U. S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

MISCELLANEOUS FIELD STUDIES
MAP MF-2254

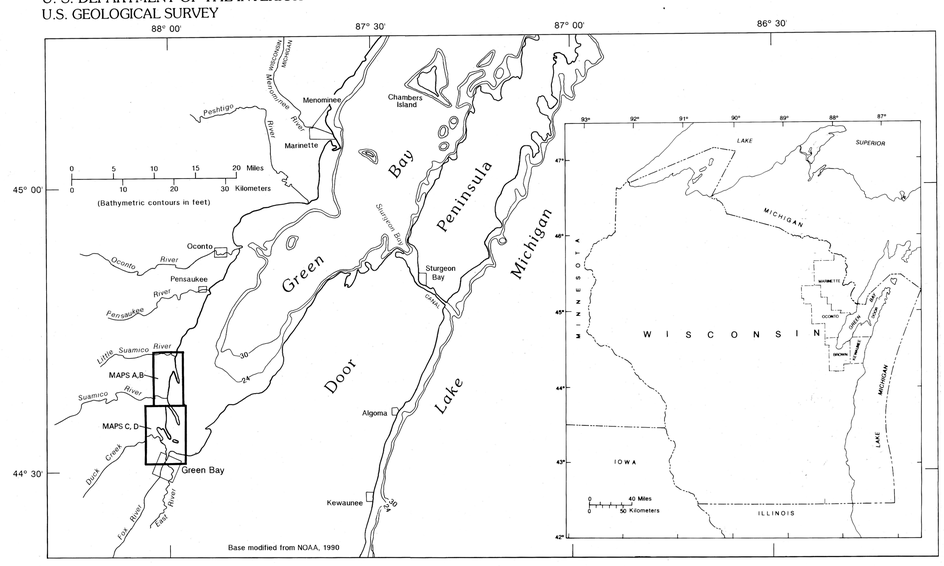

Figure 1. Location maps of Green Bay and the two study localities: Little Tail Point (Maps A,B), and Long Tail Point—Fox River (Maps C,D).

INTRODUCTION

The positions of shorelines and the areal extent of adjacent coastal wetland tracts in the Great Lakes region have exhibited substantial temporal variability during both prehistoric and historical times. Shoreline migration has resulted in environmental problems such as flooding and the coastal erosion of lakefront property, as well as the destruction of coastal wetland resources. In the Great Lakes region, the main natural cause for changes in shoreline position and adjacent wetland area is lake-level fluctuations, which results from two interactive factors. One factor is the glacio-isostatic rebound of the lake basins that has occurred from the end of the late Wisconsin glaciation to the present. This crustal rebounding has resulted in the slow uplifting of previous lake outlets and warping of lake basins, contributing to changing lake levels and shoreline migration. Historic lake-level gauge records indicate modern differential vertical uplift rates that range from 0.26 ft/century in the southern part of the Great Lakes drainage basin to 1.74 ft/century in the northern part of the basin (Larsen, 1989). The second factor contributing to lake-level fluctuations is climate variability, which causes variations in the amount of regional precipitation and evaporation, storm frequency, runoff, and resulting lake levels. Climate variability can occur over a wide spectrum of time scales, from seasonal variations, to longer-term trends of a few years or decades in duration, to trends lasting hundreds or thousands of years. A combination of both climatic variations and glacio-isostatic rebound has resulted in substantial temporal variability of the Great Lakes shorelines and associated coastal wetland tracts during post-glacial times.

Coastal wetland ecosystems can be defined in general terms as lands transitional between terrestrial and aquatic systems; they are characterized by periodic submergence or a water table at or near the surface and a predominance of hydric soils and hydrophytes. Coastal wetlands are essential natural resources that provide numerous environmental and socio-economic benefits, and serve as critical habitats for fish and wildlife populations. Their preservation is an important national priority because these valuable resources are prone to destruction by both natural processes and human activities. Shoreline migration resulting from lake-level fluctuations is the primary natural cause of wetland acreage losses. In general, high lake levels and associated flooding and wave erosion result in the damage and destruction of wetlands. Depending upon the rate and duration of lake-level changes and local coastal conditions, some destroyed wetlands may be re-established and acreage losses only temporary. Under other conditions, wetland acreage losses may be permanent. Human activities have also caused great losses in coastal wetland acreage, and these losses tend to be permanent. For example, agricultural activities such as the draining and clearing of wetlands for cultivation have resulted in large-scale losses of wetland acreage. Another major cause of wetland loss has been the urbanization process. The large-scale industrial, commercial, and residential expansions associated with urban development have destroyed large tracts of wetlands by using them as construction sites. In addition to the physical losses of coastal wetland acreage resulting from construction, the functional quality of some wetland habitats also has been degraded by human activities. The most severe adverse impacts on wetland quality result from industrial and municipal pollution from many point sources throughout the Great Lakes region. Polluted urban and agricultural runoff also contribute to the functional degradation of wetland quality. Consequently, these valuable coastal wetland resources are constantly subject to both permanent acreage losses and quality degradation from both human activities and natural processes.

STUDY OBJECTIVES

The purpose of this study was to conduct an historical assessment to determine trends in shoreline position and areal changes in adjacent wetlands over the last few decades, focusing on a critical coastal wetland sector along the Wisconsin shoreline of Lake Michigan. Defining these past trends is necessary in an effort to predict future trends in coastal-zone behavior, which in turn is essential for effective environmental and coastal land-use management programs.

The studied critical sector is the coast of lower Green Bay in southern Oconto and Brown Counties (fig. 1). This relatively flat, low-lying coastal sector includes ecologically important wetland tracts that have been adversely impacted by both natural lake-level fluctuations and human activities. Urban development associated with the City of Green Bay has substantially changed wetland acreage. In addition, the quality of lower bay waters and associated wetlands has been severely degraded by the cumulative long-term pollution effects from a combination of industrial, municipal, and agricultural sources. The lower bay area adjacent to the City of Green Bay and the lower Fox River, which enters the bay along the city shoreline, have together been identified by the International Joint Commission (1985) as one of 42 Great Lakes Areas of Concern (AOC) because of poor water-quality conditions. This water-quality problem is largely the result of pollution discharging from the highly industrialized Fox River, which introduces a large variety of toxic organic and heavy-metal contaminants into the lower bay ecosystem. The Fox River also discharges large volumes of turbid water into the bay, and discharges high concentrations of agricultural nutrients, such as phosphorus, that cause excessive algal blooms and eutrophication. All of these contaminants have severely degraded the lower bay waters, bay-bottom sediments, and the surrounding coastal wetlands. In turn, this has adversely affected local fish and wildlife populations, and has greatly reduced public benefits from these resources. The Wisconsin Department of Natural Resources (WDNR) now has a Remedial Action Plan to guide the restoration and future preservation of the lower Green Bay-lower Fox River ecosystem over the next 15-20 years (Wisconsin Department of Natural Resources, 1988). The plan includes a key provision for the preservation, rehabilitation, and effective future management of the remaining wetland habitats in the lower Green Bay region. The shoreline and wetland trends outlined in this study will contribute to the scientific database needed to help accomplish these planned coastal-zone management objectives. A similar investigation was conducted along the west shore of Green Bay north of this study area (Shideler, 1994).

METHODS

Along the lower Green Bay coastal sector, two localities were selected for historical assessment studies to determine trends in shoreline and coastal wetland variability during the 1951-86 period; the sites are the Little Tail Point locality (Maps A, B) and the Long Tail Point-Fox River locality (Maps C, D). At both localities, temporal changes in shoreline position and morphology were determined from a comparative analysis of vertical stereoscopic aerial photography flown during 1951 and 1986. The earlier photography consisted of black-and-white photographs at a 1:23,600 scale. The later photography consisted of color-infrared photographs at a 1:58,000 scale. Using a photogrammetric plotter, shorelines were mapped on the two sets of aerial photographs and transferred to scale-stable base maps consisting of the latest revision of U.S. Geological Survey (USGS) topographic quadrangles (1:24,000 scale). The photogrammetric plotter both eliminated any error resulting from optical distortions of the imagery and permitted the reduction of multi-scale photographic data to a common-scale base map for comparison. The total maximum plotting error was approximately 150 ft. The USGS topographic quadrangles used as base maps also were originally prepared by field-checked photogrammetric methods from aerial photographs, supplemented by U.S. National Ocean Survey/National Oceanic and Atmospheric Administration (NOS/NOAA) hydrographic data. In the present study, the position of the shoreline and the distribution of coastal wetlands outlined on the USGS topographic base maps were assumed to be the existing conditions at the time of map publication (1974 for Little Tail Point locality, 1982 for Long Tail Point-Fox River locality), and were used as a reference baseline for comparing conditions interpreted from the earlier (1951) and later (1986) aerial photography. This allowed an incremental comparison of shoreline and wetland changes at the two localities over a 35-year time period. At the Little Tail Point locality, incremental comparisons were made for the 1951-74 (23-year duration) and 1974-86 (12-year duration) time intervals. At the Long Tail Point-Fox River locality, comparisons were made for the 1951-82 (31-year duration) and 1982-86 (4-year duration) intervals. Only coastal wetlands contiguous to the shoreline were evaluated during this study; wetlands further inland were excluded from consideration. Lake Michigan water levels during the dates of photography were determined from hydrographic charts of the monthly mean levels of the Great Lakes (U.S. Dept. of Commerce, 1987), which helped in the interpretation of coastal changes.

Changes in shoreline positions and morphology were interpreted in terms of coastal erosion or accretion. Erosional areas were indicated by shoreline recession resulting from a combination of both submergence and the physical removal of coastal sediments. Accretionary areas were indicated by shoreline progradation resulting from a combination of emergence and sediment accumulation. Erosional and accretionary areas are mainly the result of natural processes; however, local man-induced effects resulting from excavations, landfills, and other construction activities also were included. In areas designated as wetlands on the USGS topographic maps, coastal erosion represented a net loss in wetland area. In contrast, coastal accretion generally represented a net gain in wetland area, possibly with a few minor exceptions at urban landfill sites. Differences in areas of wetlands during specific time intervals were determined using the GSMAP computer program (Selner and Taylor, 1992). This program used a planimetric approach, which required the digitization of wetland areas for the comparative time intervals; the areal differences for specific time intervals were then calculated in terms of net losses and gains of wetland acreage for the two study sites; these areal changes are summarized in table 1.

The methods used in this study are based on certain assumptions and the results are subject to some limitations. A basic assumption is that the shoreline positions and coastal wetland distributions illustrated on the 1974 and 1982 USGS topographic quadrangle maps, which were used as the reference baseline for comparisons, actually represented the existing conditions at the time of their publication. It should be noted that in the preparation of these two topographic maps, the standard cartographic procedure was to photogrammetrically normalize the shoreline position (determined from aerial photographs) to reflect an approximate mean lake-level elevation of 580 ft above sea level; however, the actual lake levels at the time of the source photography was somewhat lower (<1 ft). Consequently, this could result in some overestimation of wetland losses indicated by shoreline recession during the earlier comparison periods (1951-74, 1951-82), and an underestimation of wetland losses during the later comparison periods (1974-86, 1982-86). However, the use of the mean lake-level elevation as a reference baseline does have the advantage of eliminating problems associated with short-term (annual) variations in shoreline positions, thus providing a more stable long-term datum. Another uncertainty in the present study is the amount of new wetland acreage developed inland from the shoreline after high-water inundations. A quantitative assessment of these inland wetlands was beyond the scope of the present study; however, their development could partially mitigate some of the shoreline wetland losses reported in this study.

DISCUSSION

Regional Setting

Green Bay is a relatively shallow, elongated appendage of Lake Michigan about 78 mi long. The maximum water depth in the lower bay offshore from the study localities is about 30 ft near the northern part of the Little Tail Point locality and decreases southward toward the head of the bay. Most of the lower bay adjacent to the study localities is generally less than 18 ft deep. Green Bay is separated from Lake Michigan by the Door Peninsula, a promontory underlain by Silurian dolomite and veneered by a variable thickness of late Wisconsin glacial and lacustrine deposits. Structurally, the eastward-dipping Silurian rocks of the Door Peninsula form part of the northwestern margin of the Michigan Basin. The shore along lower Green Bay in Oconto and Brown Counties, site of the two study localities, is a relatively flat and low-lying coastal sector, which represents a late Wisconsin silt and clay lacustrine plain (Lineback and others, 1983). The Quaternary deposits along this lower bay coastal sector range from less than 50 ft to more than 100 ft in thickness (Trotta and Cotter, 1973) and overlie Ordovician dolomitic bedrock.

The lower Green Bay shore is well suited for the development of coastal wetlands. The flat and low-lying area is highly susceptible to lake-level fluctuations and periodic inundation, which can occur at varying time scales. Relatively short-period fluctuations (hours to days), such as storm surges and seiches, are transient weather-related events. Wave erosion and inundation during severe storms can result in substantial shoreline and wetland changes, the cumulative effects of which are a major component of longer-term coastal trends. The study localities are also subject to seasonal inundations by higher summer lake levels (annual variations of the Lake Michigan level are generally in the 1.0-1.5 ft range). These annual variations are superimposed on longer period (10-20 years) climate-controlled lake level fluctuations. During the time interval covered by this study, hydrographic charts (U.S. Dept. of Commerce, 1987) indicate that Lake Michigan had relatively high mean water levels resulting from above-normal precipitation during the 1952-53, 1973-74, and 1985-86 periods. The maximum monthly mean water levels during these three periods are the following (elevations in feet above mean water level at the 1955 International Great Lakes Datum): 1952-53, 580.95 ft; 1973-74, 581.15 ft; and 1985-86, 581.65 ft. The highest monthly mean water level (581.65 ft) occurred in October 1986; this was the highest level in over a century and it caused extensive flooding and erosion along the Lake Michigan shoreline. In addition to lake-level fluctuations, this section of the coastline is also influenced by stream runoff. Four rivers associated with substantial wetland development enter Lake Michigan along this sector of lower Green Bay. The general physiographic, biotic, and cultural features of the coastal wetlands at the two study localities discussed in this report have been summarized by Herdendorf and others (1981). In addition, the Remedial Action Plan (Wisconsin Department of Natural Resources, 1988) for the lower Green Bay-Fox River AOC also discusses the regional setting of the Long Tail Point-Fox River locality. Land use along the lower bay coastal zone is variable. The land is mainly rural open space and agricultural at the Little Tail Point locality and in the northern half of the Long Tail Point-Fox River locality. Farther southward, land use ranges from urban open space to highly industrial and residential in the vicinity of the City of Green Bay.

Little Tail Point Locality

The Little Tail Point locality is in southern Oconto County and northern Brown County in the Little Tail Point and Suamico 1:24,000-scale topographic quadrangles (Maps A, B). Physiographic features in this locality include Little Tail Point, a prominent southward-trending barrier spit structure, and the mouths of the Suamico River and the Little Suamico River. Coastal wetlands at this locality form a nearly continuous tract along the northeast-southwest trending shoreline. Most of the wetland tract is directly exposed to bay waters; the only wetlands that are partially protected are those that occur shoreward of the Little Tail Point spit. The total aggregate acreage of coastal wetlands within about 1¼ miles inland of the shoreline at this locality, as indicated on the 1974 USGS topographic quadrangles, is approximately 931 acres; of this amount, approximately 376 acres occur in Oconto County and 555 acres in Brown County. Some of the wetland acreage in Brown County, near the mouth of the Suamico River, has been designated as the Sensiba State Wildlife Area.

Shoreline and Wetland Changes (1951-74)

In general, the Little Tail Point locality during the 1951-74 interval was a site where local erosional areas slightly exceeded local accretionary areas, which resulted in a small net loss (5.5 acres) of wetlands over the 23-year period. Using the 1974 shoreline position as a reference baseline, the 1951 shoreline was further bayward (east) at various locations; this indicates local areas of shoreline recession and the erosional loss of some wetland acreage over this time interval. The overall loss of wetlands was relatively minor, amounting to 64.6 acres. The locations of the greatest wetland acreage losses were in the vicinities of the Sensiba State Wildlife Area (20.4 acres), the Little Suamico River mouth (15.5 acres), the Suamico River mouth (7.4 acres), and the southern terminus of Little Tail Point (5.9 acres); the remaining erosional losses of wetlands were along small localized areas distributed along the rest of the shoreline.

In contrast to shoreline recession and erosional wetland losses, the 1974 shoreline position was further bayward of the 1951 shoreline along various coastal sectors; this indicated local areas of shoreline progradation and coastal accretion, resulting in localized gains of wetland acreage during the 1951-74 interval. The total gain of wetlands from accretionary processes was also relatively minor and amounted to 59.1 acres, which was slightly less than the amount of erosional wetland losses. Most accretion and wetland gains occurred in the vicinities of the Little Suamico River mouth (22.6 acres), the Sensiba State Wildlife Area (12.8 acres), and at the head of Dead Horse Bay (9.6 acres) at the southern extremity of the locality; the remaining gains in wetland acreage were distributed in small areas along the rest of the shoreline. Some small accretionary gains are associated with manmade coastal structures (groins, boat docks), such as those immediately north of the Sensiba State Wildlife Area.

Some coastal sectors showed no significant net changes in the 1951 and 1974 shoreline positions, indicating equilibrium conditions and areas of relative coastal stability during this time interval. Relatively stable coastal sectors included substantial segments of the undeveloped shoreline along the Little Tail Point spit, and a short residentially developed sector immediately north of the Suamico River mouth.

Shoreline and Wetland Changes (1974-86)

During the 1974-86 interval, the locality had only very minor accretion and was generally characterized by extensive shoreline recession and erosion, resulting in a large net loss (494.6 acres) of wetland acreage over this 12-year period. Relative to the 1974 shoreline position, the 1986 shoreline was further inland throughout most of the locality, reflecting inundation by higher bay water levels (the 1986 water level at the time of photography was about 1 ft higher than the 1974 level). The total erosional wetland losses throughout the locality during this time interval amounted to 504.5 acres. The sites of the most extensive wetland acreage losses were along the following shoreline sectors: Little Tail Point (112.4 acres), Sensiba State Wildlife Area vicinity (109 acres), vicinity of the Little Suamico River mouth (105.6 acres), the mainland sector landward of the Little Tail Point (97.4 acres), and the head of Dead Horse Bay immediately south of the Suamico River mouth (72.7 acres).

There was very little shoreline progradation and coastal accretion that resulted in a gain of wetland acreage during the 1974-86 interval. Four small accretionary areas localized near the base and terminus of the Little Tail Point spit resulted in a total gain of only 9.9 acres of wetlands. There were also very few areas of coastal stability that were indicated by an absence of change in the 1974 and 1986 shoreline positions. The only relatively stable shoreline sectors were along the eastern side of the central part of the Little Tail Point spit, and the residentially developed sector immediately north of the Suamico River mouth. The extensive net erosional wetland loss during the 1974-86 interval, in conjunction with the small net erosional loss during the preceding 1951-74 interval, resulted in a total net loss of 500 acres of wetlands at the Little Tail Point locality over this 35-year period.

Long Tail Point-Fox River Locality

The Long Tail Point-Fox River locality is entirely in Brown County immediately south of the Little Tail Point locality, and in the West Green Bay and East Green Bay 1:24,000-scale topographic quadrangles (Maps C, D). The locality represents the western half of the lower Green Bay-Fox River AOC addressed by the WDNR Remedial Action Plan. Physiographic features along this coastal sector include Long Tail Point, a prominent southeasterly trending barrier spit separated from the mainland by Dead Horse Bay. The sector also includes the mouths of the Fox River and Duck Creek, which enter the head of Green Bay in the western part of the City of Green Bay. The lower bay also has several small bayhead islands and a dredged navigation channel extending bayward from the mouth of the Fox River. Extensive coastal wetlands occur west of the Fox River mouth along the city's bayfront shoreline. Wetlands also extend northward along the shoreline intermittently to Long Tail Point, which also contains an extensive wetland tract; most of the wetland acreage north of the city has been designated as the Green Bay West Shores State Wildlife Area. Most of the coastal wetlands west of the Fox River mouth are directly exposed to bay waters. Some wetlands also occur in the city east of the Fox River mouth, primarily in an area that has been designated as a wildlife sanctuary; this wetland tract occurs somewhat inland from the bayfront shoreline, and is protected from direct exposure to bay waters by roads and other cultural features. Very little coastal wetland area occurs along the steeper eastern shore of lower Green Bay, except in the vicinity of a low-lying spit structure (Point au Sable) located east of the locality. The total aggregate acreage of coastal wetlands within about 1¼ mi inland of the shoreline at the Long Tail Point-Fox River locality is approximately 1,353 acres, as indicated on the 1982 USGS topographic quadrangles.

Shoreline and Wetland Changes (1951-82)

During the 1951-82 interval, the Long Tail Point-Fox River locality was characterized by very extensive shoreline recession and major erosional losses of wetland acreage, with relatively minor wetland gains in accretionary areas; this resulted in a large net loss of 635.9 acres of wetlands over the 31-year period. The total erosional losses of wetland acreage at the locality was 740.3 acres. The area of greatest wetland loss was a prominent bird-foot delta at the mouth of Duck Creek along the southern half of the Peats Lake embayment. In 1951, the Duck Creek delta was comprised of 336.2 acres of wetlands, all of which were destroyed by 1982. There was no reduction in the sediment load of Duck Creek during this time period that would have reduced the deltation process (R.L. Fassbender, WDNR, oral commun., 1993). The wetland delta was a highly visible and conspicuous feature on 1951 aerial photography that was taken when lake level was at a relatively low elevation (578.64 ft). The main destruction factor was probably subsequent periods of mean high water levels, such as during the 1952-53 (580.95 ft) and 1973-74 (581.15 ft) periods; the high water levels resulted in the widespread inundation and destruction of the deltaic wetland vegetation. Another probable contributing factor to the loss of the Duck Creek delta was permanent destruction effects from a severe storm in April 1973. This storm was accompanied by high-velocity northeasterly winds that produced wind tides several feet above normal water level, resulting in widespread flooding along the lower Green Bay coast (R.L. Fassbender, WDNR, oral commun., 1993). This severe storm probably caused a large-scale redistribution of shallow bayfloor sediments; this may have included the erosional destruction of the deltaic substrate, thus preventing the subsequent re-establishment of wetland vegetation. In addition to the loss of the Duck Creek delta, some wetland loss (30.1 acres) also occurred farther upstream along Duck Creek west of Highway 41; this may be a man-induced effect associated with highway construction and diversion of the Duck Creek watercourse during the 1960's. The city's bayfront shoreline southeast of Duck Creek also experienced some losses (30.7 acres); these losses appear to be mainly from natural erosional processes, except for a slip excavation in the area immediately east of the Fox River mouth. A second location experiencing a major erosional wetland loss, amounting to 101.1 acres, was in the vicinity of Peters Marsh. There was also the complete loss (41.3 acres) of an entire sequence of bayhead islands that extended southeasterly from Peters Marsh to Cat Island. Other bayhead islands in the vicinity of Cat Island also were partly eroded, resulting in some acreage loss (12.3 acres). The loss of the bayhead islands can also probably be attributed to a combination of high water levels and the destructive erosional effects of the April 1973 storm. The Long Tail Point spit, which is part of the Green Bay West Shores State Wildlife Area, also experienced major erosional wetland losses amounting to 142.3 acres along the length of the spit. Minor erosional losses occurred along the mainland coast west of Little Tail Point and at the head of Dead Horse Bay where some small islands (6 acres) were destroyed.

Coastal accretion that resulted in gains of wetland acreage was relatively minor during the 1951-82 interval. The total gain of coastal land from accretionary processes amounted to 104.4 acres. Much of this accretion was not associated with natural processes and shoreline progradation, but resulted from man-induced effects. The largest accretionary area (52 acres) is a man-made spoil island (Renard Isle) located just east of the Fox River mouth. This island is a confined disposal facility constructed in 1978 by the U.S. Army Corps of Engineers from spoil materials dredged from the Port of Green Bay harbor and navigation channel. The island presently serves as an important tern nesting area and habitat for some endangered species. Accretionary gains of 20 acres also occurred along the city's bayfront shoreline east of Duck Creek; these gains appear to be largely the result of man-induced effects reflecting landfills. Natural accretion and wetland gain (24.5 acres) occurred in small localized areas distributed along the length of Long Tail Point. Additional small areas of accretion also occurred on some bayhead islands in the vicinity of Cat Island (4.8 acres) and as channel fill (3.2 acres) along the former course of Duck Creek near the Highway 41 crossing. There also appears to have been some very minor incipient shoreline accretion landward of Renard Isle. Relatively stable coastal sectors, as indicated by no significant changes in the 1951 and 1982 shoreline positions, included much of the city's bayfront shoreline east of the Fox River mouth. After the destructive effects of the April 1973 storm, a protective flood-control dike system was constructed later that year by the U.S. Army Corps of Engineers along this bayfront sector. Small coastal sectors along the mainland west of Long Tail Point also were relatively stable during this time interval.

Shoreline and Wetland Changes (1982-86)

During 1982-86, the Long Tail Point-Fox River locality was characterized by continued shoreline recession and the extensive erosional losses of additional wetland acreage, with only very minor local areas of wetland accretion; this resulted in a large net loss of 402.2 acres of wetlands over the 4-year period. The continued shoreline recession and erosion can be attributed to inundation by higher bay water levels during the 1985-86 period (at the time of the 1986 photographs the bay was about 1 ft higher than the 1982 level). The total erosional loss of wetlands was 420.7 acres. The greatest erosional loss was at the mouth of Duck Creek and vicinity, where the loss amounted to 204.5 acres; most of this wetland acreage loss occurred east of the Highway 41 crossing, but some loss (46.6 acres) also occurred west of crossing. The city's bayfront shoreline east of Duck Creek also experienced some erosional losses (32.3 acres), where the shoreline receded landward to the positions of flood-control dikes. The area that experienced the second greatest loss of wetlands was Long Tail Point (123.6 acres). In 1985-86, this low-lying spit was inundated and much of it submerged by the high water levels, resulting in a substantial reduction in subaerial wetland acreage along the length of the spit. Other areas of erosional wetland losses were the Peters Marsh vicinity (27.4 acres), along the mainland west of Long Tail Point (26 acres), and the small bayhead islands in the vicinity of Cat Island (5.3 acres).

Accretionary gains in wetland acreage during 1982-86 were very minor, amounting to a total of only 18.4 acres. Small local areas of accretion (11.7 acres) occurred along the shoreline of Peats Lake and Peters Marsh. Other small accretionary areas (6.7 acres) were located near the Fox River mouth, which may be largely landfills; a small amount of shoreline accretion also occurred landward of Renard Isle. A few relatively stable coastal sectors, as indicated by no significant changes in the 1982 and 1986 shoreline positions, were located mainly along the city's diked bayfront shoreline at the eastern extremity of the locality, and the mainland shoreline along the northern half of Dead Horse Bay. The extensive erosional net loss of wetlands during the 1982-86 interval, combined with the previous extensive net losses during the 1951-82 interval, resulted in a total net loss of 1,038 acres of wetlands at the Long Tail Point-Fox River locality over this 35-year period.

SUMMARY

The lower Green Bay coastal zone experienced substantial variability in shoreline positions and adjacent wetland acreage during the 1951-86 interval. Climate-induced lake level fluctuations and storm effects resulted in predominantly erosional shorelines at two localities, which caused a total net loss of approximately 1,500 acres of coastal wetlands over the 35-year period. The Little Tail Point locality in southern Oconto and northern Brown Counties experienced a 500-acre erosional net loss of coastal wetlands, with most of the loss occurring during the 1974-86 interval as a result of high bay water levels. The Long Tail Point-Fox River locality in Brown County, which is part of a Great Lakes AOC, experienced a 1,038-acre net loss of coastal wetlands. The greatest loss occurred during 1951-82, as a result of high bay water levels and a severe 1973 storm event; the remaining loss occurred during the 1982-86 period as a result of high bay water levels. This study has documented substantial past losses of wetland acreage in the lower bay region. Future wetland losses in the region may be mitigated by a trend of lower lake levels since 1986, and by the program of future wetland protection and management presented in the State Remedial Action Plan.

ACKNOWLEDGMENTS

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REFERENCES CITED

Herdendorf, C.E., Hartley, S.M., and Barnes, M.D., eds., 1981, Lake Michigan, Volume 5 of Fish and wildlife resources of the Great Lakes coastal wetlands within the United States: U.S. Fish and Wildlife Service, FWS/OBS-81/02-v. 5, 1,592 p.

International Joint Commission, 1985, Report on Great Lakes water quality: Kingston, Ontario, Great Lakes Water Quality Board, 212 p.

Larsen, C.E., 1989, Geological history of glacial Lake Algonquin and the upper Great Lakes: U.S. Geological Survey Bulletin 1801, 36 p.

Lineback, J.A., Bleuer, N.K., Mickelson, D.M., Farrand, W.R., and Goldthwait, R.P., 1983, Quaternary geologic map of the Chicago 4°x 6° quadrangle, United States: U.S. Geological Survey Miscellaneous Investigations Series Map I-1420 (NK-16), scale 1:1,000,000.

Selner, G.I., and Taylor, R.B., 1992, System 8; GSMAP, GSMEDIT, GSMUTIL, GSPOST, GSDIG, and other programs version 8, for the IBM PC and compatible microcomputers, to assist workers in the earth sciences: U.S. Geological Survey Open-File Report 92-217, 217 p.

Shideler, G.L., 1994, Shoreline and coastal wetland variability along sections of the west shore of Green Bay, Marinette and Oconto Counties, Wisconsin: U.S. Geological Survey Miscellaneous Field Studies Map MF-2252, scale 1:24,000.

Trotta, L.C., and Cotter, R.D., 1973, Depth to bedrock in Wisconsin: Wisconsin Geological and Natural History Survey Map, scale 1:1,000,000.

U.S. Department of Commerce, 1987, Hydrograph of Monthly Mean Levels of the Great Lakes (1860-1987): U.S. National Ocean Survey/National Oceanic and Atmospheric Administration, Washington, D.C.

Wisconsin Department of Natural Resources, 1988, Lower Green Bay Remedial Action Plan: Madison, PUBL-WR-175-87, REV88, 319 p.

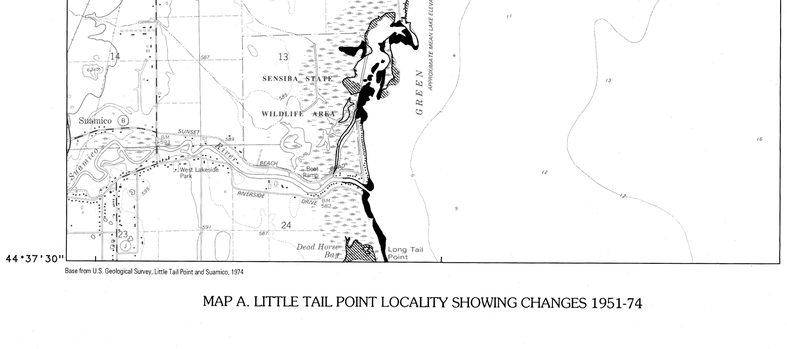
Table 1.—*Summary of coastal wetland areal changes, lower Green Bay, Oconto and Brown Counties, Wisconsin*

Time Interval		Areal Changes (in acres)
Little Tail Point locality		
1951-74	Erosion	64.6
	Accretion	59.1
	Net change	5.5 loss
1974-86	Erosion	504.5
	Accretion	9.9
	Net change	494.6 loss
1951-86	Total net change	500.1 loss
Long Tail Point-Fox River locality		
1951-82	Erosion	740.3
	Accretion	104.4
	Net change	635.9 loss
1982-86	Erosion	420.7
	Accretion	18.4
	Net change	402.2 loss
1951-86	Total net change	1,038.1 loss*

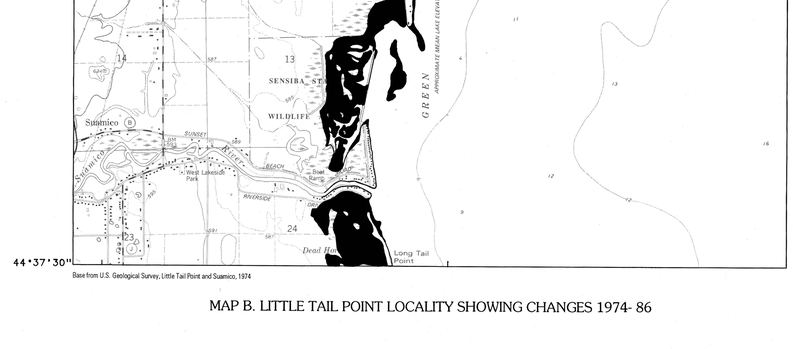
*May include small amounts of nonwetland acreage along the City of Greey Bay shoreline

CONVERSION FACTORS

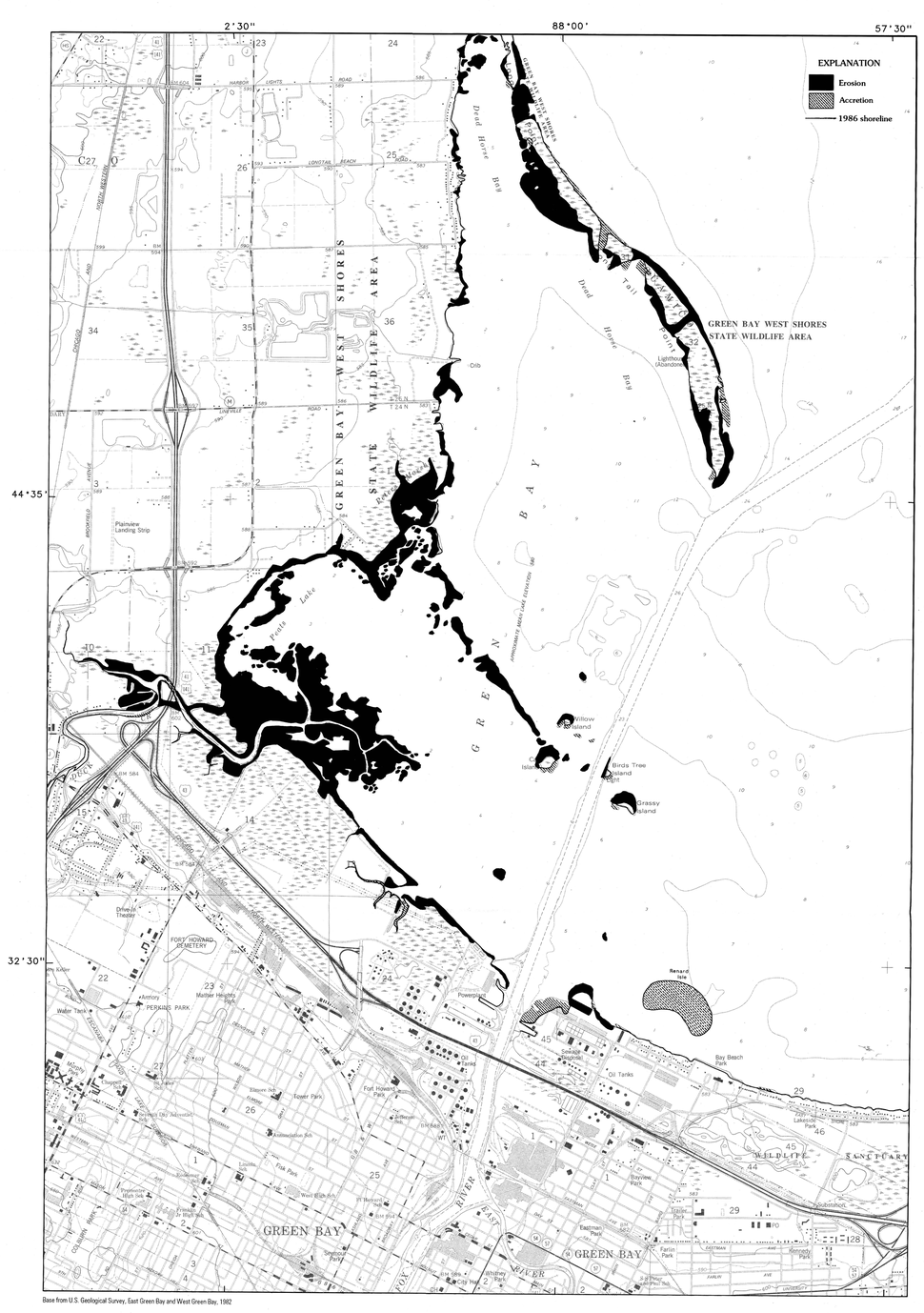
Multiply	By	To obtain
inches (in)	2.54	centimeters (cm)
feet (ft)	0.3048	meters (m)
miles (mi)	1.609	kilometers (km)



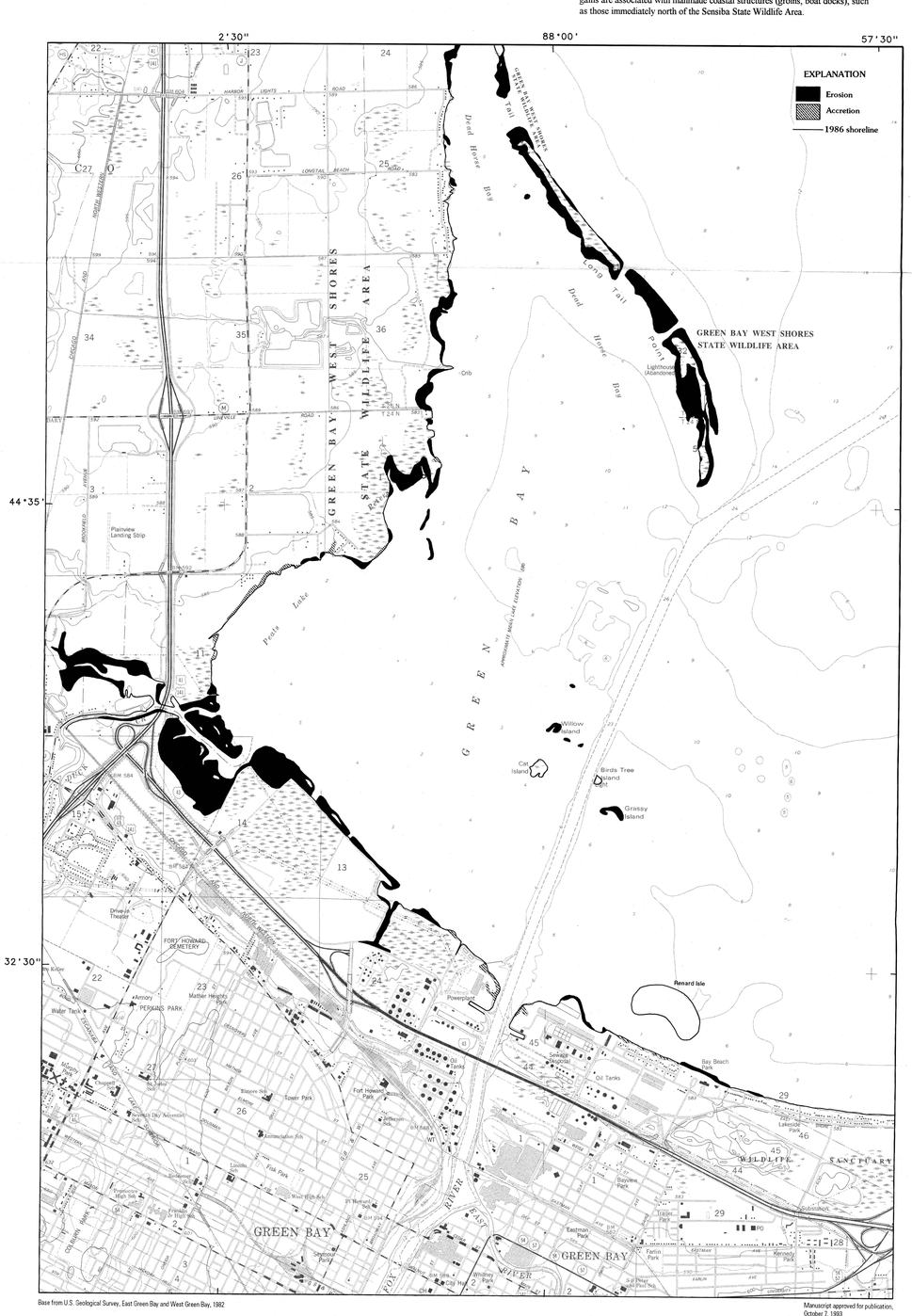
MAP A. LITTLE TAIL POINT LOCALITY SHOWING CHANGES 1951-74



MAP B. LITTLE TAIL POINT LOCALITY SHOWING CHANGES 1974- 86



MAP C. LONG TAIL POINT—FOX RIVER LOCALITY SHOWING CHANGES 1951-82



MAP D. LONG TAIL POINT—FOX RIVER LOCALITY SHOWING CHANGES 1982-86

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SCALE 1:24 000
1 ½ 0 1 2 3 MILES
1 .5 0 1 2 3 KILOMETERS
CONTOUR INTERVAL 5 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929
DEPTH CURVES AND SOUNDINGS IN FEET—DATUM IS LOW WATER 576.8 FEET

TEMPORAL VARIABILITY OF SHORELINE POSITIONS AND COASTAL WETLANDS ALONG LOWER GREEN BAY, OCONTO AND BROWN COUNTIES, WISCONSIN

By
Gerald L. Shideler
1994

INTERIOR—GEOLOGICAL SURVEY, RESTON, VIRGINIA—1994

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