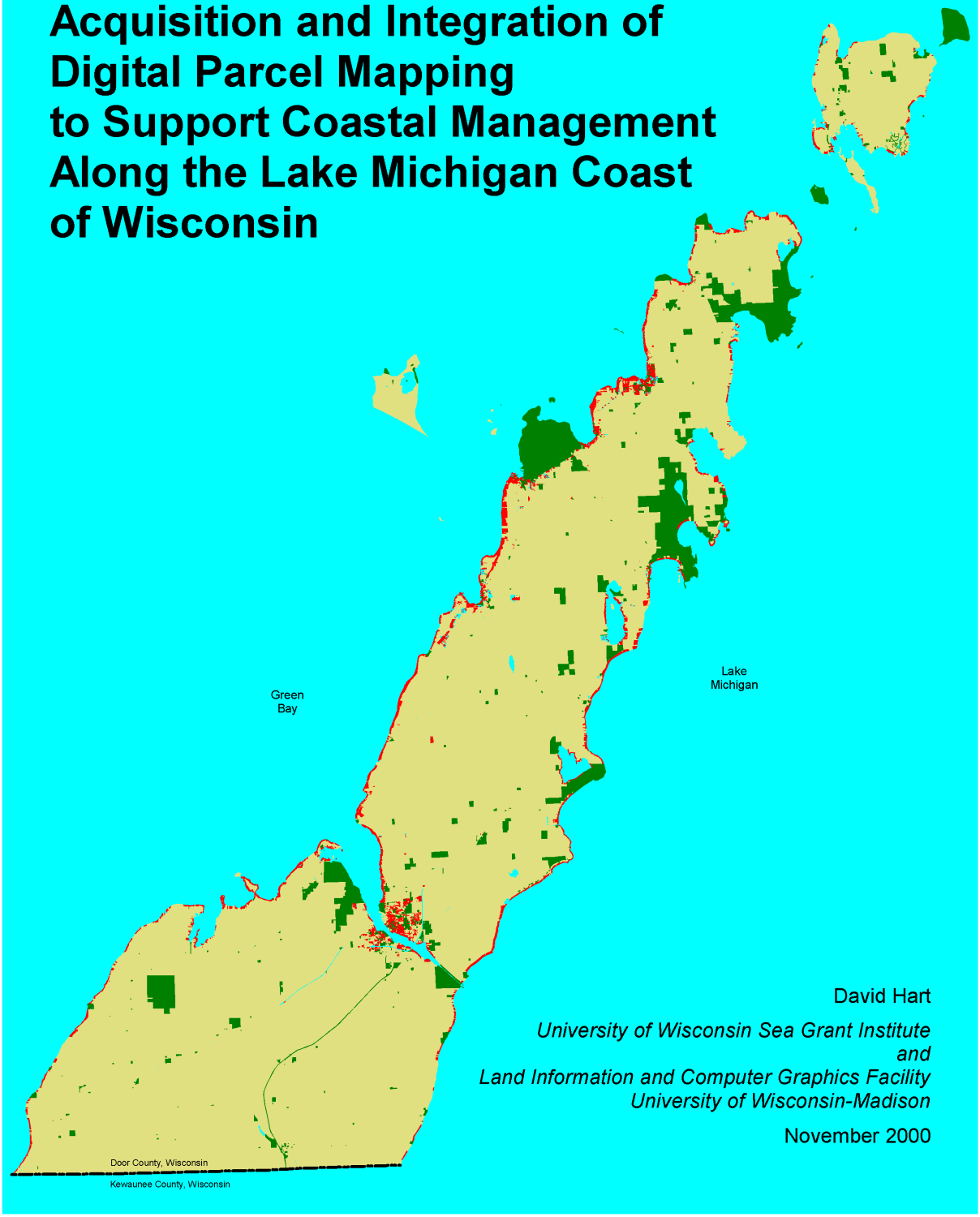
Acquisition and Integration of Digital Parcel Mapping to Support Coastal Management Along the Lake Michigan Coast of Wisconsin



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the University of Wisconsin-Madison and
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About the Cover: The image on the cover shows the assessed value of land per square foot in 2000 for Door County, Wisconsin. The parcels in red have an assessed value of $1 per square foot or higher. The parcels in yellow have an assessed value of under $1 per square foot. The parcels in dark green are listed in the tax roll as tax exempt. These include federal, state, county, and other tax exempt lands.

EXECUTIVE SUMMARY

Coastal management issues often influence broad geographic areas that cross political boundaries. Geographic information systems for coastal management have typically been built to cover large coastal regions using small-scale, coarse resolution data sets from federal and state government sources. Such spatial data sources are used because they are available, affordable, and in a consistent format. While it may be easier to integrate small-scale spatial data for regional-scale coastal GIS applications, exclusive reliance on small-scale spatial data limits the effectiveness of coastal management. Local governments collect and maintain a variety of land records at a level of detail useful for coastal management and are actively modernizing these records. With the adoption and use of GIS at the local government level reaching a more mature level, there is a need to examine the issues associated with building regional-scale GIS applications that utilize a "bottom-up" rather than a "top-down" approach to spatial data development.

The primary objective of this research is to assess the issues associated with the acquisition and integration of digital parcel mapping generated at the local level of government so that it can be utilized to support decision-making about coastal management at a regional scale. It examines the status of digital parcel mapping along the Lake Michigan coast of Wisconsin and the presents the results of an effort to acquire and integrate digital parcel mapping from local governments for a 1000-meter zone inland from the Lake Michigan shore in Wisconsin. Four key factors were identified related to the acquisition of digital parcel mapping from coastal local governments. These include the number of contact points for data requests, the cost of data acquisition, the time required to receive data after the request is made, and restrictions placed on the use and dissemination of digital data. Nine factors were identified that affect the ability to integrate data for use in analysis and decision-making related to regional-scale issues. Many of these are technical in nature. They include: (1) the media used for the transfer of files; (2) the size of the files received; (3) the extent to which the parcel data are documented, (4) the software format of the digital files; (5) the number of map tiles comprising digital parcel mapping for the coastal study area; (6) the compilation methods used for digital parcel mapping; (7) the coordinate system and datum; (8) the data structure of the digital parcel mapping; and (9) the status of coding digital parcel mapping with parcel identification numbers along with the ability to create a linkage between digital parcels and tax roll data to support thematic mapping of ownership and assessment information. Through September 23, 2000, approximately two years after initial data requests, digital parcel mapping has been integrated for 489.7 of 540.1 shoreline miles (91%) of the Lake Michigan coast in Wisconsin. A linkage between tax roll data and digital parcel mapping has been made for 415.8 of 540.1 shoreline miles (77%), allowing some analysis of coastal property ownership and value.

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INTRODUCTION

This research identifies and examines issues associated with the acquisition and integration of local government spatial data for use in coastal resource management at a regional scale. Government programs for protection and management of coastal resources require the acquisition and integration of large amounts of spatial data to be effective. Examples of spatial data commonly used in coastal management include: location of the shoreline, regulatory zones on both the land and water sides of the shore, land ownership, demographics, bathymetry, coastal geomorphology, infrastructure, cultural features, and habitat area delineations.

Coastal management issues often influence broad geographic areas and are rarely confined to neat administrative boundaries. For example, analysis of coastal erosion hazards requires an understanding of coastal landforms, wave dynamics, sediment budgets, and development patterns at a regional scale. In addition, management of coastal resources requires input from a variety of disciplines and organizations. In the case of managing coastal erosion hazards, the expertise of geologists, civil engineers, planners, and public administrators is required. Because of the regional scope and multi-disciplinary nature of many coastal management issues, spatial data used in decision-making about these issues must be integrated in both a horizontal and vertical manner[1].

Geographic information systems (GIS) provide the means to manage, integrate, and analyze spatial data for use in coastal management. Bartlett (1990) identifies several benefits of a GIS approach to coastal management, including: (1) the ability to model, test, and compare alternative scenarios – before the proposed strategy is imposed on the real world; (2) the ability to handle much larger data bases and to integrate and synthesize data -- leading to a more holistic and coordinated management strategies; and (3) enhanced capacity for data exchange (p. 33). In addition, a GIS approach to coastal management provides a process to bring together groups that cut across professional disciplines to work together toward a common goal and more effectively communicate information about coastal management issues to decision-makers.

[1] Horizontal integration addresses consistency across space. In other words, data sharing to analyze issues that cross political boundaries. For the purposes of this report, vertical integration addresses consistency among different levels of government -- municipal, county, regional, state and federal -- as well as the private sector. Other perspectives exist concerning vertical integration. One is that it addresses consistency across data themes and that relevant relationships among features in different themes are maintained (e.g. alignment of hydrography and elevation data) (FGDC 1997). This may be termed "thematic" integration. Another is that data can be shared across different professions or disciplines. This may be termed "disciplinary" integration.

Typically, geographic information systems for coastal management have been built to cover large coastal regions using small-scale[2], coarse resolution data sets from federal and state government sources. Small-scale spatial data are used because they are available, affordable, and in a consistent format. While it may be easier to integrate small-scale spatial data for regional-scale[3] coastal GIS applications, exclusive reliance on small-scale spatial data limits the effectiveness of coastal management. In large part, this is because such systems lack data specific to individual land parcels. Parcels boundaries are important because the actions of individual property owners have a cumulative impact on coastal resources and a parcel-based GIS allows analysis of these impacts.

Local governments collect and maintain a variety of land records at a level of detail useful for coastal management. In addition to parcels, examples include planimetric features (building outlines, road pavement edges, lakes and streams, utility poles, etc), topographic features (contour elevations and spot elevations), digital orthophotos, land use, zoning, and infrastructure. Local governments are actively modernizing their land records, creating automated land information systems. A recent survey of 200 city and county governments in the United States indicates that 77 percent of survey respondents used GIS in 1996, with 87 percent expecting to use GIS in 1997 (Warnecke et al. 1998). With the adoption and use of GIS at the local government level reaching a more mature level, there is a need to examine the issues associated with building regional-scale GIS applications that utilize a "bottom-up" rather than a "top-down" approach to spatial data development. Such an approach is consistent with the principles set forth in the practice of integrated coastal zone management -- a management strategy gaining acceptance around the world (Clark 1992; Cicin-Sain et al. 1998).

Wisconsin provides an interesting backdrop for study of the integration and aggregation of local government spatial data for use in coastal management. This is due to the interaction of three unique state-level programs related to land records modernization, coastal management, and coastal research and outreach. The Wisconsin Land Information Program (WLIP), a statewide program to support modernization of land records, has accelerated implementation of GIS/LIS at the local government level (Moyer and Niemann 1998; Moyer 1998; Tulloch and Niemann 1996; Miller 1990). The Wisconsin Coastal Management Program (WCMP) is a networked[4] coastal management program that promotes interaction between state and local governments

[2] Because this report is focused on data integration, the terms "small-scale" and "large-scale" are used in the cartographic sense. This is opposed to the meaning used by planners and ecologists, where large-scale refers to a large project area and a broad spatial extent. In cartography, the scale of a map is often represented as a ratio of the length of a feature on the map compared to the true length of the feature on the earth (e.g. 1:24,000 or 1 inch equals 1,200 feet). A larger-scale map will have a smaller denominator (e.g. 1:1,200 or 1 inch equals 100 feet) and show features in greater detail (e.g. building outlines, property lines, and infrastructure for a small section of an urban area). A smaller-scale map (e.g. 1:1,000,000) will have a larger denominator and show features in a more generalized manner (e.g. a state highway map).

[3] A regional-scale GIS application is one that addresses an issue that crosses political boundaries and requires integration of spatial data from multiple sources. It could be multi-county, multi-state, or even international in scope.

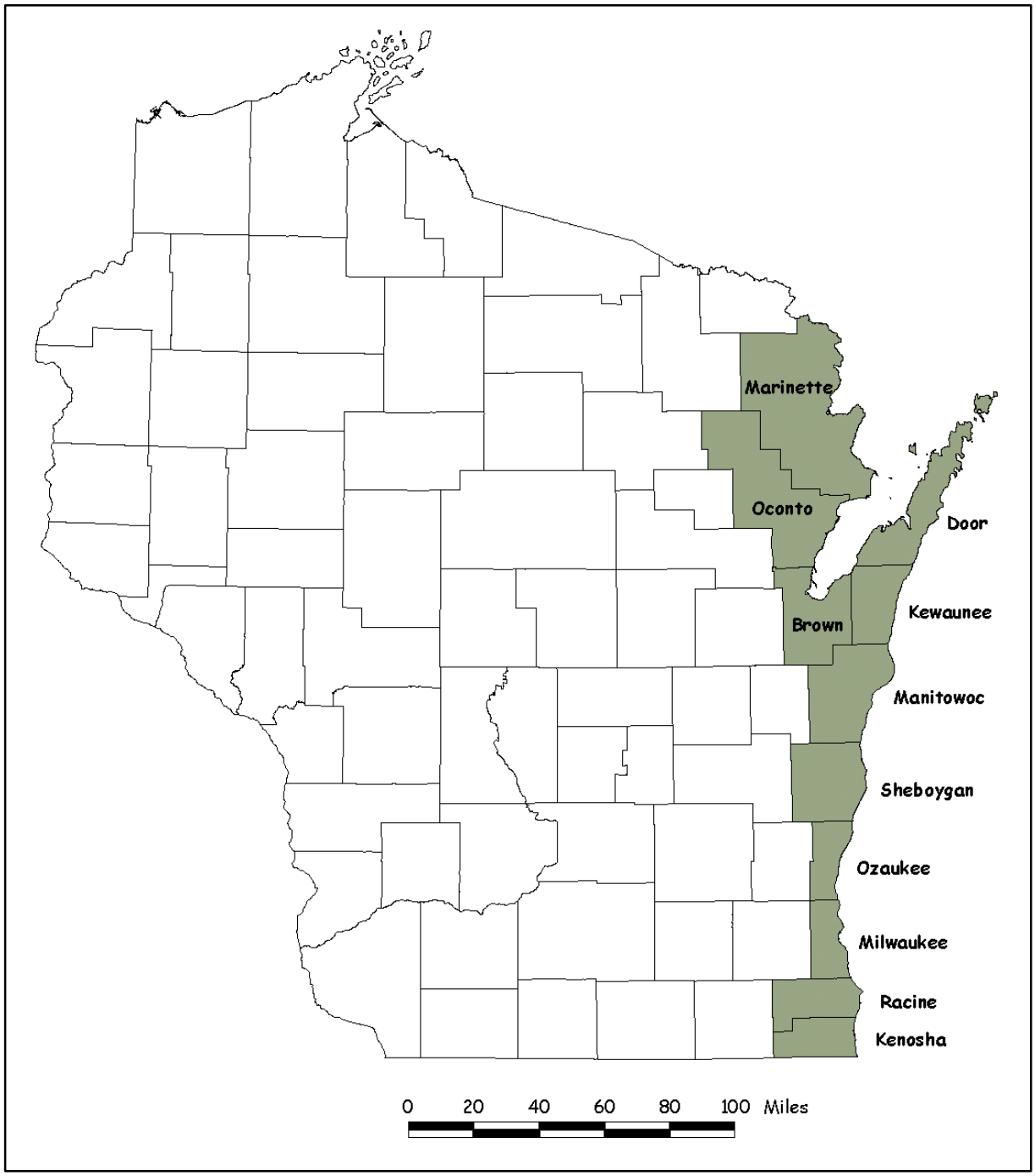
[4] A networked coastal management program relies on the coordination of existing agencies and institutions to improve coastal policy development and regulation. This can be contrasted with state agencies such as the California Coastal Commission that have broad powers to enact and enforce regulations.

(Born and Miller 1988). Finally, the University of Wisconsin Sea Grant Institute (UWSG) sponsors and disseminates research on a variety of coastal issues and serves as an impartial source of scientific information for public policy and decision-makers. UW Sea Grant, through a cooperative venture with the Land Information and Computer Graphics Facility (LICGF) at the University of Wisconsin-Madison titled the Wisconsin Coastal GIS Applications Project, provides university-based outreach to Wisconsin coastal governments and other organizations to ensure that local land information systems are used to improve decision-making related to coastal management issues. The combination of these three programs creates a rich research environment for the study of coastal GIS that, in many ways, provides insight about and sets trends on issues facing other coastal regions.

The Wisconsin Coastal GIS Applications Project has facilitated collaboration with several other organizations regarding coastal GIS. Of particular relevance to this research is a cooperative agreement with the U.S. Army Corps of Engineers, Detroit District to inventory, acquire, and integrate seven large-scale spatial data sets (parcels, planimetric features, topography, digital orthophotos, land use, land cover, and soils) for a 1000-meter zone inland from the Lake Michigan shore in Wisconsin. The cooperative agreement supports the Lake Michigan Potential Damages Study (LMPDS), whose purpose is to assess "potential shoreline damages due to changes in Lake Michigan water levels over the next 50 years" (USACE, Detroit District 1998, p. 1).

Building upon these interactions and projects, the primary objective of the research presented in this paper is to assess the issues associated with the acquisition and integration of digital parcel mapping generated at the local level of government so that it can be utilized to support decision-making about coastal management at a regional scale. In addition to the primary role of supporting the Lake Michigan Potential Damages Study (LMPDS), the research also serves as an early test of the ability of the Wisconsin Land Information Program to support collaborative regional efforts. The first section provides a short summary of the status of digital parcel mapping in the counties that border Lake Michigan in Wisconsin (see Figure 1). The second section discusses findings associated with the acquisition of digital parcel mapping along the Lake Michigan coast of Wisconsin. The third section discusses findings related to the integration of this parcel mapping into a common framework for the entire coast. The paper concludes with a summary and discussion of the range of factors that affect the ability to acquire and integrate digital parcel mapping.

FIGURE 1
LAKE MICHIGAN COASTAL COUNTIES IN WISCONSIN



THE STATUS OF DIGITAL PARCEL MAPPING IN LAKE MICHIGAN COASTAL COUNTIES

In order to better understand the status of digital geospatial data development at the local government level along the Lake Michigan coast of Wisconsin, detailed surveys were conducted in the 11 counties that border Lake Michigan. These surveys were conducted in person in county offices from January 29 to March 17, 1998 and were used to support a study of the issues associated with the development of a horizontally and vertically integrated GIS for coastal management using local government spatial data sponsored by the Wisconsin Coastal Management Program. The survey included a total of 70 questions about the completeness, compilation method, format, and documentation of digital mapping of parcels, planimetric features, orthophotography, elevations, zoning, soils, wetlands, land use, natural resources, and infrastructure (Hart and Miller 1998). Information from this survey was synthesized to provide a detailed picture of the status of digital parcel mapping in the Lake Michigan coastal counties (Hart 1999). Additional surveys on the status and progress of land records modernization in all Wisconsin counties associated with the Wisconsin Land Information Program were undertaken in 1999 and 2000 and provided an opportunity to update the status of digital parcel mapping in the Lake Michigan coastal counties.

Generally speaking, digital parcel mapping in Wisconsin's Lake Michigan coastal counties is fairly well advanced with 85 of the approximately 788,000 parcels complete (see Table 1). Digital parcel mapping is complete in six of the 11 Lake Michigan coastal counties – Door, Kewaunee, Manitowoc, Sheboygan, Milwaukee, and Kenosha. Digital parcel mapping is under active development in the remainder of coastal counties, ranging from 8 to 80 percent complete. These figures include digital parcel mapping in both incorporated and unincorporated areas of the counties.

A more detailed examination of the status of digital parcel mapping along Lake Michigan coast can be undertaken by reviewing coastal municipalities. Municipalities, as designated by Wisconsin law, consist of cities, villages, and towns.[5] There are a total of 18 cities, 13 villages, and 40 towns along the Lake Michigan coast of Wisconsin (see Table 2). Digital parcel mapping is complete for all coastal municipalities in 7 of the 11 Lake Michigan coastal counties. This includes Racine County in addition to the six counties where digital parcel mapping is complete countywide. Figure 2 shows a map of the coastal municipalities where digital parcel mapping is complete, partially complete, or not yet started.

[5] In Wisconsin, towns are a unit of local government, whose jurisdiction often, but not always, coincides with the area of a surveyor's township as designated by the Public Land Survey System (Paddock 1997, p. 115).

TABLE 1
COMPLETENESS OF DIGITAL PARCEL MAPPING
IN LAKE MICHIGAN COASTAL COUNTIES

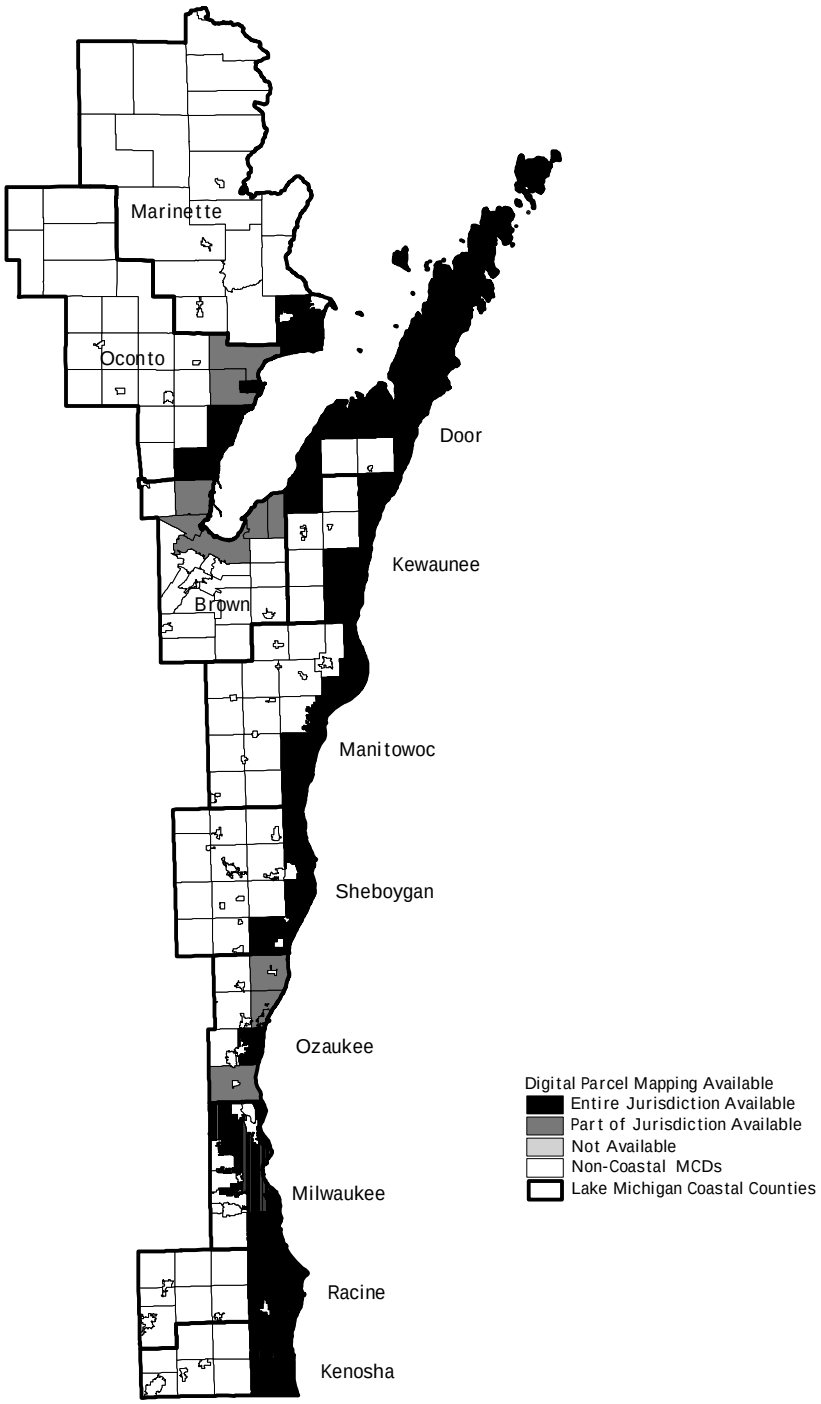
County	Parcel Count	Percent Complete	Approx. Count of Parcels in Digital Format
Marinette	50,058	8%	4,005
Oconto	44,000	30%	13,200
Brown	90,000	80%	72,000
Door	36,000	100%	36,000
Kewaunee	16,000	100%	16,000
Manitowoc	56,273	100%	56,273
Sheboygan	60,228	100%	60,228
Ozaukee	33,000	70%	23,100
Milwaukee	265,000	100%	265,000
Racine	76,000	80%	60,800
Kenosha	61,514	100%	61,514
Totals	**788,073**	**85%**	**668,120**

Note: Parcel count and percent completeness figures are taken from a survey on land records modernization undertaken for the Wisconsin Land Information Board in summer 2000 with the exception of Manitowoc County. Because the parcel count provided for Manitowoc County in this survey appears to omit incorporated areas, the figure used is derived from 1998 parcel counts from the Wisconsin Department of Revenue.

TABLE 2
COMPLETENESS OF DIGITAL PARCEL MAPPING
IN LAKE MICHIGAN COASTAL MUNICIPALITIES

County	Coastal Cities	Coastal Villages	Coastal Towns	1998 DOR Parcel Count in Coastal Municipalities	Percent Complete in Coastal Municipalities
Marinette	1	0	1	8,188	42%
Oconto	1	0	4	10,560	65%
Brown	1	1	3	45,761	72%
Door	1	3	12	35,521	100%
Kewaunee	2	0	5	11,449	100%
Manitowoc	2	1	5	25,775	100%
Sheboygan	1	0	4	25,863	100%
Ozaukee	2	1	3	16,785	93%
Milwaukee	5	4	0	185,907	100%
Racine	1	2	2	47,029	100%
Kenosha	1	1	1	37,639	100%
Totals	**18**	**13**	**40**	**450,477**	

FIGURE 2
STATUS OF DIGITAL PARCEL MAPPING
IN LAKE MICHIGAN COASTAL MUNICIPALITIES



ACQUISITION OF DIGITAL PARCEL MAPPING FOR THE LAKE MICHIGAN COAST

Building upon the 1998 survey of the status of digital geospatial data development in Lake Michigan coastal counties, a research project was initiated to acquire and integrate these data for the purpose of regional-scale analyses of coastal hazards on the Great Lakes. The project, sponsored by the U.S. Army Corps of Engineers, Detroit District, was designed to acquire and integrate seven large-scale, local government spatial data sets to support the analysis of the potential damages associated with changing water levels in Lake Michigan. The digital spatial data sets in question included: parcels, planimetric and topographic mapping, digital orthophotos, land use, land cover, and soils. The location of the study covers a 1000-meter zone inland from the Lake Michigan shore in Wisconsin. Data requests were made, during the summer of 1998, of the 11 Lake Michigan coastal counties. In addition, data requests were made of four coastal municipalities as discussed later in the section. Detailed notes of the data acquisition process were maintained.

One method of examining the status of the acquisition of digital parcel mapping along the coast is to document the amount of shoreline miles where such mapping has been acquired. There are a total of 540.1 miles of shoreline along Lake Michigan in Wisconsin, as measured from 1:100,000 scale mapping provided as part of the TIGER/Line files.[6] Through September 23, 2000, digital parcel mapping has been received for 490.6 of 540.1 shoreline miles (91%) of the Lake Michigan coast in Wisconsin (see Table 3). Complete digital parcel mapping of the shoreline has been received for 7 of the 11 Lake Michigan coastal counties. Partial coverage of digital parcel mapping of the shoreline has been received representing the remaining 4 counties. Figure 3 indicates the spatial extent of the digital parcel mapping received by coastal municipality.

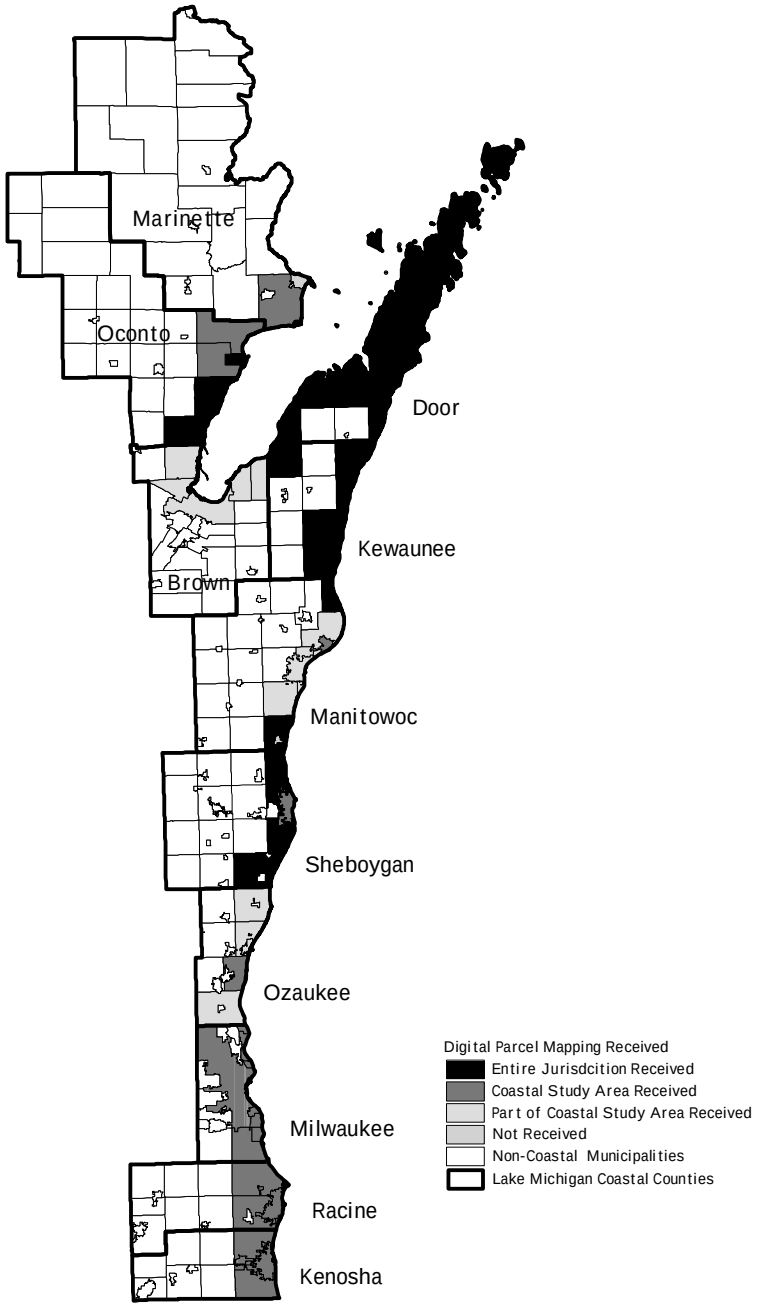
The following sections describe the results of the efforts to acquire digital parcel mapping for the study area. The topics covered include the number of contact points for data requests, the cost of data acquisition, the time elapsed from order to receipt of parcel mapping, and restrictions placed on the use and dissemination of digital data.

[6] It is worth noting that the use of larger-scale mapping results in an increase in the detail of the shoreline and a corresponding increase in the total amount of shoreline miles. The Wisconsin Department of Natural Resources has measured the Great Lakes coast of Wisconsin at 816 miles using 1:2,000,000 scale maps, 950 miles using 1:100,000 scale mapping and 1,017 miles using 1:24,000 scale maps.

TABLE 3
DIGITAL PARCEL MAPPING RECEIVED
FOR THE LAKE MICHIGAN COASTAL STUDY AREA

Jurisdiction	Total Shoreline Miles	Received Digital Parcel Mapping From Jurisdiction	Shore Miles of Coastal Parcels Received	Percent Received
Marinette County	28.1	Yes	20.4	72%
Oconto County	37.5	Yes	37.5	100%
Brown County	50.0	Yes	23.8	48%
Door County	245.1	Yes	245.1	100%
Kewaunee County	29.2	Yes	29.2	100%
Manitowoc County	24.8	Yes	24.8	100%
City of Two Rivers	4.6	Yes	4.6	100%
City of Manitowoc	5.4	Yes	5.4	100%
Sheboygan County	20.8	Yes	20.8	100%
City of Sheboygan	5.5	Yes	5.5	100%
Ozaukee County	27.8	Yes	13.5	49%
Milwaukee County	19.9	Yes	19.9	100%
City of Milwaukee	10.6	Yes	10.6	100%
Racine County	16.2	Yes	16.2	100%
Kenosha County	14.5	Yes	14.5	100%
Totals	**540.1**		**491.9**	**91%**

FIGURE 3
DIGITAL PARCEL MAPPING RECEIVED
FOR LAKE MICHIGAN COASTAL MUNICIPALITIES



Points of Contact

As stated in the previous section, data requests associated with this project were made of 15 jurisdictions (11 counties and 4 cities). Initial data requests were made of land information offices[7] in the Lake Michigan coastal counties. In eight counties, the land information office was able to provide the requested data for all coastal municipalities, including cities, villages, and towns. In three counties (Manitowoc, Sheboygan, and Milwaukee), there were specific municipalities that independently create and maintain their own digital mapping products. These municipalities include the Cities of Two Rivers and Manitowoc in Manitowoc County, the City of Sheboygan in Sheboygan County, and the City of Milwaukee in Milwaukee County.

Cost of Data Acquisition

The cost of acquiring digital parcel mapping from the 15 local government jurisdictions was $3,722.73 (see Table 4). Four of the coastal jurisdictions charged for digital parcel mapping, with one at approximately $100 and three over $1,000. The cost ranged from 2 to 9 cents per parcel in these jurisdictions. The remaining 11 jurisdictions did not charge for digital parcel mapping.

Acquisition of digital parcel mapping for Kewaunee County was provided through their mapping consultant – Ruekert and Mielke, Inc. of Waukesha, Wisconsin. The fee was set to cover the cost of responding to the request. Two separate requests were made for digital parcel mapping in Kewaunee County. The initial request, made in June 1998, covered mapping for all of the coastal study area, except the Town of Carlton and was processed for a fee of $75. The second request, made in March 1999, covered the coastal study area in the Town of Carlton and was processed for a fee of $30.

Parcel mapping in all areas of Milwaukee County, except the City of Milwaukee and the City of West Allis, was completed by the Southeastern Wisconsin Regional Planning Commission (SEWRPC) through the Milwaukee County Automated Mapping and Land Information System (MCAMLIS) project. MCAMLIS is a consortium of Milwaukee County local governments and utilities formed for the purpose of implementing cadastral mapping, planimetric and topographic mapping, and addressing. The formal fee structure for cadastral mapping, planimetric and topographic mapping from MCAMLIS is $65 for the first quarter-section and $30 for each subsequent quarter-section. A total of 91 quarter-sections of digital cadastral maps and 134 quarter-sections of planimetric and topographic mapping were obtained from MCAMLIS. Using the formal MCAMLIS pricing structure, the cost of the digital files would have been $6,785. An invoice from MCAMLIS for $3,400 was received to cover the cost of the cadastral and planimetric/topographic mapping. The pro-rated share of the digital parcel mapping is $1,383.80.

[7] In order to participate in the Wisconsin Land Information Program, a county board must create a land information office to coordinate land information activities and develop a land records modernization plan (Wisc. Stat. 59.72 (3)). Associated with the land information office is a land information officer that acts as a point of contact between the WLIP and the county.

TABLE 4
COST OF DIGITAL PARCEL MAPPING
FROM LAKE MICHIGAN COASTAL JURISDICTIONS

Jurisdiction	Cost	Number of Parcels	Cost per Parcel
Marinette County	$ -	830	$ -
Oconto County	$ -	14,357	$ -
Brown County	$ -	10,792	$ -
Door County	$ -	35,506	$ -
Kewaunee County	$ 105.00	5,001	$ 0.02
Manitowoc County	$ -	2,003	$ -
City of Two Rivers	$ -	5,418	$ -
City of Manitowoc	$ -	7,584	$ -
Sheboygan County	$ -	9,895	$ -
City of Sheboygan	$ -	6,725	$ -
Ozaukee County	$ -	1,123	$ -
Milwaukee County	$ 1,383.80	19,506	$ 0.07
City of Milwaukee	$ 1,125.00	12,402	$ 0.09
Racine County	$ -	35,759	$ -
Kenosha County	$ 1,108.93	14,326	$ 0.08
Total	**$ 3,722.73**	**181,227**	**$ 0.02**

The formal fee structure for digital parcel mapping from the City of Milwaukee is $25 per quarter-section. A total of 45 quarter-sections of digital parcel mapping were requested in July 1998. An invoice was received for $1,400 from the city, which covered $1,125 for the digital parcel mapping and $275 for the Master Property File.

The pricing structure for digital cadastral data from Kenosha County is $40 per PLSS section. The data are available using the following media/delivery formats (8mm DAT tape written in Unix "tar" format ($25 each), 3.5" DOS diskettes, files compressed if necessary ($1.50 each), Compact Disc, written to ISO 9660 Level II specifications ($30 each), ftp download (no charge), and http download (no charge). A total of 27 sections in the coastal area were requested in June 1998. An invoice was received for $1,125 from Kenosha County, which covered $1,080 for the digital parcel mapping, $40 for one section of planimetric/topographic mapping and $30 for the CD media fee. The pro-rated share of the digital parcel mapping and CD media fee is $1,108.93.

The City of Manitowoc also has developed a policy for dissemination of digital spatial data. After the original request for data, city staff stated there may be a fee associated with acquisition of digital spatial data, but that fee may possibly be waived if a letter is sent describing the benefit to the city for providing the data. A letter was prepared and the city responded by processing the data request at no cost.

Time Elapsed from Order to Receipt of Digital Parcel Mapping

The range of time required to fill spatial data requests ranged from 2 days to 531 days (see Table 5). A breakdown of the time required between the initial request and the date when the first shipment of digital parcel mapping was received showed a typical request took about two months to fill. Two requests took under two weeks to process, while two others took six months or more.

TABLE 5
TIME REQUIRED TO RECEIVE DIGITAL PARCEL MAPPING FROM LAKE MICHIGAN COASTAL JURISDICTIONS

Jurisdiction	Start Date	End Date*	Time (days)
Marinette County	6/22/98	8/19/98	58
Oconto County	6/23/98	6/25/98	2
Brown County	6/23/98	8/18/98	56
Door County	6/23/98	7/6/98	13
Kewaunee County	6/22/98	8/14/98	53
Manitowoc County	6/23/98	12/6/99	531
City of Two Rivers	7/24/98	9/28/98	66
City of Manitowoc	7/24/98	8/14/98	21
Sheboygan County	6/23/98	7/8/98	15
City of Sheboygan	7/24/98	9/16/98	54
Ozaukee County	8/6/98	9/9/98	34
Milwaukee County	7/17/98	1/13/99	180
City of Milwaukee	7/28/98	8/24/98	27
Racine County	7/17/98	9/7/98	52
Kenosha County	6/25/98	9/10/98	77
Average			**83**

* Note: In the case of multiple shipments, this represents the date that the first shipment of digital parcel mapping was received.

Several data requests required subsequent interaction between university and local government staff to clarify the type and format of the data needed and check on the status of the request. In particular, this was the case with data requests from Manitowoc and Racine Counties, where multiple interactions with local staff were required to check the status of additional data processing needed to fulfill the request. The data request from Milwaukee County also required additional attention by university and local government staff. The license agreement from the Milwaukee County Automated Mapping and Land Information System (MCAMLIS) included an indemnification clause that was not acceptable to the UW-Madison Purchasing office. After negotiations between attorneys representing MCAMLIS and the university were unable to modify the language of the license agreement in a manner acceptable to both parties, an alternative was

presented to purchase liability insurance through the UW-Madison Risk Management office. A $1,000,000 commercial liability insurance policy for the period of September 1, 1998 to September 1, 1999 was purchased for $263.50, which allowed the acquisition of data to proceed.

Restrictions on Use and Dissemination of Data

Several restrictions were placed on the use and dissemination of digital spatial data (including digital parcel mapping) by coastal jurisdictions. Table 6 summarizes the restrictions placed on use and dissemination of digital parcel mapping by coastal jurisdictions. A total of nine jurisdictions placed no restrictions on use and dissemination of the digital data, although two of those included disclaimers in the data transmittal that were relevant to use of the data. A total of six jurisdictions placed significant restrictions on use and dissemination of the digital data. These range from informal requests to notify the jurisdiction before sharing the data with others (Brown County) to a formal license agreement that required signatures (Milwaukee County). Kewaunee County provided digital parcel mapping through its consulting mapping company. The consulting mapping company, Ruekert and Mielke, Inc., requires the data recipient to accept terms and conditions associated with use of the digital files.

TABLE 6
RESTRICTIONS PLACED ON USE AND DISSEMINATION OF DIGITAL DATA BY JURISDICTION

Jurisdiction	Restrictions Placed on Use and Dissemination of Digital Data
Marinette County	No
Oconto County	No
Brown County	Yes, Informal Request (Please Don't Share Data Without Contacting the County First)
Door County	No
Kewaunee County	Yes, "Terms and Conditions of Use For Digital Files" Provided by the County's Engineering Consultants
Manitowoc County	No
City of Two Rivers	No, (Cover Letter Includes Statement About Need to Check for Accuracy Because Data is a Partial Product)
City of Manitowoc	Yes, Copyright and License Agreement
Sheboygan County	No, (Disclaimers Included. County has Voluntary License Agreement, But Not Included)
City of Sheboygan	No
Ozaukee County	No
Milwaukee County	Yes, Formal Licence Agreement with Signature Required
City of Milwaukee	Yes, License Agreement (Included on Property Data CD, but not Cadastral Data CD)
Racine County	No
Kenosha County	Yes, Statement in Cover Letter (Data for Sole Use - County Notification Required for Dissemination to Third Party)

INTEGRATING DIGITAL PARCEL MAPPING FOR THE LAKE MICHIGAN COAST

Once the digital parcel mapping was received from coastal counties and municipalities, it was converted into a common file format (ARC/INFO coverage) and a common coordinate system for the Lake Michigan coast of Wisconsin (Universal Transverse Mercator, Zone 16 – NAD83(86)). Through September 23, 2000, approximately two years after initial data requests, digital parcel mapping has been integrated for 489.7 of 540.1 shoreline miles (91%) of the Lake Michigan coast in Wisconsin (see Table 7). Digital parcel mapping has been integrated for entire coastal study area covering 1000 meters inland from the Lake Michigan shore in seven of the 11 Lake Michigan coastal counties. Digital parcel mapping has been partially integrated in the remaining four counties. Figure 4 indicates the spatial extent of the digital parcel mapping integrated by coastal municipality.

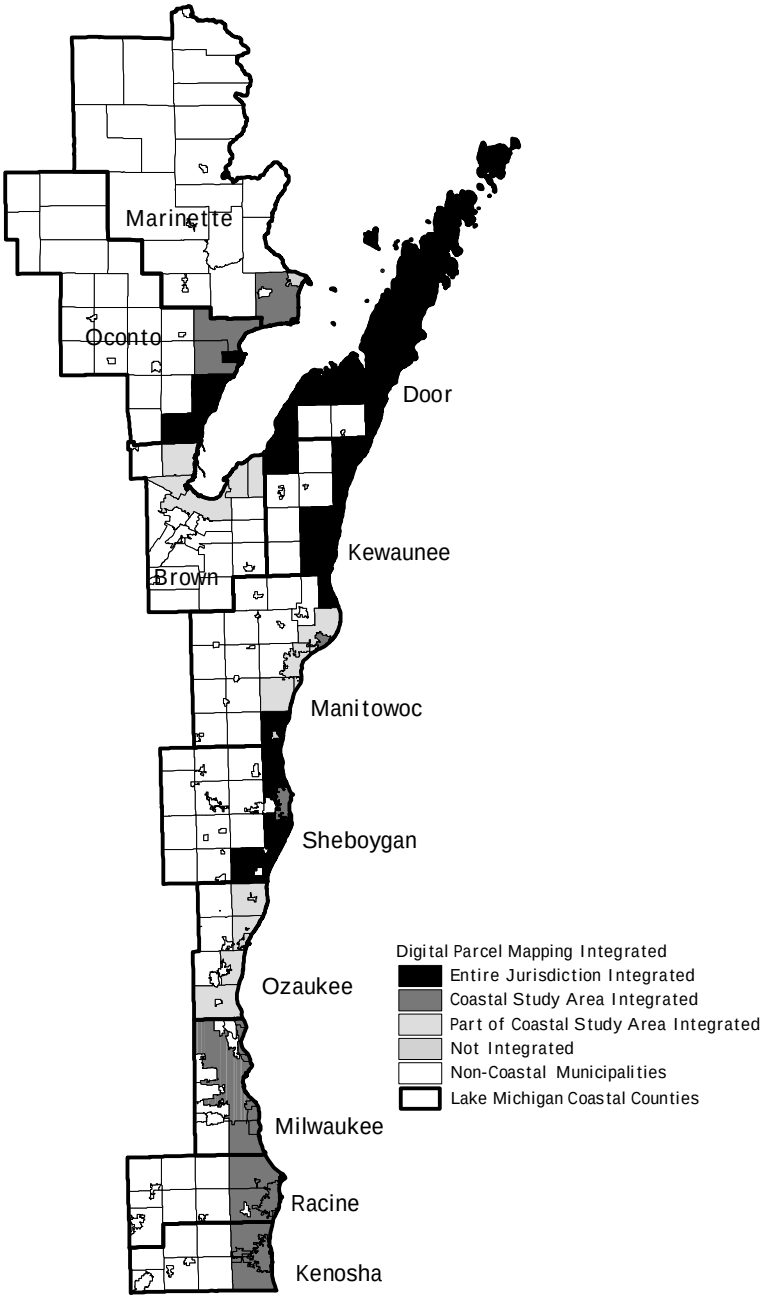
The following sections describe the results of the effort to integrate digital parcel mapping for the study area. The topics covered include:

1. Media/File Transfer Methods
2. File Size
3. Documentation
4. Software Format
5. Tile Structure
6. Compilation Method
7. Coordinate System and Datum
8. Data Structure
9. Linkage to Tax Roll

TABLE 7
STATUS OF INTEGRATING DIGITAL PARCEL MAPPING
FOR THE LAKE MICHIGAN COASTAL STUDY AREA

Jurisdiction	Total Shoreline Miles	Shore Miles of Coastal Parcels Integrated	Percent Integrated
Marinette County	28.1	20.4	72%
Oconto County	37.5	37.5	100%
Brown County	50.0	23.8	48%
Door County	245.1	245.1	100%
Kewaunee County	29.2	29.2	100%
Manitowoc County	24.8	23.6	95%
City of Two Rivers	4.6	4.6	100%
City of Manitowoc	5.4	5.4	100%
Sheboygan County	20.8	20.8	100%
City of Sheboygan	5.5	5.5	100%
Ozaukee County	27.8	12.6	45%
Milwaukee County	19.9	19.9	100%
City of Milwaukee	10.6	10.6	100%
Racine County	16.2	16.2	100%
Kenosha County	14.5	14.5	100%
Totals	**540.1**	**489.7**	**91%**

FIGURE 4
DIGITAL PARCEL MAPPING INTEGRATED
FOR LAKE MICHIGAN COASTAL MUNICIPALITIES



Media/File Transfer Methods

Data requested as part of the project were received on a variety of media, including 3.5" diskettes, Zip disks, compact discs (CDs), and 4mm Digital Audio Tape (DAT) (see Table 8).

Most data sets were sent on physical media through the U.S. Postal Service, although electronic file transfer methods were used in some cases. These include File Transfer Protocol (FTP) and attachments to Email messages.

All files were successfully transferred to a consolidated location, although the Land Information and Computer Graphics Facility (LICGF) does not possess a 4mm DAT reader and had to request the assistance of the Environmental Remote Sensing Center at UW-Madison to read and transfer the files to the file repository at LICGF.

TABLE 8
MEDIA AND FILE TRANSFER METHODS

Jurisdiction	Media	File Transfer Method
Marinette County	Diskettes (2)	Mail
Oconto County	Diskettes (6)/FTP	Mail/FTP
Brown County	FTP	FTP
Door County	Compact Disc (2)	Mail/In Person
Kewaunee County	Compact Disc/Email	Mail/Email Attachment
Manitowoc County	FTP	FTP
City of Two Rivers	Compact Disc	Mail/FTP
City of Manitowoc	Compact Disc (3)	Mail/FTP
Sheboygan County	Zip Disk	Mail
City of Sheboygan	Zip Disk	Mail
Ozaukee County	Compact Disc	Mail/In Person
Milwaukee County	Compact Disc (2)	Mail
City of Milwaukee	Compact Disc (2)	Mail
Racine County	4mm DAT/FTP	Mail/FTP
Kenosha County	Compact Disc/Diskettes (2)	Mail

File Size

Depending on map compilation methods, the density of parcels and other factors, digital parcel files can be quite large. The total file size of digital parcel mapping for the Lake Michigan coast received as of September 23, 2000 is 268.6 Megabytes (MB). The range of file size extends from 3.4 to 66.5 MB per jurisdiction (see Table 9). The file size normalized per parcel ranged from 0.55 to 10.38 KB.

TABLE 9
FILE SIZE FOR DIGITAL PARCEL MAPPING

Jurisdiction	File Size (MB) Original Format	Number of Parcels	File Size (KB) per Parcel
Marinette County	3.9	830	4.70
Oconto County	16.0	14,357	1.11
Brown County	20.0	10,792	1.85
Door County	31.0	35,506	0.87
Kewaunee County	23.2	5,001	4.64
Manitowoc County	20.8	2,003	10.38
City of Two Rivers	3.9	5,418	0.72
City of Manitowoc	6.2	7,584	0.82
Sheboygan County	21.0	9,895	2.12
City of Sheboygan	7.2	6,725	1.07
Ozaukee County	3.3	1,123	2.94
Milwaukee County	66.5	19,506	3.41
City of Milwaukee	12.7	12,402	1.02
Racine County	19.8	35,759	0.55
Kenosha County	13.1	14,326	0.91
Total	**268.6**	**181,227**	**1.48**

Documentation

Adequate documentation of spatial data is very important in data integration projects. At a fundamental level, specific information is needed to transform local spatial data to represent a "seamless" view of the Lake Michigan coastline. Documentation of digital parcel mapping received from the coastal jurisdictions took a variety of forms. These included "readme" files and cover letters sent with the data, development of contract specifications for parcel mapping, and development of parcel mapping guidebooks (see Table 10). In some cases, information about parcel mapping methods were placed on the digital files themselves as annotation. Generally speaking, these forms of documentation did not provide all the information needed to effectively integrate digital parcel mapping. Follow up contact with coastal jurisdictions was needed. Two counties (Brown and Kenosha) developed comprehensive documentation of digital parcel mapping that follows the Content Standards for Digital Geospatial Metadata adopted by the Federal Geographic Data Committee.

TABLE 10
DOCUMENTATION OF DIGITAL PARCEL MAPPING

Jurisdiction	Documentation Provided for Digital Parcel Mapping
Marinette County	No
Oconto County	Information sheets on layer names and attributes.
Brown County	FGDC Metadata on Wisconsin Land Information Clearinghouse.
Door County	Detailed documentation of parcel mapping methods and specifications.
Kewaunee County	Information sheet on layer names.
Manitowoc County	No
City of Two Rivers	Cover letter on file format and naming convention. Notes on Digital Map Sheet.
City of Manitowoc	Cover letter describing file format and parcel mapping methods. Information sheet on coordinate system, file format, and data quality. Annotation on digital mapping.
Sheboygan County	Information sheets on file names, file format, coordinate system, attributes, and medium. Disclaimer statement.
City of Sheboygan	No
Ozaukee County	Parcel mapping guidebook on County website.
Milwaukee County	Information sheets on file naming conventions, layer names, map symbolization, and feature tags. Annotation on digital mapping.
City of Milwaukee	Readme files on layer names and attributes.
Racine County	No
Kenosha County	Information sheets on layer names, feature tags, and map symbolization. FGDC Metadata on Wisconsin Land Information Clearinghouse.

Software/File Format

A variety of software is used to create and maintain digital parcel mapping along the Lake Michigan coast. Table 11 indicates the software and file formats utilized by coastal jurisdictions when digital parcel mapping was requested in 1998. Most coastal jurisdictions use AutoCAD software for parcel mapping. Other choices include GenaMap, Intergraph, Arc/Info, ArcCAD, and ArcView shapefiles. Most GIS and CAD software packages support a range of formats for export of digital files. Several jurisdictions (including Door, Sheboygan, Milwaukee, and Kenosha Counties) support at least two alternatives for the file format used to distribute digital parcel mapping.

All files were successfully converted to Arc/Info coverages and ArcView shape files. Extra effort was needed to convert digital parcel mapping received from Racine County. Originally the files were sent in GenaMap format and project staff did not have access to software that could convert GenaMap files into Arc/Info coverages or ArcView shapefiles. As the project progressed, Racine County obtained a translator with assistance from project staff and successfully translated GenaMap data into ArcView shape files.

TABLE 11
SOFTWARE AND FILE FORMAT FOR DIGITAL PARCEL MAPPING

Jurisdiction	Software Used by Jurisdiction for Digital Parcels	File Format Received
Marinette County	AutoCAD	AutoCAD (DWG)
Oconto County	Arc/Info	Arc/Info (coverage)
Brown County	AutoCAD	AutoCAD (DWG)
Door County	AutoCAD and ArcCAD	Arc/Info (coverage)
Kewaunee County	AutoCAD	AutoCAD (DWG)
Manitowoc County	AutoCAD	ArcView Shapefile (SHP), pcArcInfo, AutoCAD (DWG)
City of Two Rivers	Intergraph	Intergraph (DGN)
City of Manitowoc	Intergraph	Intergraph (DGN), ArcView Shapefile (SHP)
Sheboygan County	Arc/Info and ArcView	ArcView Shapefile (SHP)
City of Sheboygan	AutoCAD	AutoCAD (DWG)
Ozaukee County	AutoCAD	AutoCAD (DWG)
Milwaukee County	GenaMap	ArcView Shapefile (SHP); AutoCAD (DWG)
City of Milwaukee	Intergraph	Intergraph
Racine County	GenaMap	GenaMap, ArcView Shapefile (SHP)
Kenosha County	GenaMap	ArcView Shapefile (SHP)

Tile Structure

Digital parcel mapping can be structured to provide a seamless representation of a geographic area or can be divided or "tiled" to cover specific areas. Table 12 indicates the different techniques used to segment digital parcel mapping along the Lake Michigan coast at the time the digital parcel mapping was requested in 1998. Three different techniques were utilized. One was to provide one file for the entire 1000-meter study area. This method was used in Kenosha County and the City of Sheboygan. Another was to tile by municipality or minor civil division (MCD). Four counties use this approach. The third technique was to tile by Public Land Survey System (PLSS) section, quarter-section, or quarter-quarter-section. The remainder of the coastal jurisdictions used this approach, including Marinette County, which used a combination of the three.

TABLE 12
TILE STRUCTURE FOR DIGITAL PARCEL MAPPING

Jurisdiction	Tile Structure	Number of Tiles Received
Marinette County	Section, 1/4 Sec, 1/4 1/4 Sec	(24+16+3)
Oconto County	Municipality, Coastal Study Area	5
Brown County	Municipality	6
Door County	Municipality	19
Kewaunee County	Section	50
Manitowoc County	Coastal Study Area (also Municipality)	(1+5)
City of Two Rivers	Section	44
City of Manitowoc	Section	17
Sheboygan County	Municipality	4
City of Sheboygan	Coastal Study Area	1
Ozaukee County	Section, 1/4 Section	65
Milwaukee County	1/4 Section	91
City of Milwaukee	1/4 Section	44
Racine County	1/4 Section	29
Kenosha County	Coastal Study Area	1
Total Tiles		**425**

Compilation Method

A variety of compilation methods are used for digital parcel mapping in the study area (see Table 13). In several instances, jurisdictions used multiple methods that evolved over time. Some jurisdictions developed digital parcel mapping in-house, while others contracted out the work. The most prevalent compilation method is the use of coordinate geometry (COGO). Several jurisdictions have digitized existing parcel maps. Most jurisdictions tied digital parcel mapping to the geodetic reference framework. Oconto County tied digital parcel mapping to the PLSS Landnet developed by the Wisconsin Department of Natural Resources, while digital parcel mapping in Manitowoc County is "floating" (i.e. not referenced to a real-world coordinate system).

TABLE 13
COMPILATION METHOD FOR DIGITAL PARCEL MAPPING

Jurisdiction	Digital Parcel Mapping Compilation Method	Is Digital Parcel Mapping Tied to the Geodetic Reference Framework Used in the County?
Marinette County	COGO	Yes
Oconto County	Digitized	No. Tied to PLSS-DNR Landnet.
Brown County	COGO	Yes
Door County	Variety of methods used	Yes
Kewaunee County	COGO	Yes
Manitowoc County	"Drawn"	Partial, for coastal area only. Most areas "floating"
City of Two Rivers	Hybrid method	Yes
City of Manitowoc	Digitized	Yes. In process of realigning to improve accuracy
Sheboygan County	COGO and Digitized	Yes
City of Sheboygan	COGO	Yes
Ozaukee County	COGO	Yes
Milwaukee County	COGO and Digitized	Yes
City of Milwaukee	Digitized	Yes
Racine County	COGO	Yes
Kenosha County	Digitiged	Yes

Coordinate System and Datum

A variety of coordinate systems and datums are used for digital parcel mapping along the Lake Michigan coast (see Table 14). The four counties in southeastern Wisconsin (Ozaukee, Milwaukee, Racine, and Kenosha) use Wisconsin State Plane Coordinates, South Zone, NAD27. The Cities of Sheboygan and Manitowoc use Wisconsin State Plane Coordinates, South Zone, but referenced to NAD83. Door and Kewaunee Counties use Wisconsin State Plane Coordinates, Central Zone, NAD83(91). The remainder of the coastal counties and the City of Two Rivers use county coordinates. In some cases, there are differences between the coordinate systems used by the county and cities within the county.

TABLE 14
COORDINATE SYSTEM AND DATUM
OF DIGITAL PARCEL MAPPING

Jurisdiction	Coordinate System	Datum
Marinette County	Marinette County Coordinates	NAD83(91)
Oconto County	Oconto County Coordinates	NAD83(91)
Brown County	Brown County Coordinates	NAD83(91)
Door County	State Plane Coordinates - Central Zone	NAD83(91)
Kewaunee County	State Plane Coordinates - Central Zone	NAD83(91)
Manitowoc County	Manitowoc County Coordinates[1]	NAD83(91)
City of Two Rivers	Manitowoc County Coordinates[1]	NAD83(91)
City of Manitowoc	State Plane Coordinates - South Zone	NAD83(91)
Sheboygan County	Sheboygan County Coordinates[1]	NAD83(91)
City of Sheboygan	State Plane Coordinates - South Zone	NAD83
Ozaukee County	State Plane Coordinates - South Zone	NAD27
Milwaukee County	State Plane Coordinates - South Zone	NAD27
City of Milwaukee	State Plane Coordinates - South Zone	NAD27
Racine County	State Plane Coordinates - South Zone	NAD27
Kenosha County	State Plane Coordinates - South Zone	NAD27

[1]Kewaunee, Manitowoc, and Sheboygan Counties share the same parameters for their county coordinate systems.

All files were successfully converted to the common coordinate system for the project (Universal Transverse Mercator, Zone 16 – NAD83(86)) using the projection command in ARC/INFO. The spatial accuracy of transformations and compilation methods was tested by examining the difference between common parcel lines at county boundaries. Ten measurements were made at each county boundary where digital parcel mapping existed on both sides. Table 15 displays the mean and standard deviation at each of nine common boundaries that met the criteria. The differences ranged from a mean 0.00 feet with a standard deviation of 0.00 feet at the Milwaukee-Racine County boundary to 28.95 feet with a range of 0.27 feet at the Kewaunee-Manitowoc County boundary. The highest variability was at the west (Lake Michigan) boundary of Door and Kewaunee Counties with a mean of 16.43 feet and a standard deviation of 10.79 feet. The mean of measurements at all county boundaries was 8.36 feet, while the standard deviation was 10.66 feet.

TABLE 15
EDGE MATCHING OF DIGITAL PARCEL MAPPING
AT COUNTY BOUNDARIES

Border	Minimum (feet)	Maximum (feet)	Mean (feet)	Std. Dev (feet)
Marinette-Oconto	0.11	1.43	0.37	0.47
Oconto-Brown	1.61	29.79	13.64	6.91
Brown-Kewaunee	0.07	4.98	2.40	1.58
Kewaunee-Door (e)	0.78	26.74	10.21	9.13
Door-Kewaunee (w)	0.32	31.74	16.43	10.79
Kewaunee-Manitowoc	28.53	29.45	28.95	0.27
Ozaukee-Milwaukee	2.64	6.43	3.20	1.15
Milwaukee-Racine	0.00	0.00	0.00	0.00
Racine-Kenosha	0.00	0.45	0.05	0.14
All Borders	**0.00**	**31.74**	**8.36**	**10.66**

Data Structure

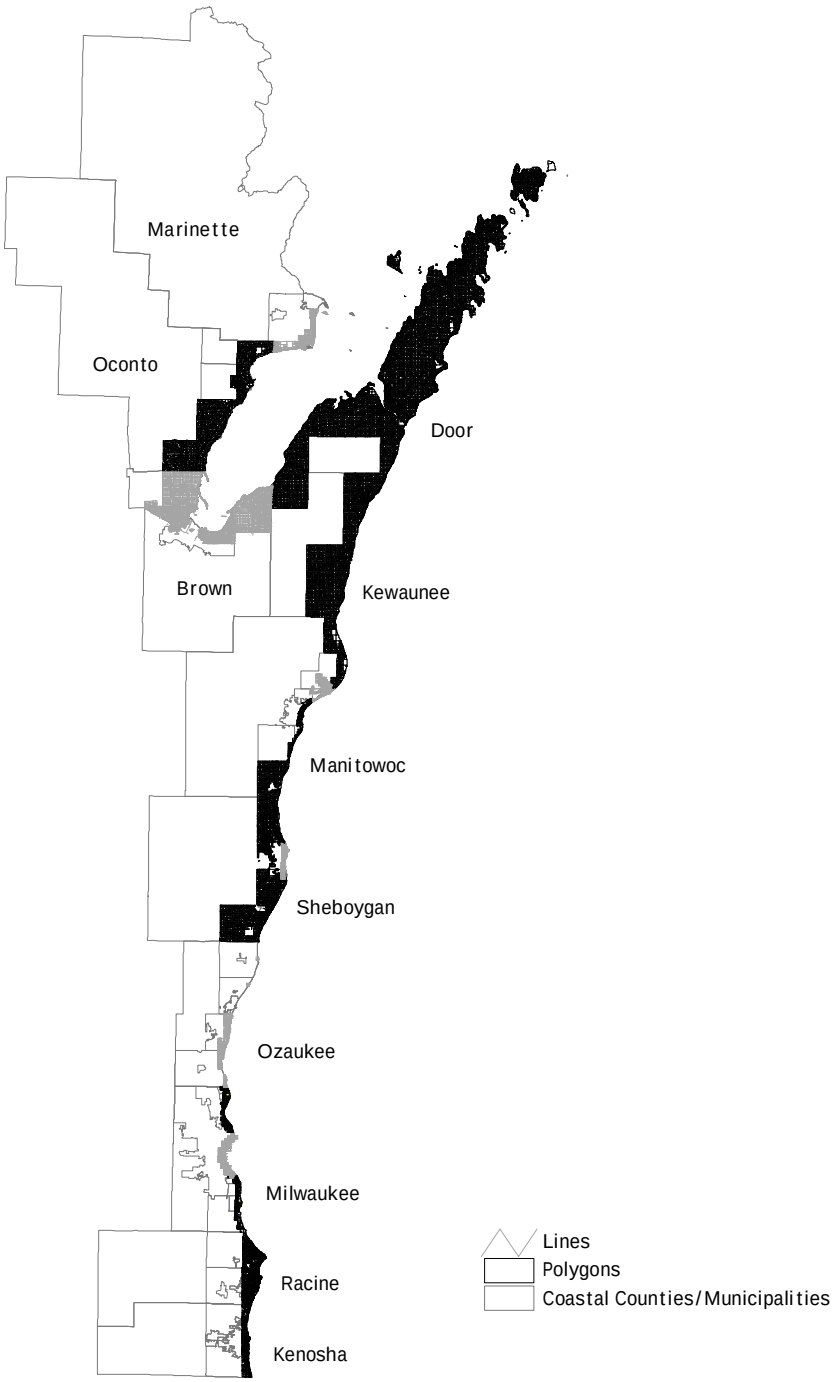
This section provides information about the data structure for digital parcel mapping (see Table 16). Figure 5 shows digital parcels are coded as polygons in black and lines in gray.

There are two typical data structures for the digital parcel mapping received for the Lake Michigan coast of Wisconsin. The first category includes jurisdictions that maintain parcels as polygons with topology. This includes seven counties and one city. The second category includes jurisdictions that maintain parcels as lines, typically in a computer-aided drafting (CAD) format, where topology is not developed (three counties and three cities). As a note, Manitowoc County maintains digital parcel mapping represented as lines in a CAD format, but, in support of this project, converted parcels in the coastal study area to a data structure where parcels are represented as polygons.

TABLE 16
DATA STRUCTURE FOR DIGITAL PARCEL MAPPING

Jurisdiction	Structure of Parcels
Marinette County	Lines
Oconto County	Polygons
Brown County	Lines
Door County	Polygons
Kewaunee County	Polygons
Manitowoc County	Lines, Polygons
City of Two Rivers	Lines
City of Manitowoc	Polygons
Sheboygan County	Polygons
City of Sheboygan	Lines
Ozaukee County	Lines
Milwaukee County	Polygons
City of Milwaukee	Lines
Racine County	Polygons
Kenosha County	Polygons

FIGURE 5
DATA STRUCTURE OF DIGITAL PARCELS
ALONG THE LAKE MICHIGAN COAST OF WISCONSIN



Linkage to Tax Roll Data

This section identifies the status of coding digital parcel mapping with parcel identification numbers (PINs) and whether a linkage can be made between digital parcels and tax roll data to support thematic mapping of ownership and assessment information.

As indicated in Table 17, all jurisdictions code digital parcel mapping for the Lake Michigan coast of Wisconsin with a parcel identification number, although in one county it is only partially complete. What varies is the method for depicting PINs. In the seven counties and one city where digital parcel mapping is structured as polygons, the PIN is an attribute of the polygon data set. In the three counties and three cities where digital parcel mapping is structured as lines in a CAD format, PINs are represented as label points. In the case of Manitowoc County, PINs were only assigned for the portion of the digital parcel mapping that was converted to a polygon data structure for the coastal study area, but are included as label points in the CAD files. The area where PINs were assigned as attributes to polygons is the Town of Two Creeks, the northernmost town along the Lake Michigan coast in Manitowoc County.

TABLE 17
PARCEL IDENTIFICATION NUMBERS
FOR DIGITAL PARCEL MAPPING

Jurisdiction	Are Digital Parcels Coded with Parcel IDs?
Marinette County	Yes, Points
Oconto County	Yes, Polygons
Brown County	Yes, Points
Door County	Yes, Polygons
Kewaunee County	Yes, Polygons
Manitowoc County	Partially Complete for Polygons
City of Two Rivers	Yes, Points
City of Manitowoc	Yes, Polygons
Sheboygan County	Yes, Polygons
City of Sheboygan	Yes, Points
Ozaukee County	Yes, Points
Milwaukee County	Yes, Polygons
City of Milwaukee	Yes, Points
Racine County	Yes, Polygons
Kenosha County	Yes, Polygons

Table 18 depicts the status of parcel identification numbers for digital parcel mapping along the Lake Michigan coast of Wisconsin. The first figure represents the total number of digital parcels integrated. This consists of either the total count of polygon features (alternatively represented as records in the attribute table for the data set) for parcels represented as polygons or the total number of label points for parcels represented as lines in a CAD format. The table also indicates the count of digital parcels that are coded with a PIN. In Marinette, Door, and Kewaunee Counties, all digital parcels are coded with a PIN. In most of the remaining jurisdictions (10 of 15), the percentage of digital parcels coded with a PIN approached 100% (the City of Manitowoc and the City of Milwaukee are depicted as 100% due to rounding error). In Oconto County only 74.0% of digital parcels are coded with a PIN. Many of those that are not coded with a PIN appear to be sliver polygons. The percentage of parcels in Manitowoc County coded with PIN includes only the Town of Two Creeks as described in the previous section. Overall, 175,033 of 181,778 (96.3%) of parcels integrated in the coastal study area have been coded with a PIN.

Table 18 also includes a count of the parcels with a unique parcel identification number. In all coastal jurisdictions, digital parcel mapping includes parcels with duplicate PINs. In most cases, the duplicates represent parcels that are owned by the same person. In some cases, duplicate PINs may represent an error in coding or the presence of many sliver polygons created by building polygon topology. In 12 of 15 jurisdictions, the comparison of unique parcel identification numbers to total digital parcels exceeds 90%. In Sheboygan County, while most parcels are coded with a PIN, the number of unique PINs drops to 79.2%. In Oconto County, the percentage of unique PINs to the total is less than half (48.2%). In Manitowoc County, although the total number of parcels coded with a PIN is low, all coded PINs in the Town of Two Creeks are unique. Overall in the coastal study area, there are 166,135 unique parcel identification numbers as compared to a total of 181,778 digital parcels (91.4%).

TABLE 18
STATUS OF PARCEL IDENTIFICATION NUMBERS (PINS)
FOR DIGITAL PARCEL MAPPING

Jurisdiction	Digital Parcels Integrated	Digital Parcels with a PIN	Number of Unique PINs	Percent of Digital Parcels with a PIN	Percent of Unique PINs to Total Digital Parcels
Marinette County	830	830	780	100.0%	94.0%
Oconto County	14,357	10,621	6,914	74.0%	48.2%
Brown County	10,792	10,581	10,444	98.0%	96.8%
Door County	35,506	35,506	34,495	100.0%	97.2%
Kewaunee County	8,830	8,830	8,431	100.0%	95.5%
Manitowoc County	2,003	483	483	24.1%	24.1%
City of Two Rivers	5,418	5,405	5,360	99.8%	98.9%
City of Manitowoc	4,306	4,304	4,276	100.0%	99.3%
Sheboygan County	9,895	9,364	7,840	94.6%	79.2%
City of Sheboygan	6,725	6,717	6,638	99.9%	98.7%
Ozaukee County	1,123	1,119	1,103	99.6%	98.2%
Milwaukee County	19,506	19,409	19,154	99.5%	98.2%
City of Milwaukee	12,402	12,401	12,249	100.0%	98.8%
Racine County	35,759	35,279	34,117	98.7%	95.4%
Kenosha County	14,326	14,184	13,851	99.0%	96.7%
Totals	**181,778**	**175,033**	**166,135**	**96.3%**	**91.4%**

The tax roll database can be linked to digital parcel mapping (either polygons or points) through the use of a common identification number. Ideally, the unique identification number in the tax roll database, commonly referred to as the tax key number, is formatted the same as the PIN in the digital database. When this is the case, a linkage can easily be established between the two databases, which allows thematic mapping of attributes in the tax roll, such as ownership, assessed value, and assessment class (a form of land use). Table 19 covers the ability to create a linkage between tax roll data to digital parcel mapping. Copies of the tax roll database for the coastal study area were requested at the same time as the request for digital parcel mapping. As of September 23, 2000, tax roll data has been received for 14 of 15 coastal jurisdictions. Of this, only part of the tax roll for the coastal study area has been received from Ozaukee County.

A linkage can be made between the tax key number in the tax roll database and the parcel identification number in the digital parcel mapping for 11 of 15 coastal jurisdictions. A linkage could not easily be established without major reformatting of either the PIN or the tax key number in Marinette County and the Cites of Two Rivers and Milwaukee. Tax roll data have not yet been received in Milwaukee County.

TABLE 19
LINKAGE OF TAX ROLL DATA TO DIGITAL PARCEL MAPPING

Jurisdiction	Received Tax Roll Data for Digital Parcels Acquired from Jurisdiction?	Can a Linkage be Made Between Tax Roll Data and Digital Parcels?
Marinette County	Yes	No
Oconto County	Yes	Yes
Brown County	Yes	Yes
Door County	Yes	Yes
Kewaunee County	Yes	Yes
Manitowoc County	Yes	Yes
City of Two Rivers	Yes	No
City of Manitowoc	Yes	Yes
Sheboygan County	Yes	Yes
City of Sheboygan	Yes	Yes
Ozaukee County	Partial	Yes
Milwaukee County	No	Tax Roll Not Received
City of Milwaukee	Yes	No
Racine County	Yes	Yes
Kenosha County	Yes	Yes

Table 20 provides a statistical summary of the linkage of tax roll data to digital parcel mapping. As of September 23, 2000, a total of 124,479 tax roll records representing 11 of the 15 coastal jurisdictions could be linked to a unique parcel identification number. This represents 75% of the 166,135 unique PINs integrated so far for the coastal study. There was a one-to-one match between tax key numbers and unique PINs in Door County and the City of Manitowoc. A match of over 90% was made in six additional counties and one city and between 80% and 90% in two counties (Brown and Ozaukee).

TABLE 20
STATUS OF THE LINKAGE OF TAX ROLL DATA TO DIGITAL PARCELS CODED WITH A PARCEL IDENTIFICATION NUMBER

Jurisdiction	Number of Unique PINs	Records in the Tax Roll Database	Tax Roll Records Linked to Parcels	Percent of Tax Roll Records Linked to Parcels Coded with a PIN
Marinette County	780	2,880	-	0%
Oconto County	6,914	8,566	6,703	97%
Brown County	10,444	29,899	8,572	82%
Door County	34,495	34,495	34,495	100%
Kewaunee County	8,431	8,585	8,372	99%
Manitowoc County	483	3,815	478	99%
City of Two Rivers	5,360	5,351	-	0%
City of Manitowoc	4,276	4,276	4,276	100%
Sheboygan County	7,840	7,525	7,355	94%
City of Sheboygan	6,638	8,945	6,520	98%
Ozaukee County	1,103	5,436	987	89%
Milwaukee County	19,154	-	-	
City of Milwaukee	12,249	157,920	-	0%
Racine County	34,117	36,382	32,945	97%
Kenosha County	13,851	14,232	13,776	99%
Totals	**166,135**	**328,307**	**124,479**	**75%**

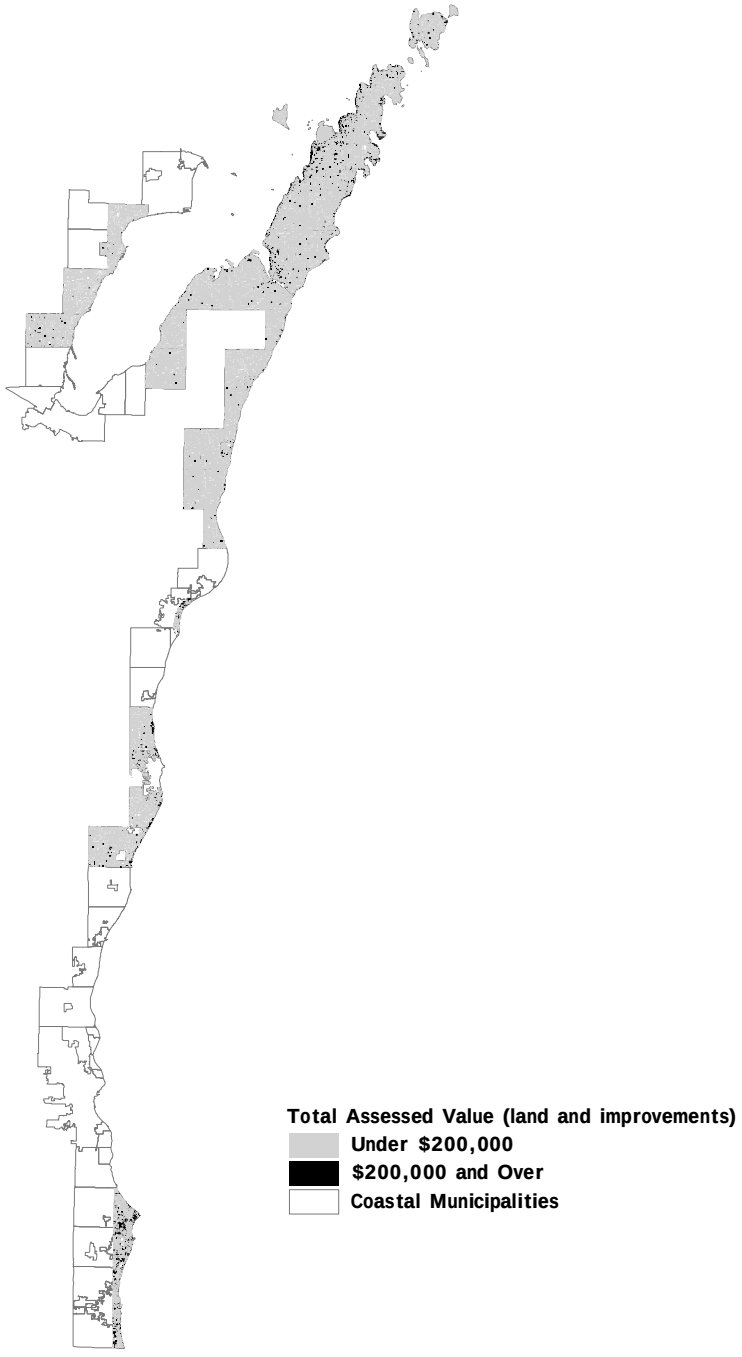
An alternative means of assessing the status of linking tax roll data to digital parcel mapping for coastal jurisdictions is to tabulate the number of shoreline miles where a linkage can be made. As indicated in Table 21, such a linkage can be made for 415.8 of 540.1 shoreline miles. This represents 77% the shoreline of Lake Michigan in Wisconsin. A complete linkage can be made in six counties and two cities and a partial linkage can be made in three counties. As of September 23, 2000, a linkage could not be established in two counties and two coastal cities.

The results of a linkage between the tax roll database and digital parcel mapping can be displayed in a graphic form. A variety of thematic maps can be created from information in the tax roll database, including ownership patterns, assessed value, and assessment class. Figure 6 depicts the assessed value of property for the Lake Michigan coastal jurisdictions where a linkage can be made between the tax roll and digital parcel mapping formatted as polygons. It displays the total assessed value of land and improvements. Distinctions are made between property assessed at under $200,000 in gray and $200,000 and over in black.

TABLE 21
STATUS OF LINKAGE OF TAX ROLL DATA
TO DIGITAL PARCEL MAPPING

Jurisdiction	Total Shoreline Miles	Shore Miles of Coastal Parcels with Linkage to Tax Roll	Percent of Shore Miles with Linkage to Tax Roll
Marinette County	28.1	-	0%
Oconto County	37.5	37.5	100%
Brown County	50.0	23.8	48%
Door County	245.1	245.1	100%
Kewaunee County	29.2	29.2	100%
Manitowoc County	24.8	6.3	26%
City of Two Rivers	4.6	-	0%
City of Manitowoc	5.4	5.4	100%
Sheboygan County	20.8	20.8	100%
City of Sheboygan	5.5	5.5	100%
Ozaukee County	27.8	11.5	41%
Milwaukee County	19.9	-	0%
City of Milwaukee	10.6	-	0%
Racine County	16.2	16.2	100%
Kenosha County	14.5	14.5	100%
Totals	**540.1**	**415.8**	**77%**

FIGURE 6
ASSESSED VALUE OF LAND AND IMPROVEMENTS
FOR THE LAKE MICHIGAN COASTAL STUDY AREA



DISCUSSION

Several factors affect the ability to acquire and integrate digital parcel mapping to address coastal management issues at a regional scale. These factors can be grouped under the following three topics: data availability, data acquisition, and data integration.

Data Availability

In the past, a project to integrate digital parcel mapping across a large region such as the Lake Michigan coast of Wisconsin would have been difficult to undertake due to the lack of available parcel mapping in a digital format. Within the past few years, there are indications that local government GIS is reaching a level of maturity where efforts to integrate digital parcel mapping across administrative boundaries will be more fruitful. Warnecke et al. (1998) reports that, of 200 city and county governments surveyed in the United States, 77 percent used GIS in 1996, with 87 percent expecting to use GIS in 1997. The National States Geographic Information Council (NSGIC) and the Federal Geographic Data Committee (FGDC) conducted a survey of 5,258 data users during late 1997 and 1998 regarding framework data themes. A total of 782 of 1,907 counties (41%) and 377 of 1,184 cities and towns (32%) that responded to the survey indicated that they create, update, integrate and/or distribute data that describe privately owned parcels.

In Wisconsin, evidence exists to show that the Wisconsin Land Information Program has accelerated implementation of GIS/LIS at the local government level (Tulloch and Niemann, 1996). In comparison to national results, a total of 56 of 70 counties (80%) and 23 of 31 cities and towns (74%) in Wisconsin that responded to the FGDC framework survey indicated that they create, update, integrate and/or distribute data that describe privately owned parcels. Preliminary analysis of a 2000 survey of the status and progress of the WLIP indicates that approximately 2,136,000 of 3,142,000 parcels (68%) in the state are in a digital format. This is up from 42% in 1997 and 57% in 1999. In addition, a total of 16 of 72 counties have parcel mapping completed for the entire county in a digital format. This is projected to increase to 48 counties by 2003.

This study shows that 85% of digital parcel mapping is complete in the 11 Lake Michigan coastal counties and that 427,926 of 450,477 (95%) of digital parcels are complete for the 71 municipalities (18 cities, 13 villages, and 40 towns) along the Lake Michigan coast of Wisconsin. Regions with this extent of parcel mapping in a digital format are likely to be isolated at present, but will grow quickly over time. Analysis of the FGDC framework survey will point to areas in other parts of the nation where parcel integration projects may be feasible.

Data Acquisition

Four factors have been identified related to data acquisition that impact data integration projects. These include the number of contact points for data requests, the cost of data acquisition, the time required to receive data after the request is made, and restrictions placed on the use and dissemination of digital data.

Points of Contact. Data requests were made of 15 jurisdictions (11 counties and four cities) associated with this project. The existence in Wisconsin of land information offices serving as designated points of contact for local government spatial data acquisition made this aspect of data acquisition relatively straightforward. Despite this, there were three counties where the land information office could not process the data acquisition request for the entire coastal area. The number of data requests that must be made as part of a data integration project will affect the level of effort needed to complete it. If the study area is fragmented into many small jurisdictions, then the project will likely be more difficult to accomplish. The same applies if spatial data management within a single local government is fragmented across many departments. On the other hand, coordinated data development and dissemination at the local or regional level will likely significantly reduce the amount of effort needed to complete a data integration project.

Cost. The cost of acquiring digital parcel mapping for this study area was $3,722.73. Although the majority of jurisdictions did not charge for digital parcel mapping (11 of 15), three of those that did so charged over $1,000 each. Depending on the nature of the data integration project, this amount may be insignificant or may prove to be the factor that makes the project infeasible. If all coastal jurisdictions charged a rate similar to that of Milwaukee County at 9.071 cents per parcel, the total cost of digital parcel acquisition would have increased over fourfold to $16,437.

Time. The amount of time to receive digital data after a request is made emerged as an important factor in this study. Only two of the 15 data requests took less than two weeks to resolve, while four took over two months. In many organizations, the amount of staff time dedicated to a data integration effort may be limited. Lengthy delays in data acquisition can hamper data integration projects.

Restrictions on Use and Dissemination of Data. Restrictions placed on the use and dissemination of digital geospatial data (including digital parcel mapping) by coastal jurisdictions emerged as an important policy issue related to the project. A total of eight jurisdictions placed no restrictions on use and dissemination of the digital data, although two of those included disclaimers in the data transmittal that were relevant to use of the data. A total of six jurisdictions placed significant restrictions on use and dissemination of the digital data. These range from informal requests to notify the jurisdiction before sharing the data with others to a formal license agreement that required signatures. One county provided digital parcel mapping through its consulting engineering company. The consulting engineering company required the data recipient to accept terms and conditions associated with use of the digital files. Of all the issues identified in this report, restrictions on the subsequent use and dissemination of digital data placed by coastal jurisdictions, potentially requiring legal interpretation and purchase of additional liability insurance, may prove to be the greatest obstacle to data integration projects.

Data Integration

After data have been received, a different set of factors, many technical in nature, affect the ability to integrate data for use in analysis and decision-making related to regional-scale issues. These include: (1) the media used for the transfer of files; (2) the size of the files received; (3) the extent to which the parcel data are documented; (4) the software format of the digital files; (5) the number of map tiles comprising digital parcel mapping for the coastal study area; (6) the compilation methods used for digital parcel mapping; (7) the coordinate system and datum; (8) the data structure of the digital parcel mapping; and (9) the status of coding digital parcel mapping with parcel identification numbers (PINs) and whether a linkage can be made between digital parcels and tax roll data.

Media/File Transfer Methods. At least four different forms of physical media and two different electronic file transfer methods were used to convey the requested files. The media range from standard 3.5" diskettes and compact discs to less common 4 mm digital audio tapes. Smaller organizations may have difficulty finding access to the range of peripherals needed to read and copy the requested files.

File Size. The overall file size of the original digital parcel mapping files received for the study area was approximately 269 MB. Although this amount seems reasonable given the standard amount of hard disk space, additional space is needed for file conversions, coordinate system projections, integration of other large-scale data sets, and back-ups.

Documentation. While most coastal jurisdictions provided some documentation of the methods used for creation, maintenance, and dissemination of digital parcel mapping, this often was not adequate to make informed decisions about the fitness of the data for use in decision-making about a range of coastal management issues. Only two counties created documentation for coastal parcels that followed the Content Standards for Digital Geospatial Metadata.

Software/File Format. Digital parcel mapping received as part of the study utilized five different file formats. Some of these file formats could be read directly into the GIS software used to integrate the digital parcel mapping. In some cases, a file conversion was necessary, leading to the same problem of multiple versions of data associated with coordinate system transformations. In one case, the GIS software used for data integration could not read the file format used to meet the initial data request. This led to a lengthy delay in processing the data request and increased expenditure of staff time of both the provider and the recipient to export the data in an acceptable format.

Tile Structure. Over 400 individual digital files were received as part of the parcel integration study. In about half of the cases, either one file was received to cover the entire coastal study area or a single file was provided to cover an entire coastal municipality. Data integration was much easier in these cases. For the other half of the jurisdictions, parcel mapping files were tiled by PLSS section, quarter-section, and/or quarter-quarter-section. These cases require substantially more processing time for data integration.

Compilation Methods. Methods used to create digital parcel mapping affect the accuracy and completeness of the product. This, in turn, affects the range of uses for which the digital parcel mapping is acceptable. A variety of methods for compilation of digital parcel mapping were used in the study area. In several instances, jurisdictions used multiple methods that evolved over time. The use of multiple methods of compilation for digital parcel mapping creates the potential for misuse of these data when integrated with other data sets and used for analysis and decision-making related to coastal management. The Wisconsin Land Information Board recently adopted standards for digital parcel mapping (WLIB Standards Committee 1999). Adherence to these standards will reduce the potential for inappropriate use of digital parcel mapping in a regional-scale decision-making context.

Coordinate System and Datum. Digital parcel mapping received as part of the study utilized eight distinct coordinate systems. Of these, four are Wisconsin county coordinate systems. These four are typically not included as default selections for coordinate systems in most GIS software and require specialized knowledge for projection into a different coordinate system. Another concern is that many GIS software packages do not support dynamic coordinate system projections. This requires that a new data set be created in the target coordinate system, leading to increased requirements for data management and overall file size. As a positive note, there seems to be a trend toward including functionality for dynamic projects in GIS software.

Data Structure. Important elements related to the data structure of digital parcel mapping include:

1. whether the parcels are structured as polygons or lines; and,
2. whether parcels structured as polygons have topology.

For the purposes of this paper, parcels with topology are defined as those structured as polygons with all lines ending at a node without under- or over-shoots. Parcels with a topological data structure and coded with a unique parcel identification number that matches the tax assessment database support thematic mapping of important attributes, such as land ownership and assessed value. A total of seven jurisdictions along the Lake Michigan coast meet these criteria.

A total of seven coastal jurisdictions create and maintain digital parcels using a computer-aided drafting (CAD) software such as AutoCAD and structure parcels as lines. In these cases, digital parcels have been structured in a manner to support more efficient drafting of parcel maps rather than display and analysis of parcel attributes. Editing of digital parcel mapping from a CAD format to a clean, topologically structured format can potentially take significant staff time or cost much in consulting services.

Linkage to Tax Roll Data. A variety of issues impact the ability to make a linkage between the tax roll database and digital parcel mapping. These include:

1. whether digital parcel mapping has been coded with a parcel identification number (PIN) that correlates to the tax key number in the tax roll database;
2. whether the PIN is structured as an attribute of a parcel polygon or as a label point associated with parcels represented as lines;

3. whether digital parcels can be structured so that each set of parcels with a common PIN and under common ownership can be aggregated into a single parcel feature with a unique PIN to support a one-to-one linkage with the tax key number in the tax roll database; and,
4. whether the format of the PIN and tax key number match.

All coastal jurisdictions code digital parcel mapping with a PIN, although, for one county, it is only partially complete in the coastal study area. For this particular county, digital parcel mapping is typically maintained by the county in a CAD format with a PIN as a label point. In response to the data request associated with this study, the county converted parcels for the coastal study area into a polygon format, but only coded PINs for one coastal town. Overall, 175,033 of 181,778 (96.3%) of parcels integrated in the coastal study area have been coded with a PIN.

The method for depicting PINs, either as an attribute of a polygon or as a label point, varies along the Lake Michigan coast. In the seven counties and one city where digital parcel mapping is structured as polygons, the PIN is an attribute of the polygon data set. In the remaining counties and cities where digital parcel mapping is structured as lines in a CAD format, PINs are represented as label points. Overall, 137,980 of 175,033 PINs (79%) are coded as polygon attributes and 37,053 (21%) are represented as label points. The former method allows a better visual perspective for thematically mapping tax roll attributes.

In all coastal jurisdictions, digital parcel mapping includes parcels with duplicate PINs. In most cases, the duplicates represent parcels that are owned by the same person, although occasionally duplicate PINs may represent an error in coding. When linking tax roll data to PINs for thematic mapping, a one-to-one relationship is desired. When the same tax roll database record is matched to a duplicate PIN, important numeric attributes may be double-counted in analysis. An example would be totaling assessed value in the coastal study area.

In 12 of 15 jurisdictions, the comparison of unique parcel identification numbers to total digital parcels exceeds 90%. In two coastal counties, the comparison is below 50%. Overall in the coastal study area, there are 166,135 unique parcel identification numbers as compared to a total of 181,778 digital parcels (91.4%).

Finally, the format of the PIN and tax key number must be similar for a successful linkage to be established in support of thematic mapping of tax roll attributes. Differences between the PIN and tax key number that can cause problems include cases where one field is structured as a character and the other as a number, or where one of the fields has leading or trailing characters (e.g. leading zeros) or has been divided with dashes or other characters. A linkage has been established between the tax key number in the tax roll database and the PIN in the digital parcel mapping (either as is or with minor reformatting) in 11 of 15 coastal jurisdictions. A linkage could not be established without major reformatting of either the tax key number or the PIN in one county and two municipalities. Tax roll data have not yet been received for one county. Overall, a total of 124,479 tax roll records were linked to a unique parcel identification number. This represents 75% of the 166,135 unique PINs integrated so far for the coastal study area.

SUMMARY

Coastal management issues often influence broad geographic areas that cross political boundaries. Geographic information systems for coastal management have typically been built to cover large coastal regions using small-scale, coarse resolution data sets from federal and state government sources. Such spatial data sources are used because they are available, affordable, and in a consistent format. While it may be easier to integrate small-scale spatial data for regional-scale coastal GIS applications, exclusive reliance on small-scale spatial data limits the effectiveness of coastal management. Local governments collect and maintain a variety of land records at a level of detail useful for coastal management and are actively modernizing these records. With the adoption and use of GIS in local governments reaching a more mature level, there is a need to examine the issues associated with building regional-scale GIS applications that utilize a "bottom-up" rather than a "top-down" approach to spatial data development.

The primary objective of this research was to assess the issues associated with the acquisition and integration of digital parcel mapping generated at the local level of government so that it can be utilized to support decision-making about coastal management at a regional scale. The status of digital parcel mapping along the Lake Michigan coast of Wisconsin was analyzed and the results of an effort to acquire and integrate digital parcel mapping from local governments for a 1000-meter zone inland from the Lake Michigan shore in Wisconsin were presented.

In summary, at 85% complete, digital parcel mapping in the 11 counties along the Lake Michigan coast of Wisconsin is well advanced. In comparison, digital parcel mapping is estimated at 68% complete statewide, and evidence exists to show that the Wisconsin Land Information Program has accelerated digital parcel mapping in relation to other states. Four key factors were identified related to the acquisition of digital parcel mapping from coastal local governments. These include the number of contact points for data requests, the cost of data acquisition, the time required to receive data after the request is made, and restrictions placed on the use and dissemination of digital data. While cost and time barriers were significant, restrictions on the subsequent use and dissemination of digital data placed by coastal jurisdictions may prove to be the greatest obstacle to the utility of regional-scale data integration projects.

Nine factors were identified that affect the ability to integrate data for use in analysis and decision-making related to regional-scale issues. Many of these are technical in nature. They include: (1) the media used for the transfer of files; (2) the size of the files received; (3) the extent to which the parcel data are documented; (4) the software format of the digital files; (5) the number of map tiles comprising digital parcel mapping for the coastal study area; (6) the compilation methods used for digital parcel mapping; (7) the coordinate system and datum; (8) the data structure of the digital parcel mapping; and (9) the status of coding digital parcel mapping with parcel identification numbers along with the ability to create a linkage between digital parcels and tax roll data to support thematic mapping of ownership and assessment information. Many of these factors added to the time and effort needed to integrate data, but perhaps the most critical was the lack of adequate documentation of digital parcel mapping by coastal jurisdictions. The lack of documentation added significantly to the amount of time needed to integrate digital parcel mapping for the coastal study area. This lack may also affect the

ability to assess whether digital parcel mapping is fit for use in decision-making about a range of coastal management issues.

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