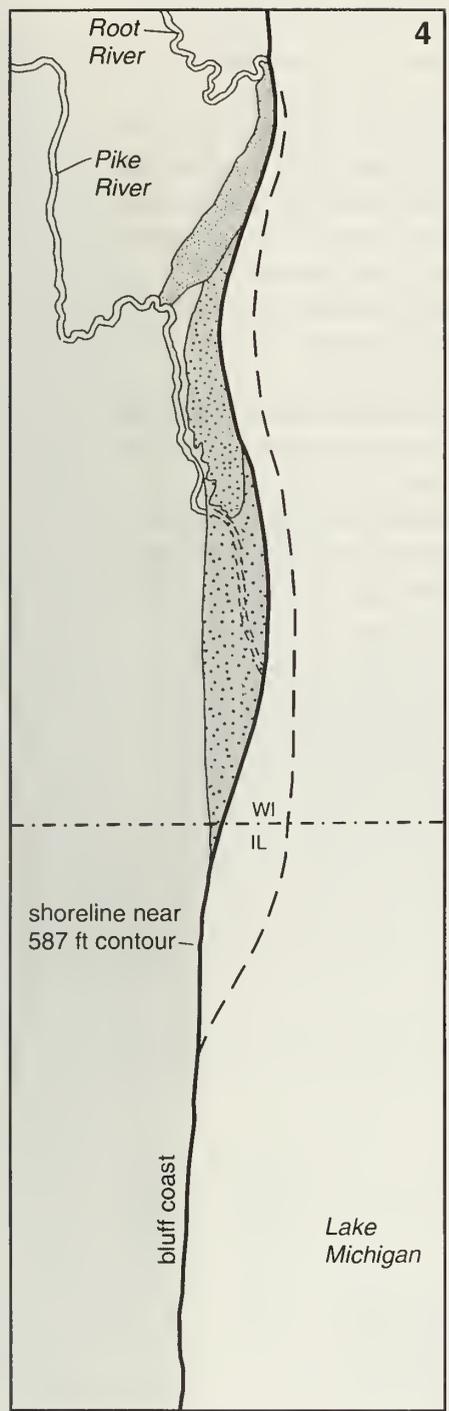
Nipissing I phase
lake level 20 ft (6 m)
above historical mean

Figure 15 Sequential reconstruction of the coastal geography between Racine, Wisconsin, and North Chicago, Illinois, over the past 12,000 years during the events leading to the formation and evolution of the Zion beach-ridge plain (from Chrzastowski, unpublished data).

~3,700 years B.P.

400 years B.P.

Today



Algoma phase
lake level 7 ft (2 m)
above historical mean

Modern phase
lake level approximates
historical mean

Continued migration of the beach-ridge plain As the process of southward advance of the plain continued, the northern part of the plain eventually began to experience erosion. This occurred when the coast between Racine and Kenosha receded landward (because of erosion) and the southward extension of this recession intercepted sediments deposited in the northern part of the plain. These eroded sediments were transported southward and deposited along the southern margin of the plain, and this process of erosion at the north end and accretion toward the south continued into historical time. By this means, the northern part of the plain continued to get narrower and the southern terminus of the plain continued to migrate southward. The long-term migration of the plain along the coast can be likened to the movement of a tank tread. The sequence of coastal reconstructions in figure 15 show this migration of the beach-ridge plain from its initial formation at Kenosha (map 3) to its present-day extent to North Chicago (map 6).

Ultimate fate of the beach-ridge plain Reconstructing the geologic evolution of the plain provides a means to project how this coastal landform would continue to evolve if no human intervention occurred, and if present-day lake levels and coastal dynamics persisted. With time, the plain would continue to advance southward along the Illinois coast, while erosion continued along the northern part of the plain. The overall shape of the plain would change with time to an ever more elongate and narrower form. Eventually erosion would remove the last vestiges of the plain along more and more of its northern segment, and waves would once again intercept the relict bluffs along the upland. The southward elongation and narrowing of the plain would eventually obscure this as a distinct coastal feature, and instead, this would be an extensive sand and gravel deposit contributing to wider beaches along the shore. The ultimate fate for all the sand and gravel of this coastal feature is to be transported southward and to accumulate along the Indiana shore. This ultimate fate would take thousands of years to achieve. If these natural processes prevailed, the Zion beach-ridge plain would be no more than a migratory and ephemeral coastal feature in the post-glacial evolution of the Illinois coast.

Guide to the Route

We'll start the trip in the main parking lot at the main beach at the South Unit of Illinois Beach State Park. The main parking lot is located at the end of Old Beach Road (NW, SW, SW, Sec. 26, T46N, R12E, 3rd P.M., Zion 7.5-Minute Quadrangle, Lake County). Mileage will start at the south entrance/exit of the parking lot.

You must travel in the caravan. Please drive with headlights on while in the caravan. Drive safely but stay as close as you can to the car in front of you. Please obey all traffic signs. If the road crossing is protected by an Illinois State Geological Survey (ISGS) vehicle with flashing lights and flags, please obey the signals of the ISGS staff directing traffic. When we stop, park as close as possible to the car in front of you and turn off your lights.

Private property The stops on the field trip are on state, municipal, and corporate property. Please conduct yourselves as guests and obey all instructions from the trip leaders. So that we may be welcome to return on future field trips, follow these simple rules of courtesy:

- Do not litter the area.
- Do not climb on fences.
- Leave all gates as you found them.
- Treat *public* property as if you were the owner—which you are!
- Parents must closely supervise their children at all times.

When using this booklet for another field trip with your students, a youth group, or family, please note that *you must get permission from the stage park office to enter the Nature Preserve located south of Dead River in the South Unit of Illinois Beach State Park.* This is the area south of Dead River. No trespassing please.

Two USGS 7.5-Minute Quadrangle maps (Waukegan and Zion) provide coverage for this field trip area.

Miles to next point	Miles from start	
0.0	0.0	Set your odometers to 0.0 at the south end of the parking lot. Exit parking lot and HEAD SOUTH on Old Beach Road. There are a large number of bicyclers and hikers in the park. Please use caution when driving through the park.
0.4	0.4	The Illinois Beach Resort and Conference Center is to the left. CONTINUE AHEAD.
0.1	0.5	Entrance to the Nature Center is to the left. CONTINUE AHEAD.
0.6	1.1	Road curves to the right and crosses between some of the park ponds. CONTINUE AHEAD. These ponds show us the elevation of the water table in this part of the park is almost at ground level. The difference between

ground elevation and the water table is only about 1 foot. The highway is elevated so that it won't flood during high water conditions.

- 0.5 1.6 Campground entrance road is to the right. CONTINUE AHEAD.
- 0.15 1.75 CAUTION: Cross railroad tracks. Single lights and guard gates (Chicago and North Western/Union Pacific Railroad).
- 0.25 2.0 STOP LIGHT. Intersection of Wadsworth Road and Sheridan Road/Illinois Route 147. TURN RIGHT (heading north).
- 0.3 2.3 STOP LIGHT. Intersection with 34th Street. CONTINUE AHEAD. K-Mart and the Piggly Wiggly are to the right.
- 0.1 2.4 STOP LIGHT. Intersection with 33th Street. CONTINUE AHEAD. Just north of this intersection, the road dips down into one of the ravines that is cut into the glacial deposits of the uplands. This is a stream valley for drainage going out to Illinois Beach State Park (see route maps).
- 0.15 2.55 Crossing low point of drainage ravine.
- 0.15 2.7 STOP LIGHT. Intersection with 31th Street. CONTINUE AHEAD.
- 0.35 2.9 STOP LIGHT. Intersection with 29th Street. CONTINUE AHEAD.
- 0.2 3.1 STOP LIGHT. Intersection with 27th Street. CONTINUE AHEAD. You are now passing through downtown Zion.
- 0.3 3.4 STOP LIGHT. Intersection with Shiloh Boulevard. CONTINUE AHEAD. The Zion Nuclear Power Station and the power house museum are located to the right, at the end of Shiloh Boulevard.
- 0.3 3.7 STOP LIGHT. Intersection with 23th Street. CONTINUE AHEAD.
- 0.2 3.9 STOP LIGHT. Intersection with 21th Street/Illinois Route 173. CONTINUE AHEAD.
- 0.4 4.3 Intersection with 17th Street. CONTINUE AHEAD. Entrance to the North Unit of Illinois Beach State Park is to the right.
- 0.2 4.5 Just north of this intersection, the road dips into Kellogg Ravine. This ravine is cut into the glacial deposits of the uplands, and the stream flow is toward the Zion beach-ridge plain (see route maps).
- 0.9 5.4 STOP LIGHT. Intersection with 9th Street. CONTINUE AHEAD. You are now entering the village of Winthrop Harbor.
- 0.2 5.6 STOP LIGHT. Intersection with 7th Street. TURN RIGHT (heading east) toward North Point Marina.

- 0.1 5.7 After passing through the intersections with Franklin, Park, and Landon Streets, the road lowers in elevation. You are coming off the glacial deposits of the upland and coming down onto the Zion beach-ridge plain.

- 0.2 5.9 CAUTION: Cross railroad tracks. Single lights and guard gates (Chicago and North Western/Union Pacific Railroad). After you cross the railroad tracks to the left is the Spring Bluff/Lake County Forest Preserve, and on the right is the North Unit of Illinois Beach State Park. Directly ahead, the green-roofed building is the administration building for North Point Marina.

- 0.55 6.45 STOP: 3-way. TURN RIGHT. Follow the North Point Marina access road toward the south (lakeshore) parking area. As you follow the access road to the east, North Point Marina is on the left. This is the largest marina in the Great Lakes. It holds 1,500 slips and has been operational since 1989.

- 0.05 6.5 STOP: 2-way; entrance into some of the marina parking areas. CONTINUE AHEAD. As you continue east, the road begins to gently rise in elevation. You are coming up onto the deposit of sand and gravel that was dredged and excavated to form the marina basin and then deposited here on the south side of the marina.

- 0.3 6.8 Road curves to the right. To the left, looking toward the lake, is a low, circular, concrete and stone sculpture that encloses an area for growing prairie grasses. This is a tribute to the Illinois prairies.

- 0.1 6.9 Entrance to parking lot just before the cul-de-sac. TURN RIGHT into the parking lot.

STOP 1 North Point Marina and Illinois Beach State Park, North Unit Feeder Beach (NW, SE, SW, Sec. 11, T46N, R12E, 3rd P.M., Zion 7.5-Minute Quadrangle, Lake County).

- 0.0 6.9 Leave Stop 1 and follow road back towards the marina entrance.

- 0.4 7.3 STOP: 2-way; entrance to some of the marina parking areas. CONTINUE AHEAD. The marina is on the right.

- 0.1 7.5 STOP: 2-way; entrance into the administration building. CONTINUE AHEAD. Note: Be ready to make a left turn at the second stop sign.

- 0.05 7.55 STOP: 2-way. TURN LEFT (heading west). As you exit North Point Marina, notice the coastal wetlands on both sides of the road. These are all fresh-water marshes. The land may look flat, but if we could get out and walk across it, it would be a washboard topography of successive ridges and swales. The relief between the lows and highs would generally be no more than 2 to 3 feet. These ridges and swales have a north-northwest to south-southwest orientation.

- 0.55 8.1 CAUTION: Cross railroad track. Single lights and guard gates (Chicago and North Western/Union Pacific Railroad). As you look ahead, you can see a change in elevation. This change marks the boundary between the lower elevation of the Zion beach-ridge plain and the higher elevation of the uplands. This elevation difference also corresponds to a difference in geologic age. All of the beach-ridge plain in Illinois is less than 3,700 years old. The higher land is primarily composed of glacial till deposited beneath the glacial ice that last occupied this area more than 14,500 years B.P. Superimposed on these glacial sediments is a patchy veneer of beach and lake-bottom deposits with ages ranging from 14,500 to 11,200 years B.P. when high lake levels were 60 to 40 feet higher than the present day and this upland was submerged.
- 0.3 8.4 STOP LIGHT. Intersection of 7th Street and Sheridan Road. TURN LEFT onto Sheridan Road (heading south).
- 0.2 8.6 STOP LIGHT. Intersection with 9th Street. CONTINUE AHEAD.
- 0.7 9.3 Just ahead, the road dips down into Kellogg Ravine. This ravine is cut into the glacial deposits of the uplands, and the stream flow is toward the Zion beach-ridge plain (see route maps). At the bottom of the ravine is an incised stream. This is one of the sources of water for the wetlands in the Zion beach-ridge plain.
- 0.3 9.6 Intersection with 17th Street. TURN LEFT (heading east). The Zion/Benton Moose Lodge No. 6677 is located on the northeast corner of this intersection. We are heading towards the Camp Logan Day Use Area of the North Unit of Illinois Beach State Park.
- 0.4 10.0 CAUTION: Cross railroad tracks. Single lights and guard gates (Chicago and North Western/Union Pacific Railroad). After crossing the railroad tracks, you once again enter onto the Zion beach-ridge plain. Continue east as the road curves, and enter the Camp Logan part of the North Unit of Illinois Beach State Park. Camp Logan was a U.S. Army boot camp during WW I and II.
- 0.4 10.4 Entrance to Sand Pond Day Use Area on the right. CONTINUE AHEAD. We're continuing on the same road, heading east. As we continue on the road, Sand Pond is on the right. The basin that this pond occupies was formed from sand excavation in the 1960s.
- 0.05 10.45 Passing access road to water treatment plant.
- 0.05 10.5 Cross bridge over Kellogg Creek. To the left are some buildings that remain from the old U.S. Army facilities. One of these buildings houses the Lake Michigan field office of the Illinois Natural History Survey.
- 0.3 10.8 Entrance to Camp Logan Day Use Area. CONTINUE AHEAD on the main road.

- 0.1 10.9 Entrance to Sailing Beach on the right. CONTINUE AHEAD on the main road.
- 0.2 11.1 Entrance to the Dunes Day Use Area. CONTINUE AHEAD on the main road.
- 0.05 11.15 Entrance to Beach Ridge Day Use Area on the right. CONTINUE AHEAD on the main road.
- 0.05 11.2 Second entrance to Beach Ridge Day Use Area on the right. CONTINUE AHEAD on main road to the cul-de-sac and parking area at the end of this road.
- 0.05 11.25 TURN RIGHT into parking lot at the cul-de-sac. There are outhouse restrooms immediately to the north of the parking area. Follow the trail to the beach.

STOP 2 Camp Logan Headland (NE, NW, Sec. 14, T46N, R12E, 3rd P.M., Zion 7.5-Minute Quadrangle, Lake County).

- 0.0 11.25 Leave Stop 2. Follow the parking lot road around and head back toward Sheridan Road. This area is called Dunes Day Use Area.
- 0.4 11.6 Pass Beach Ridge Day Use Area access road to the left.
- 0.05 11.65 Pass second Beach Ridge Day Use Area access road to the left.
- 0.15 11.8 Pass Sailing Beach access road to your left. CONTINUE AHEAD on the main road.
- 0.15 11.95 Camp Logan Day Use Area access road to the left. CONTINUE AHEAD on the main road.
- 0.35 12.3 Cross Kellogg Creek.
- 0.1 12.4 Pass Sand Pond Day Use Area access road to the left. CONTINUE AHEAD on the main road.
- 0.35 12.75 CAUTION: Cross railroad tracks. Single lights and guard gates (Chicago and North Western/Union Pacific Railroad). Leaving the Zion beach-ridge plain.
- 0.35 13.1 STOP: 2-way; intersection of 17th Street and Sheridan Road. TURN LEFT onto Sheridan Road (heading south). After you make the turn, you enter the city of Zion.
- 0.5 13.6 STOP LIGHT. Intersection with 21th Street/Illinois Route 173 and Sheridan Road/Illinois Route 137. CONTINUE AHEAD
- 0.2 13.8 STOP LIGHT. Intersection with 23rd Street. CONTINUE AHEAD.

- | | | |
|------|-------|---|
| 0.3 | 14.1 | STOP LIGHT. Intersection with Shiloh Boulevard. CONTINUE AHEAD. |
| 0.25 | 14.35 | STOP LIGHT. Intersection with 27 th Street. CONTINUE AHEAD. |
| 0.25 | 14.6 | STOPLIGHT. Intersection with 29 th Street. CONTINUE AHEAD. |
| 0.25 | 14.85 | STOPLIGHT. Intersection with 31 st Street. CONTINUE AHEAD. |
| 0.35 | 15.2 | STOPLIGHT. Intersection with 33 rd Street. CONTINUE AHEAD. |
| 0.1 | 15.3 | STOPLIGHT. Intersection with 34 rd Street. CONTINUE AHEAD. |
| 0.2 | 15.5 | STOPLIGHT. Intersection with Wadsworth Road. TURN LEFT.
This is the road leading to the South Unit of Illinois Beach State Park. |
| 0.35 | 15.9 | CAUTION: Cross railroad tracks. Single lights and guard gates (Chicago and North Western/Union Pacific Railroad). |
| 0.1 | 16.0 | T-intersection from the left. Entrance road to campgrounds. CONTINUE AHEAD. Road curves to the south, and the entrance to the youth group camping area is on the right. |
| 0.4 | 16.4 | Pass through area with small ponds to the right and left. The wetlands surrounding the ponds are freshwater marshes. Prior to European settlement, freshwater marshes were common throughout Illinois; but today, only a few remnants remain. |
| 0.5 | 17.1 | T-intersection from the right. Entrance to Nature Preserve and Visitor Center. CONTINUE AHEAD. |
| 0.15 | 17.25 | Pass entrance to new ranger station on the right. |
| 0.25 | 17.5 | Pass entrance to the park office on your right. |
| 0.05 | 17.55 | STOP: 4-way; entrance to the main parking lot. Beach and camp store to your right. CONTINUE AHEAD and head toward the north end of the parking lot. The picnic area is straight ahead. We will have lunch here. We will restart our mileage after lunch, beginning again at 0.0 at the main parking lot exit. |

STOP 3 : Lunch Picnic Area Near Main Swimming Beach (NW, SW, SW, Sec. 26, T46N, R12E, 3rd P.M., Zion 7.5-Minute Quadrangle, Lake County).

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|-----|-----|--|
| 0.0 | 0.0 | Intersection of the entrance/exit to the main parking lot at the South Unit and Old Beach Road. Exit the parking lot and head south on Old Beach Road. |
|-----|-----|--|

- 0.4 0.4 The Illinois Beach Resort and Conference Center is to the left. CONTINUE HEAD.
- 0.1 0.5 T-intersection from the left. TURN LEFT. Entrance road to the Nature Preserve and Nature Center. Enter parking lot at the Nature Center.
- 0.2 0.7 South end of the parking lot; pull around and park your vehicles. Take the beach trail, which heads east out of the parking lot.

Stop 4 Mouth of Dead River and the Nature Preserve at the South Unit of Illinois Beach State Park (NE, SW, NW, Sec. 2, T45N, R12E, 3rd P.M., Zion 7.5-minute Quadrangle, Lake County)

Two trails can take you to the mouth of Dead River. We suggest you follow the Beach Trail (east) to the junction of Oak Ridge Trail, and head south along the ridge trail to the mouth of Dead River. After leaving the Dead River area, follow the beach (north) to the Beach Trail, which will take you back to the parking lot.

- 0.0 0.7 Leave Stop 4 and exit parking lot.
- 0.15 0.85 Stop: 1-way. TURN LEFT and head towards the park exit. CAUTION: Look out for bicycle and pedestrians; because we are in the vicinity of the resort, it may be a little busy.
- 0.55 1.4 Road passes through the area of the ponds. As we continue on this road, to the north we get a view of the Zion Nuclear Power Station. This plant is now inactive and is a storage facility for the spent fuel rods of the nuclear plant.
- 0.7 2.1 CAUTION: Cross railroad tracks. Single lights and guard gates (Chicago and North Western/Union Pacific Railroad). Leaving the Zion beach-ridge plain and ascending an incline onto the uplands. This higher land is composed of glacial till with a patchy veneer of beach and lake-bottom deposits from when this area was submerged during the higher lake levels of the Glenwood and Calumet phases. During the Calumet phase (11,800 to 11,200 yrs B.P.), lake level was about 40 feet higher than present, and the shoreline was about half-way up this incline between the railroad tracks and the intersection with Sheridan Road. During the Glenwood phases (14,500 to 12,200 yrs B.P.), maximum lake level was about 60 feet higher than present, and the shoreline then was located just west of the intersection with Sheridan Road.
- 0.3 2.4 STOP LIGHT. Intersection with Wadsworth and Sheridan Road/Illinois Route 137. TURN LEFT onto Sheridan Road (heading south). After making the turn, you enter the village of Beach Park. Just past McDonald's, the road dips down into the ravine cut by Bull Creek. This ravine funnels drainage out to the Zion beach-ridge plain. Bull Creek is the main stream that feeds what becomes Dead River flowing out of the beach-ridge plain.

- 0.6 3.0 STOPLIGHT. Intersection with Beach Road. CONTINUE AHEAD.
- 0.8 3.8 STOPLIGHT. Intersection with York House Road. CONTINUE AHEAD.
- 1.1 4.9 STOPLIGHT. Intersection with Myra Florris Avenue. CONTINUE AHEAD.
The road begins to dip down into another one of the ravines that cross the glacial upland and allow drainage out onto the beach-ridge plain.
- 0.4 5.3 Bowen Park is on the left side of the road; passing by Jack Benny Boulevard. Jack Benny is one of the famous natives of Waukegan, Illinois. Merge into the left lane and prepare to turn left at next stoplight.
- 0.3 5.6 STOPLIGHT. Intersection of Sheridan Road and Greenwood Avenue.
TURN LEFT. Bob and Ann's Restaurant is located on the southeast corner of the intersection. Note: Stay in the left lane after making the turn.
- 0.25 5.85 The right lane turns off to the entrance to the Amstutz Expressway. CONTINUE AHEAD. Follow the road up and over the overpass of the Amstutz Expressway.
- 0.15 6.0 STOP: 4-Way; intersection with Pershing Road. CONTINUE AHEAD. To your left is what remains of the large plant of the Johns Manville Corporation, located here in the Waukegan industrial area. This is slated for demolition in the near future. Among the plant's products were asbestos-containing materials used for house siding, roofing, and water-supply and sewer pipes.
- 0.2 6.2 CAUTION: Cross the single ungated railroad track (which has lights). The Johns Manville plant is still on the left. Ahead and to the right is the Waukegan Generating Station, a coal-fired power plant now owned by Midwest Generation and previously owned by Commonwealth Edison. This plant is one of the real work horses of the electrical grid in northeastern Illinois. The plant was built in the 1930s, and you can see a touch of art deco style in its architecture.
- 0.5 6.7 Pass through the gate and continue to the parking area for the fishing pier. The pier is owned by the power plant, but access and fishing along the pier is managed by the Illinois Department of Natural Resources (DNR). Far off to the south are two large topographic features. The black one to the west is the reservoir of coal that eventually will be supplied to the coal-fired power plant. The yellow stockpile to the east is sand that has been dredged from the floor of Lake Michigan to maintain the proper intake clearance for the channels supplying cooling water for the power plant.
- 0.2 6.9 STOP and park vehicles next to the pedestrian access gates to the fishing pier.

STOP 5 Cooling-Water Channels at the Waukegan Generating Station (NW, NW, NW, Sec. 14, T45N, R12E, 3rd P.M., Zion 7.5-minute Quadrangle, Lake County)

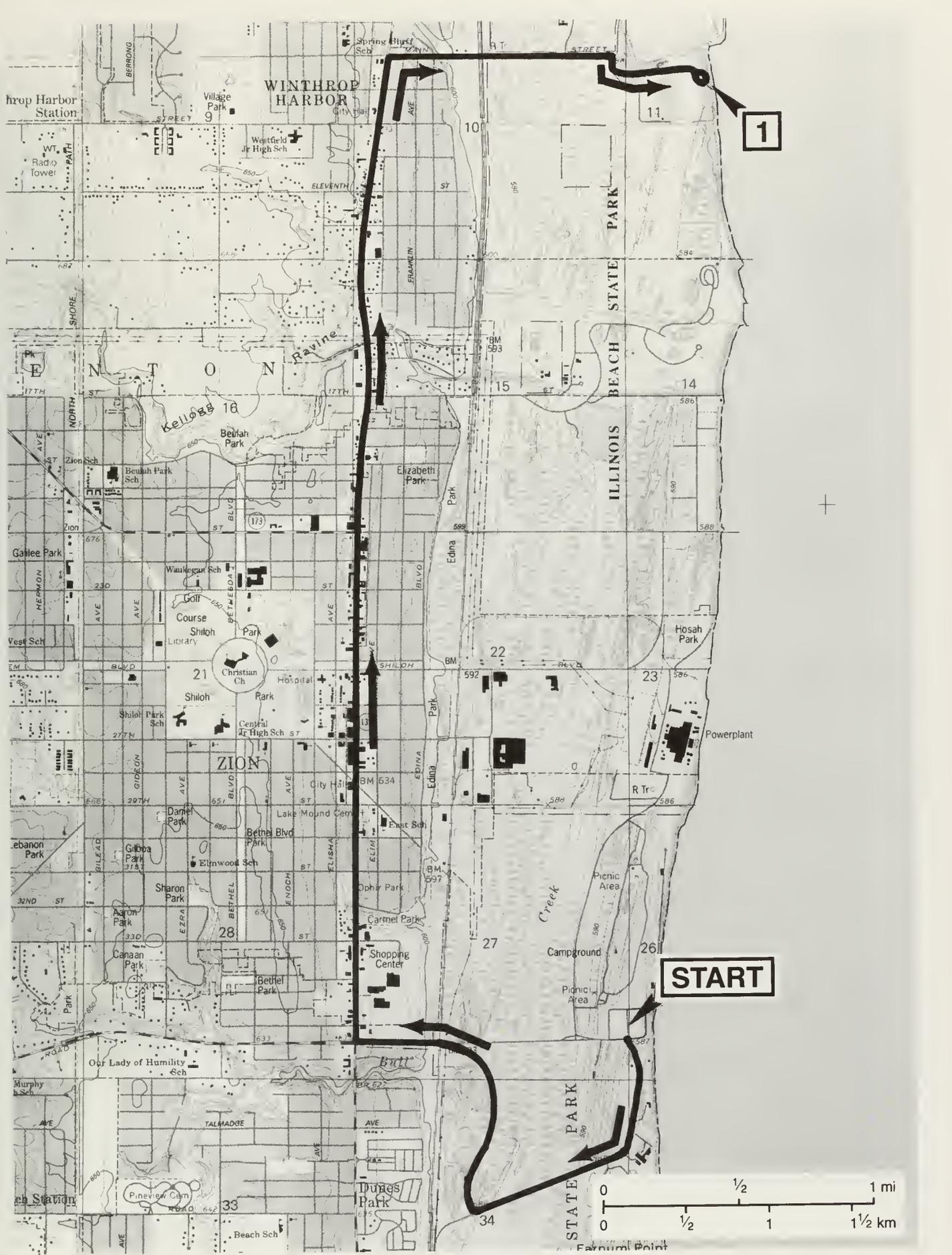
- 0.0 6.9 Leave Stop 5 and retrace the route westbound past the power plant, which will be on the left, and the Johns Manville property, which will be on the right. The large earthen mound on your right is a landfill of waste material from the Johns Manville plant. As we drive out of the gate, we'll be able to see the reservoir of coal stockpiled on the south side of the power plant.
- 0.7 7.6 CAUTION: Cross the single ungated railroad track (which has lights). CONTINUE AHEAD (west) to a stop sign.
- 0.1 7.7 STOP: 4-way stop; intersection of Greenwood Drive and Pershing Road. TURN LEFT onto Pershing Road (heading south). We're still on the beach-ridge plain. The west boundary of the beach-ridge plain is to the right on the far side of the Amstutz Expressway at the base of a wooded bluff.
- 0.25 7.95 CAUTION: Cross another railroad track (no lights and no gate). The road we are on approximates the shoreline position in the late 1700s and early 1800s, the time of the earliest European settlement in this part of the Great Lakes region.
- 0.4 8.35 T-intersection from the left (Darringer Road). CONTINUE AHEAD. A large number of commercial properties are to the left.
- 0.75 9.1 The road ascends an overpass. STOP (3-way) at top of overpass. T-intersection from the right (Mathon Drive). CONTINUE AHEAD on Pershing Road. Note: Prepare to make a left turn at the stop sign at the bottom of the overpass
- 0.15 9.25 STOP: 4-way; intersection of Pershing and Clayton Road. TURN LEFT. On the northeast corner of the intersection is Mathon's Restaurant.
- 0.05 9.3 T-intersection from the left (Sea Horse Drive). TURN LEFT. To the right is Waukegan Harbor. It is one of the three federally maintained commercial harbors in Illinois (the other two are Chicago Harbor and Calumet Harbor).
- 0.4 9.75 Pass by the gated entry to National Gypsum Company. The road curves to the right. As we continue around the bend, now heading out toward the lake, the international headquarters of Outboard Marine Corporation is on the left. On our right are the boat slips and dry storage operated by Larson Marine, one of the largest commercial marine operations along the shore of Lake Michigan. You are driving out on younger land. Much of this land is a direct result of sediment accumulation on the north side of the jetties and break-water at Waukegan Harbor.

- 0.35 10.1 STOP: 3-way. TURN RIGHT. We are heading south towards the Waukegan beach and the entrance to Waukegan Harbor. As we make the turn, to the left is a parking area and a boardwalk. On our right is a fenced in area containing additional facilities of the Outboard Marine Corporation
- 0.4 10.5 STOP (2-way) at one of the entrances to the Outboard Marine Corporation. Note: Turn right into the parking lot, 10 to 15 feet past the stop sign. This is public parking for the city of Waukegan beach and lake shore park.

STOP 6 Waukegan Harbor Entrance Channel (NE, NE, SW, Sec. 22, T45N, R12E, 3rd P.M., Waukegan 7.5-minute Quadrangle, Lake County).

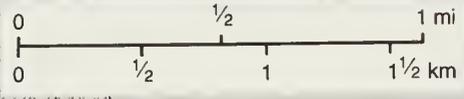
- 0.0 10.5 Leave Stop 6. End of trip. Follow the road back out to get home.
- 0.5 11.0 STOP: 2-way. TURN LEFT.
- 0.8 11.8 STOP: 1-way. Intersection of Clayton and Sea Horse Drive. TURN RIGHT.
- 0.05 11.85 STOP: 4-way. Intersection of Pershing and Clayton Road. CAUTION: Cross single railroad track (lights, no guard gates) and TURN RIGHT.
- 0.15 12.0 The road ascends an overpass. STOP: 3-way; top of overpass. T-intersection from the right (Mathon Drive). TURN LEFT and cross over railroad tracks and entrance to Amstutz Expressway at top of the overpass.
- 0.1 12.1 STOPLIGHT: intersection with Sheridan Road/Illinois Route 137.

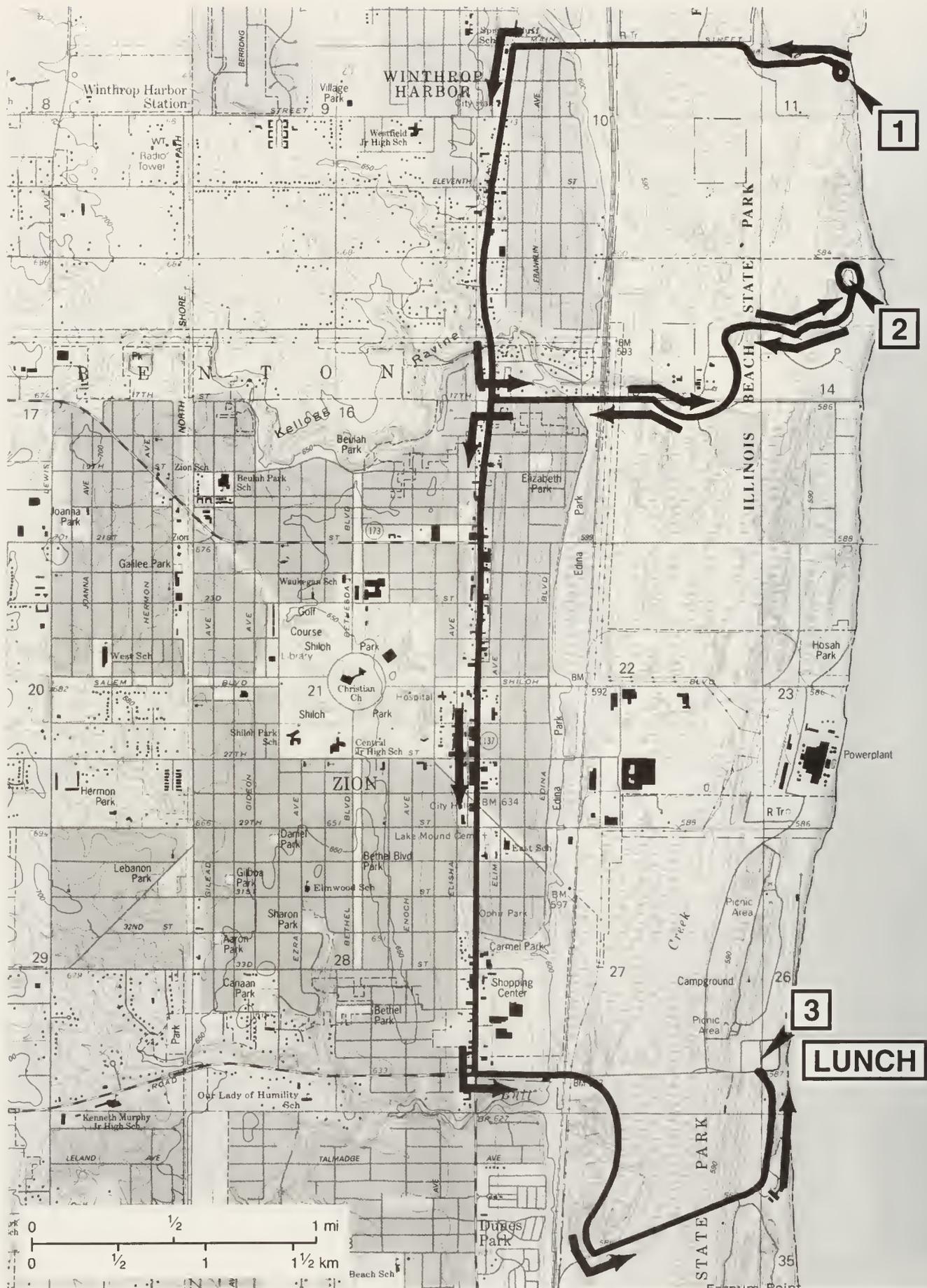
We hope you enjoyed the day. Have a safe trip home.

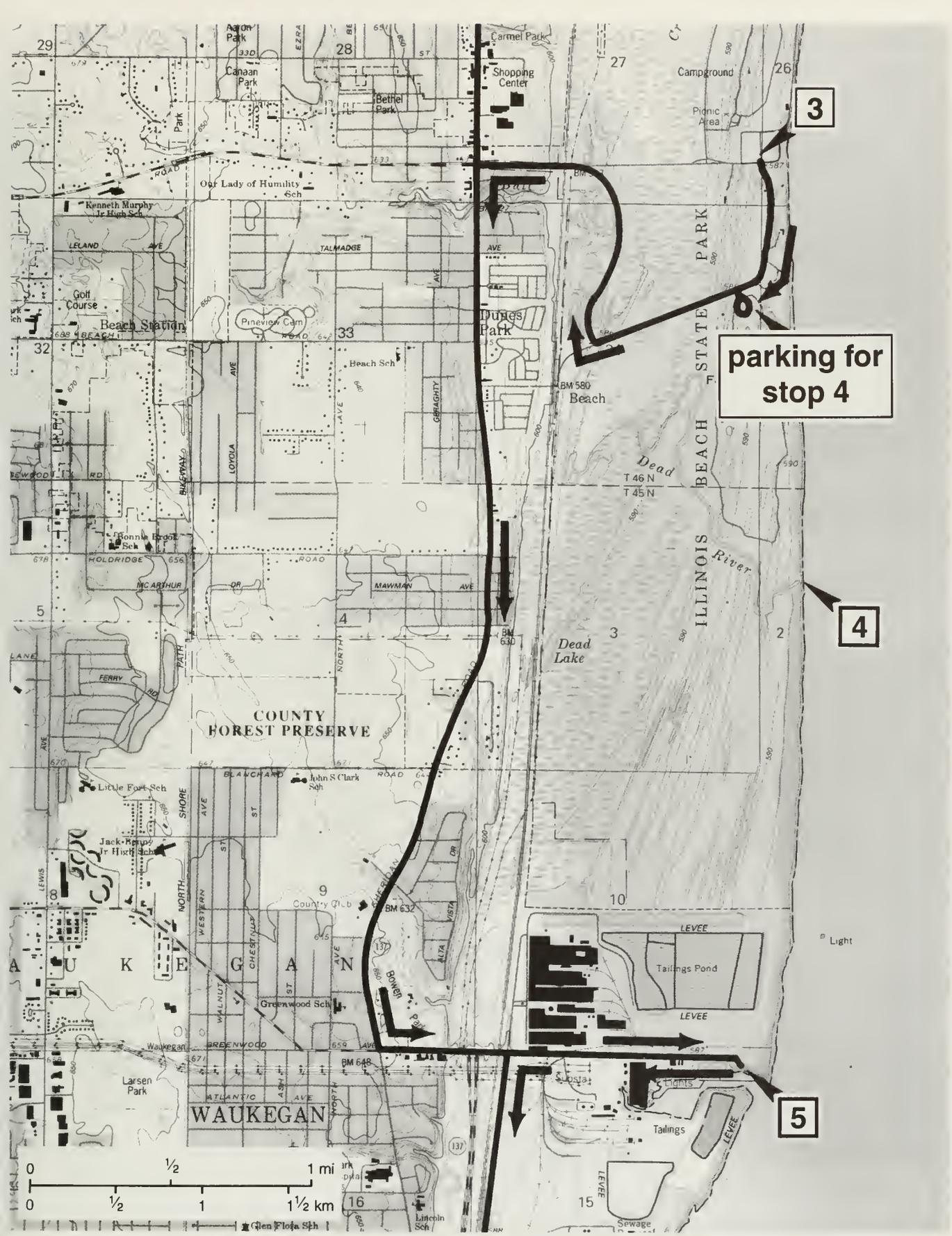


START

1



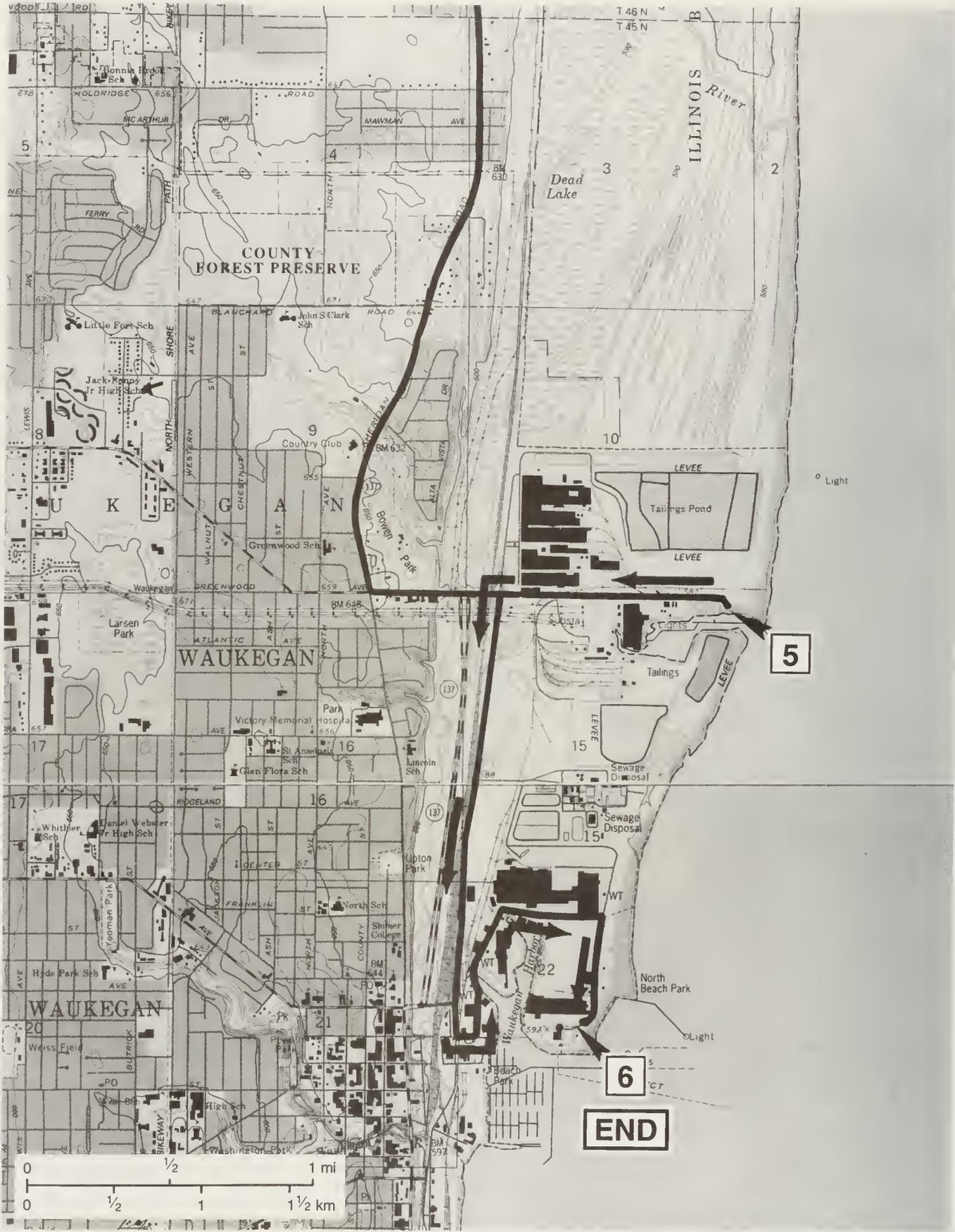




**parking for
stop 4**

4

5



5

6

END

Stop Descriptions

STOP 1 North Point Marina and Illinois Beach State Park, North Unit Feeder Beach
(NW, SE, SW, Sec. 11, T46N, R12E, 3rd P.M., Zion 7.5-Minute Quadrangle, Lake County).

Excavation and dredging of the basin for North Point Marina between 1987 and 1989 resulted in the transfer of nearly 1.5 million cubic yards of sand and gravel from the basin to the shore immediately south of the marina. The South Parking Area (fig.16) sits atop part of this sand pile. The shore in this vicinity has had the most rapid rates of shoreline recession ever documented in Illinois, thus giving this site the designation as an erosion “hot spot.” Annual beach nourishment is necessary south of the parking area to slow the shoreline recession. The shore south of the parking area is also a hot spot for finding asbestos-containing material (ACM) along the beach.

Coastal Geology

None of the sediment that you stand on at the south parking area or the shore to the south was deposited by natural coastal processes. This is sediment placed here by hydraulic means during the marina basin dredging, or brought here by truck for the purpose of nourishing the shore. The sand placement has raised the land elevation as much as 15 feet above the shoreline. The naturally occurring beach at this site has been buried beneath this imported sand and gravel. Prior to the marina construction, the shoreline was located beneath what is now the western part of the parking area.

This stop is located along the erosional part of the beach-ridge plain. Erosional processes have been causing the shoreline to recede in this area for the past several hundred to a thousand years or more. Evidence for this erosion and the former much greater lakeward extent of the plain occurs on historical maps that show the naturally occurring beach ridges in this area. They are oriented toward the north-northeast and are truncated by the modern shore. They “point” offshore to a much broader plain that had a shoreline across what is now an open-water area. The significance of these truncated beach ridges is further discussed at Stop 2.

Historical Shoreline Changes

The most persistent and highest rates of historical shoreline recession along the Illinois coast have occurred in this vicinity. Historical maps document that over a 150-year record of change the shoreline in the vicinity of present-day North Point Marina has been receding at an average rate of about 10 feet (3 m) per year (Jennings 1990). Figure 17 shows that the 1872 shoreline was lakeward of the marina’s breakwaters, and in 1910 the shoreline was approximately at the position of the south breakwater.

Erosion and shoreline recession presented a major threat to housing development that existed along this shore and the shore to the south in the 1960s and 1970s (fig. 18). Despite attempts by homeowners to defend and stabilize the shore, many dwellings suffered severe erosion damage and were abandoned or condemned. All the properties in this area were eventually acquired by the Illinois Department of Conservation (presently Illinois Department of Natural Resources), and all

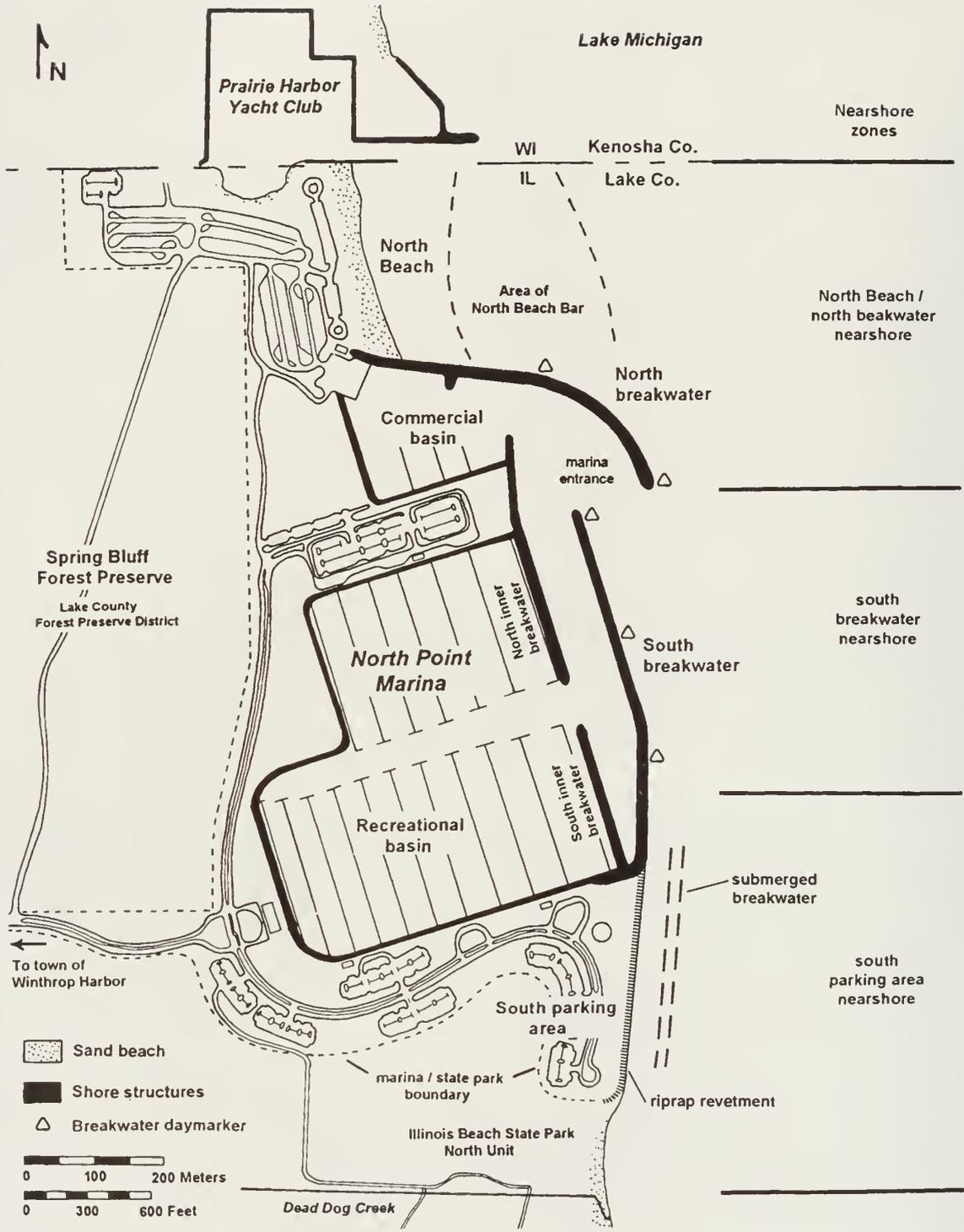


Figure 16 Index map of place names in the vicinity of North Point Marina.

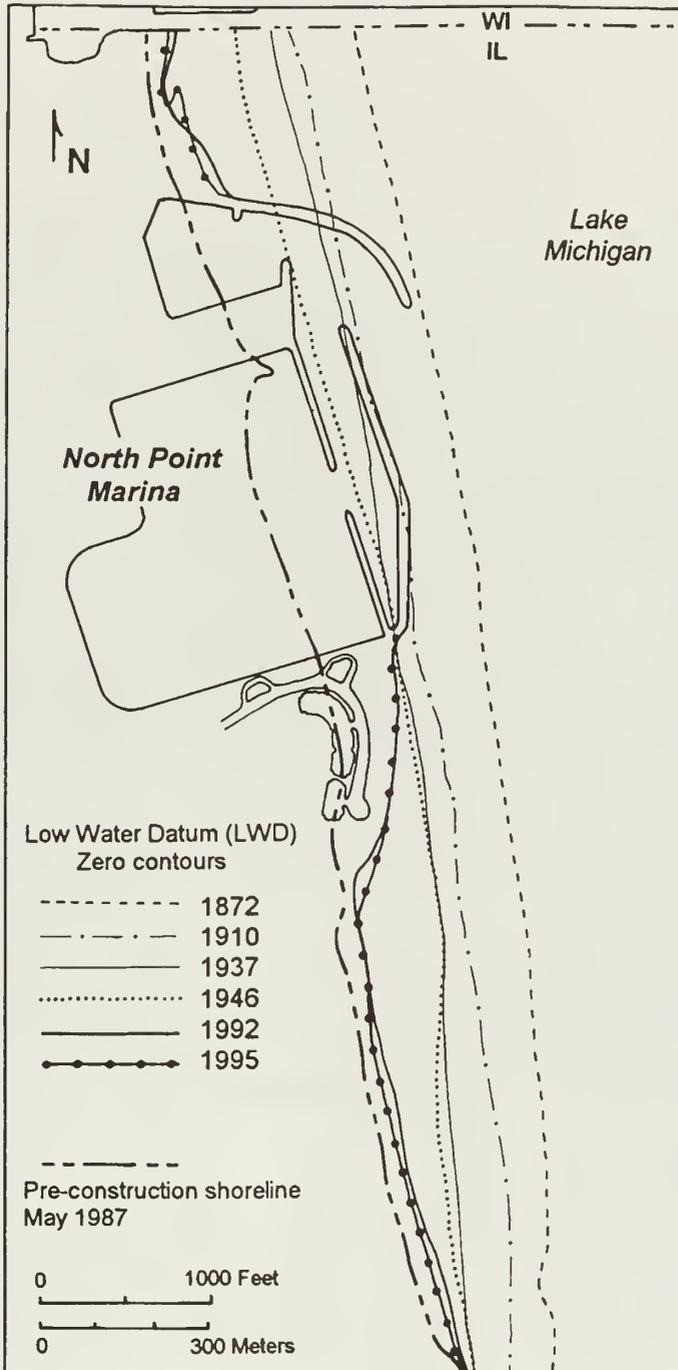


Figure 17 Historical shorelines near the present site of North Point Marina. This map shows the zero-depth contours relative to low water datum (LWD), which provides a reference that approximates the shoreline, but allows comparisons independent of lake-level differences. The 1987 shoreline approximates the shore configuration just prior to marina construction (from Chrzastowski et al. 1996).



Figure 18 Example of the degree of property destruction from coastal erosion that occurred along this shore in the 1960s and 1970s. This house was located north of the Zion Nuclear Power Station (in distance) (photo by Illinois State Geological Survey, April 1973).

the houses and associated above-ground structures were leveled and removed from the area. This land acquisition set the stage for establishing the North Unit of the state park and the planning for the development of North Point Marina. The footprint of the marina basin covers an area where the densest concentration of residential properties once existed (fig. 19).

Human Impact on the Coast

The residential properties that previously occupied this shore led to the earliest attempts at erosion control in this area. These attempts were not successful in halting erosion, but the existence of this former housing development has had a profound impact on the coast. The remains of house foundations and shore protection structures have been exposed in the shallow nearshore area just south of the south parking area (fig. 20), and they influence present-day wave dynamics and sediment transport. Sewer lines, water pipes, sidewalks, foundations, and a variety of building materials are being exposed by the nearshore erosion, broken by wave action, and washed onto the shore. The sediments in the beach here include a variety of housing debris and some debris that is asbestos-containing material (ACM). This ACM includes pieces of water and sewer pipe, siding, roofing, and floor tile. The ACM is not a health hazard because the asbestos fibers are held within a cement matrix, and thus they are not free to become airborne. ACM washing up on the beach is collected by state park officials and disposed.

The greatest human impact to occur along this shore was the construction of North Point Marina. This 72-acre basin holds 1,500 slips and is the largest marina in the Great Lakes and one of the largest in the nation. Construction began in 1986 and most work was completed by 1989. The

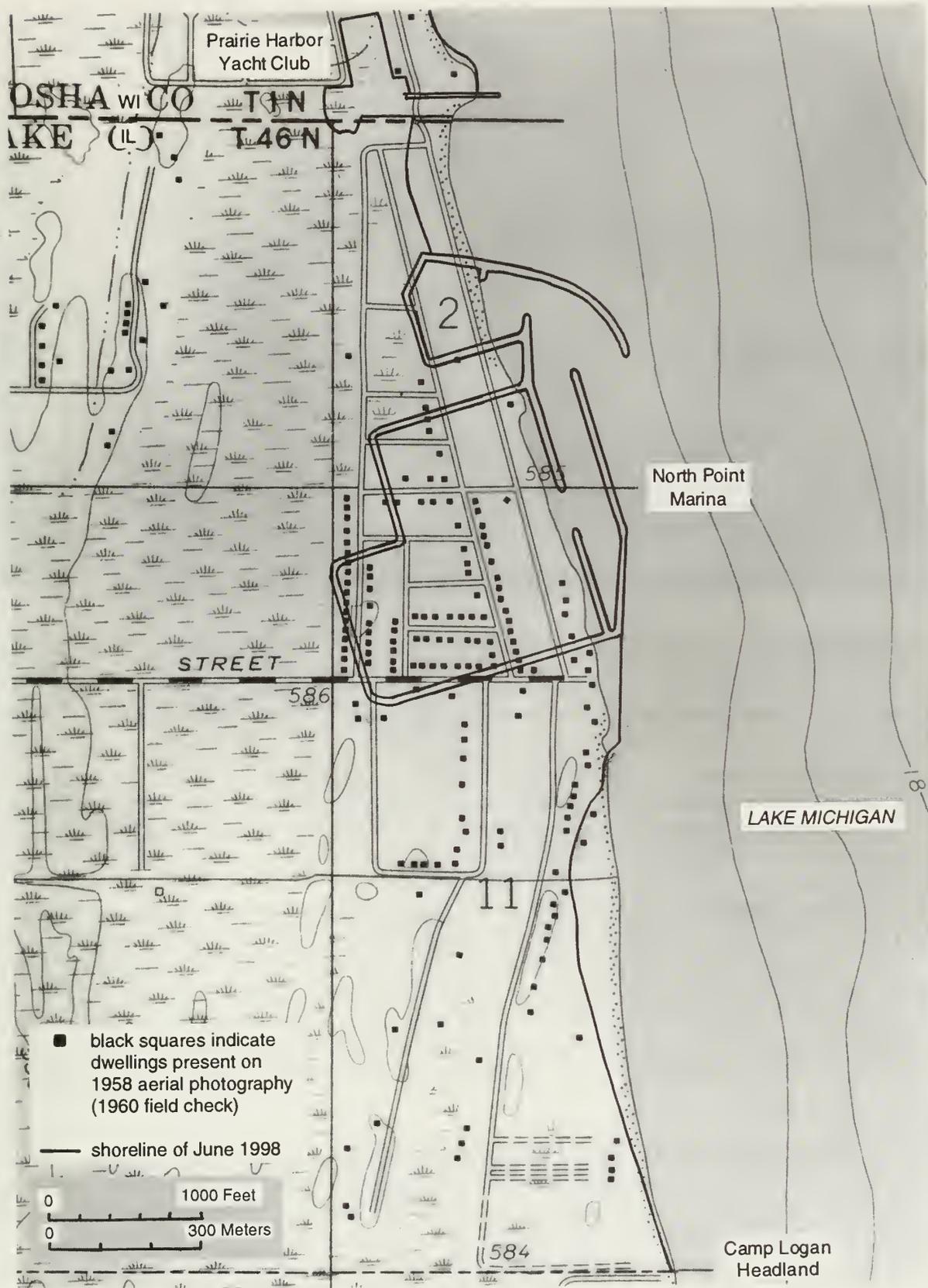


Figure 19 Comparison of a 1958 topographic map of the marina vicinity and the superposition of the present-day marina footprint. Each square symbol represents a house or other structure that was demolished prior to the marina construction.



Figure 20 Aerial view of the beach and nearshore just south of North Point Marina. The submerged remains of former shore protection structures and building foundations are visible under the water in the nearshore area. These structures now act somewhat as a submerged breakwater, reducing wave energy along the shore and locally contributing to a wider beach (photo by M. Chrzastowski, May 2000).

approximately 1.5 million cubic yards of sand and gravel excavated and dredged to make the marina basin was stockpiled in two locations on the south side of the marina. One is along the shore at the present location of the south parking area, and the other is inland just west of the south parking area. The placement of this sediment initially translated the shoreline south of the marina farther lakeward than the most lakeward extent of the south breakwater (fig. 16). Erosion caused rapid shoreline recession and provided large volumes of sand and gravel to supply the beach south of the marina. As this erosion continued and posed a threat to the south parking area, several phases of shore defense occurred (Chrzastowski 1991). Ultimately a submerged *breakwater* was constructed just offshore to “trip” incoming waves and reduce their height and energy, and a *revetment* was constructed along the shore just lakeward of the parking area to stabilize this shoreline. During the boating season, the location of the submerged breakwater is marked by a series of buoys.

Since 1990, the shore area immediately south of the south parking area has been used as a feeder beach, which is a beach where beach sediment is stockpiled for the purpose of providing input to the littoral transport and thus supplying sediment to the *downdrift* shore (fig. 21). A second feeder beach is located at the north end of the state park’s South Unit. On average, this feeder beach near the marina has been supplied with about 20,000 cubic yards per year. The sediment is trucked here from dredging operations at the Waukegan Generating Station (Stop 5) or from inland sand and gravel pits. Waves approaching this segment of shore from the north bring little if any littoral sediment. The feeder beach provides sediment to the wave transport and thus counteracts



Figure 21 A front loader is redistributing sand across the North Unit feeder beach in summer 1995. The sand was trucked to this site from a stockpile of sediment dredged from the entrance to the cooling channels at Waukegan Generating Station (photo by M. Chrzastowski, July 1995).

the net erosion that would otherwise occur here. Because of the minimal contribution of littoral sediment coming south across the state line and because of minimal sediment moving lakeward around the marina, this feeder beach is a primary sediment source for the littoral sediment supply along much of the state park shore.

Challenges in Coastal Management

As long as waves and associated sediment transport continue in the marina vicinity, combined monitoring of beach and lake-bottom conditions will be needed to identify and remediate any developing problems before they become too severe. Maintenance dredging will be necessary in the marina entrance area, which can act as a sediment trap. Monitoring of the lake bottom along the toe of the breakwater stones is important to assure that no undermining is occurring that could cause a shifting of stones.

The major challenge in coastal management will focus on the shore south of the south parking area. As already mentioned, waves approaching this area from the north bring little if any sand, and thus nearly all the wave energy is capable of eroding the shore. If the feeder beach is not maintained and no other remedial action is taken, the shoreline between the south parking area and the Camp Logan headland will erode into an embayed shoreline that could be as much as 500 feet landward of the present shoreline (fig. 22, shoreline B). This event would be a permanent loss of land to the North Unit of Illinois Beach State Park, which is a designated nature preserve.

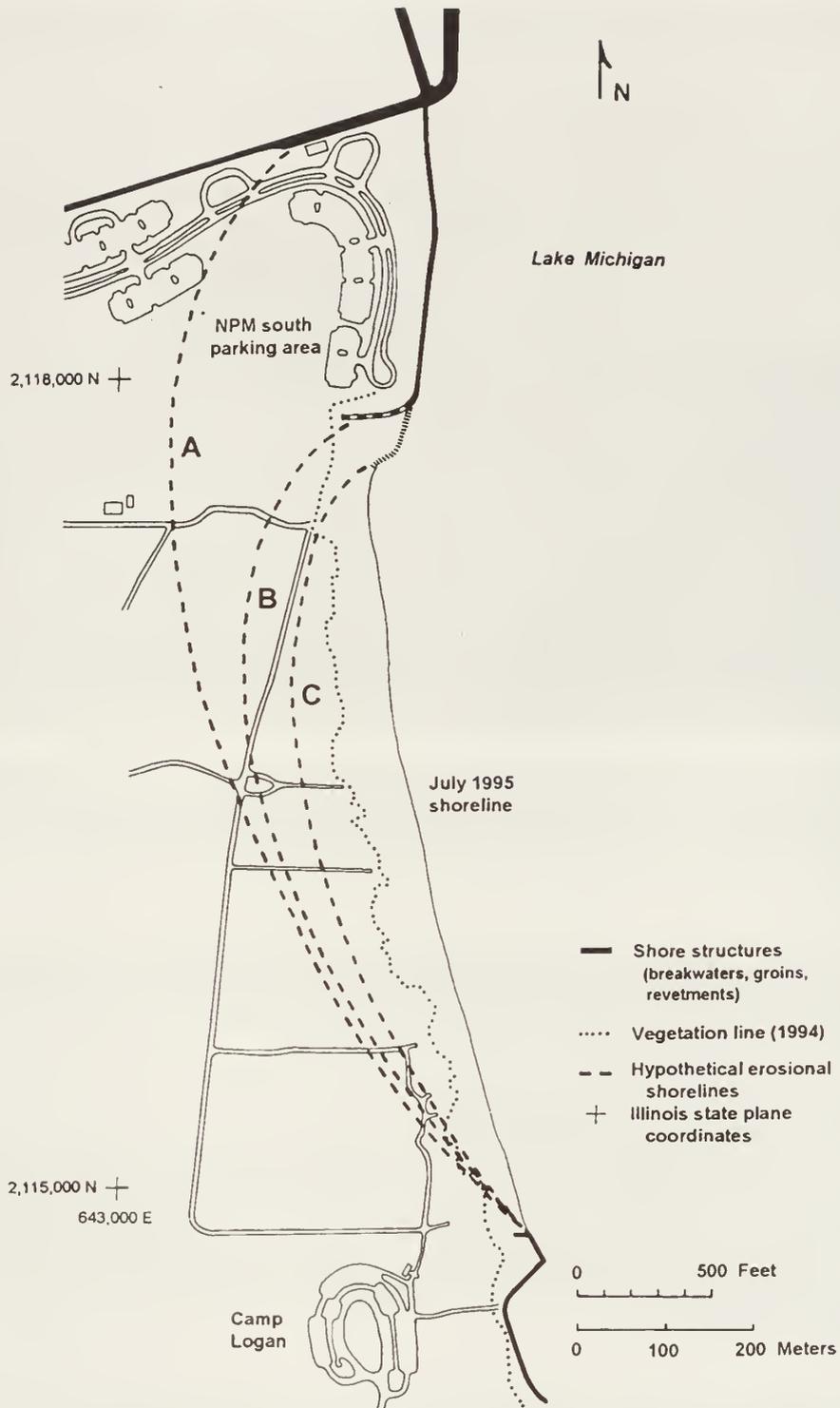


Figure 22 Potential shorelines for different erosion scenarios between the North Point Marina south parking area and the protected shore at the Camp Logan headland. Shoreline A assumes absence of the parking area and its shore protection; shoreline B assumes erosion beginning along the south limit of the revetment at the parking area; and shoreline C assumes erosion beginning at the south limit of rock debris dispersed south of the parking area (from Chrzastowski et al. 1996).

The feeder beach located just south of the south parking area is the present means by which DNR is managing the erosional processes along this shore. This supply of nourishment is slowing but not eliminating erosional trends. Studies of the local sediment budget indicate that to have a balanced sediment budget (no net gain or loss) the annual supply at this particular feeder beach would need to be more than two to three times the amount currently being delivered each year.

STOP 2 Camp Logan Headland (NE, NW, Sec. 14, T46N, R12E, 3rd P.M., Zion 7.5-Minute Quadrangle, Lake County).

The Camp Logan headland is a lakeward promontory of the state park shoreline that has been protected from shoreline recession by a complex of shore-defense structures. This site demonstrates how structures can work to stabilize the shore and also demonstrates some of the benefits and deficiencies of those structures. Beach ridges near this site oriented at an angle to the present shore indicate that the beach-ridge plain of 2,000 to 1,000 years ago trended northeast–southwest in this vicinity and extended farther east across what is now the open water of the nearshore zone.

Coastal Geology

A headland is a lakeward (or seaward) protrusion of the shoreline. Typically this refers to a high, steep-faced promontory on the coast. The name “headland” is informally given to the shoreline protrusion at Camp Logan because it protrudes so much farther lakeward than the shoreline to either the north or south. This lakeward protrusion of the shoreline is not a natural feature. The shore has been stabilized by coastal engineering. Erosional processes have occurred along the shore both north and south of this protected area; as shoreline recession occurred in these areas, the protected shore at Camp Logan became a shoreline promontory.

The beach-ridge plain just south of the Camp Logan headland preserves excellent examples of beach ridges that are oriented tangential to the present-day shoreline (fig. 23). These angled beach ridges indicate that during their formation, the beach-ridge plain extended east of the present shoreline at Camp Logan, and occupied what is now the nearshore zone between the Camp Logan headland and North Point Marina. The beach ridges near the headland record shoreline positions from about 2,000 to 1,000 years ago, and indicate that not only has there been substantial erosion here and along the shore to the north, but there has also been a substantial change in the shoreline orientation. These coastal changes are part of the process of coastal evolution as the beach-ridge plain has migrated southward and become narrower and more elongate with time (see fig. 15).

Historical Shoreline Changes

This shore is within the erosional reach of the beach-ridge plain and has undergone shoreline recession during historical time. At a minimum, the 1872 and 1911 shorelines were respectively about 420 and 250 feet (128 and 76 m) lakeward of the present headland shoreline (fig. 23). Shore protection began to be installed along this shore in the 1950s, and since that time no significant shoreline recession has occurred.



Figure 23 Aerial photo of the Camp Logan headland vicinity (photo by Illinois Department of Transportation, March 1997).

Human Impact on the Coast

The ruins of concrete piers are present in the nearshore. A series of four piers that were present in the 1950s were used for vessels coming to the U. S. Army's Camp Logan. As the effects of shoreline recession became a problem, shore protection was installed. Several phases of shore protection were installed here, and several designs and materials were used. A steel sheetpile bulkhead protects much of the southern part of the headland shore. One of the consequences of building such a vertical wall along a shore is that it directs some of the incoming wave energy downward, which in turn contributes to the erosion of local beach and nearshore sediments. This action accounts for the absence of a beach along much of this bulkhead.

Two steel sheetpile *groins* extend lakeward from the bulkhead. A groin is a structure perpendicular to the shore that crosses the beach and extends into the nearshore for the purpose of trapping and holding littoral sediment to maintain a beach and prevent shoreline recession. The groins at Camp Logan have trapped some of the littoral sediment in transport along this shore and have small beaches on their landward ends (fig. 23). Examination of these beaches can show how groins interact with the littoral transport process (see fig. 9). A groin forms a barrier to littoral transport, and sediment will accumulate on the updrift side of the groin. The beaches at the Camp Logan groins are quite variable in their height, areal extent, and sediment cover depending on recent storms and lake-level changes, and at times beaches may be present on both sides of the groins. But the beach on the north side of the groin will typically be larger in area and higher in elevation because of the greater volume of beach sediment. Such beach morphology shows that the north side is the updrift side of the groin, and that the net littoral transport direction is from north to south. The beach accretion against groins is one of several geomorphic indicators used to determine the direction of net littoral transport along a coast.

The northern part of the shore at the Camp Logan headland is an example of a crescent-shaped or embayed beach or shoreline that will naturally develop along this shore between erosion-resistant points, also called “hard points.” Figure 22 shows the projection of such an embayed shoreline that would evolve between North Point Marina and the Camp Logan headland if no intervention occurred. The embayed shore at the Camp Logan headland is a small-scale version of the same response. The crescent-shaped shoreline results from a combination of incoming waves refracting around the updrift hard point and causing shoreline recession, while the down-drift hard point limits the landward extent of this erosion. The greater the distance between the two hard points, the greater the landward extent of the embayed shore.

Challenges in Coastal Management

The coastal engineering at the Camp Logan headland demonstrates that the shore can be stabilized with structures, but that without special design and engineering that stabilization can have detrimental effects such as elimination of all beach in front of a bulkhead or alteration of the shoreline configuration. Coastal engineering will be necessary at some locations along the state park shoreline in the future, and the challenge will be to design and build structures that are not only functional for shore protection, but also have a minimal negative impact on the visual features of the state park’s coastal setting. The structures at Camp Logan present a challenge in developing a regional coastal management plan. These structures were placed specifically for the protection of this segment of shore, but as a regional coastal management plan is developed for the entire state park shore, some of the structures at Camp Logan may need to be altered, rebuilt, or removed.

STOP 3: LUNCH Picnic Area Near Main Swimming Beach (NW, SW, SW, Sec. 26, T46N, R12E, 3rd P.M., Zion 7.5-Minute Quadrangle, Lake County).

This stop provides ample parking, picnic tables, rest rooms, and easy walking access to the main swimming beach of the South Unit of Illinois Beach State Park. In the 1970s, the shoreline recession along the main swimming beach resulted in the need for demolition of the state park’s original bathhouse.

Coastal Geology

The picnic area and the nearby campground are located amid beach ridges that were forming about 200 years ago. At that time, the shoreline crossed this area and extended toward the southwest in a broad arc that reached the upland to the west of the Johns Manville property, located about 3 miles (4.8 km) southwest of this stop.

The shore along the nearby swimming beach is within the erosional zone of the beach-ridge plain. Rates of shoreline recession have not been as great as those recorded in the vicinity of North Point Marina (Stop 1), but substantial shoreline recession has occurred. Figure 24 shows shoreline changes along the swimming beach between 1953 and 1973, and shows the 1997 shoreline for a more recent comparison. The local shoreline recession was a major factor in the decision to remove a bathhouse that formerly existed lakeward of the camp store at the south end of the swimming beach (figs. 25 and 26).

Challenges in Coastal Management

Erosion has been a serious threat to the service road that runs along the lakeward side of the series of bath houses located north of the swimming beach. It has been necessary to place riprap along most of this reach. On several occasions, additional stone has been necessary to counteract potential undermining of the road, which was made vulnerable by shifting and settling of the stones. Near the north end of the service road is where sand is periodically trucked in and placed in a feeder beach located on the lakeward side of the riprap. This is the second of two feeder beach locations in the park. This feeder beach provides nourishment along the toe of the service-road riprap, along the swimming beach, and southward along the rest of the South Unit. Beach nourishment is also intermittently placed directly at the swimming beach to assure an adequate sand cover for the recreational use of this beach.

The expansive parking lots of this area are an example of the conflict faced in many state parks and natural areas where preservation of a unique landscape is the park's objective but infrastructure (such as parking lots) is necessary to serve park visitors. Construction of these parking lots required leveling and paving across what was originally nearly 10 acres (40 square m) of beach ridges, dunes, and wetlands.

STOP 4 Mouth of Dead River and the Nature Preserve at the South Unit of Illinois Beach State Park (NE, SW, NW, Sec. 2, T45N, R12E, 3rd P.M., Zion 7.5-minute Quadrangle, Lake County).

The least disturbed areas of the state park occur in the southern part of the South Unit. This stop begins at the parking area at the Nature Center and includes a walk along trails and the beach to the mouth of Dead River. The walk is an opportunity to view a nearly pristine landscape of beach ridges, dunes, wetlands, and a shore free of any erosion-defense structures. The mouth of Dead River preserves a setting characteristic of the pre-development condition of most rivers along the shore of Lake Michigan. The discharge of these rivers to the lake was hindered by wave action, and the resulting sediment transport along the shore tended to close off the river mouth.

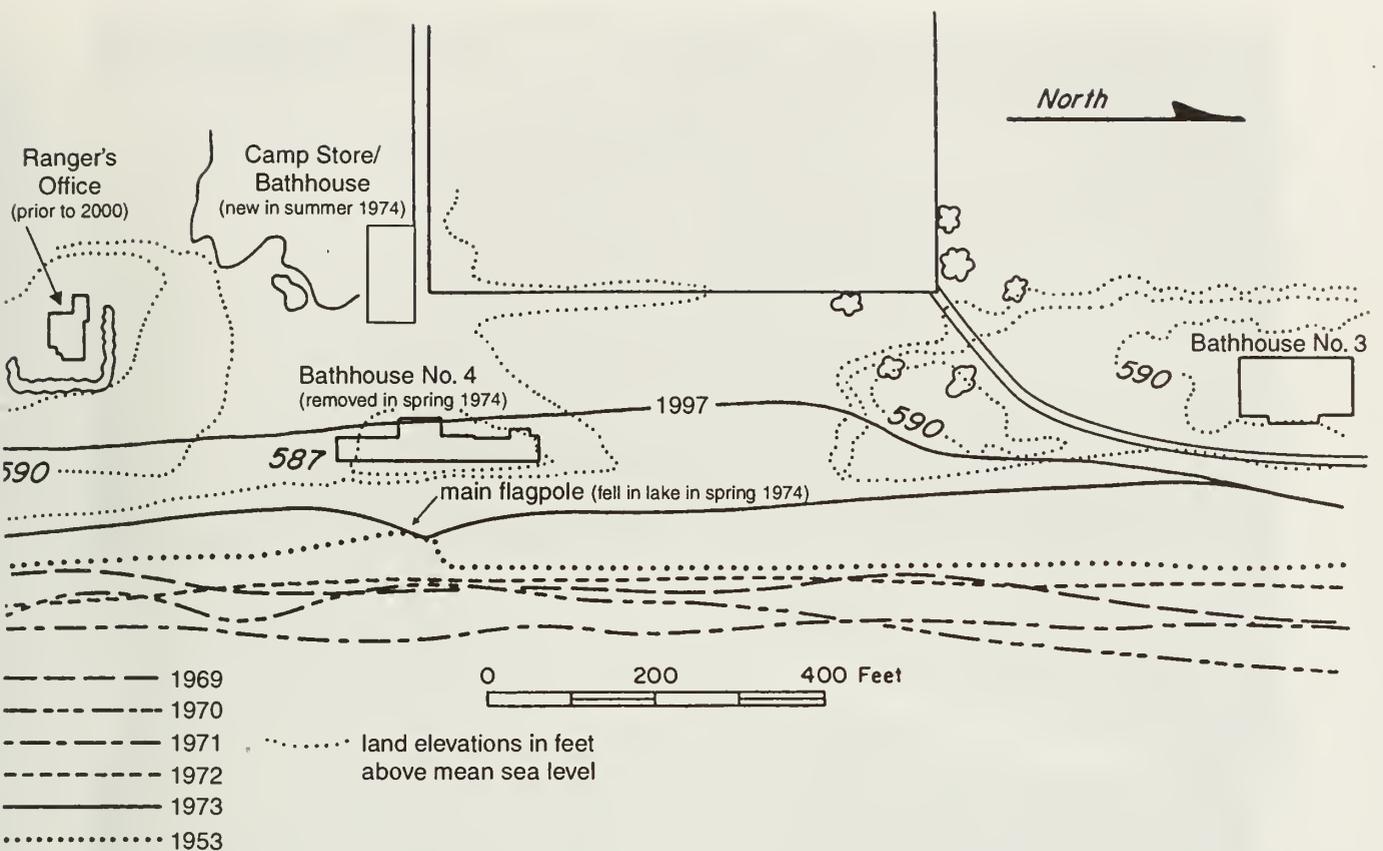


Figure 24 Shoreline recession at the Main Swimming Beach for the 20-year record of 1953 through 1973. Shorelines are for the lake level that existed at the time of the survey (modified from Collinson et al. 1974).

Coastal Geology

The shore for about 1 mile to either side of the mouth of Dead River is a unique segment along the beach-ridge plain. The segment is a transition zone between the erosional shore that dominates north of this segment, and the accretional shore that dominates south of this segment. This transition zone has a balance between sediment gain and loss. The shoreline position here has changed very little throughout historical time, and this part of the shore is therefore in dynamic equilibrium.

Because of the migratory nature of the Zion beach-ridge plain, there has always been a transition zone between the erosional shore along the northern part of the plain and the accretional zone along the southern part of the plain. This transition zone has migrated southward as the plain has migrated. For most of historical time, the transition zone has been centered near the mouth of Dead River. This is one factor that probably contributes to the river mouth occurring at this location (fig. 27).

Dead River is the largest stream draining the beach-ridge plain and is the surface drainage for nearly all of the South Unit. Dead River is the continuation of Bull Creek, which receives flow from a series of tributaries in ravines that reach as far west as Green Bay Road (fig. 6). Sheridan Road crosses the Bull Creek ravine just south of the intersection with Wadsworth Road (see road log between Stops 4 and 5). The name *Dead River* probably results from the typical presence of a sand deposit blocking the river's flow from entering the lake: thus the flow is halted or "dead."



Figure 25 February 1974 photograph of the beach house at the Main Swimming Beach threatened by shoreline recession. Note the evergreen tree (arrow) near the front of the beach house on the left side (Illinois State Geological Survey photo).



Figure 26 October 1974 photograph showing new camp store and beach house. Note evergreen tree (arrow) marking position of original beach house shown in figure 26 (Illinois State Geological Survey photo).



Figure 27 Aerial view of the mouth of Dead River at a time of open discharge to the lake. The southward deflection of the channel across the beach results from the influence of beach deposits from northerly waves. The darker color of the river water entering the lake is due to tannins and lignins that the river water acquired while draining the upland forests and the coastal wetlands (photo by J. Dexter, May 2000).

Rivers with this kind of intermittently blocked mouth are sometimes called “blind rivers” because they don’t “see” out to the water body that they discharge to.

A sand deposit typically forms across the river mouth when the volume of sediment being transported along the shore overwhelms the ability of the river flow to maintain a channel across the beach. When the river is dammed by this sand deposit, some water discharges to the lake by percolating through the sand deposits. When the river level rises sufficiently to breach a channel across the beach, the initial formation of this outlet channel can be a rather sudden event and cause a swift river current (fig. 28). The channel will remain open until the river’s flow decreases sufficiently, or lake waves are sufficient to redistribute sand and close the channel.

The mouth of Dead River, the surrounding wetlands, dunes, and beach ridges provide a glimpse back in time to the pre-development setting at the mouth of the Chicago River and the site of downtown Chicago. Historical accounts, sketches, and maps document the similarity of these two settings and the similarity in the dynamics at the mouth of the two rivers (fig. 29). In its natural setting, the mouth of the Chicago River was often blocked by sand accretion. After Fort Dearborn was constructed along the banks of the river, soldiers stationed there often needed to dig trenches across the beach to assist the river’s discharge and lessen the threat of flooding to the fort (Andreas 1884, Chrzastowski 1998).

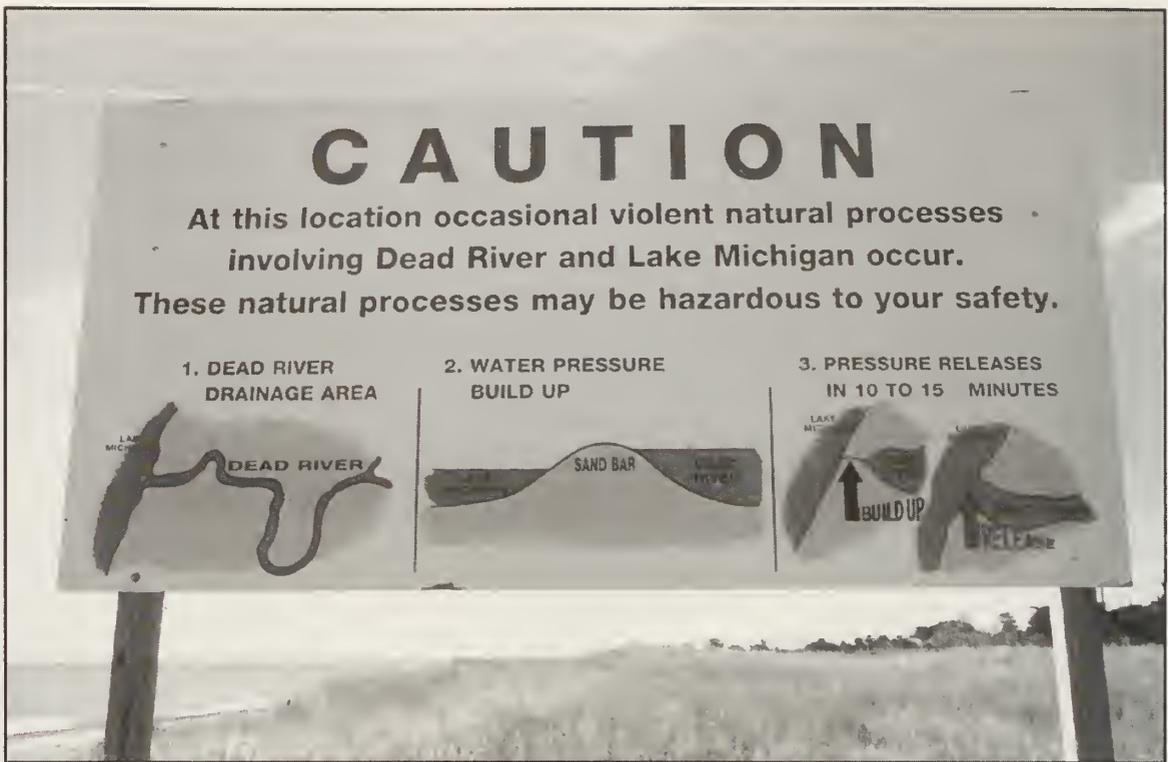


Figure 28 Public information sign placed near the mouth of Dead River explains the potentially sudden and rapid river discharge to Lake Michigan (photo by M. Chrzastowski, September 1997).



Figure 29 Rendering of the natural setting at the mouth of the Chicago River in 1779. This landscape is much like that seen today near the mouth of Dead River (modified from a rendering by R. Varin; original sketch by E. White, published in Andreas 1884).

Historical Coastal Change

As previously mentioned, the shoreline position in the vicinity of the mouth of Dead River has generally been stable through historical time. This shoreline is located in the transition zone along the beach-ridge plain between the erosional shore to the north and the accretional shore to the south. To the south of Dead River, the amount of historical change in the coastline has been substantial. Accretion has shifted the shoreline lakeward and changed the orientation of the shore from one having an arcuate trend toward the southwest to one trending more north–south. This historical change is further discussed in the text for the next stop (Stop 5).

Human Impact on the Coast

This is the most pristine area along the state park shore, but still there have been some significant human impacts on the setting. The more lakeward segment of the trail between the nature center and Dead River passes the concrete ruins of a former ice factory. Historical maps document a railroad spur that once extended across the beach-ridge plain and then split to a terminus adjacent to a loading facility near the beach and a terminus along the beach about ½ mile north of the mouth of Dead River, a place then known as Farnum Point (see fig. 32). These tracks were used to transport large volumes of sand and gravel excavated from the beach to be used as building material and in making concrete. Such sand and gravel extraction is a practice known as “beach mining.” Ruins of the railroad are preserved at some locations in the South Unit; in 1997 erosion along the beach exposed the tracks for the first time in several decades (fig. 30).

The landscape has also been altered by the introduction of exotic plant species. The extensive stand of pine trees visible to the south of Dead River is not a natural occurrence. These trees result from planting in the late 1800s by Robert Douglas, a local nurseryman and naturalist, for the purpose of making a forested, park-like setting, possibly similar to the pine forests that occur along the sand plains of the U.S. mid-Atlantic coast of New Jersey, Delaware, Maryland, and Virginia. Although this introduced pine forest has been successful, the natural vegetation at this site would be dominated by sand prairie, savannah, and open oak forest.

Challenges in Coastal Management

The dynamic equilibrium of erosion and accretion that occurs along this shore has precluded any need for managing erosion or accretion. As long as an adequate supply of littoral sand moves along this reach of shore, this shore will require minimal management. However, managing visitor access and visitor use of this area is a major concern. Figure 28 shows there is a need for an information sign to ensure public safety due to the unusual dynamics of Dead River. The Nature Preserve at the South Unit, which is the land area south of the Dead River, is maintained as a wild area with limited access (by permission only) as a means to preserve this setting. The area north of the river is open to hikers, but here the management challenge is to ensure visitors follow the established trails. Hiking across vegetated areas of the dunes, ridges, and wetlands can damage or destroy the vegetation. Subsequent erosion could adversely alter the landscape.



Figure 30 Beach erosion in 1997 exposed the remains of railroad tracks used in the late 1800s to transport sand and gravel excavated from the beach for use as construction material. Since this photo was taken, the tracks have been reburied by beach sand (photo by A. Foyle, 1997).

STOP 5 Cooling-Water Channels at the Waukegan Generating Station (NW. NW, NW, Sec. 14, T45N, R12E, 3rd P.M., Zion 7.5-minute Quadrangle, Lake County).

This stop is along the accretional part of the Zion beach-ridge plain. Trying to maintain an open channel across a shore where there is a net influx of littoral sediment is an engineering challenge. At the Waukegan Generating Station, it is accomplished to maintain a flow of cooling water. Sand is a surplus at this site, and maintenance dredging is necessary to maintain a minimum depth for water intake. In the past, this dredged sand has been trucked northward to supply the two feeder beaches in the state park, but asbestos-containing material (ACM) in this dredged sand has raised some issues concerning its use.

Coastal Geology

The Waukegan Generating Station was built by Commonwealth Edison Company and completed in 1938. This coal-fired, electric power plant requires an uninterrupted supply of cooling water, which is supplied by Lake Michigan. The system for inflow and outflow between the lake and the power plant is designed to work with the natural coastal processes along this shore. A steel sheetpile *jetty* separates the intake and discharge channels (fig. 31). Water is taken in on the south (downdrift) side of the jetty, and returned to the lake along the north (updift) side. The discharge

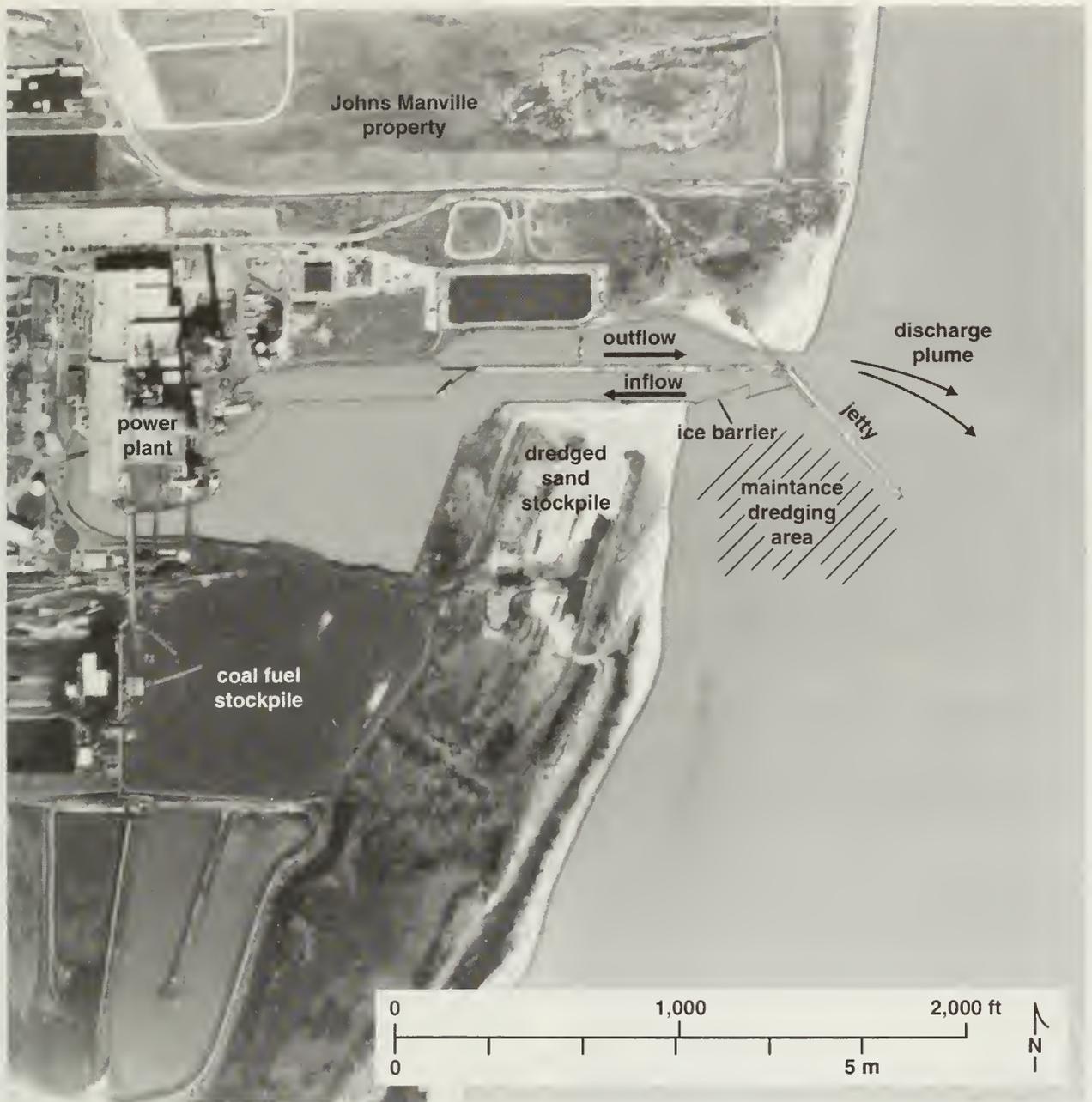


Figure 31 Aerial view of the Waukegan Generating Station and the adjacent coastal land (photo by Illinois Department of Transportation, March 1997).

current is sufficient to prevent any major sand accumulation that would otherwise occur against the updrift (north) side of the jetty. To prevent any ice from entering the intake channel during winter months, a steel ice barrier extends from the jetty, across the intake channel, and over to the south shore.

The water area on the south side of the jetty is protected from the direct influence of northerly waves. Because of this protection, the area is prone to deposition of littoral sediments. The accumulation of sediment reduces water depth, which can restrict inflow to the cooling channel. In winter months, the problem can become acute if ice becomes grounded on the shallow bottom.

forming a barrier to the water flow. Maintenance dredging is therefore necessary to maintain depths sufficient for year-round water flow into the intake channel. Maintenance dredging removes an average of about 35,000 to 40,000 cubic yards per year from this depositional area, which is about half of the 80,000 cubic yards per year that approaches this shore area from the north. The remaining 40,000 cubic yards per year moves past the power plant facility and continues southward toward Waukegan Harbor. Sand removed in the dredging is stockpiled just landward of the beach area on the south side of the power plant property.

Historical Shoreline Changes

In 1872 the shoreline was about 600 to 700 feet east of where the power plant is located. Since that time, the shoreline has shifted nearly 1,300 feet lakeward. Most of this accretion is due to the natural accumulation of sediment along this depositional part of the beach-ridge plain, but some of the accretion can be attributed to the updrift influence of the cooling-channel jetties and the breakwater at Waukegan Harbor a little over 1 mile (1.6 km) to the south. The jetty/cooling-channel system at the power plant has caused the shoreline to shift lakeward on the updrift (north) side of the system (fig. 31). The degree of historical shoreline change at the power plant site and to the south is illustrated in the map comparison in figure 32. No natural channel, lagoon, or open-water area existed at the power plant site prior to its construction. The wetland drainage patterns on the 1908 topographic map indicate that the wetlands west of the present power plant site drained southward to Little Dead River, which had an outlet to the lake about ½ mile (0.8 km) north of the entrance to Waukegan Harbor.

Human Impact on the Coast

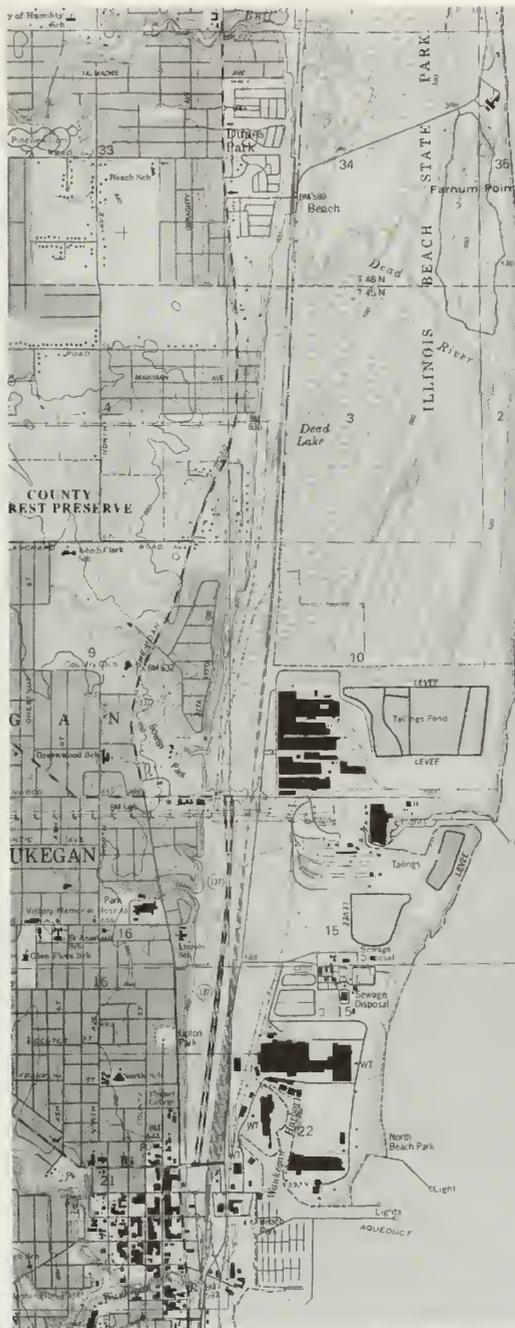
The Waukegan Generating Station, the neighboring Johns Manville property, and the industrial land immediately south of the power plant have all impacted the coastal setting. The outflow from the power plant produces a current strong enough to capture some of the incoming littoral sediments, move them lakeward, and build a large underwater fan. Such a feature would be unstable along this shore if not for the influence of the jet-like flow from the discharge channel. The Johns Manville property is a Superfund Site with landfills of buried asbestos used in the manufacture of a variety of asbestos-containing products. The planned demolition of the Johns Manville buildings will result in the on-site burial of tons of demolition debris, some of which will include asbestos materials. The landfills on the Manville property will be a long-term testament to the industrial history of the site.

Challenges in Coastal Management

Although the routine maintenance dredging at the Waukegan Generating Station has been an effective means of managing the sand surplus, it has long been recognized that reducing or eliminating this need would reduce the plant's operational costs. A proposed groin on the updrift (north) side of the discharge channel could trap littoral sand (Bridges and Ettema 1999). This entrapment could then be a sediment supply to be excavated and trucked northward to be placed on the feeder beaches in the state park. This approach would avoid the need for dredging equipment. Such capturing of littoral sand in a downdrift location and returning it to an updrift location, called "backpassing," is an effective means of conserving sand resources along a specific reach of shore. Before such a backpassing program could be implemented, the long-term governmental and private sector commitments and responsibilities need to be resolved. In the mean time, maintenance dredging will continue at the intake channel and sand will be stockpiled onshore.



1908



1993

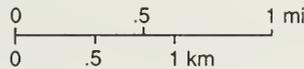


Figure 32 Comparison of 1908 (left) and 1993 (right) topographic maps for the segment of beach-ridge plain between the site of the Waukegan Generating Station and Waukegan Harbor. Note the existence of Little Dead River on the 1908 map, which has been lost to industrial development (from U.S. Geological Survey, Waukegan Quadrangle, 1:62,500, 1908, and Zion and Waukegan Quadrangles, 1:24,000, 1993).

STOP 6 Waukegan Harbor Entrance Channel (NE, NE, SW, Sec. 22, T45N, R12E, 3rd P.M., Waukegan 7.5-minute Quadrangle, Lake County).

Waukegan Harbor, near the southern terminus of the Zion beach-ridge plain, is now the terminal area for nearly all littoral sediment moving southward along the plain. Construction of the harbor halted the southward migration of the plain; former dredging of the harbor entrance resulted in a permanent loss of sand resources from the Illinois coast.

Coastal Geology

Waukegan Harbor is located in the accretional part of the Zion beach-ridge plain and also near the southern limit of the plain. The southern limit occurs along the shore at North Chicago about 2 miles (3.2 km) south of Waukegan Harbor. Accretion on the updrift side of the harbor entrance has been rapid and large scale (fig. 32). Such sediment entrapment against shore structures results in offsets in the shoreline position to either side of the structure. At Stop 2 (Camp Logan Headland), the shoreline offset was a few tens of feet on either side of a groin. By contrast, the shoreline is offset to either side of the Waukegan Harbor complex by as much as 3,000 feet (914 m). This is the largest such offset associated with any coastal engineering structure anywhere along the Lake Michigan coast.

Waukegan Harbor is federally maintained. The Chicago District of the the U.S. Army Corps of Engineers is responsible for maintenance dredging to maintain a depth of 25 feet (7.6 m) below low water datum (LWD) in the outer approach channel, and 23 feet (7.0 m) below LWD between the two jetties and within the central harbor area (fig. 33). Most accretion occurs in the outer part of the approach channel as littoral sediment bypasses the breakwater to the north of the harbor entrance, and then is trapped in the deep water of the channel. Although some littoral sediment gets past the harbor entrance and continues in southward transport, the dredged channel effectively captures most littoral sediment.

The dredging history at Waukegan Harbor goes back to 1889 and has been an intermittent maintenance requirement ever since. In general, dredging has occurred every one or two years and, on average, has removed approximately 40,000 cubic yards per year (Chrzastowski and Trask 1995). The dredging history has had two overlapping phases. In the initial phase, sand dredged from the harbor entrance area was barged to a deep-water disposal area located 2.5 miles due east of the harbor entrance. This offshore disposal spanned a total of 93 years (1889–1982) and resulted in the removal of 2.1 million cubic yards of sand from the littoral drift of the Illinois coast. Beginning in 1977, dredged sand was disposed of in the nearshore area south of the harbor. Offshore disposal occurred again in 1982, but then in 1984 and continuing until the mid-1990s, disposal has been in the nearshore area downdrift of the harbor. This designated disposal area is located 2,000 feet (610 m) south of the entrance to Waukegan Marina (fig. 34). Sediment is barged here and disposed in this area, which originally had depths in the range of 12 to 15 feet (3.6 to 4.6 m) (LWD). This downdrift disposal assists the littoral sediment to bypass the harbor entrance and continue its net southward littoral transport. In the summer of 2000, for the first time, sediment dredged from the harbor entrance was barged northward and deposited in the nearshore just south of North Point Marina. This effort was to assist in the beach nourishment along the state park. Since 1977, a little more than 0.5 million cubic yards of sediment has been dredged from the harbor entrance and returned to the nearshore. This is only about a fourth of the volume that was deposited in the deep-water disposal site and permanently lost from the littoral system.

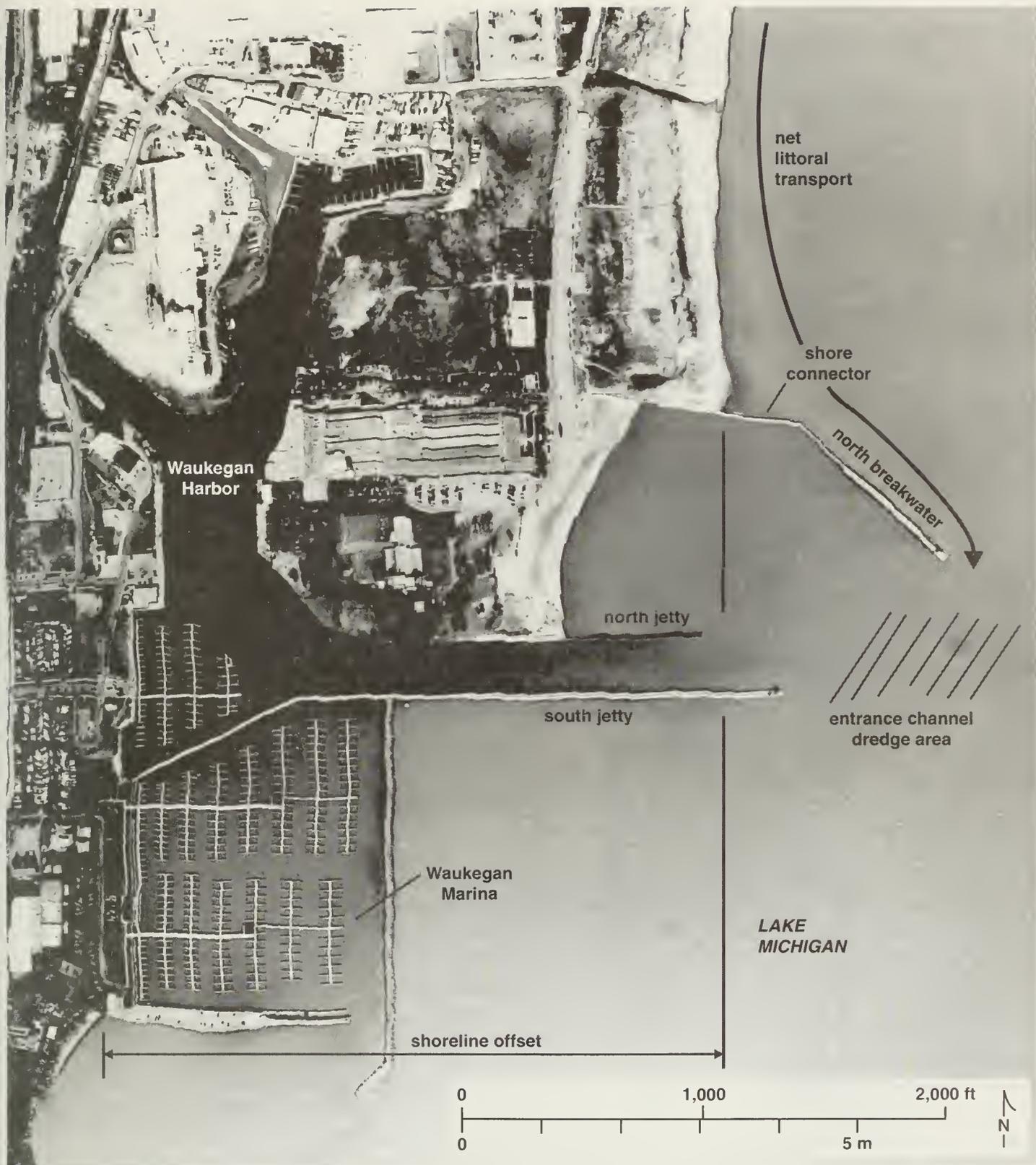


Figure 33 Aerial photo of the Waukegan Harbor complex (Illinois Department of Transportation photo, March 1997).



Figure 34 Location of the designated nearshore disposal site for sediment dredged from the Waukegan Harbor entrance channel (from Chrzastowski and Trask 1995).

Historical Shoreline Change

Since the 1880s, shoreline changes at Waukegan have been significantly influenced by the coastal engineering of Waukegan Harbor. Two privately owned piers were in place along the shore at Waukegan in the 1850s for commercial loading and unloading, but these offered no storm protection. The U.S. Army Corps of Engineers built timber cribs to form a harbor here in the 1880s (fig. 35). Despite successive extensions and modifications to the structures, this early harbor was plagued with sand accretion, and between 1885 and 1889, accretion filled most of the northern half of the harbor. The footprint of this early Waukegan Harbor lies entirely within the footprint of the present harbor (fig. 35, inset map).

The present-day Waukegan Harbor was constructed in two phases in the 20th century. During the first phase, from 1902 to 1906, the jetties were built to their present length, and the northwest–southwest segment of the north breakwater was built as an offshore (detached) breakwater (fig. 32, 1908 map). In the second phase, from 1930 to 1932, a breakwater extension was built to connect the original offshore breakwater to the shore in order to better restrict sand accretion near the entrance channel.

Figure 36 shows the record of shoreline change on the updrift (north) side of the Waukegan Harbor between 1839 and 1991. The shoreline accretion between 1839 and 1872 pre-dates any coastal structures for Waukegan Harbor. The 1906 and 1910–11 shorelines show how the accretion on the north side of the north jetty formed a shoreline segment with a north–south orientation. Further accretion against the north jetty built the shoreline closer to the jetty end and facilitated transport of sand into the entrance channel. To halt this accretion, the breakwater segment to close the gap between the offshore breakwater and the beach was built beginning in 1930. The 1937 to 1991 shorelines show the beach accretion that occurred on the north side of this breakwater extension. Since the 1930s, the shoreline between the breakwater extension and the north jetty has shifted with changes in lake level, but has not had any major accretion. The littoral sediment that arrives from the north now migrates along the north side of the north breakwater and is directed into the harbor entrance channel.

Human Impact on Coastal Change

Construction of Waukegan Harbor has had the most profound impact on the entire Zion beach-ridge plain of any manmade structure. This construction produced a shoreline change that would not have occurred naturally; it essentially halted the southward migration of the beach-ridge plain and deprived the littoral sediment supply to the downdrift area. Survey comparisons document that between 1910 and 1974 the elevation of the shallow lake bottom on the downdrift (south) side of the harbor was lowered as much as 3 to 6 feet (0.9 to 1.8 m) as the lake-bottom sand eroded in response to the loss of sand supply (Chrzastowski and Trask 1995).

What would have occurred along this coastal reach had Waukegan Harbor not been built? It is possible to project how this shore would have evolved if it were free of any coastal engineering. Components in making this projection are the pre-development (1872) shoreline along the southern part of the plain and the configuration, age, and spacing of the beach ridges. Based on these data, the estimated natural-state, average rate of southward shoreline advance along this part of the beach-ridge plain was about 33 feet (10 m) per year (Chrzastowski and Trask 1995). Using this rate, figure 37 shows a projection of selected shoreline positions in the Waukegan Harbor vicinity to the year 2200, assuming the absence of the harbor. The southward migration of the plain would continue as sand was deposited south and east of the harbor. The beach-ridge plain would eventually migrate south and east, covering all the area now occupied by the present-day harbor.

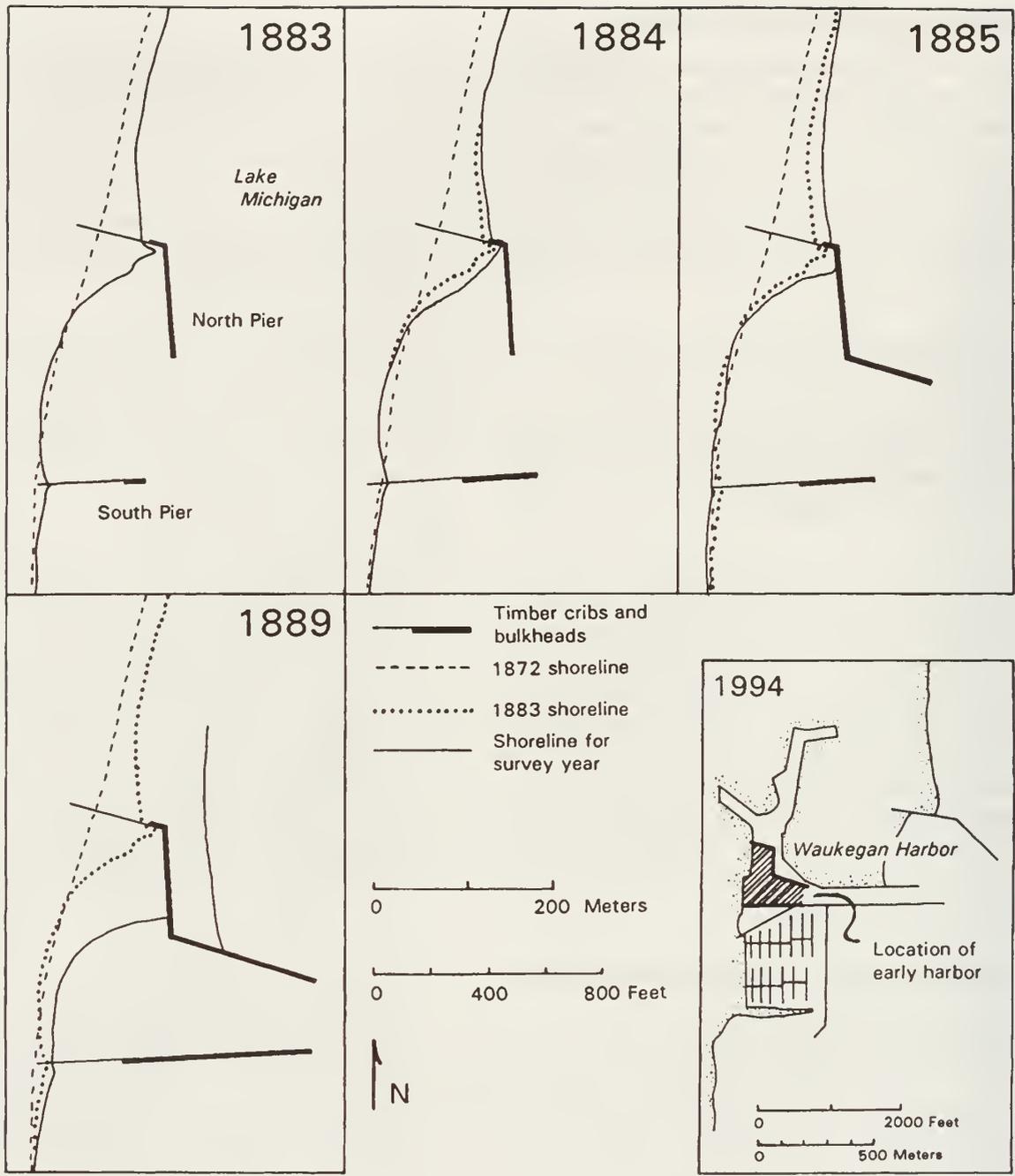


Figure 35 Successive stages in the construction of the early Waukegan Harbor (1883–1889) and associated shoreline changes (modified from U.S. Army Corps of Engineers Annual Reports 1882–1889; from Chrzastowski and Trask 1995).

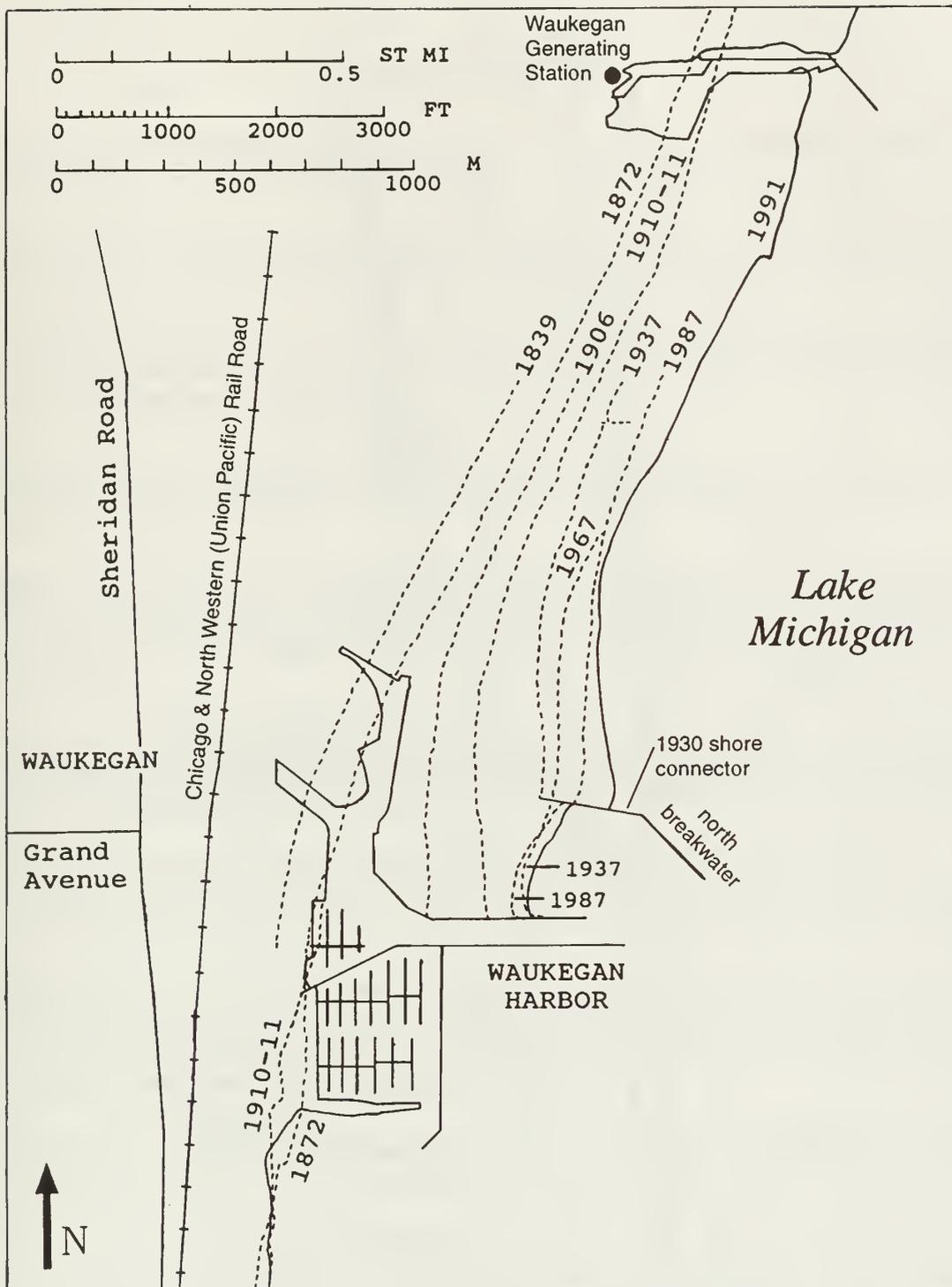


Figure 36 Historical shorelines documenting accretion on the updrift (north) side of Waukegan Harbor. Shorelines are for the lake level at the time of mapping except the 1910–11 shoreline, which is corrected to low water datum (LWD) (from Chrzastowski and Trask 1995).

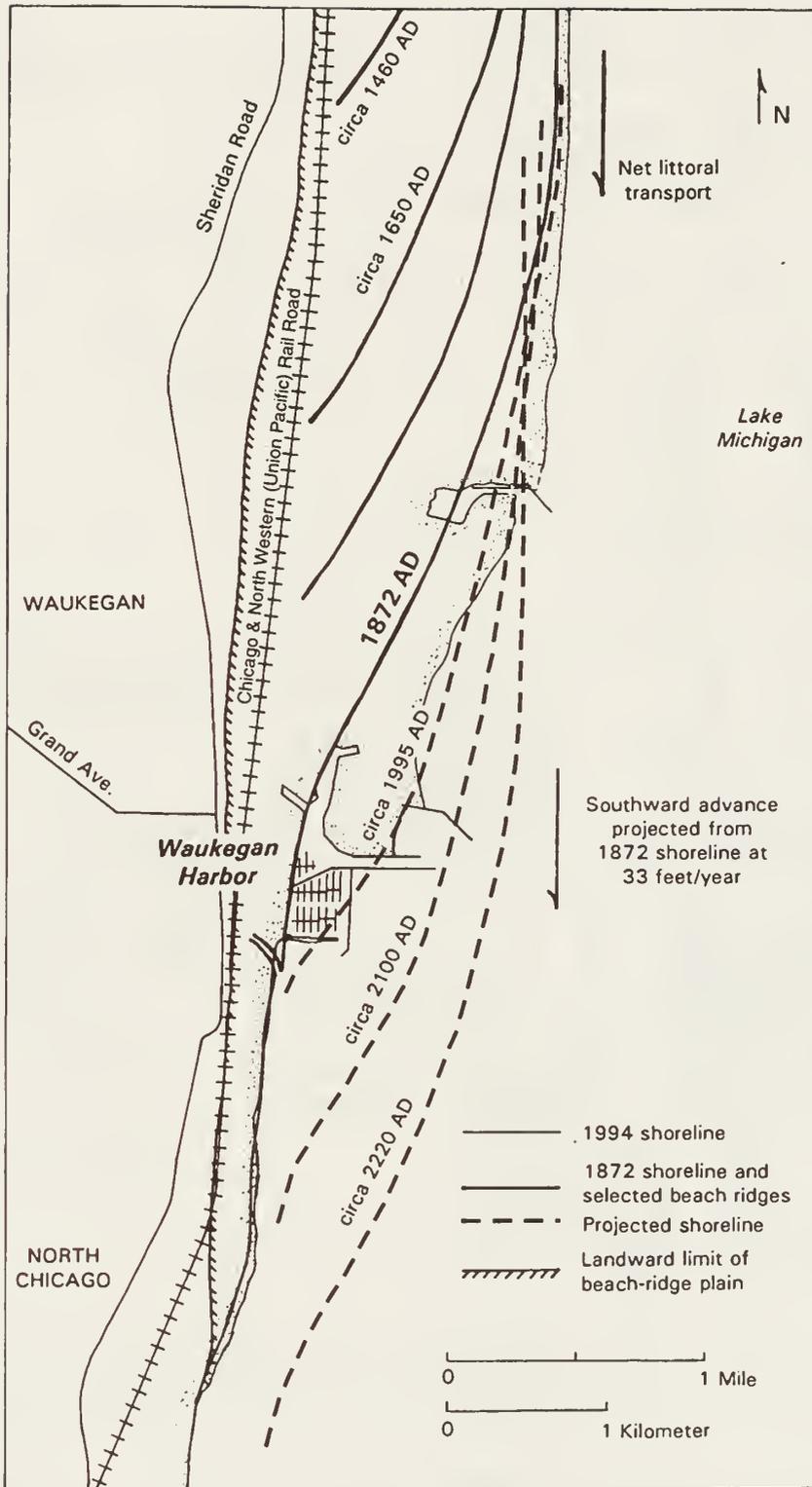


Figure 37 Projection of how the Zion beach-ridge plain would continue to advance southward along the coast were the Waukegan Harbor complex not present (from Chrzastowski and Trask 1995).

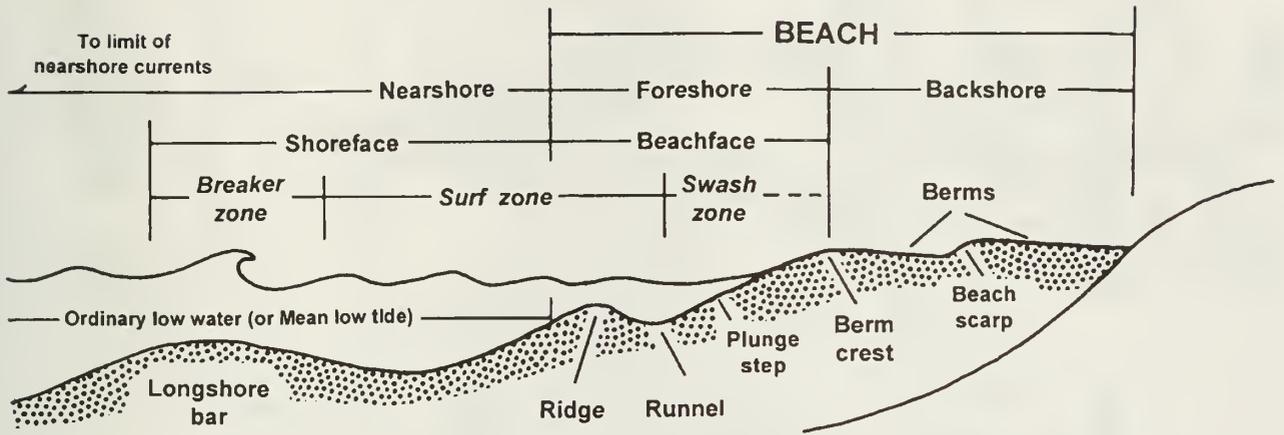
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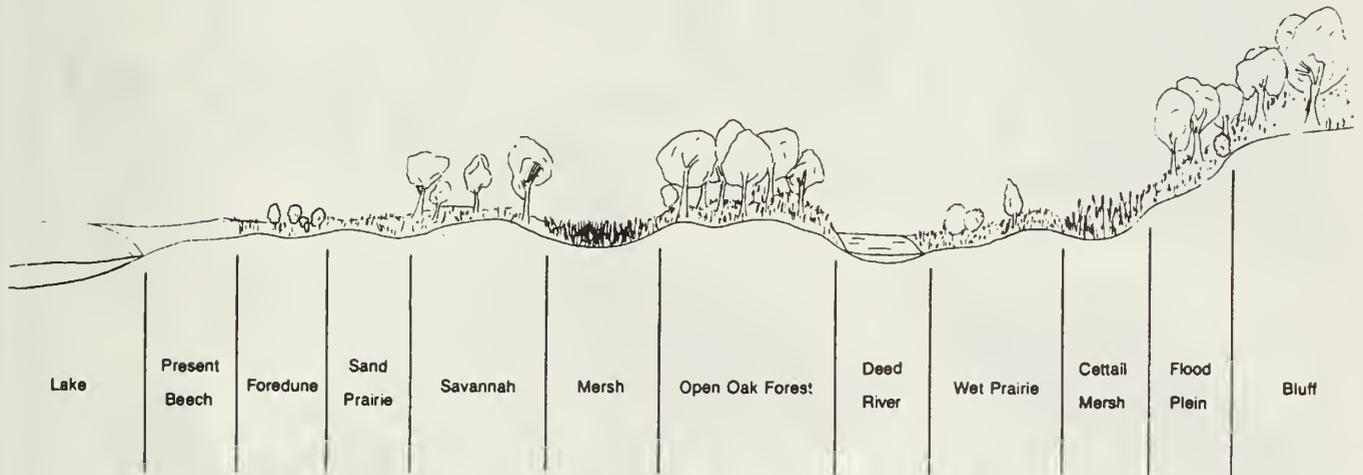
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Appendix 1: Features and Zones along the Beach and Nearshore



Common Natural Shore and Beach Features at Illinois Beach State Park



Time Line — Present — 160 B.P. — 790 B.P. — 1500 B.P. — 2500 B.P.* —

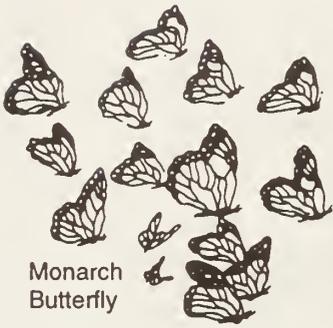
Time line shows age of the old beach ridges

* B.P. = Before Present

Plant Succession from the Beach to the Bluff on an East-West Line Running Just South of the Nature Center

Source: *Illinois Beach State Park: Illinois' Only Dunesland*, Illinois Department of Conservation poster, 1987.

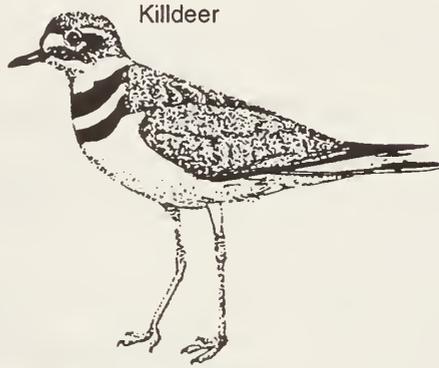
Appendix 2: Dunesland Plants and Animals Common to Illinois Beach State Park



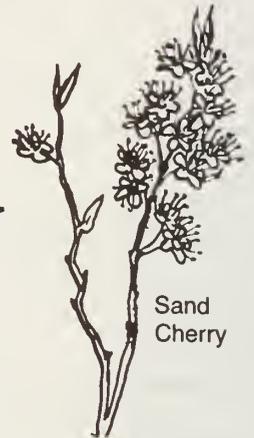
Monarch
Butterfly



Sea
Rocket



Killdeer



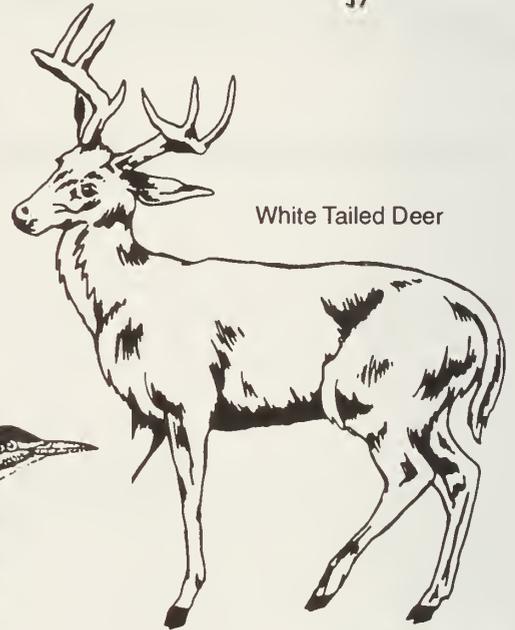
Sand
Cherry



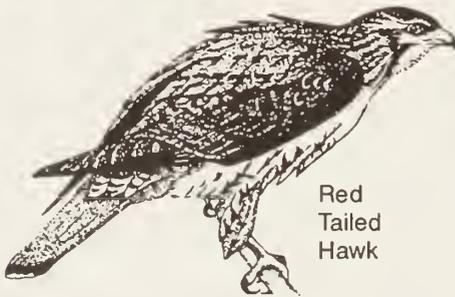
Great
Horned
Owl



Prickly
Pear Cactus



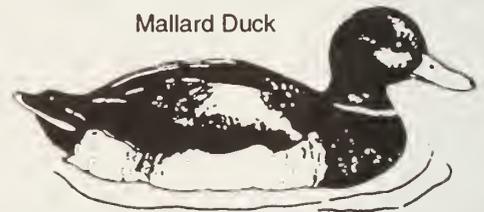
White Tailed
Deer



Red
Tailed
Hawk



Great
Blue
Heron



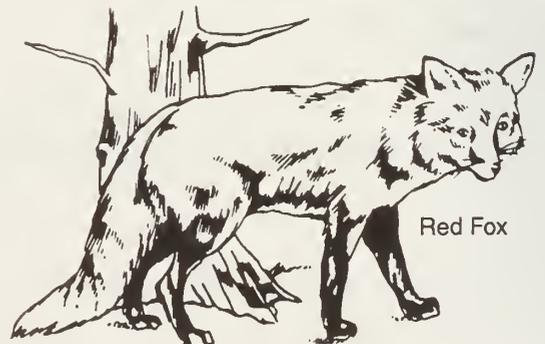
Mallard
Duck



Choke
Cherry

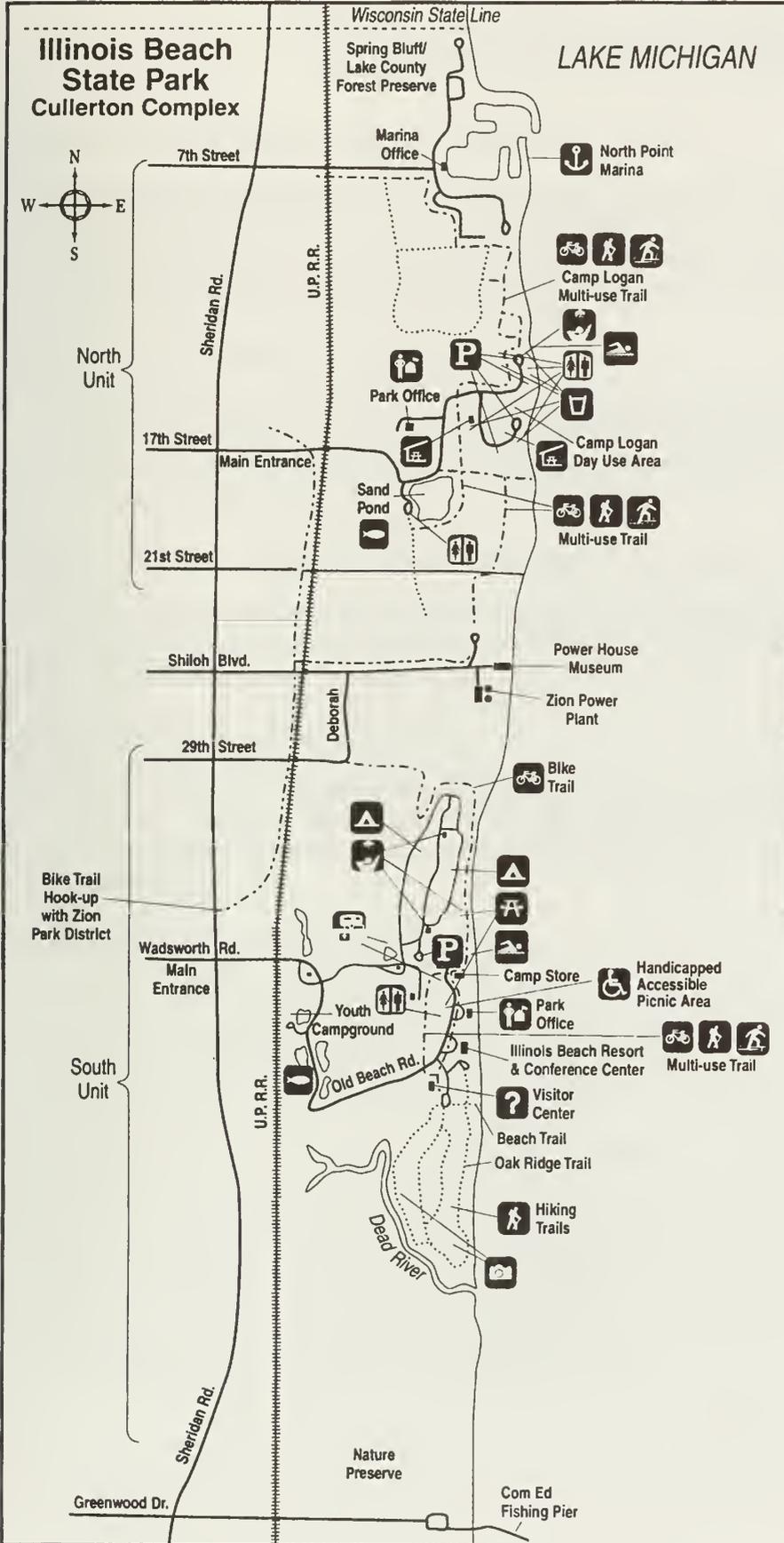


Ground
Hog



Red
Fox

Appendix 3: Map of Illinois Beach State Park



Legend

- Park Offices
- Biking
- Camping
- Cross-country Skiing
- Fishing
- Handicapped Accessible
- Hiking
- Marina
- Overlook
- Parking Area
- Picnic Area
- Picnic Shelter
- Restrooms
- Sanitary Dump Station
- Showers
- Swimming Area
- Water

TRAIL IDENTIFICATION

- Zion Bike Trail
- Multi-use Trail
- Hiking Trail

Alcoholic beverages are prohibited at Illinois Beach State Park, except at the State Park Lodge and Conference Center.

Source: Cullerton Complex, Illinois Beach State Park, Department of Natural Resources brochure, 2000.

Twenty Frequently Asked Questions (FAQs) About the Coastal Geology at Illinois Beach State Park

1. What is a beach ridge and how does it differ from a dune?

Beach ridges are formed by the run-up of waves accumulating sediment into an elongate mound, usually along the upper part of a beach, and mostly during storms. Beach ridges may contain coarse sediments that can be moved by water, such as pebbles and cobbles. Dunes are formed by wind action blowing fine sand from the dry part of the beach into the back beach area.

2. Why is it called the Zion beach-ridge plain?

Illinois Beach State Park occupies a distinct coastal landform consisting of a succession of nearly parallel beach ridges. Such coastal landforms occur worldwide where a depositional area receives abundant littoral sediment. This plain is informally named the “Zion beach-ridge plain” because it is centered at Zion, Illinois, where it also has its maximum width.

3. Why does the beach contain so much gravel, pebbles and cobbles?

The sediments that make up the beach-ridge plain were eroded from a delta formed by the sediments of a glacially fed river that flowed into ancestral Lake Michigan. Cobbles, pebbles, gravel, and sand are typical sediments of such river systems.

4. How old is the Zion beach-ridge plain?

The plain began to form just south of Kenosha, Wisconsin, about 5,500 years B.P. It advanced across the Wisconsin–Illinois state line about 3,700 years B.P. When earliest European settlement was occurring in the area, beach ridges were forming along the southern leading edge of the plain near Waukegan.

5. What is the rate of erosion at the state park?

Erosion is quite variable from location to location and from year to year. Storm frequency and intensity, lake level, and sediment supply are all variables. In general, the highest rates of erosion occur at the North Unit. Historical maps indicate that the long-term landward shift in shoreline position near the north end of the North Unit has been 10 feet per year.

6. Is there any way to permanently stop the erosion at Illinois Beach State Park?

There are engineering means to permanently stop the erosion. However, erosion defense may permanently alter the natural processes of coastal change on which the flora and fauna of the state park are dependent. The challenge is to prevent any net loss by erosion, while maintaining wave dynamics and the natural movement of sand along the shore. The Illinois Department of Natural Resources has been using beach nourishment to meet this challenge, but the annual volume of beach nourishment must be doubled to assure no net erosion.

7. *How much sediment supply would be needed yearly to assure no net erosion along the state park?*

The supply would need to be about 80,000 cubic yards per year. This volume would cover an entire football field to a height of 45 feet.

8. *What is the source for the sand and gravel used in beach nourishment at the park?*

Several sources have been used. A major source has been sand dredged from near the cooling channels at the Waukegan generating station. In recent years, sand has also been supplied from dredging at the approach to Waukegan Harbor. Some sand and gravel has been purchased from inland pits. Other sources are sand dredged from the entrance of North Point Marina and dredging from the entrance to Prairie Harbor Yacht Club located just north of the Wisconsin-Illinois state line.

9. *The stockpile of sand and gravel just south of North Point Marina is called a "feeder beach." What is a feeder beach?*

A feeder beach is an area that is allowed to erode by wave action and thus "feed" sediment into the littoral transport along the shore.

10. *Why are there so many pieces of brick, concrete, steel pipe, and other kinds of building debris along parts of the beach?*

Segments of this shore once had residential housing. Severe erosion of these lakeside properties led to some housing materials washing into the lake and becoming part of the beach and lake-bottom deposits. Remains of these structures resting on the lake bottom in the nearshore zone are being broken up by wave action and the debris is washing onto the shore.

11. *Has the construction of North Point Marina caused erosion at the state park?*

The marina is located along a part of the beach-ridge plain that has been eroding through all of historical time, so any erosion occurring there since the marina was constructed is part of this continuing process. The marina entrance does trap some sand that would otherwise move southward along the shore, but when maintenance dredging is done in the entrance, this sand is removed and placed into the nearshore on the south side of the marina thus allowing continued southward transport.

12. *When ice forms along the shore in winter, does this protect the shore from erosion?*

Yes and no. The ice that forms along the lower beach protects this area from any direct wave attack. However, the lakeward edge of the ice is a nearly vertical face that directs wave energy downward and can result in erosion of the lake floor. Sediment from this erosion can be moved by the wave turbulence, lifted upward, and deposited and frozen into the ice complex. When the ice breaks free, the sediment can be rafted away and deposited miles away in the middle of the lake when the ice-raft melts..

13. *Is there any risk of Lake Michigan water flooding across all of the state park?*

The ridges and dunes in the park have maximum elevations ranging from 10 to nearly 20 feet above mean lake level. The lake water would have to rise 10 feet or more for waves to erode the ridges and dunes and flood across the park area.

14. *If no future erosion protection was done, is the state park at risk of completely eroding away?*

If there were no coastal structures already in place along the shore, complete erosion of the present-day park area would occur as the beach-ridge plain continued its southward migration. The existing structures will resist erosion and would persist as promontories or “headlands” along the shore. Erosion would then form embayed shorelines between these hard points. The end result would be a net loss of land from all the embayed areas, and an irregular shoreline of successive bays and headlands.

15. *News reports tell of the asbestos scattered along the state park beach. Does this make the beach unsafe for visitors?*

Asbestos is a known health hazard if the asbestos fibers are in the air and can be breathed. Asbestos-containing material (ACM) that can release fibers into the air is called “friable.” The ACM found on the beach at Illinois Beach State Park is not friable. The asbestos fibers are held within a cement matrix. Some abrasion may occur as the ACM is rolled along the beach by wave action, and in some cases some fibers may become free, but air testing at the park has not detected any air-borne asbestos.

16. *What is the source for this ACM?*

Multiple sources have probably contributed ACM to the beaches. Some likely comes from the debris from the residential properties that once existed along the shore in the North Unit, and from housing between Kenosha, Wisconsin, and the state line that fell into the lake and was transported into Illinois by the littoral currents. Some of the ACM may also have been used in building the berms for a shooting range located between the Johns Manville property and the Waukegan Generating Station. After the berms were leveled, ACM could have been intercepted by wave action, redeposited near the power plant cooling channels, captured during maintenance dredging, and then dispersed along the shore as the dredged sediment was used in beach nourishment.

17. *Why are the sand dunes in the park so low in elevation compared to the dunes along the Indiana and Michigan lakeshores?*

This is the western shore of Lake Michigan, and the prevailing winds are from the west. The prevailing winds tend to blow the fine sands toward the lake rather than across the beach and into dunes.

18. *Why is it called “Dead River”?*

This name likely refers to the river’s typical condition of having its flow into Lake Michigan blocked by a sand deposit across the mouth. The river is thus “dead” in the sense that it has almost no lakeward flow.

19. *How deep does the water get offshore from the state park?*

The lake bottom has a very gradual slope away from the shore and, on average, at a distance of about ½ mile offshore the water depth ranges from 20 to 30 feet.

20. *What are the largest storm waves that can occur along the state park shore?*

During storms, waves of 9 feet or more have been documented. These higher waves generally occur in the fall, winter, and spring, and most come from the northeast.

Glossary

- Beach** – The zone of unconsolidated material along the coast that extends between the mean low-water line to the where there is a marked change in material or physiographic form. A beach includes a foreshore and a backshore.
- Beach ridge** – An elongate, generally coast-parallel mound of beach sediments accumulated by wave action and usually formed on the upper part of the beach.
- Beach-ridge plain** – An expanse of coastal land formed by deposition and migration of a succession of nearly parallel beach ridges.
- Breakwater** – A structure that protects a shore area, harbor, anchorage, or basin from waves.
- Downdrift** – Referring to the direction along the coast of predominant movement of littoral sediment. (Along the Illinois coast, downdrift is toward the south.)
- Groin** – A shore protection structure, generally built perpendicular to the shore, for the purpose of trapping or holding beach material. The structure is narrow in width and variable in length.
- Jetty** – A structure built to influence current or protect the entrance to a river or harbor. A pair of jetties commonly protects the entrance to a river or harbor.
- Littoral** – Of or pertaining to the shore.
- Littoral drift** – The material that moves along the littoral zone under the influence of waves and currents. (Note: This term is also loosely used to refer to the process of movement.)
- Littoral transport** – The movement of material along the shore under the influence of waves and currents.
- Nearshore** – An indefinite zone along the coast that generally includes the zone from the mean low-water line to the limit of nearshore currents.
- Revetment** – A facing of stone, concrete, or other materials built to protect an embankment or shore from erosion by waves or currents.
- Riprap** – A layer, facing, or protective mound of randomly placed loose stones to prevent erosion, scour, or sloughing of a structure or embankment. Also refers to the stone so used. A revetment may be constructed with riprap.
- Spit** – A tongue-like deposit of beach materials formed by littoral transport extending from an upland area into an embayment.
- Swale** – The low area between two adjacent beach ridges.
- Updrift** – Referring to the direction along the coast opposite to the predominant movement of littoral sediment. (Along the Illinois coast, updrift is toward the north.)

Quaternary Glaciations in Illinois

ORIGIN OF THE GLACIERS

Over the past 1.6 million years, known as the Quaternary (kwa-TURN-ah-ree) Period of geologic time, most of the northern hemisphere above the 50th parallel was repeatedly covered by glacial ice. The cooling of the earth's surface began at least 2 million years ago, and with that cooling, ice sheets eventually formed in sub-arctic regions and spread outward until they covered the northern parts of North America. With ongoing climatic change during this period, these ice sheets would form and reform many times.

Early studies of the glaciated landscape concluded that four separate glacial episodes had occurred in North America. The deposits from each episode were separated from each other by buried soils, which formed on the land during warmer intervals between glaciations. More recent studies have shown that there were more than four glaciations, but the actual number is not yet known. These studies, based on buried soils and glacial deposits, estimate 4 to 8 episodes of ice advance and melting over Illinois. We now know that the older glacial sediments are more complex than originally thought and probably represent more than one episode. Until we know more, all of the glacial deposits before the Illinois Episode (from 300,000 to 125,000 years ago) are classified as pre-Illinoian deposits.

The North American ice sheets developed when the mean annual temperature was perhaps 4° to 7°C (7° to 13°F) cooler than it is now and winter snows did not completely melt during the summers. Because this time of cooler conditions lasted tens of thousands of years, thick masses of snow and ice accumulated to form glaciers. As the ice thickened, the great weight of the ice and snow caused the glaciers to flow outward at their margins, in several instances for hundreds of miles. As the ice sheets expanded, the areas in which snow accumulated probably also increased in extent.

Several times, huge tongues of ice, called lobes, flowed southward from two different centers, one east and one west of present-day Hudson Bay, and converged in the central lowland between the Appalachian and Rocky Mountains. There the glaciers made their farthest advances to the south. The sketch at right shows the centers of flow, the general directions of flow from the centers, and the southern extent of glaciation. Because Illinois lies entirely in the central lowland, it was invaded by lobes from both accumulation centers.



EFFECTS OF GLACIATION

Quaternary glaciers and the waters melting from them changed the landscapes they covered. The glaciers scraped and smeared the landforms they overrode, leveling and filling many of the minor valleys and even some of the larger ones. Moving ice carried colossal amounts of rock and earth, commonly for hundreds of miles; the glaciers scoured the land surface and kneaded much of the rock debris into the moving ice.

The continual floods of glacial meltwaters entrenched new drainageways and deepened old ones, and partly refilled them with the great quantities of rock and earth carried by the glaciers. According to some estimates, the amount of water that was drawn from the sea and changed into ice during a glacial episode lowered the sea level by 300 to 400 feet below its present level. When these continental ice sheets melted, tremendous volumes of water eroded and transported sediments.

In most of Illinois, glacial and meltwater deposits buried the previous rocky, low, hill-and-valley terrain and created the flatter landforms that became our prairies. The glaciers deposited across roughly 90% of the state a mantle of ground-up rock debris, gravel, sand, and clay that at points reaches thicknesses of 400 to 500 feet. These deposits are of incalculable value to Illinois residents because they are the parent material of our rich soils, the source of drinking water for much of the state, and provide large amounts of sand and gravel for construction.

GLACIAL DEPOSITS

Drift is the term for all the deposits of earth and rock materials moved by glacial activity. **Till** is the type of drift deposited directly by glacial ice. Because till was not moved much by water, this sediment is unsorted, containing particles of many different sizes and compositions. It is also unstratified (unlayered). A till may contain materials ranging in size from microscopic clay particles to large boulders. Most tills in Illinois are pebbly clays with only a few boulders. For descriptive purposes, a mixture of clay, silt, sand, and boulders is called **diamicton**. This term describes a deposit that could be interpreted as till or as a product of a different process called mass wasting, which includes such things as rockslides or other similar gravity-propelled earth movements.

End moraines are the arc-shaped ridges that formed when till piled up along a glacier's leading edge when the ice was melting at roughly the same rate as the flowing ice moved forward. Till also formed **ground moraines**, or **till plains**, which have gently undulating surfaces formed as the ice front melted back. Deposits of till identify areas once covered by glaciers. The many alternating ridges and plains in northeastern Illinois are the successive end moraines and till plains formed by the retreating Wisconsin Episode glaciers (about 25,000 to 13,500 years ago).

Outwash is the sorted and stratified sediments deposited by meltwater flowing away from the glacier. Outwash deposits are layered in beds because the flow of water that moved the material varied in gradient, volume, velocity, and direction. As a meltwater stream carried the rock materials along, it sorted them by size. As stream velocity decreased, heavier gravels and cobbles were deposited before fine sands, silts, and clays, which were deposited farther downstream. Typical Quaternary outwash in Illinois consists of multilayered beds of sands and gravels and some silts. These beds look much like modern stream deposits in some places. Outwash tends to be coarser and less weathered than stream sediment (alluvium), which is generally finer than medium sand and contains variable amounts of weathered rock debris.

Meltwater deposits are found not only in the area once covered by the glaciers but also in areas far beyond it. Meltwater streams ran off the top of the glacier, in crevices within the ice, and under the ice. In some places, the cobble-gravel-sand filling of the bed of a stream that flowed within or under the ice is preserved as a sinuous ridge called an **esker**. Some eskers in Illinois are made up of sandy, silty, gravelly deposits and contain mass-wasted diamicton material. Cone-shaped mounds of coarse outwash, called **kames**, were formed where meltwater plunged through crevasses in the ice.

The finest outwash sediments, the silts and clays, formed bedded deposits in the ponds and lakes that filled glacier-dammed stream valleys, the low-lying areas on till plains, and some low till plains where meltwaters were diked behind end moraines. Meltwater streams that entered a lake rapidly lost velocity and dropped the sands and gravels they carried, forming deltas at the edge of the lake. Very fine sands and silts were commonly redistributed on the lake bottom by wind-generated currents, and the clays, which stayed in suspension longest, slowly settled out and accumulated with them.

Along the ice front, meltwater ran off in innumerable shifting, cross-cutting, and short-lived streams (called braided streams), which laid down an **outwash plain**, a broad, flat blanket of outwash. Outwash was also carried away from the glaciers in valleys cut by floods of meltwater. The Mississippi, Illinois, and Ohio Rivers occupy valleys that were major channels for meltwaters and that were greatly widened and deepened during the greatest meltwater floods. When the floods waned, these valleys were partly filled with outwash far beyond the ice margins. Such outwash deposits, largely sand and gravel, are known as **valley trains**. Valley train deposits may be both extensive and thick. For instance, the long valley train of the Mississippi River Valley is up to 200 feet thick in places.

LOESS, EOLIAN SAND, AND SOILS

One of the most widespread types of sediment resulting from glaciation was carried not by ice or water, but by wind. **Loess** (rhymes with “bus”) is the name given to windblown deposits dominated by silt-sized particles. Most of the silt was derived from wind erosion of the valley trains. Wind action also sorted out sand, which commonly formed **sand dunes** on the valley trains or on the adjacent uplands. In places, sand dunes have migrated up to 10 miles away from the principal source of sand. Flat areas between dunes are generally underlain by **eolian** (windblown) **sand** that was usually reworked by water action. On uplands along the major valley trains, loess and eolian sand are commonly interbedded. With increasing distance from the valleys, the eolian sand thins and disappears, often within one mile from the valleys.

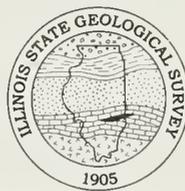
Eolian deposition occurred when certain climatic conditions, most likely following a seasonal pattern, were met. Deposition was probably in the fall, winter, or spring when low precipitation volumes and low temperatures caused meltwater floods to abate, exposing the surfaces of the valley trains and permitting them to dry out. Throughout the Quaternary Period, prevailing westerly winds deposited loess more thickly on the east sides of the source valleys. Although the loess thins rapidly away from the valleys, it extends over almost all of Illinois.

Each glacial episode was followed by an interglacial episode that began when the climate warmed enough to melt the glaciers and their snowfields. During these warmer intervals, when the climate was similar to that of today, drift and loess surfaces were exposed to weather and the activities of living things. Consequently, over most of the glaciated terrain, soils developed on the glacial deposits and altered the composition, color, and texture of the deposits. Such soils were generally destroyed by later glacial advances, but some were buried. Those that survive serve as “key beds,” or stratigraphic markers, and are evidence of the passage of a long interval of time.

*Contributed by Dwain J. Berggren
Revised January 2000 by Myrna M. Killey*

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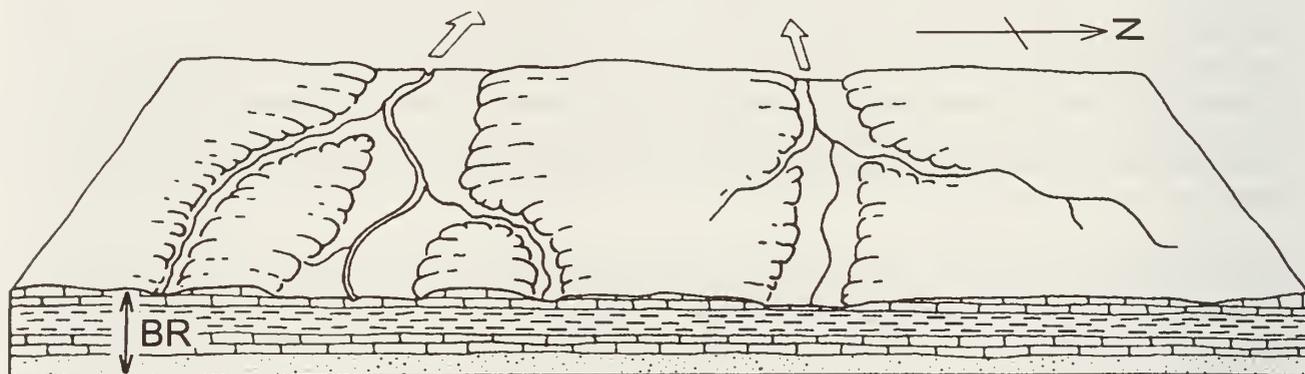
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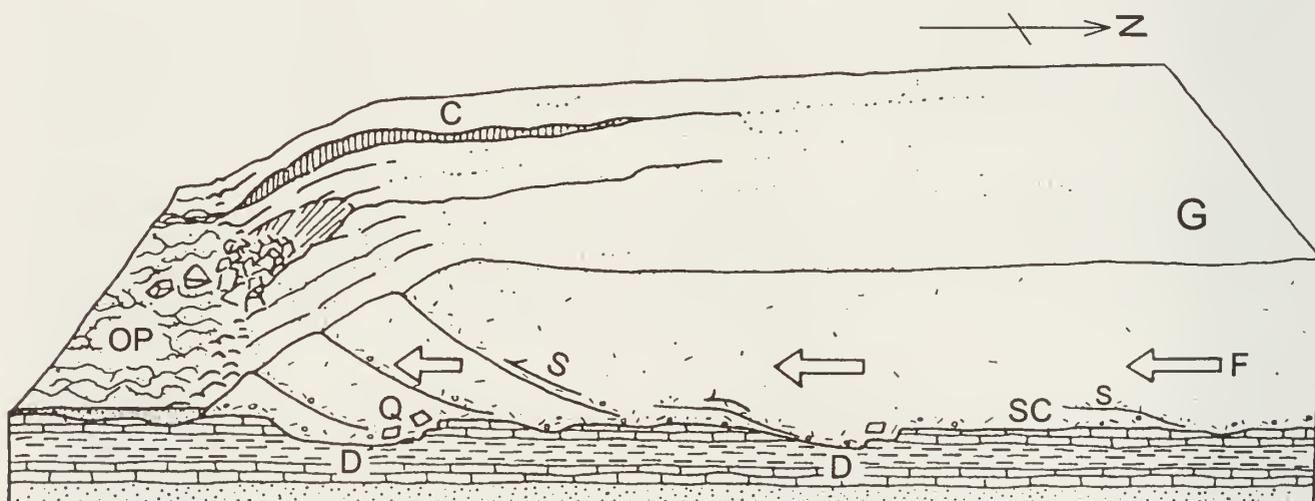
GLACIATION IN A SMALL ILLINOIS REGION

These diagrams show how a continental ice sheet might have looked at various stages as it moved across a small region in Illinois. The diagrams illustrate how the ice sheet could change the old terrain and create a landscape like the one we live on. To visualize how these glaciers looked, geologists study the landforms and materials left in the glaciated regions, as well as present-day mountain glaciers and polar ice caps.

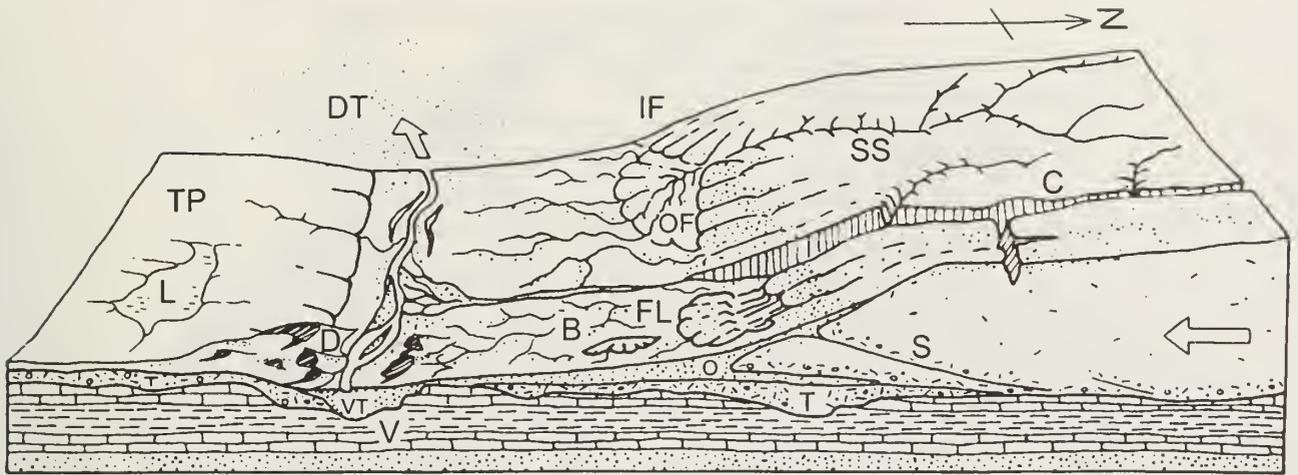
The block of land in the diagrams is several miles wide and about 10 miles long. The vertical scale is exaggerated; layers of material and landforms are drawn proportionally thicker and higher than they actually are so that they can be easily seen.



1 The Region before Glaciation — Like most of Illinois, the region illustrated is underlain by almost flat-lying beds of sedimentary rocks—layers of sandstone (), limestone (), and shale (). Millions of years of erosion have planed down the bedrock (BR), creating a terrain of low uplands and shallow valleys. A residual soil weathered from local rock debris covers the area but is too thin to be shown in the drawing. The streams illustrated here flow westward and the one on the right flows into the other at a point beyond the diagram.



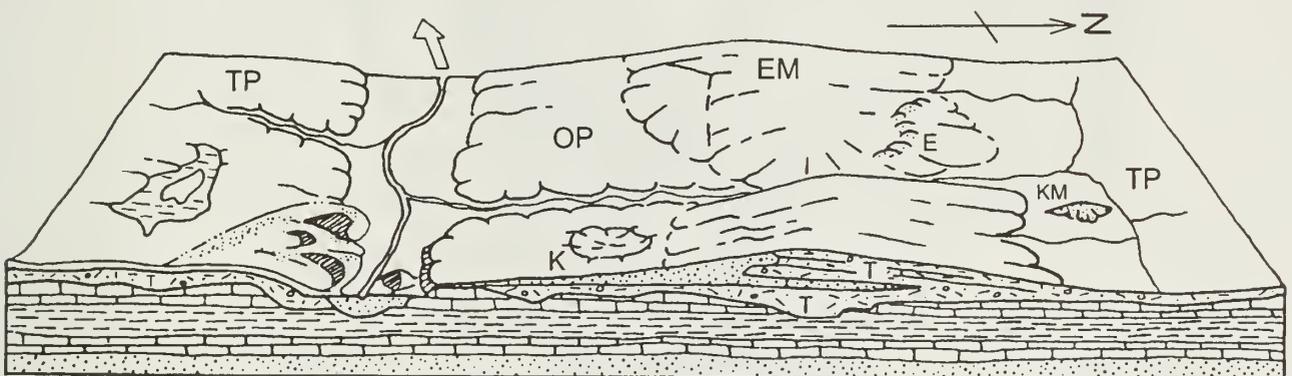
2 The Glacier Advances Southward — As the glacier (G) spreads out from its ice snowfield accumulation center, it scours (SC) the soil and rock surface and quarries (Q)—pushes and plucks up—chunks of bedrock. The materials are mixed into the ice and make up the glacier's "load." Where roughness in the terrain slows or stops flow (F), the ice "current" slides up over the blocked ice on innumerable shear planes (S). Shearing thoroughly mixes the load. As the glacier spreads, long cracks called "crevasses" (C) open parallel to the direction of ice flow. The glacier melts as it flows forward, and its meltwater erodes the terrain in front of the ice, deepening (D) some old valleys before ice covers them. Meltwater washes away some of the load freed by melting and deposits it on the outwash plane (OP). The advancing glacier overrides its outwash and in places scours much of it up again. The glacier may be 5,000 or so feet thick in Canada and tapers to the margin, which was probably in the range of several hundred feet above the old terrain. The ice front advances perhaps as much as a third of a mile per year.



3 The Glacier Forms an End Moraine — A warming climate halts the glacier advance across the area, and the ice begins to melt as fast as it advances. The ice front (IF) is now stationary, or fluctuating in a narrow area, and the glacier is forming an end moraine.

As the top of the glacier melts, some of the sediment that is mixed in the ice accumulates on top of the glacier. Some is carried by meltwater onto the sloping ice front (IF) and out onto the plain beyond. Some of the debris slips down the ice front in a mudflow (FL). Meltwater runs through the ice in a crevasse (C). A supraglacial stream (SS) drains the top of the ice, forming an outwash fan (OF). Moving ice has overridden an immobile part of the front on a shear plane (S). All but the top of a block of ice (B) is buried by outwash (O).

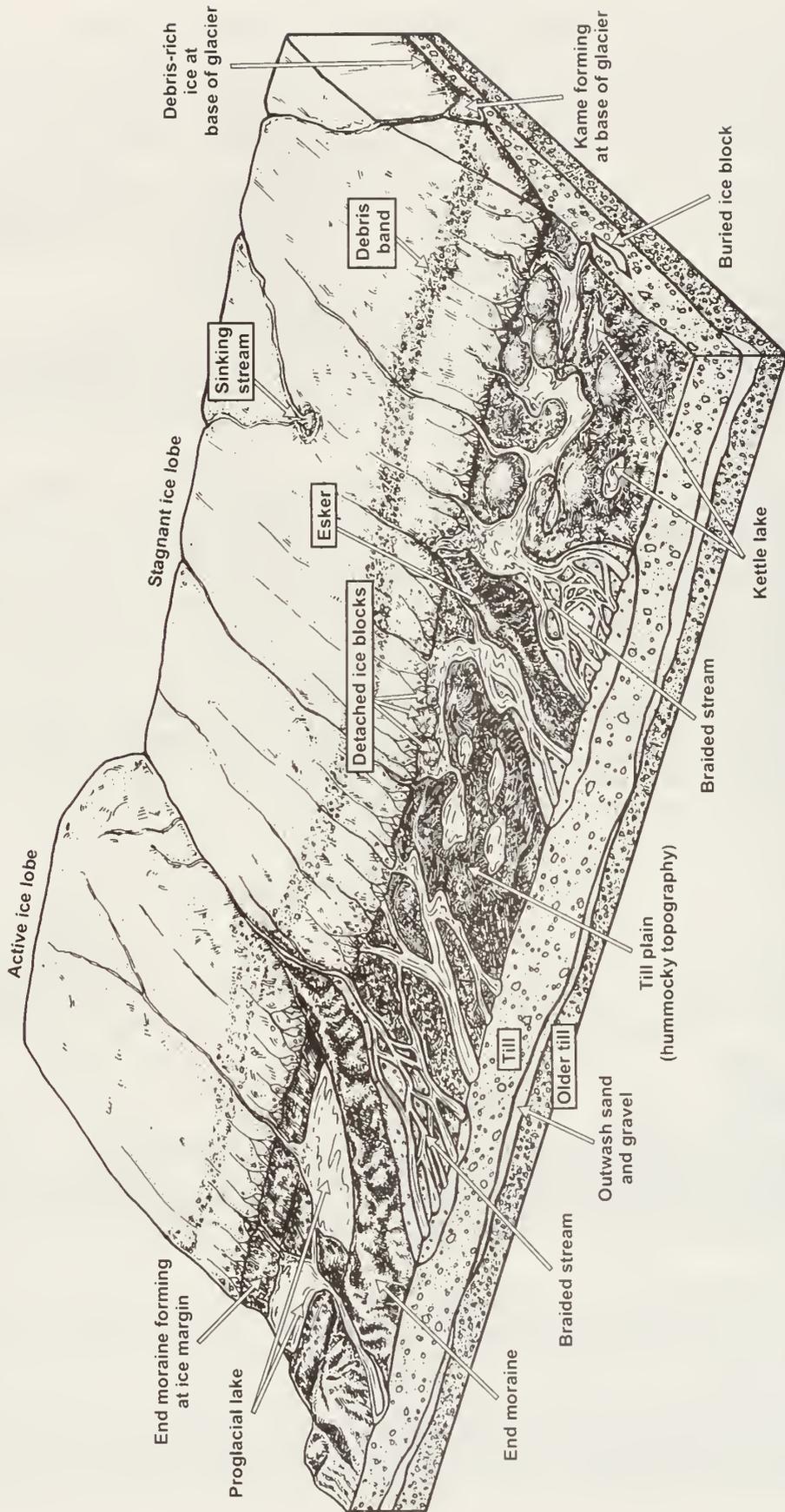
Sediment from the melted ice of the previous advance (figure 2) remains as a fill layer (T), part of which forms the till plain (TP). A shallow, marshy lake (L) fills a low place in the plain. Although largely filled with drift, the valley (V) remains a low spot in the terrain. As soon as the ice cover melts, meltwater drains down the valley, cutting it deeper. Later, outwash partly refills the valley: the outwash deposit is called a valley train (VT). Wind blows dust (DT) off the dry floodplain. The dust will form a loess deposit when it settles. Sand dunes (D) form on the south and east sides of streams.



4 The Region after Glaciation — As the climate warms further, the whole ice sheet melts, and glaciation ends. The end moraine (EM) is a low, broad ridge between the outwash plain (OP) and till plains (TP). Run-off from rains cuts stream valleys into its slopes. A stream flows through the end moraine along the channel cut by the meltwater that ran out of the crevasse in the glacier.

Slopewash and vegetation are filling the shallow lake. The collapse of outwash into the cavity left when the ice block melted has formed a kettle (K). The outwash that filled a tunnel draining under the glacier is preserved in an esker (E). The hill of outwash left where meltwater dumped sand and gravel into a crevasse or other depression in the glacier or at its edge is a kame (KM). A few feet of loess covers the entire area but cannot be shown at this scale.

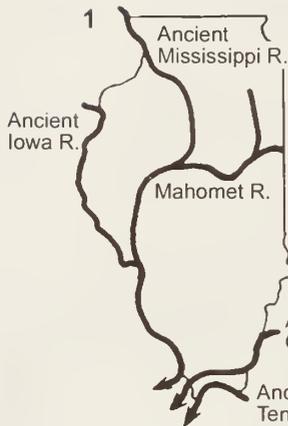
Continental Glacier



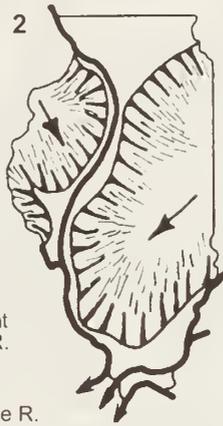
TIMETABLE OF EVENTS IN THE ICE AGE IN ILLINOIS

Years before present	Time-distance diagram Interglacial and glacial episodes	Sediment record	Dominant climate conditions Dominant land forming and soil forming events
HOLO-CENE	interglacial episode	River, lake, wind, and slope deposits.	Warm; stable landscape conditions. Formation of modern soil; running water, lake, wind, and slope processes.
10,000	<p>WISCONSIN (late) glacial episode</p> <p>glacial ice</p>	Till and ice-marginal deposits; outwash and glacial lake deposits; loess.	Cold; unstable landscape conditions. Glacial deposition, erosion, and landforming processes (e.g., formation of end moraines, outwash plains, valley trains, proglacial lakes, kettles), plus running water, lake, wind, and slope processes.
25,000		WISCONSIN (early and middle) glacial margin north of Illinois	Loess; river, lake, and slope deposits.
75,000	SANGAMON interglacial episode	River, lake, wind, and slope deposits.	Warm; stable. Weathering, soil formation (Sangamon Soil); running water, lake, wind, and slope processes.
125,000	<p>ILLINOIS glacial episode</p>	Till and ice-marginal deposits; outwash and glacial lake deposits; loess.	Cold; unstable. Glacial deposition, erosion, and landforming processes, plus proglacial running water, lake, wind, and slope processes; possible minor soil formation.
300,000		YARMOUTH interglacial episode	River, lake, wind, and slope deposits.
425,000	<p>PRE-ILLINOIS glacial and</p> <p>interglacial episodes</p>	Till and ice-marginal deposits; outwash and glacial lake deposits; loess plus nonglacial river, lake, wind, and slope deposits.	Alternating stable and unstable intervals of uncertain duration. Glacial deposition, erosion, and landforming processes, plus proglacial and interglacial running water, lake, wind, and slope processes; interglacial weathering and soil formation.
1,600,000 and older			

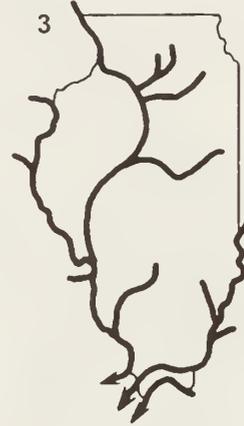
SEQUENCE OF GLACIATIONS AND INTERGLACIAL DRAINAGE IN ILLINOIS



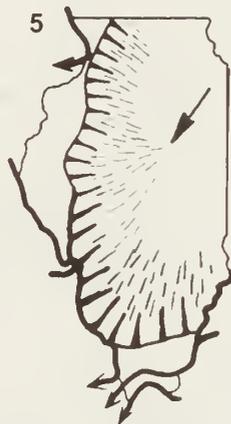
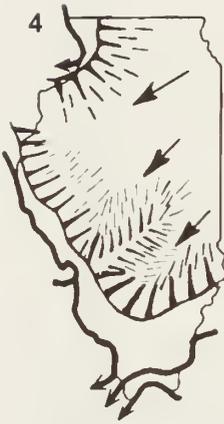
1
PRE-PLEISTOCENE
major drainage



2
PRE-ILLINOIS
inferred glacial limits



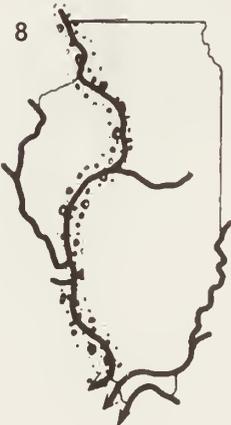
3
YARMOUTH
major drainage



4 5 6
ILLINOIS
extent of three glacial advances



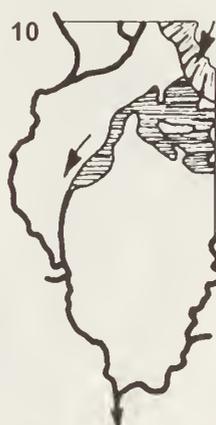
7
SANGAMON
major drainage



8
WISCONSIN
(early and middle)
glacial margin
north of Illinois



9
maximum
glacial advance



10
WISCONSIN (late)
ice and
Kankakee Flood



11
drainage
glacial lakes

Quaternary Deposits of Illinois

Hudson and Wisconsin Episodes

Mason Group and Cahokia Fm

-  Cahokia and Henry Fms; sorted sediment including waterlain river sediment and windblown and beach sand
-  Equality Fm; fine grained sediment deposited in lakes

Wedron Group (Tiskilwa, Lemont, and Wadsworth Fms) and Trafalgar Fm; diamicton deposited as till and ice-marginal sediment

-  End moraine
-  Ground moraine

Illinois Episode

-  Winnebago Fm; diamicton deposited as till and ice-marginal sediment
-  Glasford Fm; diamicton deposited as till and ice-marginal sediment
-  Teneriffe Silt and Pearl Fm, including Hagerstown Mbr; sorted sediments including river and lake deposits and wind blown sand

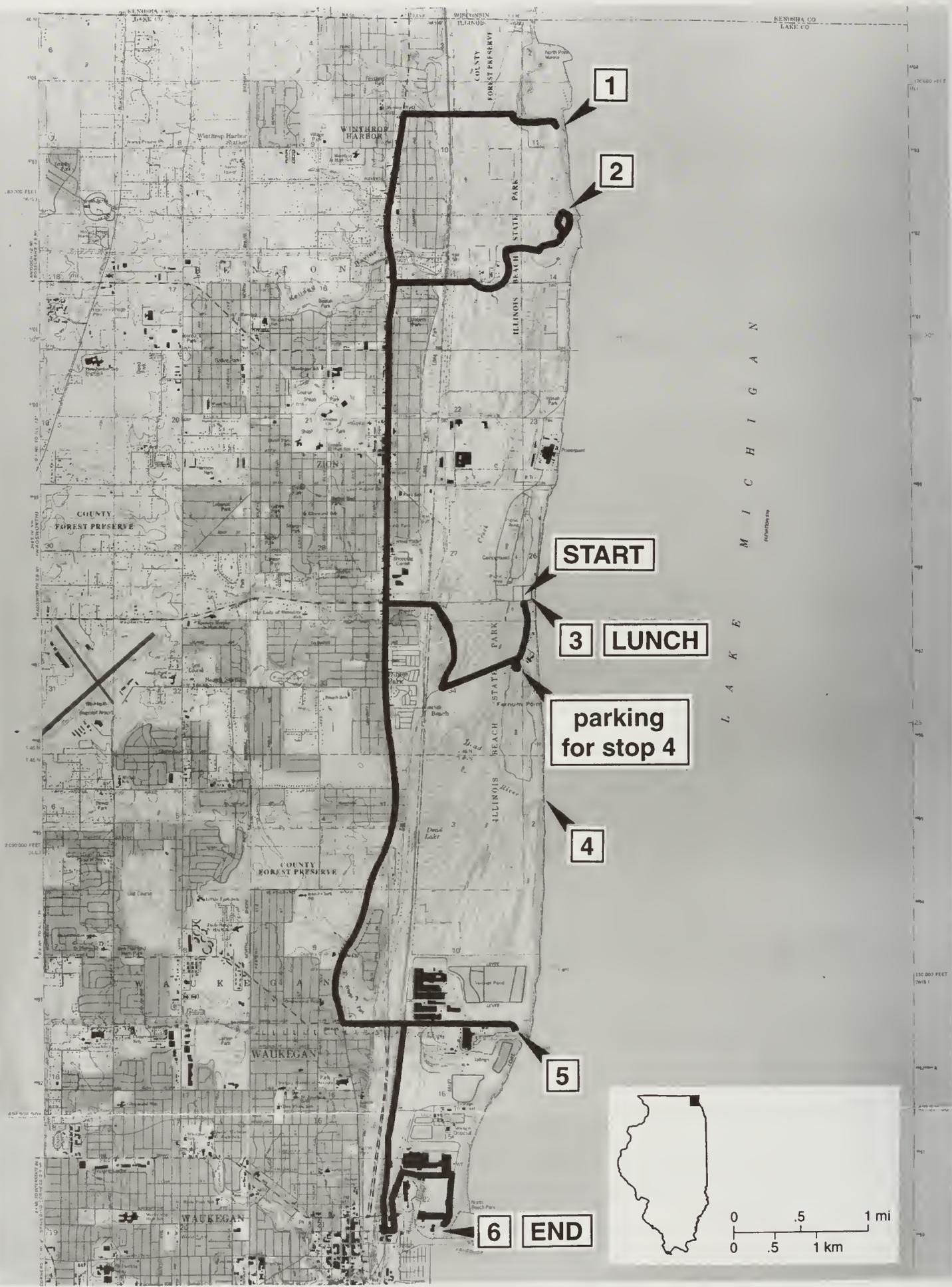
Pre-Illinois Episodes

-  Wolf Creek Fm; predominantly diamicton deposited as till and ice-marginal sediment

Paleozoic, Mesozoic, and Cenozoic

-  Mostly Paleozoic shale, limestone, dolomite, or sandstone; exposed or covered by loess and/or residuum





1

2

START

3 LUNCH

parking for stop 4

4

5

6 END

L A K E M I C H I G A N

