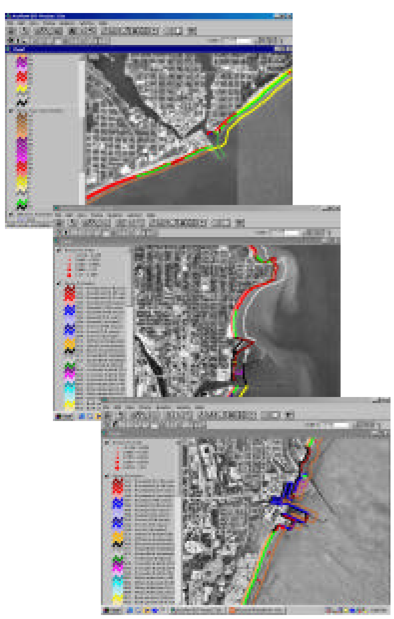
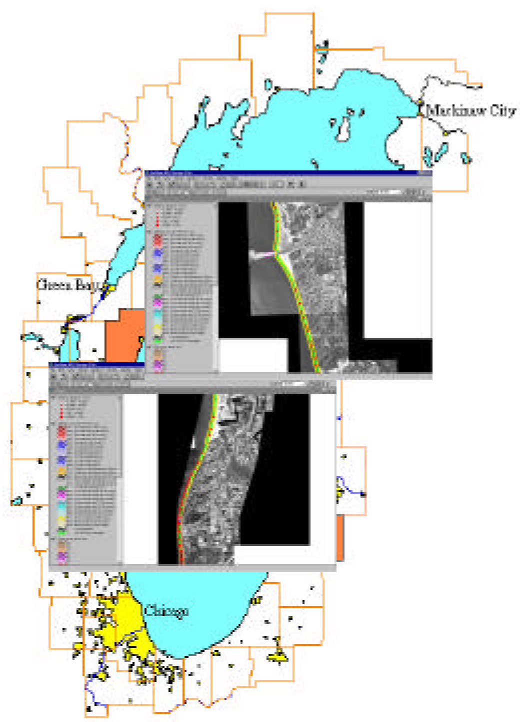
U.S. Army Corps of Engineers - Detroit District

OPEN COAST REACH DELINEATION AND RE-ATTRIBUTION OF SHORE CLASSIFICATION MAPPING, LAKE MICHIGAN PROTOTYPE COUNTIES

OTTAWA COUNTY, MI
ALLEGAN COUNTY, MI
OZAUKEE COUNTY, WI
MANITOWOC COUNTY, WI
SHEBOYGAN COUNTY, WI

LAKE MICHIGAN POTENTIAL DAMAGES STUDY





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1.0 Introduction

1.1 Background

The U.S. Army Corps of Engineers - Detroit District has initiated an extensive and long-term assessment of potential shoreline damages over the next 50 years due to fluctuating lake levels along the Lake Michigan shoreline. This "Lake Michigan Potential Damages Study" (LMPDS) will ultimately lead to the development of a series of state-of-the-art engineering, mapping and coastal zone management tools that can be used for the accurate prediction of flood and erosion damages that might arise due to fluctuating lake levels.

A key task in this assessment is to determine the relationship between coastal processes and water level change and various physical factors along the shoreline including shoreline type, the extent, type and quality of structural shore protection in place, and the composition of the nearshore portion of the shoreline.

In this regard, and in an effort to further shoreline classification and erosion sensitivity work that was initially conducted by the Erosion Processes Task Group during the IJC Water Level Study in 1993 (Stewart and Pope, 1993), the entire shoreline of Lake Michigan was reclassified in the early stages of the LMPDS using a revised three-tiered classification scheme that took into account significant details about shoreline type, the extent and quality of shoreline protection structures, and the nearshore (underwater) geology (see Stewart 1997a and 1998). Recession rate data for the entire shoreline was also collected and updated (see Stewart, 1994 and 1997b) and along with the three levels of classification information, were summarized over a series of 1 kilometer reach segments that had been ascribed to the shoreline for reference purposes. This kilometer-by-kilometer information was then used as data input to the Flood and Erosion Prediction System (FEPS) model that is being utilized in the LMPDS for the prediction of flood and erosion damages along these shorelines.

As mentioned above, in developing various coastal zone databases for the LMPDS, the majority of data (e.g., shoreline classification, recession rates, land use, etc.) have been ascribed to the shoreline using a series of 1 kilometer reach segments. These segments were defined during the IJC Water Level Reference Study in 1993, using what, at that time, were the best available mapping products to "define" the shoreline.

With advances in digital mapping and digital photographic and photogrammetric techniques over the past few years, a new digital shoreline, with a much higher resolution, has been produced by USACE Detroit for the LMPDS. Upon examination of this new shoreline, it was apparent that the original 1993 shoreline contained a number of errors, omissions and inaccuracies, that thus called into question (primarily) the spatial accuracy of the classification and recession rate data that had been collected and mapped, and that also resulted in errors in the total lengths of certain shoreline types reported, or in the complete omission of particularly sensitive shoreline areas that were not captured in the 1993 shoreline definition (e.g., embayments). As a result of these errors, the 1 kilometer reach segments that were defined in 1993 were no longer applicable and needed to be revised to reflect this higher resolution mapping.

In addition, data collected for these 1 kilometer reach segments had been summarized (averaged) over this 1 kilometer segment and has been visually represented on various LMPDS mapping products using a symbol tied to the center point of each 1 kilometer reach segment. While this presented a general characterization of the reach section for the data in question, it did not accurately reflect variations that might occur within this 1 kilometer stretch.

Given that new GIS shoreline data for the LMPDS is being collected in a "continuous" fashion along the shoreline, not on a kilometer-by-kilometer basis, there was a need to reinterpret and re-attribute the kilometer-by-kilometer classification data to bring it into consistency with the remainder of the GIS data being developed for the study and provide a more accurate representation of the open coast classification data.

1.2 Objectives of This Activity

In 2000, USACE Detroit District requested the re-attribution of reach and coastal zone information within the five prototype counties that have been the focus of LMPDS investigations in 1999 and 2000 (Figure 1). These were:

1) Ottawa County, MI;
2) Allegan County, MI
3) Ozaukee County, WI;

4) Manitowoc County, MI; and
5) Sheboygan County, WI

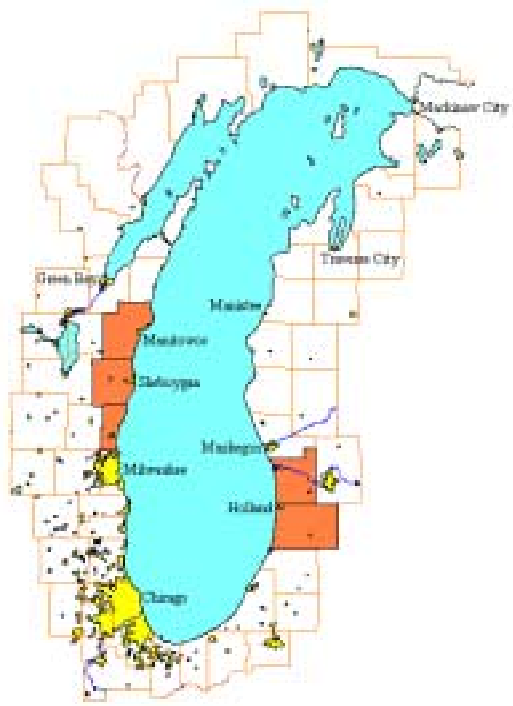

Figure 1 - Lake Michigan Prototype Counties (shaded)

Specifically there were 5 objectives that were to be carried out:

1) **New Reach Delineation** - New reaches were to be defined on a county-by-county basis using a 100 meter interval and provided as a continuous ArcView coverage. Reaches were to start at "0" for each new county and be numbered consecutively, in a clockwise direction along / around the shoreline.

2) **Re-Interpret Geomorphic Classification** - The shoreline type classification was to be re-interpreted and provided as a continuous ArcView coverage on a county-by-county basis;

3) **Re-Interpret Nearshore Geology** - The nearshore geology classification was to be re-interpreted and provided as a continuous ArcView coverage on a county-by-county basis;

4) **Re-Interpret Shore Protection Classification** - The shoreline protection classification was to be re-interpreted and provided as a continuous ArcView coverage on a county-by-county basis; and

5) **Re-Interpret Recession Rate Data** - The recession rate data available for these shorelines was to be re-interpreted and provided as a continuous ArcView coverage on a county-by-county basis.

All data were to be mapped in an ArcView GIS format and statistical summaries were to be calculated where appropriate.

1.3 Format of This Report

The approach and methodology used in the re-attribution of these five data sets is presented in Section 2.0. Resulting mapping products and related statistical data are presented in Section 3.0. Recommendations and conclusions are presented in Section 4.0 and hardcopy printouts of the mapping for all five prototype counties is presented in an Appendix.

2.0 Methodology

2.1 Data Sources and Limitations

Detailed field mapping of the layers of information were not required for this task. As such, various data sources were relied upon to develop continuous GIS mapping coverages for each item. A brief description of each source and their limitations is provided below. Further details on the use of each data source are also found in the methodology description for each data layer starting in Section 2.2.

2.1.1 Previous Classification / Coastal Zone Data

The kilometer-by-kilometer classification data that was developed earlier in the LMPDS (Stewart, 1997a and 1998) served as a primary data reference for this activity and provided a coarse delineation of the start and end points of the various levels of information for shoreline type and nearshore geology.

General information on shoreline protection was also obtained from this initial classification, but more specific detail on the start and end points of various structures was obtained from shore protection mapping that was conducted on a 1/10th of a kilometer basis for these five counties in 1999 (see Stewart, 1999).

Recession rate data used to compile and update the kilometer-by-kilometer historical recession rate database (see Stewart, 1994 and 1997b) was re-examined in order to note specific location of recession rate transects or points of measurement along the shoreline. These "original" data sets were utilized in part to create the recession rate coverage for this activity.

2.1.2 Aerial Photography

To develop continuous GIS mapping coverages for the various data layers, their specific start and end points had to be determined. This was done in part by examining various air photos, including the air photos used in developing the original shoreline classification. This included 1:6000 scale 1989 and 1999 aerial photography for Ottawa and Allegan Counties, in Michigan and 1978 and 1992 air photography for Ozaukee, Sheboygan and Manitowoc Counties in Wisconsin.

Limitations in the use of these photos were primarily related to shadows and glare obscuring the boundary between two different shore types, or obscuring the type of shore protection present. Generally speaking however, when combined with previous classification data and other data sources, the transitions between two different class types were located with a high degree of certainty.

Air photos were not available for Reaches 1265-1267 on the Wisconsin shoreline. As such, the digital orthophotos and other data sources were used to attempt the re-attribution of associated data in this area.

2.1.3 Digital Orthophotography

Digital orthophotography that has been prepared for the Lake Michigan shoreline was used as a secondary level of data where air photography and other data sources did not exist. In most cases it served as a backdrop for the GIS mapping activities that were undertaken. Where video and air photography were not available, re-attribution was done directly from the available DOP or DOQQ image. In most cases this was adequate, but some transitions may not have been recorded accurately as they may not have been clearly visible at the scale and resolution of the digital orthophoto.

2.1.4 Mr. Sid Images

Mr. Sid images were provided for portions of the shoreline being mapped. In most cases, these served as an excellent data source for verifying transitions between shoreline types or the type and extent of various shore protection structures observed on the standard air photo, as the resolution and clarity of the images, particularly when zoomed in, were extremely good, and allowed for on-screen determination of features that could not be seen with the stereoscopes on the air photos.

2.1.5 Video Tape

Video tape of the Michigan and Wisconsin shoreline was obtained by USACE staff in 1997 and was used in the original re-classification of the Lake Michigan shoreline. This video tape was re-examined occasionally to observe sections of shoreline that could not be seen clearly on the air photos and served basically as a confirmation data source.

2.1.6 Digital Shoreline and Other Digital Planimetric Information

A new digital shoreline was obtained from USACE Detroit and served as a baseline for the re-attribution and re-mapping of the various data layers. This digital shoreline was generated from recently collected high resolution digital aerial photography (DOPs) and high definition bluff line mapping products. These included 1"=200' DOPs for Allegan and Ottawa Counties in Michigan and 1"=400' bluff line mapping for Ozaukee, Sheboygan and Manitowoc Counties in Wisconsin. In addition, other digital planimetric information (e.g., toe of bluff, top of bluff) was also obtained and used occasionally to assist in determining transitions between different shore types, or different shoreline protection structures.

2.2 New Reach Delineation

To define new reaches for each county, the new digital shoreline was imported into ArcMap and then segmented into 100 meter reach segments using the Divide Tool. For Michigan counties (Ottawa and Allegan), reaches began with a zero point at the northern border of the county. For Wisconsin counties (Sheboygan, Manitowoc and Ozaukee), reaches began with a zero point at the southern border of the county. This was in keeping with the original clockwise progression of reach numbering around the lake. This new segmented shoreline shape file was then brought back into ArcView as a separate GIS coverage for each county (see Figure 2).

Table 1 below shows the total number of new reaches for each county based on the new 100 meter segmentation and new digital shoreline position. Note, that these are for alongshore reaches only. Reaches for the four drowned river mouth areas that were under investigation in 2000 were delineated separately from the open coast reaches and are provided as a separate ArcView GIS coverage (see Stewart, 2000).

Table 1 - Total Number of New 100 Meter Reaches by County

County	Number of 100m Reaches
Ottawa County, MI	405
Allegan County, MI	398
Ozaukee County, WI	443
Sheboygan County, WI	426
Manitowoc County, WI	573

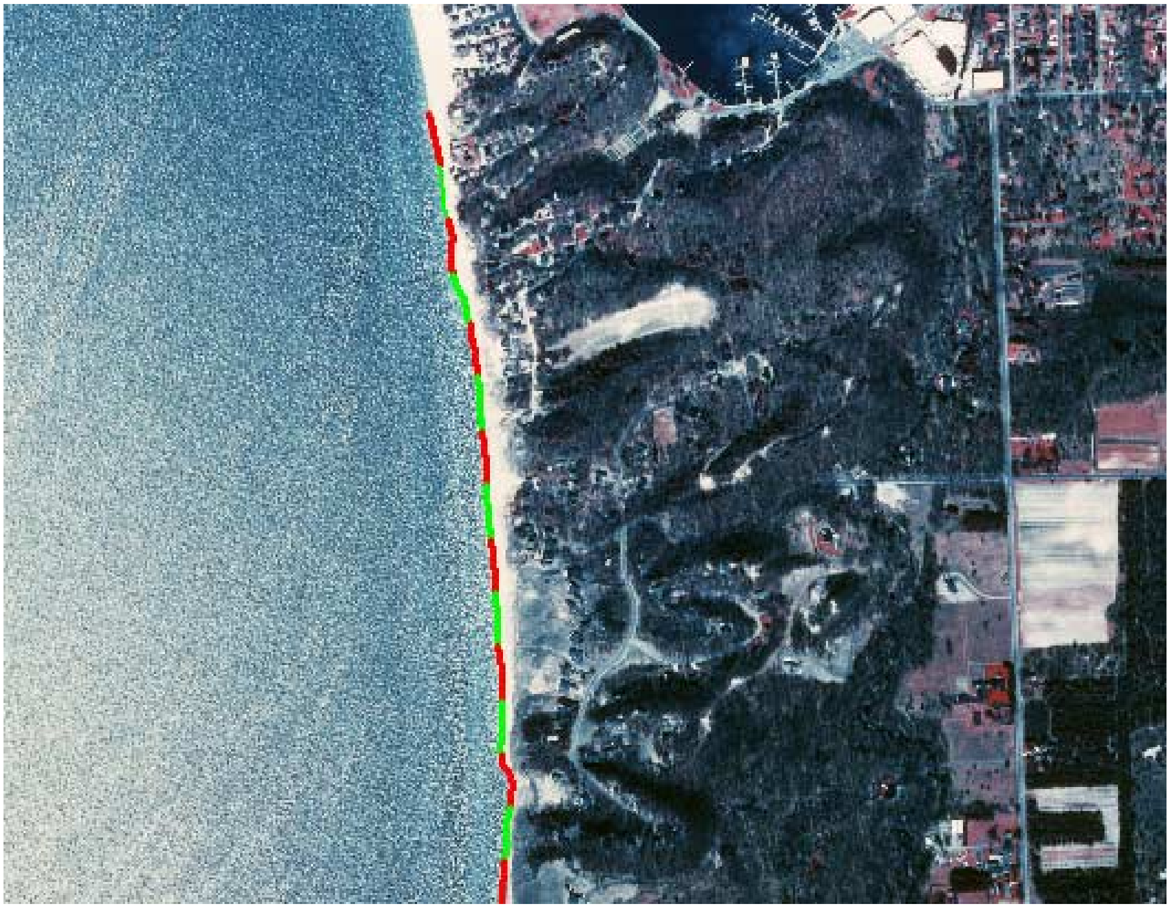

Figure 2 - New 100 m Reach Segments, Allegan County (as depicted in ArcView)

2.3 Geologic Shoreline Type Re-Attribution

The re-attribution and re-mapping of the shoreline type classification was completed directly in ArcView GIS for each county in question. First, the new digital shoreline for the county was plotted and the associated digital orthophotos were brought in to serve as a backdrop for reference purposes and to assist where needed in determining the transitions between shore types.

Second, the original kilometer-by-kilometer shoreline classification data (Stewart, 1998) was imported into ArcView and displayed on screen in order to provide a general reference as to where major changes in shore types occurred and as to what these sections of shoreline had been previously classified as. Using the original classification as a guideline and proceeding linearly along the shoreline, start and end points of each discernable change in geologic shoreline type were obtained through the examination of the various other data sources (air photos, digital orthophotography, Mr. Sid images and occasional video). These were then plotted on the new digital shoreline by bi-secting the shoreline line string in the appropriate spot. This created a distinct line segment in ArcView which was then classified using the geologic shoreline type classification scheme developed for Lake Michigan in the first phases of the LMPDS study (Table 2).

Table 2 - Shoreline Type Classification (Stewart, 1998)

1. Sand or Cohesive Bluffs (define heights and other information as separate attributes)
- 1a. Homogeneous Bluffs (sand content 0-20%)
- 1b. Homogeneous Bluffs (sand content 20-50%)
- 1c. Homogeneous Bluffs (sand content >50%)
- 1d. Composite Bluffs (sand content 0-20%)
- 1e. Composite Bluffs (sand content 20-50%)
- 1f. Composite Bluffs (sand content >50%)

2. Sand or Cohesive Bluffs With Beach (define heights and other information as separate attributes)
- 2a. Homogeneous Bluffs (sand content 0-20%)
- 2b. Homogeneous Bluffs (sand content 20-50%)
- 2c. Homogeneous Bluffs (sand content >50%)
- 2d. Composite Bluffs (sand content 0-20%)
- 2e. Composite Bluffs (sand content 20-50%)
- 2f. Composite Bluffs (sand content >50%)

3. Low Bank
- 3a. (Sand content 0-20%)
- 3b. (Sand content 20-50%)
- 3c. (Sand content >50%)

4. Baymouth Barrier

5. Sandy Beach / Dune

6. Coarse Beaches

7. Bedrock (Resistant)

8. Bedrock (Non-Resistant)

9. Open Shoreline Wetlands

10. Artificial

11. Unclassified

2.4 Shore Protection Classification Re-Attribution

The re-attribution and re-mapping of the shore protection classification was completed directly in ArcView GIS for each county in question. First, the new digital shoreline for the county was plotted and the associated digital orthophotos were brought in to serve as a backdrop for reference purposes and to assist in determining the transitions between shore types.

Second, the more recent detailed 1/10th of a kilometer shore protection classification information that was prepared for these counties in 1999 (Stewart, 1999) was imported into ArcView and displayed on screen in order to provide a general reference as to where major changes in shore protection types occurred and as to what types of shore protection structures had previously been observed. This data was fairly detailed and served as the main data source for mapping the start and end points of various structures. Air photos and other data sources were used to more accurately confirm the start and end point of the structures. These were then plotted on the new digital shoreline by bi-secting the shoreline line string in the appropriate spot. This created a distinct line segment in ArcView which was then classified using the shore protection classification scheme developed for Lake Michigan in the first phases of the LMPDS study (Table 3).

It should be noted that in areas where more than one shore protection structure was present along a length of shoreline (e.g., a seawall with a rip rap revetment fronting it, or a seawall with groins), only the primary mode of protection that was in place was included in the continuous GIS coverage that was developed. For this purpose, primary shore protection was defined as that which would bear the initial brunt of any wave activity or other coastal processes. Secondary shore protection structures were then noted in the "Comments" column of the attribute table associated with the line segment. In addition, groins, jetties, and other shore perpendicular structures, where they were visible on air photos, were digitized and included in a separate "Offshore" ArcView coverage.

Table 3: Shore Protection Type Classification (Stewart, 1998)

1. Coastal Armoring

1A1 - Revetments >45 year lifespan
1A2 - Revetments 5-45 year lifespan
1A3 - Revetments 0-5 year lifespan
1A4 - Revetments 0 year lifespan (disrepair)

1B1 - Seawalls/Bulkheads >45 year lifespan
1B2 - Seawalls/Bulkheads 5-45 year lifespan
1B3 - Seawalls/Bulkheads 0-5 year lifespan
1B4 - Seawalls/Bulkheads 0 year lifespan (disrepair)

2. Beach Erosion Control Devices

2A1 - Groins >45 year lifespan
2A2 - Groins 5-45 year lifespan
2A3 - Groins 0-5 year lifespan
2A4 - Groins 0 year lifespan (disrepair)

2B1 - Jetties >45 year lifespan
2B2 - Jetties 5-45 year lifespan

2B3 - Jetties 0-5 year lifespan
2B4 - Jetties 0 year lifespan (disrepair)

2C1 - Offshore Breakwaters >45 year lifespan
2C2 - Offshore Breakwaters 5-45 year lifespan
2C3 - Offshore Breakwaters 0-5 year lifespan
2C4 - Offshore Breakwaters 0 year lifespan (disrepair)

3. Non-Structural

3A1 - Beach Nourishment >45 year lifespan
3A2 - Beach Nourishment 5-45 year lifespan
3A3 - Beach Nourishment 0-5 year lifespan
3A4 - Beach Nourishment 0 year lifespan (disrepair)

3B1 - Vegetation Planting >45 year lifespan
3B2 - Vegetation Planting 5-45 year lifespan
3B3 - Vegetation Planting 0-5 year lifespan
3B4 - Vegetation Planting 0 year lifespan (disrepair)

3C1 - Slope/Bluff Stabilization >45 year lifespan
3C2 - Slope/Bluff Stabilization 5-45 year lifespan
3C3 - Slope/Bluff Stabilization 0-5 year lifespan
3C4 - Slope/Bluff Stabilization 0 year lifespan (disrepair)

4. Protected Wetlands

5. Ad-Hoc Structures

5A1 - Concrete Rubble >45 year lifespan
5A2 - Concrete Rubble 5-45 year lifespan
5A3 - Concrete Rubble 0-5 year lifespan
5A4 - Concrete Rubble 0 year lifespan (disrepair)

5B1 - Other Materials >45 year lifespan
5B2 - Other Materials 5-45 year lifespan
5B3 - Other Materials 0-5 year lifespan
5B4 - Other Materials 0 year lifespan (disrepair)

6 - Unclassified

7 - No Protection

2.5 Nearshore Geology Re-Attribution

Re-attribution of the nearshore geology classification data was somewhat more problematic than the data layers for shoreline type and for shore protection for the simple reason that the data sources being utilized did not allow for direct observation of the geology and hence the transition zones between two different nearshore shore types. Neither the air photos, nor the video provided enough penetration into the water to see the geology. Similar issues were encountered in the original classification of this data in 1998 and the classifiers relied upon geologic reports, as well as the input of those familiar with the nearshore geology to accurately define the nearshore geologic type.

To obtain more detail on nearshore bathymetry and potentially better definitions of nearshore geology, USACE Detroit undertook the collection of bathymetric LIDAR (light detection and ranging) data using the USACE Scanning Hydrographic Operational Airborne Lidar Survey (SHOALS) system for the five prototype counties. Processing of the SHOALS data was completed in early 2000 and was used in this activity as a data source for determining the transition zones between different nearshore geologic shore types. Unfortunately, due to poor weather conditions prior to the SHOALS survey, complete coverage in the targeted areas was not achieved. Also, where SHOALS data was collected, high turbidity in harbor entrance areas and in some nearshore areas prevented the light beam from penetrating to obtain a bottom depth reading. As such SHOALS data was unable to be used in some areas.

Where SHOALS data was available, it was used in conjunction with the original nearshore classification data to try and accurately determine the transitions between different nearshore types. Both data sets, along with the new digital shoreline, were imported into ArcView (Figure 3) and where the original data sets showed a change from one shore type to another, the SHOALS contours were examined to see if they could assist in determining a more precise location of the change.

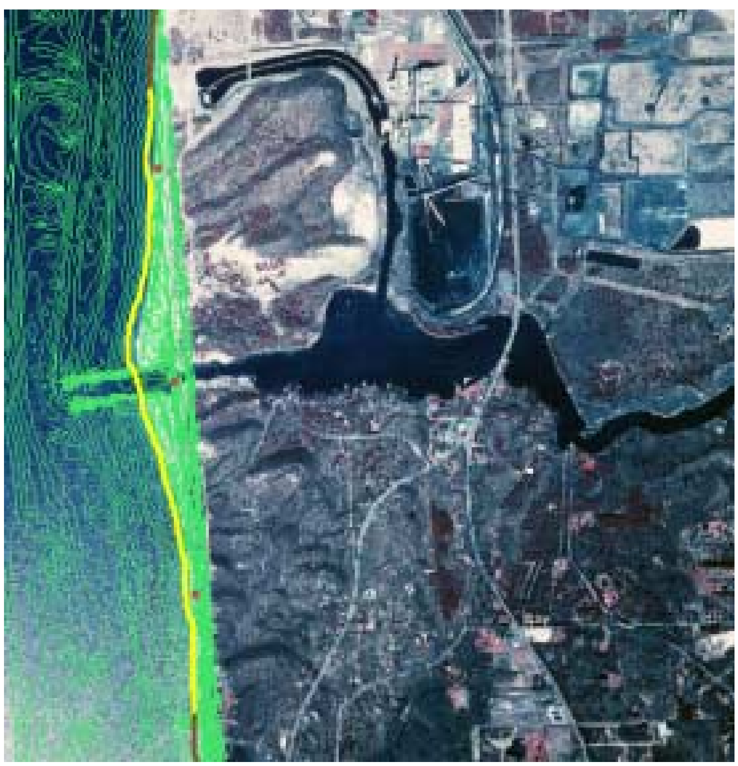

Figure 3 - SHOALS Data Being Used forNearshore Re-Attribution

Using the combination of the SHOALS data and the original nearshore classification data, start and end points of changes in the nearshore geology were plotted as accurately as possible on the new digital shoreline by bi-secting the shoreline line string in the appropriate spot. This created a distinct line segment in ArcView which was then classified using the nearshore geology classification scheme developed for Lake Michigan in the first phases of the LMPDS study (Table 4).

Table 4: Nearshore Geology Classification (Stewart, 1998)

1. Cohesive (Till)
- 1a. Thick Sand Cover (>200 m3/m)
- 1b. Moderate Sand Cover (50-200 m3/m)
- 1c. Thin Sand Cover (<50 m3/m)

2. Cohesive (Laccustrine Clay)
- 2a. Thick Sand Cover (>200 m3/m)
- 2b. Moderate Sand Cover (50-200 m3/m)
- 2c. Thin Sand Cover (<50 m3/m)

3. Cobble / Boulder Lag Over Cohesive
- 3a. Thick Sand Cover (>200 m3/m)
- 3b. Moderate Sand Cover (50-200 m3/m)
- 3c. Thin Sand Cover (<50 m3/m)

4. Sandy

5. Bedrock (Resistant)

6. Bedrock (Non-Resistant)

7. Unclassified

2.6 Recession Rate Data Re-Attribution

2.6.1 Introduction

A wealth of recession rate data has been collected for the Lake Michigan shoreline by various interests, including State natural resource agencies, academics, consulting companies, local municipalities and shoreline stakeholder groups. Much of this data has been compiled in a recession rate database for the Lake Michigan shoreline (Stewart, 1994) and provides a comprehensive listing of all data on a kilometer-by-kilometer basis, as well as brief descriptions of the nature of the data, it's accuracy, confidence, etc.

In the early part of the LMPDS, this 1994 database was updated (Stewart, 1997b) with new or updated recession rate data, and for LMPDS modeling purposes, a representative value of recession was selected from the available data to provide a single recession rate value for each kilometer reach that was defined along the Lake Michigan shoreline.

Similar to the shore type classification, questions arose as to whether a single value of recession adequately represented the true erosion rates occurring in a one-kilometer segment, particularly when local variations in recession rate within that kilometer could be quite different. Also, with the redefinition of the shoreline using new and improved digital mapping products, uncertainty again arose as to how representative the erosion rates were, given the errors and inaccuracies that were contained in the original (1993-1994) shoreline. Given this, there was a need to re-examine the recession rate data and determine if there was a more suitable way of representing the data as a continuous GIS mapping coverage - one that was tied to the new digital shoreline developed for the study.

2.6.2 Data Selection

A first step in this activity was to re-examine the original data and determine which data would be suitable for plotting in a continuous GIS mapping format. Such data would consist primarily of those data sets that were "point location - discrete value" data sets, i.e., there was a specific point along the shoreline where the recession rate was measured (which could then be plotted as a point on the new shoreline), and there is a specific, or discrete, value of recession that has been calculated for that point. Point location data sets where a range of recession rates were provided, as opposed to a discrete value, could also be mapped in a similar fashion. Data sets that included a value of recession over a distance, or linear zone, of shoreline were not included.

The end result of this is that only a few of the many recession rate data sets included in the comprehensive recession rate database were selected for inclusion in the continuous mapping coverages for the five counties. These include:

For Ottawa and Allegan Counties:

State of Michigan, Department of Environmental Quality: The Michigan Department of Environmental Quality is responsible for the determination of erosion setbacks for development along the Michigan shoreline. To calculate these setbacks, they have determined detailed recession rates for most of the Lake Michigan shoreline, including Ottawa and Allegan Counties. The USACE database contains a large amount of this data, including updated data for Ottawa and Allegan Counties that was carried out in 1995 and 1996. In the updates for these counties, 1938 aerial photos were compared to 1988 or 1989 photography resulting in a period of record of 50 years for most of the data (there were a few exceptions). This expanded the original calculations by approximately 15 years as original data was calculated using 1973 photos. As these data sets were considered to be the most up to date, most comprehensive, and most accurate data for these shorelines, they were selected for inclusion in GIS mapping coverage to be developed.

For Ozaukee, Sheboygan and Manitowoc Counties:

SEWRPC (1997) Lake Michigan Recession and Bluff Stability in Southeastern Wisconsin - In August of 1994, the Southeastern Wisconsin Regional Planning Commission (SEWRPC) responded to a request from the Wisconsin Department of Administration for the conduct of a study of current shoreline erosion and bluff stability conditions along the Lake Michigan shoreline of Southeastern Wisconsin. The report covers the shoreline in four coastal counties - Kenosha, Racine, Milwaukee and Ozaukee. The recession rate data collected in this study essentially provides updates and improvements to data already included in the USACE database from previous SEWRPC and Wisconsin Coastal Management Program reports and thus was considered to be the most up to date and most comprehensive data for inclusion in GIS mapping coverage to be developed. Calculations are provided for the periods 1963-1995, 1970-1995 and 1975-1995.

Bay/Lakes Regional Planning Commission (1997), **Lake Michigan Recession and Bluff Stability in Southeastern Wisconsin** - In August of 1994, the Bay-Lake Regional Planning Commission (BLRPC) responded to a request from the Wisconsin Department of Administration for the conduct of a study of current shoreline erosion and bluff stability conditions along the Lake Michigan shoreline of Northeastern Wisconsin. The report is similar to that above for the Southeastern shoreline and covers the shoreline in four northeastern coastal counties - Sheboygan, Manitowoc, Kewaunee and Door. The recession rate data collected in this study essentially provides updates and improvements to data already included in the USACE database from previous Wisconsin Coastal Management Program reports and thus was considered to be the most up to date and most comprehensive data for inclusion in GIS mapping coverage to be developed. Calculations are provided for the period 1978-1992.

Wisconsin Recession Rate Study, SEH and Baker (1997) - In 1995 the State of Wisconsin Coastal Management Program retained engineering consultants Short, Elliot and Hendrickson Inc. (SEH) and the Michael Baker Corporation (Baker) to develop a state-of-the-art methodology for determining recession rates along the Wisconsin shoreline of Lake Michigan. The methodology used both GIS and digital orthophotos to determine recession rates along three 10 mile test segments. Three specific study areas were selected for analysis, two of which fell in the prototype counties. In Manitowoc County, the area begins at the north county line and extends 10 miles to the south. In Ozaukee County the area begins at the south county line and extends north for 10 miles. Over the past few years, discussions with State of Wisconsin personnel have indicated some concerns with the data and approach used in deriving this data. As a result, the USACE database (see Stewart, 1997b) ranked this data as "Moderately Certain." Despite this however, it is some of the only recession rate data available for portions of Manitowoc and Ozaukee Counties, and where this is the case, was deemed to be suitable for inclusion in the GIS mapping coverage to be developed.

2.6.3 Data Mapping

The re-attribution and re-mapping of the recession rate data was completed directly in ArcView GIS for each county in question. First, the new digital shoreline for the county was plotted and the associated digital orthophotos were brought in to serve as a backdrop for reference purposes and to assist in determining the location of recession rate transects, or data points. Second, maps and photo plots of the original recession rate data points or transects contained in the source documentation were examined and the location of all recession rate transects, or measurement points, were plotted as accurately as possible as a point on the new digital shoreline (see Figure 4).

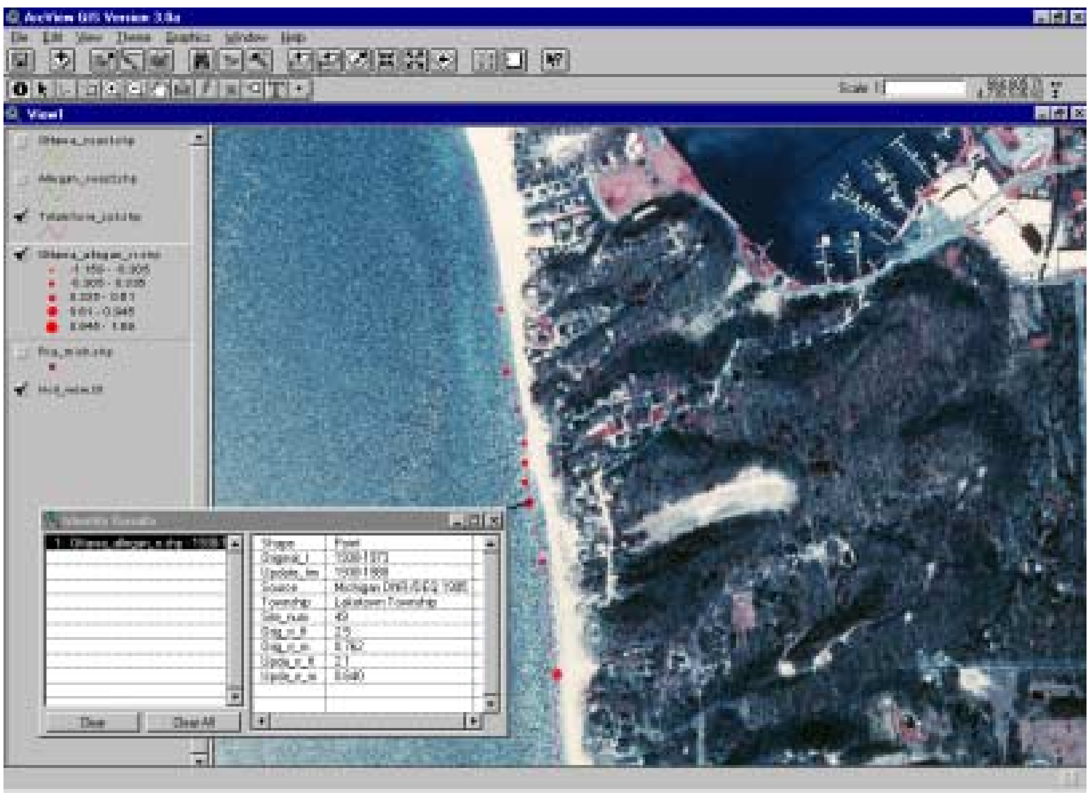

Figure 4 - Example of Recession Rate Data Mapping, Allegan County, MI.

For each data point, the corresponding recession rate data presented in the source material was recorded in the attribute table for the point in question (see Section 3.1).

Once plotted, a legend theme was applied to the data points, such that higher recession rates would show as larger symbols, smaller rates as smaller symbols (see Figure 4). It should be noted that a simple default theme was used in this exercise. This legend can be manipulated by a user to represent different ranges of recession rate, or to provide different color themes for the various ranges defined.

3.0 Data Presentation and Analysis

3.1 Data Structure

All classification and recession rate data was entered directly into attribute tables within ArcView GIS. These tables contained the following key information:

Length - This provided the length of the particular shoreline segment (and classification type) in meters based on the start and end points that were mapped;

Geo_type - The shore type classification as assigned. Applies only to the shore type classification attribute table.

Shore_prot - The shore protection classification as assigned. Applies only to the shore protection classification attribute table.

Ns_type - The nearshore geology classification as assigned. Applies only to the nearshore geology classification attribute table.

Comments - any relevant additional information regarding the classified segment. For the shore protection classification, this usually included information on any secondary shore protection present.

Recall that shore perpendicular structures (jetties, groynes, etc.) were mapped as a separate coverage. As such their attribute information is slightly different. For these structures, the following attribute information is recorded:

Length - the total length of the line segment that defines the structure.

Offshore_t - the shore protection, or shore perpendicular structure classification code as assigned.

Offshore_l - the actual offshore length of the structure measured from the shoreline line segment.

Comments - any relevant additional information.

Similarly, recession rate data has different attribute information associated with it, given the different data sets used. This information also varies between Michigan and

Wisconsin. Figure 5 is an enlargement of the attribute tables for Michigan and Wisconsin data points. The following information is recorded:

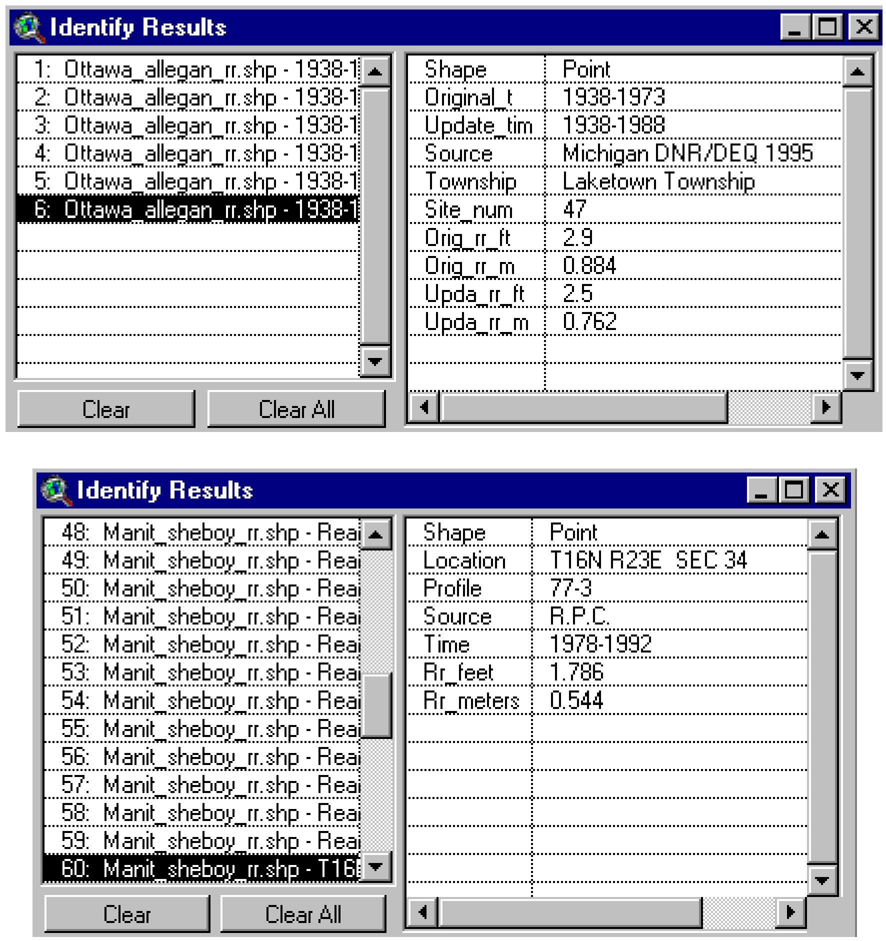

Figure 5 - Example of Recession Rate Data Attribute Tables. Top, Michigan Data Sets; Bottom, Wisconsin Data Sets

For Michigan Data:

Original_t: The original period of record for recession rate calculations. In this example 1938-1973.

Update_tim: The updated period of record, in this case 1938-1988.

Source: The original source of the data.

Township: The Township in question. Michigan DEQ prepare recession rate calculations on a township basis.

Site_Num: Corresponds to the site (transect) number assigned by Michigan DEQ in the original source data.

Orig-rr_ft: The original recession rate in feet.

Orig-rr_m: The original recession rate in meters.

Upda_rr_ft: The updated recession rate in feet.

Upda_rr_m: The updated recession rate in meters.

For Wisconsin Data:

Location: SEWRPC and BLRPC measurements were made parallel to the east-west U.S. Public Survey Section lines. The number here is the reference number for the section line where the measurement was made. For SEH and Baker data a reach number is referenced.

Profile (Sheboygan and Manitowoc Counties): Refers to the profile number assigned in the SEWRPC or BLRPC original source data.

Source: The original source of the data.

Time (Sheboygan and Manitowoc Counties): The period of record for recession rate measurement.

Time_"n" (Ozaukee County): Where "n" equals 1, 2, or 3. Refers to the periods of record for recession rate measurement. Three periods were recorded for Ozaukee County.

Rr_feet (Sheboygan and Manitowoc Counties): The recession rate in feet.

Rr_"n"_feet (Ozaukee County): Where "n" equals, 1,2, or 3. The recession rate in feet associated with the corresponding period of record.

Rr_meters (Sheboygan and Manitowoc Counties):: The recession rate in meters.

Rr_"n"_m_ (Ozaukee County): Where "n" equals, 1,2, or 3. The recession rate in meters associated with the corresponding period of record.

Comments - any relevant additional information.

3.2 Data Presentation

The shore type, shore protection, nearshore geology, offshore structure and recession rate data were all mapped in ArcView GIS and provided as separate data coverages (Arc shape files) which were delivered electronically to USACE Detroit. While each data layer could be mapped individually, for presentation purposes in this activity, there was a desire to display all data layers at the same time. Given that all the data layers (except the offshore structures) were tied to the new digital shoreline, displaying each layer in it's "true" position would not be possible since they would each overlap one another. As such, each mapping coverage was offset slightly from the others so that they were all visible. This produced a "banded" mapping product with three lines representing the three levels of shoreline classification, and a series of red circular symbols representing the recession rate data. An example of this mapping is presented below in Figure 6. Map plots for all five counties are provided in the Appendix to this report.

Of the three line segments represented, the *landward* most line represents the shore type classification. It is offset slightly landward from the true shoreline position.

The middle line segment represents the shore protection classification. This line segment has been plotted in the true shoreline position.

The *lakeward* most line segment, usually plotted a bit further offshore from the others represents the nearshore geology classification.

The recession rate data is represented by a series of point data, symbolized using a series of red dots, sized according to recession rate ranges. These points are plotted slightly offshore from the shore protection line segment, but landward of the nearshore geology line segment.

3.3 Data Analysis

For analysis purposes, data was exported from the ArcView GIS program into MS-Excel in order to compute overall statistics on the total lengths of the different classification types along the open coast of Lake Michigan for each of the five counties, as well as the

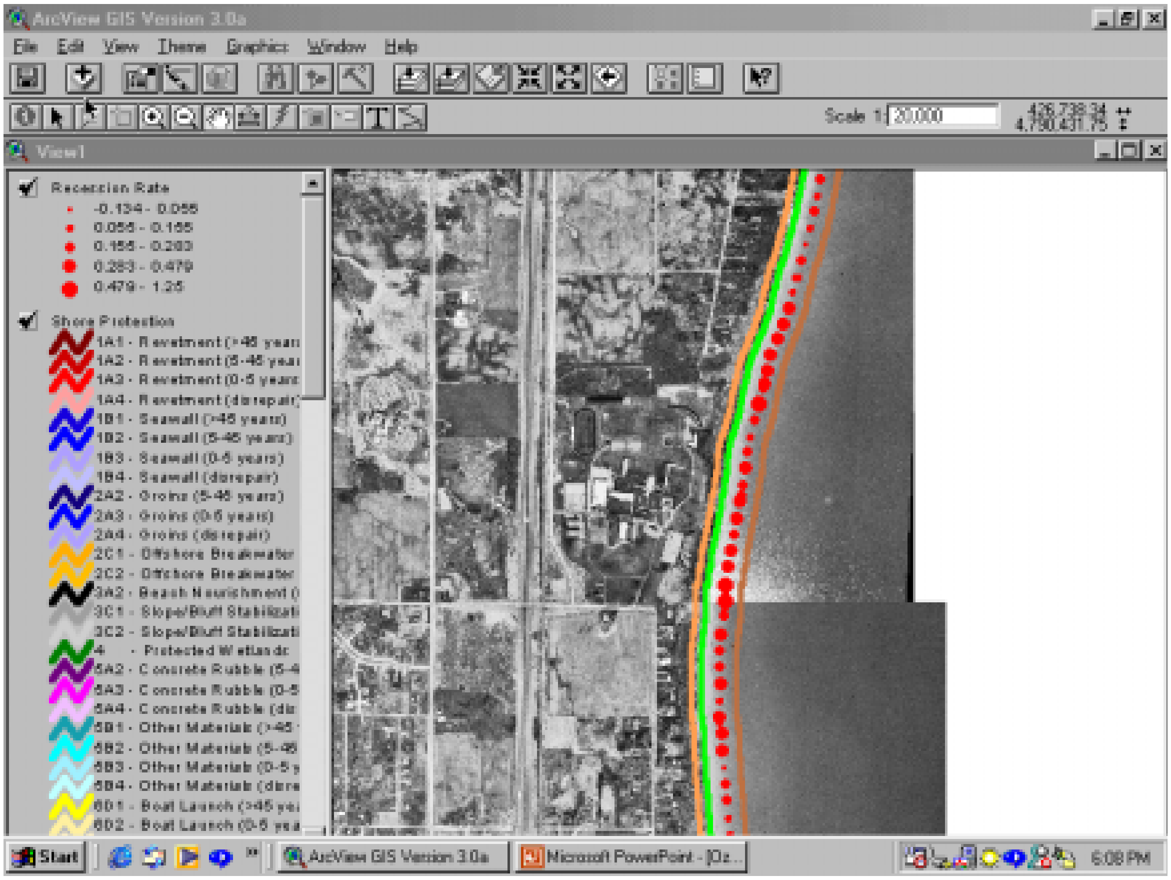

Figure 6 - Example of Open Coast Mapping, Ozaukee County, WI.

types and numbers of shore perpendicular structures. Analysis of the data for each of the five counties is presented below.

3.3.1 Ottawa County, Michigan

Shore Type

Summary statistics on the lengths of different shore types found along the open coast of Ottawa County are provided in Table 5.

Table 5
Geomorphic Shore Type Summary (Ottawa County, Michigan)

Type	Description	Length (m)
1C	Homogeneous Bluffs Sand Content > 50%	2,828
5	Sandy Beach / Dune	37,382

Shore Protection

Summary statistics on the type and extent of shore protection structures found along the open coast of Ottawa County are provided in Table 6.

Table 6
Shore Protection Summary (Ottawa County, Michigan)

Type	Description	Length (m)
1. Coastal Armoring		
1A1	Revetments >45 year lifespan	694
1A2	Revetments 5-45 year lifespan	342
1A2 with Groins	Revetments (5-45) with Groins in front	79
1B2	Seawalls 5-45 year lifespan	3,050
1B2 with Groins	Seawalls (5-45) with Groins in front	2,334
1B3	Seawalls 0-5 year lifespan	110
1B3 with Groins	Seawalls (0-5) with Groins in front	110
2. Beach Erosion Control Devices		
2A2	Groins 5-45 year lifespan	5,056
2A3	Groins 0-5 year lifespan	222
2B2	Jetties 5-45 year lifespan	175
3. Non Structural		
3A2	Beach Nourishment 5-45 year lifespan	2,062
3A2 with Seawall(s)	Beach Nourishment with Seawall(s)	1,259
7	No Shore Protection	28,917

Offshore Structures

Table 7 shows the total number of offshore (shore perpendicular) structures observed along the Ottawa County coastline.

Nearshore Geology

Summary statistics on the type of nearshore geology found along the open coast of Ottawa County are provided in Table 8.

Table 7
Shore Perpendicular Structure Counts (Ottawa County, Michigan)

Type	Description	Number
2A2	Total Number of Groins (5-45 year lifespan)	120
2A3	Total Number of Groins (0-5 year lifespan)	13
2A4	Total Number of Groins (0 year lifespan - disrepair)	10
2B	Total Number of Jetties	6

Table 8
Near Shore Type Summary (Ottawa County, Michigan)

Type	Description	Length (m)
1A	Cohesive Till, Thick Sand Cover (>200 m3/m)	26,284
4	Sandy	14,216

3.3.2 Allegan County, MI

Shore Type

Summary statistics on the lengths of different shore types found along the open coast of Allegan County are provided in Table 9.

Table 9
Geomorphic Shore Type Summary (Allegan County, Michigan)

Type	Description	Length (m)
1A	Homogeneous Bluffs Sand Content 0-20%	6,739
1E	Composite Bluffs Sand Content 20-50%	9,623
2A	Homogeneous Bluffs With Beach Sand Content 0-20%	3,287
2E	Composite Bluffs With Beach Sand Content 20-50%	4,629
5	Sandy Beach / Dune	15,695

Shore Protection

Summary statistics on the type and extent of shore protection structures found along the open coast of Allegan County are provided in Table 10.

Table 10
Shore Protection Type Summary (Allegan County, Michigan)

Type	Description	Length (m)
1A1	Revetments >45 year lifespan	783
1A1 with Groins	Revetments (>45) with Groins in front	114
1A2	Revetments 5-45 year lifespan	943
1A3	Revetments 0-5 year lifespan	96
1A4	Revetments 0 year lifespan (disrepair)	64
1B2	Seawalls 5-45 year lifespan	2,767
1B2 with Groins	Seawalls (5-45) with Groins in front	800
2A2	Groins 5-45 year lifespan	990
2A4	Groins 0 year lifespan (disrepair)	25
2B2	Jetties 5-45 year lifespan	10
3C1	Slope/Bluff Stabilization >45 year lifespan	257
3C2	Slope/Bluff Stabilization 5-45 year lifespan	337
3C2 with Groins	Slope/Bluff Stabilization (5-45) with Groins in front	186
5A2	Concrete Rubble 5-45 year lifespan	125
5A3	Concrete Rubble 0-5 year lifespan	53

5A4	Concrete Rubble 0 year lifespan (disrepair)	931
5A4 with Groins	Concrete Rubble (disrepair) with Groins in front	231
7	No Shore Protection	32,165

Offshore Structures

Table 11 shows the total number of offshore (shore perpendicular) structures observed along the Allegan County coastline.

Table 11
Shore Perpendicular Structure Counts (Allegan County, Michigan)

Type	Description	Number
2A2	Total Number of Groins (5-45 year lifespan)	58
2A3	Total Number of Groins (0-5 year lifespan)	6
2B	Total Number of Jetties	6

Nearshore Geology

Summary statistics on the nearshore geology found along the open coast of Allegan County are provided in Table 12.

Table 12
Near Shore Type Summary (Allegan County, Michigan)

Type	Description	Length (m)
1. Cohesive (Till)		
1A	Thick Sand Cover (>200 m3/m)	7,065
1B	Moderate Sand Cover (50-200 m3/m)	12,948
3. Cobble / Boulder Lag Over Cohesive		
3B	Moderate Sand Cover (50-200 m3/m)	7,034
4	Sandy	12,753

3.3.3 Ozaukee County, WI

Shore Type

Summary statistics on the lengths of different shore types found along the open coast of Ozaukee County are provided in Table 13.

Table 13
Geomorphic Shore Type Summary Statistics (Ozaukee County, Wisconsin)

Type	Description	Length (m)
1. Sand or Homogenous Bluffs		
1E	Composite Bluffs Sand Content 20-50%	29,270
3. Low Bank		
3C	Sand Content > 50%	11,240
10	Artificial	3,752

Shore Protection

Summary statistics on the type and extent of shore protection structures found along the open coast of Ozaukee County are provided in Table 14.

Table 14
Shore Protection Summary Statistics (Ozaukee County, Wisconsin)

Type	Description	Length (m)
1. Coastal Armoring		
1A1	Revetments >45 year lifespan	674
1A2	Revetments 5-45 year lifespan	2,188
1A3	Revetments 0-5 year lifespan	900
1B1	Seawalls >45 year lifespan	2,405
1B2	Seawalls 5-45 year lifespan	1,155
1B2 with Revetment	Seawalls (5-45) with Revetment in front	262
1B2 with Concrete Rubble	Seawalls (5-45) with Concrete Rubble in front	216
1B3	Seawalls 0-5 year lifespan	220

5. Ad-Hoc Structures		
5A2	Concrete Rubble 5-45 year lifespan	397
5A3	Concrete Rubble 0-5 year lifespan	558
5B2	Other Materials 5-45 year lifespan	24
6. Unclassified & Other		
6D1	Boat Launch >45 year lifespan	32
7	No Shore Protection	35,805

Offshore Structures

Table 15 shows the total number of offshore (shore perpendicular) structures observed along the Ozaukee County coastline.

Table 15
Shore Perpendicular Structure Counts (Ozaukee County, Wisconsin)

Type	Description	Number
2B	Total Number of Jetties	5
6B	Total Number of Marina Docks	6
6D	Total Number of Boat Launch Docks	4

Nearshore Geology

Summary statistics on the nearshore geology found along the open coast of Ozaukee County are provided in Table 16.

Table 16
Near Shore Type Summary Statistics (Ozaukee County, Wisconsin)

Type	Description	Length (m)
1. Cohesive (Till)		
1B	Moderate Sand Cover (50-200 m3/m)	31,151
6	Bedrock (non-resistant)	13,112

3.3.4 Manitowoc County, WI

Shore Type

Summary statistics on the lengths of different shore types found along the open coast of Manitowoc County are provided in Table 17.

Table 17
Geomorphic Shore Type Summary Statistics (Manitowoc County, Wisconsin)

Type	Description	Length (m)
1. Sand or Homogenous Bluffs		
1A	Homogeneous Bluffs Sand Content 0-20%	2,456
1B	Homogeneous Bluffs Sand Content 20-50%	9,985
1C	Homogeneous Bluffs Sand Content > 50%	1,571
1E	Composite Bluffs Sand Content 20-50%	9,819
2. Sand or Cohesive Bluffs with Beach		
2C	Homogeneous Bluffs Sand Content > 50%	1,006
2E	Composite Bluffs Sand Content 20-50%	1,181
3. Low Bank		
3B	Sand Content 20-50%	13,883
5	Sandy Beach / Dune	13,364
10	Artificial	2,560

Shore Protection

Summary statistics on the type and extent of shore protection structures found along the open coast of Manitowoc County are provided in Table 18.

Table 18
Shore Protection Summary (Manitowoc County, Wisconsin)

Type	Description	Length (m)
1. Coastal Armoring		
1A1	Revetments >45 year lifespan	1,942
1A2	Revetments 5-45 year lifespan	8,591

1A3	Revetments 0-5 year lifespan	2,184
1B1	Seawalls >45 year lifespan	472
1B2	Seawalls 5-45 year lifespan	887
2. Beach Erosion Control Devices		
2B1	Jetties >45 year lifespan	40
3. Non Structural		
3C2	Slope/Bluff Stabilization 5-45 year lifespan	117
5. Ad-Hoc Structures		
5A3	Concrete Rubble 0-5 year lifespan	114
5A4	Concrete Rubble 0 year lifespan (disrepair)	130
6. Unclassified & Other		
6D1	Boat Launch >45 year lifespan	39
6D2	Boat Launch 5-45 year lifespan	7
7	No Shore Protection	42,597

Offshore Structures

Table 19 shows the total number of offshore (shore perpendicular) structures observed along the Manitowoc County coastline.

Table 19
Shore Perpendicular Structure Counts (Manitowoc County, Wisconsin)

Type	Description	Number
2A2	Total Number of Groins (5-45 year lifespan)	3
2B	Total Number of Jetties	9
6B	Total Number of Marina Docks	7
6C	Total Number of Commercial & Industrial Docks	3
6D	Total Number of Boat Launch Docks	2

Nearshore Geology

Summary statistics on the nearshore geology found along the open coast of Manitowoc County are provided in Table 20.

Table 20
Near Shore Type Summary Statistics (Manitowoc County, Wisconsin)

Type	Description	Length (m)
1. Cohesive (Till)		
1B	Moderate Sand Cover (50-200 m3/m)	9,984
3. Cobble / Boulder Lag Over Cohesive		
3B	Moderate Sand Cover (50-200 m3/m)	25,971
4	Sandy	21,293

3.3.5 Sheboygan County, WI

Shore Type

Summary statistics on the lengths of different shore types found along the open coast of Sheboygan County are provided in Table 21.

Table 21
Geomorphic Shore Type Summary Statistics (Sheboygan County, Wisconsin)

Type	Description	Length (m)
1. Sand or Homogenous Bluffs		
1A	Homogeneous Bluffs Sand Content 0-20%	10,926
1D	Composite Bluffs Sand Content 0-20%	4,698
3. Low Bank		
3C	Sand Content > 50%	22,882
10	Artificial	924

Shore Protection

Summary statistics on the type and extent of shore protection structures found along the open coast of Sheboygan County are provided in Table 22.

Table 22
Shore Protection Summary (Sheboygan County, Wisconsin)

Type	Description	Length (m)
1. Coastal Armoring		
1A1	Revetments >45 year lifespan	942
1A2	Revetments 5-45 year lifespan	8,784
1A2 with Groins	Revetments (5-45) with Groins in front	1,427
1A3	Revetments 0-5 year lifespan	2,165
1A3 with Groins	Revetments (0-5) with Groins in front	630
1A4	Revetments 0 year lifespan (disrepair)	610
1A4 with Groins	Revetments (disrepair) with Groins in front	256
1B2	Seawalls 5-45 year lifespan	800
1B2 with Revetment	Seawalls (5-45) with Revetment in front	101
1B2 with Concrete Rubble	Seawalls (5-45) with Concrete Rubble in front	83
1B3	Seawalls 0-5 year lifespan	82
2. Beach Erosion Control Devices		
2A2	Groins 5-45 year lifespan	136
2B1	Jetties >45 year lifespan	28
5. Ad-Hoc Structures		
5A2	Concrete Rubble 5-45 year lifespan	918
5A3	Concrete Rubble 0-5 year lifespan	64
5A4	Concrete Rubble 0 year lifespan (disrepair)	880
6. Unclassified & Other		
6D1	Boat Launch >45 year lifespan	29
7	No Shore Protection	27,133

Offshore Structures

Table 23 shows the total number of offshore (shore perpendicular) structures observed along the Sheboygan County coastline.

Table 23
Shore Perpendicular Structure Counts (Sheboygan, Wisconsin)

Type	Description	Number
2A2	Total Number of Groins (5-45 year lifespan)	20
2A4	Total Number of Groins (0 year lifespan - disrepair)	6
2B	Total Number of Jetties	3
6B	Total Number of Marina Docks	2
6C	Total Number of Commercial & Industrial Docks	1
6D	Total Number of Boat Launch Docks	4

Nearshore Geology

Summary statistics on the nearshore geology found along the open coast of Sheboygan County are provided in Table 24.

Table 24
Near Shore Type Summary Statistics (Sheboygan County, Wisconsin)

Type	Description	Length (m)
1. Cohesive (Till)		
1A	Thick Sand Cover (>200 m3/m)	1,026
1B	Moderate Sand Cover (50-200 m3/m)	4,000
3. Cobble / Boulder Lag Over Cohesive		
3B	Moderate Sand Cover (50-200 m3/m)	13,025
4	Sandy	12,958
6	Bedrock (non-resistant)	11,220
7	Unclassified	347

4.0 Summary and Conclusions

The open coast reach delineation and re-attribution of shoreline classification exercise carried out in this task has resulted in the development of continuous GIS mapping coverages for key coastal zone data sets in five counties surrounding Lake Michigan. Newly mapped data includes shoreline type, shore protection, nearshore geology and recession rate data. In addition, a new digital shoreline has had new, $1/10^{th}$ of a kilometer reaches ascribed to it on a county-by-county basis. These new reaches effectively replace the previous 1 kilometer reach delineations that were in place and can be used for reference purposes during future activities along these shorelines. As a result of this exercise, there are a number of conclusions and recommendations that should be considered during future exercises of this nature:

1) The creation of individual mapping coverages for each data layer provides a degree of flexibility in the display and visualization of the information. Each layer can be mapped or presented individually, or they can be presented at the same time, with a slight offset from each other so that they are easily visible.

2) The newly created digital shoreline provides a much more accurate "baseline" on which to map the related information and with the county-by-county, $1/10^{th}$ of a kilometer reach delineation that has been ascribed to it, provides for an ability to conduct future modeling exercises and analyses at a greater level of detail than at the 1 kilometer scale previously in place.

3) The shore protection mapping that has been developed in this activity only maps the primary shore protection that is in place. Secondary shore protection structures are then referenced in the attribute table, or else captured in the "offshore" mapping coverage that has been developed. This needs to be kept in mind during any future examination of related costs/impacts to shore protection structures and those conducting such an analysis may wish to use the continuous mapping data in conjunction with the detailed $1/10^{th}$ of a kilometer inventory conducted for these counties in 1999 (Stewart, 1999) as this inventory captures these secondary structures in greater detail.

4) In developing the nearshore geology mapping coverage, it is important to note that there was no solid evidence of the exact delineation (boundary) between different nearshore geologic types. The boundaries were largely determined using the previous classification information, with limited help from SHOALS bathymetric data. For future exercises of this nature, it would be helpful to have more accurate nearshore mapping information, so that this delineation could be done with more confidence.

5) Given some of the limitations noted above and in Section 2.1, perhaps a more accurate mapping of open coast classification information in other counties along Lake Michigan would be realized through an on-site field mapping exercise. This would result in a more accurate determination of the start and end points of the different shore types and shore protection, and perhaps nearshore geology, as well as a better assessment of things like shore protection structure quality, or sand content of bluffs. Physical changes in the shoreline, or structures put in place subsequent to the date of any photography proposed to be used could also be noted. Such a field mapping exercise could likely be done in tandem with video taping of the shoreline in these areas. Information could be mapped on air photo or map copies in the field and then transferred into ArcView once back in the office, using the video and other associated data sources (air photos, Mr. Sid images, etc.) for additional guidance where required.

6) Continuous GIS mapping coverages for other counties around Lake Michigan will ultimately be required at this level in order to develop consistent data sets for the Lake and to conduct more detailed potential damages modeling and FEPS modeling for the whole lake. As such, USACE should proceed, as budget permits, with an extension of this mapping for the remaining counties along the Lake Michigan shoreline.

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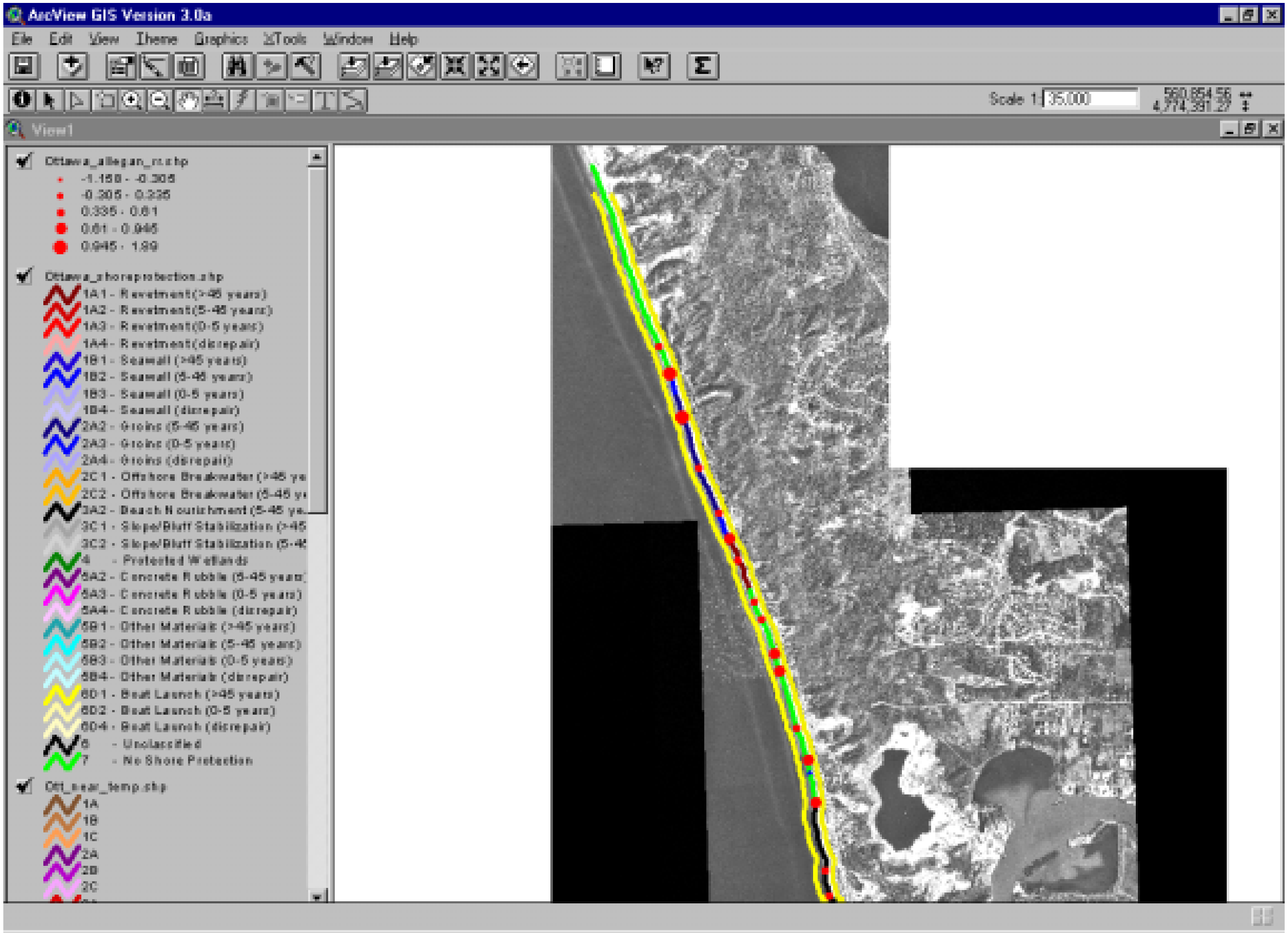
APPENDIX 1

OPEN COAST MAPPING PRINTOUTS

LMPDS PROTOTYPE COUNTIES

OTTAWA COUNTY, MICHIGAN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1A1 - Revetment(>45 years)
1A2 - Revetment(5-45 years)
1A3 - Revetment(0-5 years)
1A4 - Revetment(disrepair)
1B1 - Seawall (>45 years)
1B2 - Seawall (5-45 years)
1B3 - Seawall (0-5 years)
1B4 - Seawall (disrepair)
2A2 - Groins (5-45 years)
2A3 - Groins (0-5 years)
2A4 - Groins (disrepair)
2C1 - Offshore Breakwater (>45 ye
2C2 - Offshore Breakwater (5-45 ye
3A2 - Beach Nourishment (5-45 ye
3C1 - Slope/Bluff Stabilization (>45
3C2 - Slope/Bluff Stabilization (5-45
4 - Protected Wetlands
5A2 - Concrete Rubble (5-45 years)
5A3 - Concrete Rubble (0-5 years)
5A4 - Concrete Rubble (disrepair)
5B1 - Other Materials (>45 years)
5B2 - Other Materials (5-45 years)
5B3 - Other Materials (0-5 years)
5B4 - Other Materials (disrepair)
6D1 - Boat Launch (>45 years)
6D2 - Boat Launch (0-5 years)
6D4 - Boat Launch (disrepair)
6 - Unclassified
7 - No Shore Protection
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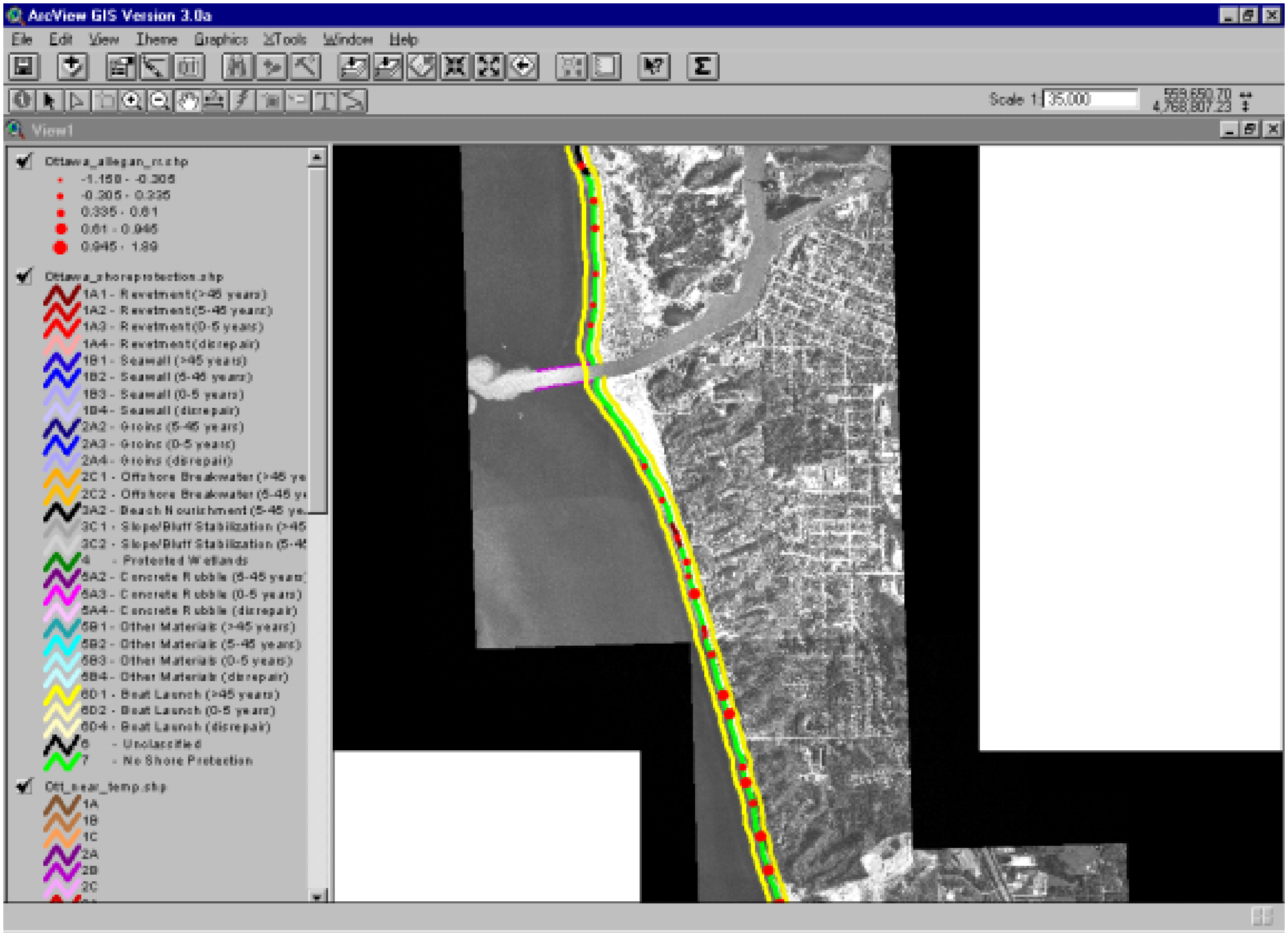
2B
2C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0.945 - 1.89
Ottawa_shoreprotection.shp
1A1 - Revetment(>45 years)
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1B1 - Seawall (>45 years)
1B2 - Seawall (5-45 years)
1B3 - Seawall (0-5 years)
1B4 - Seawall (disrepair)
2A2 - Groins (5-45 years)
2A3 - Groins (0-5 years)
2A4 - Groins (disrepair)
2C1 - Offshore Breakwater (>45 ye
2C2 - Offshore Breakwater (5-45 y
3A2 - Beach Nourishment (5-45 ye
3C1 - Slope/Bluff Stabilization (>45
3C2 - Slope/Bluff Stabilization (5-4
4 - Protected Wetlands
5A2 - Concrete Rubble (5-45 years)
5A3 - Concrete Rubble (0-5 years)
5A4 - Concrete Rubble (disrepair)
5B1 - Other Materials (>45 years)
5B2 - Other Materials (5-45 years)
5B3 - Other Materials (0-5 years)
5B4 - Other Materials (disrepair)
6D1 - Boat Launch (>45 years)
6D2 - Boat Launch (0-5 years)
6D4 - Boat Launch (disrepair)
6 - Unclassified
7 - No Shore Protection
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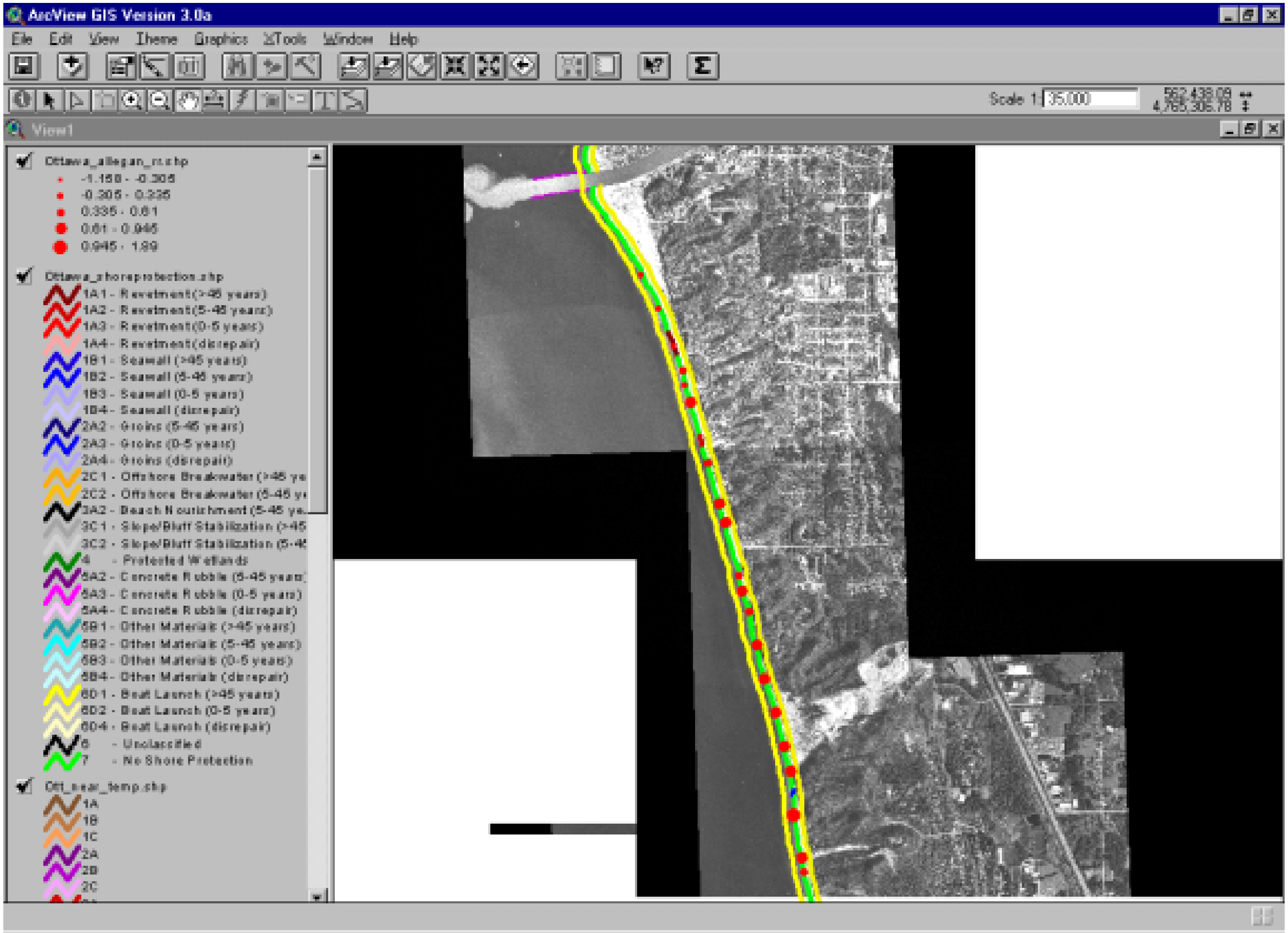
1B
1C
2A
2B
2C



ArcView GIS Version 3.0a
File Edit View Theme Graphics XTools Window Help
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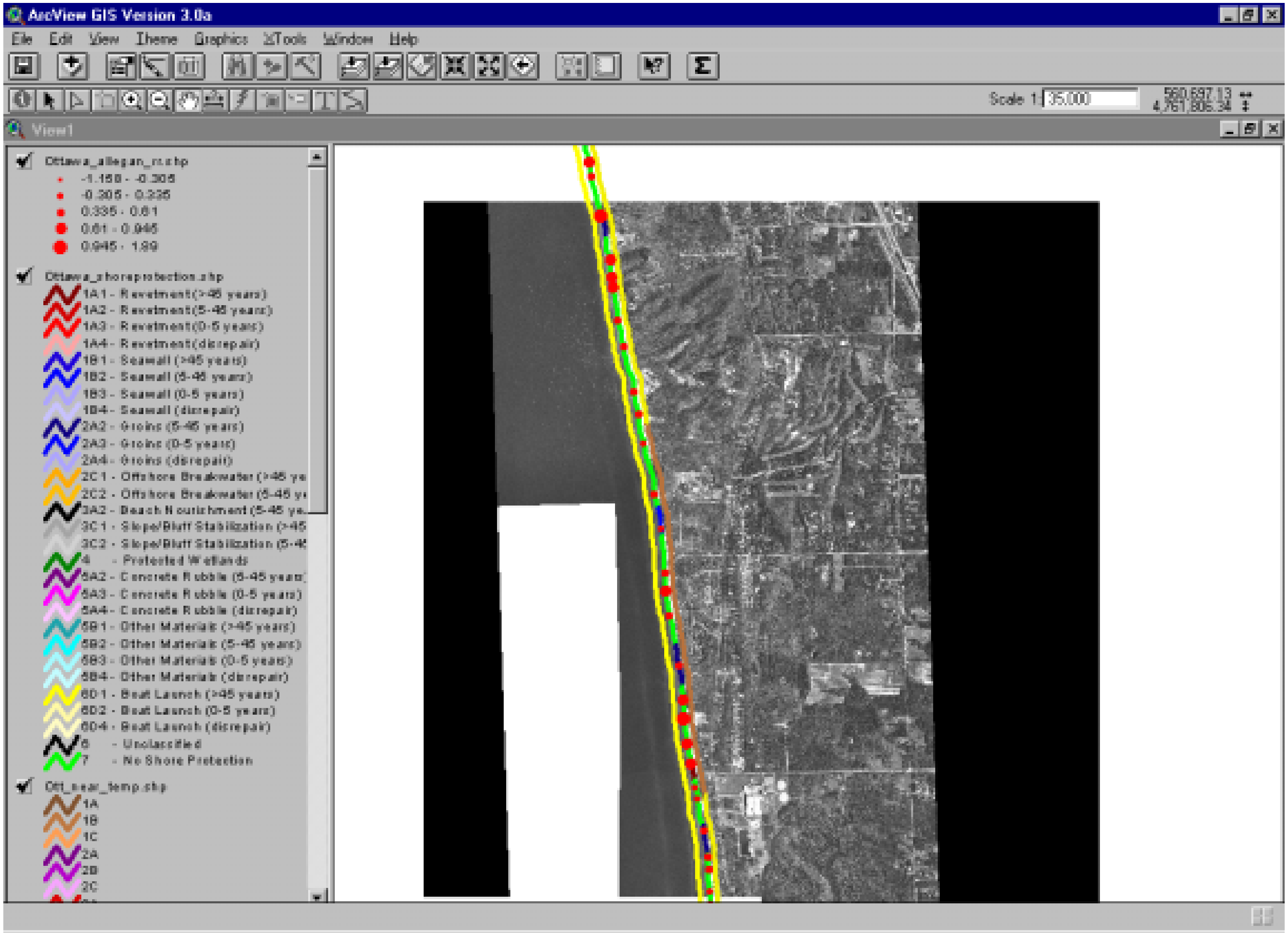
1A2 - Revetment(5-45 years)
1A3 - Revetment(0-5 years)
1A4 - Revetment(disrepair)
1B1 - Seawall (>45 years)
1B2 - Seawall (5-45 years)
1B3 - Seawall (0-5 years)
1B4 - Seawall (disrepair)
2A2 - Groins (5-45 years)
2A3 - Groins (0-5 years)
2A4 - Groins (disrepair)
2C1 - Offshore Breakwater (>45 ye
2C2 - Offshore Breakwater (5-45 ye
3A2 - Beach Nourishment (5-45 ye
3C1 - Slope/Bluff Stabilization (>45
3C2 - Slope/Bluff Stabilization (5-45
4 - Protected Wetlands
5A2 - Concrete Rubble (5-45 years)
5A3 - Concrete Rubble (0-5 years)
5A4 - Concrete Rubble (disrepair)
5B1 - Other Materials (>45 years)
5B2 - Other Materials (5-45 years)
5B3 - Other Materials (0-5 years)
5B4 - Other Materials (disrepair)
6D1 - Boat Launch (>45 years)
6D2 - Boat Launch (0-5 years)
6D4 - Boat Launch (disrepair)
6 - Unclassified
7 - No Shore Protection
Ott_rear_temp.shp
1A
1B
1C
2A
2B
2C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Ottawa_allegan_rr.shp
-1.158 - -0.305
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0.335 - 0.61
0.61 - 0.945
0.945 - 1.89
Ottawa_shoreprotection.shp
1A1 - Revetment(>45 years)
1A2 - Revetment(5-45 years)
1A3 - Revetment(0-5 years)
1A4 - Revetment(disrepair)
1B1 - Seawall (>45 years)
1B2 - Seawall (5-45 years)
1B3 - Seawall (0-5 years)
1B4 - Seawall (disrepair)
2A2 - Groins (5-45 years)
2A3 - Groins (0-5 years)
2A4 - Groins (disrepair)
2C1 - Offshore Breakwater (>45 ye
2C2 - Offshore Breakwater (5-45 y
3A2 - Beach Nourishment (5-45 ye
3C1 - Slope/Bluff Stabilization (>45
3C2 - Slope/Bluff Stabilization (5-4
4 - Protected Wetlands
5A2 - Concrete Rubble (5-45 years)
5A3 - Concrete Rubble (0-5 years)
5A4 - Concrete Rubble (disrepair)
5B1 - Other Materials (>45 years)
5B2 - Other Materials (5-45 years)
5B3 - Other Materials (0-5 years)
5B4 - Other Materials (disrepair)
6D1 - Boat Launch (>45 years)
6D2 - Boat Launch (0-5 years)
6D4 - Boat Launch (disrepair)
6 - Unclassified
7 - No Shore Protection
Ott_near_temp.shp
1A
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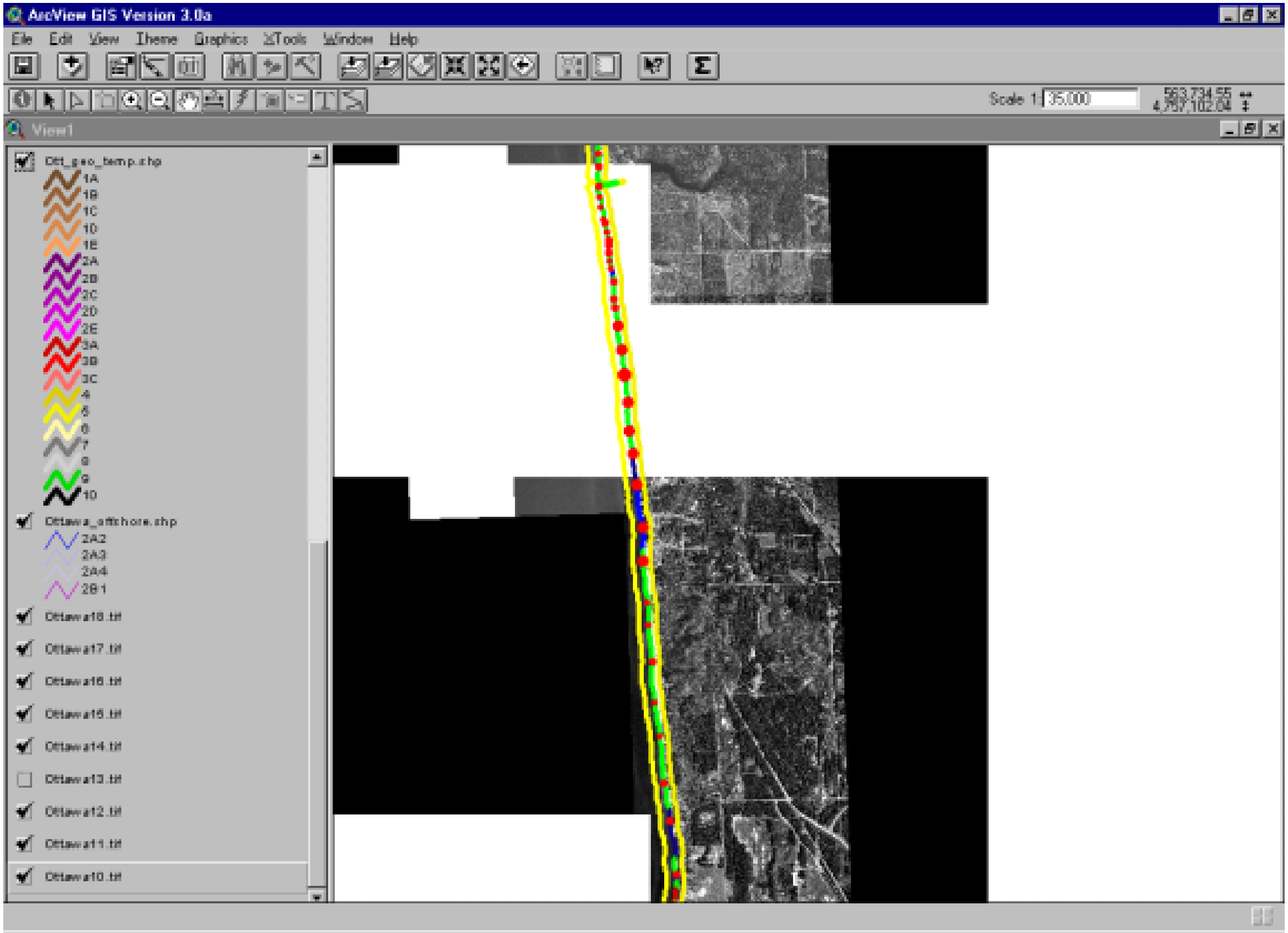
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3A
3B
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10
Ottawa_offshore.shp
2A2
2A3
2A4
2B1
Ottawa18.tif
Ottawa17.tif
Ottawa16.tif
Ottawa15.tif
Ottawa14.tif
Ottawa13.tif
Ottawa12.tif
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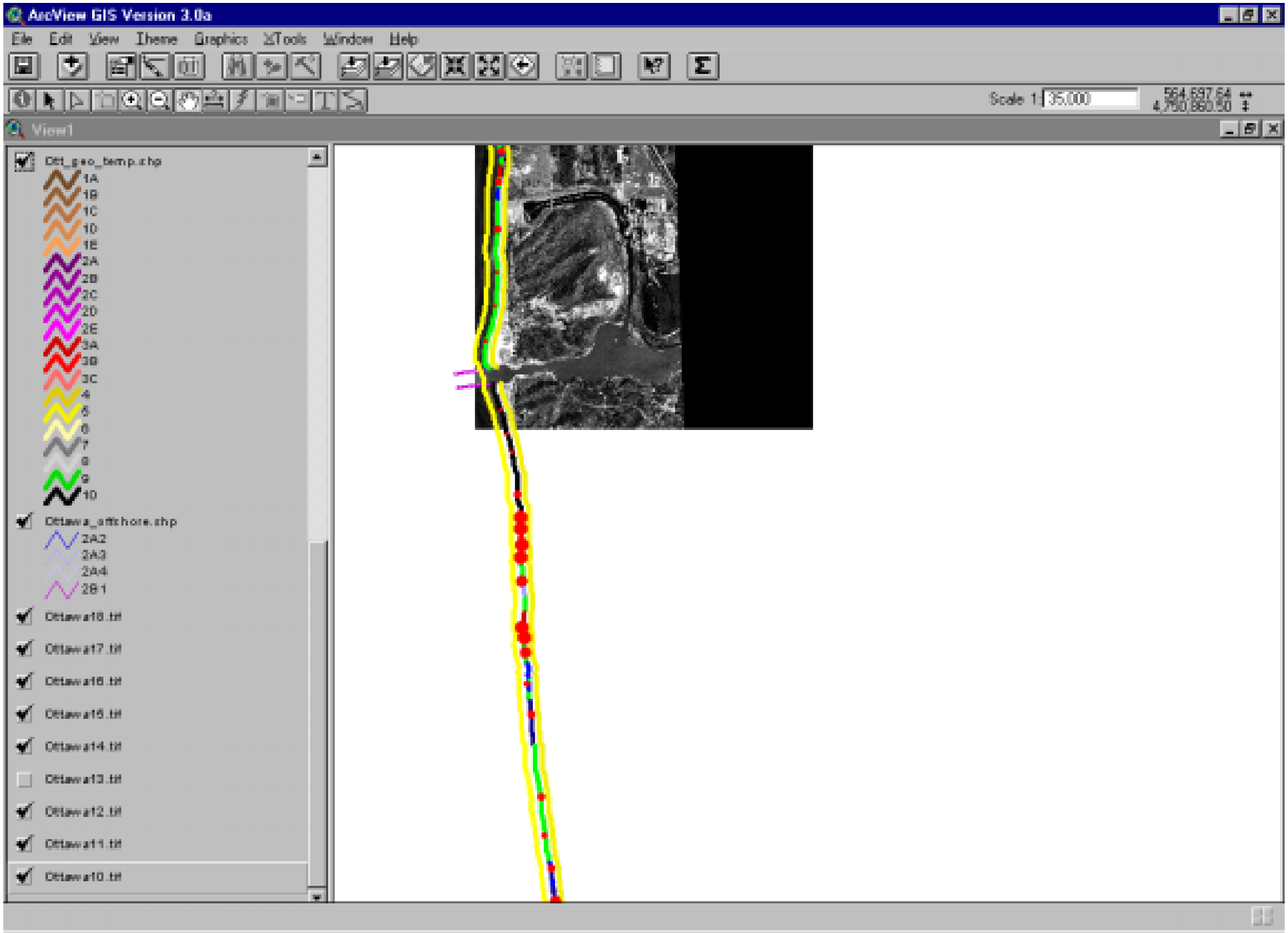
Ottawa10.tif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File
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Window
Help
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Ottawa_offshore.shp
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2B1
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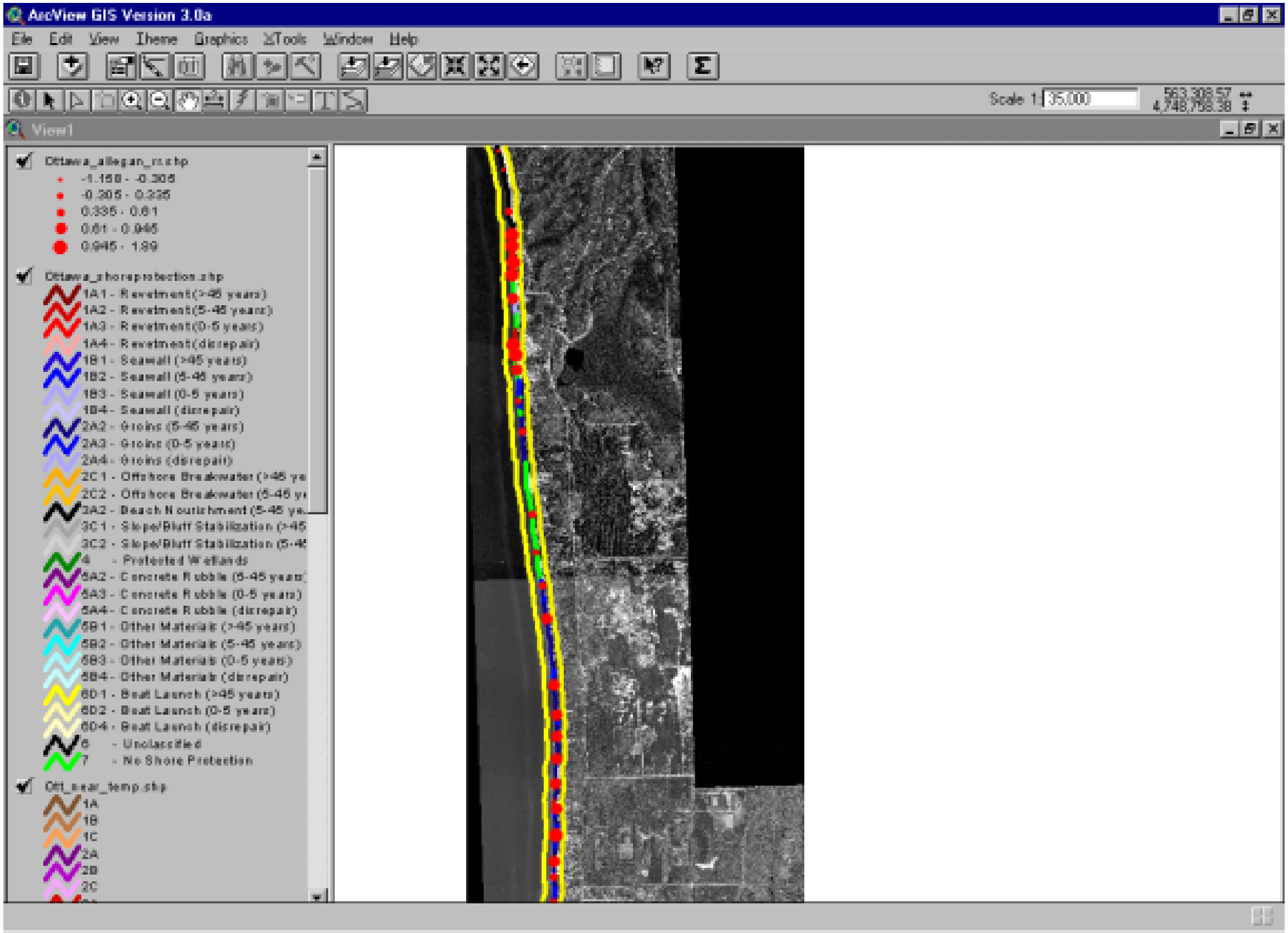
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View1
Ottawa_allegan_rr.shp
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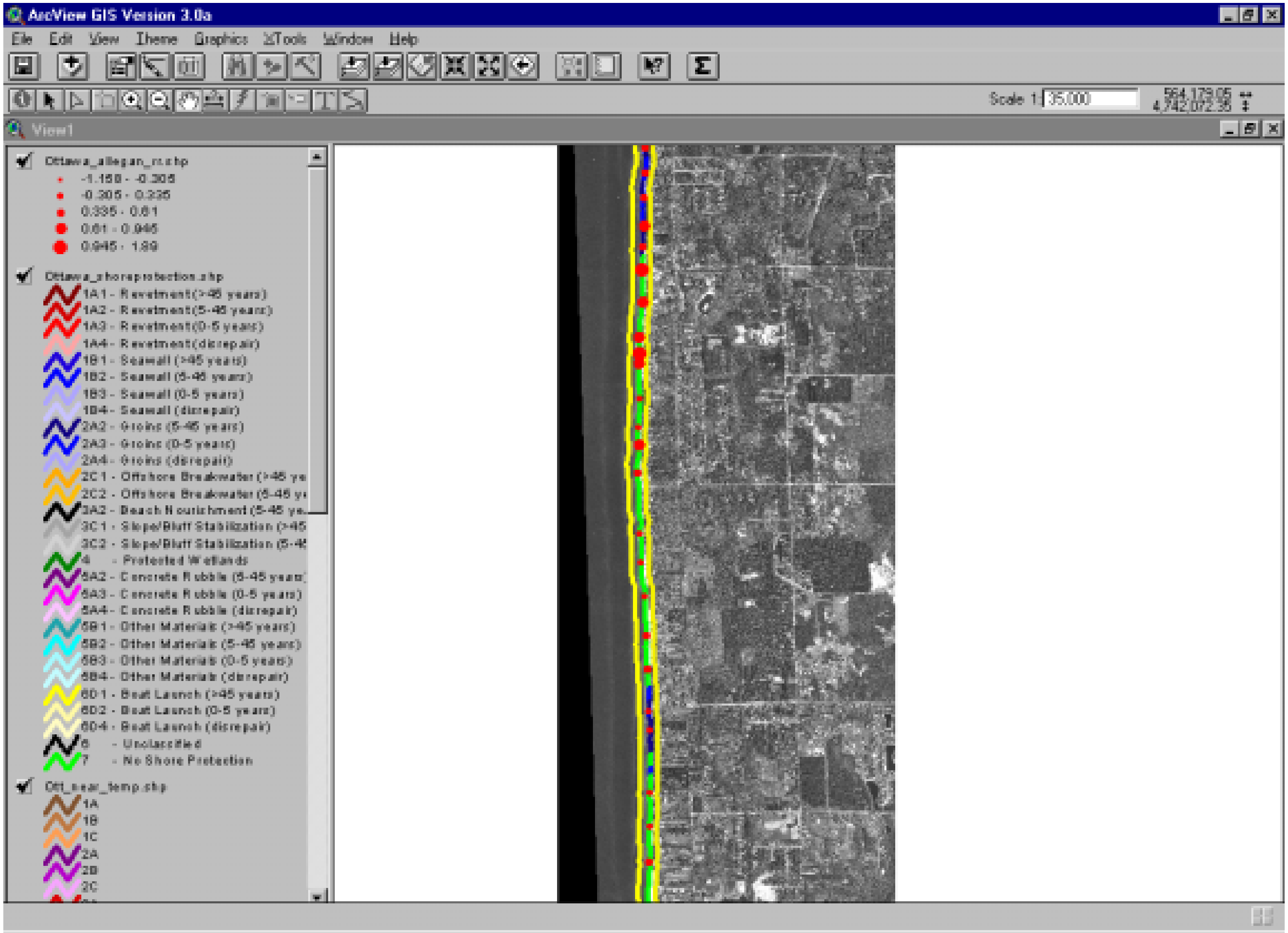
0.61 - 0.945
0.945 - 1.89
Ottawa_shoreprotection.shp
1A1 - Revetment(>45 years)
1A2 - Revetment(5-45 years)
1A3 - Revetment(0-5 years)
1A4 - Revetment(disrepair)
1B1 - Seawall (>45 years)
1B2 - Seawall (5-45 years)
1B3 - Seawall (0-5 years)
1B4 - Seawall (disrepair)
2A2 - Groins (5-45 years)
2A3 - Groins (0-5 years)
2A4 - Groins (disrepair)
2C1 - Offshore Breakwater (>45 ye
2C2 - Offshore Breakwater (5-45 ye
3A2 - Beach Nourishment (5-45 ye
3C1 - Slope/Bluff Stabilization (>45
3C2 - Slope/Bluff Stabilization (5-45
4 - Protected Wetlands
5A2 - Concrete Rubble (5-45 years)
5A3 - Concrete Rubble (0-5 years)
5A4 - Concrete Rubble (disrepair)
5B1 - Other Materials (>45 years)
5B2 - Other Materials (5-45 years)
5B3 - Other Materials (0-5 years)
5B4 - Other Materials (disrepair)
6D1 - Boat Launch (>45 years)
6D2 - Boat Launch (0-5 years)
6D4 - Boat Launch (disrepair)
6 - Unclassified
7 - No Shore Protection
Ott_near_temp.shp
1A
1B
1C
2A
2B
2C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-0.305 - 0.335
0.335 - 0.61
0.61 - 0.945
0.945 - 1.89
Ottawa_shoreprotection.shp
1A1 - Revetment(>45 years)
1A2 - Revetment(5-45 years)
1A3 - Revetment(0-5 years)
1A4 - Revetment(disrepair)
1B1 - Seawall (>45 years)
1B2 - Seawall (5-45 years)
1B3 - Seawall (0-5 years)
1B4 - Seawall (disrepair)
2A2 - Groins (5-45 years)
2A3 - Groins (0-5 years)
2A4 - Groins (disrepair)
4 - Protected Wetlands
5A3 - Concrete Rubble (0-5 years)
5A4 - Concrete Rubble (disrepair)
5B1 - Other Materials (>45 years)
5B2 - Other Materials (5-45 years)
5B3 - Other Materials (0-5 years)
5B4 - Other Materials (disrepair)
6D1 - Boat Launch (>45 years)
6D2 - Boat Launch (0-5 years)
6D4 - Boat Launch (disrepair)
6 - Unclassified
7 - No Shore Protection
Ott_near_temp.shp
1A
1B
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2A
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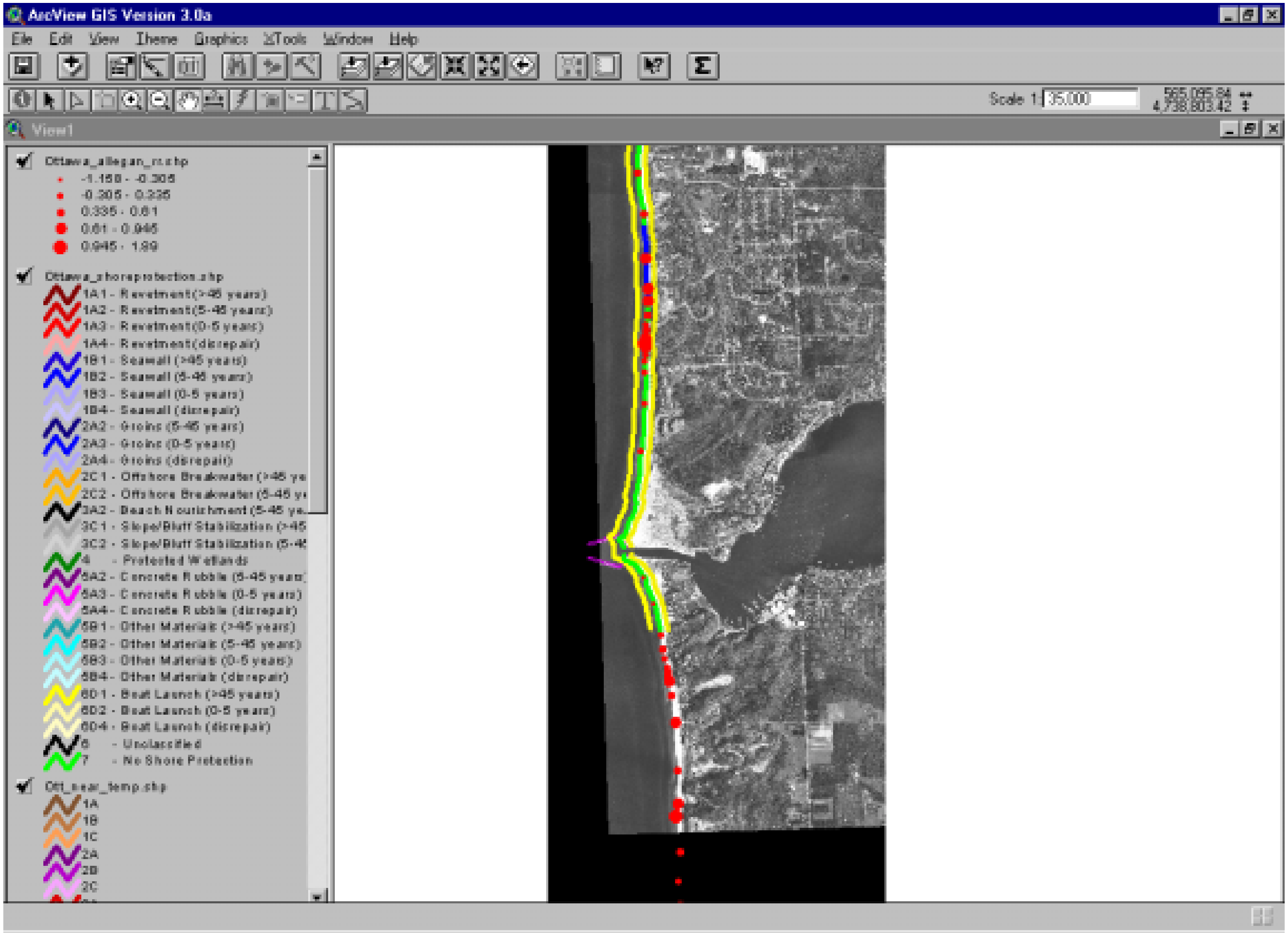
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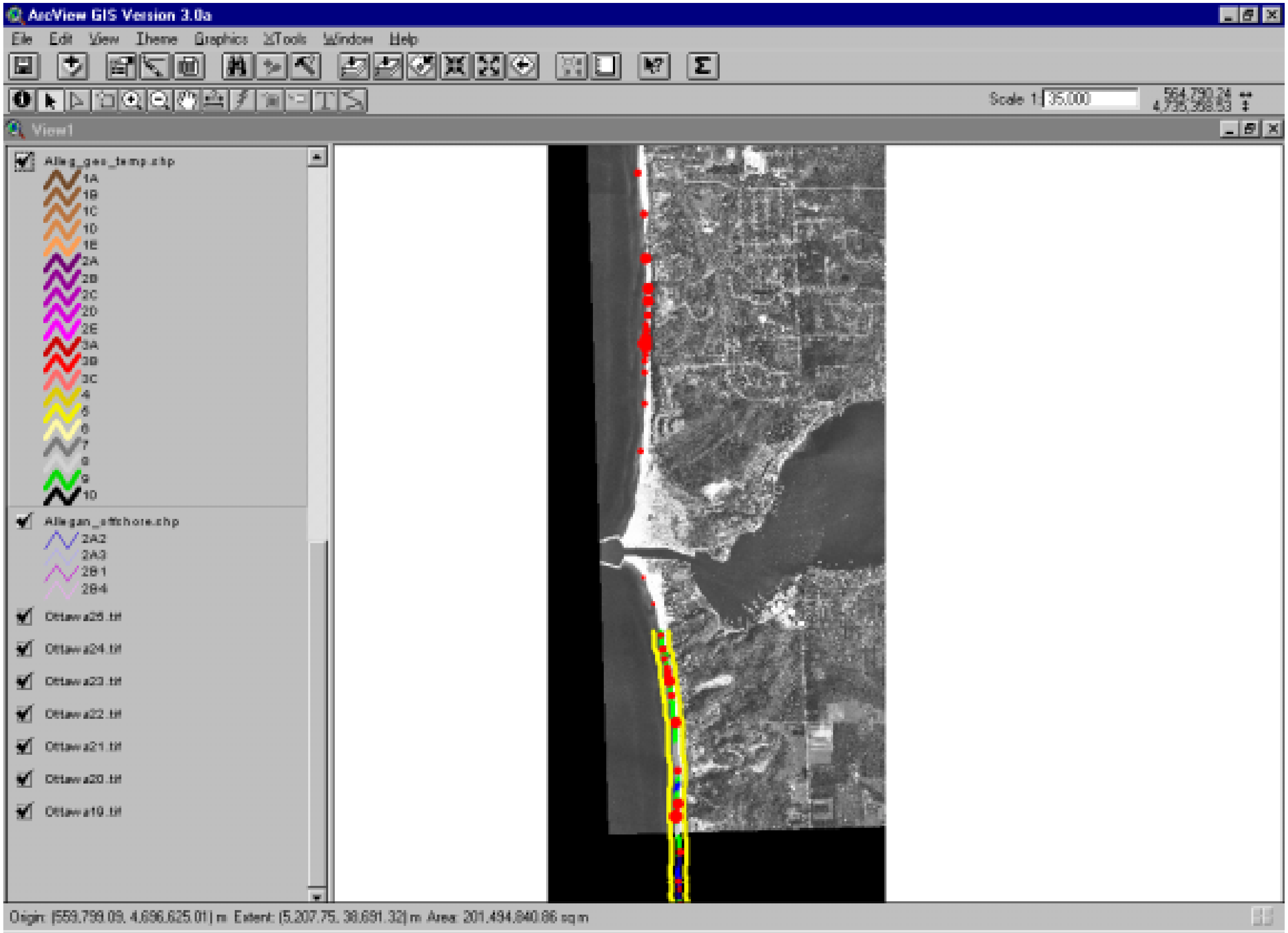
-0.305 - 0.335
0.335 - 0.61
0.61 - 0.945
0.945 - 1.89
Ottawa_shoreprotection.shp
1A1 - Revetment(>45 years)
1A2 - Revetment(5-45 years)
1A3 - Revetment(0-5 years)
1A4 - Revetment(disrepair)
1B1 - Seawall (>45 years)
1B2 - Seawall (5-45 years)
1B3 - Seawall (0-5 years)
1B4 - Seawall (disrepair)
2A2 - Groins (5-45 years)
2A3 - Groins (0-5 years)
2A4 - Groins (disrepair)
3A2 - Beach Nourishment (5-45 ye
3C1 - Slope/Bluff Stabilization (>45
3C2 - Slope/Bluff Stabilization (5-4
4 - Protected Wetlands
5A2 - Concrete Rubble (5-45 years)
5A3 - Concrete Rubble (0-5 years)
5A4 - Concrete Rubble (disrepair)
5B1 - Other Materials (>45 years)
5B2 - Other Materials (5-45 years)
5B3 - Other Materials (0-5 years)
5B4 - Other Materials (disrepair)
6D1 - Boat Launch (>45 years)
6D2 - Boat Launch (0-5 years)
6D4 - Boat Launch (disrepair)
6 - Unclassified
7 - No Shore Protection
Ott_near_temp.shp
1A
1B
1C
2A
2B
2C

ALLEGAN COUNTY, MICHIGAN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View1
Alleg_geo_temp.shp
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1E
2A
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Allegan_offshore.shp
2A2
2A3
2B1
2B4
Ottawa25.tif
Ottawa24.tif
Ottawa23.tif
Ottawa22.tif
Ottawa21.tif
Ottawa20.tif
Ottawa19.tif
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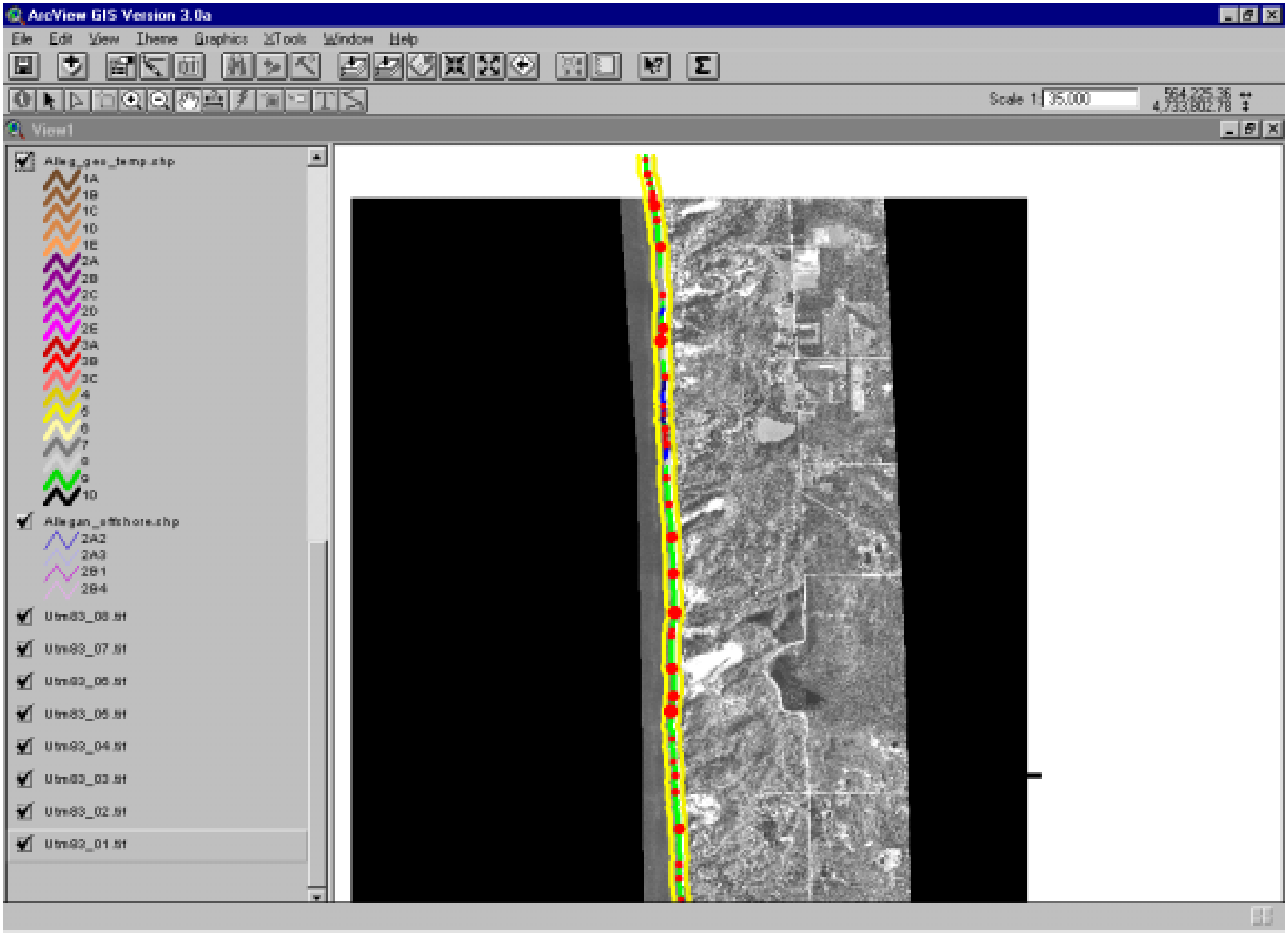
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Allegan_offshore.shp
2A2
2A3
2B1
2B4
Utm83_08.tif
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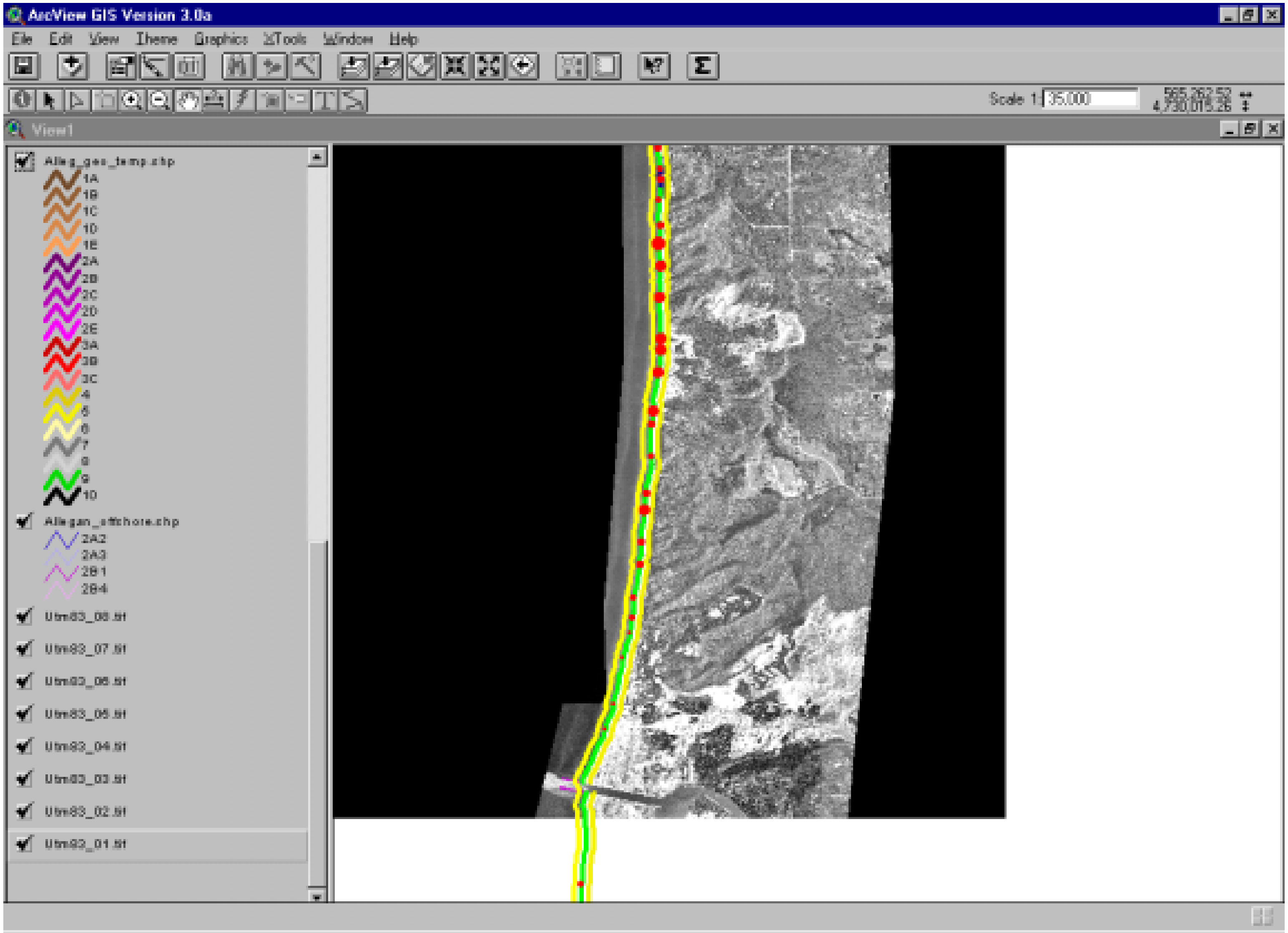
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Allegan_offshore.shp
2A2
2A3
2B1
2B4
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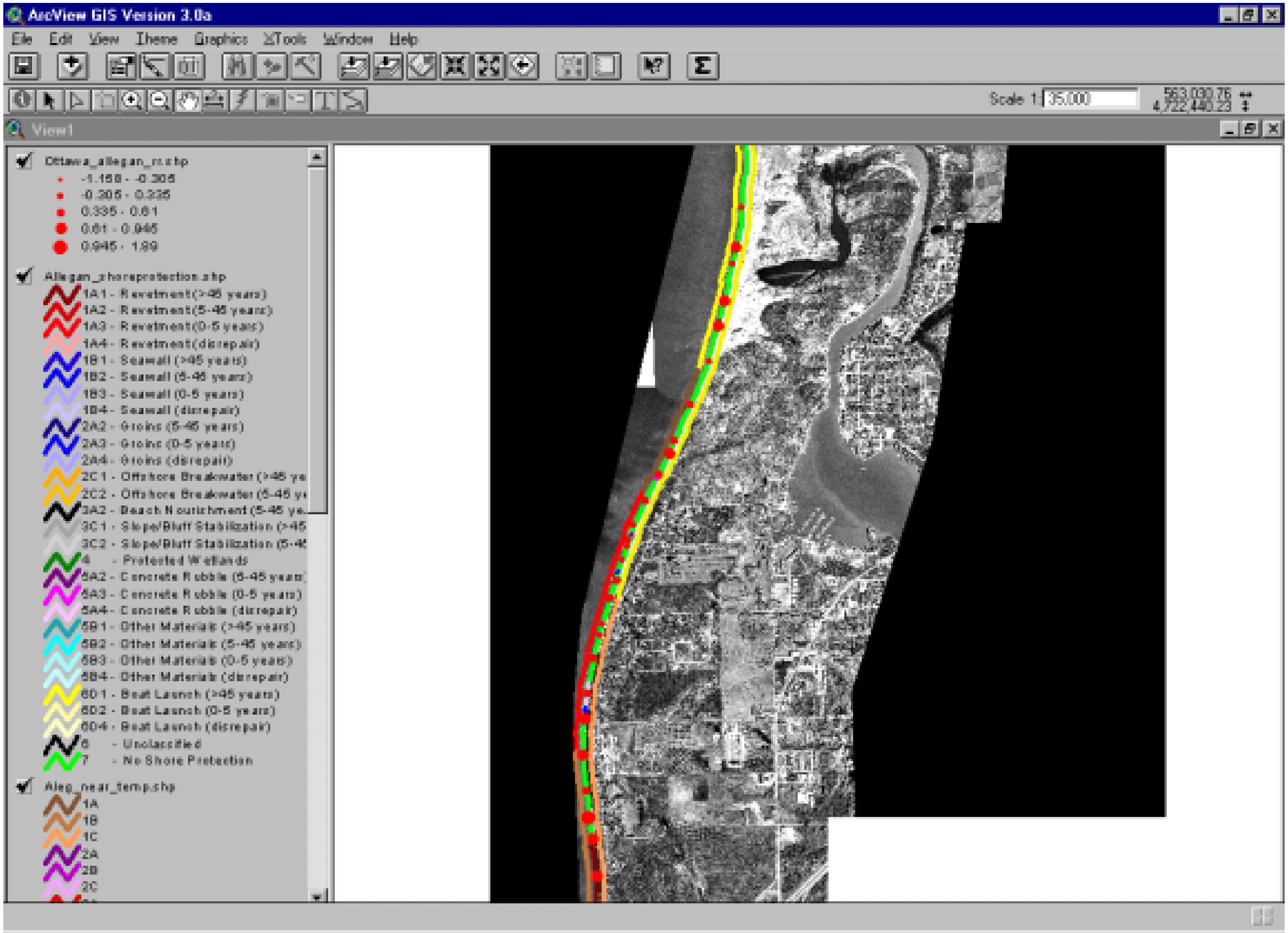
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View1
Ottawa_allegan_rr.shp
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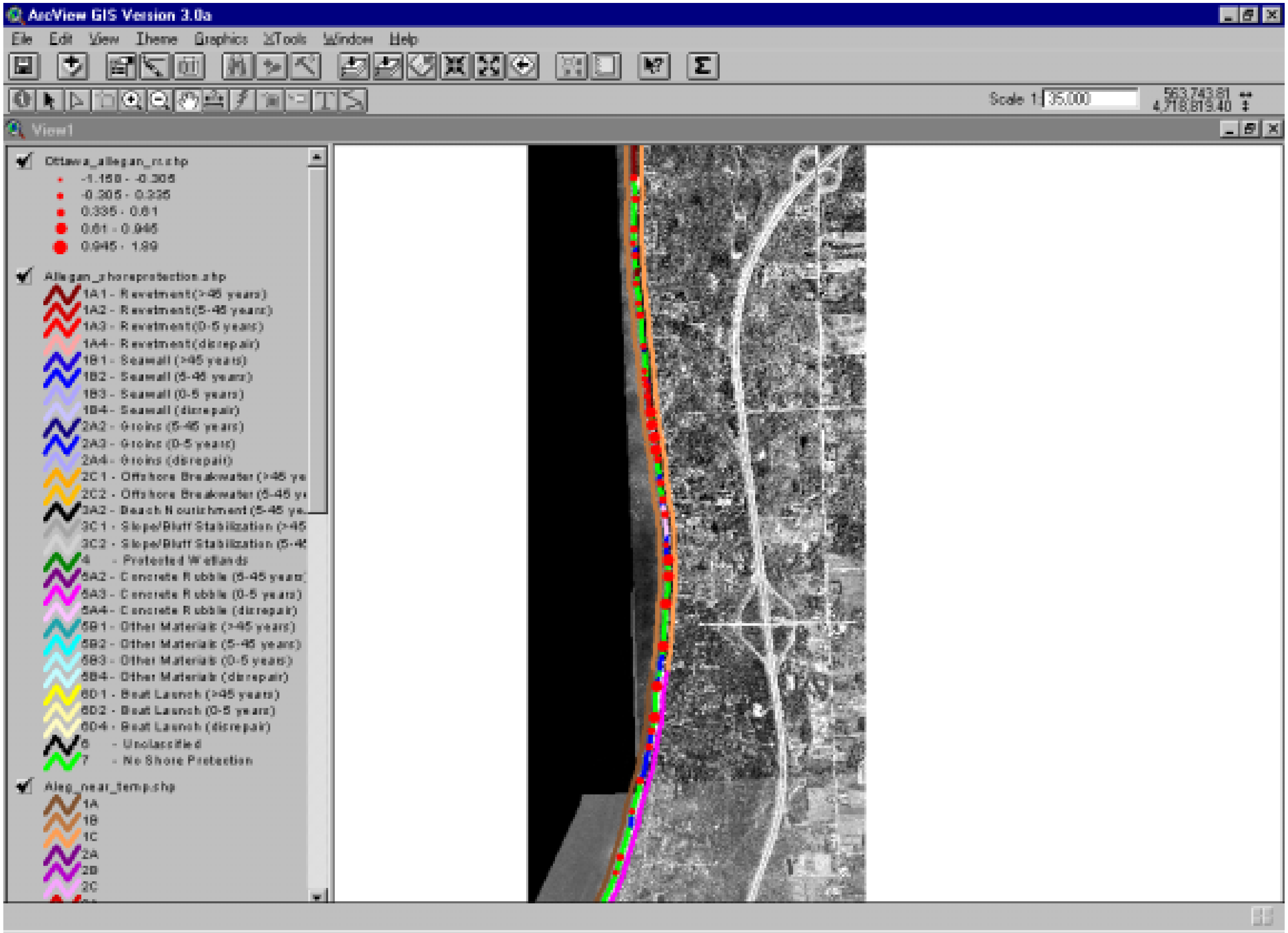
-0.305 - 0.335
0.335 - 0.61
0.61 - 0.945
0.945 - 1.89
Allegan_shoreprotection.shp
1A1 - Revetment(>45 years)
1A2 - Revetment(5-45 years)
1A3 - Revetment(0-5 years)
1A4 - Revetment(disrepair)
1B1 - Seawall (>45 years)
1B2 - Seawall (5-45 years)
1B3 - Seawall (0-5 years)
1B4 - Seawall (disrepair)
2A2 - Groins (5-45 years)
2A3 - Groins (0-5 years)
2A4 - Groins (disrepair)
2C1 - Offshore Breakwater (>45 ye
2C2 - Offshore Breakwater (5-45 y
3A2 - Beach Nourishment (5-45 ye
3C1 - Slope/Bluff Stabilization (>45
3C2 - Slope/Bluff Stabilization (5-4
4 - Protected Wetlands
5A2 - Concrete Rubble (5-45 years)
5A3 - Concrete Rubble (0-5 years)
5A4 - Concrete Rubble (disrepair)
5B1 - Other Materials (>45 years)
5B2 - Other Materials (5-45 years)
5B3 - Other Materials (0-5 years)
5B4 - Other Materials (disrepair)
6D1 - Boat Launch (>45 years)
6D2 - Boat Launch (0-5 years)
6D4 - Boat Launch (disrepair)
6 - Unclassified
7 - No Shore Protection
Aleg_near_temp.shp
1A
1B
1C
2A
2B
2C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Ottawa_allegan_rr.shp
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-0.305 - 0.335
0.335 - 0.61
0.61 - 0.945
0.945 - 1.99
Allegan_shoreprotection.shp
1A1 - Revetment(>45 years)
1A2 - Revetment(5-45 years)
1A3 - Revetment(0-5 years)
1A4 - Revetment(disrepair)
1B1 - Seawall (>45 years)
1B2 - Seawall (5-45 years)
1B3 - Seawall (0-5 years)
1B4 - Seawall (disrepair)
2A2 - Groins (5-45 years)
2A3 - Groins (0-5 years)
2A4 - Groins (disrepair)
2C1 - Offshore Breakwater (>45 ye
2C2 - Offshore Breakwater (5-45 y
3A2 - Beach Nourishment (5-45 ye
3C1 - Slope/Bluff Stabilization (>45
3C2 - Slope/Bluff Stabilization (5-4
4 - Protected Wetlands
5A2 - Concrete Rubble (5-45 years)
5A3 - Concrete Rubble (0-5 years)
5A4 - Concrete Rubble (disrepair)
5B1 - Other Materials (>45 years)
5B2 - Other Materials (5-45 years)
5B3 - Other Materials (0-5 years)
5B4 - Other Materials (disrepair)
6D1 - Boat Launch (>45 years)
6D2 - Boat Launch (0-5 years)
6D4 - Boat Launch (disrepair)
6 - Unclassified
7 - No Shore Protection
Aleg_near_temp.shp
1A
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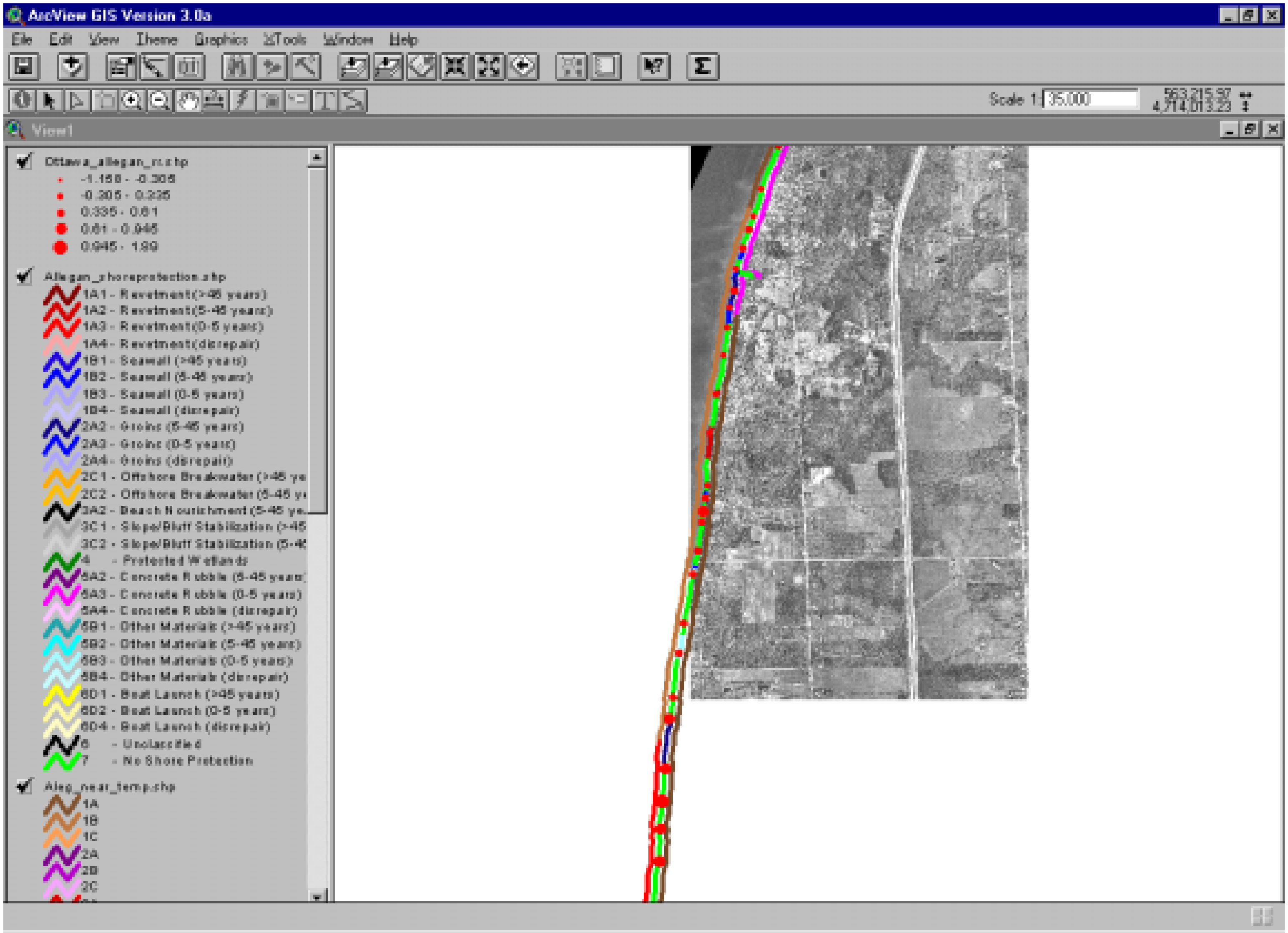
2B
2C



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0.335 - 0.61
0.61 - 0.945
0.945 - 1.89
Allegan_shoreprotection.shp
1A1 - Revetment(>45 years)
1A2 - Revetment(5-45 years)
1A3 - Revetment(0-5 years)
1A4 - Revetment(disrepair)
1B1 - Seawall (>45 years)
1B2 - Seawall (5-45 years)
1B3 - Seawall (0-5 years)
1B4 - Seawall (disrepair)
2A2 - Groins (5-45 years)
2A3 - Groins (0-5 years)
2A4 - Groins (disrepair)
2C1 - Offshore Breakwater (>45 ye
2C2 - Offshore Breakwater (5-45 ye
3A2 - Beach Nourishment (5-45 ye
3C1 - Slope/Bluff Stabilization (>45
3C2 - Slope/Bluff Stabilization (5-45
4 - Protected Wetlands
5A2 - Concrete Rubble (5-45 years)
5A3 - Concrete Rubble (0-5 years)
5A4 - Concrete Rubble (disrepair)
5B1 - Other Materials (>45 years)
5B2 - Other Materials (5-45 years)
5B3 - Other Materials (0-5 years)
5B4 - Other Materials (disrepair)
5D1 - Boat Launch (>45 years)
5D2 - Boat Launch (0-5 years)
5D4 - Boat Launch (disrepair)
6 - Unclassified
7 - No Shore Protection
Aleg_near_temp.shp
1A
1B
1C
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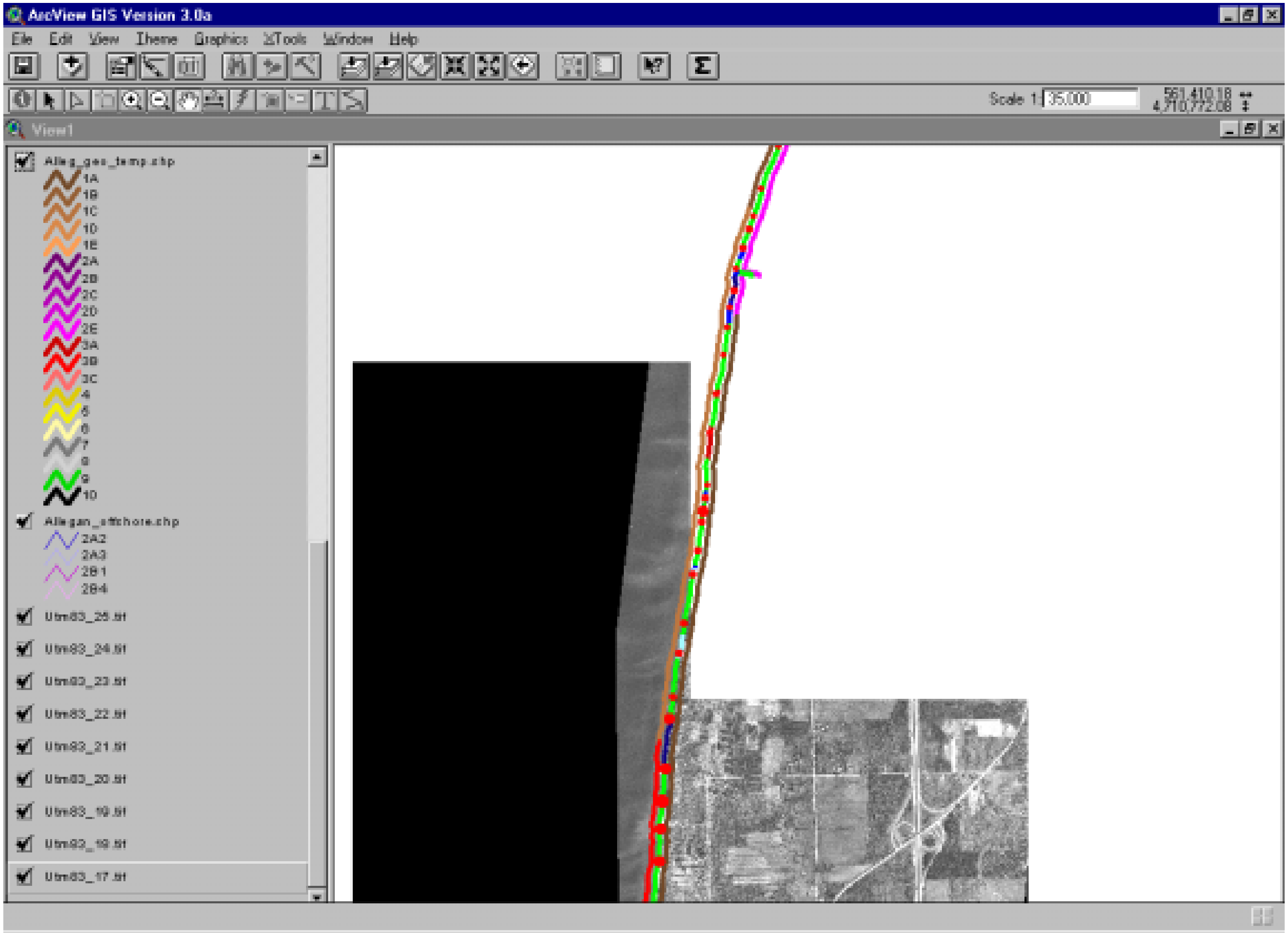
2C


ArcView GIS Version 3.0a
File
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XTools
Window
Help
View1
1A
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1E
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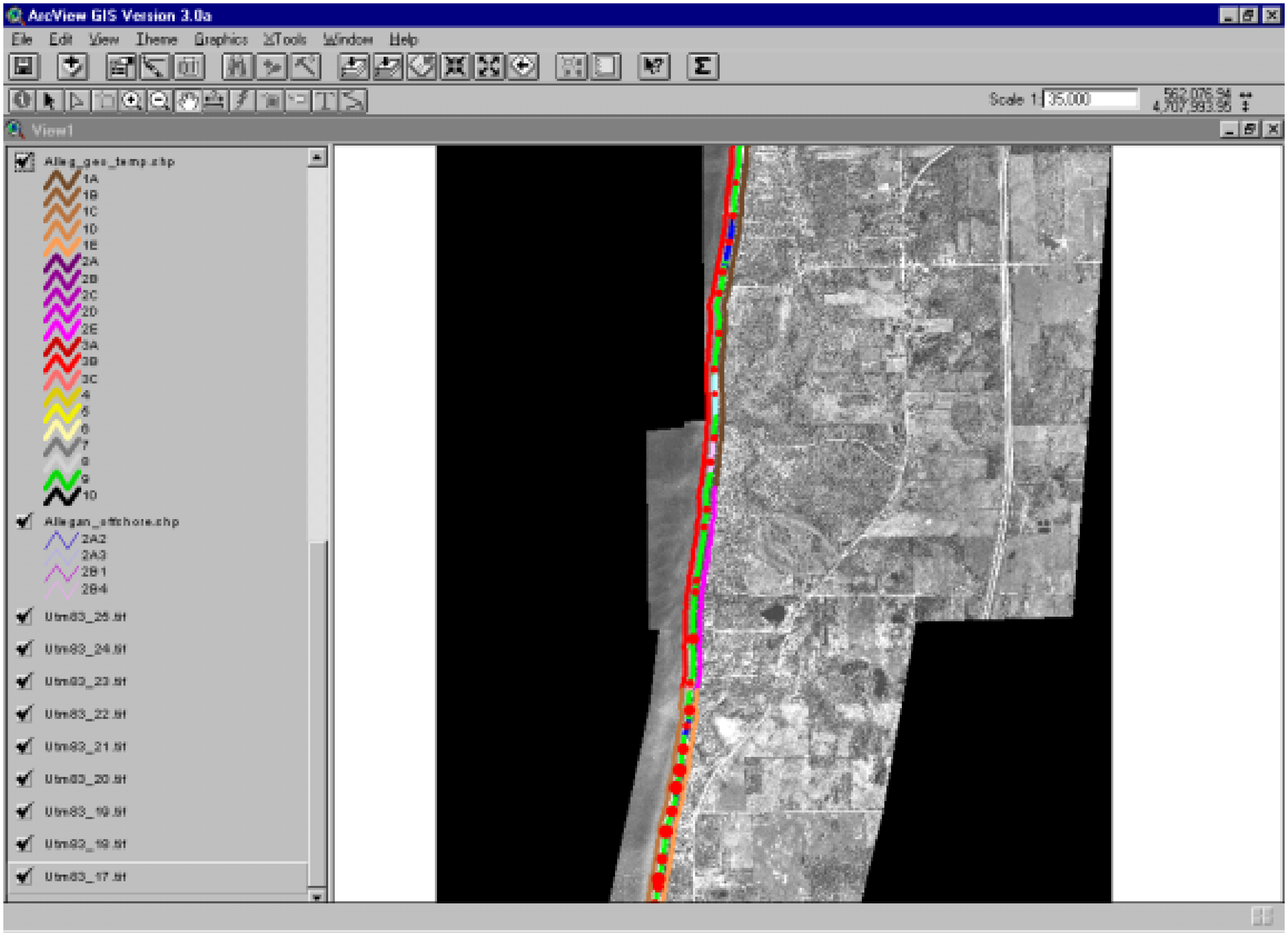
ArcView GIS Version 3.0a
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View1
Alleg_ges_temp.shp
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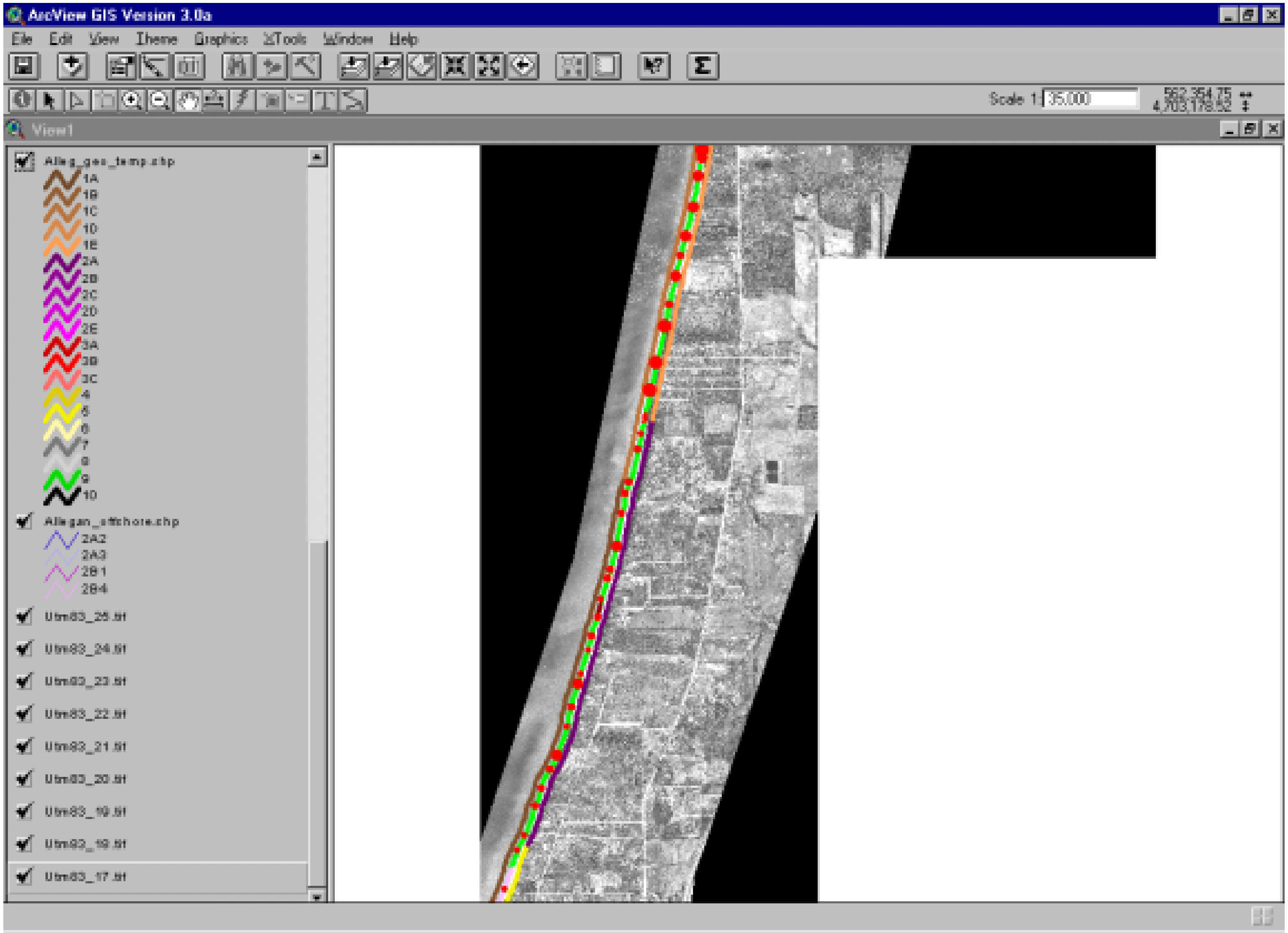
Allegan_offshore.shp
2A2
2A3
2B1
2B4
Utm83_25.tif
Utm83_24.tif
Utm83_23.tif
Utm83_22.tif
Utm83_21.tif
Utm83_20.tif
Utm83_19.tif
Utm83_18.tif
Utm83_17.tif


ArcView GIS Version 3.0a
File Edit View Theme Graphics XTools Window Help
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View1
Alleg_geo_temp.shp
1A
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1E
2A
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2E
3A
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Allegan_offshore.shp
2A2
2A3
2B1
2B4
Utm83_25.sif
Utm83_24.sif
Utm83_23.sif
Utm83_22.sif
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Utm83_20.sif
Utm83_19.sif
Utm83_18.sif
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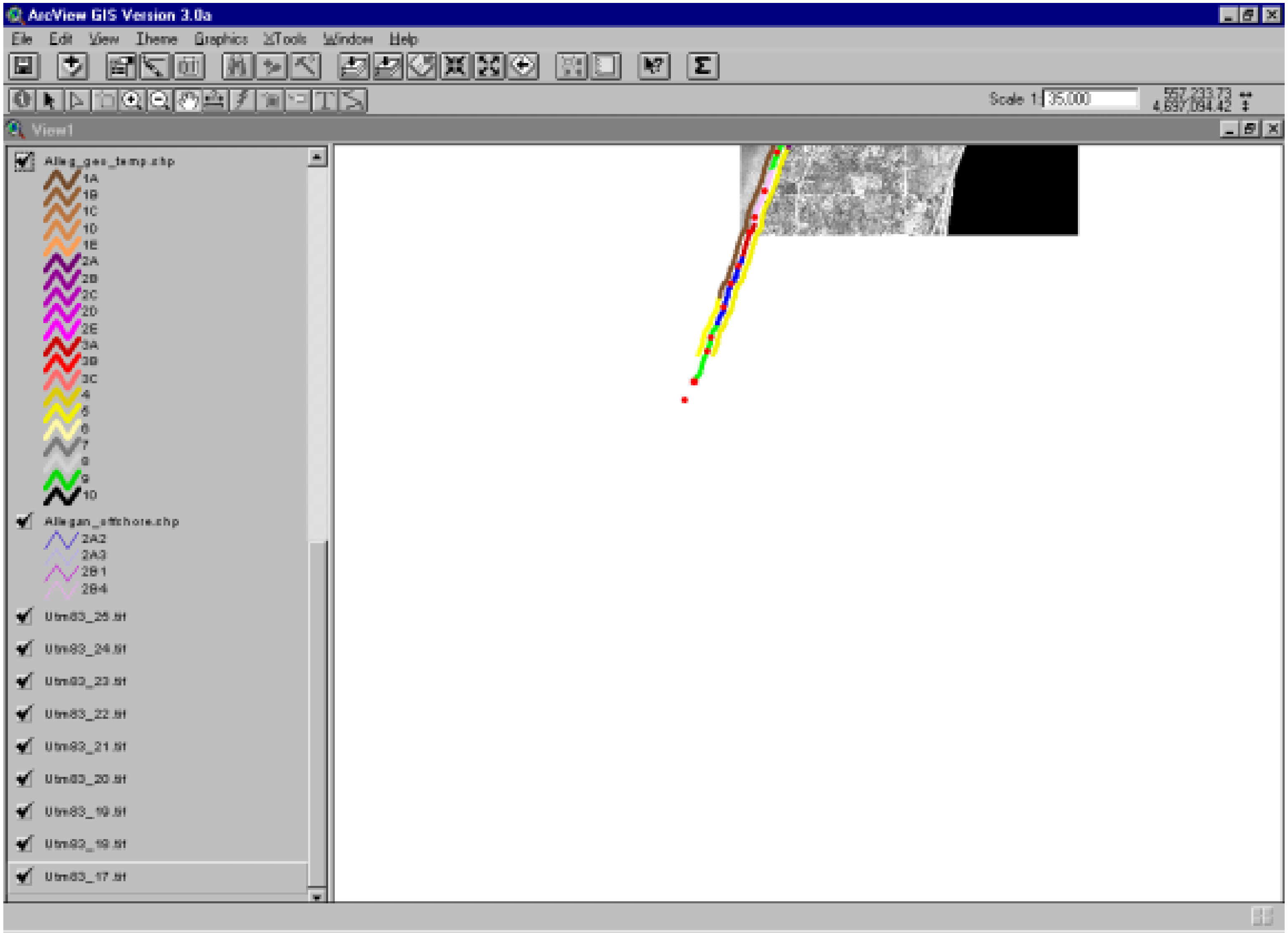
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Alleg_geo_temp.shp
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Allegan_offshore.shp
2A2
2A3
2B1
2B4
Utm83_25.tif
Utm83_24.tif
Utm83_23.tif
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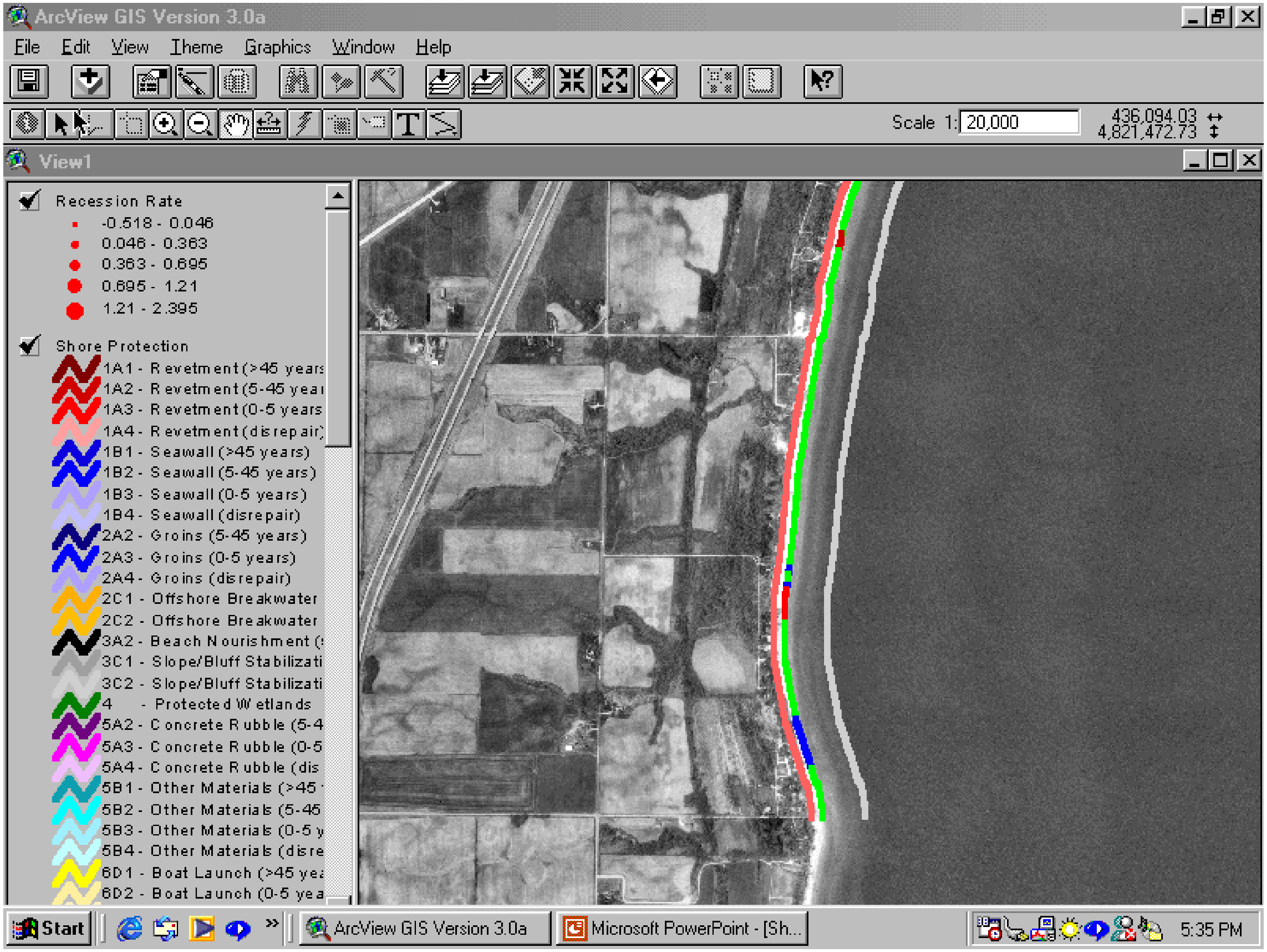
Utm83_17.tif

OZAUKEE COUNTY, WISCONSIN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4,821,472.73
View1
Recession Rate
-0.518 - 0.046
0.046 - 0.363
0.363 - 0.695
0.695 - 1.21
1.21 - 2.395
Shore Protection
1A1 - Revetment (>45 years
1A2 - Revetment (5-45 year
1A3 - Revetment (0-5 years
1A4 - Revetment (disrepair)
1B1 - Seawall (>45 years)
1B2 - Seawall (5-45 years)
1B3 - Seawall (0-5 years)
1B4 - Seawall (disrepair)
2A2 - Groins (5-45 years)
2A3 - Groins (0-5 years)
2A4 - Groins (disrepair)
2C1 - Offshore Breakwater
2C2 - Offshore Breakwater
3A2 - Beach Nourishment (
3C1 - Slope/Bluff Stabilizati
3C2 - Slope/Bluff Stabilizati
4 - Protected Wetlands
5A2 - Concrete Rubble (5-4
5A3 - Concrete Rubble (0-5
5A4 - Concrete Rubble (dis
5B1 - Other Materials (>45
5B2 - Other Materials (5-45
5B3 - Other Materials (0-5 y
5B4 - Other Materials (disre
6D1 - Boat Launch (>45 yea
6D2 - Boat Launch (0-5 yea
Start
ArcView GIS Version 3.0a
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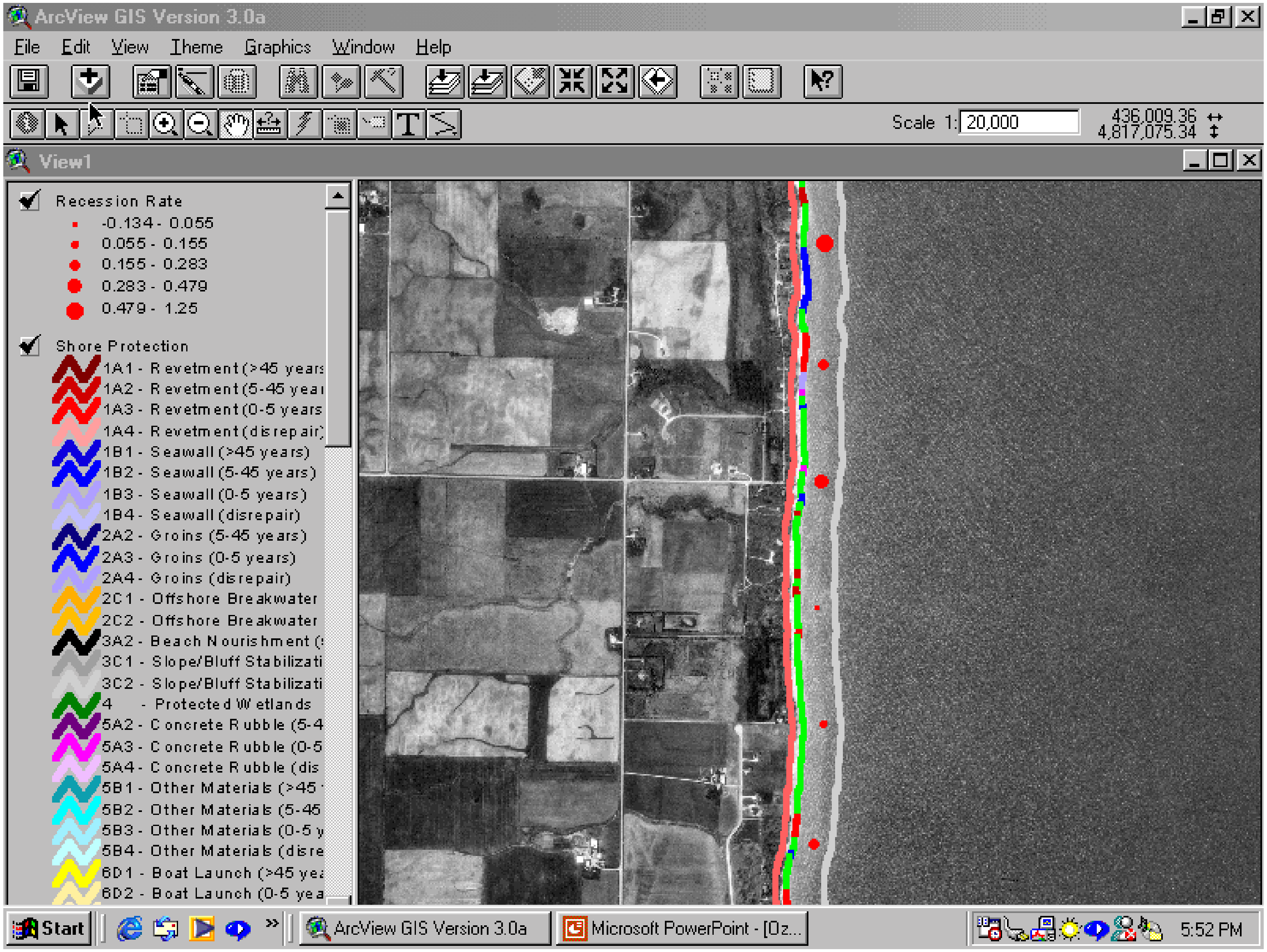
5:35 PM



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0.479 - 1.25
Shore Protection
1A1 - Revetment (>45 years
1A2 - Revetment (5-45 year
1A3 - Revetment (0-5 years
1A4 - Revetment (disrepair)
1B1 - Seawall (>45 years)
1B2 - Seawall (5-45 years)
1B3 - Seawall (0-5 years)
1B4 - Seawall (disrepair)
2A2 - Groins (5-45 years)
2A3 - Groins (0-5 years)
2A4 - Groins (disrepair)
2C1 - Offshore Breakwater
2C2 - Offshore Breakwater
3A2 - Beach Nourishment (
3C1 - Slope/Bluff Stabilizati
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4 - Protected Wetlands
5A2 - Concrete Rubble (5-4
5A3 - Concrete Rubble (0-5
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5B1 - Other Materials (>45
5B2 - Other Materials (5-45
5B3 - Other Materials (0-5 y
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6D1 - Boat Launch (>45 yea
6D2 - Boat Launch (0-5 yea
Start
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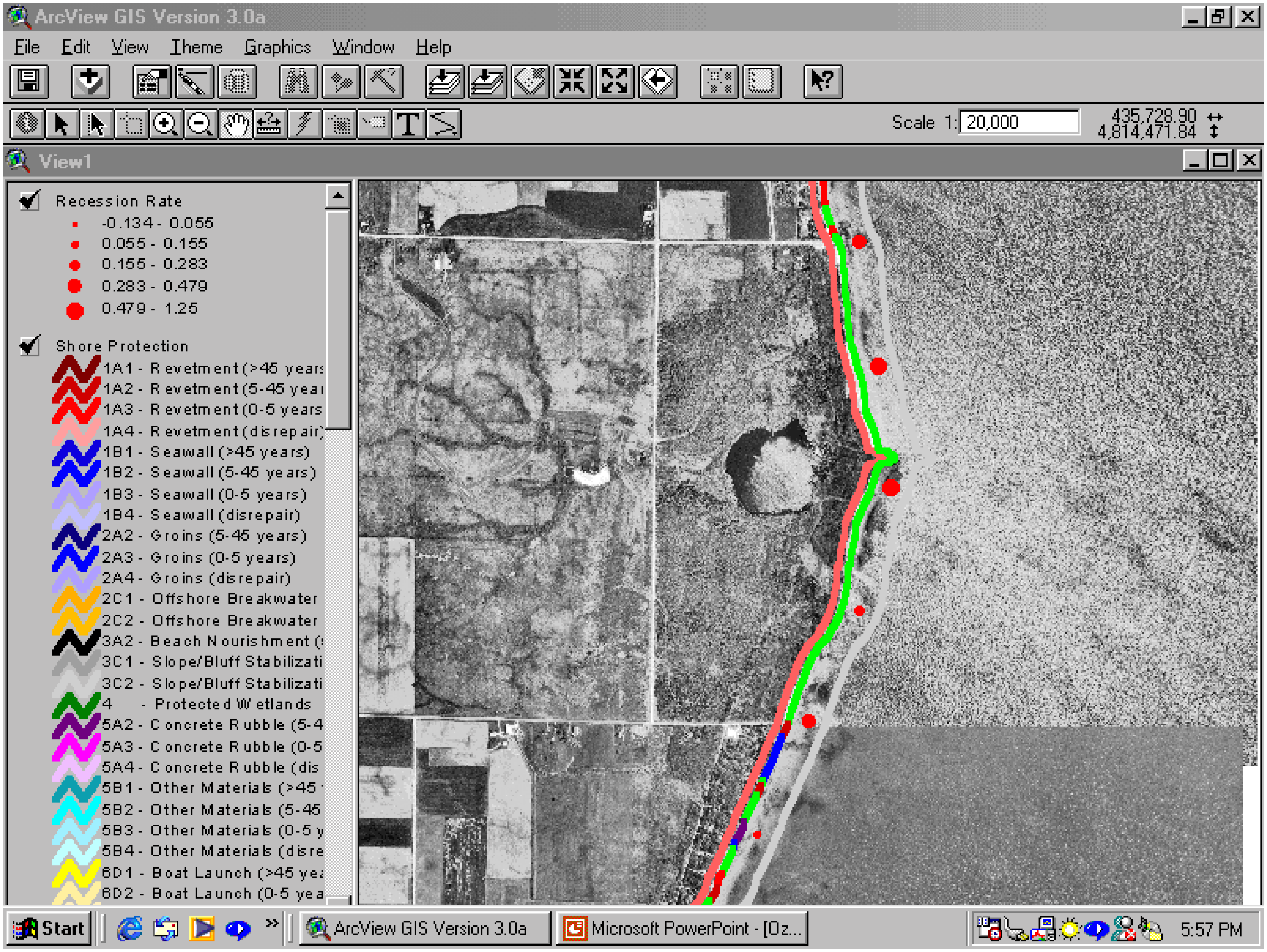
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1A2 - Revetment (5-45 year
1A3 - Revetment (0-5 years
1A4 - Revetment (disrepair)
1B1 - Seawall (>45 years)
1B2 - Seawall (5-45 years)
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1B4 - Seawall (disrepair)
2A2 - Groins (5-45 years)
2A3 - Groins (0-5 years)
2A4 - Groins (disrepair)
2C1 - Offshore Breakwater
2C2 - Offshore Breakwater
3A2 - Beach Nourishment (
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3C2 - Slope/Bluff Stabilizati
4 - Protected Wetlands
5A2 - Concrete Rubble (5-4
5A3 - Concrete Rubble (0-5
5A4 - Concrete Rubble (dis
5B1 - Other Materials (>45
5B2 - Other Materials (5-45
5B3 - Other Materials (0-5 y
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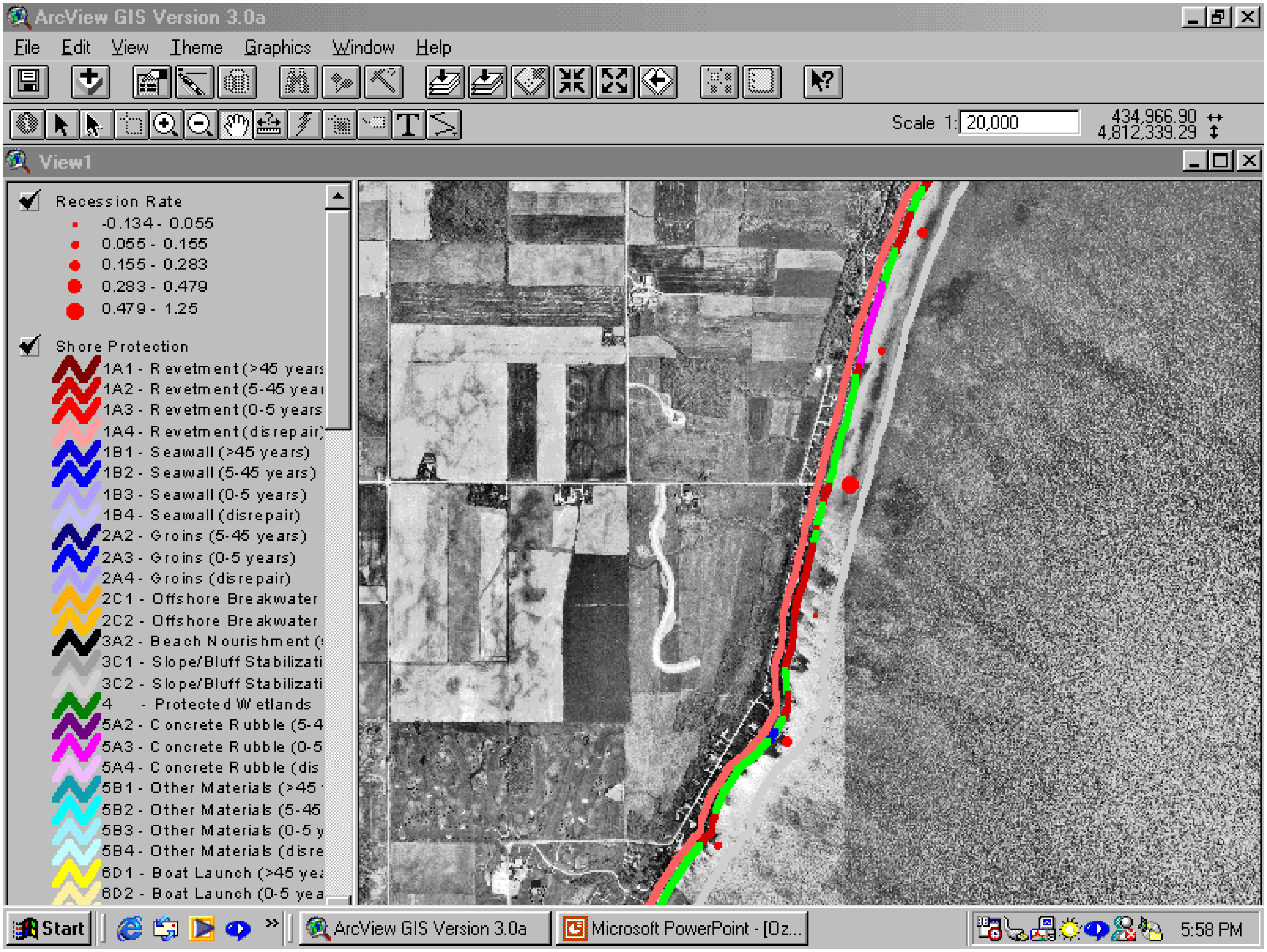
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1A3 - Revetment (0-5 years
1A4 - Revetment (disrepair)
1B1 - Seawall (>45 years)
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1B3 - Seawall (0-5 years)
1B4 - Seawall (disrepair)
2A2 - Groins (5-45 years)
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2A4 - Groins (disrepair)
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3A2 - Beach Nourishment (
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4 - Protected Wetlands
5A2 - Concrete Rubble (5-4
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5A4 - Concrete Rubble (dis
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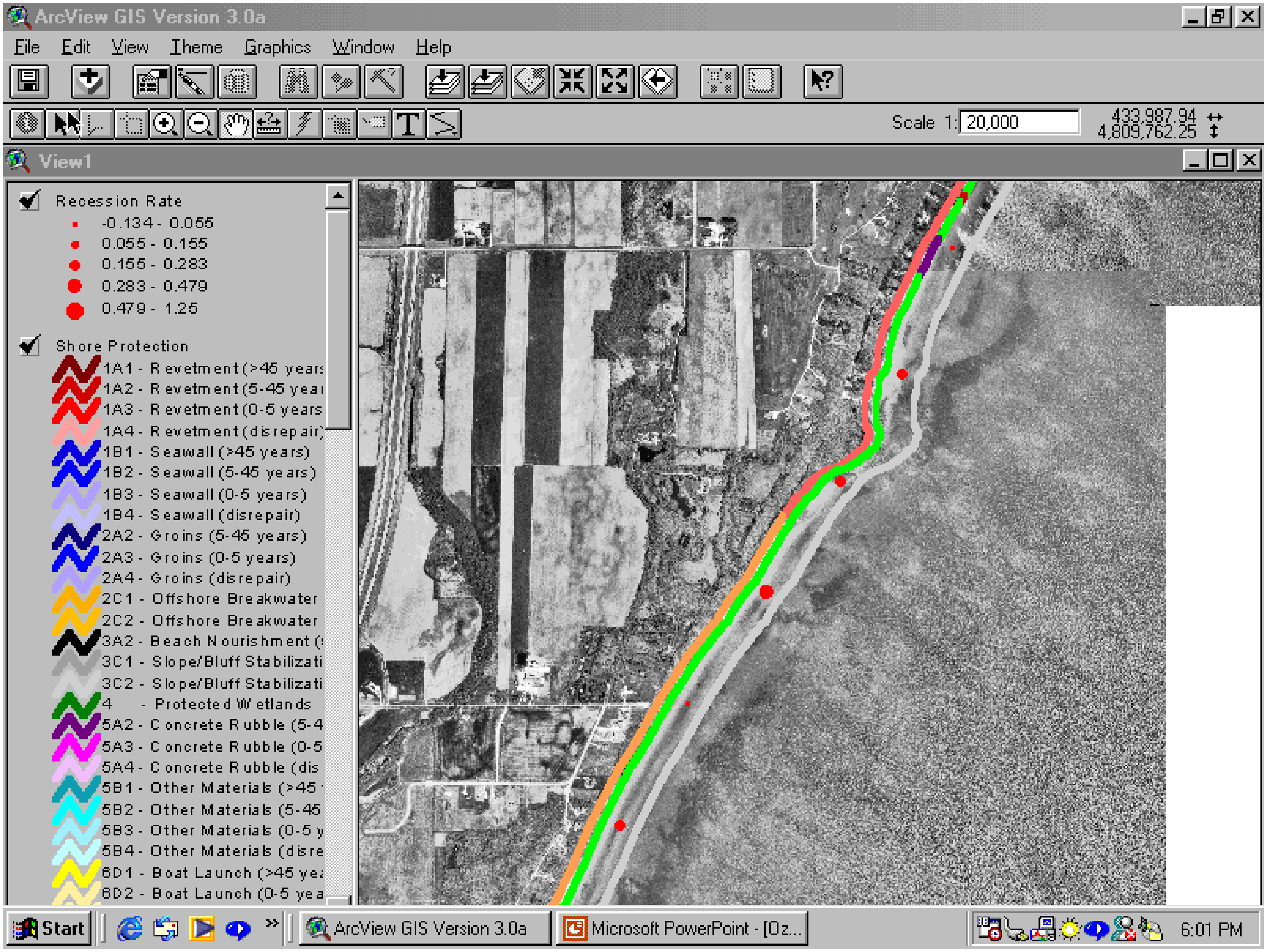
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1A4 - Revetment (disrepair)
1B1 - Seawall (>45 years)
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1B4 - Seawall (disrepair)
2A2 - Groins (5-45 years)
2A3 - Groins (0-5 years)
2A4 - Groins (disrepair)
2C1 - Offshore Breakwater
2C2 - Offshore Breakwater
3A2 - Beach Nourishment (
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3C2 - Slope/Bluff Stabilizati
4 - Protected Wetlands
5A2 - Concrete Rubble (5-4
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5A4 - Concrete Rubble (dis
5B1 - Other Materials (>45
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Shore Protection
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1A3 - Revetment (0-5 years
1A4 - Revetment (disrepair)
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1B4 - Seawall (disrepair)
2A2 - Groins (5-45 years)
2A3 - Groins (0-5 years)
2A4 - Groins (disrepair)
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3A2 - Beach Nourishment (
3C1 - Slope/Bluff Stabilizati
3C2 - Slope/Bluff Stabilizati
4 - Protected Wetlands
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5A4 - Concrete Rubble (dis
5B1 - Other Materials (>45
5B2 - Other Materials (5-45
5B3 - Other Materials (0-5 y
5B4 - Other Materials (disre
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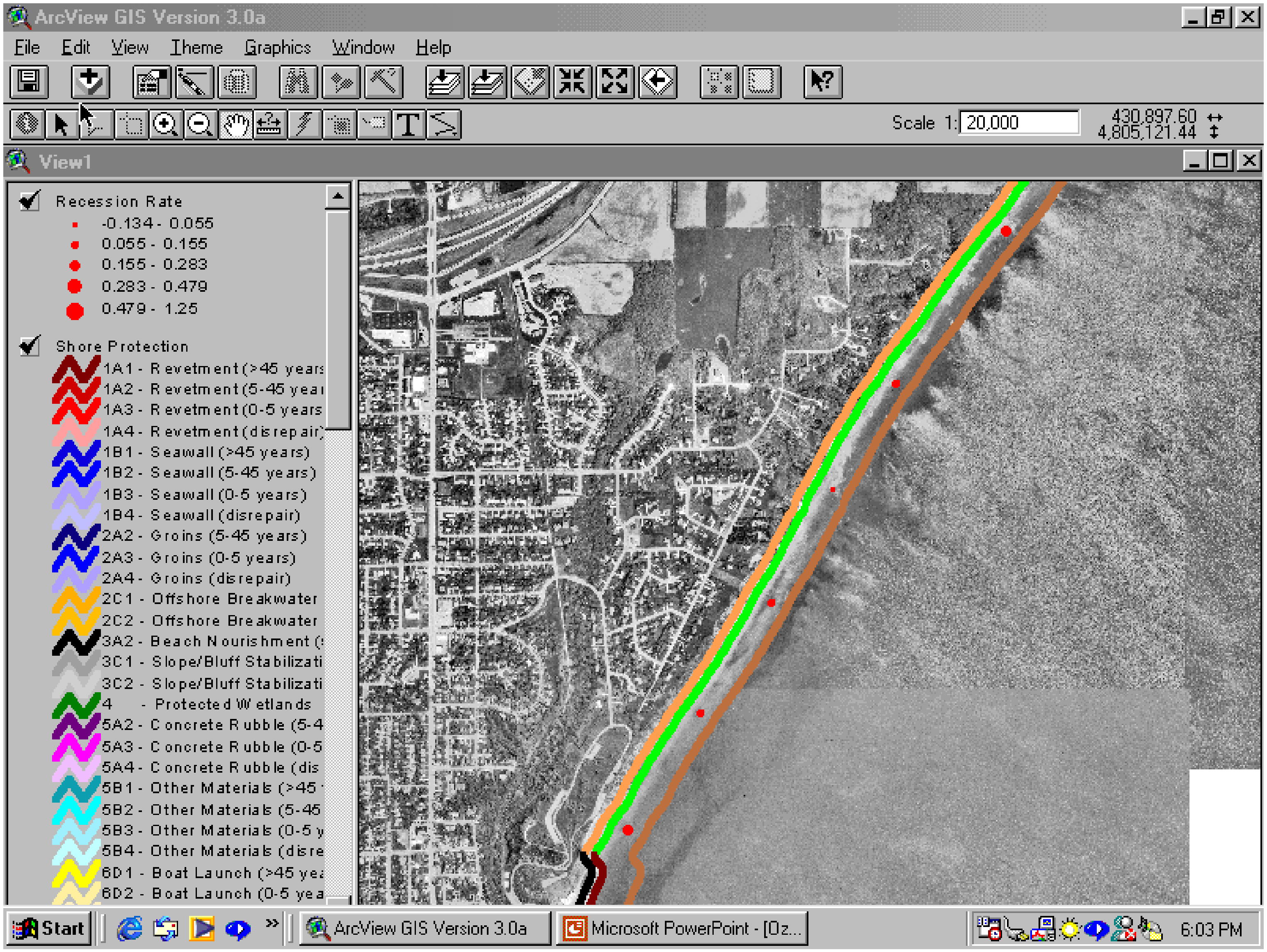
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Shore Protection
1A1 - Revetment (>45 years
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1A4 - Revetment (disrepair)
1B1 - Seawall (>45 years)
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1B4 - Seawall (disrepair)
2A2 - Groins (5-45 years)
2A3 - Groins (0-5 years)
2A4 - Groins (disrepair)
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3A2 - Beach Nourishment (
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4 - Protected Wetlands
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5A4 - Concrete Rubble (dis
5B1 - Other Materials (>45
5B2 - Other Materials (5-45
5B3 - Other Materials (0-5 y
5B4 - Other Materials (disre
6D1 - Boat Launch (>45 yea
6D2 - Boat Launch (0-5 yea
Start
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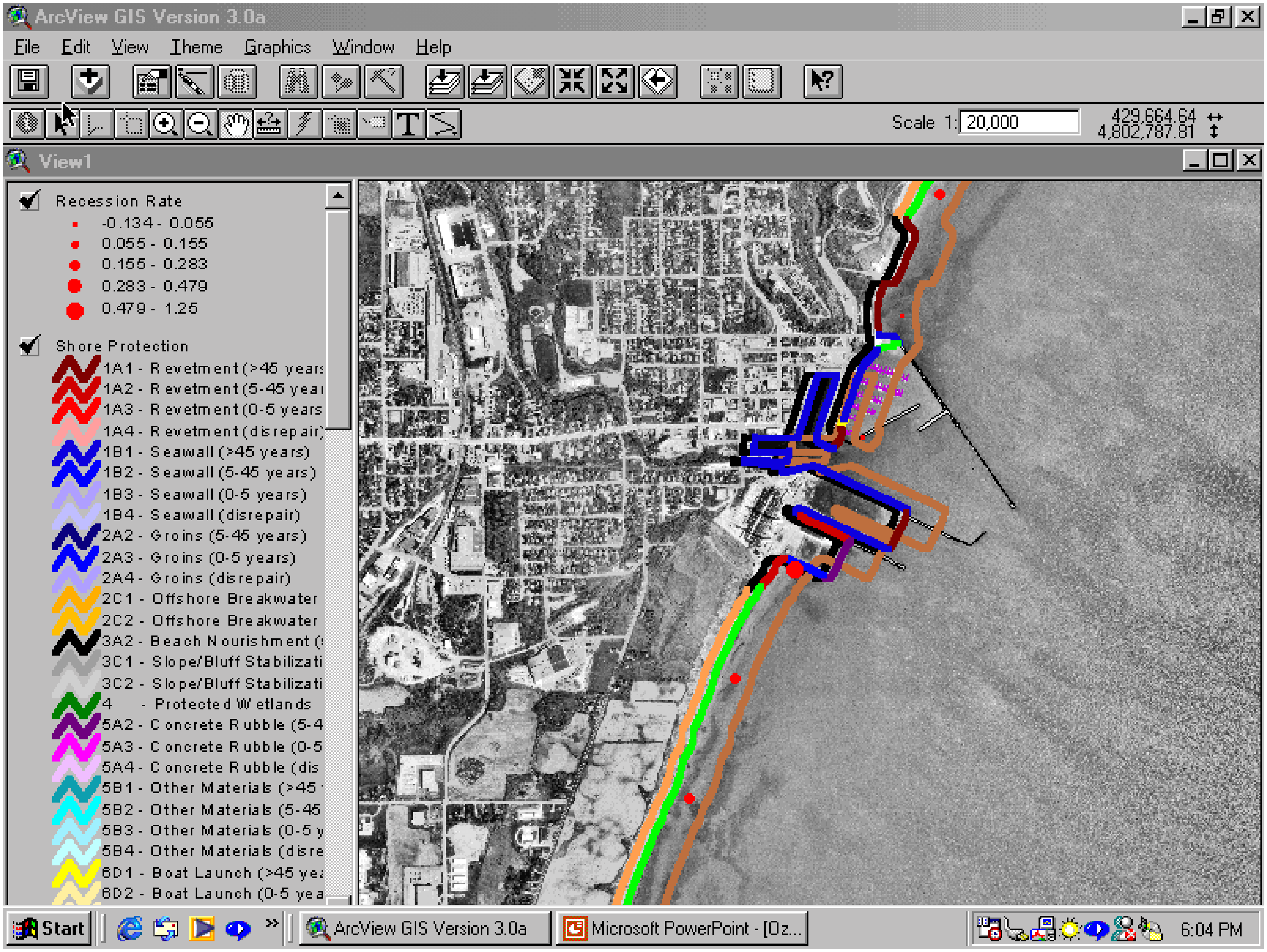
6:03 PM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Shore Protection
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1B4 - Seawall (disrepair)
2A2 - Groins (5-45 years)
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2A4 - Groins (disrepair)
2C1 - Offshore Breakwater
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3A2 - Beach Nourishment (
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3C2 - Slope/Bluff Stabilizati
4 - Protected Wetlands
5A2 - Concrete Rubble (5-4
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5A4 - Concrete Rubble (dis
5B1 - Other Materials (>45
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5B3 - Other Materials (0-5 y
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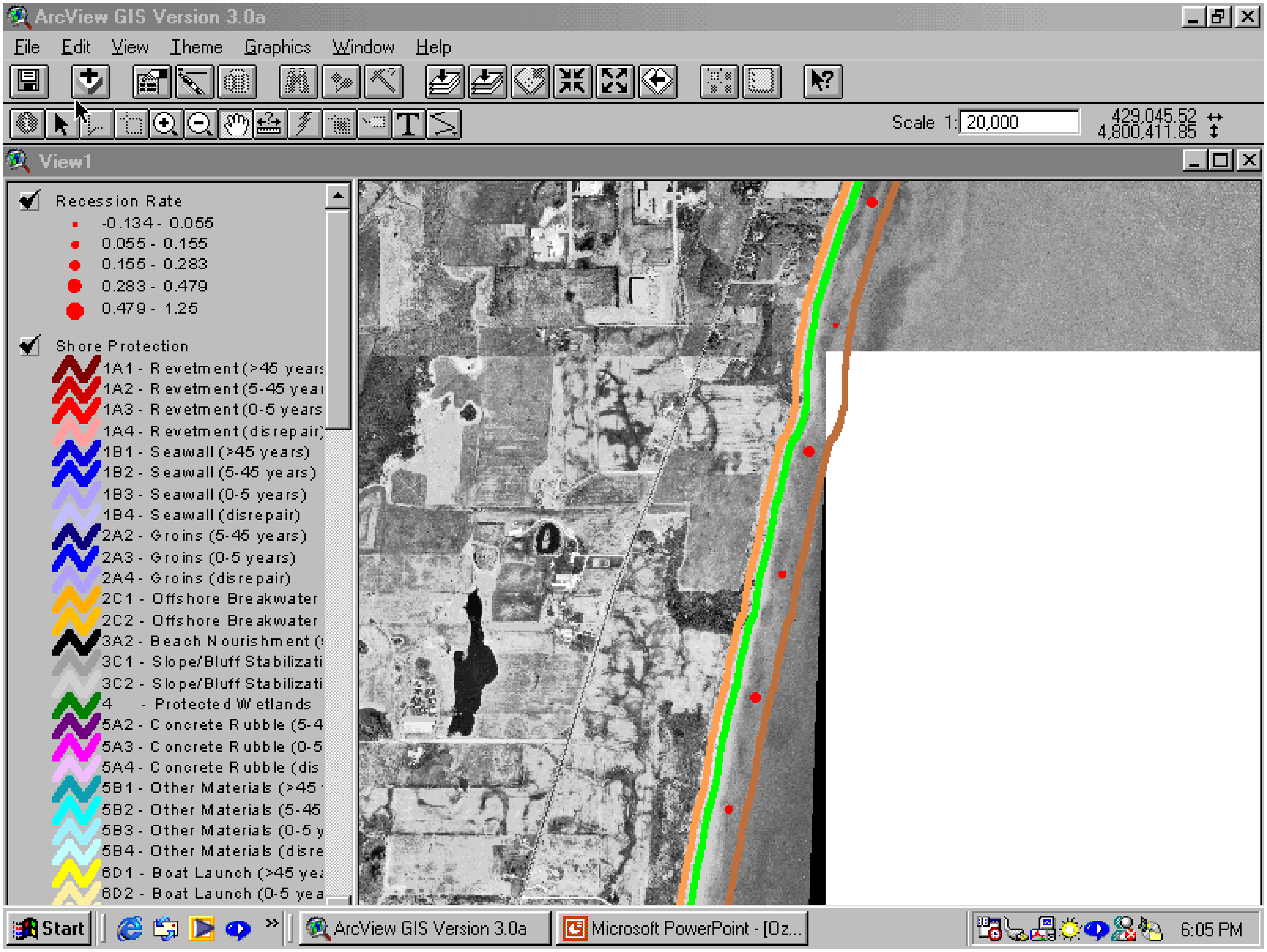
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Shore Protection
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1A3 - Revetment (0-5 years
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1B1 - Seawall (>45 years)
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1B4 - Seawall (disrepair)
2A2 - Groins (5-45 years)
2A3 - Groins (0-5 years)
2A4 - Groins (disrepair)
2C1 - Offshore Breakwater
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3A2 - Beach Nourishment (
3C1 - Slope/Bluff Stabilizati
3C2 - Slope/Bluff Stabilizati
4 - Protected Wetlands
5A2 - Concrete Rubble (5-4
5A3 - Concrete Rubble (0-5
5A4 - Concrete Rubble (dis
5B1 - Other Materials (>45
5B2 - Other Materials (5-45
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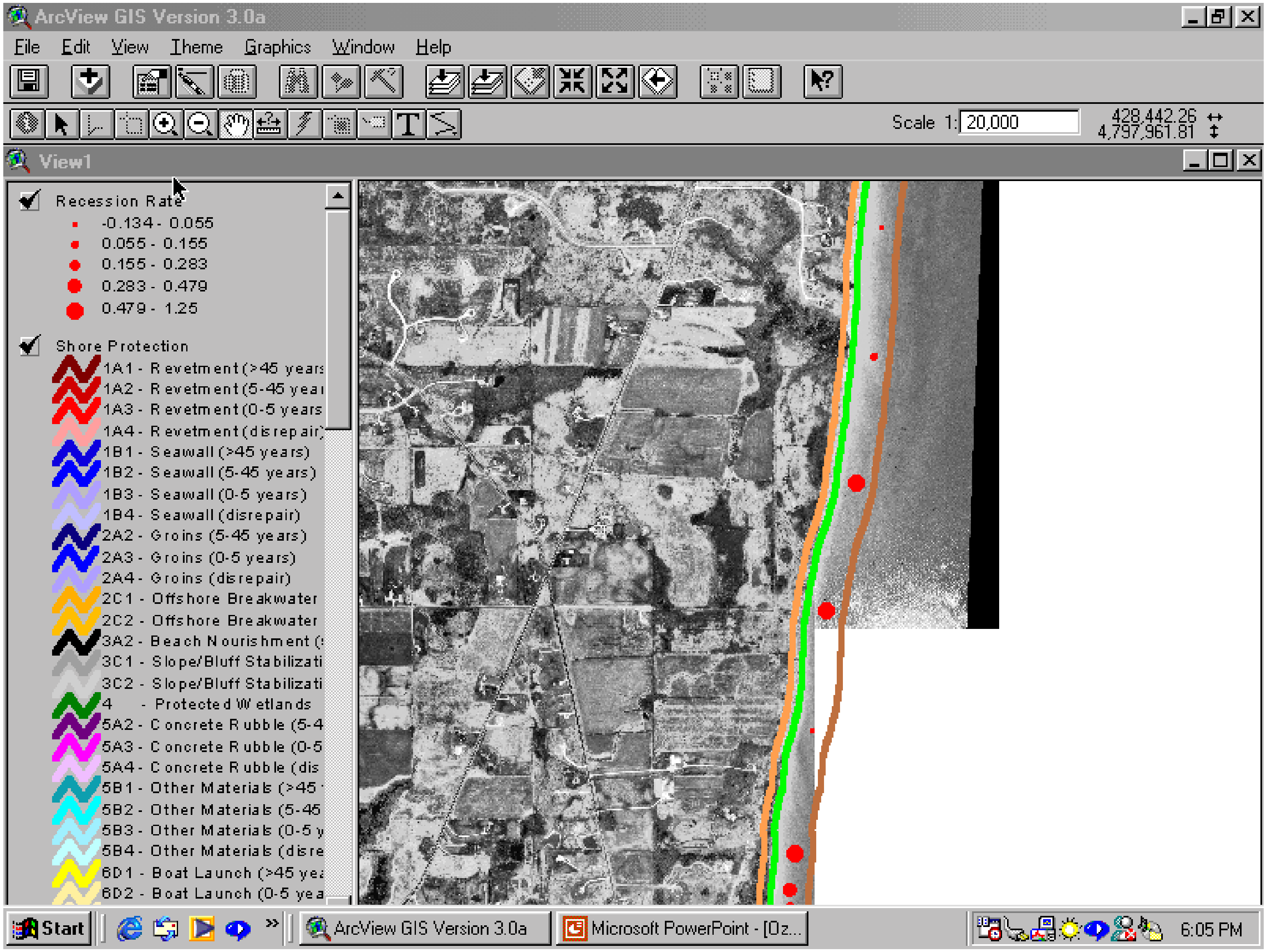
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Shore Protection
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1A3 - Revetment (0-5 years
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1B4 - Seawall (disrepair)
2A2 - Groins (5-45 years)
2A3 - Groins (0-5 years)
2A4 - Groins (disrepair)
2C1 - Offshore Breakwater
2C2 - Offshore Breakwater
3A2 - Beach Nourishment (
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4 - Protected Wetlands
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5B1 - Other Materials (>45
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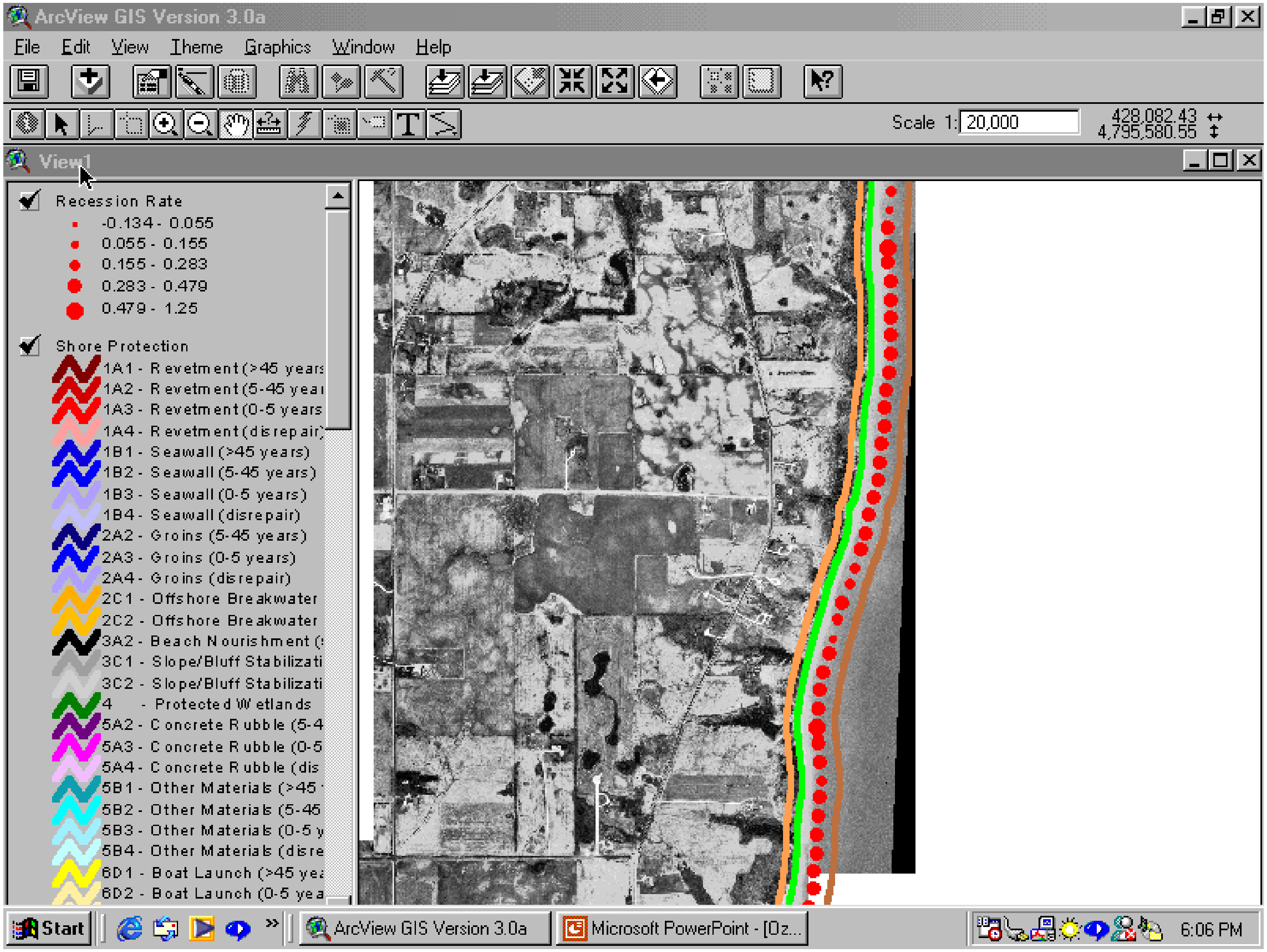
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Shore Protection
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1B4 - Seawall (disrepair)
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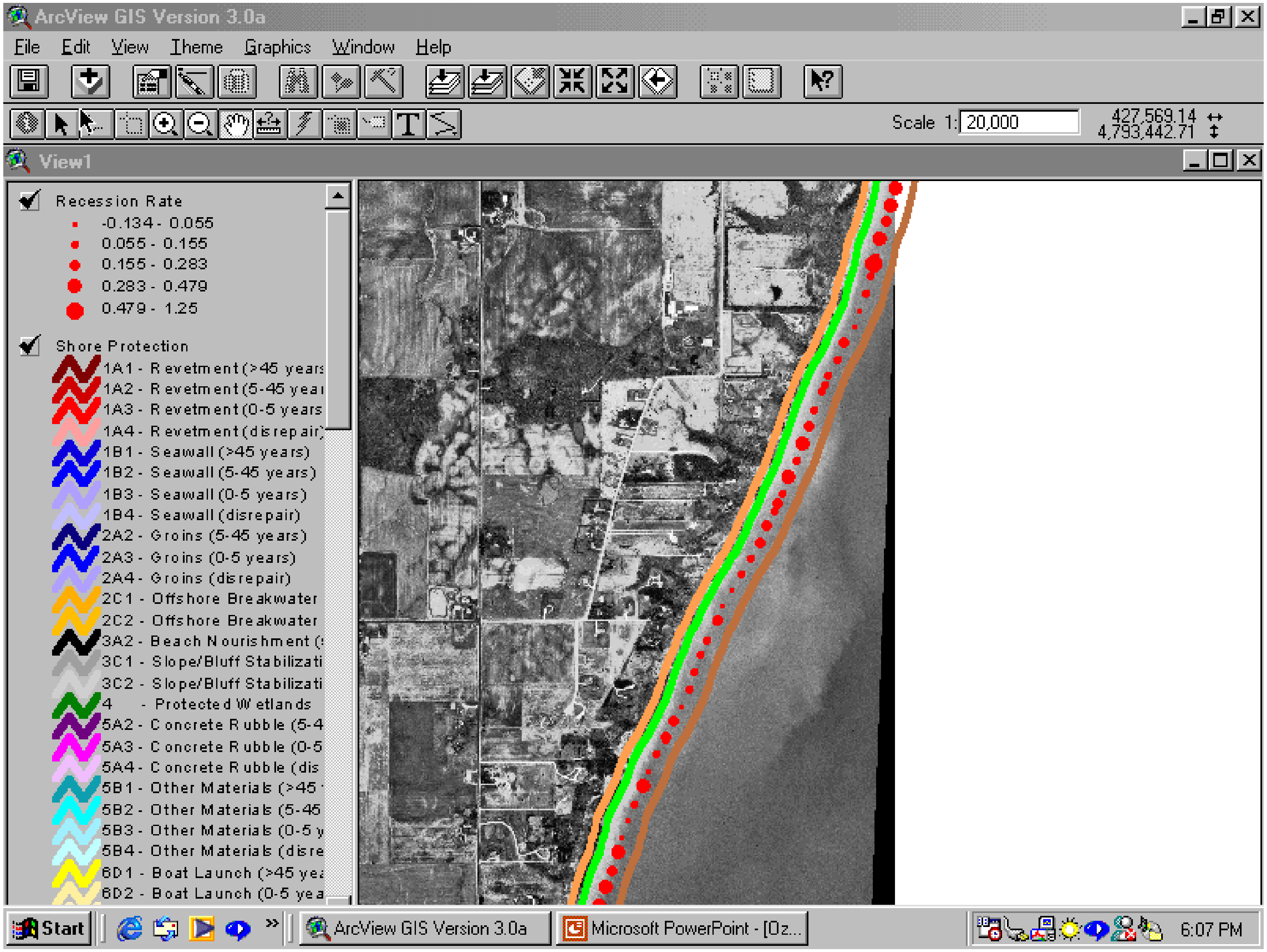
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Shore Protection
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2A4 - Groins (disrepair)
2C1 - Offshore Breakwater
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3A2 - Beach Nourishment (
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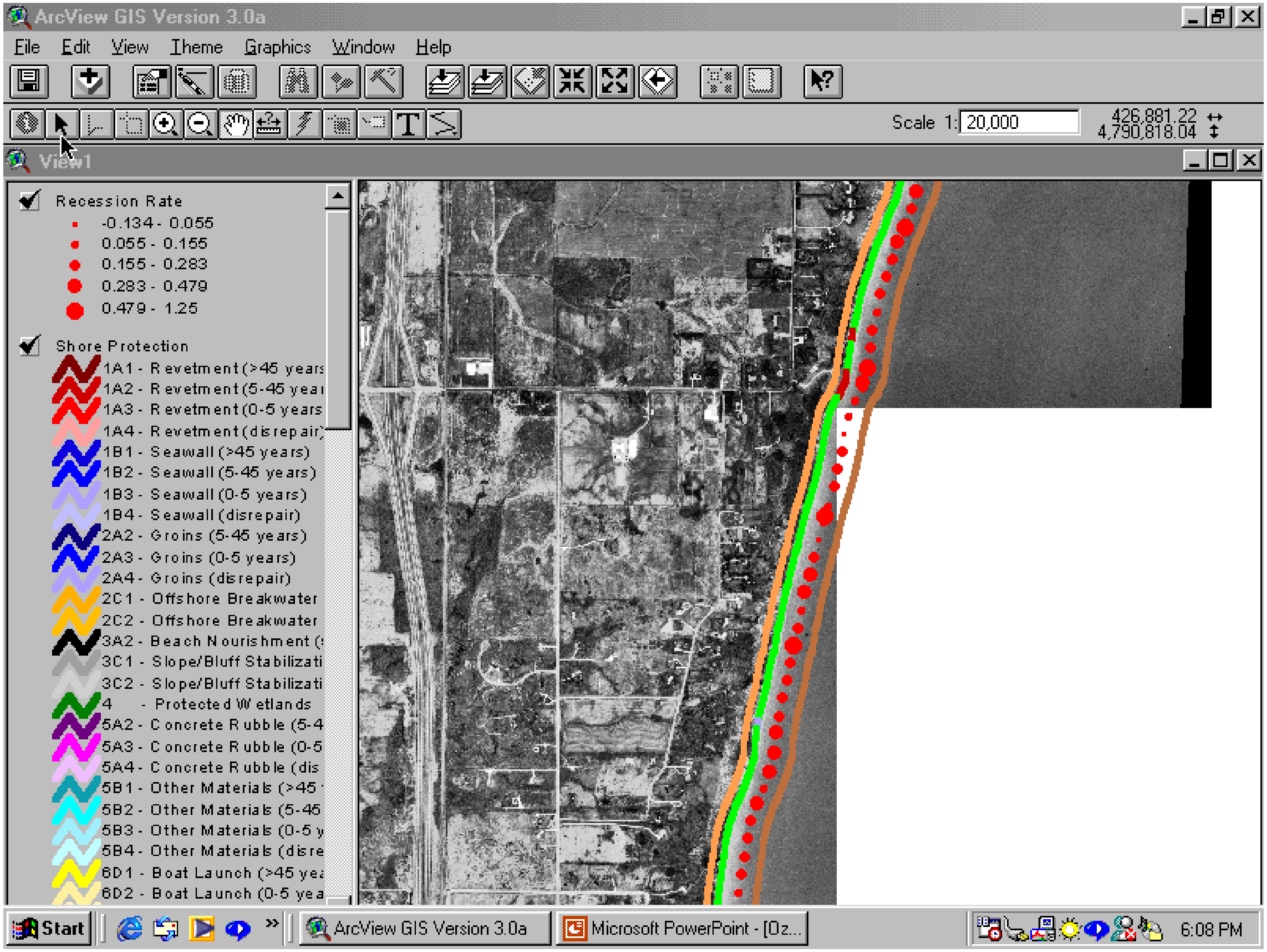
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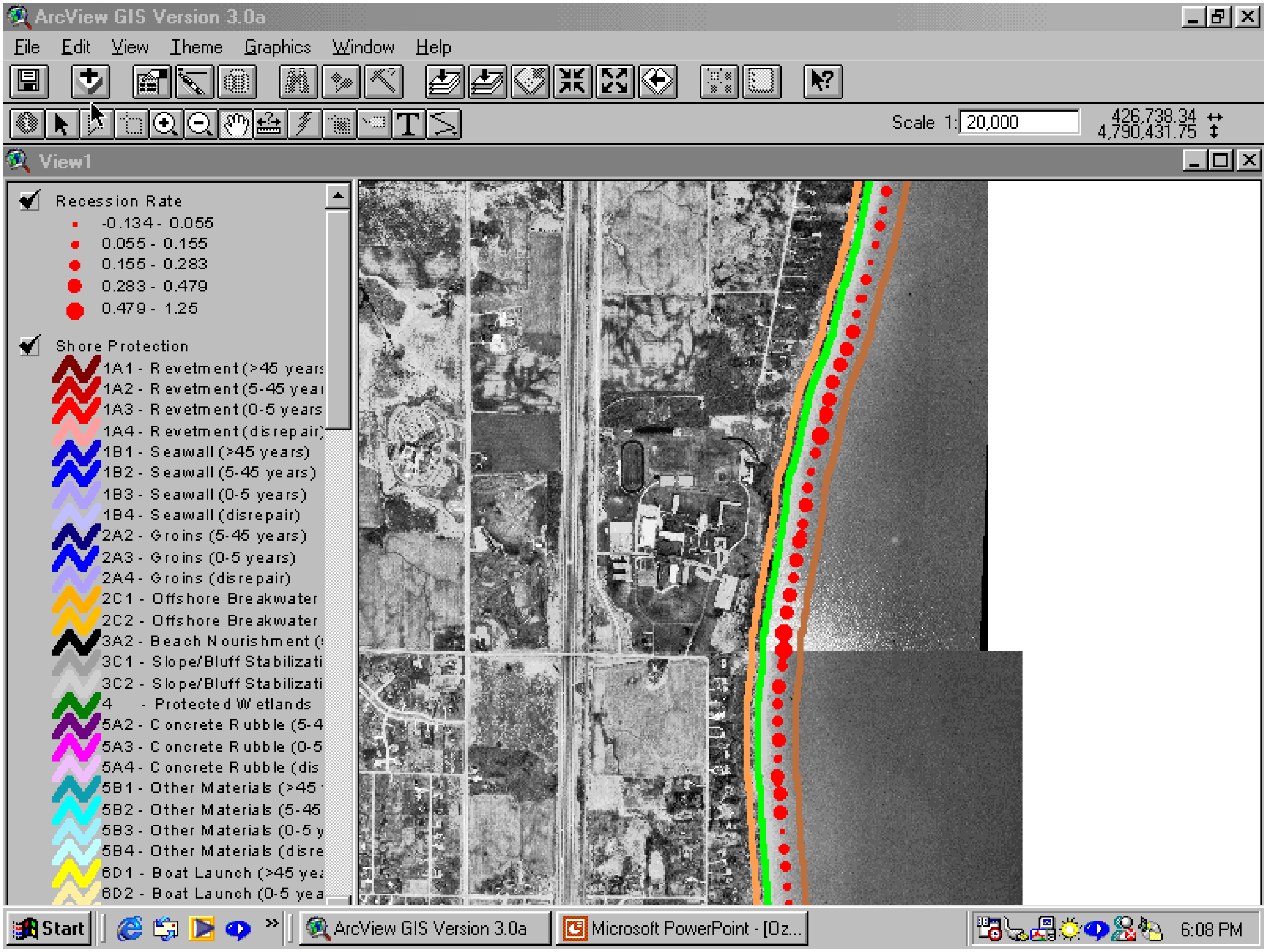
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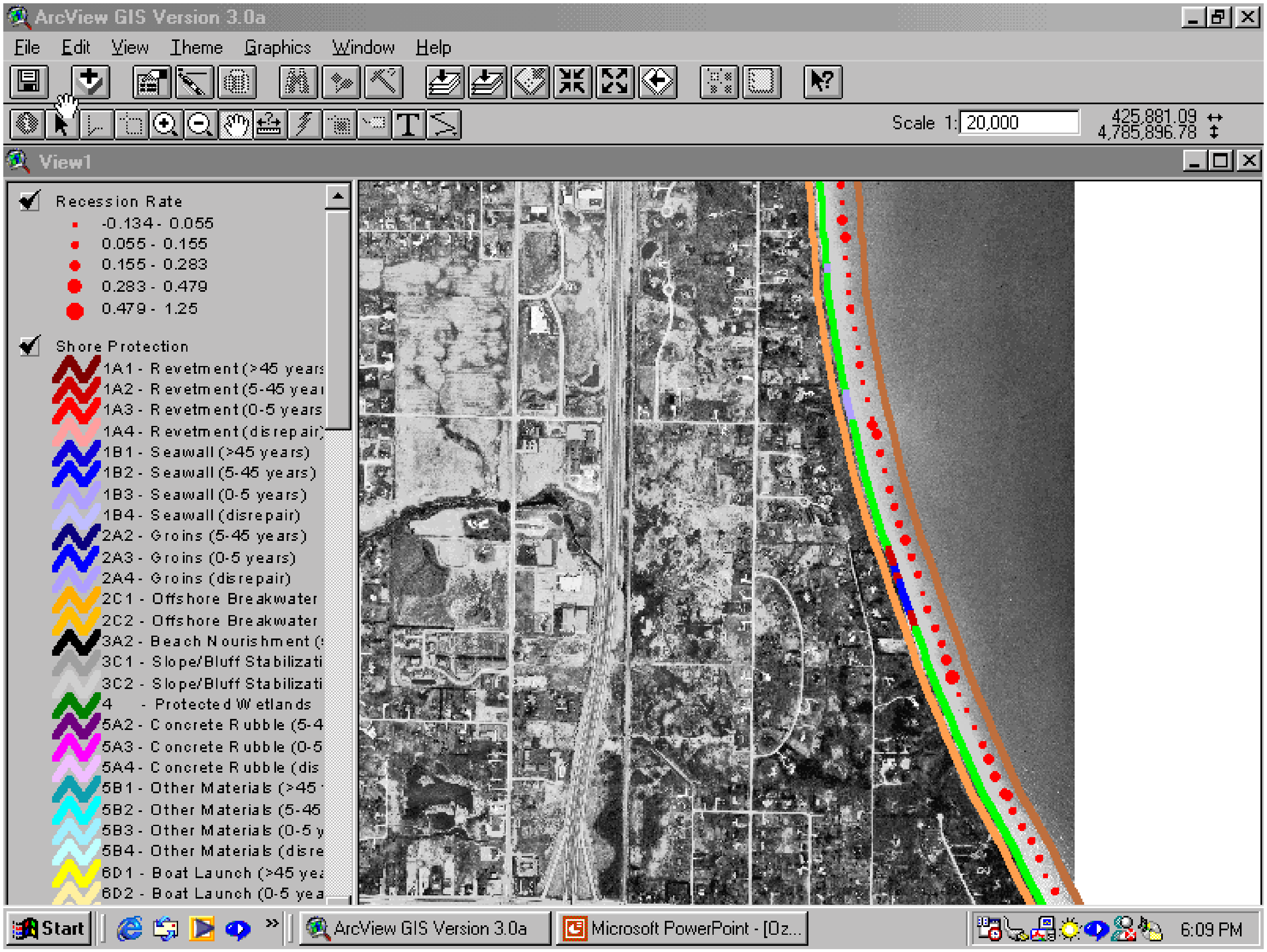
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1A3 - Revetment (0-5 years
1A4 - Revetment (disrepair)
1B1 - Seawall (>45 years)
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1B3 - Seawall (0-5 years)
1B4 - Seawall (disrepair)
2A2 - Groins (5-45 years)
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2A4 - Groins (disrepair)
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3A2 - Beach Nourishment (
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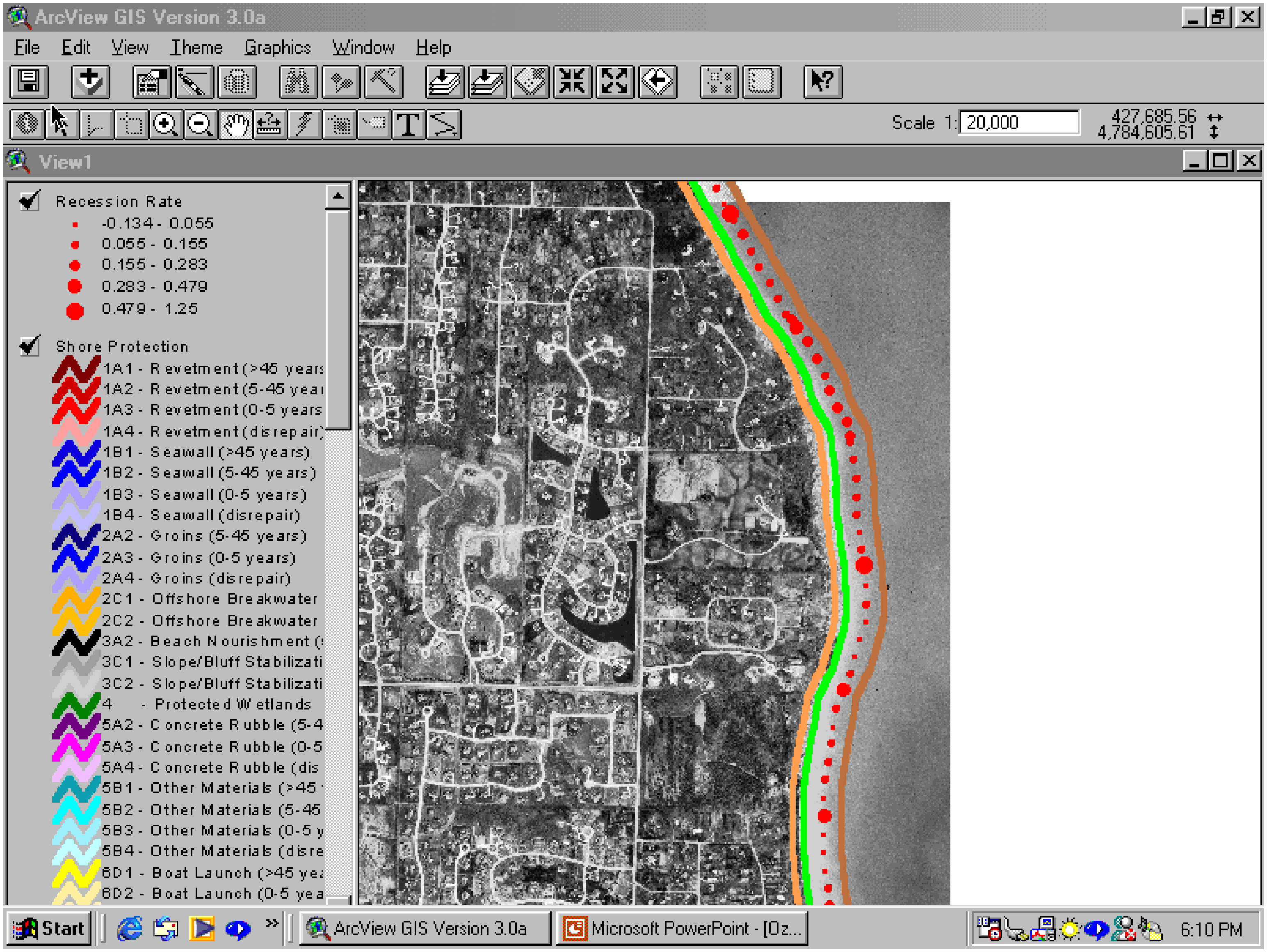
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0.055 - 0.155
0.155 - 0.283
0.283 - 0.479
0.479 - 1.25
Shore Protection
1A1 - Revetment (>45 years
1A2 - Revetment (5-45 yea
1A3 - Revetment (0-5 years
1A4 - Revetment (disrepair)
1B1 - Seawall (>45 years)
1B2 - Seawall (5-45 years)
1B3 - Seawall (0-5 years)
1B4 - Seawall (disrepair)
2A2 - Groins (5-45 years)
2A3 - Groins (0-5 years)
2A4 - Groins (disrepair)
2C1 - Offshore Breakwater
2C2 - Offshore Breakwater
3A2 - Beach Nourishment (
3C1 - Slope/Bluff Stabilizati
3C2 - Slope/Bluff Stabilizati
4 - Protected Wetlands
5A2 - Concrete Rubble (5-4
5A3 - Concrete Rubble (0-5
5A4 - Concrete Rubble (dis
5B1 - Other Materials (>45
5B2 - Other Materials (5-45
5B3 - Other Materials (0-5 y
5B4 - Other Materials (disre
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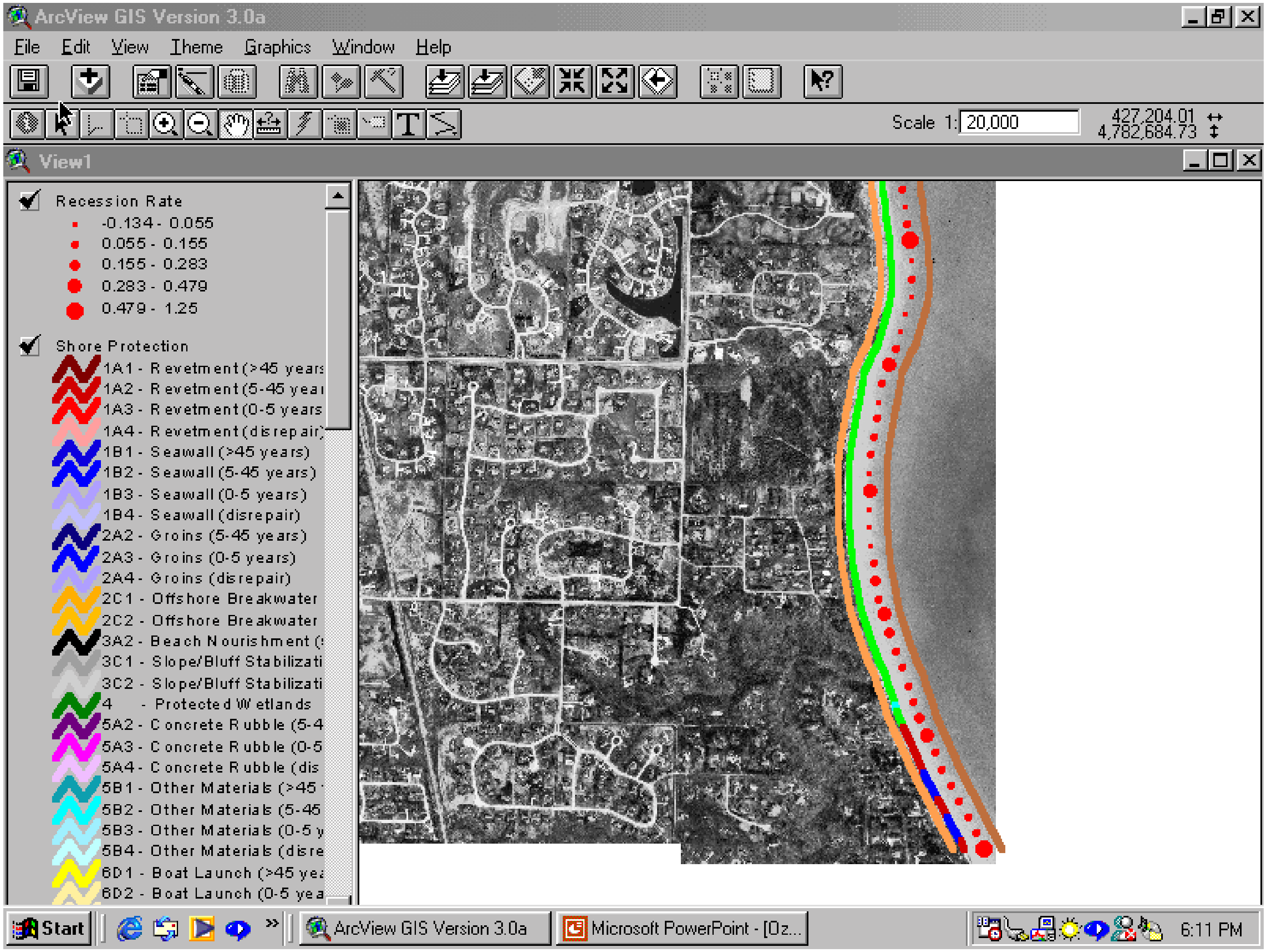
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0.479 - 1.25
Shore Protection
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1A2 - Revetment (5-45 yea
1A3 - Revetment (0-5 years
1A4 - Revetment (disrepair)
1B1 - Seawall (>45 years)
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1B4 - Seawall (disrepair)
2A2 - Groins (5-45 years)
2A3 - Groins (0-5 years)
2A4 - Groins (disrepair)
2C1 - Offshore Breakwater
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3A2 - Beach Nourishment (
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4 - Protected Wetlands
5A2 - Concrete Rubble (5-4
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5A4 - Concrete Rubble (dis
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5B2 - Other Materials (5-45
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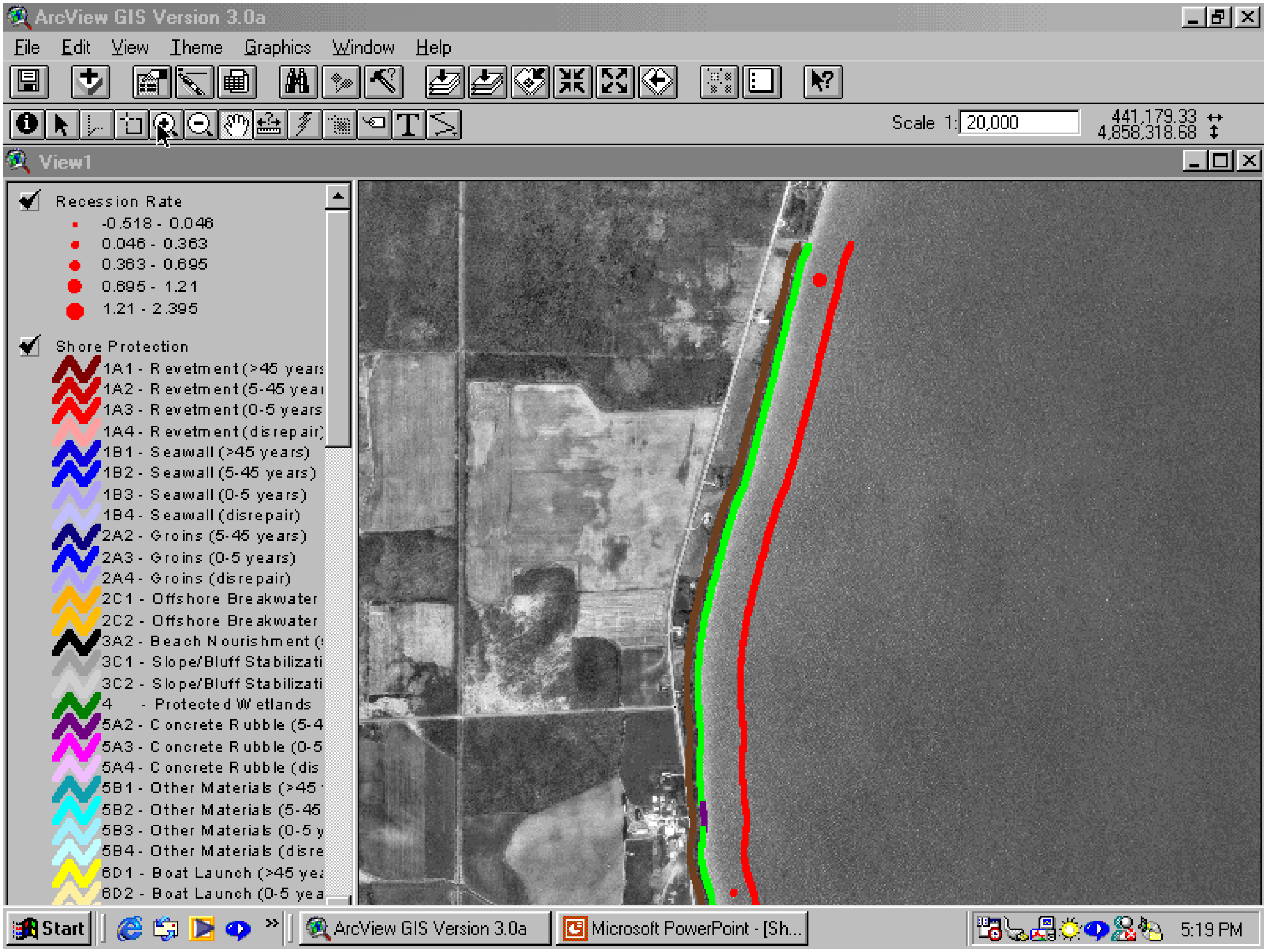
SHEBOYGAN COUNTY, WISCONSIN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Shore Protection
1A1 - Revetment (>45 years
1A2 - Revetment (5-45 year
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1A4 - Revetment (disrepair)
1B1 - Seawall (>45 years)
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1B4 - Seawall (disrepair)
2A2 - Groins (5-45 years)
2A3 - Groins (0-5 years)
2A4 - Groins (disrepair)
2C1 - Offshore Breakwater
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3A2 - Beach Nourishment (
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4 - Protected Wetlands
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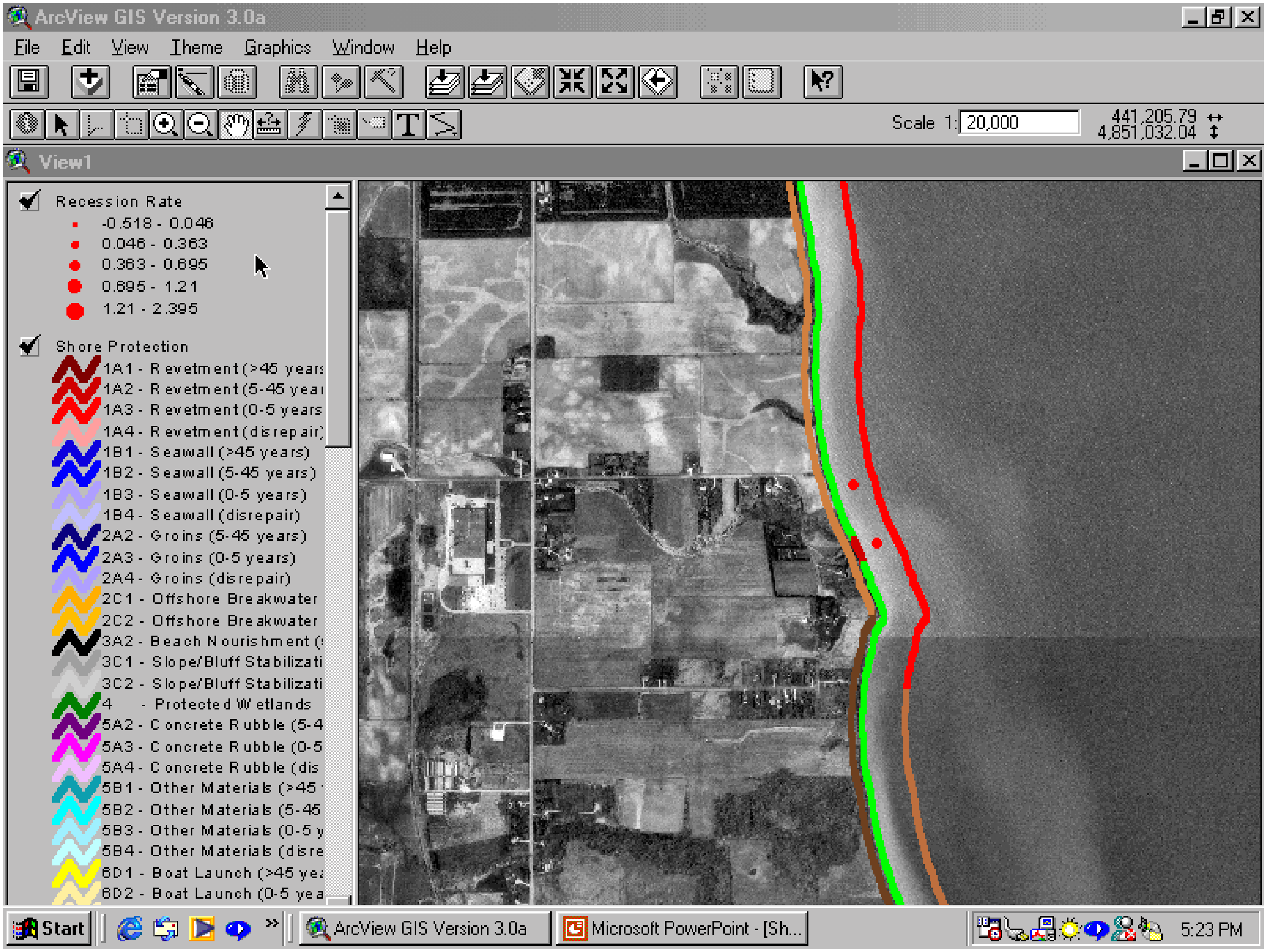
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1A4 - Revetment (disrepair)
1B1 - Seawall (>45 years)
1B2 - Seawall (5-45 years)
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1B4 - Seawall (disrepair)
2A2 - Groins (5-45 years)
2A3 - Groins (0-5 years)
2A4 - Groins (disrepair)
2C1 - Offshore Breakwater
2C2 - Offshore Breakwater
3A2 - Beach Nourishment (
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4 - Protected Wetlands
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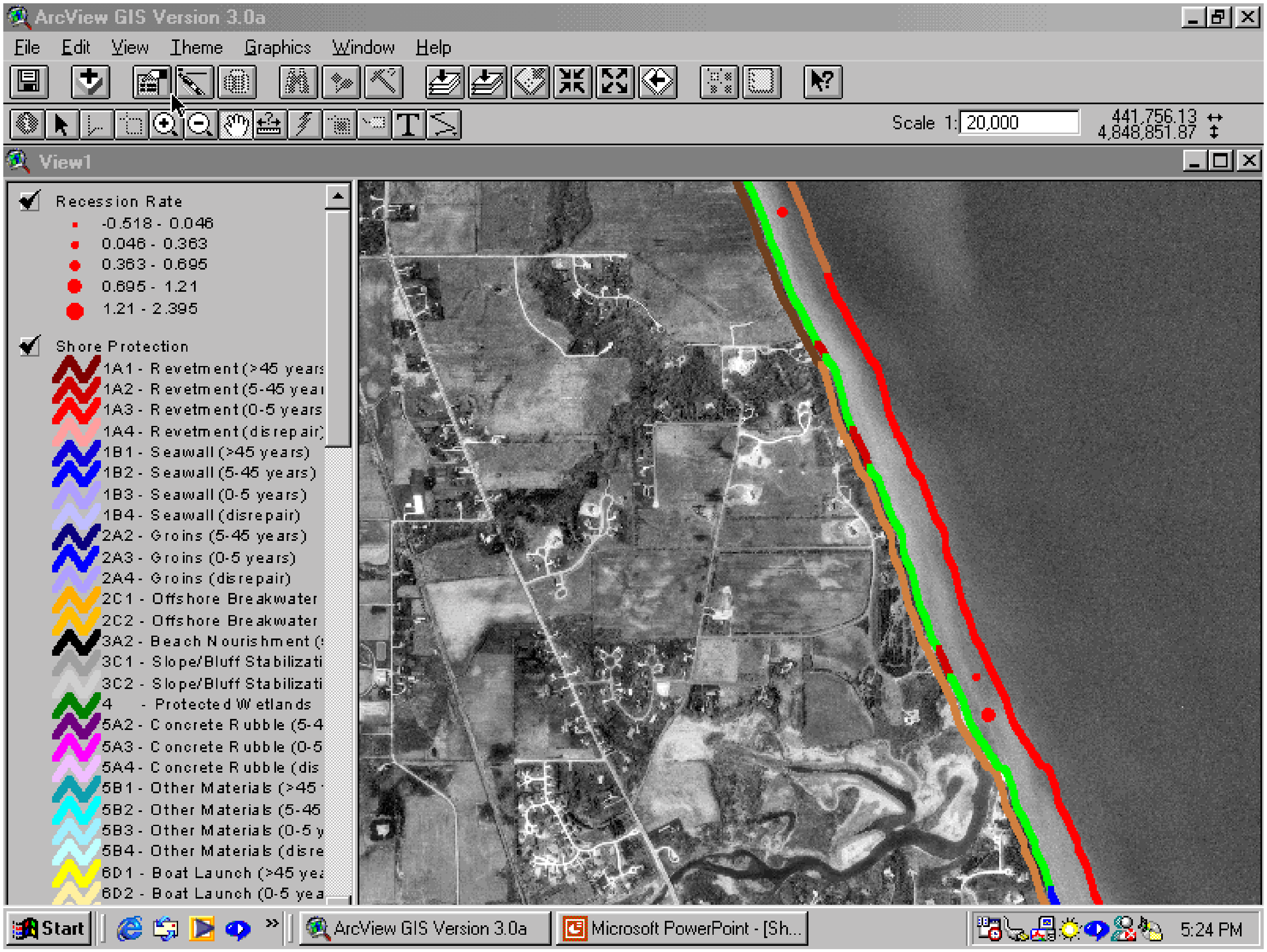
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1B4 - Seawall (disrepair)
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2A3 - Groins (0-5 years)
2A4 - Groins (disrepair)
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2C2 - Offshore Breakwater
3A2 - Beach Nourishment (
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4 - Protected Wetlands
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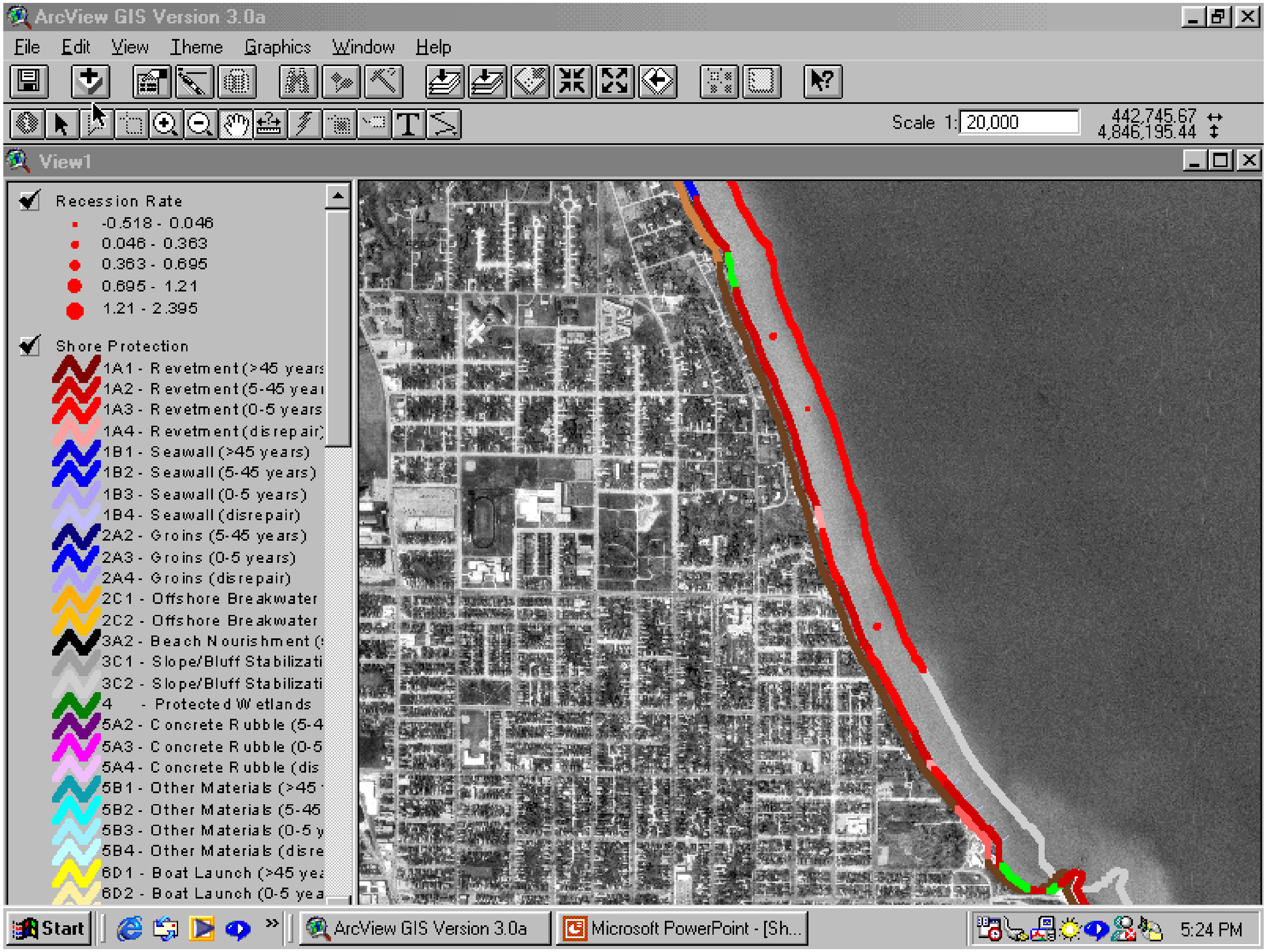
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1B4 - Seawall (disrepair)
2A2 - Groins (5-45 years)
2A3 - Groins (0-5 years)
2A4 - Groins (disrepair)
2C1 - Offshore Breakwater
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3A2 - Beach Nourishment (
3C1 - Slope/Bluff Stabilizati
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4 - Protected Wetlands
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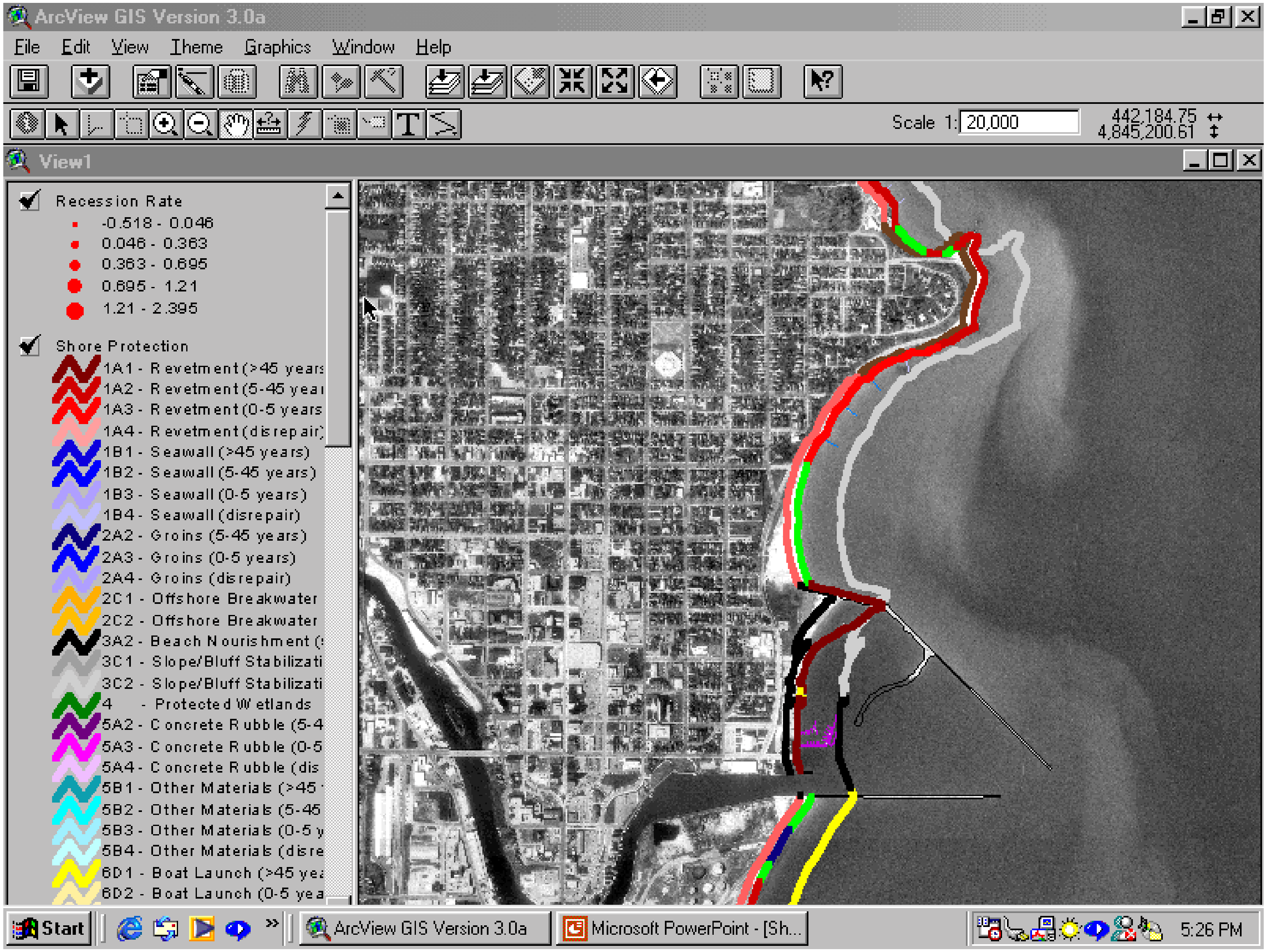
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2A3 - Groins (0-5 years)
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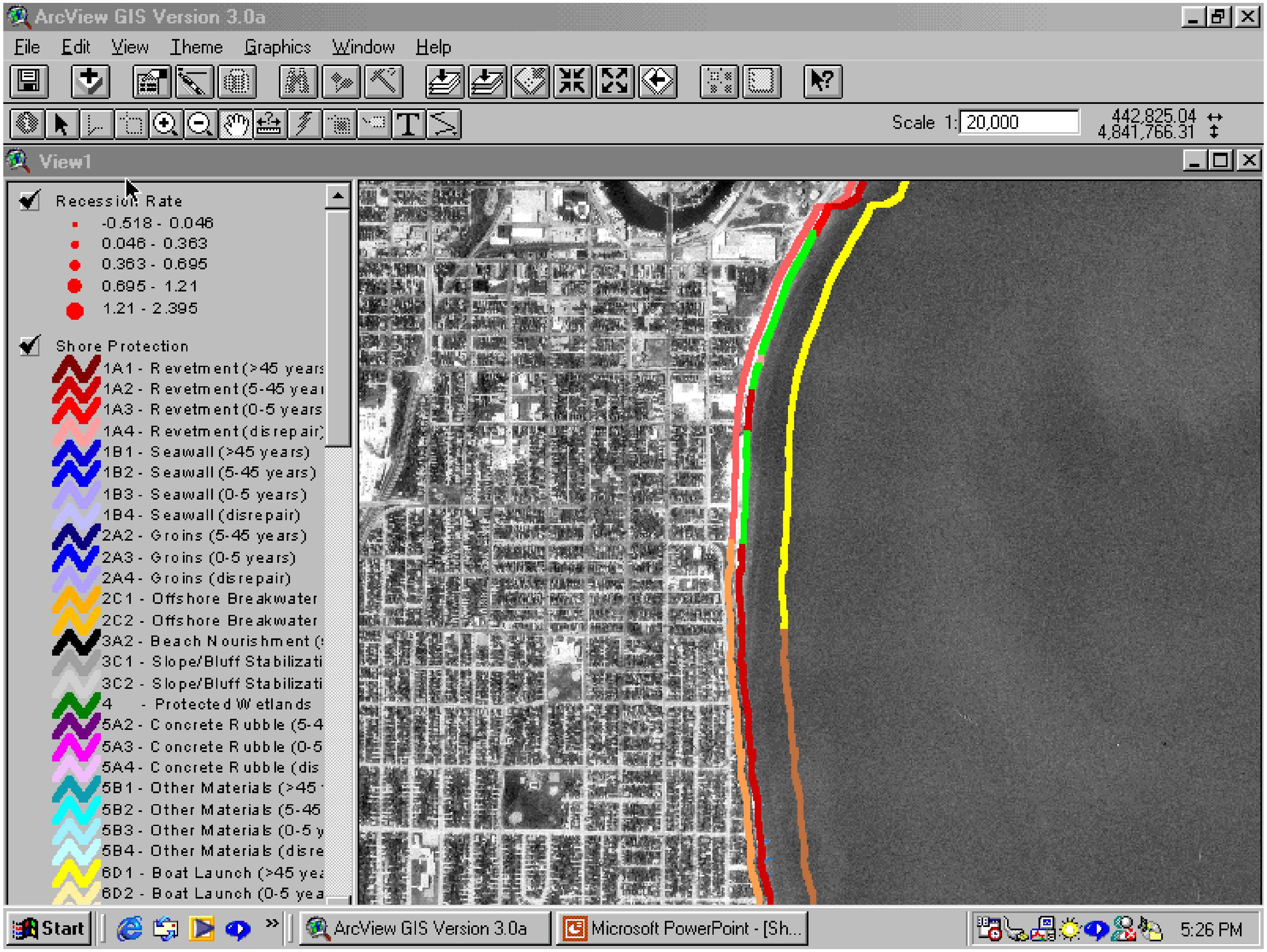
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Shore Protection
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1B4 - Seawall (disrepair)
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2A4 - Groins (disrepair)
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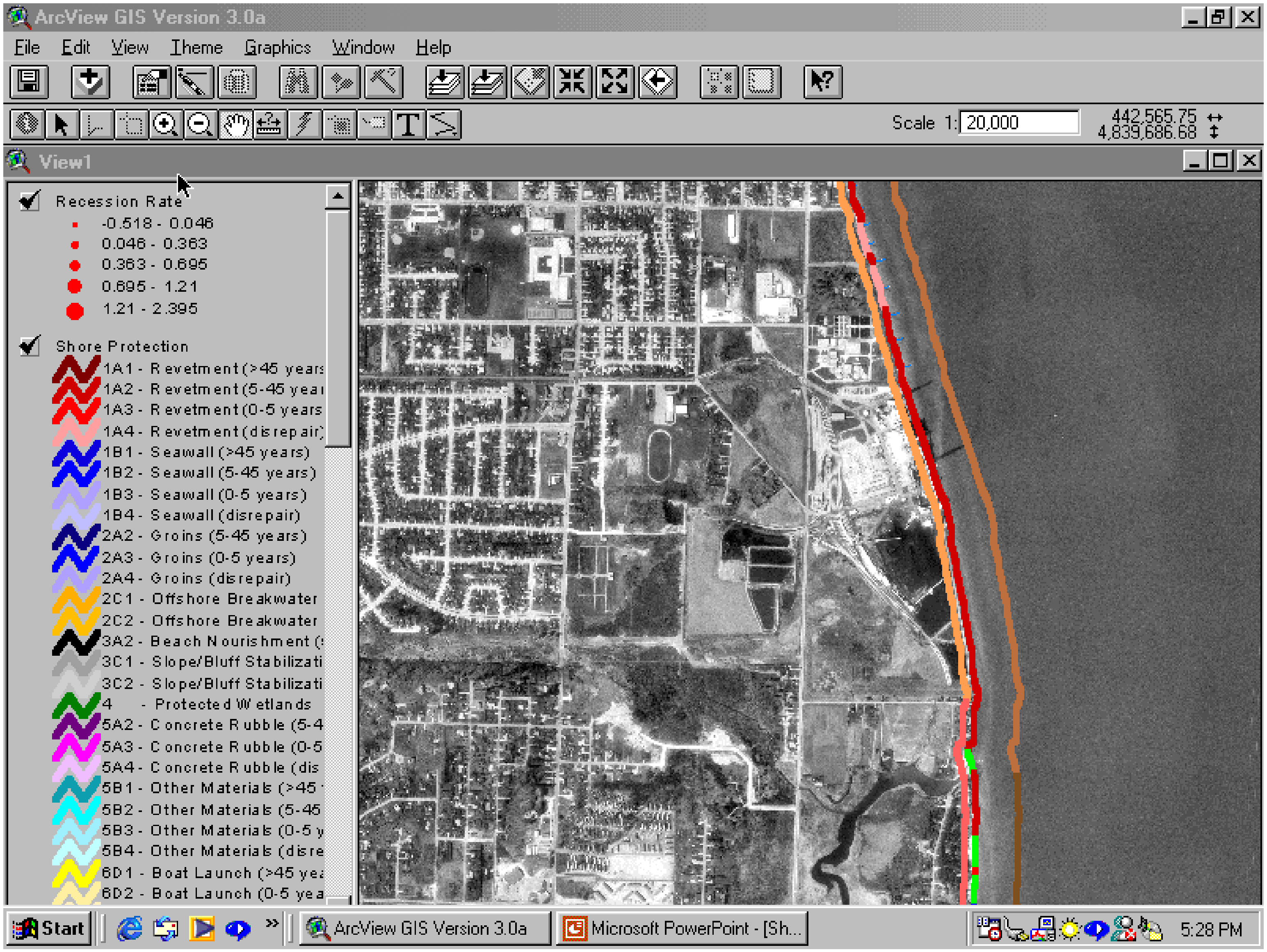
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Shore Protection
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1A4 - Revetment (disrepair)
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1B4 - Seawall (disrepair)
2A2 - Groins (5-45 years)
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2A4 - Groins (disrepair)
2C1 - Offshore Breakwater
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3A2 - Beach Nourishment (
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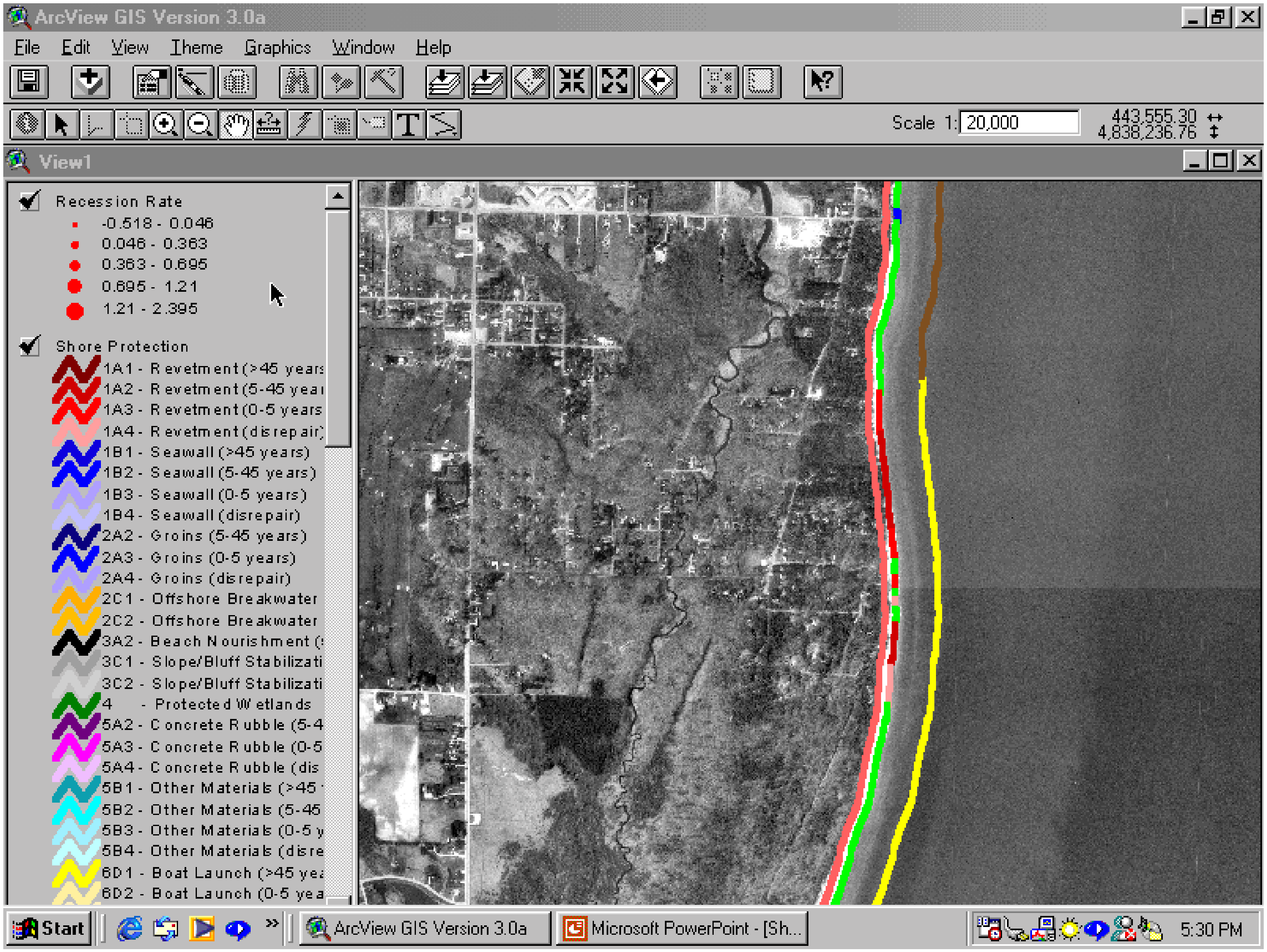
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1B4 - Seawall (disrepair)
2A2 - Groins (5-45 years)
2A3 - Groins (0-5 years)
2A4 - Groins (disrepair)
2C1 - Offshore Breakwater
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3A2 - Beach Nourishment (
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4 - Protected Wetlands
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5B1 - Other Materials (>45
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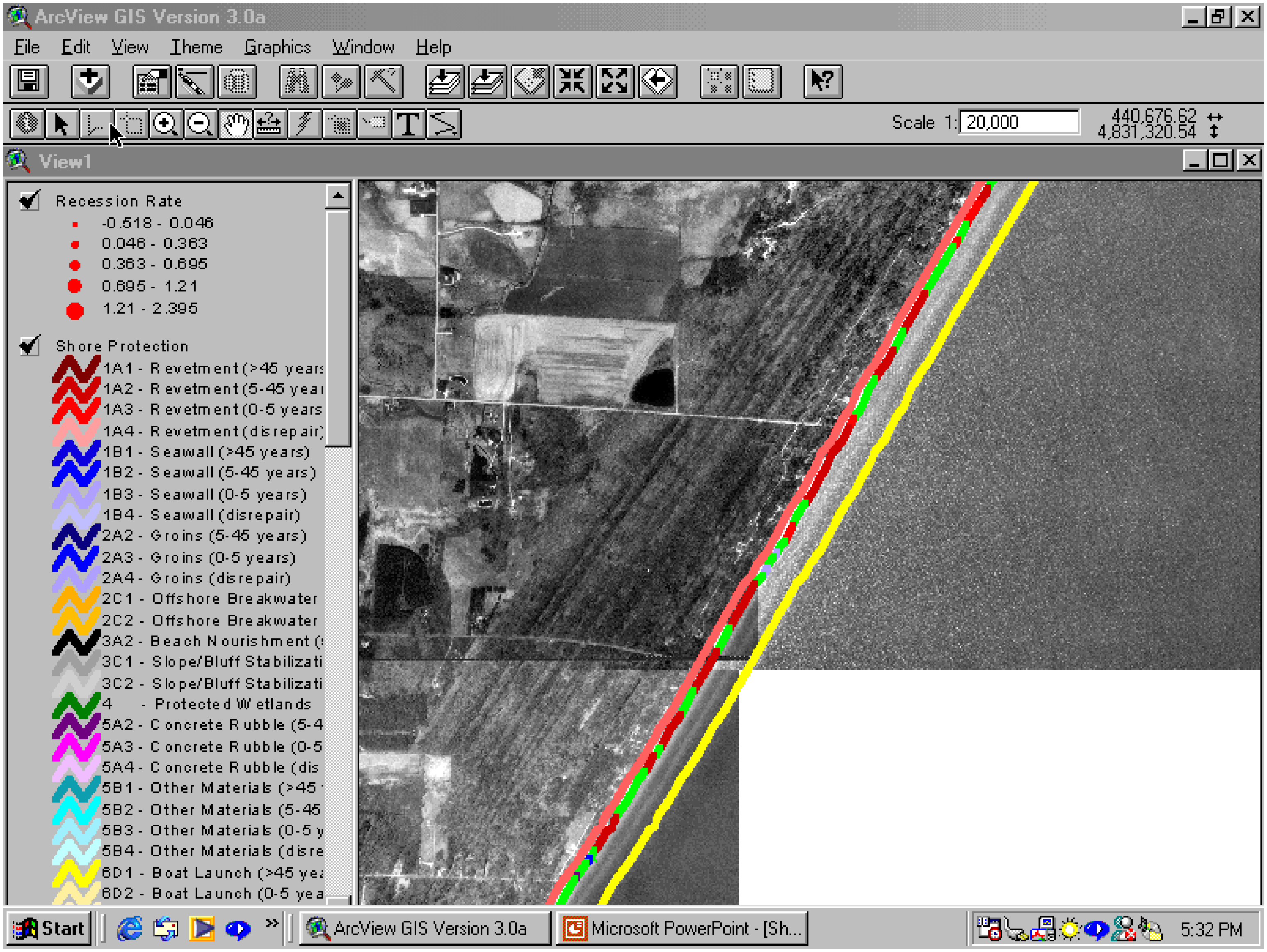
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1A1 - Revetment (>45 years
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1A4 - Revetment (disrepair)
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1B4 - Seawall (disrepair)
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2A4 - Groins (disrepair)
2C1 - Offshore Breakwater
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3A2 - Beach Nourishment (
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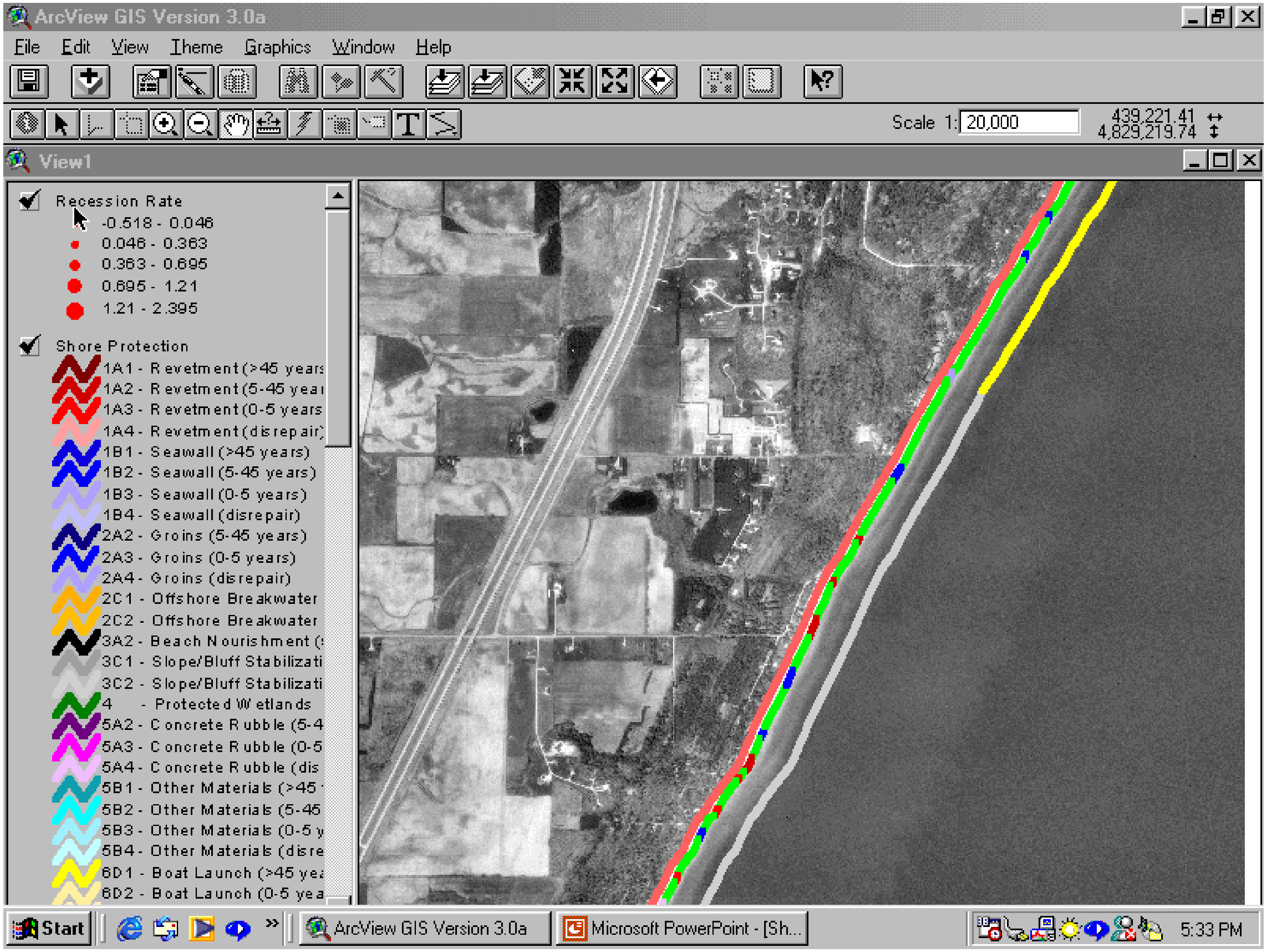
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Shore Protection
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1A3 - Revetment (0-5 years
1A4 - Revetment (disrepair)
1B1 - Seawall (>45 years)
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1B3 - Seawall (0-5 years)
1B4 - Seawall (disrepair)
2A2 - Groins (5-45 years)
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3A2 - Beach Nourishment (
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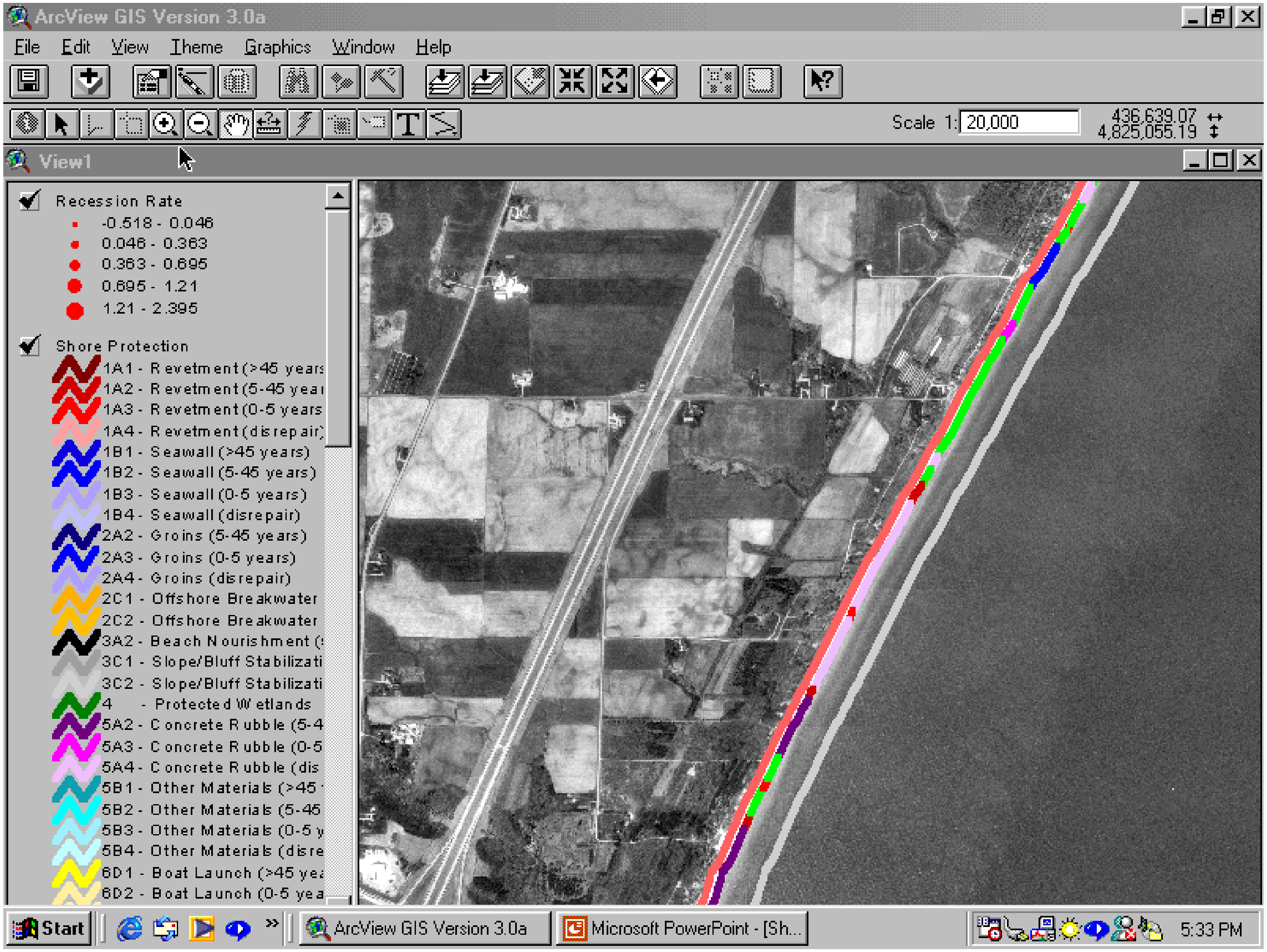
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Shore Protection
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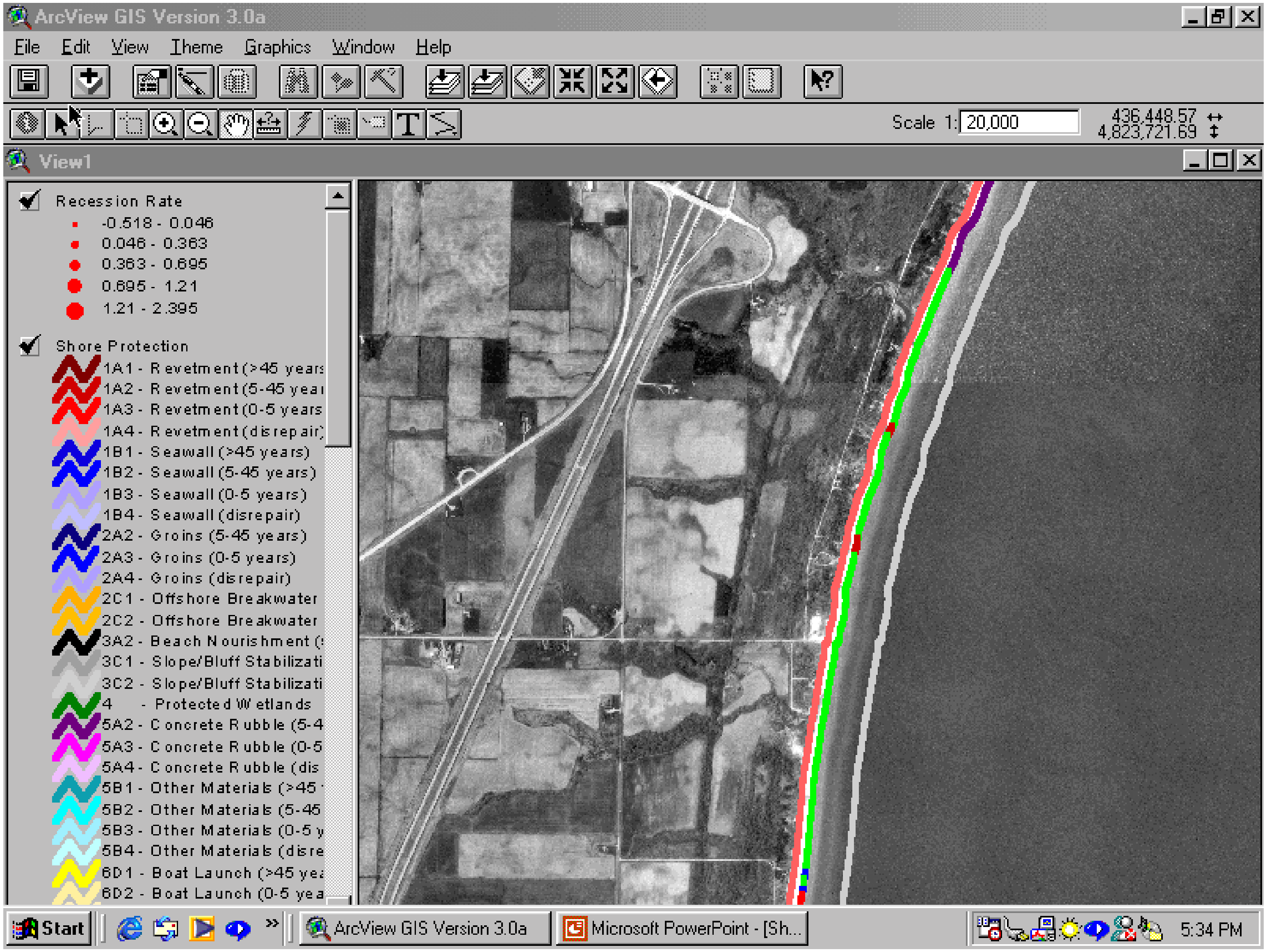

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1B1 - Seawall (>45 years)
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1B4 - Seawall (disrepair)
2A2 - Groins (5-45 years)
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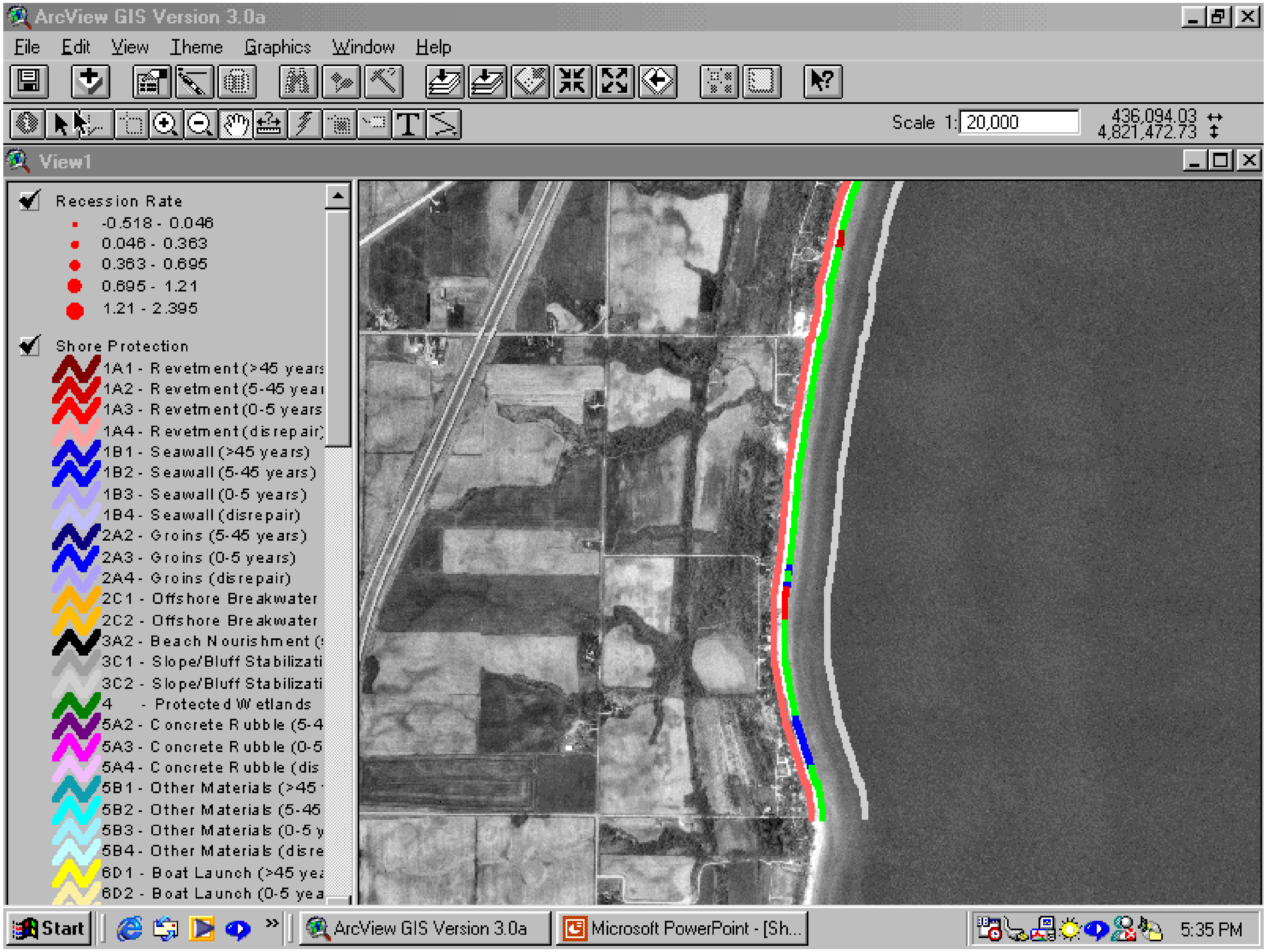
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1B2 - Seawall (5-45 years)
1B3 - Seawall (0-5 years)
1B4 - Seawall (disrepair)
2A2 - Groins (5-45 years)
2A3 - Groins (0-5 years)
2A4 - Groins (disrepair)
2C1 - Offshore Breakwater
2C2 - Offshore Breakwater
3A2 - Beach Nourishment (
3C1 - Slope/Bluff Stabilizati
3C2 - Slope/Bluff Stabilizati
4 - Protected Wetlands
5A2 - Concrete Rubble (5-4
5A3 - Concrete Rubble (0-5
5A4 - Concrete Rubble (dis
5B1 - Other Materials (>45
5B2 - Other Materials (5-45
5B3 - Other Materials (0-5 y
5B4 - Other Materials (disre
6D1 - Boat Launch (>45 yea
6D2 - Boat Launch (0-5 yea
Start
ArcView GIS Version 3.0a
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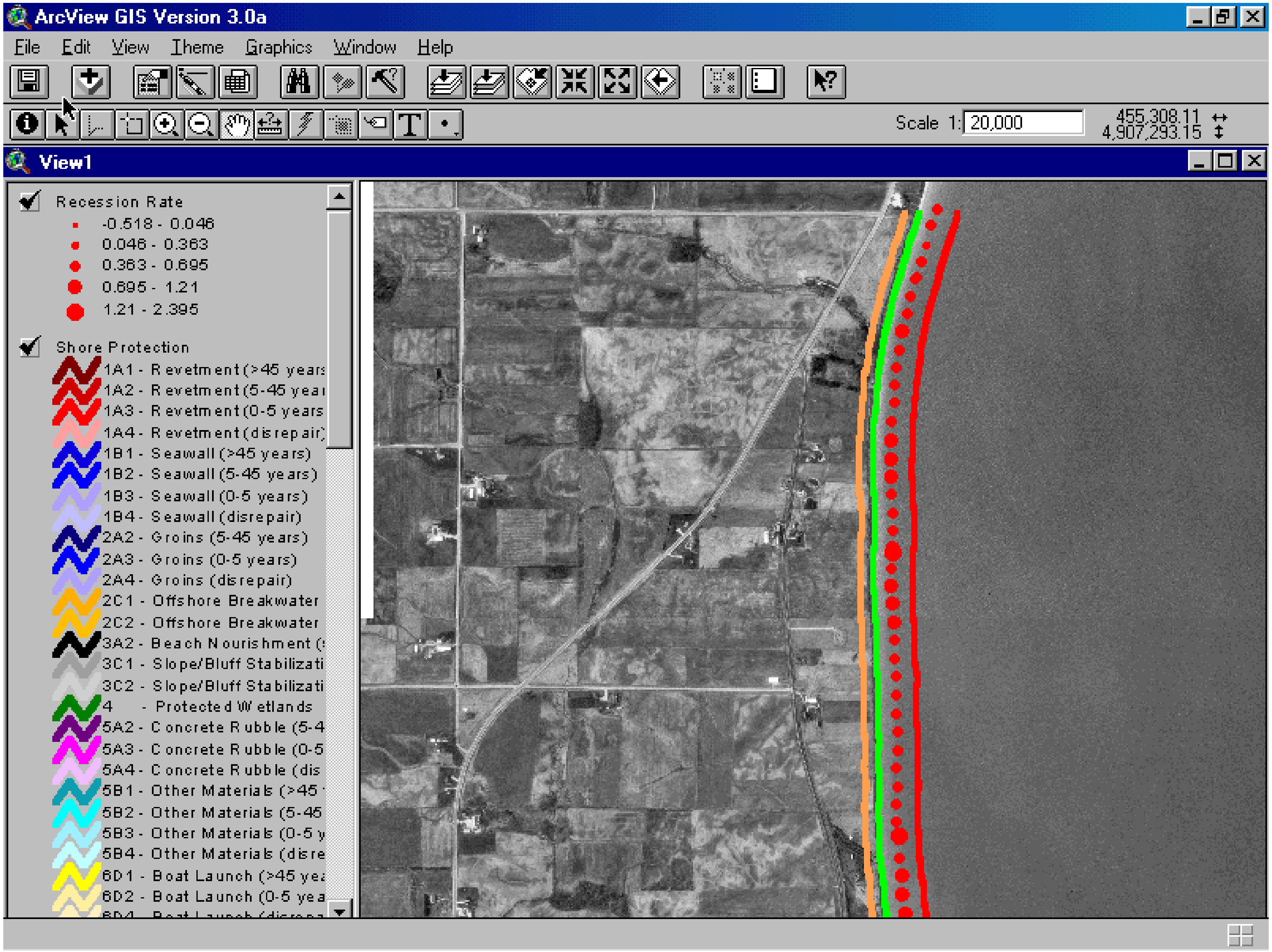
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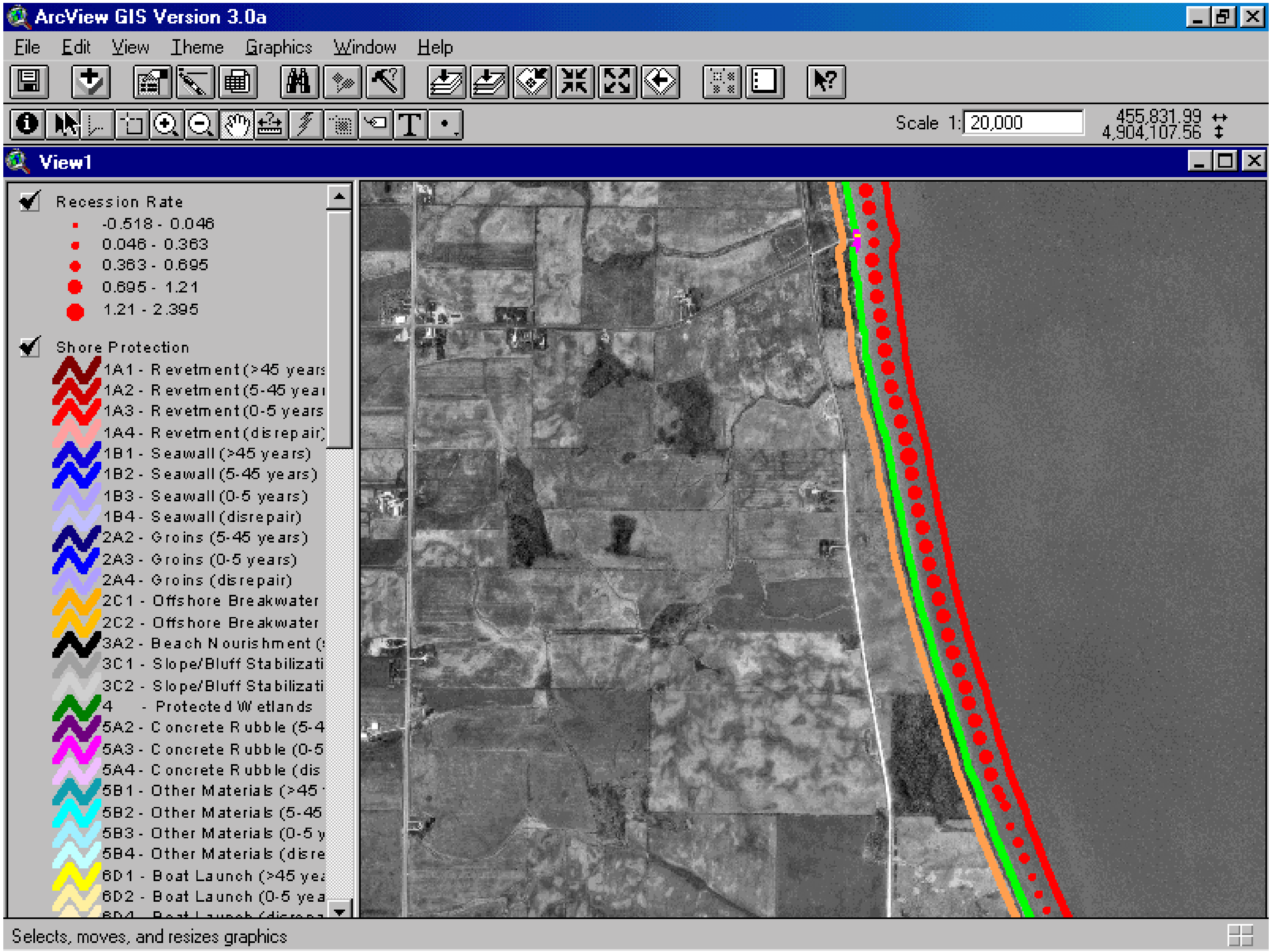
0.046 - 0.363
0.363 - 0.695
0.695 - 1.21
1.21 - 2.395
Shore Protection
1A1 - Revetment (>45 years
1A2 - Revetment (5-45 yea
1A3 - Revetment (0-5 years
1A4 - Revetment (disrepair)
1B1 - Seawall (>45 years)
1B2 - Seawall (5-45 years)
1B3 - Seawall (0-5 years)
1B4 - Seawall (disrepair)
2A2 - Groins (5-45 years)
2A3 - Groins (0-5 years)
2A4 - Groins (disrepair)
2C1 - Offshore Breakwater
2C2 - Offshore Breakwater
3A2 - Beach Nourishment (
3C1 - Slope/Bluff Stabilizati
3C2 - Slope/Bluff Stabilizati
4 - Protected Wetlands
5A2 - Concrete Rubble (5-4
5A3 - Concrete Rubble (0-5
5A4 - Concrete Rubble (dis
5B1 - Other Materials (>45
5B2 - Other Materials (5-45
5B3 - Other Materials (0-5 y
5B4 - Other Materials (disre
6D1 - Boat Launch (>45 yea
6D2 - Boat Launch (0-5 yea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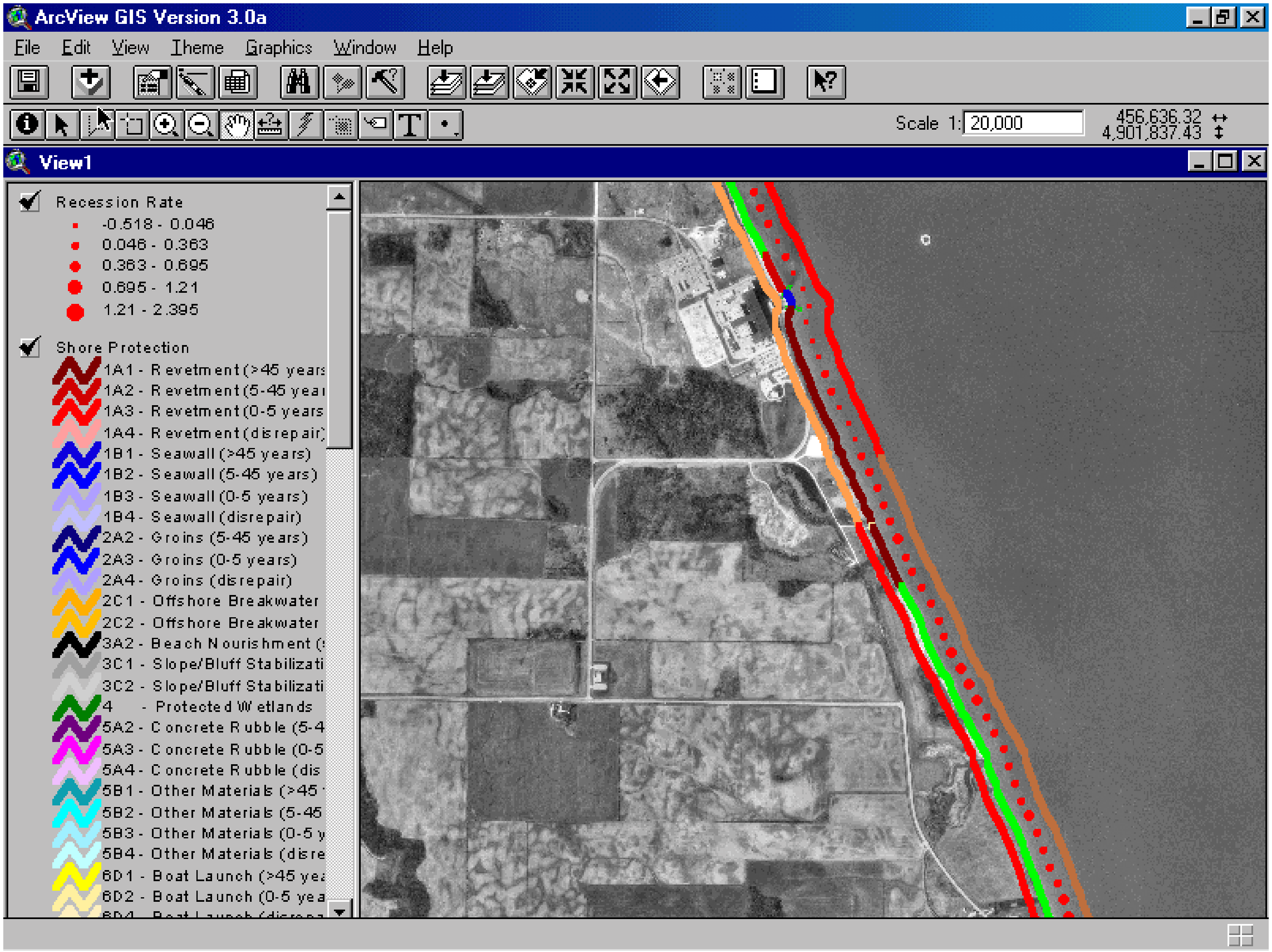
0.695 - 1.21
1.21 - 2.395
Shore Protection
1A1 - Revetment (>45 years
1A2 - Revetment (5-45 year
1A3 - Revetment (0-5 years
1A4 - Revetment (disrepair)
1B1 - Seawall (>45 years)
1B2 - Seawall (5-45 years)
1B3 - Seawall (0-5 years)
1B4 - Seawall (disrepair)
2A2 - Groins (5-45 years)
2A3 - Groins (0-5 years)
2A4 - Groins (disrepair)
2C1 - Offshore Breakwater
2C2 - Offshore Breakwater
3A2 - Beach Nourishment (
3C1 - Slope/Bluff Stabilizati
3C2 - Slope/Bluff Stabilizati
4 - Protected Wetlands
5A2 - Concrete Rubble (5-4
5A3 - Concrete Rubble (0-5
5A4 - Concrete Rubble (dis
5B1 - Other Materials (>45
5B2 - Other Materials (5-45
5B3 - Other Materials (0-5 y
5B4 - Other Materials (disre
6D1 - Boat Launch (>45 yea
6D2 - Boat Launch (0-5 yea
Selects, moves, and resizes graphics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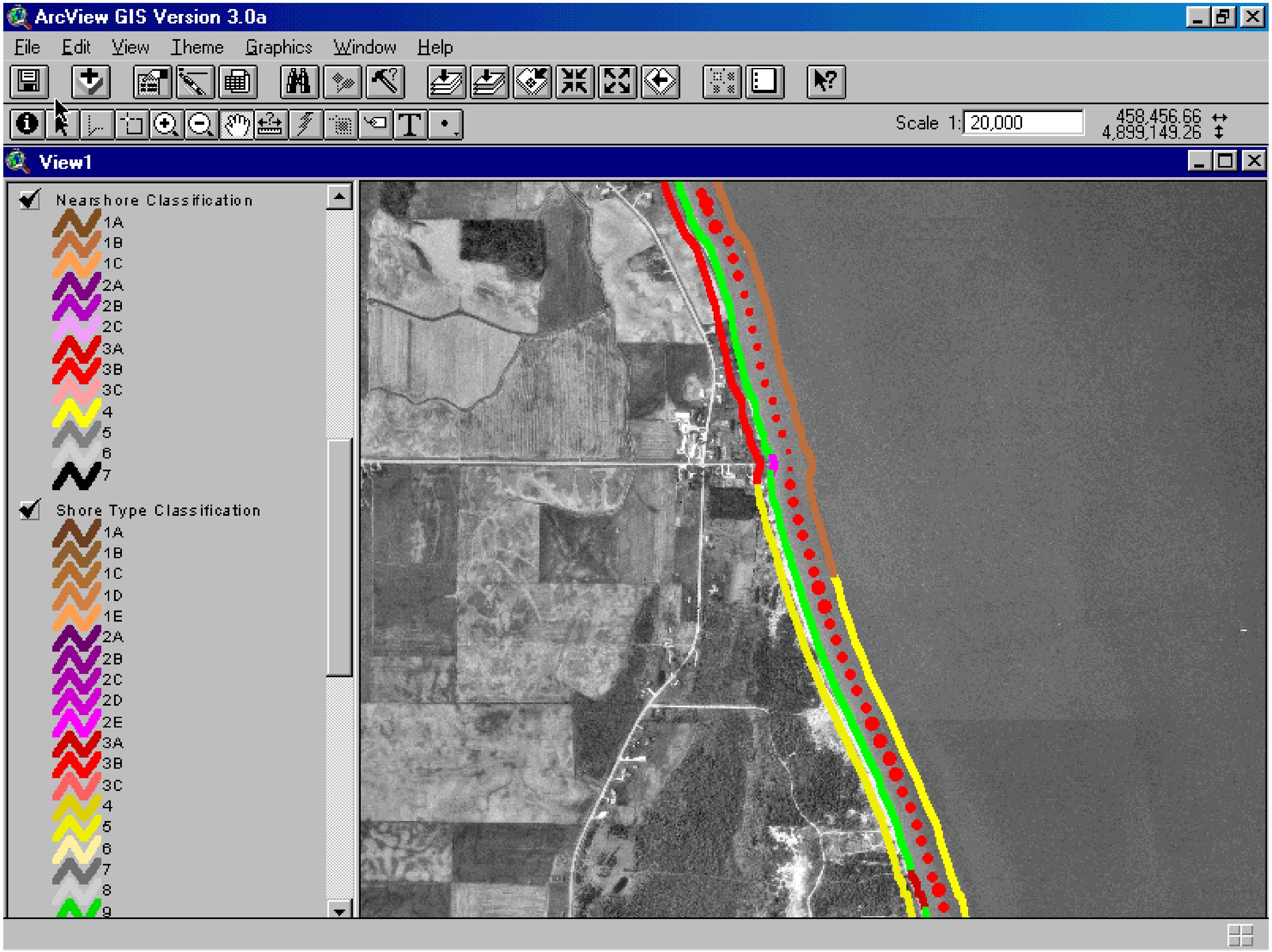
0.695 - 1.21
1.21 - 2.395
Shore Protection
1A1 - Revetment (>45 years
1A2 - Revetment (5-45 year
1A3 - Revetment (0-5 years
1A4 - Revetment (disrepair)
1B1 - Seawall (>45 years)
1B2 - Seawall (5-45 years)
1B3 - Seawall (0-5 years)
1B4 - Seawall (disrepair)
2A2 - Groins (5-45 years)
2A3 - Groins (0-5 years)
2A4 - Groins (disrepair)
2C1 - Offshore Breakwater
2C2 - Offshore Breakwater
3A2 - Beach Nourishment (
3C1 - Slope/Bluff Stabilizati
3C2 - Slope/Bluff Stabilizati
4 - Protected Wetlands
5A2 - Concrete Rubble (5-4
5A3 - Concrete Rubble (0-5
5A4 - Concrete Rubble (dis
5B1 - Other Materials (>45
5B2 - Other Materials (5-45
5B3 - Other Materials (0-5 y
5B4 - Other Materials (disre
6D1 - Boat Launch (>45 yea
6D2 - Boat Launch (0-5 yea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Nearshore Classification
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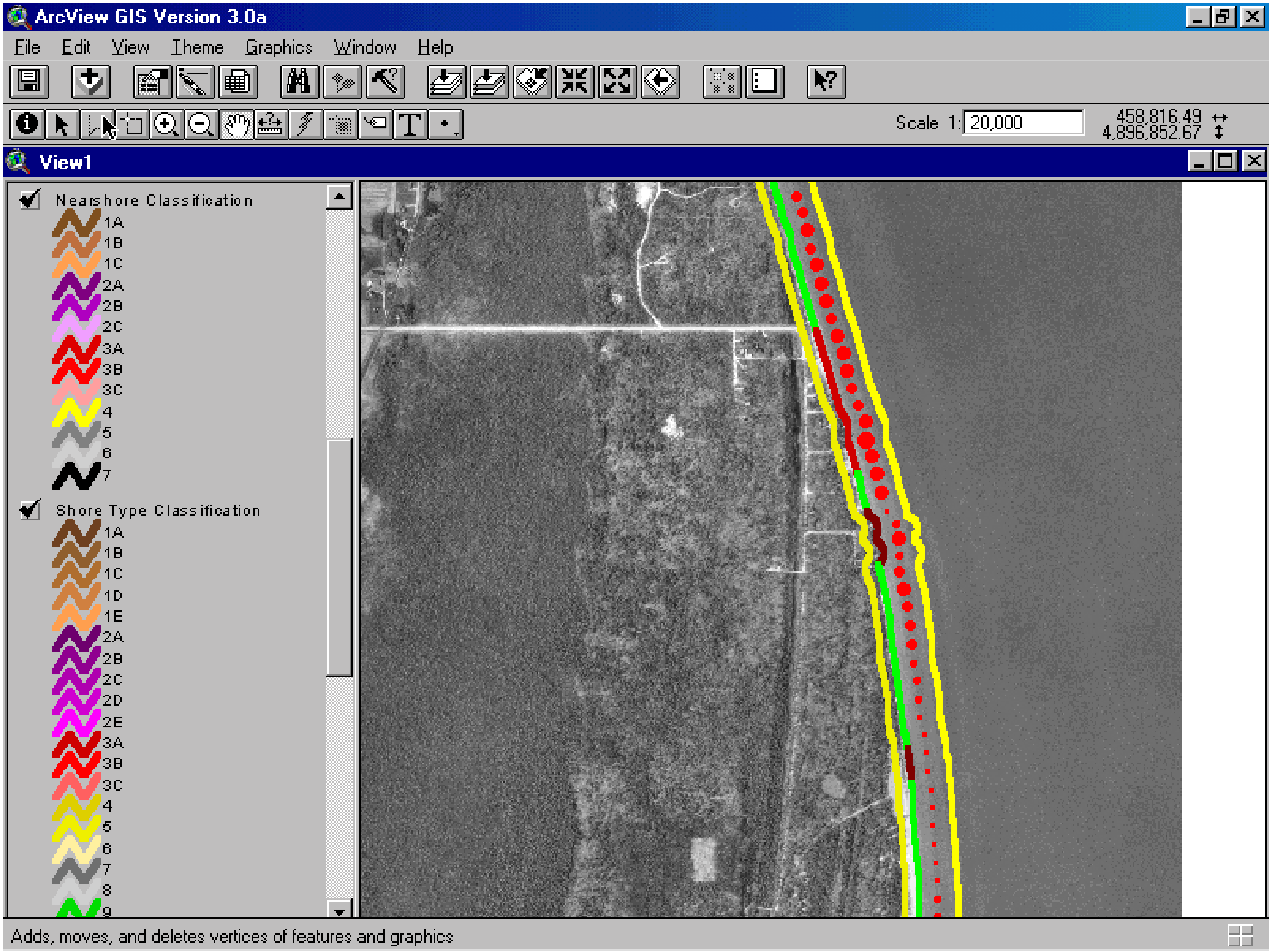
1B
1C
2A
2B
2C
3A
3B
3C
4
5
6
7
Shore Type Classification
1A
1B
1C
1D
1E
2A
2B
2C
2D
2E
3A
3B
3C
4
5
6
7
8
9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View1
Nearshore Classification
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1B
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2A
2B
2C
3A
3B
3C
4
5
6
7
Shore Type Classification
1A
1B
1C
1D
1E
2A
2B
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2E
3A
3B
3C
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7
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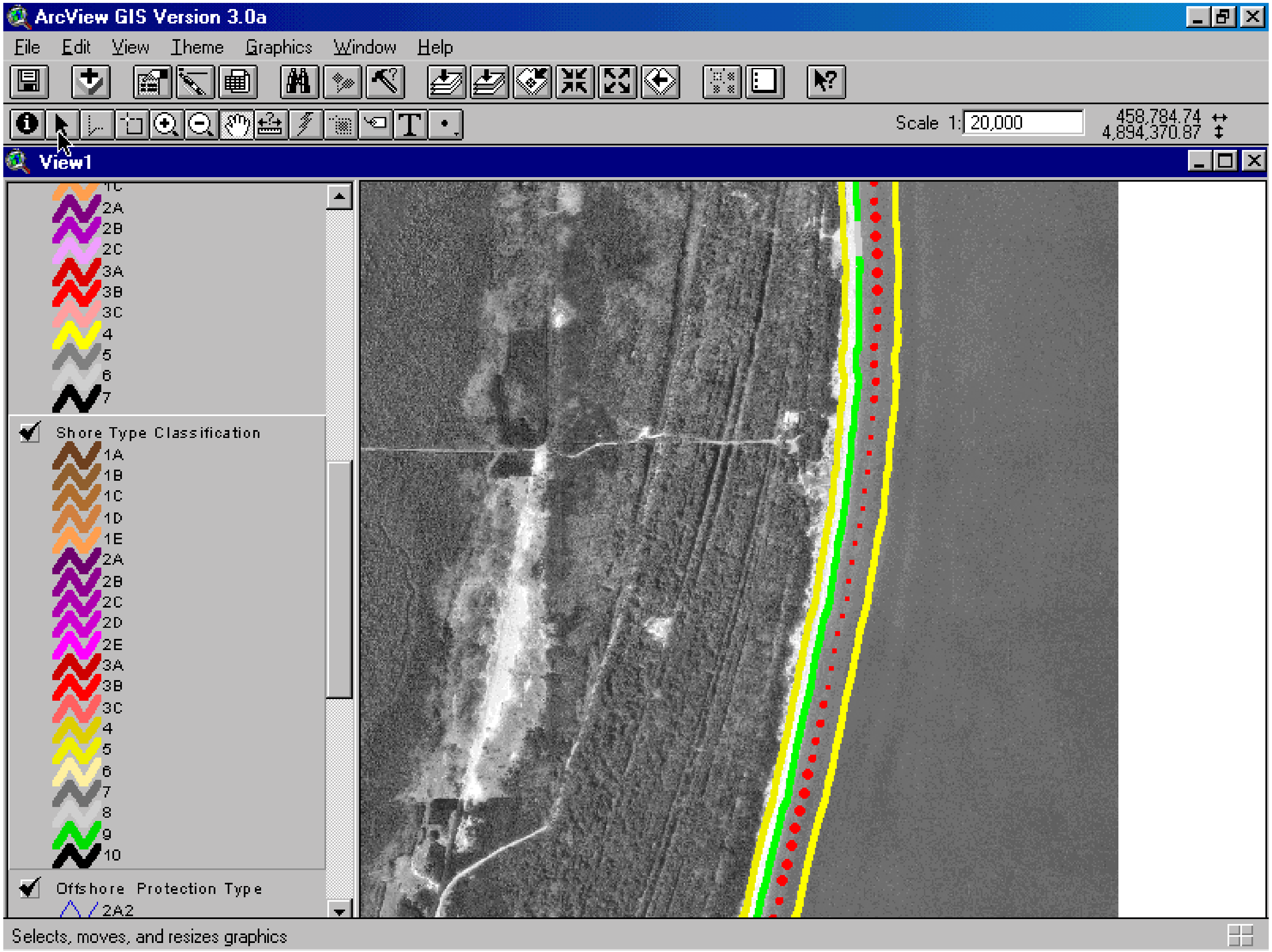
Adds, moves, and deletes vertices of features and graphics



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2A
2B
2C
3A
3B
3C
4
5
6
7
Shore Type Classification
1A
1B
1C
1D
1E
2A
2B
2C
2D
2E
3A
3B
3C
4
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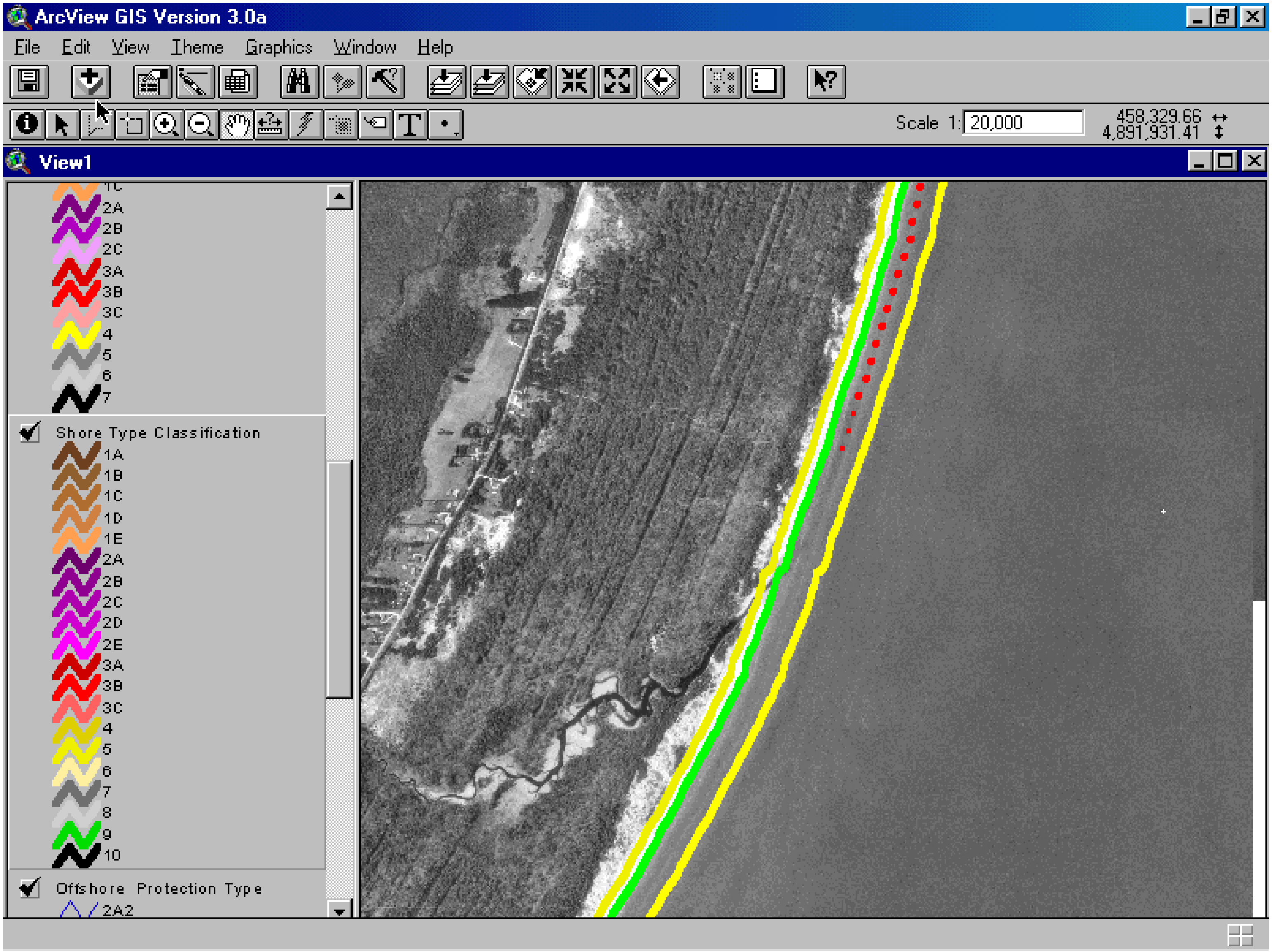
10
Offshore Protection Type
2A2
Selects, moves, and resizes graphics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Graphics
Window
Help
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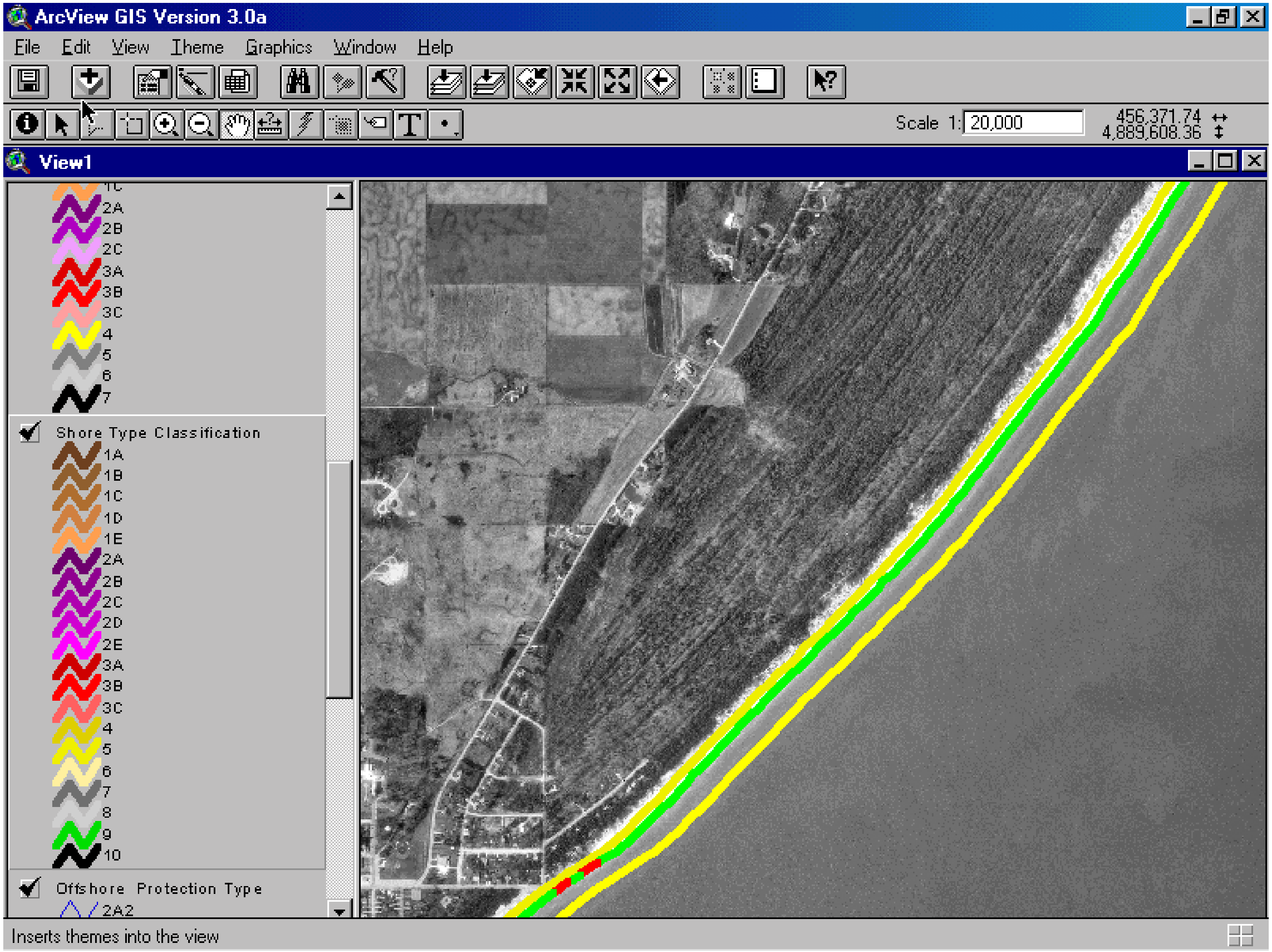
View1
1C
2A
2B
2C
3A
3B
3C
4
5
6
7
Shore Type Classification
1A
1B
1C
1D
1E
2A
2B
2C
2D
2E
3A
3B
3C
4
5
6
7
8
9
10
Offshore Protection Type
2A2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View1
1C
2A
2B
2C
3A
3B
3C
4
5
6
7
Shore Type Classification
1A
1B
1C
1D
1E
2A
2B
2C
2D
2E
3A
3B
3C
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5
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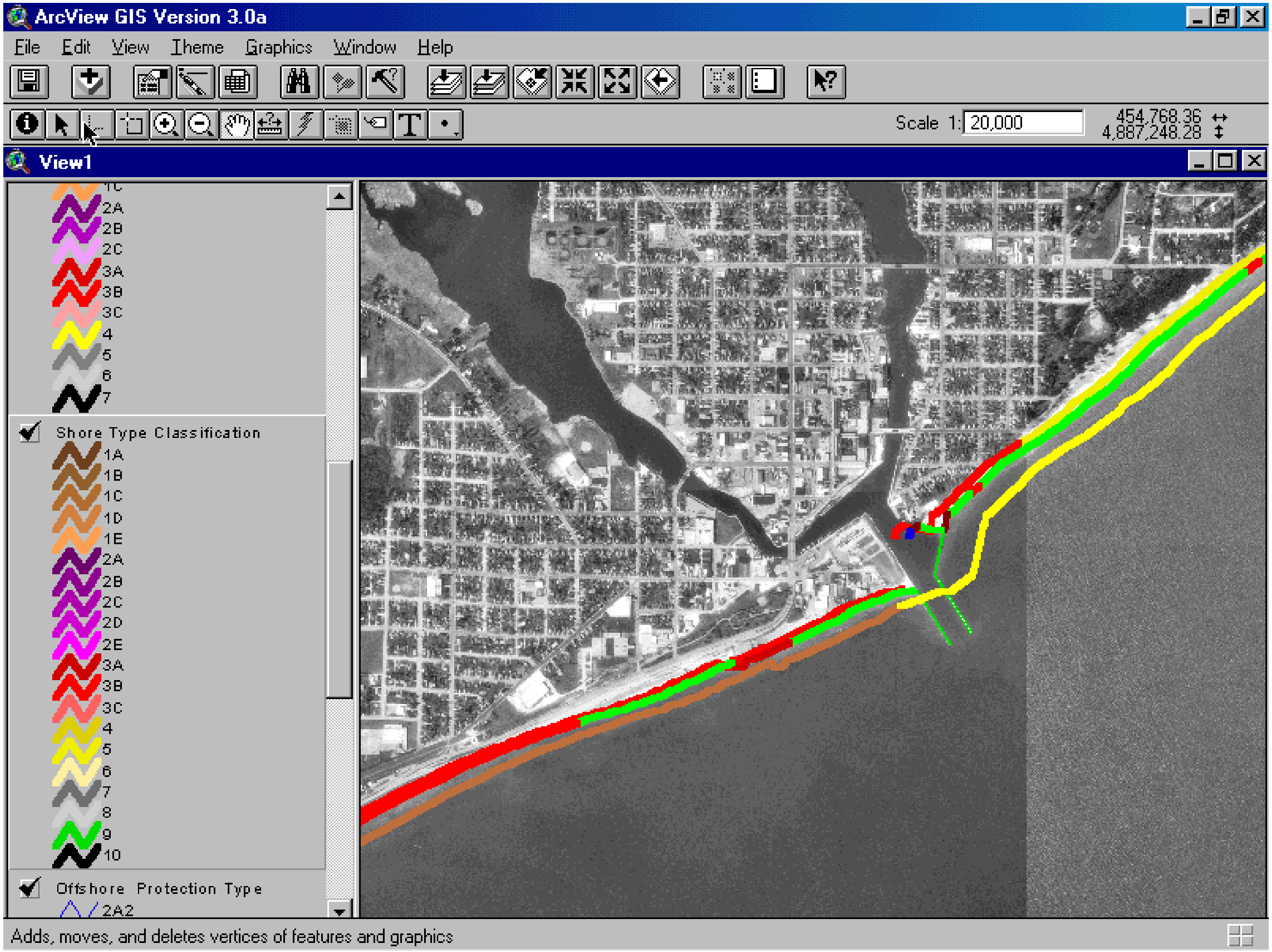
7
8
9
10
Offshore Protection Type
2A2
Inserts themes into the view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1C
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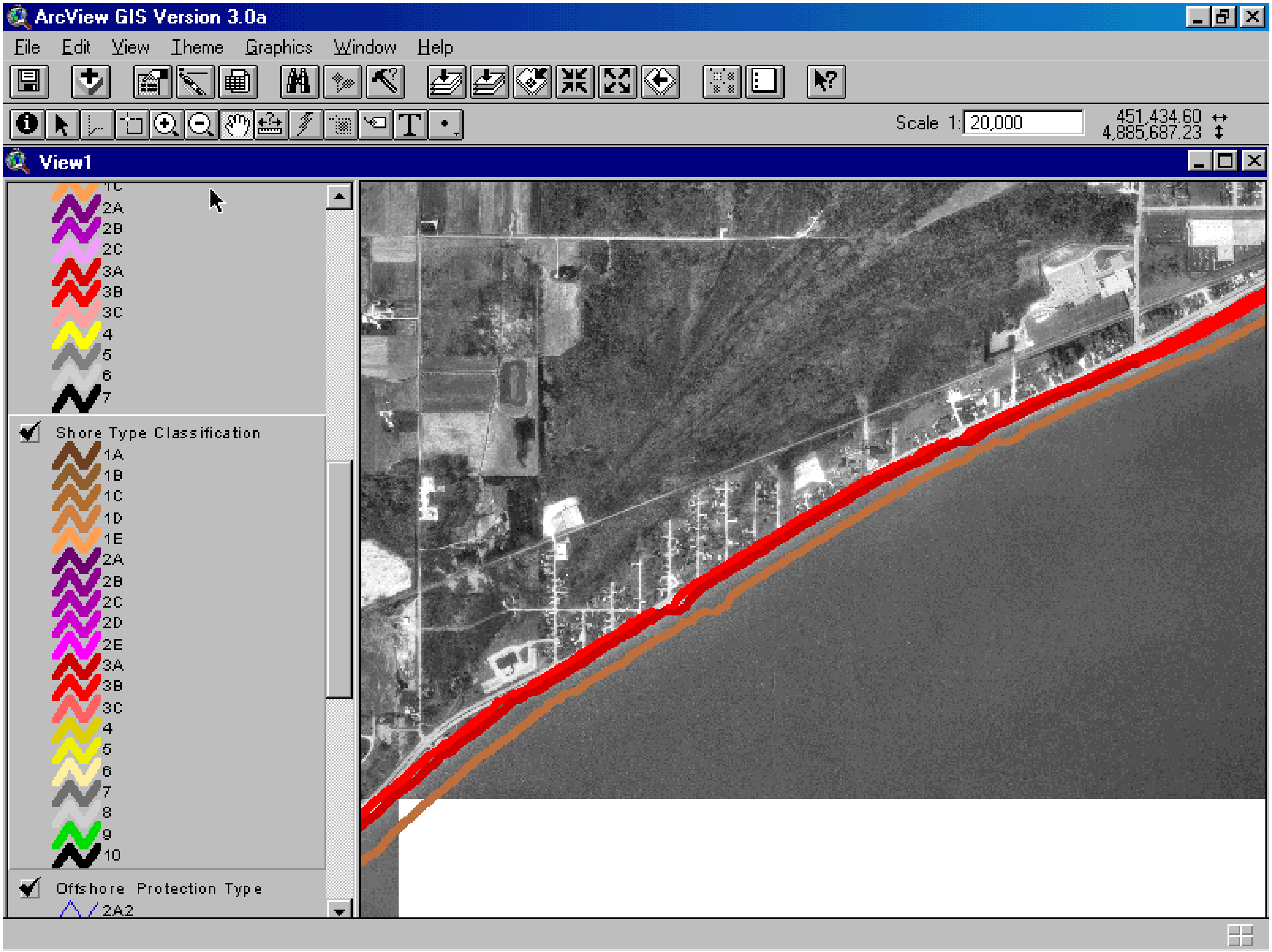
2B
2C
3A
3B
3C
4
5
6
7
Shore Type Classification
1A
1B
1C
1D
1E
2A
2B
2C
2D
2E
3A
3B
3C
4
5
6
7
8
9
10
Offshore Protection Type
2A2
Adds, moves, and deletes vertices of features and graphics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View1
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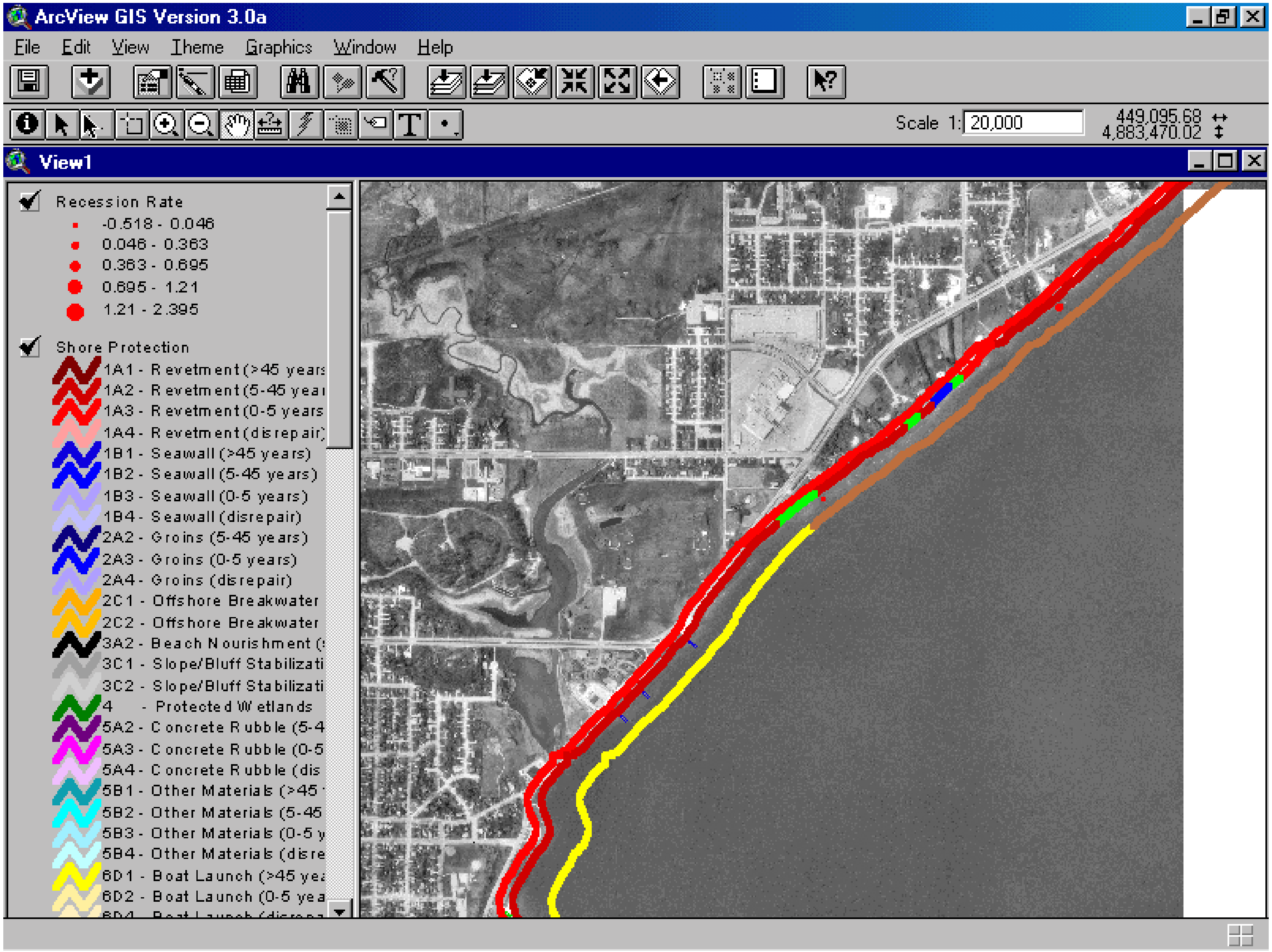
2B
2C
3A
3B
3C
4
5
6
7
Shore Type Classification
1A
1B
1C
1D
1E
2A
2B
2C
2D
2E
3A
3B
3C
4
5
6
7
8
9
10
Offshore Protection Type
2A2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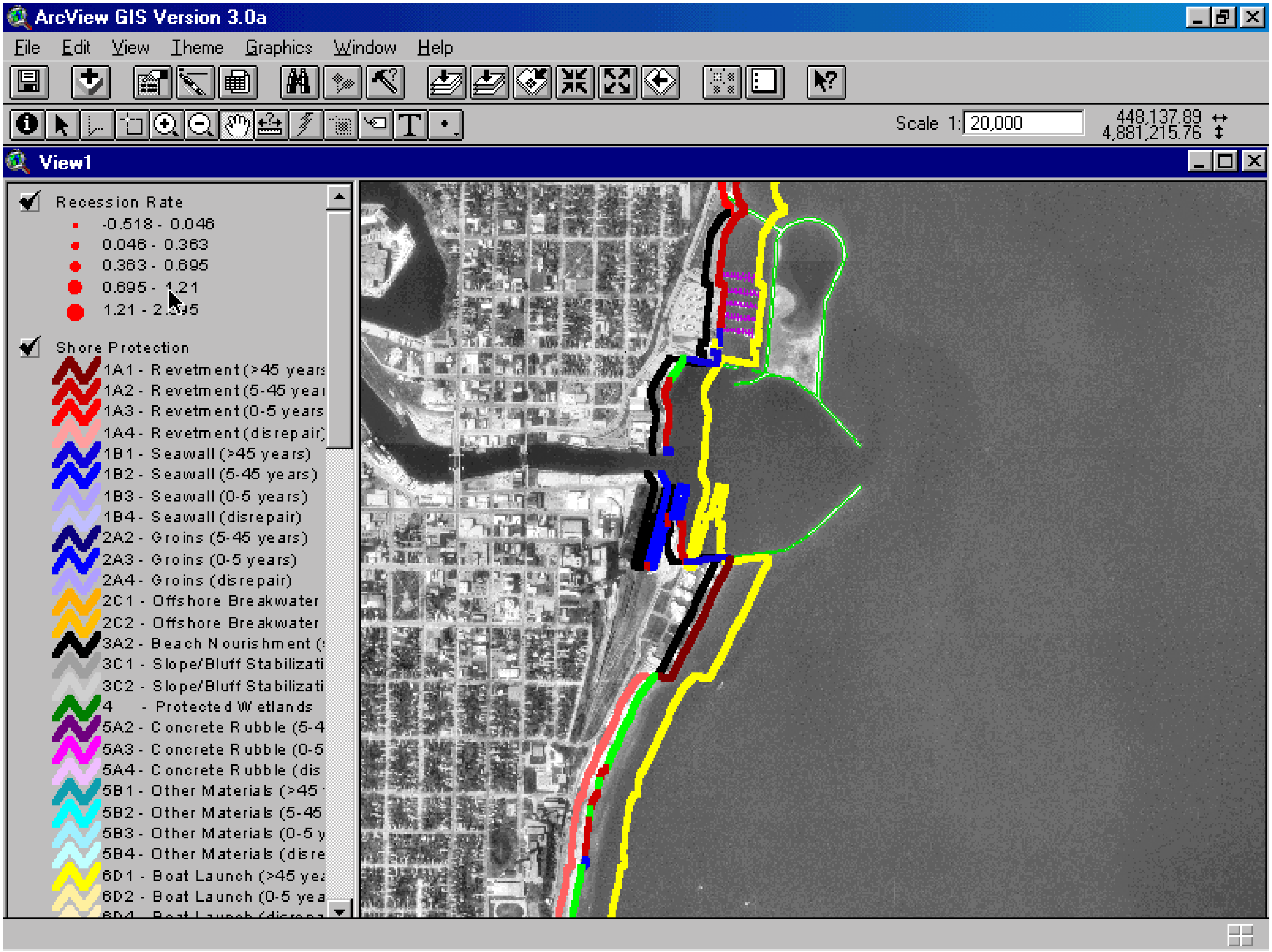
0.046 - 0.363
0.363 - 0.695
0.695 - 1.21
1.21 - 2.395
Shore Protection
1A1 - Revetment (>45 years
1A2 - Revetment (5-45 yea
1A3 - Revetment (0-5 years
1A4 - Revetment (disrepair)
1B1 - Seawall (>45 years)
1B2 - Seawall (5-45 years)
1B3 - Seawall (0-5 years)
1B4 - Seawall (disrepair)
2A2 - Groins (5-45 years)
2A3 - Groins (0-5 years)
2A4 - Groins (disrepair)
2C1 - Offshore Breakwater
2C2 - Offshore Breakwater
3A2 - Beach Nourishment (
3C1 - Slope/Bluff Stabilizati
3C2 - Slope/Bluff Stabilizati
4 - Protected Wetlands
5A2 - Concrete Rubble (5-4
5A3 - Concrete Rubble (0-5
5A4 - Concrete Rubble (dis
5B1 - Other Materials (>45
5B2 - Other Materials (5-45
5B3 - Other Materials (0-5 y
5B4 - Other Materials (disre
6D1 - Boat Launch (>45 yea
6D2 - Boat Launch (0-5 yea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View1
Recession Rate
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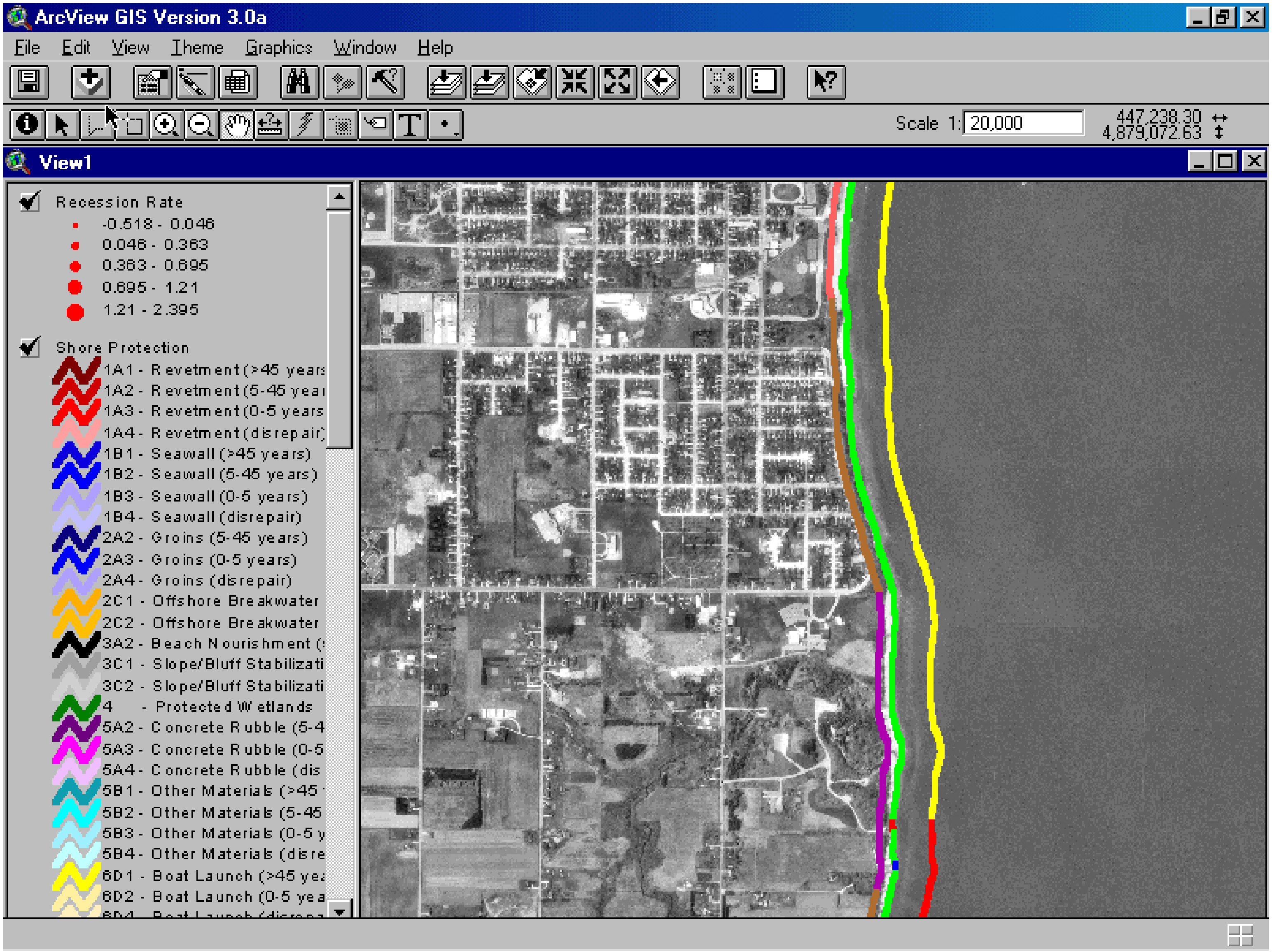
0.363 - 0.695
0.695 - 1.21
Shore Protection
1A1 - Revetment (>45 years
1A2 - Revetment (5-45 yea
1A3 - Revetment (0-5 years
1A4 - Revetment (disrepair)
1B1 - Seawall (>45 years)
1B2 - Seawall (5-45 years)
1B3 - Seawall (0-5 years)
1B4 - Seawall (disrepair)
2A2 - Groins (5-45 years)
2A3 - Groins (0-5 years)
2A4 - Groins (disrepair)
2C1 - Offshore Breakwater
2C2 - Offshore Breakwater
3A2 - Beach Nourishment (
3C1 - Slope/Bluff Stabilizati
3C2 - Slope/Bluff Stabilizati
4 - Protected Wetlands
5A2 - Concrete Rubble (5-4
5A3 - Concrete Rubble (0-5
5A4 - Concrete Rubble (dis
5B1 - Other Materials (>45
5B2 - Other Materials (5-45
5B3 - Other Materials (0-5 y
5B4 - Other Materials (disre
6D1 - Boat Launch (>45 yea
6D2 - Boat Launch (0-5 yea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View1
Recession Rate
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0.046 - 0.363
0.363 - 0.695
0.695 - 1.21
1.21 - 2.395
Shore Protection
1A1 - Revetment (>45
1A2 - Revetment (5-45
1A3 - Revetment (0-5 years
1A4 - Revetment (disrepair)
1B1 - Seawall (>45 years)
1B2 - Seawall (5-45 years)
1B3 - Seawall (0-5 years)
1B4 - Seawall (disrepair)
2A2 - Groins (5-45 years)
2A3 - Groins (0-5 years)
2A4 - Groins (disrepair)
2C1 - Offshore Breakwater
2C2 - Offshore Breakwater
3A2 - Beach Nourishment
3C1 - Slope/Bluff
3C2 - Slope/Bluff
4 - Protected Wetlands
5A2 - Concrete Rubble
5A3 - Concrete Rubble
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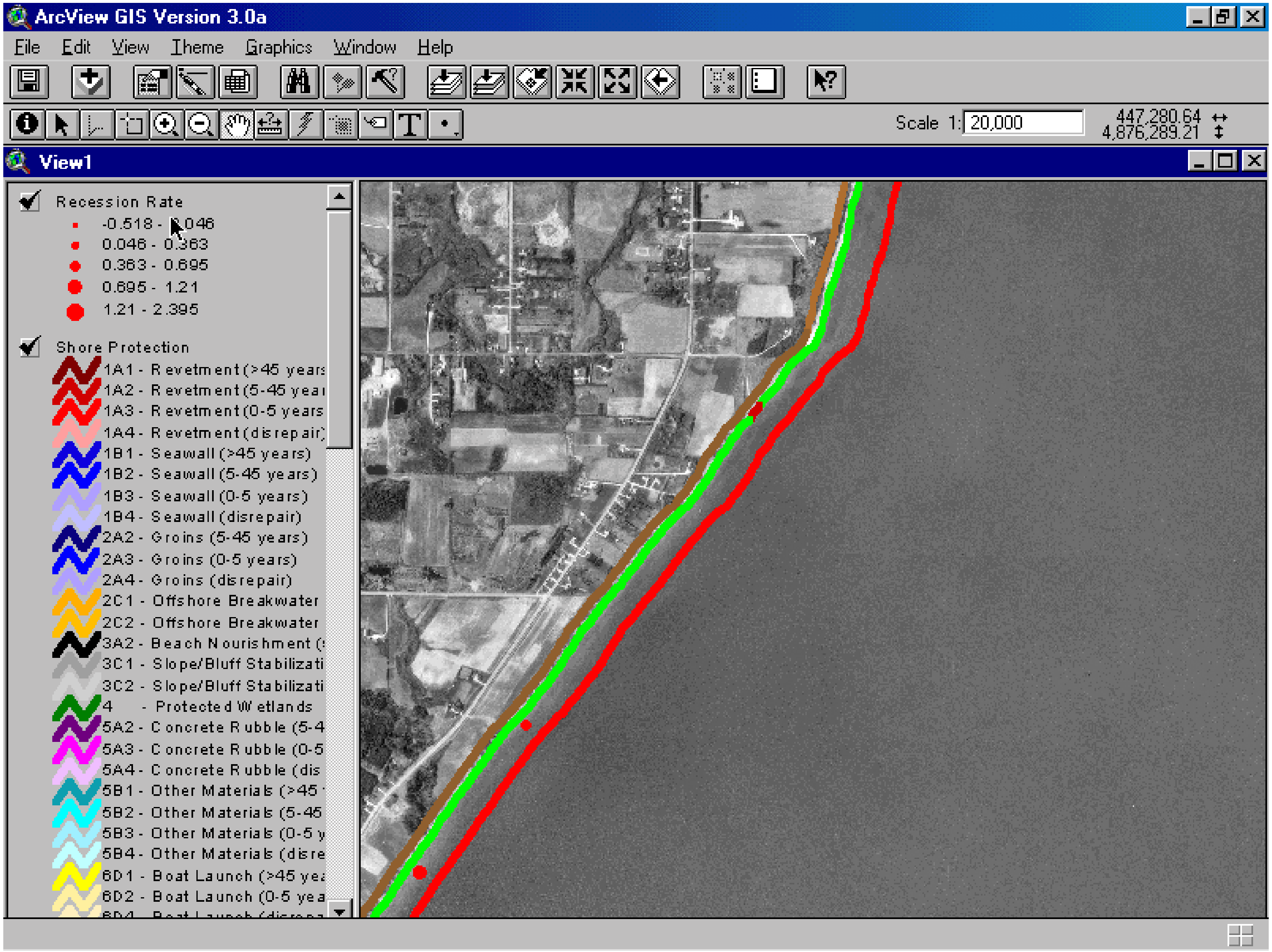
5B4 - Other Materials
6D1 - Boat Launch
6D2 - Boat Launch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Recession Rate
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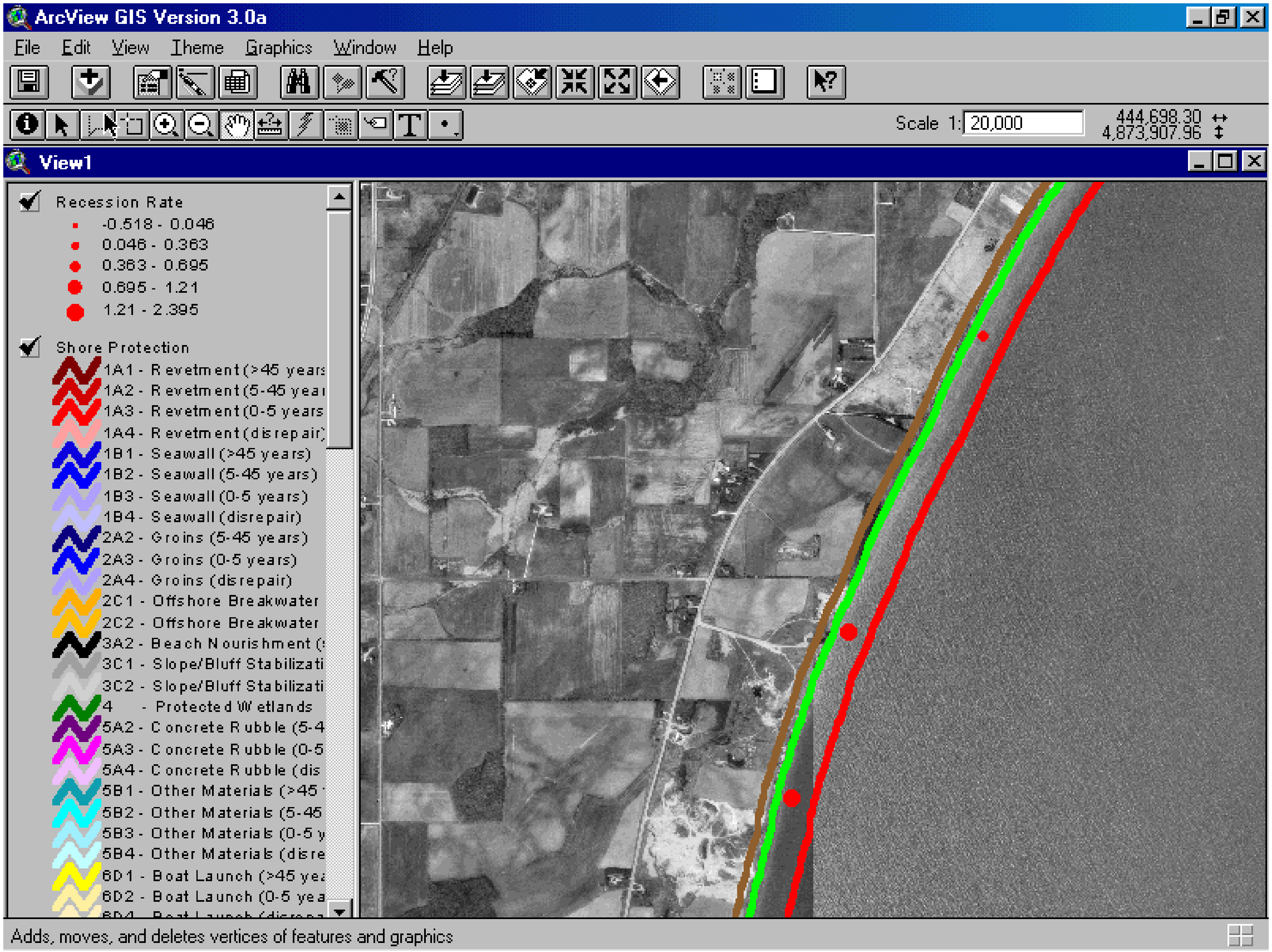
0.363 - 0.695
0.695 - 1.21
1.21 - 2.395
Shore Protection
1A1 - Revetment (>45 years
1A2 - Revetment (5-45 year
1A3 - Revetment (0-5 years
1A4 - Revetment (disrepair)
1B1 - Seawall (>45 years)
1B2 - Seawall (5-45 years)
1B3 - Seawall (0-5 years)
1B4 - Seawall (disrepair)
2A2 - Groins (5-45 years)
2A3 - Groins (0-5 years)
2A4 - Groins (disrepair)
2C1 - Offshore Breakwater
2C2 - Offshore Breakwater
3A2 - Beach Nourishment (
3C1 - Slope/Bluff Stabilizati
3C2 - Slope/Bluff Stabilizati
4 - Protected Wetlands
5A2 - Concrete Rubble (5-4
5A3 - Concrete Rubble (0-5
5A4 - Concrete Rubble (dis
5B1 - Other Materials (>45
5B2 - Other Materials (5-45
5B3 - Other Materials (0-5 y
5B4 - Other Materials (disre
6D1 - Boat Launch (>45 yea
6D2 - Boat Launch (0-5 yea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View1
Recession Rate
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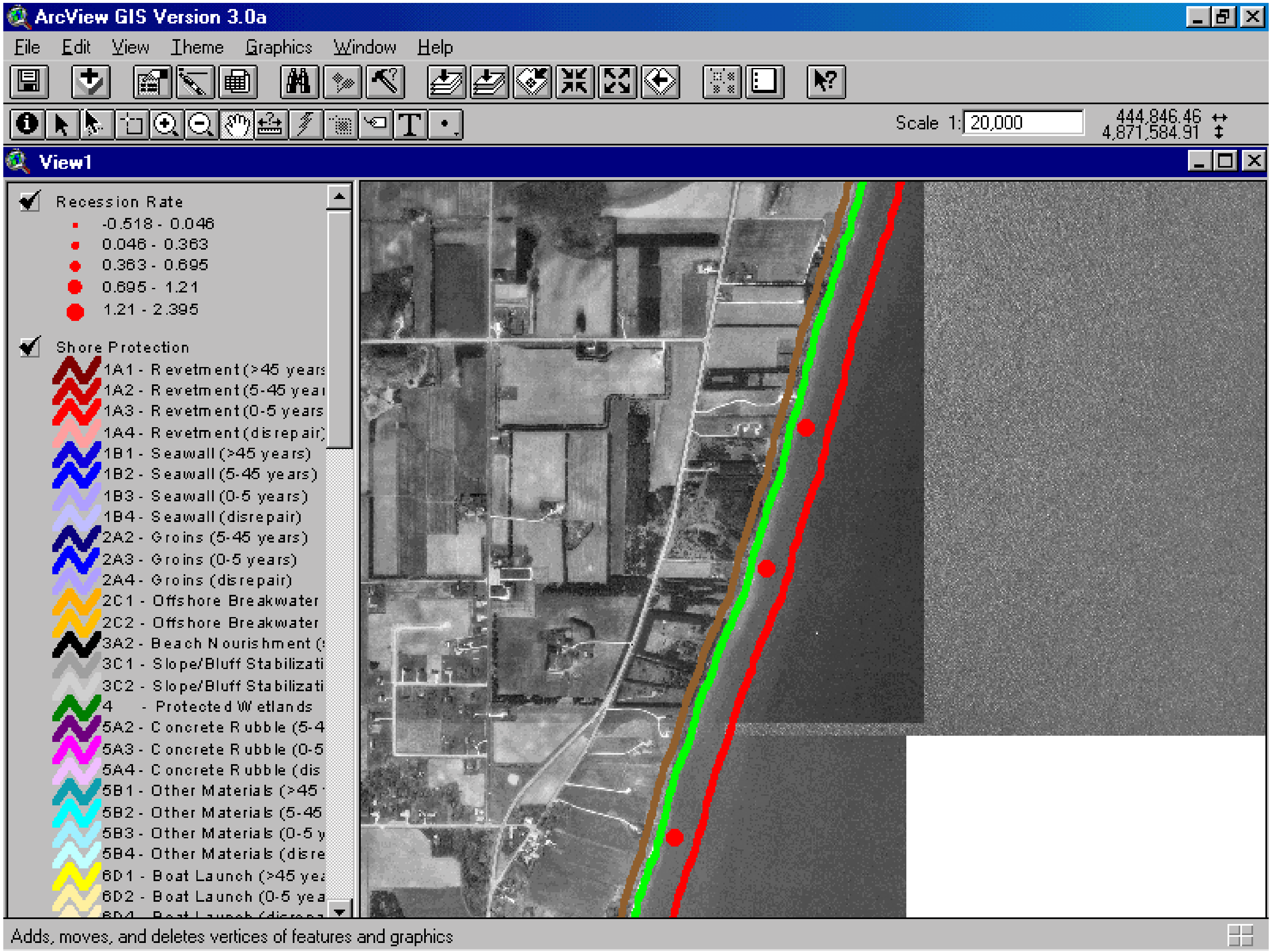
0.363 - 0.695
0.695 - 1.21
1.21 - 2.395
Shore Protection
1A1 - Revetment (>45 years
1A2 - Revetment (5-45 year
1A3 - Revetment (0-5 years
1A4 - Revetment (disrepair)
1B1 - Seawall (>45 years)
1B2 - Seawall (5-45 years)
1B3 - Seawall (0-5 years)
1B4 - Seawall (disrepair)
2A2 - Groins (5-45 years)
2A3 - Groins (0-5 years)
2A4 - Groins (disrepair)
2C1 - Offshore Breakwater
2C2 - Offshore Breakwater
3A2 - Beach Nourishment (
3C1 - Slope/Bluff Stabilizati
3C2 - Slope/Bluff Stabilizati
4 - Protected Wetlands
5A2 - Concrete Rubble (5-4
5A3 - Concrete Rubble (0-5
5A4 - Concrete Rubble (dis
5B1 - Other Materials (>45
5B2 - Other Materials (5-45
5B3 - Other Materials (0-5 y
5B4 - Other Materials (disre
6D1 - Boat Launch (>45 yea
6D2 - Boat Launch (0-5 yea
Adds, moves, and deletes vertices of features and graphics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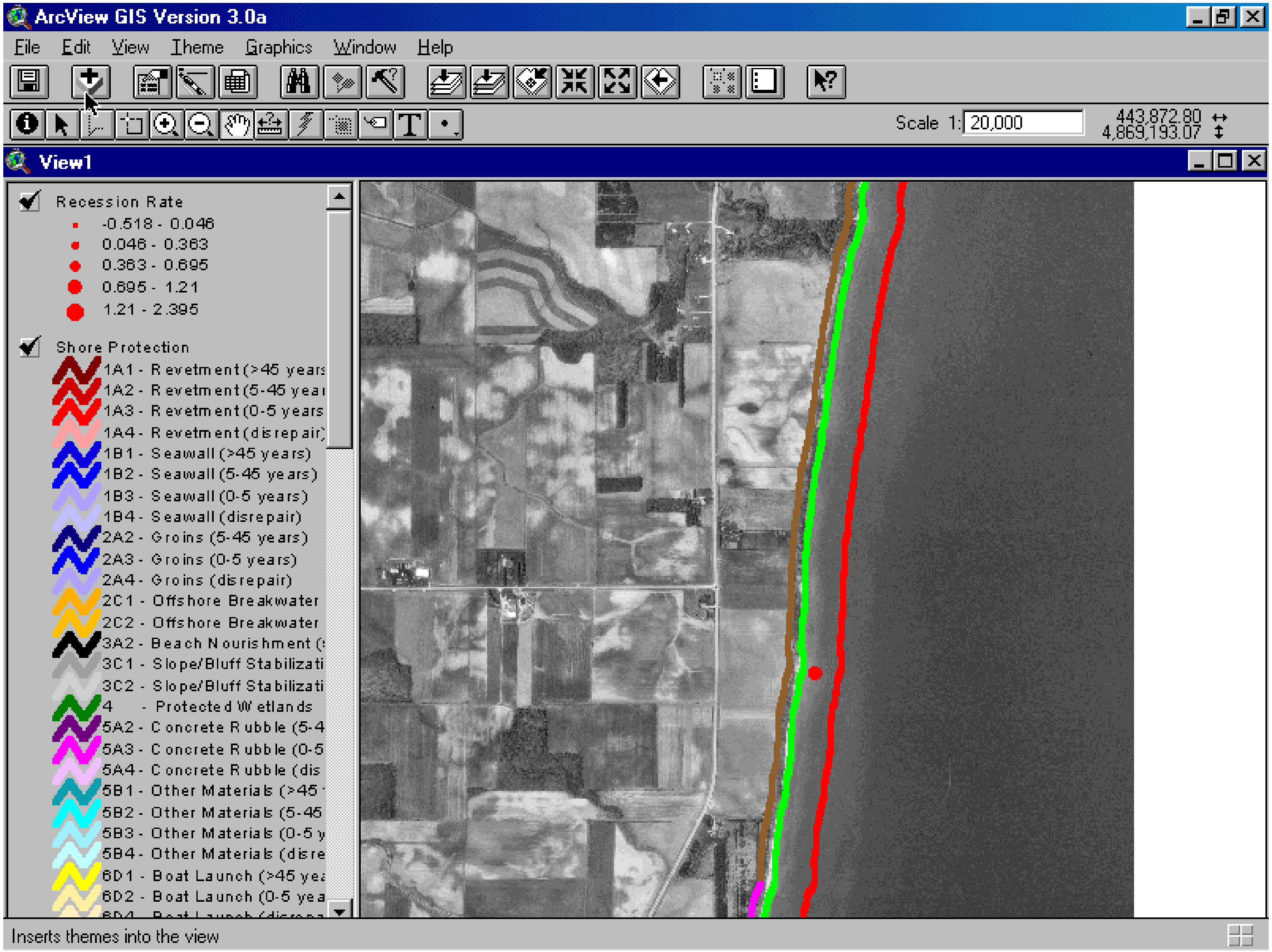
0.695 - 1.21
1.21 - 2.395
Shore Protection
1A1 - Revetment (>45 years
1A2 - Revetment (5-45 year
1A3 - Revetment (0-5 years
1A4 - Revetment (disrepair)
1B1 - Seawall (>45 years)
1B2 - Seawall (5-45 years)
1B3 - Seawall (0-5 years)
1B4 - Seawall (disrepair)
2A2 - Groins (5-45 years)
2A3 - Groins (0-5 years)
2A4 - Groins (disrepair)
2C1 - Offshore Breakwater
2C2 - Offshore Breakwater
3A2 - Beach Nourishment (
3C1 - Slope/Bluff Stabilizati
3C2 - Slope/Bluff Stabilizati
4 - Protected Wetlands
5A2 - Concrete Rubble (5-4
5A3 - Concrete Rubble (0-5
5A4 - Concrete Rubble (dis
5B1 - Other Materials (>45
5B2 - Other Materials (5-45
5B3 - Other Materials (0-5 y
5B4 - Other Materials (disre
6D1 - Boat Launch (>45 yea
6D2 - Boat Launch (0-5 yea
Adds, moves, and deletes vertices of features and graphics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Recession Rate
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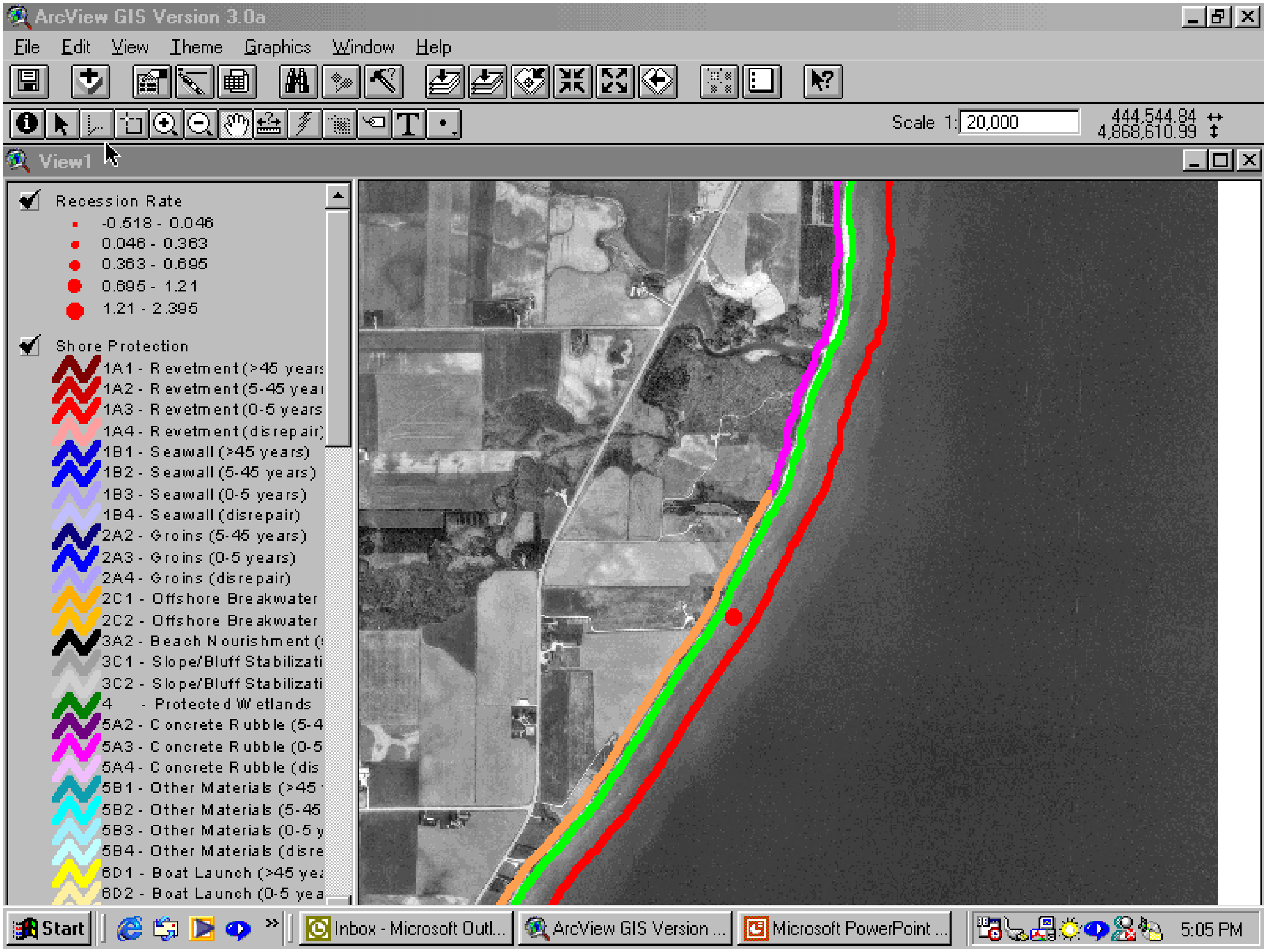
0.695 - 1.21
1.21 - 2.395
Shore Protection
1A1 - Revetment (>45 years
1A2 - Revetment (5-45 year
1A3 - Revetment (0-5 years
1A4 - Revetment (disrepair)
1B1 - Seawall (>45 years)
1B2 - Seawall (5-45 years)
1B3 - Seawall (0-5 years)
1B4 - Seawall (disrepair)
2A2 - Groins (5-45 years)
2A3 - Groins (0-5 years)
2A4 - Groins (disrepair)
2C1 - Offshore Breakwater
2C2 - Offshore Breakwater
3A2 - Beach Nourishment (
3C1 - Slope/Bluff Stabilizati
3C2 - Slope/Bluff Stabilizati
4 - Protected Wetlands
5A2 - Concrete Rubble (5-4
5A3 - Concrete Rubble (0-5
5A4 - Concrete Rubble (dis
5B1 - Other Materials (>45
5B2 - Other Materials (5-45
5B3 - Other Materials (0-5 y
5B4 - Other Materials (disre
6D1 - Boat Launch (>45 yea
6D2 - Boat Launch (0-5 yea
Inserts themes into the view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0.363 - 0.695
0.695 - 1.21
1.21 - 2.395
Shore Protection
1A1 - Revetment (>45 years
1A2 - Revetment (5-45 yea
1A3 - Revetment (0-5 years
1A4 - Revetment (disrepair)
1B1 - Seawall (>45 years)
1B2 - Seawall (5-45 years)
1B3 - Seawall (0-5 years)
1B4 - Seawall (disrepair)
2A2 - Groins (5-45 years)
2A3 - Groins (0-5 years)
2A4 - Groins (disrepair)
2C1 - Offshore Breakwater
2C2 - Offshore Breakwater
3A2 - Beach Nourishment (
3C1 - Slope/Bluff Stabilizati
3C2 - Slope/Bluff Stabilizati
4 - Protected Wetlands
5A2 - Concrete Rubble (5-4
5A3 - Concrete Rubble (0-5
5A4 - Concrete Rubble (dis
5B1 - Other Materials (>45
5B2 - Other Materials (5-45
5B3 - Other Materials (0-5 y
5B4 - Other Materials (disre
6D1 - Boat Launch (>45 yea
6D2 - Boat Launch (0-5 yea
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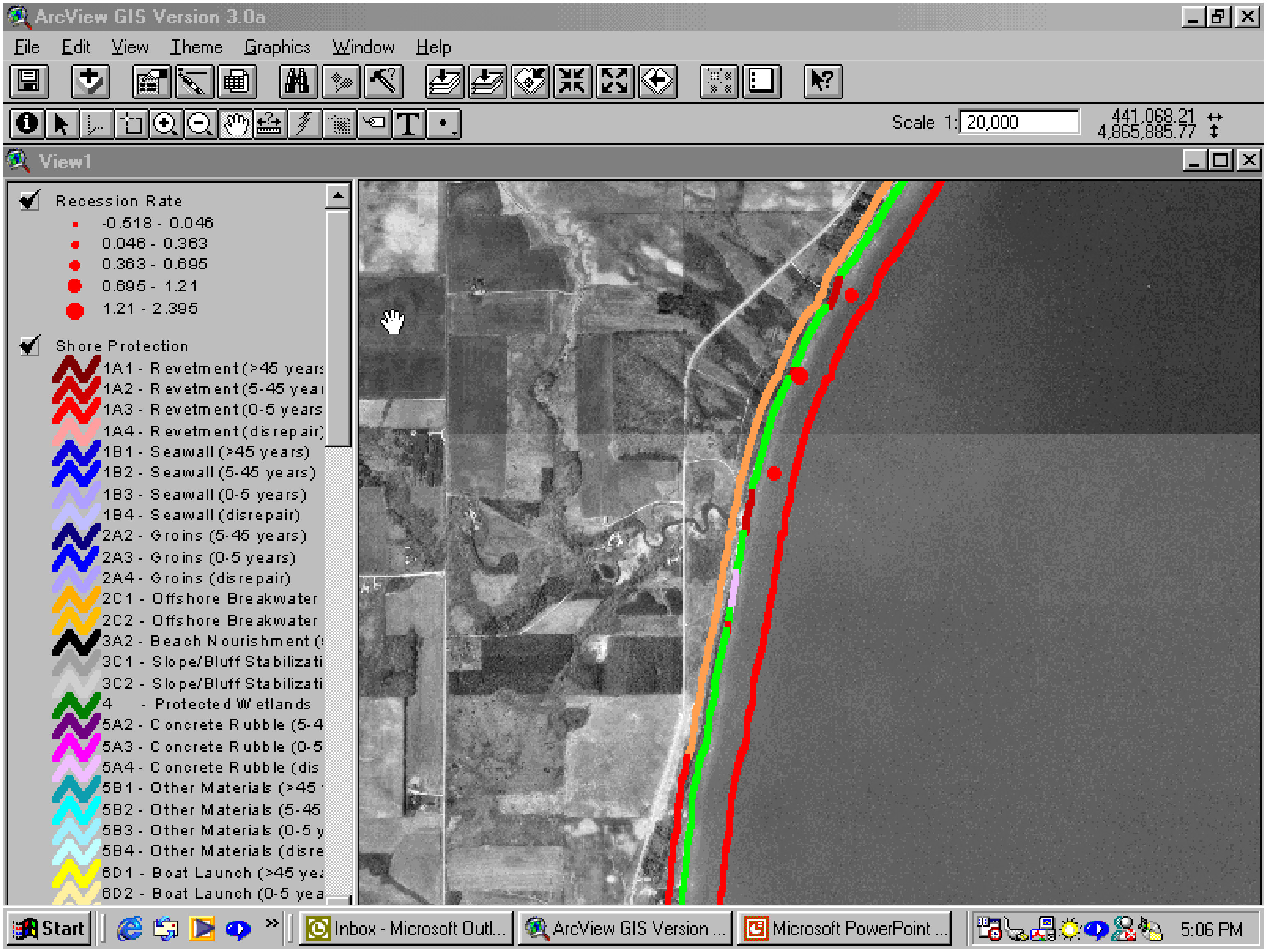
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0.046 - 0.363
0.363 - 0.695
0.695 - 1.21
1.21 - 2.395
Shore Protection
1A1 - Revetment (>45 years
1A2 - Revetment (5-45 yea
1A3 - Revetment (0-5 years
1A4 - Revetment (disrepair)
1B1 - Seawall (>45 years)
1B2 - Seawall (5-45 years)
1B3 - Seawall (0-5 years)
1B4 - Seawall (disrepair)
2A2 - Groins (5-45 years)
2A3 - Groins (0-5 years)
2A4 - Groins (disrepair)
2C1 - Offshore Breakwater
2C2 - Offshore Breakwater
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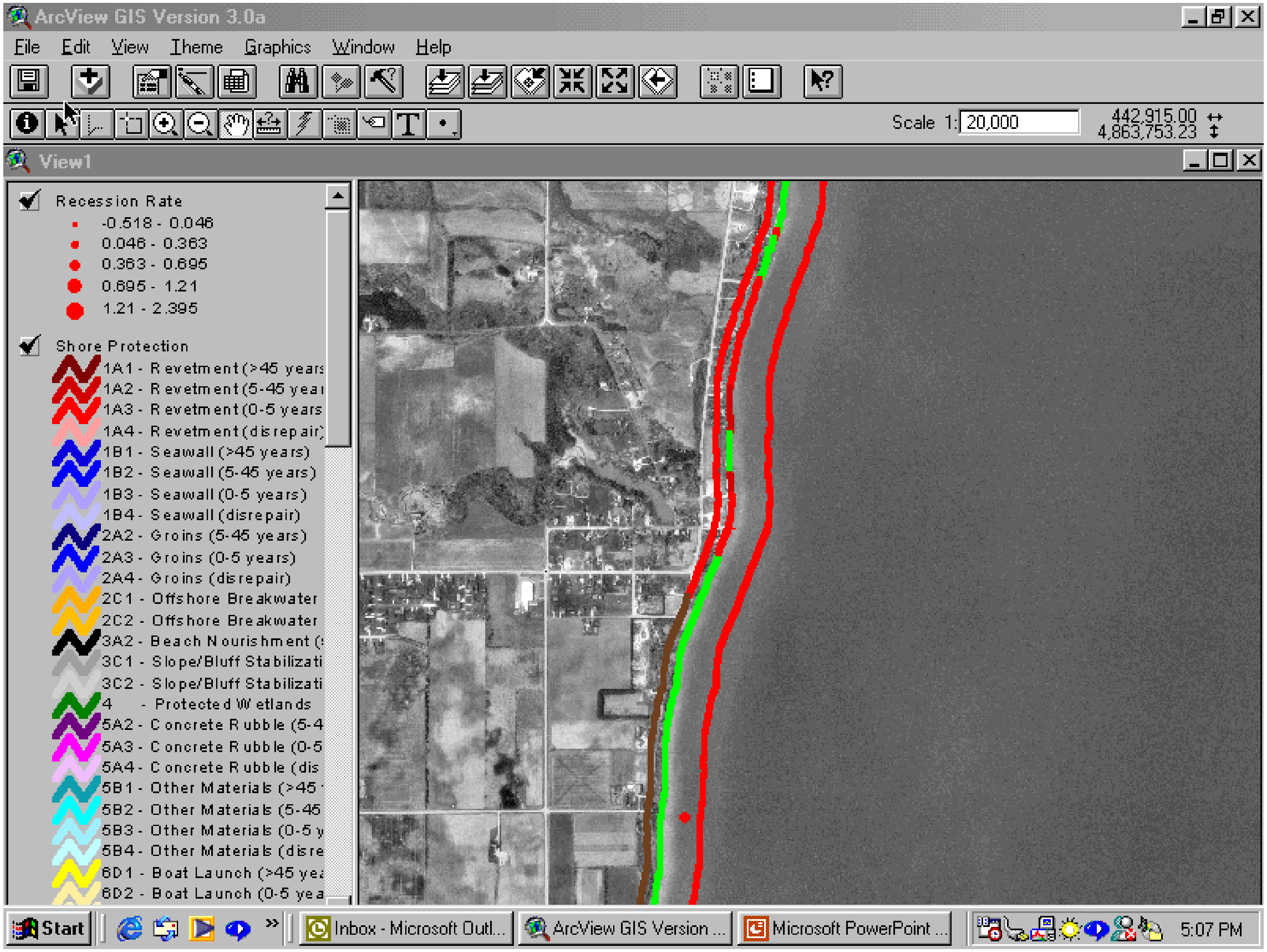
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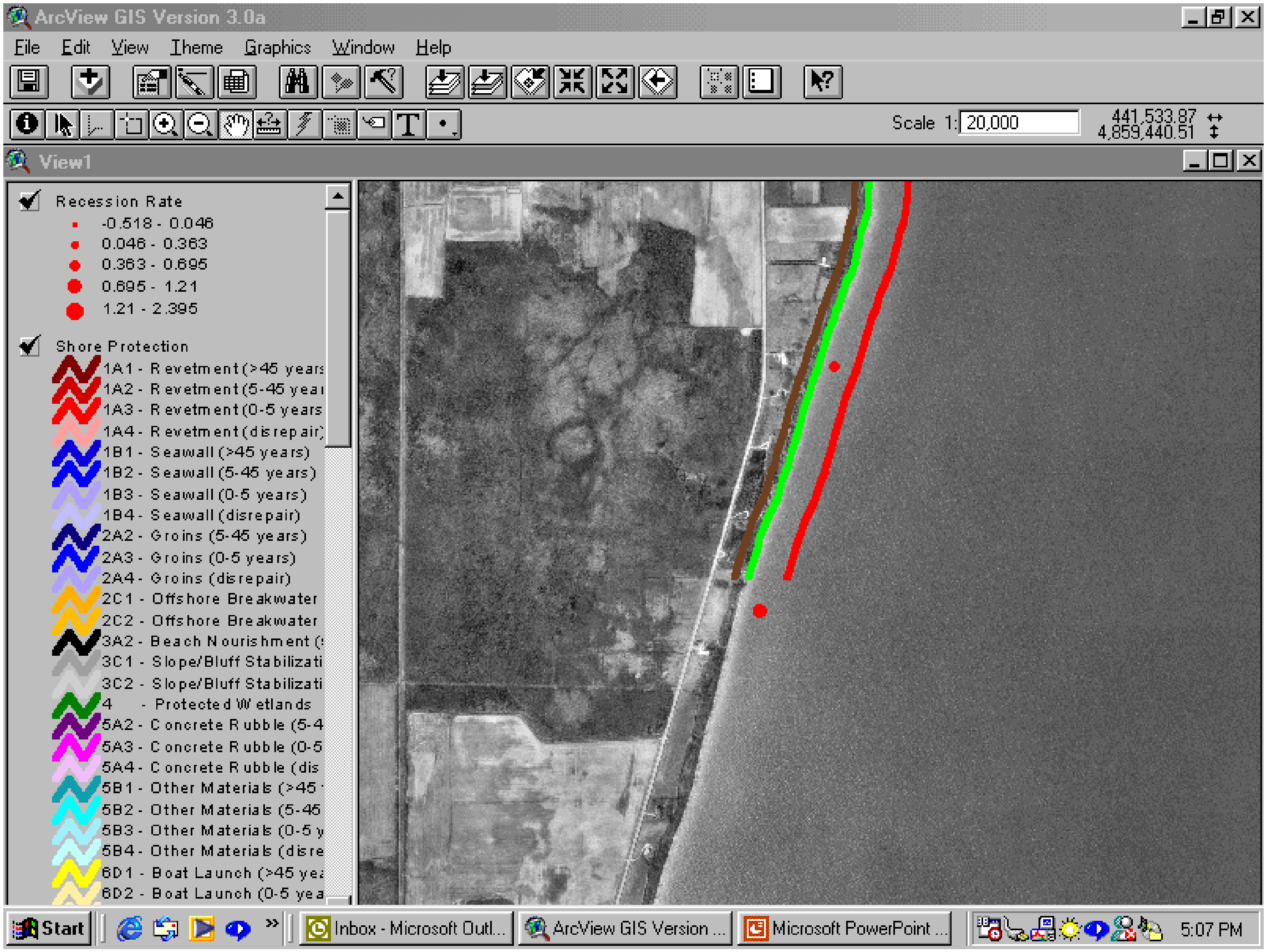
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