The Chicago River—A Legacy of Glacial and Coastal Processes

Guidebook for the 2009 Meeting of the North-Central Section of the Geological Society of America

Rockford, Illinois
April 2–4, 2009

Michael J. Chrzastowski

Guidebook 37   2009

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Cover photograph: The Chicago architectural tour boat *M/V Chicago's First Lady* heading eastbound in the Main Stem Chicago River just after passing beneath the LaSalle Street Bridge. Photograph by M. Chrzastowski, Illinois State Geological Survey, June 2008.

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Introduction

The landscape of Chicagoland is the product of glacial and coastal processes. Glacial ice built the system of moraines that form the uplands to the north, west, and south of Chicago and also shaped the low-slope plain on which most of Chicago is built. Coastal processes of wave-induced erosion and sediment transport and deposition created beaches and spits that added relief to the low-slope plain.

Despite urbanization over the last 150 years, many geomorphic features remain that are a legacy of these glacial and coastal processes. One of the most important features of this region is the Chicago River. The river is the reason for the initial settlement at Chicago and the economic impetus for the city's historic growth during the mid to late 1800s.

Much has been written about the commercial and transportation history of the Chicago River (e.g., Solzman 1998, Hill 2000) and the geology of the Chicago area in general (e.g., Leverett 1897; Alden 1902; Wright 1918; Bretz 1939, 1955; Willman 1971). However, the river's geologic history has received minimal attention, despite the fact that it is an integral part of the transformation of the Chicagoland landscape over the past 14,000 years.

This field trip guidebook provides a graphic-based presentation of the geomorphology and geomorphic evolution of select locations near and within Chicago that relate to the geologic history of the Chicago River (Figure 1). This guidebook is divided into three parts: (1) an overview of the geologic framework that is important to understanding the river evolution; (2) an overview of the geologic history of the river; and (3) geologic descriptions for five select stops that relate to the Chicago River's geologic history.

This guidebook is designed for use during a motor coach tour. The emphasis on graphics reduces what needs to be read during the tour, yet allows participants to refer to the maps, photos, and illustrations that are such an important component in telling the story of Chicago.

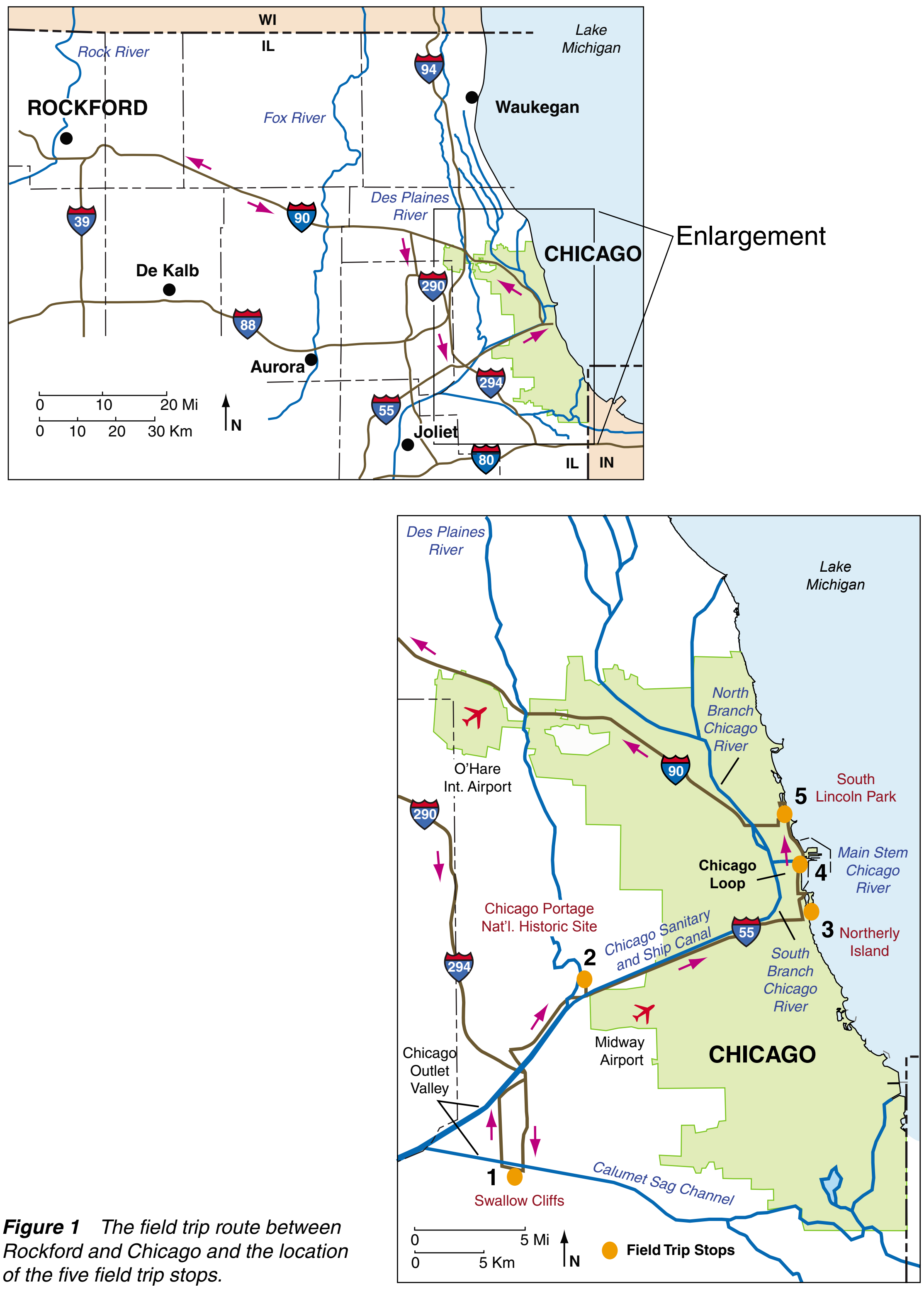


Figure 1 *The field trip route between Rockford and Chicago and the location of the five field trip stops.*

Geologic Framework

Bedrock Topography

The regional bedrock of the Chicago area is Silurian age dolomite of the Racine Formation (Willman 1971). Bedrock outcrops are randomly distributed in the Chicago area, primarily in the southern half of the city and west and south of the city. Across Chicago and the close-in suburbs, the maximum depth to bedrock is about 100 feet (Piskin and Bergstrom 1975).

The bedrock surface documents the erosion of a well-defined drainage system that is both similar and different from present-day drainage (Figure 2). The similarity is the major watershed divide that occurred across this region to the west of Cook County. This watershed boundary, an ancient sub-continental drainage divide, separated westward drainage to the ancestral Illinois and Mississippi River systems and eastward drainage toward what is now the Lake Michigan basin. The drainage of today is different in that most surficial drainage in Lake and Cook Counties is now oriented north-south rather than east-west because of the topography resulting from glacial and coastal deposition.

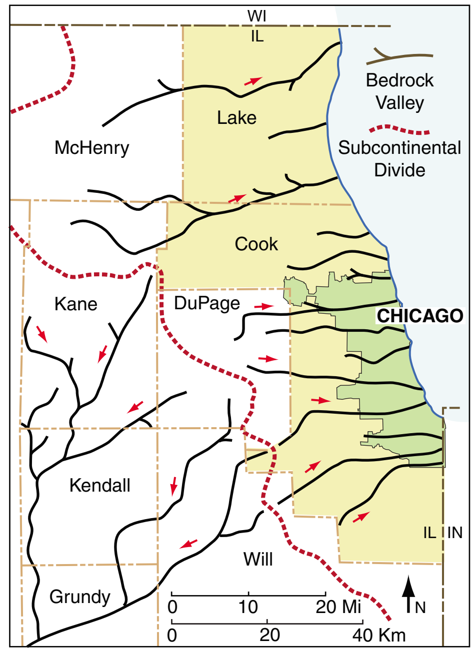


Figure 2 *Bedrock valleys indicate that Lake and Cook Counties had pre-glacial eastward drainage (after Suter et al. 1959).*

Modern Topography

Chicago and the surrounding region consist of three distinct landscapes (Figure 3). First, to the north, west, and south of Chicago are rolling hills and ridges that are multiple Wisconsin Episode end moraines. These uplands are as much as 100 to 300 feet above the level of Lake Michigan. Second is the Chicago Lake Plain, which contains most of the city of Chicago. The lake plain is an eastward-sloping surface as much as 60 feet above the level of Lake Michigan. This glacially formed surface was inundated to varying degrees during high lake levels during late glacial and post-glacial time. This plain is an emergent part of the glacially shaped surface forming the floor of southern Lake Michigan. The third landscape is a prominent Y-shaped erosional valley cut through the morainal uplands to the west of Chicago. This feature, called the Chicago Outlet Valley or simply the Chicago Outlet, provided an intermittent outlet for glacial Lake Chicago, which occupied the southern Lake Michigan basin in late-glacial time. This valley was also an outlet for ancestral Lake Michigan as recently as about 5,500 to 2,500 years B.P. The north and west valley arms are the route of the Des Plaines River and Chicago Sanitary and Ship Canal westward across the morainal uplands. The south arm provides the route for the Calumet Sag Channel.

Figure 3 *This digital elevation model shows the contrast of the Chicagoland morainal uplands, the Chicago Lake Plain, and the Chicago Outlet Valley. Vertical exaggeration, 10×. (Modified from Chrzastowski 2005b.)*

Geologic Framework

Surficial Sediments

Till is the dominant surficial sediment of the Chicago region (Figure 4). Where outwash, coastal sand, peat, or other deposits occur, these are nearly always superimposed on till. The distribution of surficial sediments reflects the regional topography. Till occurs across the morainal uplands, whereas lake, lagoonal, and coastal deposits occur across the Chicago Lake Plain.

The coastal deposits consist of sand deposited in beaches along the upland lake margin or in spits that extend from the upland onto the lake plain. Submergence of the lake plain during times of high lake level combined with wave action and an abundant supply of littoral sand from the north set the stage for the spit development. The relict spits are prominent topographic features rising up to 15 feet above the neighboring lake plain.

Lake Level History

Over the past 14,000 years, the southern Lake Michigan basin has seen wide fluctuations in lake level—as much as 60 feet higher and 260 feet lower than the historical mean (Figure 5). The high levels between 14,000 and 11,200 years B.P. (Glenwood I, II and Calumet phases) are attributed to times when glacial ice was present in the Lake Michigan basin and water levels rose sufficiently for glacial Lake Chicago to discharge through the Chicago Outlet. Intervening low levels of uncertain maximum decline occurred when ice recession opened alternate outlets in the northern part of the basin. A prolonged low lake level occurred from 10,000 to 5,800 years B.P. (Chippewa phase) that corresponded to ice recession opening an isostatically depressed outlet in southern Ontario, Canada (North Bay Outlet). During the Chippewa phase, a rapid decline in lake level caused by the sudden opening of the outlet was followed by a long-term gradual rise that occurred with the isostatic uplift of the outlet.

Post-glacial adjustments in the Upper Great Lakes hydrology resulted in a high lake level from about 5,800 to about 3,800 years B.P. (Nipissing I and II). Outflow through the Chicago Outlet was temporarily reactivated. Lake level was still above the historical mean during the Algoma phase (~3,800 to 2,500 years B.P.) but was gradually declining. By about 2,500 years B.P., lake level began to approximate the historical mean, and modern lake hydrology was established with outflow through Lake Huron. This timing provides a distinction between ancestral and modern Lake Michigan. The Chicago Outlet Valley floor and the historical mean lake elevation are nearly equal at 580 feet MSL. Thus, short-lived high lake levels during the past 2,500 years potentially resulted in limited lake water flow into the channels leading to the valley.

The high lake levels resulted in submergence to varying degrees across the Chicago Lake Plain. The precise lake level heights during these high phases are debated (Chrzastowski and Thompson 1992, 1994), but what is certain is that a series of successively lower high lake levels occurred. The classical lake level history for southern Lake Michigan has three successive levels at 20-foot declines (Leverett 1897; Alden 1902; Bretz 1939, 1955). Relative to the historical mean (580 feet MSL), the maximum level of these high lake phases are Glenwood (+60 feet), Calumet (+40 feet), and Nipissing (+20 feet) (Willman 1971). Actual levels may have been about 5 feet lower.

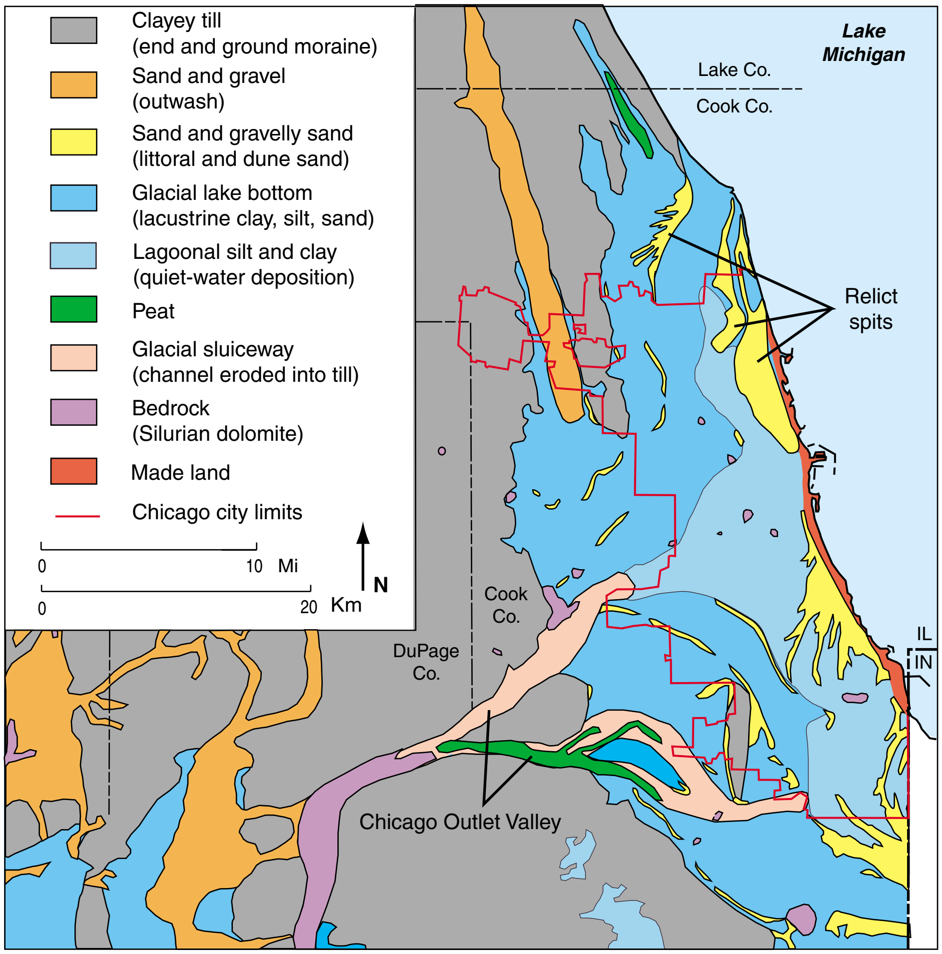


Figure 4 *Surficial geology of the Chicago area (modified from Willman and Lineback 1970).*

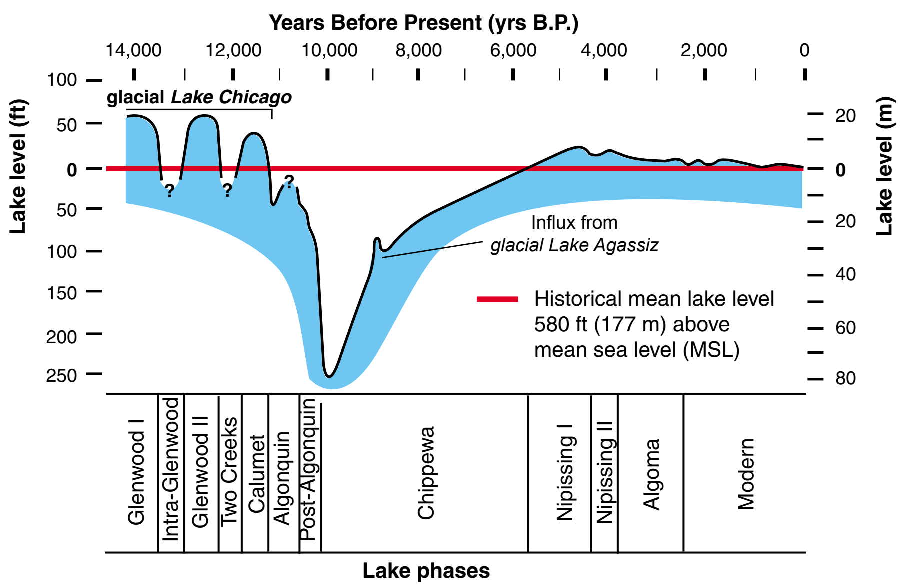


Figure 5 *Southern Lake Michigan lake-level curve for the past 14,000 years (Hansel and Michelson 1988, Chrzastowski and Thompson 1992, Colman et al. 1995).*

Geologic Framework

Watersheds and Surficial Drainage

Chicago and the close-in suburbs in the predevelopment setting contained three river watersheds: Des Plaines River, Chicago River, and Calumet River. A fourth watershed surface drained directly to Lake Michigan (Figure 6). What existed in the natural setting has been significantly modified by the major canal building and river engineering during the late 1800s and early 1900s. The geography of the watersheds and rivers and their alteration by engineering are a critical framework for understanding the geologic history of the Chicago River.

The Des Plaines River is the major river of Chicagoland. It originates in southern Wisconsin about 12 miles north of the Illinois-Wisconsin state line and follows a southward course through low land between end moraines. Where the river traverses the western part of the Chicago Lake Plain just south of Chicago O'Hare International Airport, a subtle topographic high prevents the river from turning east to flow to Lake Michigan. The river reaches the sluiceway leading to the north arm of the Chicago Outlet Valley and there turns southwestward to flow through the valley.

The Chicago River has three main components: North Branch, South Branch, and Main Stem. The North Branch results from the confluence of three headwater rivers that originate in the morainal uplands in southern Lake County. The sub-parallel configuration of these three headwater rivers is notable. Also notable is how the North Branch follows a broad arc where it crosses the northern part of the city of Chicago and then turns abruptly toward the southeast. The South Branch is entirely on the lake plain and less than a third as long as the North Branch. The Main Stem, shortest of the three components, runs approximately one mile east-west between Lake Michigan and the junction of the North and South Branches.

Prior to 1900, the North and South Branches converged at the Main Stem and then flowed eastward to discharge into Lake Michigan. In the natural setting, the South Branch had its headwaters along the West Fork South Branch, which originated just east of the Des Plaines River. The separation between the Des Plaines and the West Fork South Branch was the route of the historical Chicago Portage. The length of the portage depended on the season, stream flow, and precipitation. The portage could be as much as 9 miles when river levels were low, but during wet seasons the Des Plaines and West Fork were at times connected by water and no portage was needed.

Completion of the Chicago Sanitary and Ship Canal in 1900 connected the South Branch with the Des Plaines River and allowed for westward gravity flow in the South Branch. This canal reversed the flow direction in the South Branch and the Main Stem, which then could flow westward. This flow reversal brought Lake Michigan water into the Chicago River in order to eliminate river discharge of sewage into the lake, which was the source of Chicago drinking water. Subsequent canal building of the North Shore Channel in 1907 diverted additional sewage away from the lake and provided lake water into the North Branch during low river flow. The Chicago Lock, completed in 1938 at the former river mouth, created a barrier between the river and lake but allowed navigation between these two water systems.

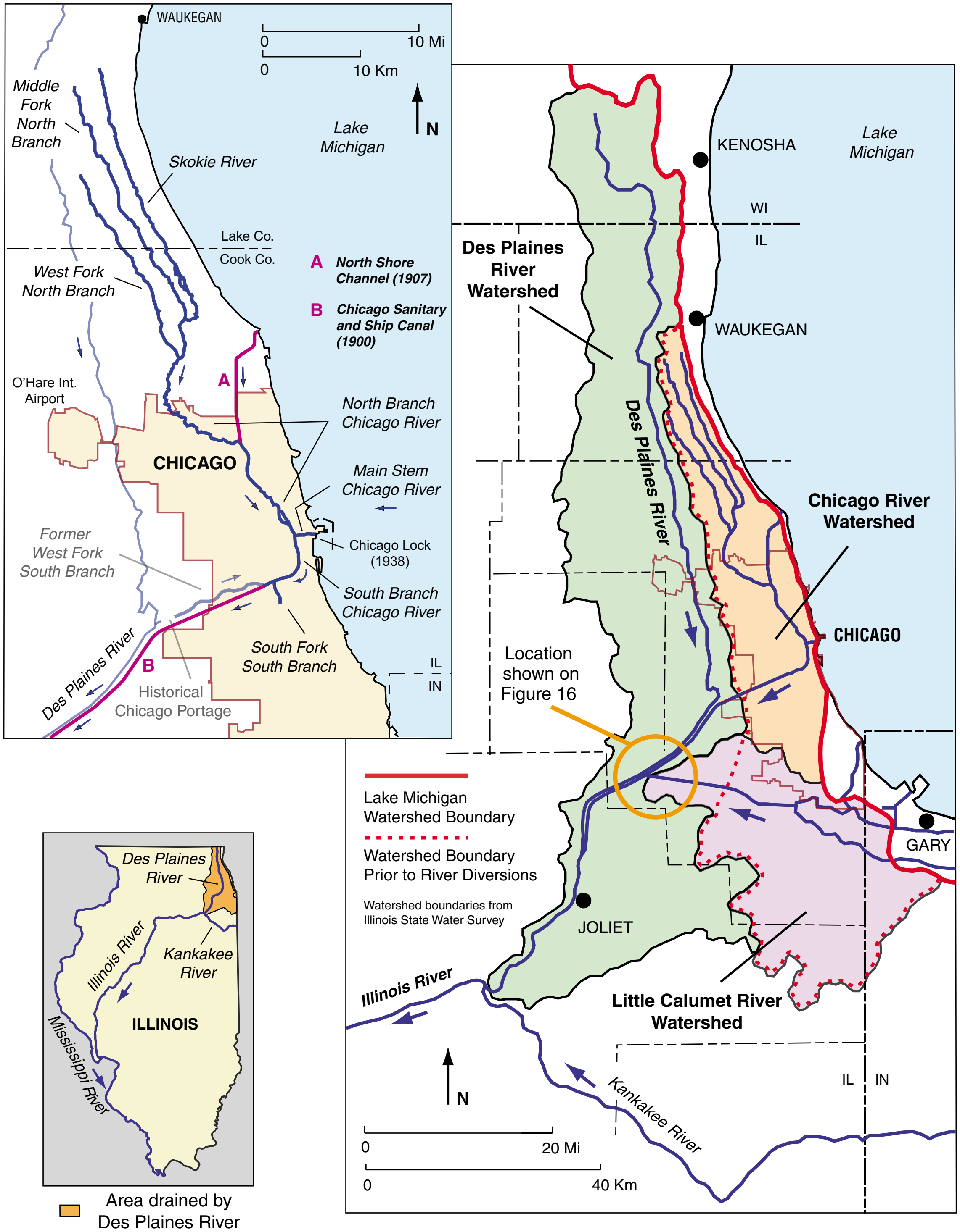


Figure 6 *Today the Chicago River watershed (and the Little Calumet River watershed) discharge to the Des Plaines River. Prior to 1900 and the completion of the Chicago Sanitary and Ship Canal, the Chicago River discharged to Lake Michigan. The Little Calumet River was diverted away from Lake Michigan with the completion of the Cal-Sag Channel in 1922. Canal building and river diversions have shifted the location of the Lake Michigan watershed boundary.*

Forming the North Branch Headwaters (~14,000 to 13,000 years B.P.)

Formation of the Park Ridge Moraine, the oldest of the lake border moraines, played a critical role in establishing overall drainage on the Chicago Lake Plain (Figure 7). The Park Ridge Moraine forms the watershed boundary between the Des Plaines River and Chicago River watersheds. Blue Island ridge is part of the Park Ridge Moraine but is separated by about 12 miles across the Chicago Lake Plain (Figure 3). The geography suggests that Blue Island ridge may originally have been contiguous with the Park Ridge Moraine to the north but became isolated due to erosion. The erosion may possibly have been related to meltwater and glacial lake outflow toward the Chicago Outlet.

The three tributary streams that form the headwaters of the North Branch Chicago River have a notable linear and parallel orientation (Figure 8). The course of these streams is along the topographic lows between the nearly parallel ridges of the lake border moraines (Figure 9). As the glacial ice receded, the west-to-east sequence in development of the end moraines corresponded to a west-to-east sequence of stream development. The West Fork North Branch formed first, then the Middle Fork, and then the Skokie River. The formation of the lake border moraines and the North Branch headwater streams occurred within a relatively short time frame of about 1,500 years.

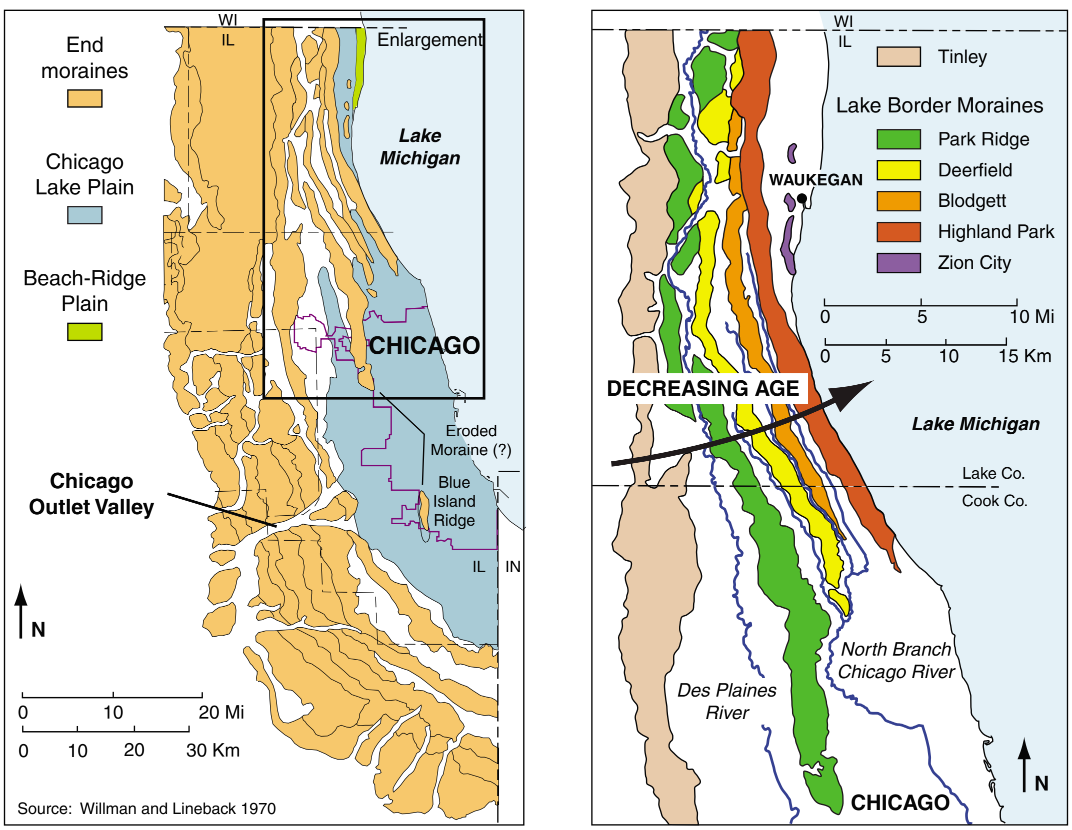


Figure 7 *The end moraines of Chicagoland have influenced drainage patterns to varying degrees. The Lake Border Moraines have had a distinctive influence in the configuration of the North Branch headwaters.*

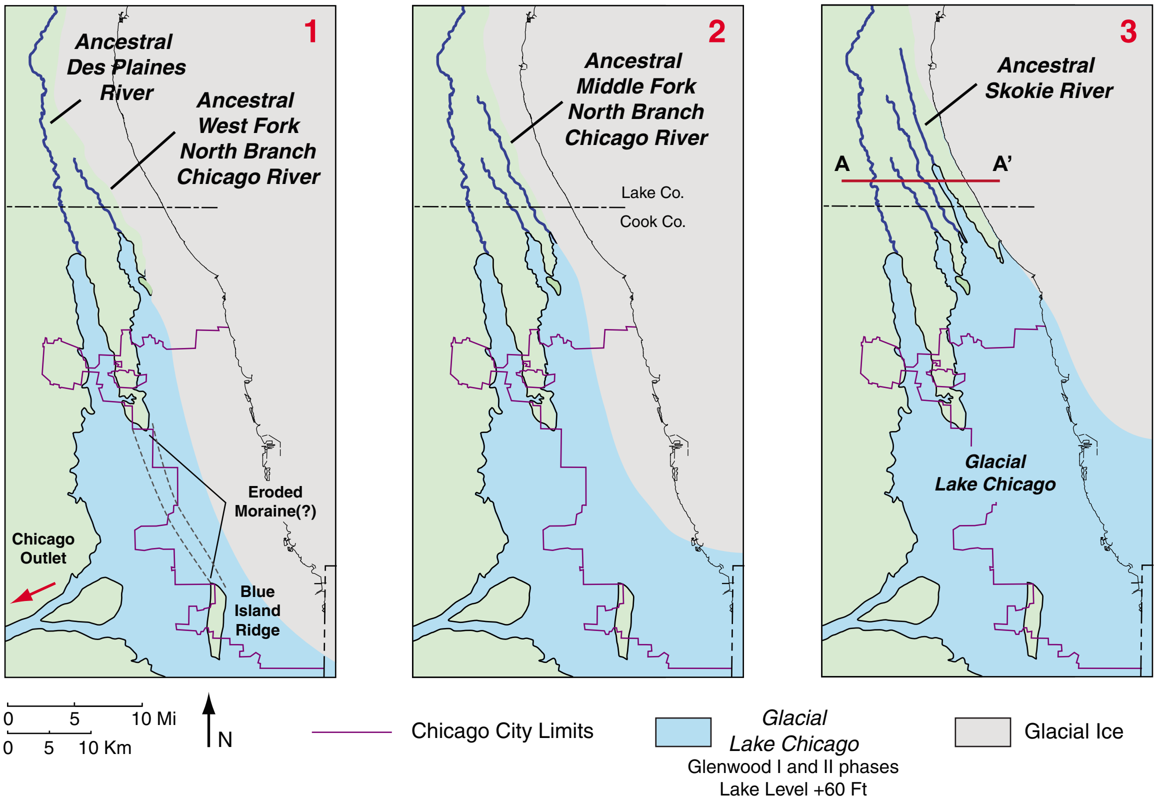


Figure 8 *The three tributaries that form the headwaters of the Chicago River formed successively from west to east as the ice margin receded into the Lake Michigan basin. The West Fork North Branch is the oldest segment of the Chicago River and the shortest of the three headwater tributaries. Once all three tributaries had formed they did not have a confluence. Each river discharged into the northern part of glacial Lake Chicago.*

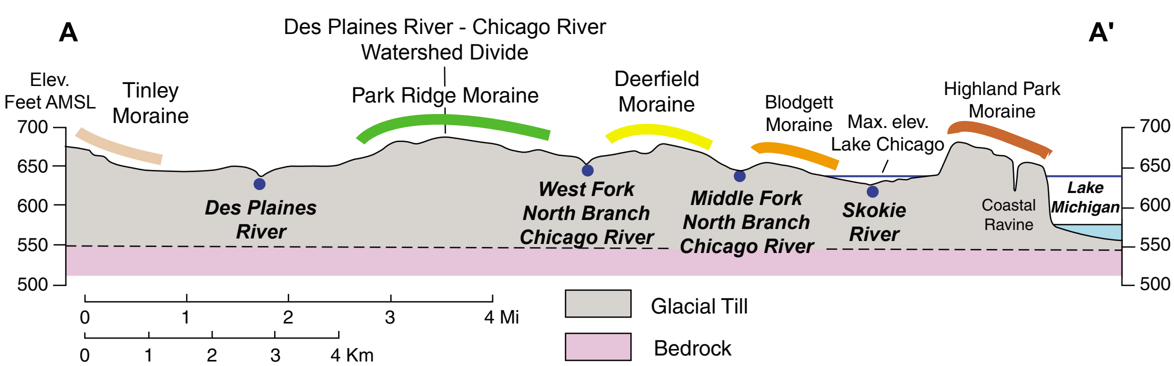


Figure 9 *A cross section of the topography in the headwaters area demonstrates how the rivers occupy the low points between the series of end moraines. The location of the cross section is shown in Figure 8 (Chrzastowski et al. 1991, Colman et al. 1995, Holcomb et al. 1996).*

Establishing the River Course on the Northern Lake Plain (~13,000 to 5,800 years B.P.)

About 13,000 years B.P., as glacial ice receded northward in the Lake Michigan basin, the area of glacial Lake Chicago continued to increase. Wave action began to erode and transport sand and gravel from the morainal bluffs along the lake margin. A net southerly transport developed along the northern Illinois coast, as occurs today. The net southward transport of sand and gravel into the embayed shoreline formed by the submergence of the Chicago Lake Plain resulted in the building of Wilmette Spit, which extends from the southern limit of the Highland Park moraine (Figure 10a).

Initially, the three North Branch headwater tributaries discharged into the semi-enclosed bay formed by the Wilmette Spit. Lake level decline near the end of the Glenwood II phase and the subsequent Two Creeks phase resulted in the streams flowing onto the emergent land west of the sand ridge formed by the relict Wilmette Spit. Convergence of the streams formed the ancestral North Branch Chicago River. The river course followed a broad arc as it circumvented the base of the Wilmette Spit.

Peak lake level during the Calumet phase was 20 feet lower than during the Glenwood phases. The ancestral North Branch discharged into a semi-enclosed water area between the relict Wilmette Spit on the west and Rose Hill Spit on the east during the Calumet phase (Figure 10b). Subsequent to the Calumet phase and the building of the Rose Hill Spit, lake level declined dramatically during the early Chippewa phase (Figure 5). All of the Chicago Lake Plain was emergent. The ancestral North Branch then flowed eastward around the southern base of Rose Hill Spit, continued east across the emergent floor of Lake Michigan, and discharged to Lake Chippewa (Figure 11). The lower base level caused the ancestral North Branch to incise its channel into the lake plain till. Borehole data (not shown) document the location of the ancestral North Branch paleochannel where it approaches the present lakeshore in the vicinity of Montrose Harbor (Figure 12).

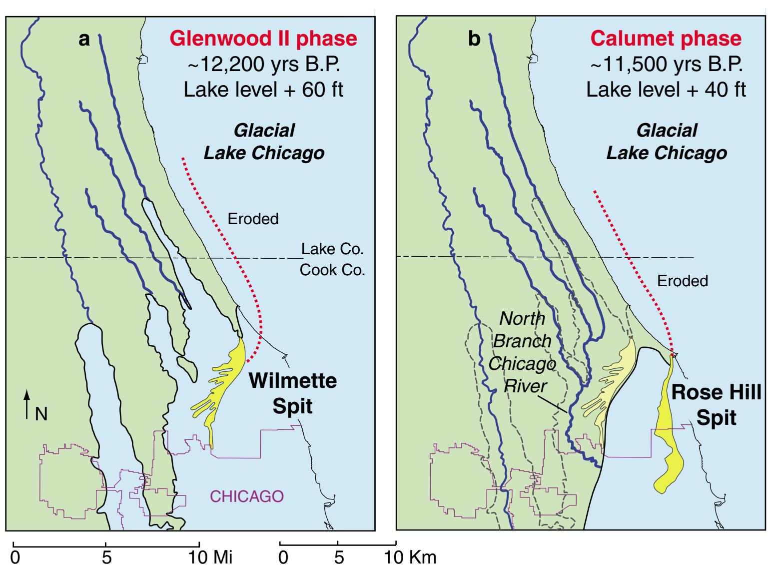


Figure 10 *The course of the North Branch has been influenced by the topographic high formed by the Wilmette Spit. The Rose Hill Spit influenced the river course during low lake level of the Chippewa phase. Confluence of the North Branch headwater streams occurred during the late Glenwood II or early Two Creeks phase when falling lake level exposed the lake plain on the west side of the Wilmette Spit.*

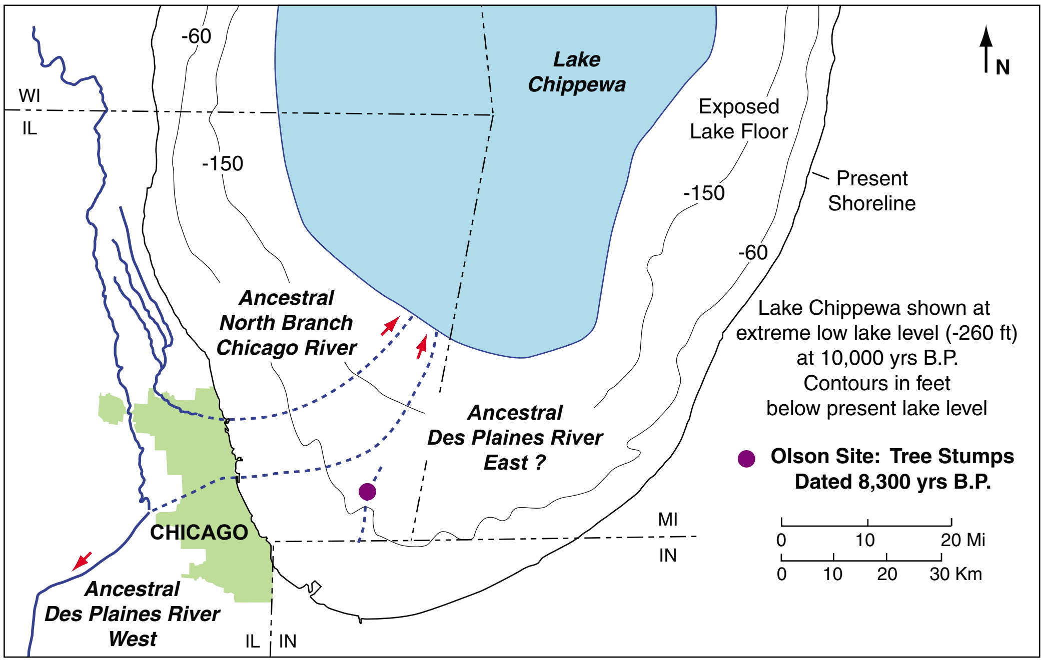
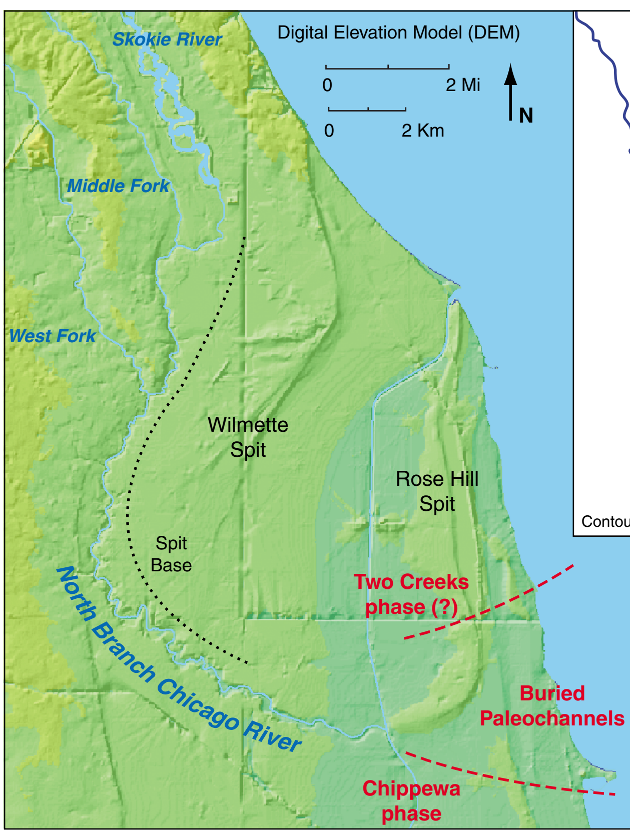


Figure 11 *During the Chippewa phase, the ancestral North Branch Chicago River flowed east across the exposed lake floor to reach Lake Chippewa. There is also the likelihood that the ancestral Des Plaines River had at least intermittent drainage to Lake Chippewa (Chrzastowski et al. 1991, Colman et al. 1995, Holcomb et al. 1996).*



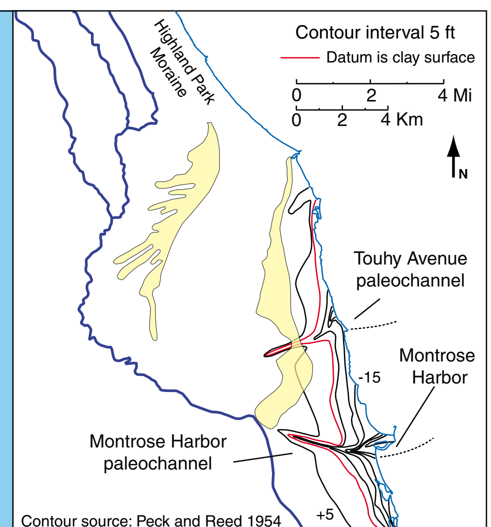


Figure 12 *The North Branch has an arcuate path around the base of the Wilmette Spit. Two buried paleochannels beneath and marginal to the Rose Hill Spit resulted from downcutting during low lake level (see Stop 3 for discussion).*

Extending the River Course on the Central Lake Plain (5,800 years B.P. to ~2,500 years B.P)

During the late Chippewa phase, the ancestral North Branch Chicago River extended across the emergent lake floor. The location of the river mouth progressively shifted westward as lake level rose. When lake level rose to the historical mean about 5,800 years B.P., the mouth of the ancestral North Branch was then near the present-day Montrose Harbor. Continued rising of the lake level began a re-submergence across the Chicago Lake Plain and initiated the Nipissing phases. Lake level ultimately reached 20 feet above the historical mean and reestablished lake outflow though the Chicago Outlet. Wave action along the western shore of the southern lake again resulted in erosion and net southerly transport of sand and gravel. A result was Graceland Spit, built onto the eastern part of the Chicago Lake Plain (Figure 13a).

During the Nipissing I phase, the ancestral North Branch Chicago River discharged into the embayed water to the west of the northern (proximal) end of Graceland Spit. The river mouth was located on the northern lake plain in a position similar to its location during the Calumet phase (Figure 10). The ultimate southward growth of Graceland Spit resulted in a spit nearly 17 miles long, making it the longest on the lake plain. A notable characteristic of central Graceland Spit is that it curved eastward (lakeward) of the present-day shoreline (Figure 13b). This lakeward protrusion likely was caused by the spit growth during the lake level decline between Nipissing I and II (Figure 5). Rising water level during Nipissing II shifted the southern spit growth toward the west (Figure 13c). As lake level then declined toward the end of Nipissing II, the southern (distal) end of Graceland Spit again progressively shifted lakeward toward the east, creating the series of finger-like ridges that characterize the spit's southern end (Figure 13d).

When Graceland Spit reached its maximum southern extent, it restricted and eventually prevented lake discharge to the Chicago Outlet by way of the northern Des Plaines River valley. Water in this back-spit area became the Chicago Lagoon, which drained westward into the northern valley of the Chicago Outlet (Figure 13c). The sedimentary record of the lagoon is a veneer of lagoonal silt and clay on the lake plain (Figure 4). The ancestral North Branch Chicago River was the primary stream discharging to the lagoon, but lagoon water level and extent were influenced by ancestral Lake Michigan, which was draining through the southern valley of the Chicago Outlet, thus creating the lagoon's base level.

Subsequent to the Nipissing II phase, lake level gradually declined during the Algoma phase to the Modern phase, and the Chicago Lagoon gradually diminished in size. The ancestral North Branch progressively extended farther across the emergent floor of the former lagoon (Figure 13d). The sand ridge of the relict Graceland Spit created a topographic barrier that blocked river access to Lake Michigan. The river ultimately extended south and west across the length of the former lagoon floor to join the Des Plaines River where it turned west toward the Chicago Outlet (Figure 13d). The ancestral North Branch Chicago River was then a tributary of the Des Plaines River. High land along the sand ridge of the relict Graceland Spit was then the divide between the Des Plaines River watershed to the west and the Lake Michigan watershed to the east.

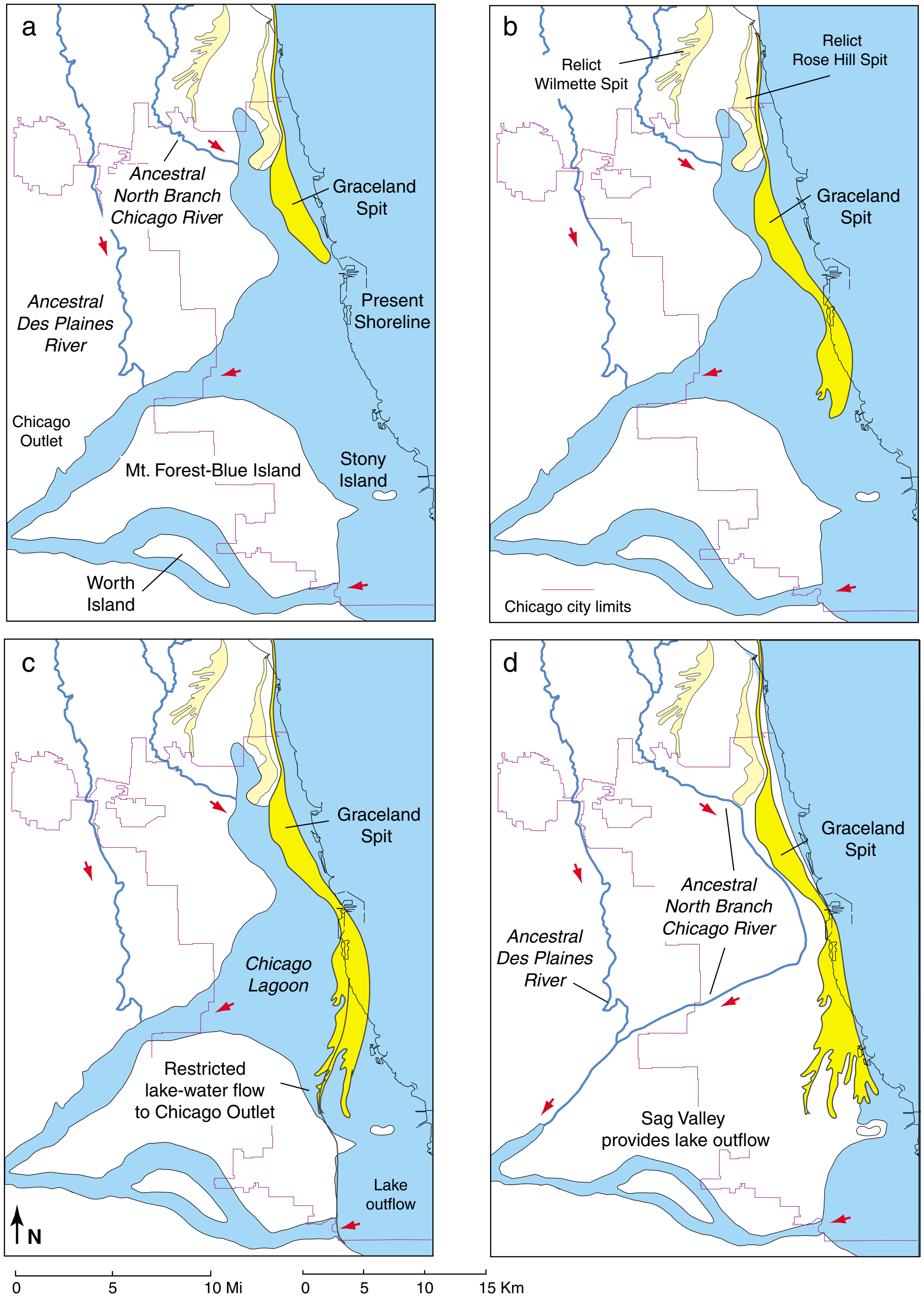


Figure 13 *Growth of the Graceland Spit created the Chicago Lagoon. As lake level declined, the emergent lagoon floor was occupied by the ancestral North Branch Chicago River. The relict Graceland Spit formed a topographic barrier for river discharge to the lake (Baker 1920; Chrzastowski and Thompson 1992, 1994).*

The Modern North Branch, South Branch, and Main Stem (Past 2,500 years B.P.)

Today, Graceland Spit is preserved in two segments, one on either side of the Chicago downtown area (Figures 4 and 14). What is missing is the segment of the former spit that extended lakeward (eastward) of the present shoreline. As previously noted, the lakeward projection of the spit can be explained by the shoreline response to the lake level decline that distinguishes the Nipissing I and II phases. The erosion of this lakeward curvature resulted from wave action tending to straighten the lake shoreline.

Spit erosion eliminated the sand ridge that formed a topographic barrier between the lake and the low land of the central lake plain. Dunes would have developed along this segment of eroded spit, but these new dunes would not have reached the crest elevation of the relict Graceland Spit, nor would the dune line have been as wide as the spit ridge. Thus, the segment of eroded spit resulted in a low and narrow physical barrier between the ancestral North Branch Chicago River and Lake Michigan. What was needed to connect these waters was a channel that breached the dune line.

Two scenarios are most likely for such a river-to-lake connection (Figure 15). The first is that a connection occurred during a flood event along the ancestral North Branch during a time of low lake level, which caused the base lake level to be lower than the river junction with the Des Plaines River. River floodwaters could have resulted in a channel through a low area in the dune line to discharge to the lake. If such a flood-related connection occurred, the connection would be short-lived. The wave dominance of this shore and the abundance of littoral sand would quickly close a river connection and the river's path of least resistance would continue to be to the west.

A second scenario is that during a time of high water on Lake Michigan, storm waves breached the dune line, allowing lake water to flow westward onto this low area of lake plain. The lake water could then have merged with the ancestral North Branch to flow with the river westward to the Des Plaines River. Such a wave-induced breach probably would have had sufficient energy to erode a formidable channel between the lake and river as typically occurs when river levees are breached or when overwash channels are formed during major storms along barrier beaches. The river could then have assumed this channel during times when the lake base level was lower than the junction with the Des Plaines River.

The timing for a connection between the river and lake would have been during the past 2,500 years when modern lake level was established. The exact timing is uncertain, and there probably were multiple events of connection and separation associated with wave dynamics, river stages, and changing lake level.

The significance of channel development between the ancestral North Branch and the lake is its creation of the three-part river system of today. Flow direction in the channel heading southwest to the Des Plaines River reversed to flow toward the east, resulting in the South Branch Chicago River. The North Branch then flowed no farther south than its junction with the South Branch. The combined flow of the North Branch and South Branch flowed lakeward along the river-to-lake channel that became the Main Stem.

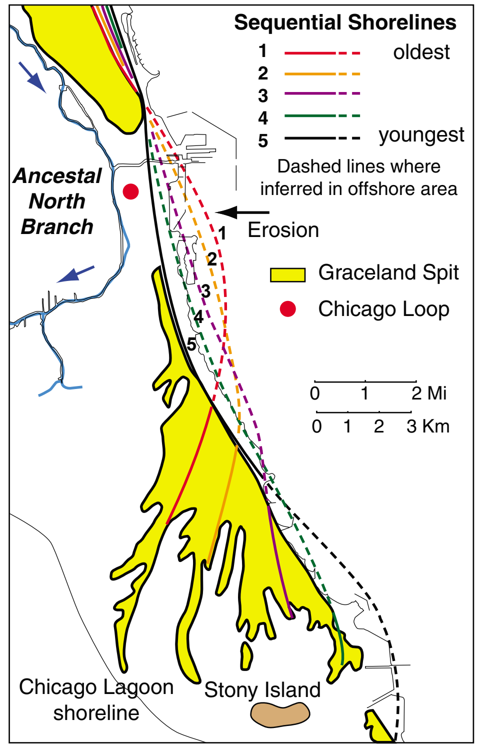


Figure 14 *Erosion of the lakeward protrusion of Graceland Spit resulted in truncated spit remnants to the north and south of the Chicago Loop (also see Figure 4) (Baker 1920; Chrzastowski and Thompson 1992, 1994).*

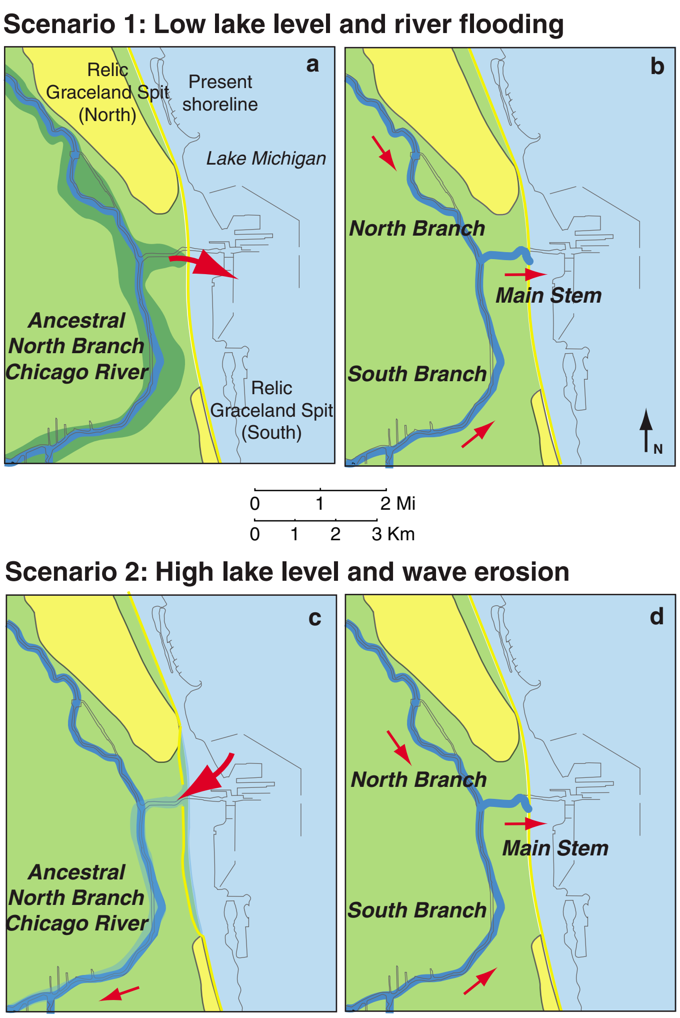


Figure 15 *This schematic shows two scenarios for a breach that resulted in the channel for the Main Stem Chicago River. In scenario 1 (**a** and **b**), river floods breach a lake outlet, and lakeward discharge is maintained after the flood. In scenario 2 (**c** and **d**), waves breach a lake outflow to the ancestral North Branch Chicago River. After the lake level declines, lakeward river discharge is established. With either scenario, once the river had a lakeward discharge, flow direction reversed in what became the South Branch Chicago River.*

Stop 1 Chicago Outlet Valley

The Chicago Outlet Valley has played a major role in the geologic history of the Chicago Lake Plain and the lake and river drainage across the plain. This Y-shaped valley provided the passage through the end moraines that elsewhere form a topographic barrier marginal to the southern Lake Michigan area (Figure 3). The valley floor is up to 1 mile wide and is as much as 100 feet lower than the crest elevation of the adjacent morainal upland. The north arm of the Chicago Outlet Valley (Des Plaines Valley) provides the pathway for the Des Plaines River and the Chicago Sanitary and Ship Canal (Figure 16). The south arm (Sag Valley) contains no major river today, but includes the Calumet-Sag Channel.

Traversing the Chicago Outlet Valley along the north-south 104th Avenue (Flavin Road/ Willow Springs Road) provides an opportunity to experience the topography of the two valley arms and the hummocky morainal upland between them (Mt. Forest Island). At Swallow Cliffs, the former toboggan facility provides the opportunity to view and climb and descend the south slope of the Sag Valley. Along the bank of the western Calumet-Sag Channel, the valley-floor bedrock is exposed in places (Figure 17).

The valley has functioned as an outlet for glacial Lake Chicago and ancestral Lake Michigan during times of high lake levels (Glenwood I and II, Calumet, Nipissing I and II, Algoma phases). Bedrock has been a limiting factor in the depth of valley erosion (Figure 18). If the bedrock surface had been slightly lower, one or both sluiceways leading toward the outlet valley might have had a greater degree of downcutting. A deeper channel (less than 5 feet deeper) along these sluiceways and through the valley could have resulted in a permanent outlet for Lake Michigan water.

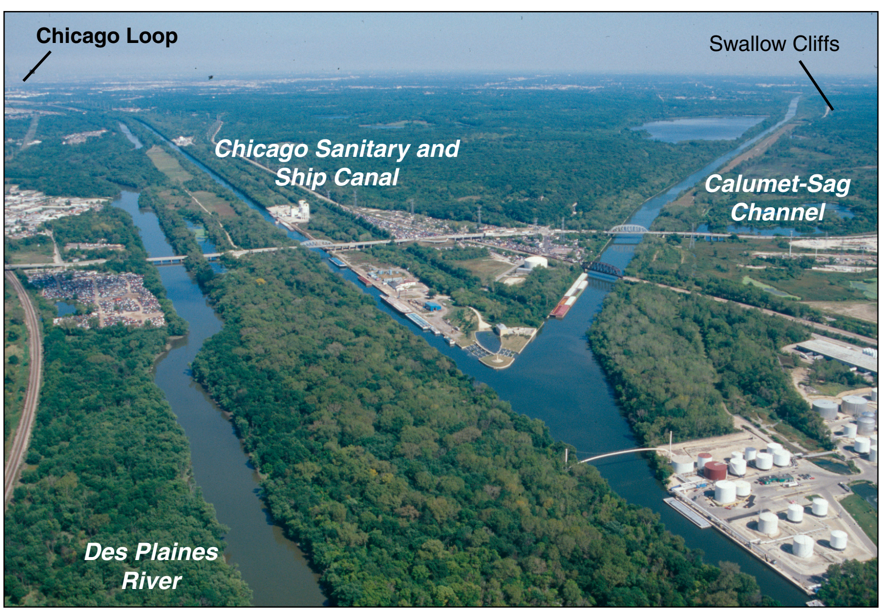


Figure 16 *Aerial view looking east across the Chicago Outlet Valley and showing the three waterways that flow through the valley. (Photograph by M. Chrzastowski 2002.)*

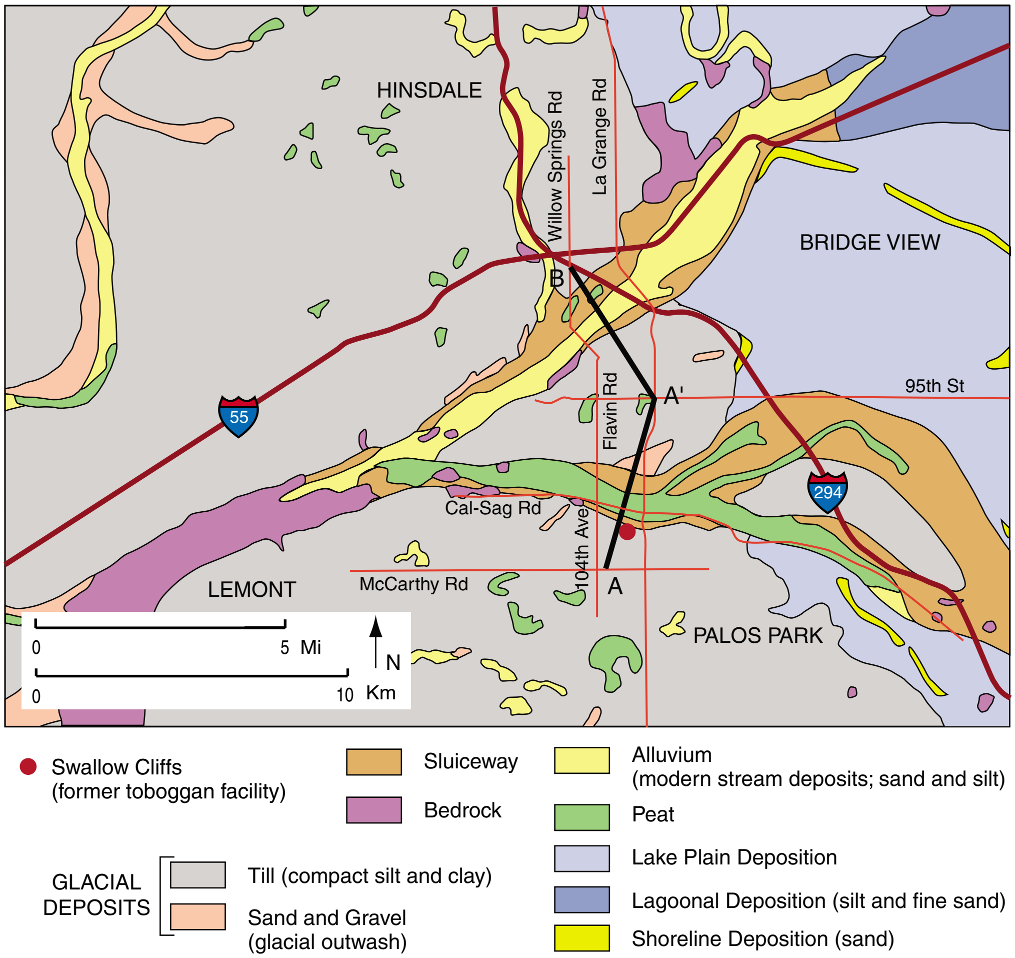


Figure 17 *The surficial geology in and near the Chicago Outlet Valley is primarily till or a veneer of post-glacial deposition overlying till. Along the valley floor bedrock is exposed or is shallowly buried. The sluiceways resulted from erosion by high stream flow during lake water discharge (modified from Willman and Lineback 1970).*

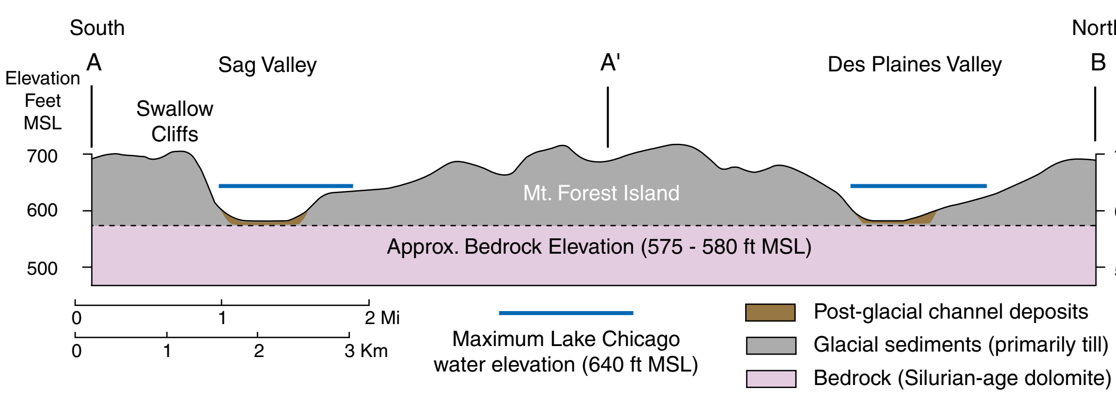


Figure 18 *This cross section through the Sag and Des Plaines Valleys shows how the bedrock surface has been a significant factor in determining the depth of valley incision (U.S. Geological Survey 1993, 1997a, b, c).*

Stop 2 Chicago Portage National Historic Site

In 1673, aided by a Native American guide, missionary Father Jacques Marquette and cartographer Louis Jolliet were the first Europeans to cross the Chicago Portage (Figure 19). This portage was between the Des Plaines River in the Mississippi River watershed and the West Fork South Branch Chicago River in the Great Lakes watershed. This portage was unique in that it was marginal to a relict river channel rather than across a topographic high (Figure 20).

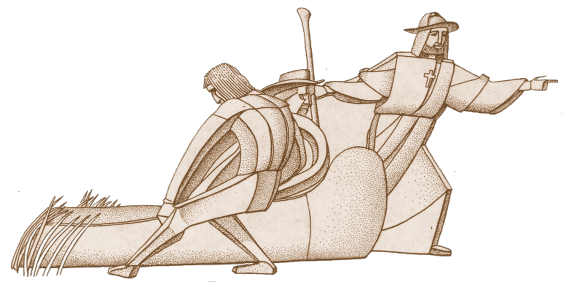


Figure 19 *Illustration of sculpture at the Chicago Portage National Historic Site. (Source: Portage National Historic Site visitor brochure.)*

Chicago Portage National Historic Site is at the western end of the former portage. The site includes Portage Creek, a tributary to the Des Plaines River, which once served as the western canoe approach to the Chicago Portage. The portage occurred between the eastern end of this creek and the western end of the West Fork. The West Fork is shown on a 1902 topographic map (Figure 21). Today, because of channel filling, all that remains of the West Fork is an approximate half-mile segment at its eastern end straddling Damen and Ashland Avenues. The Chicago Sanitary and Ship Canal (completed in 1900) merges with this West Fork remnant.

Historical accounts note that during times of spring runoff or high river stage, there was sometimes a water connection between the Des Plaines River and the West Fork that allowed continuous canoe passage. During drier times and typical river levels, portage was necessary. The length of portage would depend on river stage.

A historic landscape feature along the Chicago Portage was a shallow, elongate lake named Mud Lake (Figure 20). The lake name relates to the mud bed that was an impediment when wading with canoes or small boats. The lake extent varied annually and seasonally. The configuration and location on historical maps indicate that Mud Lake occupied one or more closed depressions along the topographic low between the West Fork and Des Plaines River. Mud Lake is interpreted as being a remnant of the river channel from when the ancestral North Branch Chicago River crossed this area with westward flow to join the Des Plaines River.

As discussed in the section Chicago River Evolution (p. 18), the Chicago River connection to Lake Michigan established the eastward flow in what became the South Branch Chicago River. The main channel of the former westward flow became the West Fork, and a tributary draining the lake plain to the south became the South Fork. Mud Lake and its neighboring marsh supplied the headwaters of the West Fork. There is also historical record of the Des Plaines River seasonally sending water eastward in Portage Creek, through Mud Lake, and into the West Fork and South Branch. In 1849, an ice dam on the Des Plaines River downstream from Portage Creek raised river levels and caused such an eastward diversion. As ice, water, and debris moved east toward Lake Michigan, severe damage occurred to docks, vessels, and bridges along the South Branch and Main Stem (Hill 2000).

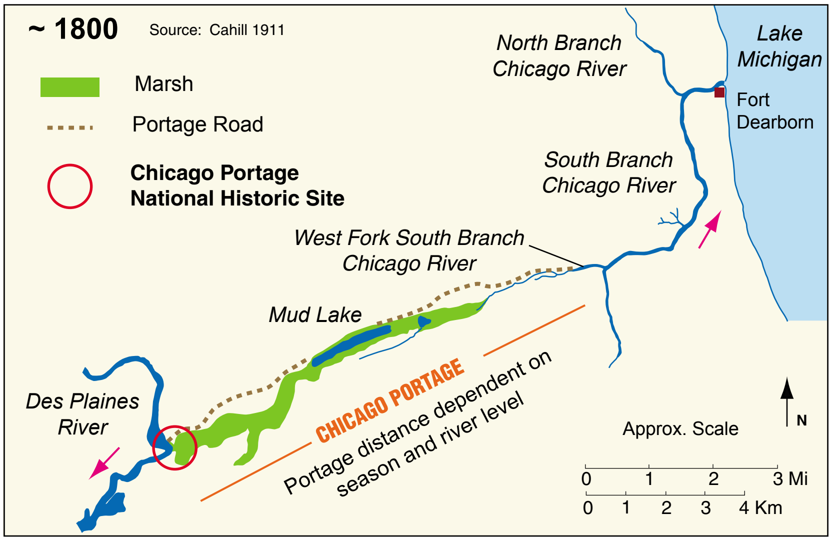


Figure 20 *This map depicts the Chicago Portage vicinity as it was mapped about 1800, likely at a time of low or possibly below average river stage. Mud Lake is shown as a water link between east and west segments of Portage Road.*

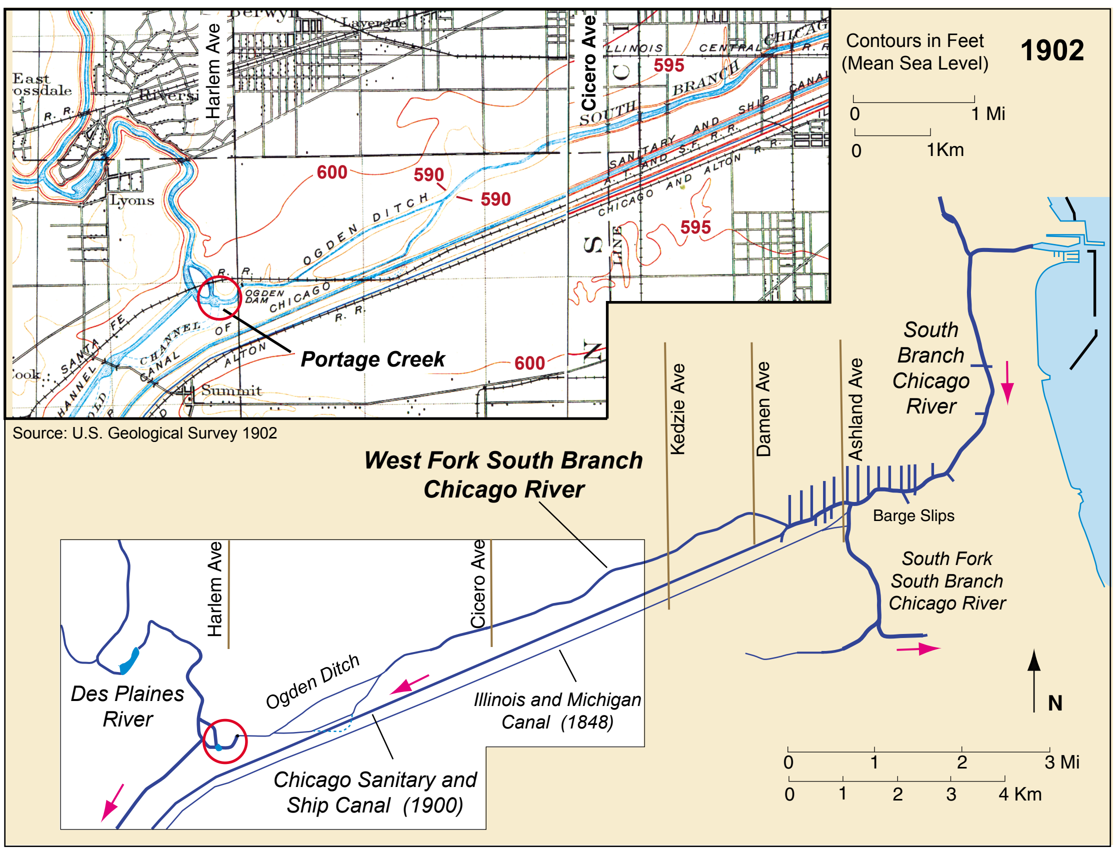


Figure 21 *The West Fork South Branch was still present in 1902 when topographic mapping was published by the U.S. Geological Survey, 2 years after completion of the Chicago Sanitary and Ship Canal. Ogden Ditch was an excavated channel built in one of two far-west channels of the West Fork leading to Portage Creek. Most of the Illinois and Michigan Canal shown here is now filled and corresponds to the route of the Stevenson Expressway (I-55).*

Stop 3 Burnham Harbor Paleochannel

Borehole data from the eastern part of the Chicago Lake Plain have identified five buried paleochannels downcut into the glacial clay (Figure 22). Two are on the north lakefront, and three are on the south lakefront. The paleochannels are here named according to the nearest arterial street along the lakefront (Touhy Ave., 31st Street, 24th Street) or the harbors that they are near or cross beneath (Montrose Harbor, Burnham Harbor).

The paleochannels record stream erosion by eastward drainage of the lake plain during low lake level. Relative dating is possible for the north channels. Assuming the Touhy Avenue channel is infilled with sand from the Rose Hill Spit (Calumet phase), then the channel formed during low lake level of the preceding Two Creeks phase (Figure 5). The Montrose Harbor channel is positioned along the distal margin of the Rose Hill Spit and is thus post-Calumet phase. This deeper channel is linked with the low water of the Chippewa phase (Figure 11). The ancestral North Branch is the parent stream for the Montrose Harbor channel and possibly the Touhy Avenue channel. The different channels potentially indicate changed river course subsequent to the building of Rose Hill Spit.

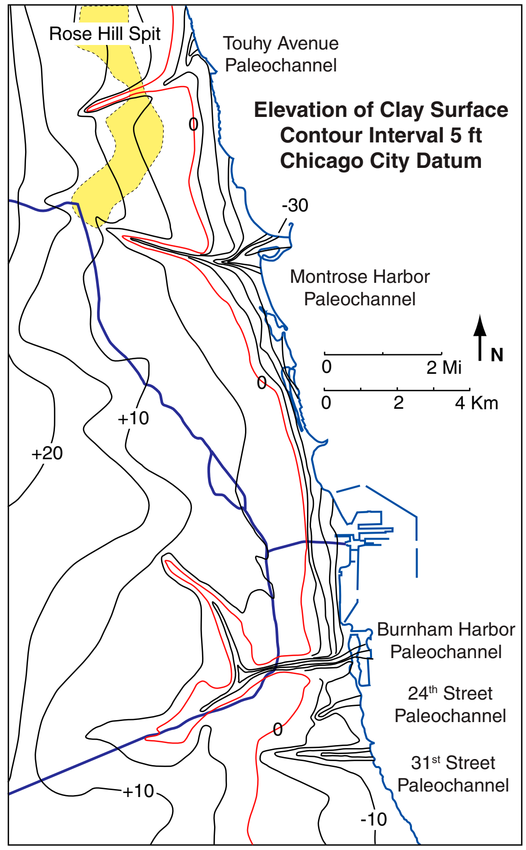
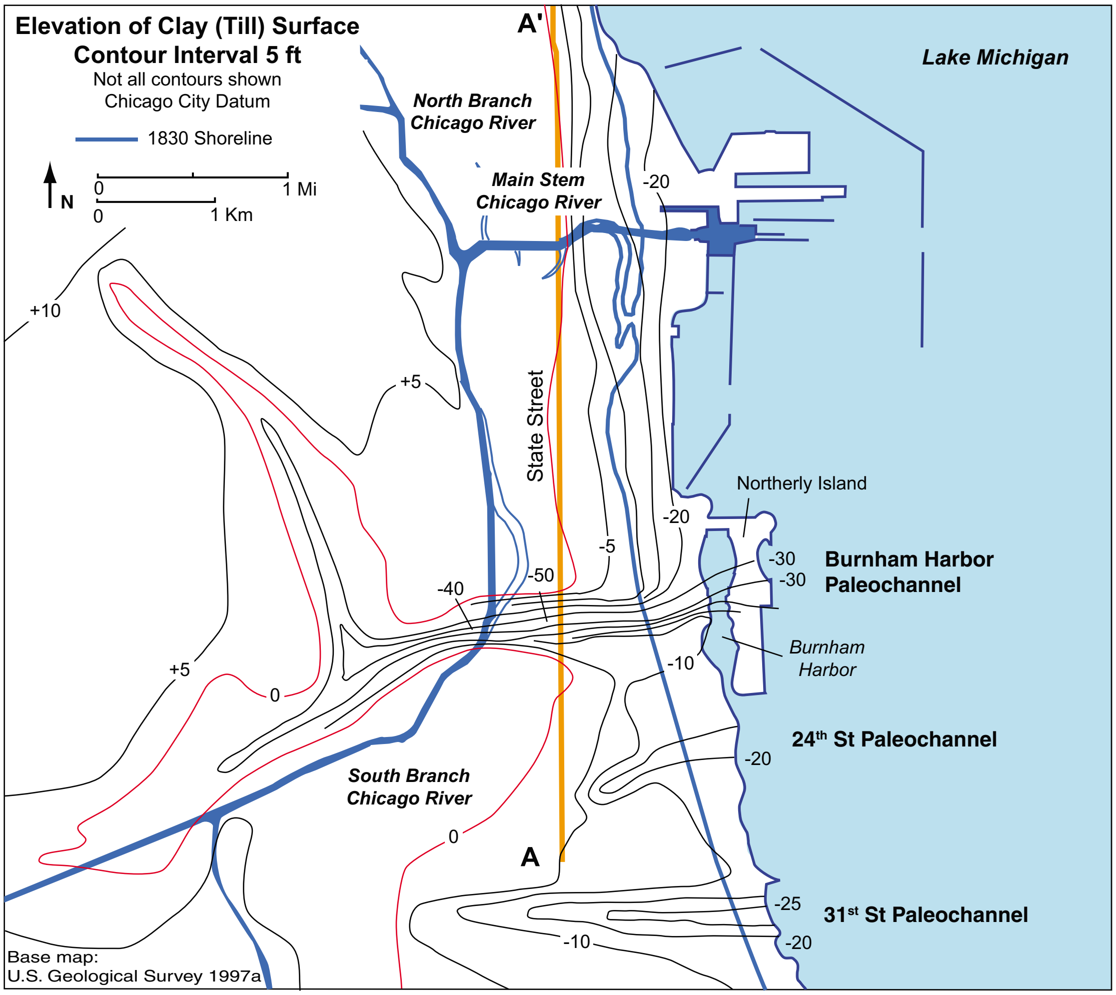


Figure 22 *Paleochannels beneath the Chicago lakefront (after Peck and Read 1954).*

Morphology of the south paleochannels compared with their northern counterparts suggests that the deeper channel (Burnham Harbor) dates to the Chippewa phase, and the shallower channel (31st Street) potentially dates to the Two Creeks phase. It is uncertain to which low-water phase the 24th Street channel belongs. The Burnham Harbor paleochannel (maximum depth 40 to 50 feet) is up to 20 feet deeper than the Montrose Harbor channel (Figure 23), which indicates greater stream flow along the Burnham Harbor channel.

The Burnham Harbor and 31st Street paleochannels are interpreted as channel downcutting by an eastward-flowing ancestral Des Plaines River (Figure 11). This river course may have been ephemeral during flood stages or when ice dams blocked westward flow. An eastward-flowing ancestral Des Plaines River would have been important in establishing an east-west river channel across the central lake plain. Such a channel was important later when used by the westward-flowing ancestral North Branch after emergence of the floor of the Chicago Lagoon (Figure 13d).



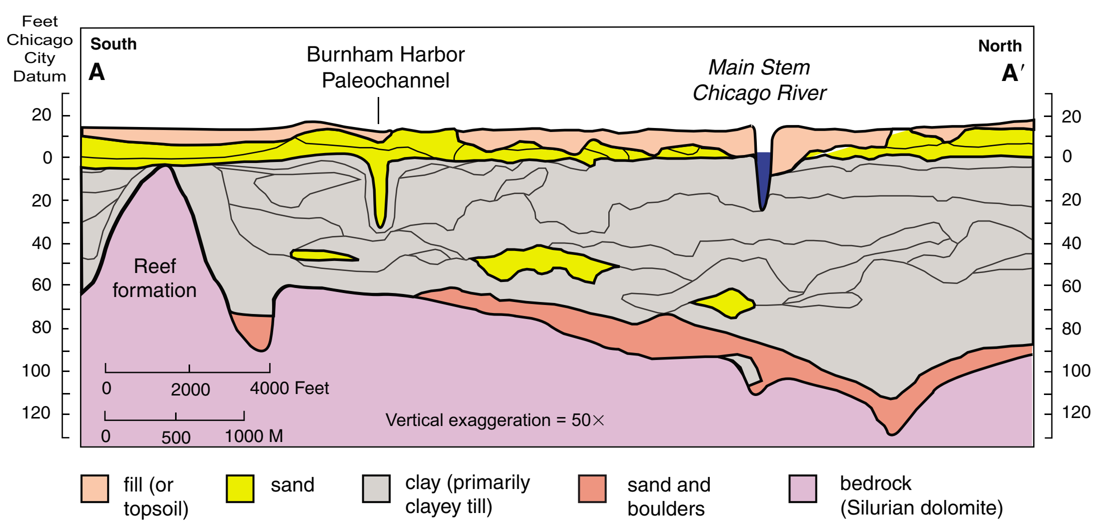


Figure 23 *The Burnham Harbor paleochannel is the deepest of the three paleochannels beneath the near-south lakefront. No paleochannel is associated with the Main Stem Chicago River (contour map and cross section after Peck and Reed 1954).*

Stop 4 Chicago River at Historic Fort Dearborn

Fort Dearborn was built in 1803, destroyed 1812, and then rebuilt in 1816 at a site atop the dunes on the south bank of the Chicago River. Today the historic fort location corresponds to Michigan Avenue at Wacker Drive (Figure 24). East of the fort, the river was deflected southward by beach accretion caused by the net southerly littoral transport. The river mouth was naturally shallow due to accretion of littoral sand, and, at times, sand accretion blocked river flow to the lake (Andreas 1884). Most of the natural course of the Main Stem was linear west to east. However, west of Fort Dearborn, the river took an abrupt turn toward the northeast, maintained this orientation for about 1,000 feet, and then curved east and south around the fort. A straightened river mouth has existed since the 1830s when jetties were built to establish a navigable channel between the river and lake. The northeast-southwest segment of the river today exists between State Street and Michigan Avenue.

Bathymetric mapping from the 1830s by the U.S. Army Engineers provides natural-state water depths prior to dredging or channel alteration. Notable are river depths north and west of Fort Dearborn, which are as much as 20 to 24 feet (Figure 25). These extreme depths occur along the northeast-southwest river segment. Downstream from this location, the river shoaled. Lake depth did not reach 18 feet until about 1,500 feet offshore.

The natural-state river depth north and west of Fort Dearborn is key geomorphic evidence supporting the model for development of the Main Stem channel by Lake Michigan water flowing westward after breaching an ancient dune line (Figure 15c and d). Laterally restricted flow at and near the breach likely would have contributed to the downcutting of a deep channel. An analog would be the localized scouring commonly seen where river levees are breached or where storm waves breach barrier islands. The northeast-southwest orientation of this channel segment is consistent with northeasterly major storm waves. It is not known how far to the east the lake shoreline was when the channel formed. This channel segment may be the western remnant of a longer northeast-southwest channel that was shortened through long-term shoreline recession. It could be argued that attributing the channel scour to one or more erosional events from hundreds to possibly a thousand or more years before this mapping is problematic. However, preservation of the scour can be attributed to lack of sediment infilling because of the near absence of sediment load of the Chicago River.

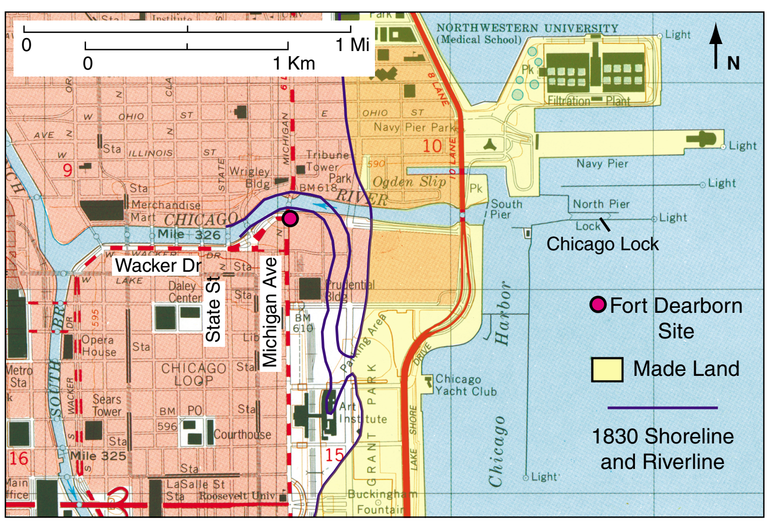
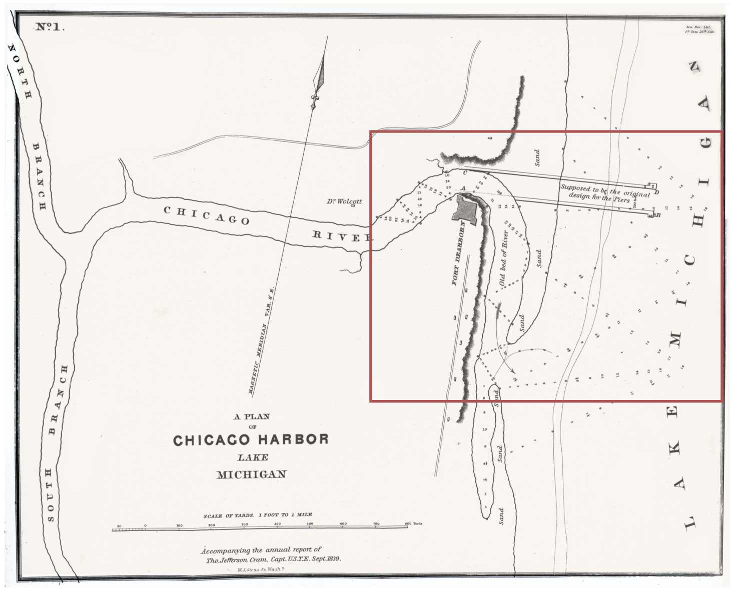


Figure 24 *The course of the Main Stem Chicago River has been totally altered east of Michigan Avenue. West of Michigan Avenue, the present river shoreline follows that of the pre-development setting (Andreas 1884, U.S. Geological Survey 1997a).*



Source: Cram 1839

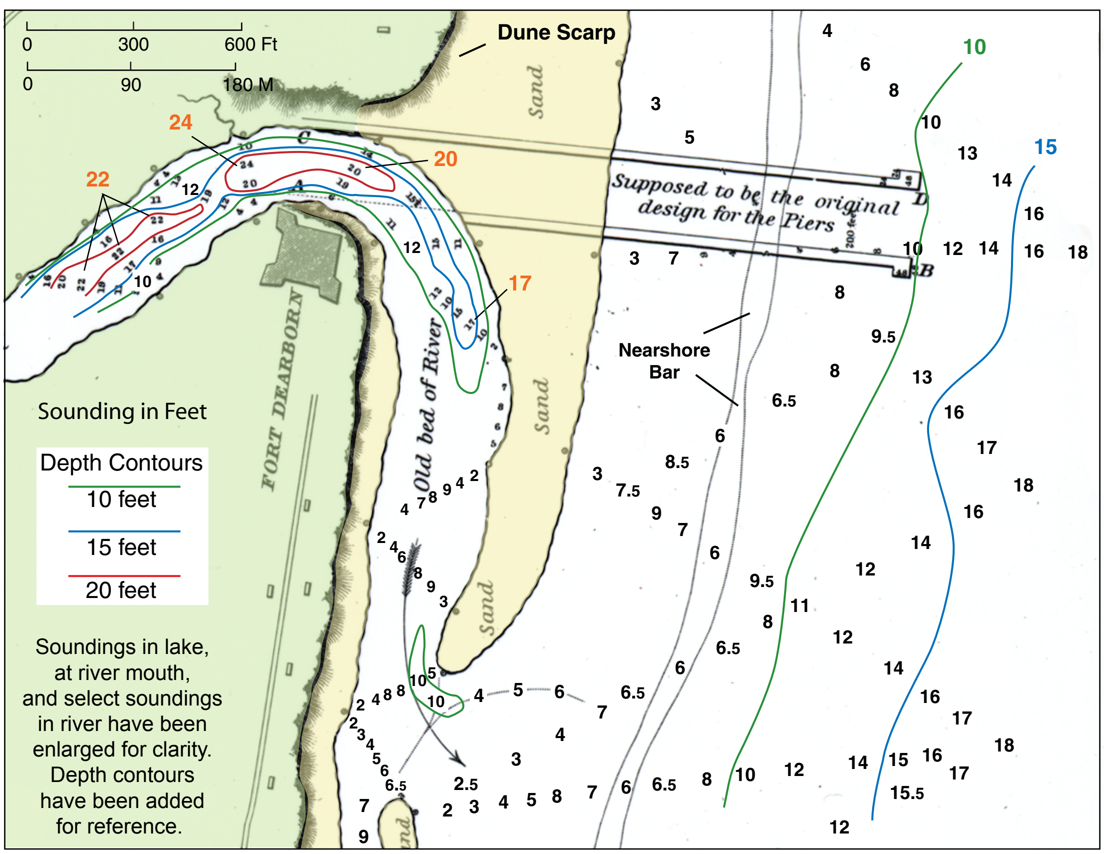


Figure 25 *Bathymetry at and near the Chicago River in the early 1830s, prior to any historical dredging, shows that the deepest water (20 to 24 feet) occurred in the northeast-southwest segment of the river channel immediately upstream from where the river turned south. Depth at the river mouth ranged from 2 to 10 feet. The southward deflection of the river mouth was caused by wave action and the net southerly transport of littoral sand. The predevelopment transport rate was approximately 100,000 cubic yards per year (Chrzastowski 1990).*

Stop 5 Graceland Spit at South Lincoln Park

Graceland Spit is named after Graceland Cemetery, which is located on Chicago's North Side along the crest of the relict spit (Figure 26). The morphology of Graceland Spit provides a record of changing lake levels during the Nipissing phases and subsequent erosion and reshaping of the shoreline (Figure 13). The spit is absent along the central Chicago lakefront because of erosion. The spit is present south of the central lakefront as one major topographic high that transitions lakeward into multiple lower-elevation ridges that formed as the distal parts of the spit during declining lake level (Figure 14). North of the central lakefront, the proximal part of the spit is preserved as a single, prominent topographic feature. Clark Street runs along the crest of the relict spit. The lake shoreline along the former spit would have run northwest-southeast across what is today the southern part of Lincoln Park. From here the spit continued toward the southeast and extended lakeward beyond the present shoreline.

Comparing land elevations across the north, central, and south lakeshore shows the significance of Graceland Spit as a topographic barrier (Figure 27). The land elevations north and south of the central lakeshore reach and exceed 600 feet, but elevation across the central lakeshore is at most from 590 to 595 feet. These elevations have been influenced by the filling and land raising that occurred in the central business district (Chicago Loop) beginning in the late 1850s to improve surface and sanitary drainage. This land raising was as much as 8 feet (Einhorn 2004). Thus, the pre-engineered land surface across the central lakeshore was more than 580 feet but less than 590 feet above mean sea level (MSL). The Chicago Loop in its natural setting had the lowest land elevation along the Chicago lakeshore north of the Stony Island bedrock hill.

While Graceland Spit was a continuous ridge from the north to south lakeshore, it was the topographic barrier that first protected the Chicago Lagoon from the open lake and subsequently prevented a connection between the lake and the ancestral North Branch (Figure 13c). Erosion of the central Graceland Spit removed this topographic barrier, setting the stage for this low area to be the location of river and lake confluence.

The course of the North Branch Chicago River has been prominently influenced by the Wilmette Spit, resulting in the arcuate trend along the western base of the spit (Figure 13a). The northern part of Graceland Spit has also influenced the river course. From where the North Branch turns southward at the distal end of Rose Hill Spit to the junction with the South Branch and Main Stem, the North Branch runs along the western base of the spit. Some of the present river course along this reach has been modified by river engineering to create a straighter channel (Hill 2000), but the overall southeasterly trend has been controlled by the topography of adjacent Graceland Spit. Because of the dominant eastward (lakeward) slope of the lake plain surface, if Graceland Spit were not present, the North Branch would have circumvented the distal end of Rose Hill Spit and continued eastward to the lake, similar to its course during the Chippewa phase (Figure 11). The combined influence of the Wilmette, Rose Hill, and Graceland Spits on the North Branch is such that the spit topography has controlled the river course for nearly the entire river transit across the northern Chicago Lake Plain.

Figure 26 *This view looking north up the Chicago lakeshore depicts how the Graceland Spit shoreline compared to the shoreline today and the pre-lakefill shoreline. (Photograph by M. Chrzastowski June 2000.)*

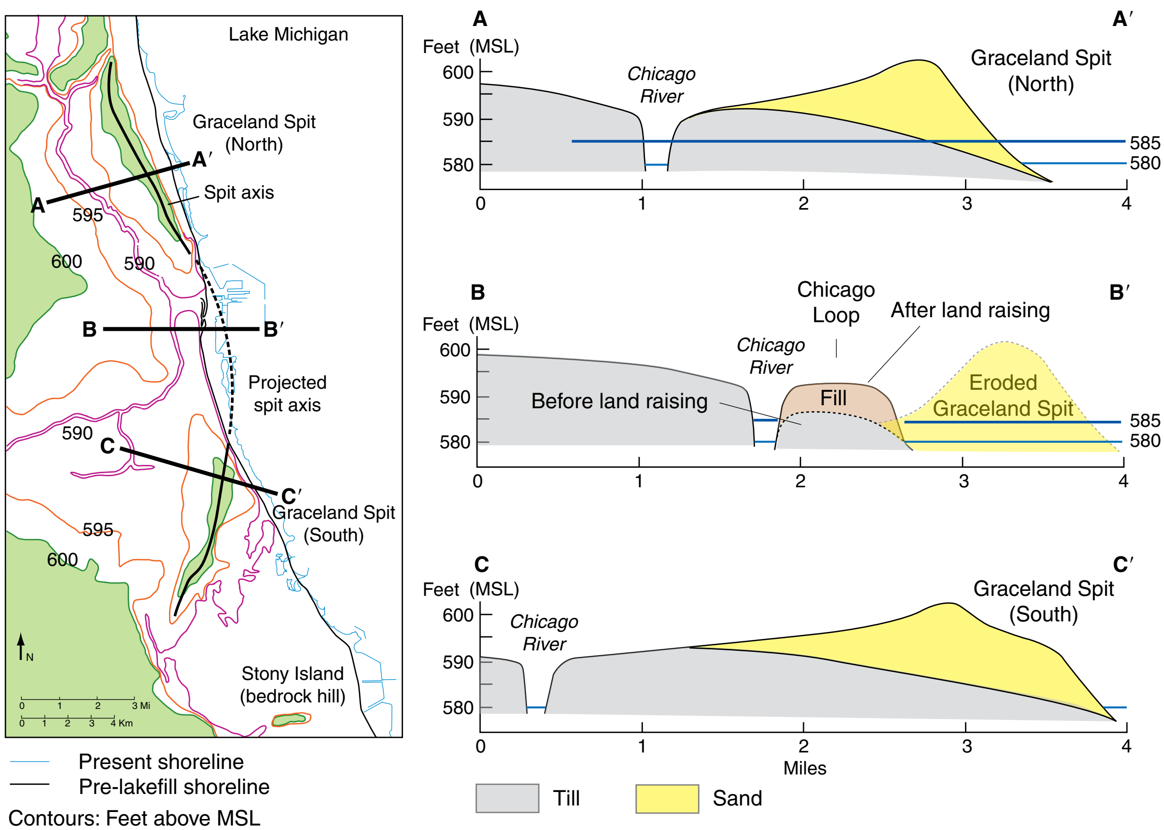


Figure 27 *Comparison of topographic cross sections along the length of the Graceland Spit (U.S. Geological Survey 1997a, b; 1998). Erosion of Graceland Spit removed the topographic barrier that separated the lake and the ancestral Chicago River. Before land raising, much of the Chicago Loop area was no more than five feet above the historical mean lake level of 580 feet.*

Summary

The geologic history of the Chicago River spans 14,500 years through a wide range in lake level (+60 to –260 feet) and involves change in river length and flow direction. The oldest part of the Chicago River is the West Fork North Branch, which formed about 14,000 years B.P., when ice recession created the inter-morainal low between the Park Ridge and Deerfield end moraines (Figure 28). The youngest part of the river is the Main Stem. When and how the Main Stem formed is not known conclusively, but it likely occurred during the past 2,500 years when modern lake level was achieved. An argument can be made that the Main Stem channel was primarily formed by one or more erosion events by Lake Michigan rather than by the ancestral Chicago River.

The South Branch is the Chicago River segment with the most complex history. This segment was once the southern part of the ancestral North Branch. This single river system flowed south and then west to join the Des Plaines River. The course of the West Fork South Branch followed a topographic low initially shaped by glacial lake water flowing to the Chicago Outlet Valley. However, the actual river channel may have formed by erosion from an eastward flowing ancestral Des Plaines River, which likely was responsible for eroding the prominent paleochannel beneath Burnham Harbor. The South Branch was the river segment most affected when a breach occurred between the river and Lake Michigan. Flow direction reversed, the river volume diminished, and the identity of the South Branch was first established. In 1900, the South Branch gained engineering notoriety when its flow direction was again changed with completion of the Chicago Sanitary and Ship Canal. The West Fork South Branch was once important for the Chicago Portage route but has been essentially erased from the landscape by channel filling.

The course of the Chicago River can be read as a record of the glacial and coastal processes that shaped Chicago and the surrounding area. The most striking example of this effect is the geologic history of the three sub-parallel headwater streams of the North Branch (West Fork, Middle Fork, and Skokie Rivers), which reflect the alignment of the series of lake border end moraines. Downstream from the confluence of these headwaters, the arcuate path of the northern North Branch circumvents the high land formed by the base of the Wilmette Spit. Further downstream, the southward, lakeshore-parallel course of the North Branch is due to the topographic barrier formed by Graceland Spit.

Two landscape features have been particularly critical to the evolution of the Chicago River. One is the Chicago Outlet Valley. If the northern valley floor had eroded more, this valley might have been a permanent outlet for Lake Michigan, and the ancestral North Branch would then have discharged directly to Lake Michigan along a lake embayment leading toward the outlet. If the valley floor had eroded less, maintaining a higher elevation, the Des Plaines River would have turned away from the valley and discharged to Lake Michigan. The North Branch would then likely be a tributary to the eastward flowing Des Plaines River, joining it on the eastern lake plain.

The other important landscape feature is Graceland Spit. If the spit were oriented parallel to the modern lakeshore, it likely would have persisted into historical time as a physical barrier preventing a connection between the river and lake. However, the eastward protrusion of the spit set the stage for that segment's subsequent erosion. The mouth of the Chicago River—and thus the site of Chicago—owes its location to erosion along the central portion of the Graceland Spit.

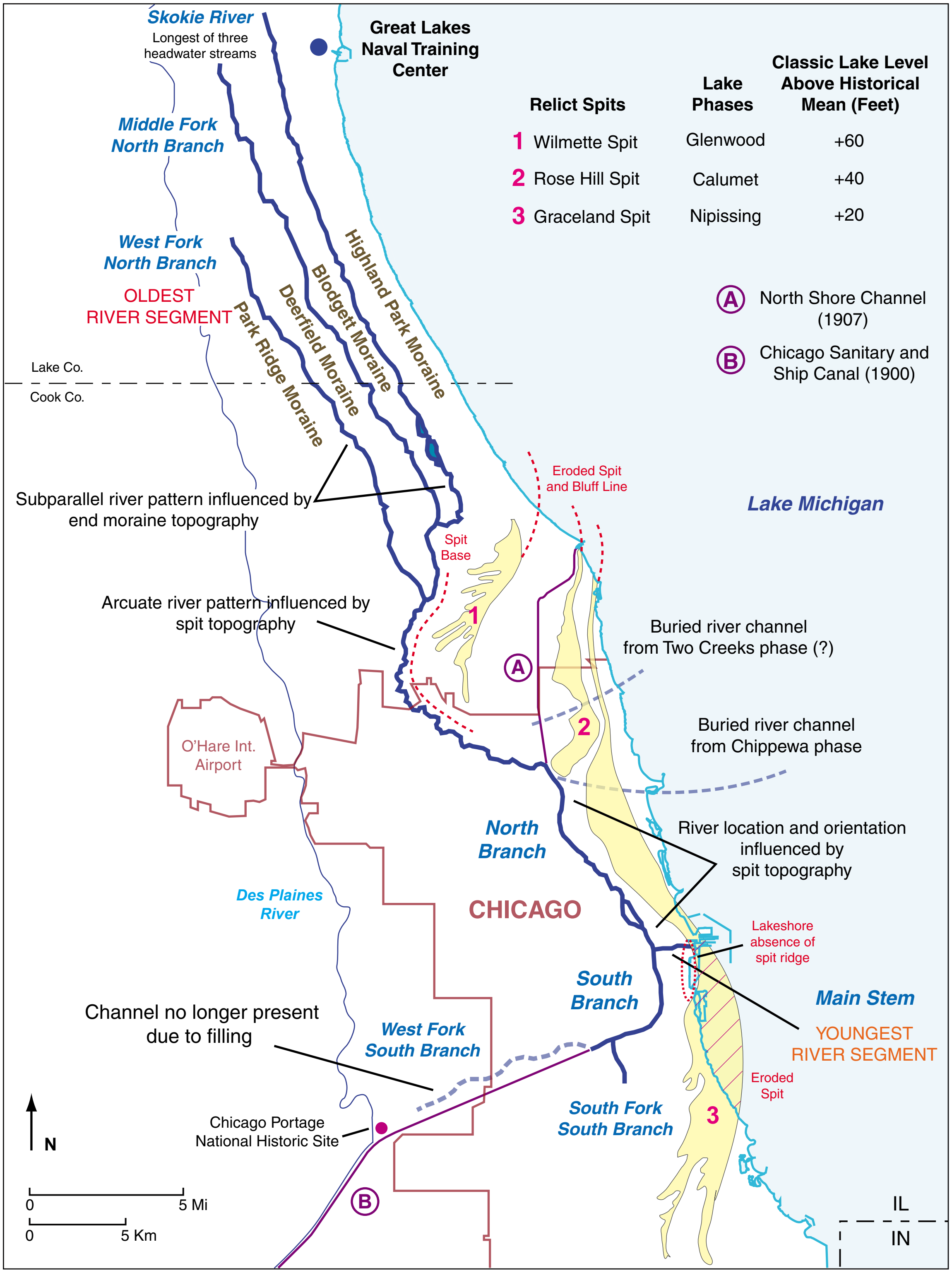


Figure 28 *The course of the Chicago River is the result of multiple glacial and coastal landscape influences. Coastal erosion was a critical factor in facilitating the connection between the river and Lake Michigan.*

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