

An aerial photograph of a coastal area, likely Kenosha County, Wisconsin, showing a shoreline with various buildings, roads, and a large body of water (Lake Michigan). The image is in black and white and has a high-contrast, grainy appearance. The shoreline is visible on the left and bottom, with buildings and roads extending inland. The water occupies the right and top portions of the image.

**ASSESSING COASTAL  
DEVELOPMENT ALONG  
KENOSHA COUNTY'S  
LAKE MICHIGAN  
SHORELINE:  
1978 - 1992**

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393  
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N54  
1995

**Prepared for the Wisconsin  
Coastal Management Program**

**July 1995**

Acknowledgements

**FUNDED IN PART BY THE WISCONSIN COASTAL MANAGEMENT PROGRAM**

Financial assistance for this *Research/Study Project* was provided by the Coastal Zone Management Act of 1972, as amended, administered by the Office of Ocean and Coastal Resource Management, National Oceanic and Atmospheric Administration pursuant to grant #NA370Z0349 and the **WISCONSIN COASTAL MANAGEMENT PROGRAM**.

**THE WISCONSIN COASTAL MANAGEMENT PROGRAM**, part of Wisconsin Department of Administration, and overseen by the **WISCONSIN COASTAL MANAGEMENT COUNCIL**, was established in 1978 to preserve, protect and manage the resources of the Lake Michigan and Lake Superior coastline for this and future generations.

The Project Team

This project required coordination and completion of several steps including map documentation, photo preparation, photo interpretation, digital area/linear measurement and data sheet preparation. The following students worked as a team to help complete this project.

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Invaluable help was provided by Karen Katers to coordinate preparation of the manuscript and project data sheets, and to manage student employment records. Her contribution deserves special recognition as part of the project team.

Also, a special thanks is made to the U.S. Army Corps of Engineers who allowed access to the aerial photos used in this project.

731  
NS4 152  
H 7393.116

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Assessing Coastal Development Along Wisconsin's  
Great Lakes Shoreline: 1978 - 1992

Coastal Management Program Contract No. 840005-501.15

INTRODUCTION

The Wisconsin Coastal Management Program mission includes developing an understanding of change along the state's Great Lakes shoreline. Such change, of course, can be natural or human-based. This study was undertaken to document natural and human-based development within the coastal zone of the state's Lake Michigan and Lake Superior shorelines. The Wisconsin legislature has defined coastal zone as land within 1,000' (304.8 meters) of the shoreline (Ordinary High Water Mark - OHWM).

Future coastal zone planning and risk assessment requirements defined the types of data to be collected. Assessment of risk to structures built in the coastal zone requires a temporal analysis of structural development and shoreline modification(s). Planning of the coastal zone requires, as well, determination of the natural resource base. This study utilized U.S. Army Corps of Engineers historic color aerial photographs taken in 1978 and 1992.

This report documents both the original and amended contract to assess natural and developmental change within the coastal zone of Wisconsin's Great Lakes shorelines. Although the original contracted work was interrupted to include elements of the amended contract, no attempt will be made in this report to keep separate original vs. amended objectives, procedures or results. Goals of the amended contract include and expand those of the original.

PROJECT GOALS

Planning and assessment of hazards within the coastal zone defined the goals of this study. Within the Lake Michigan and Superior coastal zones, project goals included:

- Development of land use databases for 1978 and 1992
- Development of 1978 and 1992 databases of human modification of the shorelines
- Develop a database of built structures for 1992

Additional goals included:

- Assess land use change within the coastal zone from 1978 to 1992
- Assess human modification of the shoreline from 1978 to 1992

STUDY AREA

The project study area comprises the Wisconsin portion of the Lake Michigan and Lake Superior coastal zone (Figure 1). In 1982, the Wisconsin state legislature defined coastal zone as being that land within 1,000 feet (304.8 meters) of lake shoreline. Accordingly, the study area represents a 1,000' wide



Figure 1. Coastal Counties of Lake Michigan and Lake Superior

zone, the landward boundary of which is parallel to the coastline.

## PROJECT METHODS

### Aerial Photography

Using aerial photos to assess coastal development requires clear statement of goals, appropriate definition of coastal zone, meaningful classification scheme, appropriate historical and current aerial photos, appropriate interpretation procedure and method of documentation, and trained personnel.

Application of aerial photography to assess urban and natural resource features is documented well (Smith, 1968; Avery and Berlin, 1985; Lo and Noble, 1990; Ciciarelli, 1991; Boge et al., 1992; Hinckley and Walker, 1993). Specific applications to urban/human activities cover a wide range including urban nonpoint pollution assessment (Kim and Ventura, 1993), gully erosion analysis (Welch et al., 1985), historical analysis of urban development into coastal wetlands (Niedzwiedz and Batie, 1984), identifying structural additions to urban residential property (Niedzwiedz, 1990), and studying agricultural land use (Marsh et al., 1990).

Aerial photos have been used to map archeological sites, urban features, and to document changes to the landscape (Smith, 1968). MacConnell (1975) reports the use of black and white aerial photography (scale 1:20000) to map 20 years of land use change within the state of Massachusetts, including the coastal zone. As part of a larger Great Lakes study, the International Joint Commission (1993) used 1:24000 scale photos to map land use features along the Berrien County, Michigan segment of the Lake Michigan shoreline. Results of the photo analysis were used to assess residential riparian erosion/recession rates caused by fluctuating water levels.

Wisconsin's coastal zone includes diverse land use, from forests and wetlands, to land devoted to agricultural or urban uses. The uses of aerial photos long have been applied to study such land uses. Befort and Viliman (1985) studied aerial photos to classify forest habitat. McCarthy et al. (1982) evaluated spruce-fir forests to aid management. Wetlands analysis is possible with aerial photos of appropriate format, scale and seasonal timing. Scarpace et al. (1981) used digitized aerial photos to map wetlands, while Ferguson et al. (1993) and Barrett and Niering (1993) have monitored sawgrass habitat and marsh vegetation change using aerial photos.

Extensive use of aerial photography has been directed at coastal resources. Scherz and Van Domelsen (1973) used aerial photos to help assess water quality in Lake Superior near Duluth, Minnesota. Numerous studies have been made with aerial photos to aid management of coastal resources (Benton et al., 1978; Hill et al., 1985; Norton et al., 1985; Welch et al., 1992), to address change in coastal wetlands (Lyon and Greene, 1992), and to

examine urban development into coastal wetlands (Niedzwiedz and Batie, 1984).

### Project Aerial Photos

In 1978, the U.S. Army Corps of Engineers (USACE) obtained panchromatic color aerial photos of the Wisconsin portion of the Lake Michigan coastline. In 1992, USACE obtained color aerial photo coverage of the Wisconsin portion of both Lake Superior and Lake Michigan coastlines. Both the 1978 and 1992 photos were flown at a scale of 1:6000 (1" = 500') and enlargements made at 1:2400 (1" = 200'). The 1978 photos were taken April 16<sup>th</sup>. The 1992 photos were flown May 13<sup>th</sup>.

Unlike most historical aerial photos covering the same area and flown at the same scale, the USACE photos of 1978 and 1992 were not flown with coincident photo centers or coverage. No individual flight lines were documented for the 1978 photos. Beginning at the Michigan border, the 1978 photos were taken incrementally to the Illinois border. Photos are documented with the photo date and photo number on the northern edge of each photo.

Flight lines were documented for the 1992 photos. Flight line #1 begins just south of the Wisconsin-Illinois border. The northern edge of each 1992 photo displays the photo date, flight line and photo number.

Both the 1978 and 1992 photo contact prints (1:6000) were flown to produce stereo coverage of the coastline. Adjacent photos overlap (endlap) about 60% with each other. The enlarged photos (1:2400) available for this study represent every other photo contact print, therefore, only photographic, not stereo coverage, is provided by the enlarged photos. Approximately 1,800 photos (1:2400) cover Wisconsin's Lake Michigan shoreline, 900 for each flight year. About 1,200 photos covering the shoreline from Marinette to Sheboygan are on file at the Green Bay office of USACE. The Waukesha office of USACE has on file about 600 photos covering the shoreline from Sheboygan to the Illinois border.

### Photo Preparation

Photos used in this study are owned by USACE. As a result, all photo documentation and interpretive work was applied to acetate affixed to each photo. Preparing photos for interpretation included the following:

1. Affix label and document photo number/flight line, photo date and Public Land Survey System (PLSS) information.
2. Mark photo fiducials (orange ink). Fiducials allow the registration of acetate overlays to the photos, if required.
3. Mark control points (orange ink). Typically these points are road intersections and/or buildings, stable objects



that could be referenced against controlled maps for future mapping applications.

4. Locate and mark interpretation boundary lines (black ink). These lines are used to denote a common boundary between adjacent photos. Land use interpretive lines end at these boundary lines, which eliminates redundant interpretive work.
5. Locate, mark and label PLSS section lines (red ink).
6. Locate, mark and label civil boundary lines (green ink).
7. Locate and mark 1,000' coastal zone boundary line (blue ink). A divider was used to scribe a line 1000' away and parallel to the line defined by land meeting water. In cases where large streams entered Lake Michigan, a straight dashed line was drawn to represent a continuation of the shoreline.
8. Locate and mark top of bluff, and bottom of bluff if slumpage is evident (black ink). In practice, these lines were not drawn until the shoreline portion of the classification scheme was applied to the photos. Refer to the section Photointerpretive Process (page 11) for additional discussion.

#### Aerial Photo Interpretation (API)

The landscape within the coastal zone can represent a complex mix of natural to urban uses. The land use classification scheme developed for this study addresses the complexity of Wisconsin's coastal zone. The scheme is a modification of the scheme developed by International Joint Commission (1993) and includes the general use categories of residential, commercial, industrial, transportation, extractive, agricultural, natural, open land and other uses. Land uses have been measured by area (acres, hectares). Structures per land use have been located and marked for spatial reference. Structures are tallied by type for 1992.

Modification of the shoreline also has resulted. Sea walls, revetments, groins and permanent docks have been constructed. Sea walls and revetments are linear types. Their interpretation and measurement are presented in feet (meters). Groins and docks were counted.

#### CLASSIFICATION SCHEME

##### Residential Land

All residential areas include infrastructure to service the area. Boundary placement is made to separate residential areas by type. No attempt is made to distinguish roads/streets from the residential areas they serve. This convention is true for other classification types as well.

- 111 Multi-Family: Medium to High Rise. Large residential structure of five (5) or more stories. Access roads, parking areas, open space and recreational facilities associated with the structure(s) would be included in the type.
- 112 Multi-Family: Low Rise. Large residential structures up to four (4) stories. Access roads, parking areas, open space and recreational facilities associated with the structure(s) would be included in the type.
- 113 Single Family, Duplex. Structures large and small used for residential use. The type includes lawn, landscaped areas, garage and driveways. Duplex structures are identified by twin driveways or a very wide driveway leading to an architecturally balanced structure.
- 115 Mobile Home Park. Residential area developed exclusively for mobile units.

#### Commercial and Industrial Land

Commercial land includes three (3) types: central business district; shopping center/mall; and, neighborhood business district. Each type includes all building structures, access roads/streets, parking facilities and other features commonly associated with each type.

- 121 Central Business District (CBD). Commercial land predominantly used for distribution or merchandizing of goods and services. Stores, hotels, office buildings, parking facilities and smaller warehouses constitute the components of this type. The CBD spatially is tight, vegetation is rare.
- 122 Shopping Center/Mall. These commercial areas have developed away from the CBD. The type includes both "strip" type development and malls. Structures can range from large, flat roofed and rectangular (centers) to large, geometrically shaped. Both types include large parking areas adjacent to or completely surrounding the commercial structures.
- 124 Neighborhood Business District (NBD). This type denotes small commercial areas within, or adjacent to residential areas. The type may be found in established or newer subdivision areas. NBD structures can range from conventional architecture to unusual geometric shapes. Small parking areas are associated with NBD commercial areas.

- 126 Institutional Land. The type reflects areas devoted to public or quasi-public uses. Examples include schools, churches, hospitals, prisons, etc., and their associated "grounds," green space, landscaping and parking facilities. When located within the CBD, public buildings without "grounds" often cannot be identified on aerial photos and would be classified as commercial (121).

#### Industrial Land

- 138 Industrial Park. The type includes both heavy and light industrial use areas.

Heavy industrial land contains facilities for the manufacture, storage and assembly of raw or partially processed products such as machinery, metals, chemicals, petroleum, or electrical power. Such industries often have large smokestacks and large storage areas. Warehouses and transportation facilities for bulk products and an open and interrupted street pattern characterize this type.

Light industrial land contains facilities for the manufacture or assembly of smaller, partially processed products such as electronics, appliances, and other secondary process products. Large smokestacks or raw material storage facilities are never present. Many modern light industries are well landscaped and are indistinguishable from commercial activity on aerial photographs.

#### Transportation Land

- 141 Air Transportation. Includes areas with airports and associated facilities, landing strips, hangers, parking areas and adjacent open areas.
- 142 Rail Transportation. This type includes railyards, terminal freight and storage facilities as well as stations for passengers. The type may include liquid storage facilities such as tank farms.
- 143 Water Transportation. This designation is applied to several water-based areas, including docks, warehouses and related land-based facilities for water transportation and commercial fishing. The type includes, as well, public marinas and their associated facilities: boat slips, buildings and parking areas.
- 143.1 Private Marina. Boat mooring areas adjacent to residential land are designated as private marinas. Often such areas include a protected slip(s), dredged waterway and, or a permanent docking structure built into the waterway.

- 143.2 Public Boat Landing. This type is applied to boat launching areas. Typically, facilities include only a ramp(s) from which boats may be launched and parking areas.
- 144 Divided Highway. This type includes transportation corridors with median strips between lanes. Typically, such roads are four or more lanes wide. Local streets are not included in this type.
- 145 Communications. Facilities and structures devoted to communications. These include radio/television towers, lighthouses and their grounds, buildings and parking areas.
- 146 Utilities. This type includes facilities for the production and distribution of energy. Such areas can include large buildings, towers, roads/parking facilities and, in the case of coal fired plants, large piles of raw coal.
- 147 Sewage Treatment Plant. Buildings, treatment lagoons, parking areas, access roads and grounds are included in this type.
- 148 Landfill. Landfill sites used to bury garbage define this type. Landfills cover an extensive area and are dominated by large excavated areas, mounds of exposed soil and access roads.

#### Extractive Land Use

- 171 Open Pit. The type represents open pit mining areas for extraction of sand, gravel, stone or rock. The type includes access roads and any structures.
- 172 Underground Mine. Mining of underground resources via shaft extraction. Surface features captured on aerial photos would be limited to small structures and access roads.
- 173 Well. Features associated with wells are limited. Identification of wells using only aerial photos is difficult.
- 179 Other Extractive Uses.

#### Agricultural and Natural Land

- 181 Abandoned Field (AF). These are agricultural units reverting to wild land. Woody vegetation and grass are abundant but tree crown cover is less than 30%. If tree crown cover were greater than 30%, the land would be classified as forest.

- 182 Agriculture Active (AG). Tilled or tillable crop land which is or recently has been intensively farmed. The boundaries on the ground usually are sharply defined and well maintained. The land supporting farm buildings is included as part of this type.
- 183 Forest (F). Areas of forest, deciduous, coniferous or mixed, having canopy closure of at least 30%. Areas with less than 30% canopy closure are classified as abandoned field.
- 184 Heath (H). Areas of heath plant community as well as grass, shrubs, and other low vegetation found on poor sandy soils.
- 185 Open Water (W). Areas of open water found in lakes, rivers and large streams. Water depth is greater than three feet during the growing season. The boundary of coastal water is located by drawing a line at the river mouth to connect the edges of the coastline, or man-made features like roads, railroads or bridges crossing rivers or inlets are used to establish such a line.
- 186 Rock Ledge (RL). Rock outcrop areas at the coastline or within the coastal zone. Such outcrops are common in Door County.
- 187 Slump Zone (SL). Land located between upland bluff and beach. Slump zones begin at the bluff line and slope down to the beach.
- 188 Wetland (WT). This type covers the full spectrum of wetlands. These include seasonally flooded flats, shrub swamps, meadows, bogs, shallow and deep marshes, and forested wetlands. Each is described below.

Seasonally flooded basins or flats occur principally on stream floodplains. The most common plants are grasses and herbaceous species. The soil is waterlogged or covered with water during spring freshets, but well-drained during the growing season.

Shrub swamps often have waterlogged soil during the growing season, as much as six (6) inches of water may be present. Vegetation types include elder, buttonbush, dogwood and willow. Sedges usually are present in tussocks.

Meadows are vegetated with grasses, rushes and sedges. Soils are waterlogged through most of the growing season. Surface water is present only for a short period during the spring.

Bogs are unique wetland types that support a distinctive plant community, including most of the following: heath shrubs, cranberries, pitcher plants and sedges. Scattered black spruce, tamarack and red maple may be present. A mat of sphagnum moss is the most common feature of bogs.

Shallow marsh is wetter than meadow. The soil is completely waterlogged and often covered with up to six inches of water during the growing season. The predominant vegetation is emergent, including such plants as cattails, bulrushes, burreed, pickerelweed and arrowhead with some grasses and sedges present. The type is common to open water bodies.

Deep marsh has water depth ranging from six inches to three feet. Fairly large open water areas are bordered by, or interspersed with, emergent vegetation like that found in shallow marsh. Floating and submergent plants such as water lilies, duckweed, watershield and pondweeds also are present.

Forested Wetlands. This type represents areas of moist to saturated soil covered by forest canopy. The type is difficult to identify without stereo photography and, or with "leaves-on" photography.

#### Open and Other Land

##### 191 Outdoor-Public Assembly

192 Urban Open Lots. Urban open is undeveloped land lying idle in the midst of urban areas or adjacent to them. This type includes land which has been cleared for urban development of an unknown use.

193 Outdoor Recreation. Outdoor recreation types are either mainly for participation, mainly for spectators, or are environmental in character. Each recreational type includes the recreational complex: access roads, parking facilities, buildings and other related facilities.

##### 194 Cemeteries

#### Shoreline Modification

Development along the lakeshore often means modification at, or near, the shoreline. Land along the lakeshore is exposed to significant erosional forces. Recession of land mass is common. Agricultural and urban land uses destabilize shoreland, in effect accelerating erosion and land recession. To protect real estate and property, many property owners have constructed walls or revetments along their shoreline. Some owners also have built non-flow-through docks at the shoreline to provide mooring and protection for their boats. Groins, large rock structures perpendicular to the shoreline, have been built along Wisconsin's Lake Michigan shoreline.

195 Sea Walls (V 195 V). These structures are built parallel to the shoreline and typically are well defined, linear

features. Construction materials can include concrete, wood or interlocking sheet steel.

- 196 Revetments (V 196 V). Large rock or slab structures built parallel to the shoreline. Interpretively, revetments are less well defined, and appear wider than do sea walls.
- 197 Groins ( \* [red] ). Groins are large rock structures built perpendicular to the shoreline into the water. Except for their distinct orientation and placement, groins appear similar to revetments.
- 198 Non-Flow-Through Dock ( \* [blue] ). Such docks are permanent structures built into near-shore waters. Typically these docks are straight, their upper surface wide and well defined.

#### Structures - Industrial, Commercial and Residential

On the 1992 photos, buildings within the coastal zone are classified by type and location. Using a template of rectangles, for each building, a rectangle is selected that best represents the area of the building's "footprint." The selected rectangle then is positioned so that the leading edge of the building (relative to the shoreline) is located. Buildings for 1978 were counted by type. However, due to photo format differences, comparison of 1978 and 1992 structural counts may be inaccurate.

#### THE PHOTOINTERPRETIVE PROCESS

After photo preparation, each photo was interpreted using the classification scheme defined above. Area (land uses), linear (shoreline modification) and point (urban structures, groins, docks) types are represented in this study. Lines and, or symbols were used to define all types. Area types are represented by perimeter boundary lines and symbols to define and identify the areas. Line types representing modification to natural shoreline were defined using both lines and symbols. All area and line type symbols are recorded in black ink. Point types are defined by symbols and colored ink (see above).

Modifications to the shoreline, such as sea walls or revetments, are delineated by placing (painting) the 'V' symbol at the beginning and end of the modification. The type of modification is represented by placing the appropriate number between the 'V' symbols. For example, 195 positioned between two 'V' symbols means that a sea wall has been built along this section of shoreline. Shoreline classification was conducted before land use so that land use boundary lines placed along the shoreline would not 'hide' shoreline information.

Groins and non-flow-through docks were defined by point symbols (see above). In both cases, the symbol was placed at the point where the structure meets land. As discussed above, for

1992, buildings also were classified using point symbols. The delineation of buildings represents the last API procedure.

#### MEASUREMENT OF AREA, LINE AND POINT TYPES LOCATED WITHIN THE COASTAL ZONE

Area types (land use polygons) and line types (shoreline modification) measurements were made using the hardware/software facilities of the GIS Lab at the University of Wisconsin-Green Bay. Photo acetate overlays were affixed to large-format digitizers and each land use polygon digitized along the perimeter. Measurements recorded in square inches were converted to acres/hectares. Line measurements (in inches) of shoreline modifications were made using digitizers as well. Linear inch measurements were converted to linear feet/meters for each type of modification.

Point types (groins, structures) simply were tallied by count for each type. The area covered by each acetate was broken into civil jurisdiction and PLSS section designations. Measurements (above) were separated by civil and PLSS designations as well, and documented permanently on each acetate overlay.

#### TALLY OF DATA

Measurements recorded on each photo acetate were transferred to data sheets. Three (3) levels of data sheets were used: PLSS Section Data; Civil Jurisdiction Summary Data; and County Summary Data (Appendix).

PLSS Section Data Sheet: One (1) PLSS Section Data sheet was used for each section located on a photo/acetate. Generally, 1-2 PLSS sections are located on a photo, however, up to four (4) sections per photo were recorded. Section level data sheets record photo documentation including photo year, photo number, county and community(ies) covered, and complete PLSS section location. Also recorded were number of residential, commercial, industrial and institutional structures (1992), area of land use by type, linear distance of sea walls and revetments, and the number of groins and non-flow-through docks.

Civil Jurisdiction Summary Data Sheet: This tally sheet summarizes the data for all PLSS section sheets found within each township, village or city. The sheet records photo year, county, name of civil jurisdiction, a complete listing of PLSS sections included in the summary, as well as all land use, shoreline and structure count data discussed above.

County Summary Data Sheet: The County Summary sheet summarizes all data for the towns, villages and cities located within the county. Documented information includes photo year, county name, an alphabetical listing of all civil jurisdictions within the county, and a summary of all land use, shoreline and



structure count data reported on Civil Jurisdiction Summary Data sheets.

#### LIMITATIONS AND SOURCES OF ERROR

The U.S. Army Corps of Engineers contracted for aerial photography of the Wisconsin portion of the Lake Michigan shoreline on April 21, 1978 and May 19, 1992. Both sets of photos are 1:6000 scale and panchromatic color, however, the 1978 photos are "leaves-off" while the 1992 photos are "leaves-on."

Copies of the original stereo photos (1:6000 scale) were not available for this study. Instead, enlargements (1:2400 scale) of the original photos were borrowed from Corps district offices in Green Bay and Waukesha. The enlargements provided photographic coverage only, not stereo coverage. Normally, for a project of this magnitude, photos would have been taken to meet the specific objectives of the study. The enlarged photos used for this project present limitations and introduce error beyond what would be reported with original photos flown specifically for this study. Limitations and errors associated with the photographs used are discussed below. Also presented below is discussion regarding methodological inconsistencies.

The following discussion of Limitations and Sources of Error is presented in an attempt to provide the reader a basic understanding of the issues. Any section of the discussion could apply to any of the results reported below. The Results sections of this report present findings without any comprehensive attempt to explain anomalies within, or between, the photo study years (1978 and 1992).

#### Photo Scale and Enlargements

All vertical aerial photographs not ratioed (enlarged or reduced to a common average scale) or rectified (common tilt/tip corrected to a horizontal reference plane) inherently are scale inaccurate. The original USACE photos (1978 and 1992) were not ratioed or rectified, therefore, their scale varies relative to topographic changes of the coastal zone, tip/tilt of the camera and changing elevation of the camera (aircraft). Enlargements of the original photos simply accentuate the inaccuracies found on the original photos.

Area and linear measurements taken off of the USACE enlarged photos reflect the inaccuracies inherent in those photos. Simple tests of shoreline distances for numerous PLSS sections within each county were conducted to establish linear accuracies of the photos. USGS topo sheets at 1:24000 scale were used to establish base shoreline distance measurements against which photo (1978 and 1992) shoreline distance measurements could be compared. No systematic errors were detected for the 1978 photos. However, only one (1) of 21 tests of the 1992 photos varied in the positive direction from USGS measurements. The remaining 20 tests varied in the negative direction and ranged from -0.8% to

-13.1%. The range of error, for 1978 was -5.3% to +9.6%, while the range of error for 1992 was -13.1% to +1.9% (see Table 1 page 17). Without a test of error for each photo used, there is no means to judge the direction or the amount of error relative to statistics associated with each photo. However, given the range of error found for the 1978 and 1992 photos, it is possible that 1,000 acres (405 ha) (actual) of coastal zone area could be reported as 1,096 acres (444 ha) in 1978 and 869 acres (352 ha) in 1992, a 227 acre (92 ha) difference.

#### "Leaves-On" Versus "Leaves-Off" Aerial Photography

There are distinct advantages and disadvantages of both "leaves-on" and "leaves-off" aerial photography. However, given the goals of this project, the 1978 "leaves-off" photography offers important advantages over the 1992 "leaves-on" photography. Vegetation in leaf can hide the details of built structures, including buildings and shoreline modifications. Roads can be hidden under tree crowns, as well as portions of lots landscaped and managed as residential land. Leaved canopies increase the effect of shadows. Shadows mask ground, understory and structural information leading to inaccurate interpretation. Land uses and/or structures hidden under the canopy of vegetation or masked by shadows can be underestimated in area, length or count. Land use types particularly affected (underestimated) are single family residential and wetland.

#### Stereo Versus Photographic Coverage

Both the 1978 and 1992 photo sets were taken to capture stereo (3-D) coverage of the Lake Michigan coastal area. This means that adjacent photos overlap approximately 60%. Stated another way, 60% of the shoreland area located on one photo also is located on an adjacent photo. The shoreland common to adjacent photos is "seen" from two different perspectives which allows stereo viewing (using a stereoscope).

The enlarged photos borrowed from USACE for this study represent photographic coverage only, or every other photo taken of shoreland. While photo (2-D) coverage at large scales can be used to interpret accurately many land use types (agricultural and most urban land), the lack of stereo viewing makes difficult the identification of wetland types and the exact location of bluff lines. Stereo viewing generally would have increased the interpretive accuracy of most land use, structural and shoreline features.

#### Incomplete Photo Coverage

For this study, the coastal zone is defined as a 1000' strip of land adjacent and parallel to the shoreline. Occasionally, photo coverage did not include all shoreland within 1000' of the water. As a result, total land area is underrepresented, the

exact land use types not covered are not known. In such cases, the area not captured on a particular photo was estimated by reference and comparison to coverage photos of the other flight year.

#### Missing Photo Coverage

Occasionally, photo coverage was missing from the USACE photo library. In such cases, as described above, coverage area missing was estimated by reference to photos of the other flight year. However, the exact land use types and shoreline features not represented on photos remain unknown.

#### Location of 1000' Coastal Zone Boundary

On each photo set, 1978 and 1992, a boundary line was drawn representing the 1000' coastal zone parallel to the shoreline. This line was located by scribing a landward line parallel to the line defined by the shoreline (where water meets land). The landward extent of the boundary line is a function of shoreline location, which in turn, is dependent on the water elevation of Lake Michigan. USACE (1978, 1992) reports that in April of 1978 Lake Michigan water elevation was about 578.4 feet (176.3 meters) and about 579.16 feet (176.5 meters) in May, 1992. The nine (9) inch difference in water elevation, while seemingly insignificant, could have shifted substantially landward the shoreline in extremely low slope beach or mud flat areas. The result of such a shift would be inclusion of inland areas NOT included in the 1978 coastal zone.

#### Lack of Beach Type in Classification Scheme

The width or extent of beach is dependent on slope of an area and water elevation. Since changes in the area of beach likely would reflect more the differences in 1978 and 1992 water levels (9 inches higher in 1992) than actual losses/gains due to erosion or development, no beach type was included in the study.

The lack of a beach type does affect measurement of area within the 1000' coastal zone. The landward extent of the coastal zone is 1000' from the shoreline. Any beach area lies between the shoreline and the base of the bluff, however area measurements of land use types were made only for those types lying between the base of the bluff and the interior boundary of the coastal zone. In most cases, beach strips represent only about five (5) acres per photo.

#### Positional Changes to the Shoreline: Natural vs. Urban Development

As discussed above, the landward extent of the 1000' coastal boundary is dependent on the location of the shoreline. Natural changes to shoreline position include both water elevation and

erosion/deposition of soil. Filling of coastal waters to accommodate urban development artificially changes shoreline location. In such cases, not only does the shoreline move "offshore," the interior coastal zone boundary line shifts toward the water. This "shift" in coastal boundaries skews area measurement. For example, in 1978 assume the coastal zone in an area to be all residential and that by 1992 100 acres of lake water is filled to develop commercial land. A "lakeward" shift in the location of the shoreline will occur due to the land filled for commercial use. However, this "shift" in the shoreline created by the filled commercial site also will result in a shift toward the water of the interior coastal zone boundary. The effect of the latter shift will be that 100 acres of residential land will not be included as part of the 1992 coastal zone. In such a case, the "raw" statistics misleadingly suggest that 100 acres of residential land use were eliminated to make room for 100 acres of commercial use.

## RESULTS

### Kenosha County Statistics

Kenosha County communities lying within the Lake Michigan coastal zone include the townships of Pleasant Prairie and Somers, and the city of Kenosha. The area measured within the coastal zone of Kenosha County was 1,430 acres (579 ha) in 1978 and 1,374 acres (557 ha) in 1992. This represents a difference of 56 acres (23 ha) or 3.9%. Area discrepancies likely are the result of errors inherent in the enlarged aerial photos, as discussed on pages 12 through 15. Using USGS maps as control, tests were conducted on the linear accuracy of the Kenosha County photos. Results of tests applied to the 1978 photos indicate some departure (~2.5% and +3.1%) from USGS measurements. Results of tests applied to the 1992 photos indicate errors of -1.6% to -9%. The range of error could yield a 67 acre (27 ha) difference between the 1978 and 1992 totals (Table 1).

Statistical summaries for Kenosha County and all communities included in this study are located in the Appendix.<sup>1</sup> Summary data sheets present land use types by area, structural counts by type (1992), shoreline modification types by length, and a count of shoreline structures by type. Data were collected at the PLSS section level. While the section level data sheets are not included in this report, copies are available upon written request.

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<sup>1</sup>Area figures used in the Results discussion reflect totals (not rounded) reported on the original tally sheets. Figures presented on the tally sheets found in the Appendix of this report have been rounded to the nearest whole number.

Table 1. County Results of Linear Accuracy Tests

Percent Deviation From USGS Base Map Measurements

<u>County</u>	<u>1978 Enlarged Photos (1:2400)</u>	<u>1992 Enlarged Photos (1:2400)</u>
Brown	-0.4% 0.03%	-8.5% -5.5%
Door	1.3% 3.9%	-1.1% -3.6%
Kenosha	-2.5% 3.1%	-9.0% -1.6%
Kewaunee	-1.5% 2.1%	-5.4% -9.6%
Manitowoc	-1.7% 2.0%	-6.4% -7.4%
Marinette (one test)	9.6%	-1.7%
Milwaukee	-4.9% -5.3%	-6.9% 1.9%
Oconto	2.9% 8.5%	-10.8% -13.1%
Ozaukee	0.2% 1.3%	-5.7% -4.4%
Racine	-3.0% 2.2%	-5.0% -0.8%
Sheboygan	-2.5% 4.6%	-1.2% -3.0%
Mean	0.95%	-5.18%
Range	-5.3% to 9.6%	-13.1% to 1.9%

## Residential Land

Within the coastal zone of Kenosha County, 2,175 residential structures were identified on 508 acres (206 ha) of land. Of the total were 1,418 residential units (single family or duplexes), 590 detached garages, 146 sheds and (3) barns. New in 1992 were 11.8 acres (4.8 ha) of land devoted to low rise multi-family dwellings. Since the 1992 photos are "leaves-on," these numbers likely underestimate the actual number of structures and area devoted to residential uses. In 1978, 473 acres (192 ha) of residential land were measured.

## Commercial and Industrial Land

Commercial land represented 131 acres (53 ha) in 1992 and 126 acres (51 ha) in 1978. Commercial structures noted within the coastal zone totaled 138. The CBD area remained stable from 1978 - 1992 at about 8.6 acres (3.5 ha) while neighborhood business district area increased from 52 acres (21 ha) in 1978 to 72 acres (29 ha) in 1992. Institutional land decreased from 65 acres (26 ha) to 50 acres (20 ha) for the same period.

No industrial land was recorded in 1992 compared to 26 acres (11 ha) in 1978. The loss could be real but could reflect as well interpretive misclassification based upon changes in photo signatures.

## Transportation Land

Land uses of the transportation category increased by 72 acres (29 ha) or 148% from 1978 to 1992. Notable increases include public boating facilities which increased by nearly 45 acres (18 ha, 413%), from 10.9 acres (4.4 ha) to 56 acres (23 ha) and landfill area which increased by 23 acres (9.3 ha) from no area in 1978 to 23 acres (9.3 ha) in 1992. Other land use types observed within the transportation category remained relatively stable over the study period. In 1992, twenty-nine (29) structures associated with the transportation category were counted on 121 acres (49 ha) of land.

## Extractive

For both 1978 and 1992, no land was observed within the extractive category.

## Agricultural and Natural Land

Overall, 123 acres (50 ha) of agricultural and natural lands were reported lost from 1978 to 1992, a trend that continues nationally. Abandoned field declined by 138 acres (56 ha) from 243 acres (98 ha) in 1978 to 105 acres (43 ha) in 1992. Land used actively for agriculture decreased from 24 acres (9.6 ha) to 5.9 acres (2.4 ha) for the same period, a loss of 18 acres (7.3

ha) or 75%. Forest and open water declined by 30% and 56%, respectively. Forest areas in 1978 covered 49 acres (20 ha) compared to 34 acres (13.8 ha) in 1992. Open water during the same years covered 24 acres (9.7 ha) and 10.6 acres (4.3 ha), respectively. The 13 acre (5.3 ha) reduction in area of slump zone is considered positive. In 1978, slump zone covered 20 acres (8.1 ha) of land compared to 6.9 acres (2.8 ha) in 1992, a reduction of 65.5%.

Another positive finding is the 74 acre (30 ha), 49% increase in wetland area from 1978 to 1992. In 1978, 152 acres (62 ha) of wetlands were observed compared to 226 acres (91 ha) in 1992.

#### Open and Other Land

Open and other land decreased from 245 acres (99 ha) in 1978 to 226 acres (92 ha) in 1992. Urban open lots remained stable at about 24 acres (9.7 ha). Sixteen (16) acres (6.5 ha) of outdoor recreational land were lost during the period while land devoted to cemeteries increased by 2.4 acres (1 ha).

#### Shoreline Modifications

Ostensibly, sea walls, revetments and groins are used to protect shorelines from erosion. Significant increases of these types of structures were reported. In 1978, 4,535 feet (1,383 m) of sea wall were reported compared to 5,298 feet (1,615 m) in 1992, representing an increase of 763 feet (233 m) or 17%. However, more significant is the 17,332 foot (5,284 m), 67% increase in revetment development since 1978. Shoreline revetment was measured at 25,970 feet (7,956 m) in 1978 and 43,302 feet (13,202 m) in 1992. Construction of groins increased dramatically as well over the 14 year period studied. In 1978, 41 groins were counted compared to 71 groins in 1992. The 30 groins represent an increase of 73%. Five (5) additional non-flow-through docks were developed along the county's shoreline since 1978, an increase of 250%.

#### Results by Community

##### City of Kenosha

Land within Kenosha's coastal zone was measured at 554 acres (225 ha) in 1978 and 566 acres (229 ha) in 1992. The difference of 12 acres (4.9 ha) represents 2.2%. The source of the difference could be photo scale anomalies as discussed above.

In 1992, 1,033 residential structures were located on 166 acres (67 ha) of land. Most of these structures (696) were single family or duplex. Other structures included 318 detached garages and 14 sheds. In 1992, (5) structures on 1.5 acres (.6 ha) of land were used for low-rise multi-family housing. In 1978, 182 acres (74 ha) of residential land are reported.

Commercial area remained stable over the study period, with 75 acres (30 ha) reported for each year. A total of 43 structures were observed in 1992. CBD area remained unchanged in 1978 and 1992. Neighborhood business district, however, increased by about (9) acres (3.6 ha), from 7.5 acres (3 ha) in 1978 to 16.4 acres (6.6 ha) in 1992. Land devoted to institutional uses declined from 58 acres (24 ha) to 50 acres (20 ha).

The analysis indicates that all 26 acres (10.6 ha) of industrial area were displaced for other uses by 1992.

From 1978 to 1992, land uses of the transportation category increased by 63 acres (25 ha) or 276%, from 23 acres (9.2 ha) in 1978 to 86 acres (35 ha) in 1992. Twenty-seven (27) structures were counted in 1992. Land use areas increasing the most include public boat facilities, highways and landfills. In 1978, public boating areas covered only 2.4 acres (1 ha) of land compared to 37 acres (15 ha) in 1992. During the same period, highway area increased by 5.2 acres (2.1 ha), from a total of 4.3 acres (1.7 ha) in 1978 to 9.5 acres (3.8 ha) in 1992. Landfill area increased from no area in 1978 to 23 acres (9.3 ha) in 1992. Other types within the transportation category either remained stable over the years studied or had no observed area.

No extractive land use areas were observed for either study year.

Agricultural and natural areas represent only 4.6% of Kenosha's coastal zone in 1992. Twenty six (26) acres (10.6 ha) of area were recorded in 1992 compared to just 13.6 acres (5.6 ha) in 1978. Two types, abandoned field and wetlands, experienced all gains recorded. Abandoned fields grew from less than (1) acre to 13 acres (5.3 ha) by 1992, while wetlands grew from less than (1) acre to (5) acres (2 ha) in 1992.

Two of three open/other category types observed lost area from 1978 to 1992. Total area of open/other was 235 acres (95 ha) in 1978 and 213 acres (86 ha) in 1992. Urban open lot decreased from about 21 acres (8.4 ha) to 15 acres (6.2 ha) while outdoor recreation decreased from 210 acres (85 ha) to 191 acres (77 ha). Area used for cemetery increased from 4.4 acres (1.8 ha) to 6.8 acres (2.8 ha) from 1978 to 1992.

Total length of sea wall declined from 2,692 feet (821 m) in 1978 to 1,710 feet (522 m) in 1992. Revetment length, however, increased by 5,383 feet (1,641 m) or 40%. Total revetment was recorded as 13,447 feet (4,100 m) in 1978 and 18,830 feet (5,741 m) in 1992. Groins along the city's shore totaled (4) in 1992, down from (7) in 1978. One (1) non-flow-through dock was observed in both study years.

#### Town of Pleasant Prairie

Coastal zone area within the township was measured at 522 acres (211 ha) in 1978 and 589 acres (238 ha) in 1992, a difference of 33 acres (13.4 ha). The town of Pleasant Prairie was one of those tested for linear accuracy of photo coverage.



Using USGS maps at 1:24000, measurements taken from the 1978 photos were +3.1% of the USGS basis. The 1992 photos deviated by -1.6% from the USGS basis.

In 1992, a total of 450 residential structures were identified on 177 acres (72 ha) of residential land. Included were 33 single family/duplex units, 55 detached garages, 76 sheds and (2) barns. Residential land covered 126 acres (51 ha) in 1978.

Little in the way of total area change occurred in the commercial category, recorded as 2.3 acres (.9 ha) in 1978 and 1.5 acres (.6 ha) in 1992. However, all of the 1978 area was recorded as institutional land while all of the 1992 area was recorded as neighborhood business. From an interpretive standpoint, the two types can be quite similar; therefore, these results may represent interpretive misclassification.

No industrial land was observed for either study year.

Public boat landing was the only transportation type observed in 1978 or 1992. The type increased from 8.5 acres (3.4 ha) in 1978 to 18.4 acres (7.5 ha) in 1992, an increase of about 10 acres (4.1 ha) or 116%.

No extractive areas were noted in 1978 or 1992.

Over the 14 year study period, significant losses of agricultural and natural areas were observed within the township. In 1978, 383 acres (155 ha) of agricultural and natural area were recorded compared to 281 acres (114 ha) in 1992. The loss of 102 acres (41 ha) represents 27% of the 1978 base. Within the category, abandoned field lost the most area (145 acres, 59 ha), decreasing from 202 acres (82 ha) in 1978 to 57 acres (23 ha) in 1992. Other notable losses include active agricultural land, from 11.2 acres (4.5 ha) to no area, forest land - from 13.5 acres (5.5 ha) to 1.2 acres (.5 ha) and open water - from 9.5 acres (3.8 ha) to 2.1 acres (.9 ha). On the positive side, wetlands increased by 73 acres (30 ha), from 147 acres (60 ha) in 1978 to 220 acres (89 ha) in 1992.

From 1978 to 1992, area of the open/other category increased by 8.7 acres (3.5 ha), from 2.5 acres (1 ha) to 11.2 acres (4.5 ha). Within the category, the type urban open lot increased by 5.7 acres (2.3 ha), from 2.5 acres (1 ha) to 8.2 acres (3.3 ha) while outdoor recreation increased to (3) acres (1.2 ha) from no recorded area in 1978.

The Pleasant Prairie shoreline experienced considerable modification from 1978 to 1992. Sea wall increased from 775 feet (236 m) in 1978 to 2,336 feet (712 m) in 1992, an increase of 1,561 feet (476 m) or 201%. Revetments, as well, increased considerably, from 10,368 feet (3,199 m) to 14,669 feet (4,472 m). The increase of 4,301 feet (1,311 m) represents 41% of the 1978 base. During the 14 year period, groins along the shoreline increased from 22 to 42 while non-flow-through docks increased from none in 1978 to (5) in 1992.

## Town of Somers

The coastal zone of the town of Somers was determined to be 354 acres (143 ha) in 1978 and 320 acres (130 ha) in 1992. The 34 acre (14 ha) difference is 9.6% of the 1978 total. The town of Somers was one of the sites tested to determine linear accuracy of the enlarged photos. The 1978 photos of Somers were determined to deviate -2.5% from USGS 1:24000 maps. The 1992 photos deviated by -9% from the USGS basis.

Total residential land located within the coastal zone remained stable from 1978 to 1992 at about 166 acres (67 ha). In 1992, 692 structures were located within the residential area, including 405 single family/duplex units, 217 detached garages and 56 sheds. Thirteen (13) structures on 10.3 acres (4.2 ha) were classified as low-rise multi-family units. Single family/duplex units were located on 156 acres (63 ha) of land.

In 1992, 94 structures were located on 54 acres (22 ha) of commercial land, up from 49 acres (19.8 ha) of commercial land in 1978. No industrial or extractive lands were observed for 1978 or 1992. Transportation area remained stable at about 17 acres (7 ha) during the period.

Within the agricultural and natural area category, each land use type observed in 1978 lost area by 1992. Total area of this category was estimated to be 115 acres (46.5 ha) in 1978 and 82 acres (33 ha) in 1992. Area losses within the category include the following: abandoned field from 41 acres (17 ha) to 35 acres (14 ha); active agriculture from 12.7 acres (5.1 ha) to 5.9 acres (2.4 ha); forest land from 35 acres (14.3 ha) to 33 acres (13.3 ha); slump zone from 18 acres (7.3 ha) to 6.2 acres (2.5 ha); and wetland from 4.1 acres (1.7 ha) to .3 acre (.1 ha).

From 1978 to 1992, open/other land uses decreased from 7.5 acres (3 ha) to 2 acres (.8 ha).

Changes to shoreline were substantial from 1978 to 1992. Sea walls increased from 1,067 feet (325 m) in 1978 to 1,252 feet (382 m) in 1992. Revetments increased by 7,647 feet (2,331 m) from a total of 2,156 feet (657 m) in 1978 to 9,803 feet (2,989 m) in 1992. This represents an increase of 355%.

The construction of groins along the town's shoreline increased dramatically as well, from 12 groins in 1978 to 25 groins in 1992. One (1) non-flow-through dock was observed for each study year.

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APPENDIX

Lake Michigan Coastal Development Inventory Project:  
1978 - 1992

County Summary Data Sheet

Year: 1978  
 County: Kenosha  
 Coastal Civil Jurisdiction included in summary (in alphabetical order).

City of Kenosha  
 Town of Pleasant Prairie  
 Town of Somers

LAND USE CATEGORIES

	<u># of structures</u>	<u>Area</u>	
		<u>Acres</u>	<u>Hectares</u>
<b><u>11 Residential</u></b>			
111 Res. units	2	2	1
garages			
sheds	1		
112 Res. units			
garages			
sheds			
113 Res. units	1257	472	191
garages	570		
sheds	167		
barns	2		
115 Res. units		<1	<1
garages			
sheds			
Subtotal	1999	473	192
<b><u>12 Commercial</u></b>			
121 Central Business Dist	11	9	4
122 Shopping Center/Mall			
124 Neighborhood Business Dist	95	52	21
126 Institutional	27	65	26
Subtotal	133	126	51
<b><u>13 Industrial</u></b>			
138 Industrial Park	12	26	11



	# of structures	Area	
		Acres	Hectares
<b>14 Transportation</b>			
141 Air Transportation			
142 Rail Transportation		2	1
143 Water Transportation			
143.1 Private Marina			
143.2 Public Boat Landing	10	11	4
144 Highways		19	8
145 Communications			
146 Utilities			
147 Sewage Treatment Plant	29	16	7
148 Landfill			
Subtotal	39	49	20

**17 Extractive**

171 Open Pit			
172 Underground			
173 Well			
179 Other Extractive			
Subtotal			

**18 Agricultural and Natural**

181 AF Abandoned Field	2	243	98
182 AG Agriculture Active		24	10
183 F Forest		49	20
184 H Heath			
185 OW Open Water		24	10
186 RL Rock Ledge			
187 SL Slump Zone		20	8
188 WT Wetland		152	62
Subtotal	2	511	207

**19 Open Land, Other**

191 Outdoor-Public Assembly	4	7	3
192 Urban Open Lots		23	9
193 Outdoor Recreation	18	210	85
194 Cemeteries		4	2
Subtotal	22	245	99

Total Acres 1430  
Total Hectares 579

**Shoreline Modifications**

		Linear	
		Feet	Meters
195 Sea Walls		4535	1383
196 Revetments		25970	7956
197 Groins	# of Groins	41	
198 Dock Non-Flow-Through	# of Docks	2	

Lake Michigan Coastal Development Inventory Project:  
1978 - 1992

County Summary Data Sheet

Year: 1992  
 County: Kenosha  
 Coastal Civil Jurisdiction included in summary (in alphabetical order).

City of Kenosha  
 Town of Pleasant Prairie  
 Town of Somers

LAND USE CATEGORIES

	<u># of structures</u>	<u>Area</u>	
		<u>Acres</u>	<u>Hectares</u>
<u>11 Residential</u>			
111 Res. units			
garages			
sheds			
112 Res. units	18	12	5
garages			
sheds			
113 Res. units	1418	496	201
garages	590		
sheds	146		
barns	3		
115 Res. units		<1	<1
garages			
sheds			
Subtotal	2175	508	206
<u>12 Commercial</u>			
121 Central Business Dist	5	9	4
122 Shopping Center/Mall			
124 Neighborhood Business Dist	112	72	29
126 Institutional	21	50	20
Subtotal	138	131	53
<u>13 Industrial</u>			
138 Industrial Park			

	# of structures	Area	
		Acres	Hectares
<u>14 Transportation</u>			
141 Air Transportation			
142 Rail Transportation		3	1
143 Water Transportation			
143.1 Private Marina		1	<1
143.2 Public Boat Landing	5	56	23
144 Highways		23	9
145 Communications			
146 Utilities	1	<1	<1
147 Sewage Treatment Plant	23	15	6
148 Landfill		23	9
Subtotal	29	121	49

17 Extractive

171 Open Pit			
172 Underground			
173 Well			
179 Other Extractive			
Subtotal			

18 Agricultural and Natural

181 AF Abandoned Field	1	105	43
182 AG Agriculture Active		6	2
183 F Forest		34	14
184 H Heath		<1	<1
185 OW Open Water		11	4
186 RL Rock Ledge			
187 SL Slump Zone		7	3
188 WT Wetland		226	91
Subtotal	1	389	158

19 Open Land, Other

191 Outdoor-Public Assembly			
192 Urban Open Lots		25	10
193 Outdoor Recreation	19	194	79
194 Cemeteries		7	3
Subtotal	19	226	92

Total Acres 1374  
Total Hectares 557

Shoreline Modifications

		Linear	
		Feet	Meters
195 Sea Walls		5298	1615
196 Revetments		43302	13202
197 Groins	# of Groins	71	
198 Dock Non-Flow-Through	# of Docks	7	

Lake Michigan Coastal Development Inventory Project:  
1978 - 1992

Civil Jurisdiction  
Summary Data Sheet

Year: 1978  
County: Kenosha  
Township, Village or City name: City of Kenosha  
PLSS section data sheets included in summary (give full description):

T1N R23E	SEC 5	T2N R23E	SEC 18
	SEC 6		SEC 19
	SEC 7		SEC 29
	SEC 8		SEC 30
			SEC 31
			SEC 32

LAND USE CATEGORIES

	<u># of structures</u>	<u>Area</u>	
		<u>Acres</u>	<u>Hectares</u>
<u>11 Residential</u>			
111 Res. units			
garages			
sheds			
112 Res. units			
garages			
sheds			
113 Res. units	641	182	74
garages	322		
sheds	48		
barns			
115 Res. units			
garages			
sheds			
Subtotal	1011	182	74
<u>12 Commercial</u>			
121 Central Business Dist	11	9	4
122 Shopping Center/Mall			
124 Neighborhood Business Dist	8	8	3
126 Institutional	23	59	24
Subtotal	42	75	30
<u>13 Industrial</u>			
138 Industrial Park	12	26	11

	# of structures	Area	
		Acres	Hectares
<b>14 Transportation</b>			
141 Air Transportation			
142 Rail Transportation			
143 Water Transportation			
143.1 Private Marina			
143.2 Public Boat Landing	4	2	1
144 Highways		4	2
145 Communications			
146 Utilities			
147 Sewage Treatment Plant	29	16	7
148 Landfill			
Subtotal	33	23	9

**17 Extractive**

171 Open Pit			
172 Underground			
173 Well			
179 Other Extractive			
Subtotal			

**18 Agricultural and Natural**

181 AF Abandoned Field		<1	<1
182 AG Agriculture Active			
183 F Forest			
184 H Heath			
185 OW Open Water		11	4
186 RL Rock Ledge			
187 SL Slump Zone		2	1
188 WT Wetland		1	<1
Subtotal		14	6

**19 Open Land, Other**

191 Outdoor-Public Assembly			
192 Urban Open Lots		21	8
193 Outdoor Recreation	18	210	85
194 Cemeteries		4	2
Subtotal	18	235	95

Total Acres 554  
Total Hectares 225

**Shoreline Modifications**

	Linear	
	Feet	Meters
195 Sea Walls	2692	821
196 Revetments	13447	4100
197 Groins	# of Groins	7
198 Dock Non-Flow-Through	# of Docks	1

Lake Michigan Coastal Development Inventory Project:  
1978 - 1992

Civil Jurisdiction  
Summary Data Sheet

Year: 1992  
 County: Kenosha  
 Township, Village or City name: City of Kenosha  
 PLSS section data sheets included in summary (give full description):

T1N R23E	SEC 5	T2N R23E	SEC 18
	SEC 6		SEC 19
	SEC 7		SEC 29
	SEC 8		SEC 30
			SEC 31
			SEC 32

LAND USE CATEGORIES

	<u># of structures</u>	<u>Area</u>	
		<u>Acres</u>	<u>Hectares</u>
<u>11 Residential</u>			
111 Res. units			
garages			
sheds			
112 Res. units	5	2	1
garages			
sheds			
113 Res. units	696	164	67
garages	318		
sheds	14		
barns			
115 Res. units			
garages			
sheds			
Subtotal	1033	166	67
<u>12 Commercial</u>			
121 Central Business Dist	5	9	4
122 Shopping Center/Mall			
124 Neighborhood Business Dist	17	16	7
126 Institutional	21	50	20
Subtotal	43	75	31
<u>13 Industrial</u>			
138 Industrial Park			

	# of structures	Area	
		Acres	Hectares
<u>14 Transportation</u>			
141 Air Transportation			
142 Rail Transportation			
143 Water Transportation			
143.1 Private Marina		1	<1
143.2 Public Boat Landing	3	37	15
144 Highways		10	4
145 Communications			
146 Utilities	1	<1	<1
147 Sewage Treatment Plant	23	15	6
148 Landfill		23	9
Subtotal	27	86	35

17 Extractive

171 Open Pit			
172 Underground			
173 Well			
179 Other Extractive			
Subtotal			

18 Agricultural and Natural

181 AF Abandoned Field		13	5
182 AG Agriculture Active			
183 F Forest			
184 H Heath			
185 OW Open Water		7	3
186 RL Rock Ledge			
187 SL Slump Zone		1	<1
188 WT Wetland		5	2
Subtotal		26	11

19 Open Land, Other

191 Outdoor-Public Assembly			
192 Urban Open Lots		15	6
193 Outdoor Recreation	18	191	77
194 Cemeteries		7	3
Subtotal	18	213	86

Total Acres 566  
Total Hectares 229

Shoreline Modifications

	Linear	
	Feet	Meters
195 Sea Walls	1710	522
196 Revetments	18830	5741
197 Groins	# of Groins	4
198 Dock Non-Flow-Through	# of Docks	1

Lake Michigan Coastal Development Inventory Project:  
1978 - 1992

Civil Jurisdiction  
Summary Data Sheet

Year: 1978  
 County: Kenosha  
 Township, Village or City name: Town of Pleasant Prairie  
 PLSS section data sheets included in summary (give full description):

T1N R23E	SEC 7	SEC 20	
	SEC 8	SEC 29	
	SEC 17	SEC 30	
	SEC 18	SEC 32	
	SEC 19		

LAND USE CATEGORIES

	<u># of structures</u>	<u>Area</u>	
		<u>Acres</u>	<u>Hectares</u>
<b><u>11 Residential</u></b>			
111 Res. units			
garages			
sheds			
112 Res. units			
garages			
sheds			
113 Res. units	242	126	51
garages	54		
sheds	55		
barns			
115 Res. units			
garages			
sheds			
Subtotal	351	126	51

**12 Commercial**

121 Central Business Dist			
122 Shopping Center/Mall			
124 Neighborhood Business Dist			
126 Institutional	2	2	1
Subtotal	2	2	1

**13 Industrial**

138 Industrial Park			
---------------------	--	--	--



	# of structures	Area	
		Acres	Hectares
<b>14 Transportation</b>			
141 Air Transportation			
142 Rail Transportation			
143 Water Transportation			
143.1 Private Marina			
143.2 Public Boat Landing	6	9	3
144 Highways			
145 Communications			
146 Utilities			
147 Sewage Treatment Plant			
148 Landfill			
Subtotal	6	9	3

**17 Extractive**

171 Open Pit			
172 Underground			
173 Well			
179 Other Extractive			
Subtotal			

**18 Agricultural and Natural**

181 AF Abandoned Field	2	202	82
182 AG Agriculture Active		11	5
183 F Forest		14	6
184 H Heath			
185 OW Open Water		10	4
186 RL Rock Ledge			
187 SL Slump Zone			
188 WT Wetland		147	60
Subtotal	2	383	155

**19 Open Land, Other**

191 Outdoor-Public Assembly			
192 Urban Open Lots		3	1
193 Outdoor Recreation			
194 Cemeteries			
Subtotal		3	1

Total Acres 522  
Total Hectares 211

**Shoreline Modifications**

	Linear	
	Feet	Meters
195 Sea Walls	775	236
196 Revetments	10368	3199
197 Groins	# of Groins	22
198 Dock Non-Flow-Through	# of Docks	

Lake Michigan Coastal Development Inventory Project:  
1978 - 1992

Civil Jurisdiction  
Summary Data Sheet

Year: 1992  
 County: Kenosha  
 Township, Village or City name: Town of Pleasant Prairie  
 PLSS section data sheets included in summary (give full description):

T1N R23E	SEC 7	SEC 20	
	SEC 8	SEC 29	
	SEC 17	SEC 30	
	SEC 18	SEC 32	
	SEC 19		

LAND USE CATEGORIES

	<u># of structures</u>	<u>Area</u>	
		<u>Acres</u>	<u>Hectares</u>
<u>11 Residential</u>			
111 Res. units	_____	_____	_____
garages	_____	_____	_____
sheds	_____	_____	_____
112 Res. units	_____	_____	_____
garages	_____	_____	_____
sheds	_____	_____	_____
113 Res. units	317	177	72
garages	55	_____	_____
sheds	76	_____	_____
barns	2	_____	_____
115 Res. units	_____	_____	_____
garages	_____	_____	_____
sheds	_____	_____	_____
Subtotal	450	177	72
<u>12 Commercial</u>			
121 Central Business Dist	_____	_____	_____
122 Shopping Center/Mall	_____	_____	_____
124 Neighborhood Business Dist	1	2	1
126 Institutional	_____	_____	_____
Subtotal	1	2	1
<u>13 Industrial</u>			
138 Industrial Park	_____	_____	_____

		Area	
	<u># of structures</u>	<u>Acres</u>	<u>Hectares</u>

14 Transportation

141 Air Transportation	_____	_____	_____
142 Rail Transportation	_____	_____	_____
143 Water Transportation	_____	_____	_____
143.1 Private Marina	_____	_____	_____
143.2 Public Boat Landing	2	18	8
144 Highways	_____	_____	_____
145 Communications	_____	_____	_____
146 Utilities	_____	_____	_____
147 Sewage Treatment Plant	_____	_____	_____
148 Landfill	_____	_____	_____
Subtotal	2	18	8

17 Extractive

171 Open Pit	_____	_____	_____
172 Underground	_____	_____	_____
173 Well	_____	_____	_____
179 Other Extractive	_____	_____	_____
Subtotal	_____	_____	_____

18 Agricultural and Natural

181 AF Abandoned Field	_____	57	23
182 AG Agriculture Active	_____	_____	_____
183 F Forest	_____	1	1
184 H Heath	_____	<1	<1
185 OW Open Water	_____	2	1
186 RL Rock Ledge	_____	_____	_____
187 SL Slump Zone	_____	_____	_____
188 WT Wetland	_____	220	89
Subtotal	_____	281	114

19 Open Land, Other

191 Outdoor-Public Assembly	_____	_____	_____
192 Urban Open Lots	_____	8	3
193 Outdoor Recreation	1	3	1
194 Cemeteries	_____	_____	_____
Subtotal	1	11	5

Total Acres	489
Total Hectares	198

Shoreline Modifications

		Linear	
		Feet	Meters
195 Sea Walls	_____	2336	712
196 Revetments	_____	14669	4472
197 Groins	_____	# of Groins	42
198 Dock Non-Flow-Through	_____	# of Docks	5

Lake Michigan Coastal Development Inventory Project:  
1978 - 1992

Civil Jurisdiction  
Summary Data Sheet

Year: 1978  
County: Kenosha  
Township, Village or City name: Town of Somers  
PLSS section data sheets included in summary (give full description):

T2N R23E SEC 5  
SEC 7  
SEC 8  
SEC 17  
SEC 18  
SEC 19

LAND USE CATEGORIES

	<u># of structures</u>	<u>Area</u>	
		<u>Acres</u>	<u>Hectares</u>
<u>11 Residential</u>			
111 Res. units	2	2	1
garages			
sheds	1		
112 Res. units			
garages			
sheds			
113 Res. units	374	164	66
garages	194		
sheds	64		
barns	2		
115 Res. units		<1	<1
garages			
sheds			
Subtotal	637	166	67
<u>12 Commercial</u>			
121 Central Business Dist			
122 Shopping Center/Mall			
124 Neighborhood Business Dist	87	45	18
126 Institutional	2	4	2
Subtotal	89	49	20
<u>13 Industrial</u>			
138 Industrial Park			

	# of structures	Area	
		Acres	Hectares
<b><u>14 Transportation</u></b>			
141 Air Transportation			
142 Rail Transportation		2	1
143 Water Transportation			
143.1 Private Marina			
143.2 Public Boat Landing			
144 Highways		15	6
145 Communications			
146 Utilities			
147 Sewage Treatment Plant			
148 Landfill			
Subtotal		17	7

**17 Extractive**

171 Open Pit			
172 Underground			
173 Well			
179 Other Extractive			
Subtotal			

**18 Agricultural and Natural**

181 AF Abandoned Field		41	17
182 AG Agriculture Active		13	5
183 F Forest		35	14
184 H Heath			
185 OW Open Water		4	2
186 RL Rock Ledge			
187 SL Slump Zone		18	7
188 WT Wetland		4	2
Subtotal		115	47

**19 Open Land, Other**

191 Outdoor-Public Assembly	4	7	3
192 Urban Open Lots			
193 Outdoor Recreation		<1	<1
194 Cemeteries			
Subtotal	4	8	3

Total Acres 354  
Total Hectares 143

**Shoreline Modifications**

		Linear	
		Feet	Meters
195 Sea Walls		1067	325
196 Revetments		2156	657
197 Groins	# of Groins	12	
198 Dock Non-Flow-Through	# of Docks	1	

Lake Michigan Coastal Development Inventory Project:  
1978 - 1992

Civil Jurisdiction  
Summary Data Sheet

Year: 1992  
 County: Kenosha  
 Township, Village or City name: Town of Somers  
 PLSS section data sheets included in summary (give full description):

T2N R23E SEC 5  
 SEC 7  
 SEC 8  
 SEC 17  
 SEC 18  
 SEC 19

LAND USE CATEGORIES

	<u># of structures</u>	<u>Area</u>	
		<u>Acres</u>	<u>Hectares</u>
<u>11 Residential</u>			
111 Res. units			
garages			
sheds			
112 Res. units	13	10	4
garages			
sheds			
113 Res. units	405	156	63
garages	217		
sheds	56		
barns	1		
115 Res. units		<1	<1
garages			
sheds			
Subtotal	692	166	67
<u>12 Commercial</u>			
121 Central Business Dist			
122 Shopping Center/Mall			
124 Neighborhood Business Dist	94	54	22
126 Institutional			
Subtotal	94	54	22
<u>13 Industrial</u>			
138 Industrial Park			

	# of structures	Area	
		Acres	Hectares
<u>14 Transportation</u>			
141 Air Transportation			
142 Rail Transportation		3	1
143 Water Transportation			
143.1 Private Marina			
143.2 Public Boat Landing			
144 Highways		14	6
145 Communications			
146 Utilities			
147 Sewage Treatment Plant			
148 Landfill			
Subtotal		17	7

17 Extractive

171 Open Pit			
172 Underground			
173 Well			
179 Other Extractive			
Subtotal			

18 Agricultural and Natural

181 AF Abandoned Field	1	35	14
182 AG Agriculture Active		6	2
183 F Forest		33	13
184 H Heath			
185 OW Open Water		1	1
186 RL Rock Ledge			
187 SL Slump Zone		6	3
188 WT Wetland		<1	<1
Subtotal	1	82	33

19 Open Land, Other

191 Outdoor-Public Assembly			
192 Urban Open Lots		2	1
193 Outdoor Recreation			
194 Cemeteries			
Subtotal		2	1

Total Acres 320  
Total Hectares 130

Shoreline Modifications

	Linear	
	Feet	Meters
195 Sea Walls	1252	382
196 Revetments	9803	2989
197 Groins	# of Groins	25
198 Dock Non-Flow-Through	# of Docks	1

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