Find Your Watershed Activity for the Science Museum of Minnesota's Map Lab

University of Minnesota
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Daphne Karypis
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ABSTRACT

The Science Museum of Minnesota (SMM) created a Map Lab consisting of Geographic Information System (GIS) technology in September of 1997. One of the goals of the Map Lab is to produce public programs in which museum visitors gain access and exposure to digital geographic information of personal interest to them. In order to achieve this goal, the SMM needed a user-friendly, hands-on GIS exhibit piece. This paper discusses the background and procedures involved in constructing the "Find Your Watershed" activity, a customized ArcView application currently on exhibit within the SMM.

INTRODUCTION

The Science Museum of Minnesota is one of the Midwest's most popular museum attractions whose mission is to invite learners of all ages to discover their world through science. The SMM takes risks to encourage innovation and discovery and values stewardship of the world's natural environment and cultures. A recent technology brought to the SMM to achieve its mission is GIS.

GIS entered the SMM in September of 1997 when it produced the SMM Map Lab through a Legislative Commission on Minnesota Resources grant. The goal of the Map Lab is to educate the public on environmental and cultural issues through the use of GIS and consists of three distinct program initiatives: 1) Public programs in which museum visitors gain access and exposure to digital geographic information of personal interest to them, 2) A GIS training facility to serve the needs of targeted audiences, and 3) A center for the applied research of spatial data.

Three key organizations help launch the SMM Map Lab: Environmental Systems Research Institute (ESRI), the Minnesota Department of Natural Resources (DNR), and the University of Minnesota's Center for Urban and Regional Affairs (CURA). ESRI supplied the museum with

GIS software and technical assistance. The DNR also provided technical assistance to the museum as well as software extensions and over 60 gigabytes of data. CURA Research Assistants utilized the Map Lab's GIS resources (e.g. data, software, printers, and plotters) to work on various projects on the museum floor, allowing museum visitors to view real-life project applications.

The data and projects occupying the Map Lab exhibit space successfully initiated GIS activity in the museum, but the unstructured deliverance and complexity of large data amounts made it difficult and time consuming for the average SMM visitor to navigate. In order to expose museum visitors to digital geographic information of personal interest to them, the SMM needed to develop a GIS exhibit piece. This piece needed to be user-friendly and capable of portraying data in a simplified context.

The SMM has a history of conducting watershed projects, most notably through its St. Croix Watershed Research Station, and wanted to extend watershed research and education through the Map Lab. CURA's Sustainable Lakes Project provided an opportunity for this. The Sustainable Lakes Project was an effort to utilize geographic data to produce lake management plans. Watersheds were used as the planning boundary. Research Assistants created many of the watershed maps created for the Sustainable Lakes Project on the museum floor and the public showed great interest.

During the spring of 1999, I was a Research Assistant for the Sustainable Lakes Project and student of the University of Minnesota's Masters of Geographic Information Science program. Seeing the SMM desire for a watershed education tool, I volunteered my services to produce a GIS application that would display information useful in lake management at a local level and assist SMM visitors to better understand their watershed environment. In the fall of 1999, I was

hired as the SMM's GIS Specialist to continue this and other work. The result of this effort is a "Find Your Watershed" activity that uses GIS to display 20 maps for any minor watershed in the state. The activity also includes informational display pieces that convey the concept of watersheds and comprehensive lake management plans.

BACKGROUND

The Sustainable Lakes Project underlying the "Find Your Watershed" activity utilized GIS to produce lake management plans. Many of the planning concepts used in the Sustainable Lakes Project are portrayed through the "Find Your Watershed" activity and are discussed below.

Comprehensive Lake Management Plans and Sustainable Development

There is an increasing awareness of the need for comprehensive lake management plans. Minnesota Planning states, "comprehensive strategies should be developed to coordinate water resources based on sustainable development principles and focused on resource systems," (*Soundings: A Minnesota Water Plan Assessment,* Minnesota Planning, Environmental Quality Board, p.14). Whether coordinated or autonomous efforts, planners are incorporating the underlying principles of sustainable development into decision making to ensure success.

Sustainable development is a relatively recent concept, which increasingly dominates planning practices at all levels within Minnesota. The Community-Based Planning Act of 1997 sets forth a framework intended to integrate sustainable development principles into local comprehensive plans. The definition of sustainable development as found in Minnesota Statute 4A.97, subd. 1 is: "development that maintains or enhances economic opportunity and community well-being while protecting and restoring the natural environment upon which people and economies depend. Sustainable development meets the needs of the present without compromising the ability of future generations to meet their own needs", (*Sustainable Development: The Very Idea.*

Minnesota Planning, Environmental Quality Board, 1998). Goals of sustainable development include: 1) Provide a high quality of life for present and future generations without exceeding the environment's ability to recycle wastes, 2) Provide resources and support a rich diversity of life, and 3) Meet current needs while leaving future generations as many options for resource use and development as possible. Sustainable development is an ambitious process in which a community develops attitudes and ongoing actions that strengthen its natural environment, economy, and social well-being. Benefits include more livable communities, lower costs, and an environment safe for future generations.

Minnesota Planning is attempting to coordinate watershed planning efforts at the county and watershed district level. Legislation has forced organizations to deal with watershed management. In the early 1990s, the Legislature mandated the Environmental Quality Board, a division of Minnesota Planning, to develop a statewide water plan every ten years. All counties, except Ramsey and Hennepin, are required by law to assume watershed planning duties. So far two counties, Scott and Carver, have (*Soundings: A Minnesota Water Plan Assessment,* Minnesota Planning, Environmental Quality Board, p.14).

There are numerous government sectors that concentrate on individual aspects related to lake planning and are improving their part in lake management. Various organizations have enhanced their water monitoring. The Minnesota Pollution Control Agency made a number of significant changes to its surface water quality-monitoring program and shifted to a basin management approach. The Department of Agriculture expanded the areas monitored for pesticides and nutrients through a state and local partnership called Local Monitoring Cooperatives. The Department of Health has increased its efforts to automate the well record database and plans to have well data accessible through a web site next year. All of these advancements improve

specific aspects related to lake management, but are not integrated. The lack of integration makes it difficult to integrate the principles of sustainable development.

The Sustainable Lakes Project

The goal of the Sustainable Lakes Project was to integrate data relating all aspects of lake management into a GIS for storage, mapping, and analysis to assist lake association members in creating comprehensive lake management plans for local, grassroots planning for five pilot lakes.

Data was obtained on three categories: lake basin, lakeshore parcel, and watershed. Lake basin data including depth contour, high/low water maps, aquatic plant inventories, water quality data, and other observations already available on the pilot lakes were used in the overall assessment of lake basin characteristics and land use impacts to water quality. Lakeshore parcel data was gathered on the concept that each individual lakeshore property owner is a mini land use manager and what happens on his or her parcel of land is the basic level of lake management (See Appendix A for data and maps created by basin and parcel). Assuming that water quality and land use practices in a lake's watershed are directly related, watershed data was collected on resource characteristics, land use, and public management for later analysis and comparison to other data.

Watershed maps served as a key tool for the five pilot lake associations in the Sustainable Lakes Project. The maps defined the nearest land area impacting each lake, and helped illustrate what goes on in each watershed (e.g. land use activities) that directly impacts the quality of water runoff into the lake and in turn the water quality of the lake. The watershed maps produced further defined current and potential water and land use problems that can affect each lake through its watershed.

Find Your Watershed Activity

Of the three data types obtained for lake management by the Sustainable Lakes Project (lake basin, lakeshore parcel, and watershed), watershed data was the most complete and available. It was also integrated in the SMM's GIS on a statewide basis. The statewide availability of the data made a customized project possible for any MN citizen to view his/her watershed. An aspiration of the Sustainable Lakes Project was to provide lake associations outside the pilot study with watershed maps. Believing the SMM would be an excellent place to educate the public on watersheds and lake management issues and a possible venue to provide lake associations with watershed maps, I decided to produce a "Find Your Watershed" activity for the SMM under the direction of Joel Halvorson, the SMM's Map Lab coordinator.

The "Find Your Watershed" activity applies the methods used in creating the Sustainable Lakes Project watershed maps statewide. The statewide maps are integrated into a modified ArcView interface with step-by-step instructions that enable museum visitors to select a watershed of interest and view maps. The application begins on a display of major North American river basins and guides the user to the minor watershed level through a city choice list. Once the user selects a minor watershed of interest, a map list appears allowing the user to select individual maps for viewing.

Three posters and an informational flip chart accompany the application to aid users in understanding watersheds and lake management. The three posters ask simple questions on one side including: "Does water flow north?", "Which city is downstream from North Dakota?", and "Where does the water flow where you live?" and provide simple answers on the other. The informational flip chart includes instructions that guide the user through the application and a map section that describes the importance of each map in lake management. The map section

was modified from a portion of the Sustainable Lakes Project planning guidebook, which is provided in Appendix B.

The "Find Your Watershed" GIS application includes two major tasks: generating raw data into maps and Avenue coding. To avoid timely processing time when using the activity, maps were generated statewide and placed within the application instead of produced for a specific watershed on the fly. To create the customized application the SMM was looking for, I manipulated ArcView's interface through existing editing functions and learned Avenue to create scripts and run my own functions. Of the two major tasks involved in this project, customizing the ArcView application through Avenue scripts took the most time.

This paper describes the "Find Your Watershed" application in two parts: maps and user interface. The watershed map part details the procedures in producing 20 Sustainable Lakes Project maps statewide. The user interface part explains the methods used in coding the "Find Your Watershed" activity into an easy-to-use application. A discussion section is provided at the end.

Specifically this paper:

1. Describes the methods used in creating the 20 statewide maps.
2. Details the screen and script chronology throughout the "Find Your Watershed" activity
3. Analyzes the functionality of the "Find Your Watershed" activity as an exhibit piece.
4. Analyzes the legends used for the statewide maps in the "Find Your Watershed" activity and projects their functionality within individual watershed maps.

MAPS

Each map was created over a base map consisting of major roads, county roads, township roads, lakes, rivers, state trails, and minor watershed boundaries, except for the *USGS Topography* and *Aerial Photography* maps, which maintain only minor watershed boundaries in its base map (See Appendix D for base map layer descriptions). The maps are broken down into simple and

complex. Simple maps are created through one dataset or image supplied by the DNR requiring no manipulation of data. Complex maps are the result of combining two or more datasets or transforming one dataset through a calculation (Table 1).

Table 1: Simple and Complex Statewide Maps Created for the "Find Your Watershed" Activity

Simple Maps	Complex Maps
1. Forest Cover	1. Aerial Photography
2. Geomorphology	2. Area Roughness
3. Government Political Boundaries	3. Erosion (Runoff) Susceptibility and Water Orientation
4. Land Use	4. Groundwater Contamination Potential
5. Pre-Settlement Vegetation	5. Public Ownership
6. Soils	6. Scenically Attractive Areas
7. Water Features	7. Scenically Attractive Private Land Within ¼ Mile from a Road
	8. Scenically Attractive Public Land Within ¼ Mile from a Road
	9. Scenically Attractive Public Land Over ¼ Mile from a Road
	10. Shaded Relief
	11. Road Septic Tank Suitability
	12. Slope
	13. Topography

With the exception of soils data, the same datasets used to create the watershed maps for the Sustainable Lakes Project were used to create the statewide maps for the "Find Your Watershed" activity (See Appendix C for basic metadata of each dataset used in the "Find Your Watershed" Activity). The Sustainable Lakes Project manually digitized County Soil Survey maps for two of the pilot lake watershed areas. Since duplicating this procedure for the entirety of the state is not

feasible for this project, less detailed soils data were used as an alternative. In addition, some of the datasets used in creating the statewide maps are generalized with fewer classifications and some map images at the statewide level are less detailed. These maps include *Soils*, *Land Use*, *Forest Cover*, and *Shaded Relief* (Table 2).

Table 2: Map differences in the Sustainable Lakes Project and the "Find Your Watershed" Activity.

Map	Sustainable Lakes Project	"Find Your Watershed"
Soils	County Soil Survey data	MLMIS 40 acre soils data
Land Use	10 – 15 classifications	8 classifications
Forest Cover	4 – 8 classifications	2 classifications
Shaded Relief	Highly enhanced	Moderately enhanced

The same methods were used in creating the statewide "Find Your Watershed" maps (with the exception of the *Erosion (Runoff) Susceptibility and Water* Orientation map), as with creating maps for each pilot lake watershed in the Sustainable Lakes Project. Maps were created either within or independently of the ArcView project and, once completed, placed as a theme within separate views for functionality within the scripted "Find Your Watershed" application. This section lists the datasets and legend classification scheme used in creating each map as well as the methods used in creating complex maps and accessing USGS topography and aerial photography images.

Simple Maps

1. Forest Cover

dataset(s) used: Land Use/Land Cover
legend: A unique value legend was created by reclassifying the Land Use/Land Cover dataset into forested and non-forested categories.

2. Geomorphology

dataset(s) used: Geomorphology of Minnesota
legend: A unique value legend was created using the Geomorphic Association (geo_assoc) value field. The geomorphic association field is comprised of 22 classifications, each colored differently with a transparent outline.

3. Government Political Boundaries

dataset(s) used: Minor Civil Divisions
legend: A unique value legend type using the Bountiful Harvest coloring scheme is used to display the cities, towns, and townships within Minnesota. The *auto label* feature was used to label all cities, towns, and townships.

4. Land Use

dataset(s) used: Land Use/Land Cover
legend: A unique value legend was created using the *map_code* value field that is composed of eight land type classifications. A DNR color and labeling scheme, which gives unique colors to nine values: unknown, urban and rural development, cultivated land, hay/pasture/grassland, brushland, forested, water, bog/marsh/fen, and mining was used to create the legend.

5. Pre-Settlement Vegetation

dataset(s) used: Vegetation at the time of the PLS Survey
legend: A unique value legend was created using the *class* value field that is composed of 18 land type classifications. A DNR color and labeling scheme, which gives unique colors to the 18 values: undefined, prairie, wet prairie, brush prairie, aspen-oak land, aspen-birch (trending to hardwoods), aspen-birch (trending to conifers), oak openings and barrens, big woods-hardwoods (oak, maple, basswood, hickory), mixed hardwood and pine (maple, white pine, basswood, etc.), white pine, mixed white pine and red pine, jack pine barrens and openings, pine flats (hemlock, spruce, fir, white pine, aspen), open muskeg, conifer bogs and swamps, river bottom forest, and lakes (open water).

6. Soils

dataset(s) used: Soil Landscape Units
legend: A unique value legend was created by breaking down the *soillu* value field into 14 classifications based on surface and subsurface soil texture. Different graduated color sets by soil type were used to display the data. Clay over clay, clay over loam, clay over sand, and clay over bedrock classifications range from light to dark green. Loam over clay, loam over loam, loam over sand, and loam over bedrock range from light to dark brown. Sand over clay, sand over loam, sand over sand, and sand over bedrock range from light to dark yellow. Two separate categories are assigned to wetlands and undifferentiated areas.

7. Water Features

dataset(s) used: National Wetlands Inventory Polygons
legend: A unique value legend was created using the Circular 39 value field that outlines wetland basins of the U.S. A DNR color and labeling scheme, which gives unique colors to twelve values: uplands, wet meadow, wooded swamp, shrub swamp, shallow marsh, deep marsh, bogs, shallow open water, riverine systems, seasonally flooded, municipal and industrial activities, and unclassified was used to create the unique legend.

Complex Maps

8. Aerial Photography

dataset(s)used: Digital Orthophoto Quadrangles
procedures: The DNR DOQ/DRG extension, that references the appropriate DOQ and/or DRG image file by interpreting a user specified area, is used to access aerial photographs for each selected watershed area.
legend: No legend was created for the *Aerial Photography* map.

9. Area Roughness

dataset(s) used: 30 Meter Digital Elevation Model

procedures: To create the *Area Roughness* map, statewide DEM data was first converted from feet to meters to coincide with the map unit properties within the ArcView application. Next, the *neighborhood statistics* calculation, located under the *analysis* menu within ArcView's view project window, was used on the DEM data. The *neighborhood statistics* calculation invokes a dialog box requiring the completion of four information fields: statistic, neighborhood, width, and height. To create the *Area Roughness* map the following were inputted into the four information fields respectively: range, circle, 0.25, and 0.25 (mile distance units). The resulting analysis, based on the four input fields, computes a new value for each pixel within the grid based on the absolute value range difference of all pixels within a quarter-mile radius of the roving kernel.

legend: A graduated color legend, labeled flat, gently rolling, and steep coinciding with values 0-12, 12-24, and 24-213 respectively were used to classify the data. Values are in meters.

10. Erosion (Runoff) Susceptibility and Water Orientation

dataset(s) used: 30 Meter Digital Elevation Model, Land Use/Land Cover, and DLG Derived Lakes.

procedures: The *map calculator* dialog located under the *analysis* menu with ArcView's view **project window** aids in the creation of an expression that produces a new output grid theme. The expression can be based on a single grid or multiple grid themes. Three binary grid themes were created for use within the *map calculator* dialog to produce the *Erosion (Runoff) Susceptibility* map: slope, land use, and water buffer. The two values for the binary slope theme are < 8% and > 8%. The two values for the binary land use theme are urban and rural development or cultivated land and non-urban and rural development or cultivated land. The two values for the binary water buffer theme are areas within a quarter-mile of a lake or stream and areas over a quarter-mile of a lake or stream.

The binary slope theme was created by reclassifying the *Slope* map using the *reclassify* option under the *analysis* menu and converting it to a grid theme through the *convert to grid* option under the *theme* menu. Reclassifying and converting the *Land Use* map in the same manner created the binary land use theme. The binary water buffer theme was created in Arc/Info using the DLG Derived Lakes and DLG Hydrography lake and wetland – lines datasets.

To create the binary water buffer theme in Arc/Info, the two datasets were first converted from shapefiles to Arc/Info coverages using the *shapearc* command. The coverages were then merged to create a new coverage consisting of all DLG Derived Lakes and DLG Hydrography lake and wetland - lines. Next, the new coverage was broken down into two additional coverages, each consisting of approximately half of the total merged line segments, to reduce the processing time and fall within Arc/Info's computational limits required by buffering the line segments. The *buffer* command was used on each line coverage to create two quarter-mile line buffer coverages, each consisting of a new item within their attribute table with values for buffered and non-buffered features. Each was built with polygon topology and checked for identical item name and attribute value labeling for buffered and non-buffered features. If the variables did not match, they were changed to coincide with each other. Next, the *union* command was used to bring the buffered coverages together into a new theme consisting of the same values for buffered and non-buffered areas. The resulting coverage was built with polygon topology, converted to grid *(arcgrid)*, and brought into ArcView resulting in the final binary theme needed for use with the *map calculator* dialog.

Once the binary slope, land use, and water buffer grid themes were created, the following expression was placed within the *map calculator* dialog box to create a new output grid theme:

([SlopeThemeName] + [LandUseThemeName] + [WaterBufferThemename]). The addition mathematic operator in this expression applies a mathematical operation to the binary values in each of the input themes resulting in an output theme consisting of attribute values for all possible input value combinations. Eight output value combinations resulted: <8% slope and urban or cultivated land and within ¼ mile of water, <8% slope and non-urban or cultivated land and over ¼ mile of water, <8% slope and urban or cultivated land and over ¼ mile of water, <8% slope and non-urban or cultivated land and within ¼ mile of water, >8% slope and urban or cultivated land and within ¼ mile of water, >8% slope and non-urban or cultivated land and over ¼ mile of water, >8% slope and urban or cultivated land and over ¼ mile of water, and >8% slope and non-urban or cultivated land and within ¼ mile of water.

legend: A unique value legend was used to create seven low, medium, and high erosion (runoff) susceptibility classifications. Elements considered susceptible to erosion include >8% slope and urban or cultivated land. Low classifications consist of no elements susceptible to erosion, medium classifications consist of one element susceptible to erosion, and high classifications consist of two elements susceptible to erosion. A color-coding scheme was used to highlight areas susceptible to erosion near water.

11. Groundwater Contamination Potential

dataset(s) used: Soil Landscape Unit

procedures: Soil Landscape Unit data are based upon four fields of information: soil texture below five feet, soil texture above five feet, drainage, and surface color. Surface soil texture above five feet was used to create the *Groundwater Contamination Potential* map. The *Septic Tank Suitability* map, created with the same Soil Landscape data, uses texture below and above five feet to rank septic tank suitability. In order to easily classify data for both maps, subsurface and surface values were combined in a newly added field. New field values were assigned by adding the subsurface and surface field values through the field calculator dialog box. For records having no values in the subsurface and surface fields, the associated legend field values, peat and rock, were assigned.

legend: A unique value legend including low, moderate, high, and water/wetlands/marsh/pear/alluvial classifications is used to display groundwater contamination potential. Low classifications include any soil unit with a clayey surface soil (CC, LC, XC, and RC). Moderate classifications include any soil unit with a loamy surface soil (LL, SL, XL, CL, YL, and RL). High classifications include any soil unit with a sand or iron surface texture (SC, LS, SS, RS, and MD). Water/wetlands/marsh/pear/alluvial classifications included any surface with a peat, hydrated soil, bedrock, or alluvial texture (AP, BP, LP, NP, SP, HH, RB, MM, AA, PEAT, or ROCK).

12. Public Ownership

dataset(s) used: Minnesota Public Lands

procedures: Public Ownership data includes an agency name value field (*Agen*_name) that includes close to 100 different agency name values. This field was used to define variables for a newly generate data field. Values for this field include: federal, state, county, tribal, and private conservancy.

legend: A bright colored unique value legend scheme was created using the newly generated data field to create five classifications of ownership: federal, state, county, tribal, and private conservancy.

13. Scenically Attractive Areas

dataset(s) used: 30 Meter Digital Elevation Model , Land Use/Land Cover, DLG Derived Lakes, and DLG Hydrography lake and wetland – lines.

procedures: Similar procedures to creating the *Erosion (Runoff) Susceptibility and Water Orientation* map were used in creating the *Scenically Attractive Areas* map. A binary area roughness theme was created with values 0 – 12 and 12 – 213. A binary land use theme was created with values forested and non-forested. The same water buffer theme was used as in the creation of the *Erosion (Runoff) Susceptibility and Water Orientation* map. The forest and roughness themes were created in ArcView and applied in the following *map calculator* function to produce a new grid theme consisting of eight classifications: ([RoughnessThemeName] + [FoirestThemeName] + [WaterBufferThemename]).

legend: A unique value legend was created by reclassifying the eight category grid theme to display areas of two or more scenic amenities. The following classifications resulted: near water and forested, near water and hilly, forested and hilly, near water and forested and hilly,

14. Scenically Attractive Private Land Within ¼ Mile of a Road

dataset(s) used: 30 Meter Digital Elevation Model , Land Use/Land Cover, DLG Derived Lakes, DLG Hydrography lake and wetland – lines, Major Roads, County Roads, Township Roads, and MN Public Lands.

procedures: The same grid theme used in the *Scenically Attractive Areas* map is used in this map. A binary ownership (public and private ownership) and a quarter-mile road buffer grid theme were created and placed atop the *Scenically Attractive Areas* theme to mask out public land and land over a quarter mile of a road to produce this map.

legend: The same legend used in the *Scenically Attractive Areas* map was used for this map.

15. Scenically Attractive Public Land Within ¼ Mile of a Road

dataset(s) used: 30 Meter Digital Elevation Model , Land Use/Land Cover, DLG Derived Lakes, DLG Hydrography lake and wetland – lines, Major Roads, County Roads, Township Roads, and MN Public Lands.

Procedures: The same grid theme used in the *Scenically Attractive Areas* map is used in this map. A binary ownership (public and private ownership) and a quarter-mile road buffer grid theme were created and placed atop the *Scenically Attractive Areas* theme to mask out private land and land over a quarter mile of a road to produce this map.

legend: The same legend used in the *Scenically Attractive Areas* map was used for this map.

16. Scenically Attractive Public Land Over ¼ Mile of a Road

dataset(s) used: 30 Meter Digital Elevation Model , Land Use/Land Cover, DLG Derived Lakes, DLG Hydrography lake and wetland – lines, Major Roads, County Roads, Township Roads, and MN Public Lands.

procedures: The same grid theme used in the *Scenically Attractive Areas* map is used in this map. A binary ownership (public and private ownership) and a quarter-mile road buffer grid theme were created and placed atop the *Scenically Attractive Areas* theme to mask out private land and land within a quarter mile of a road to produce this map.

legend: The same legend used in the *Scenically Attractive Areas* map was used for this map.

17. Septic Tank Suitability

dataset(s) used: Soil Landscape Units

procedures: Soil texture below and above five feet were used to create the *Septic Tank Suitability* map. Refer to the *Groundwater Contamination Potential* map procedure section for the procedures used in this map.

legend: New field values were used to create a unique value legend including suitable, somewhat suitable, poorly suitable, and water/wetlands/marsh/pear/alluvial classifications. Suitable

classifications include any soil unit with a loamy surface soil over a texture other than rock (CL, YL, LL, SL, and XL). Somewhat suitable classifications include any soil unit with a sandy surface soil over a texture other than rock (CS, LS, and SS). Poorly suitable classifications include any clay or iron surface over any texture in addition to sand and loam textures over rock (CC, LC, XC, RC, MD, RS, and RL). Water/wetlands/marsh/pear/alluvial classifications include any surface soil with a peat, hydrated soil, bedrock, marsh, or alluvial surface (AP, BP, LP, NP, SP, HH, RB, MM, and AA, PEAT, and ROCK).

18. Shaded Relief

dataset(s) used: Shaded Relief
procedures: This map is a DNR product of a shaded relief process on the 30 meter resolution DEM data. This image was created using a custom AML developed by the DNR and reflects a light source in the Northwest with a sun angle of 45 degrees. The Shaded Relief dataset has a cell resolution of 30 meters and was created from the 1:24,000 DEMs created by the USGS.
legend: A graduated color bar legend displaying lowest to highest elevation colors was used for the *Shaded Relief* map.

19. Slope

dataset(s) used: 30 Meter Digital Elevation Model
procedures: To create the *Slope* map, statewide DEM data was first converted from feet to meters to coincide with the map unit properties within the ArcView application. Next, the *derive slope* calculation, located under the *surface* menu within ArcView's view project window, was used on the DEM data. This calculation computes the rate of maximum change for locations on grid or TIN themes representing continuous attributes, such as elevation, and creates a grid theme as output with each cell containing a continuous slope value represented in degrees.
legend: A graduated color legend was used to classify the following slope values: 0-2%, 2-5%, 5-8%, 8-12%, 12-20%, 20-32%, and 32-44%, 44-56%, and 56-70%. A light yellow to dark red fill with transparent outline coloring scheme was used to display the data.

20. Topography

dataset(s) used: 1:250,000, 1:100,000, and 1:24,000 Digital Raster Graphics-Collars Removed
procedures: The DNR DOQ/DRG extension, that references the appropriate DOQ and/or DRG image file by interpreting a user specified area, is used to access USGS topography images for each selected watershed area.
legend: No legend was created for *Topography* map.

USER INTERFACE

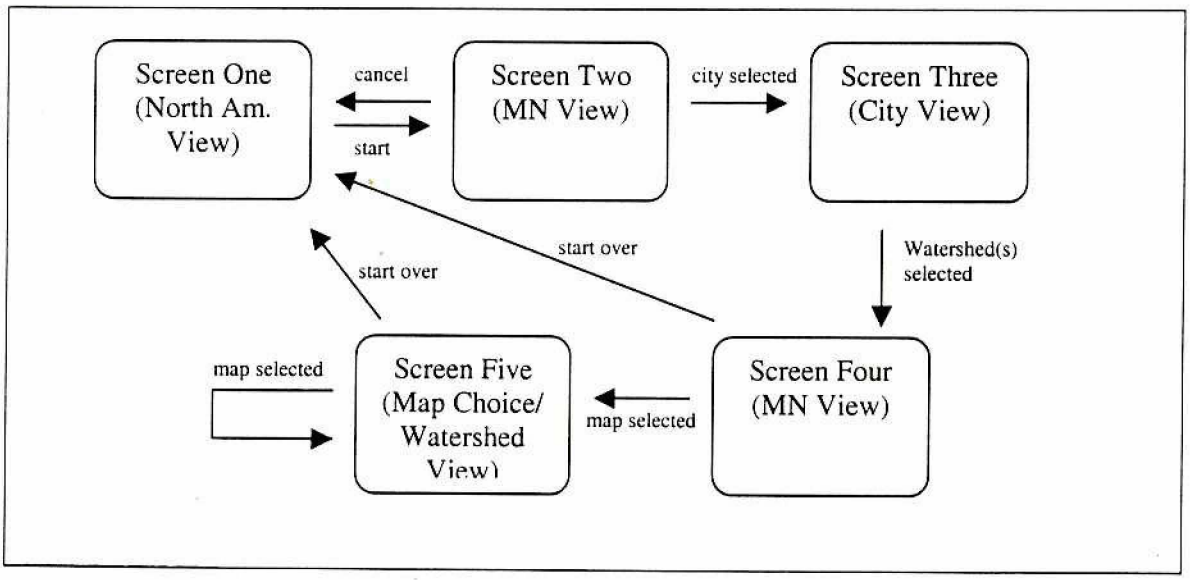
The "Find Your Watershed" activity was created in ArcView through the use of ArcView's dialog designer extension, the DNR's DOQ/DRG extension, and newly generated Avenue scripts. The dialog designer extension allows for customized display boxes, including map lists, instructions, and tool buttons. The DOQ/DRG extension references DEM and DOQ quad images for a defined area within an ArcView view screen and inserts them as a theme. With the exception of DOQs and DRGs, which are referenced for viewing in this manner, all statewide

maps are placed as themes within separate views and named identical to its view for scripting purposes. A total of 22 scripts were created for this project (available at the SMM).

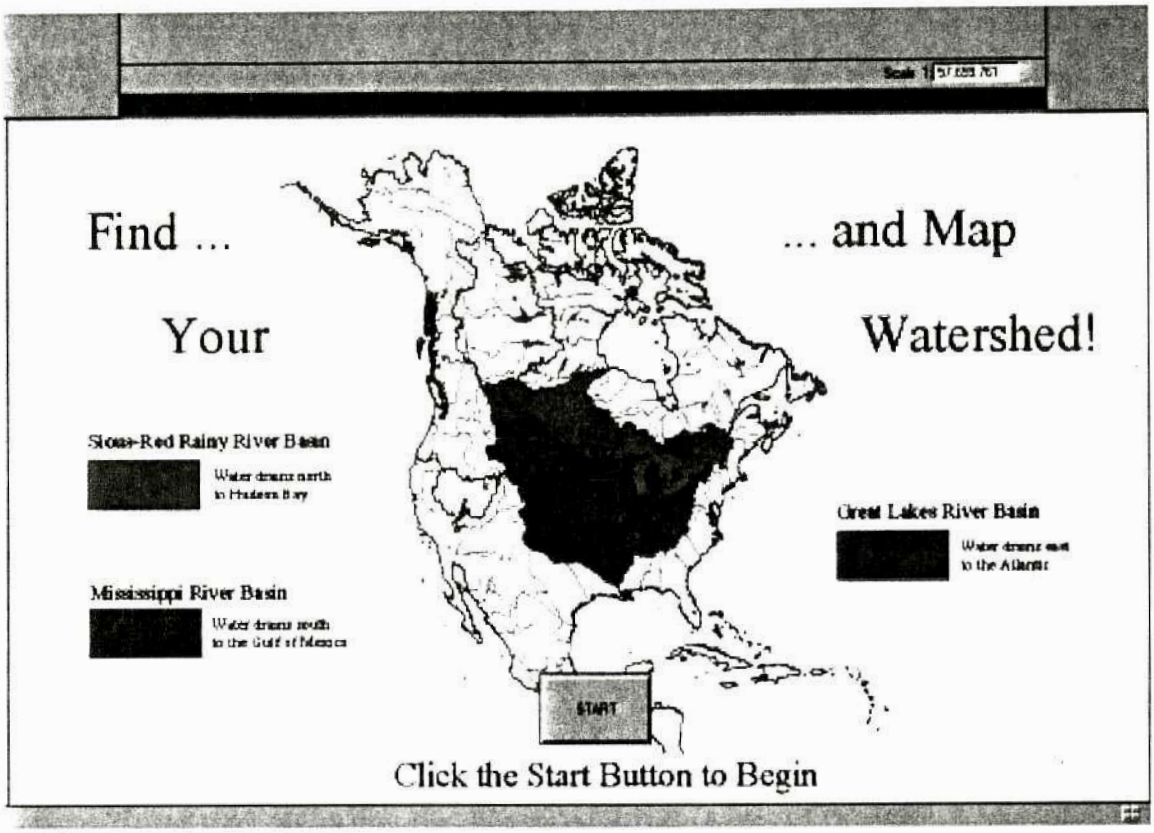
Coded for exhibit purposes, the project is mouse-driven and hides traditional interface buttons, tools, menu options, etc. from ArcView's interface. A kiosk software program installed on the computer system confines it to run only the "Find Your Watershed" project.

Not including map windows, the "Find Your Watershed" activity has four screens, each an ArcView view displaying different themes, text, and dialogs. Table 3 diagrams the screen sequence of the project. The following section illustrates and describes each screen and explains the technical processes involved in creating them.

Table 3: "Find Your Watershed" Activity Screen Diagram



Screen One



Visible on the Screen

The program starts out on a screen displaying major river basins of North America, highlighting the Sious-Red Rainy, Great Lakes, and Mississippi river basins that trisect Minnesota and describing the direction and drainage points of each. The user is prompted to click a start button to begin the activity.

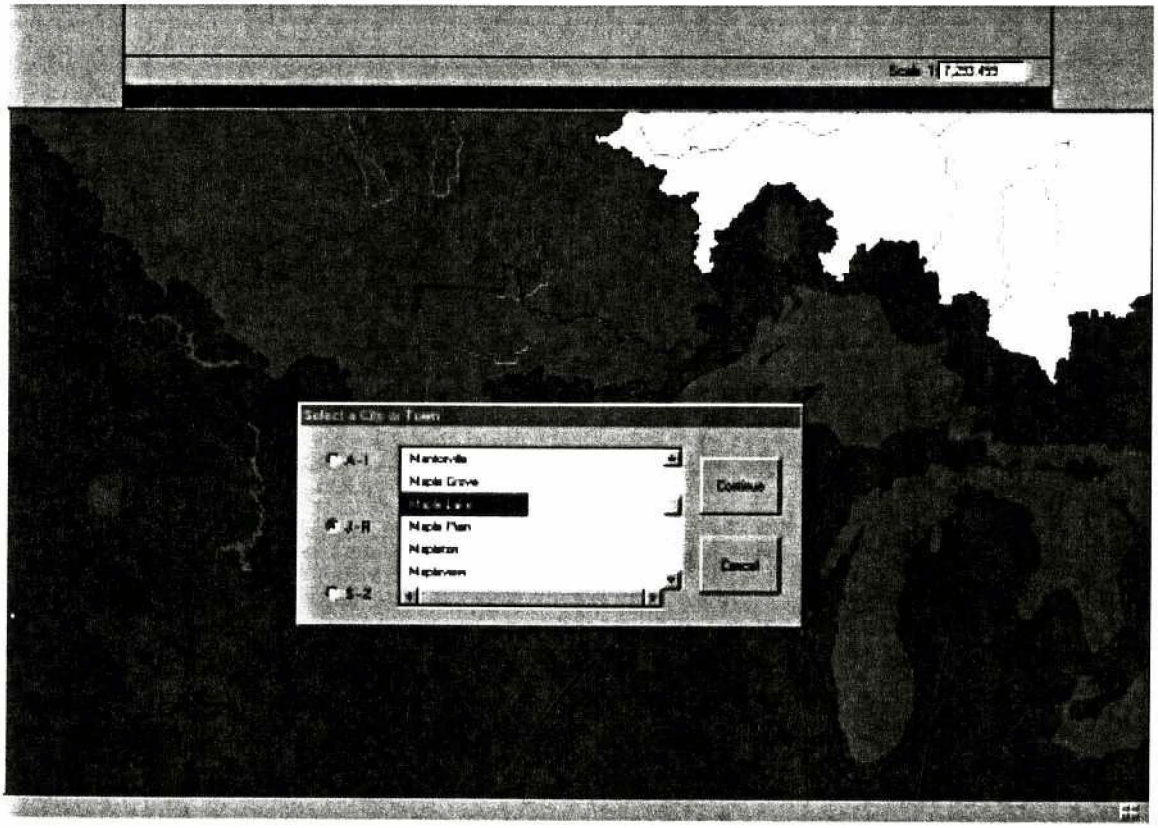
Behind the Scenes

A start up script (*Lake.StartUp)* launches the program setting a number of parameters before displaying the initial screen including four themes: river basins, lakes, and streams of North America and a Minnesota outline. Two masking dialogs in the upper-left and upper-right corners of the project window are opened to prevent access to icons that can minimize the project window

screen or close the project. Menu and tool icons generated through the DNR DOQ/DRG extension during project startup are set invisible. All themes are locked visible and the legend editor script is disabled through the *Lake.Nothing* script.

The script (*Lake.ClickonMap*), attached to the start button, closes the initial screen and start dialog button before setting the extent and appropriate themes visible and opening the city selection dialog for displaying the second view screen.

Screen Two



Visible on the Screen

The second screen displays a "Select a City or Town" dialog placed over a scene identical to the initial view, focused on Minnesota. Care was given to selecting streams data that highlights the directional flow of water in each river basin. The "Select a City or Town" dialog allows the user

to select from over 600 city and towns, broken down into three alphabetical lists to reduce length, in order to direct them to an area of interest within the state. Once the user selects a city or town, the continue button advances them to the next screen. The cancel button closes this screen and opens the first.

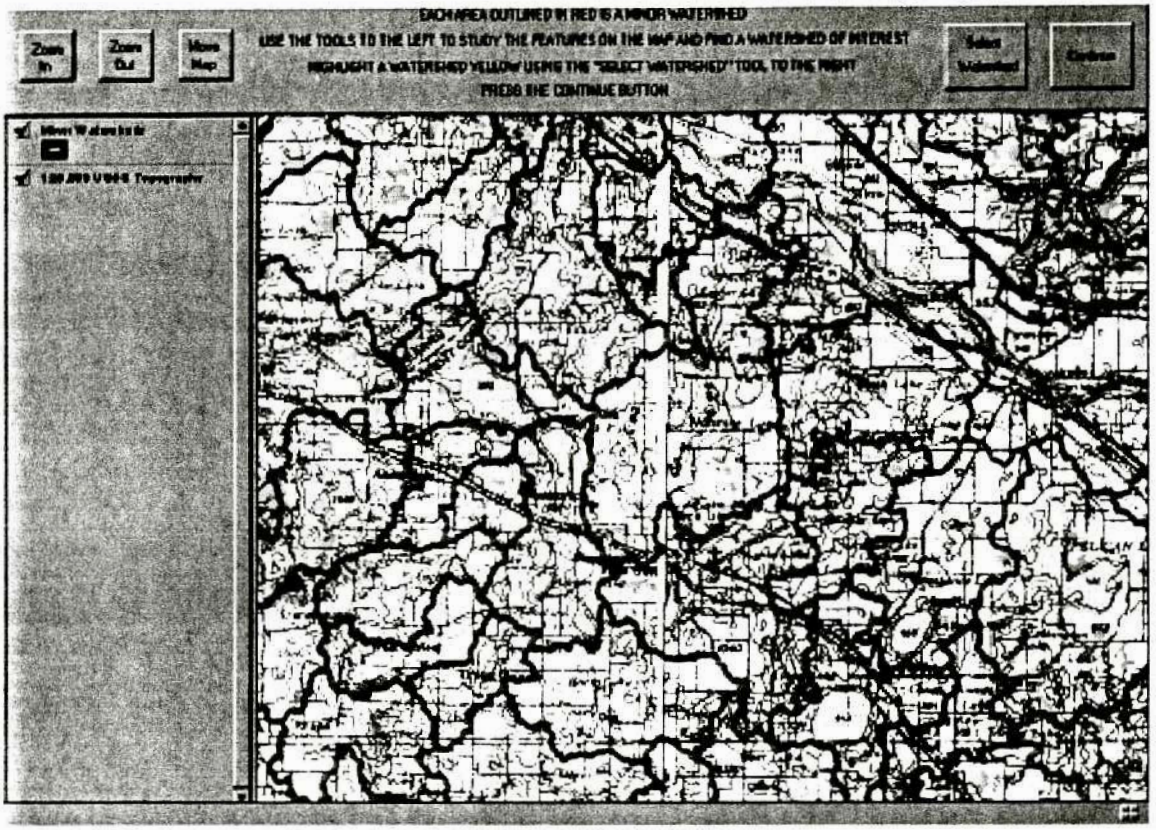
Behind the Scenes

The "Select a City or Town" dialog has five scripts embedded within it, one attached to each radio and label button. Scripts *Lake.CitiesListAI, Lake.CitiesListJR* and *Lake.CitiesListSZ* are attached to radio buttons displayed as A-I, J-R, and S-Z respectively. Each script fills the list box with a name field from separate data tables created to include only those city or towns within a defined alphabetical range. Attached to the 'Cancel' button is the *Lake.CancelFromCity* script that reestablishes appropriate settings for closing View Two and starting the program over at View One. Attached to the 'Continue' button is the *Lake.OKFromCity* script.

The *Lake.OKFromCity* script begins by assuring a city or town is picked from the list, prompting the user if one is not. The second screen, although it displays data identical to the first, contains two additional themes: MN Cities and Major Watersheds. Once a municipality is chosen from the dialog list, the text string is selected from the view's MN Cities theme table and copied in order to create a default bitmap theme unique to the selection. The bitmap theme is copied and placed for use in View Three before deleting it from and closing View Two.

The bitmap is used in View Three to select minor watersheds that intersect the chosen city or town area before being deleted. View three is zoomed into the intersected watersheds and a customized tool bar menu is opened, setting the 'Select Feature' tool active before the third screen is made visible to the user.

Screen Three



Visible on the Screen

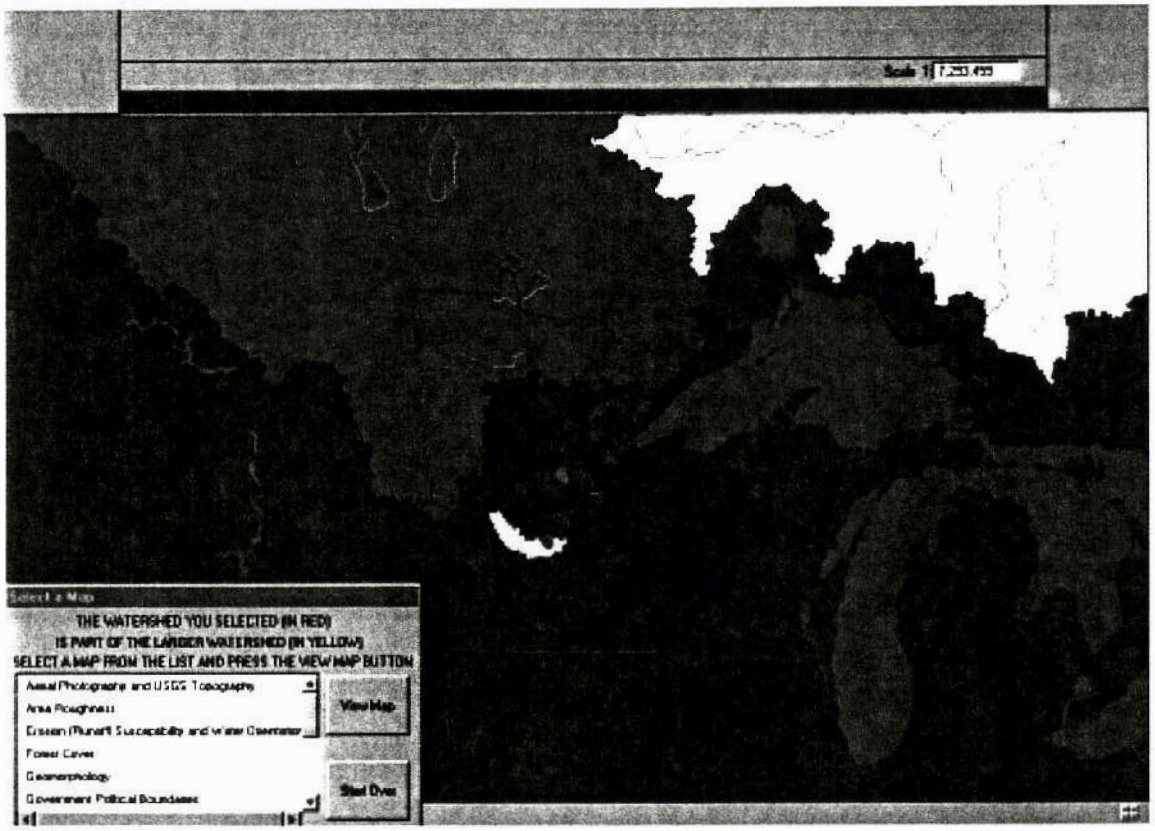
Screen three displays minor watershed boundaries atop a 1:250,000 scale USGS Topography map image. Unlike the first two scenes, which act more like backdrop pictures than GIS data layers, scene three uncovers the themes that make up the view image, lending to a conceptual understanding of how the map is created. It is at this point that the user begins to interact with the information displayed on the screen through zoom in, zoom out, move map, and select watershed buttons located within a customized dialog bar to identify the watershed(s) of interest. Once the watershed(s) is chosen, the continue button takes the user to the next screen.

Behind the Scenes

Each button (zoom in, zoom out, move map, select watershed, and continue) located on the dialog bar in scene three has an attached script (*Lake.ToolZoomIn, Lake.ToolZoomOut, Lake.ToolPan, Lake.ToolSelectWatershed, and Lake.SelectMap* respectively). Except for the *Lake.SelectMap* script attached to the continue button, each script selects a tool from ArcView's interface containing an apply event script, triggered by user interaction on the screen (*View.ZoomInTool*or *Lake.doqdrg*, *View.ZoomOutTool*, *View.Pan*, and *Lake.IconSelectInterest respectively).* The *View.ZoomInTool*, *View.ZoomOutTool*, and *View.Pan* scripts are ArcView system scripts unaltered in any way. The *Lake.doqdrg* script is a manipulated DNR script used in later scenes. The *Lake.IconSelectInterest* script manipulates ArcView's *View.SelectPoint* system script to select only Minor Watersheds features from the view. The select watershed tool is set active when entering the view to allow users to initially choose a watershed without selecting the button.

The *Lake.SelectMap* script attached to the continue button assures a minor watershed is selected, prompting the user if one is not, before it executes the *Lake.SelectMap2* script. The *Lake.SelectMap2* script prepares to open the next view screen and close the current one by first cloning the Minor Watersheds theme from the active view (view three) to create a default bitmap theme of the selected watershed(s) within view two. The bitmap maintains the legend properties of the Minor Watersheds theme that is visible in the next scene. The default bitmap theme is used to select the major watershed that completely contains it, defaulting to a yellow color, also visible in the next scene. ArcView's pointer tool is selected to avoid any manipulative mouse clicking actions and a "Click on a Map" dialog, filled with a list of maps, is displayed previous to opening the next scene.

Screen Four



Visible on the Screen

The next view screen displays the same view as screen two with the selected minor watershed(s) displayed in red and the major watershed that completely contains it displayed in yellow. This scene image acts as a locator map and reviews the different levels of watersheds from minor to major watersheds in Minnesota to the major river basins of North America. A "Select a Map" dialog is included in this scene that allows the user to select one of 20 maps of the selected watershed for viewing in the next scene. Once the user selects a map from the list, the view map button advances them to the next screen.

Behind the Scenes

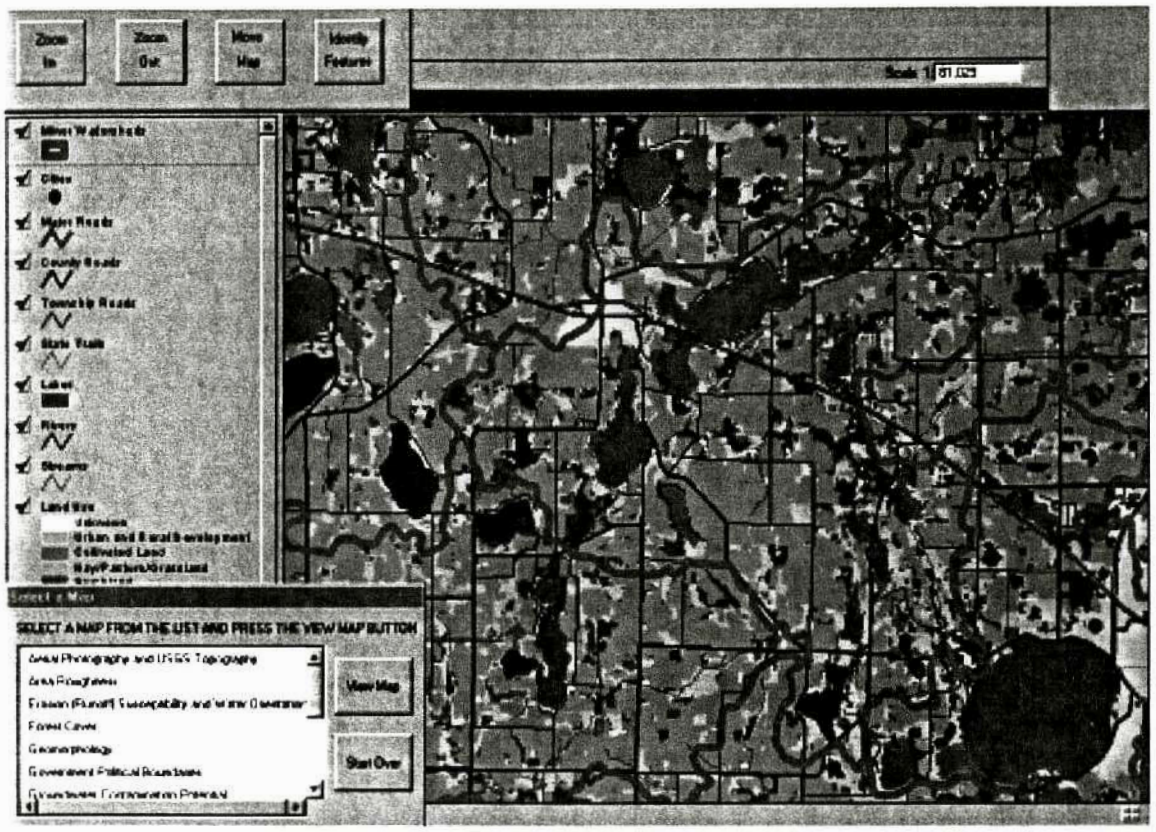
The "Select a Map" dialog within scene four has attached scripts to the view map and start over buttons (*Lake.ViewMap* and *Lake.End* respectively). The *Lake.End* script reestablishes

appropriate settings for closing screen four, closing view two and starting the program over at View One. The *Lake.ViewMap* script initially verifies a map selection from the dialog list, prompting the user to select one if necessary. After a map is chosen, the Minor Watersheds theme that includes the selected watershed from the previous scene is copied and placed within the selected map's view. The "Select a Map" dialog and screen four are then closed and preparations made for opening the selected map's view.

Each map from the list, excluding *Aerial Photography* and *USGS Topography*, contains nine base layer themes: minor watersheds, cities, major roads, county roads, township roads, state trails, lakes, rivers, and streams within its view. Five of the maps have additional themes including wetlands to enhance detail and masking themes to display proper information on the map. Within the *Lake.ViewMap* script, the legend editor script is disabled through the *Lake.Nothing* script, but the visibility and rearrangement of themes remain alterable. This flexibility allows the user to interact with GIS layering capabilities. Proper theme order and visibility each time a map view is opened is guaranteed by cutting and pasting themes in appropriate sequence and setting all themes visible through a number of if-then statements.

The map choice view is zoomed into the selected watershed within the Minor Watersheds theme and a second "Select a Map" dialog different, but similar, to the first and a tool bar dialog are opened. Finally, the map choice view is displayed.

Screen Five– Land Use Example



Visible on the Screen

Screen five shows the chosen map's view centering on the selected watershed and displaying all themes used in its creation. The themes can be checked on or off and repositioned. A tool bar consisting of zoom in, zoom out, move map, and identify features tools allows the user to browse the map and extract theme attribute information. A "Select a Map" dialog allows the user to select and view additional map views or end the program.

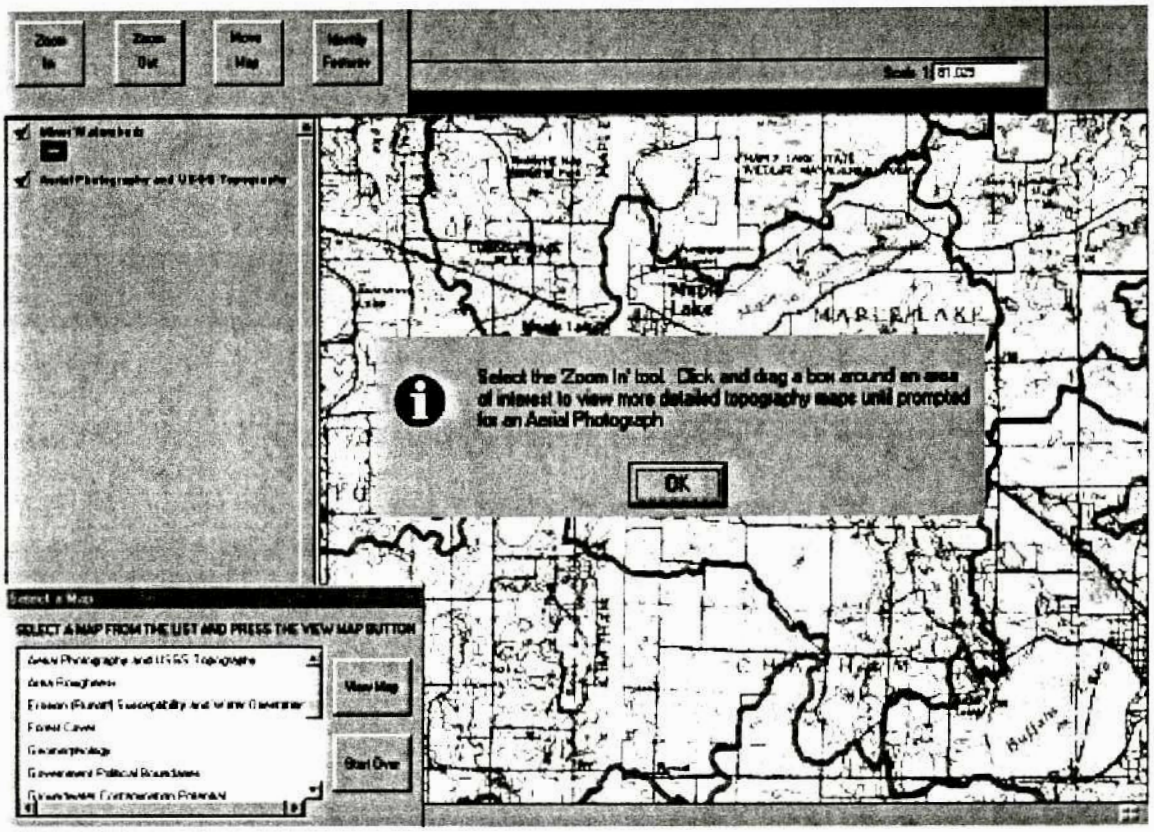
Behind the Scenes

Three of the four tools included in the tool bar dialog (zoom in, zoom out, and move map) utilize the same scripts corresponding to matching tools in screen three (*Lake.ToolZoomIn* or *Lake.doqdrg, Lake.ToolZoomOut, Lake.ToolPan,*and *Lake.ToolSelectWatershed*). The *Lake.doqdrg* script executes only when the zoom in tool is selected within the *Aerial*

Photography and *USGS Topography* map view. Attached to the identify features tool is the *Lake.ToolIdentifyFeatures* script that manipulates ArcView's system *View.Identify* script by selecting all base themes present within the map view in order to display specific item attribute information for each.

The "Select a Map" dialog box contains different instructional text and attaches a different script (*Lake.ViewMap2*) to the view map button than the "Select a Map" dialog found in screen four. All other properties (i.e. start over button and map list) remain the same. The *Lake.ViewMap2* script differs from its script counterpart, *Lake.ViewMap,* attached to the view button in screen four in two ways: it closes the map choice view instead of scene four and opens the "Select a Map" dialog designed for its screen. When a new map is selected from the dialog list, the *Lake.ViewMap2* script runs again, displaying the same "Select a Map" dialog designed for this screen and tool bar over a newly opened map view. This process continues until the start over button is pressed invoking the *Lake.End* script that reestablishes the appropriate settings for closing the map choice view and starting the program over at view one.

Screen Five – Aerial Photography and USGS Topography Example



Visible on the Screen

The *Aerial Photography* and *USGS Topography* map view is unique in that it requires user interaction to view larger scale USGS topography maps and aerial photographs dependent of view scale. When the user first enters the *Aerial Photography* and *USGS Topography* view, a 1:100,000 scaled DRG and Minor Watersheds theme appear. The user is prompted to click and drag a box around an area of interest to view more detailed topography maps until prompted for an aerial photograph.

Behind the Scenes

The zoom in tool selects the *Lake.doqdrg* instead of the *Lake.ToolZoomIn* script when the *Aerial Photography* and *USGS Topography* map view is displayed. The *Lake.doqdrg* script adds a zooming element to a DNR script that creates DOQ and DRG image catalog themes for a

specified area and adds them to the active view. When the user zooms to a 1:200,000 scale or less, a 1:250,000 DRG image theme appears. When the user zooms to a scale greater than 1:200,000 but less than 1:24,000, the 1:100,000 scaled DRG redraws. Once the view reaches a 1:24,000 scale or greater, a 1:24,000 scaled DRG image is added as a theme to the view and a message box appears asking the user if they would like to view an aerial photograph. Each time the user zooms into a scale greater than 1:24,000 they have an option of viewing an aerial photograp, allowing them to bypass it initially while still being able to access it later.

DISCUSSION

User Interface

The "Find Your Watershed" activity is currently located in the SMM's Map Shop exhibit space where I have the opportunity to assist and observe visitors with the program. As one might expect, there are varied responses to the program. Those with no computer experience have trouble understanding the functionality of tools (e.g. zoom in, zoom out, move map). Some do not take the time to read screen instructions and quit before going through the entire project. Others go through and understand the projects' tools and functions and view numerous maps of their watershed.

There is a lot of information to view in this activity and often people do not take the time to view it all. With assistance, visitors tend to spend more time interacting with the activity, learning about watersheds, planning, and GIS. Some learn what a watershed is for the first time. Many bypass the watershed concept but are pleased to view maps and information about an area in the state personal to them. Still others walk away with an understanding of both the watershed concept and importance of analyzing maps for planning purposes.

A definite attractor to the activity is the aerial photographs. When visitors realize they can view aerial photographs of their residences, lines start to form. Sometimes visitors come to the activity wanting simply to view aerial photographs without taking the time to educate themselves on the watershed concept or other available map information. Although not focused on the watershed, this attraction connects visitors with GIS.

The "Find Your Watershed" activity is currently active only with staff or volunteer assistance. Volunteers with no GIS background are recently trained to support the activity and increase its use. With more time to evaluate visitor feedback, improvements can be made to make it a stand-alone exhibit.

Another purpose in mind when creating this project was to provide all Minnesota lake associations with a venue for obtaining watershed maps, similar to those created for the five pilot lakes in the Sustainable Lakes Project. The statewide maps and watershed indexing system created in this project allows this to happen quite easily. The "Find Your Watershed" project is currently being manipulated into a new project that maintains ArcView's traditional interface of buttons, menus, etc. while adding map layout and printing capabilities. The intended operator of this project is an experienced GIS user. Lake associations have expressed interest in obtaining these watershed maps.

The maps created in this project are used differently in the "Find Your Watershed" exhibit than they are for planning purposes by lake associations. Map detail is less important to a visitor of the museum who is simply trying to gain a sense of what a watershed is and how GIS can be used for lake management than to a lake association that utilizes the information to create lake management plans. Map classifications direct the information displayed through maps. The statewide map classifications used in the "Find Your Watershed" activity needs to be evaluated to

determine their appropriateness for displaying information through the exhibit piece and for individual watershed maps.

Simple Maps

The three simple map images (*Aerial Photography, USGS Topography*, and *Shaded Relief*) required no legend classification. A DNR classification scheme was used for the *Land Use, Pre-Settlement Vegetation*, and *Water Features* maps. The *Forest Cover, Geomorphology, Government Political Boundaries, Public Ownership*, and *Soils* maps were classified independently of this project. Of the maps categorized under the DNR classification scheme, the *Pre-Settlement Vegetation* map required the largest number of classifications at 17. Different fill palettes (e.g. dotted and striped lines) and colors were used to distinguish features.

Of the maps classified independently of this project, the *Geomorphology* map has the greatest number of classifications at 22. As with the *Pre-Settlement Vegetation* map, different fill palettes and colors were used to differentiate classifications, however, there is difficulty in differentiating colors. Not wanting to reduce the number of categories statewide in the "Find Your Watershed" activity, features can be extracted using the identify features tool. Legends can be reduced and new color schemes created for individual watershed maps by displaying only those classifications present within that watershed.

The *Soils* map consists of 14 classifications broken down into different graduated color sets by soil type. For example: clay over clay, clay over loam, clay over sand, and clay over bedrock classifications range from light to dark green; while loam over clay, loam over loam, loam over sand, and loam over bedrock range from light to dark brown. This classification scheme works to distinguish each of the 14 classifications as well as represent and rank like soil types by texture. The statewide soils data are generalized to the 40-acre parcel. The Sustainable Lakes Project

realized the crudeness of this data and manually digitized more detailed soils information into its database for three of its pilot lakes' watersheds. It will be considered whether more detailed soils data, if available digitally, will be substituted when producing individual watershed maps. Currently, wetlands data are laid atop soils information to improve detail.

The *Government Political Boundaries* map does not display a legend, but uses an ArcView coloring scheme and auto label feature to represent different cities and townships. The scheme works well to display different municipalities. The Pub*lic Ownership* and *Forest Cover* maps, representing standard number of classifications (six and two respectively), depict their information well.

With the exception of the *Geomorphology* map, all simple map classification schemes are rated well for both the "Find Your Watershed" activity and individually produced watershed maps. The data differences used in the Sustainable Lakes Project and "Find Your Watershed" activity, however, prevent individual watershed maps from displaying more detailed information. Eight classifications are available for the statewide *Land Use* map, giving the museum visitor a good understanding of land use in their watershed. Land use data with more classifications was used in the Sustainable Lakes Project and it is beneficial to watershed planners to utilize these additional classifications when making management decisions. The same holds true for forest cover information. Less detailed shaded relief images are not as crucial because both provide a sense of land elevation, one just more accentuated than the other. To supply lake associations with more detailed land use and forest cover information, individual watershed maps can be created with different datasets, including greater numbers of classifications.

Complex Maps

The *Slope* map includes nine classifications broken down through a combination of natural break and equal interval "cuts". This tactic was used because only portions of the statewide map are viewed at a time and it is not known what classifications will be present for any chosen watershed in hopes to represent distinct slope classifications for any watershed area being investigated. When producing individual watershed maps, it may be necessary to reclassify the data to better represent slope within smaller areas.

Three classifications were used in the *Area Roughness* map: flat, gently rolling, and steep. Visual observations were used to validate classifications that ended up similar to the breakdowns used in the Sustainable Lakes Project's five pilot lake watershed areas, eliminating the need for reclassification at a larger scale.

The *Groundwater Contamination Potential* and *Septic Tank Suitability* maps were both created through reclassification of soils data. Potential watershed map customers and inquiring "Find Your Watershed" activity participants should be cautioned about the level of accuracy involved in creating these maps. As with the *Soils* map, wetlands data are laid atop *Groundwater Contamination and Septic Tank Suitability* data layers to augment the maps.

Two more maps involving soils data are *Erosion (Runoff) Susceptibility and Water Orientation* and *Possible Agriculture Irrigation Areas on Private Land with Less than 8% Slope.* Unlike the agriculture irrigation map, soils data can be seen as an enhancement to the erosion model and not a necessity. Because of this and crude statewide soils data, soils information was omitted from the statewide erosion model.

The remaining maps consist of the *Scenically Attractive Areas* series. These maps were created in the same manner for both the Sustainable Lakes Project and "Find Your Watershed" activity. When visually checking the statewide version it was realized that ditches, included in the DLG Hydrography lake and wetland – lines data, showed through on the final map as attractive sites, particularly in the northern portion of the state dominant with wetland features. It was decided to overlay wetlands data in order to more accurately display scenically attractive features statewide. This addition is an enhancement to the data and will be used in both the "Find Your Watershed" activity and individually produced watershed maps.

With the manipulation of some of the datasets and legend classifications, watershed maps provided to watershed map customers will be extremely similar to those produced in the Sustainable Lakes Project and can provide lake associations and other organizations with a comprehensive set of maps to assist in planning procedures.

Appendix A

Sustainable Lakes Project: Lake Basin

Data Obtained
1. Depth
2. Aquatic vegetation
3. Clarity

Maps Created
1. Depth
2. Littoral Area
3. Aquatic Vegetation
4. High and Low Water Records

Sustainable Lakes Project: Lakeshore Parcel

Attribute Data Obtained from County Government
1. Total Market Value
2. Land Market Value
3. Building Market Value
4. Tax Class
5. Date of Septic System Installation
6. Soil Type
7. Parcel Identification Number
8. Fire Number
9. Name
10. Address

Spatial Data Obtained from County Government*
1. Half-section Maps
2. GPS Parcel Coordinates
3. CAD Drawings

* need only one of the three spatial data types

Data Obtained from Photographs
1. Lawn Type
2. Slope
3. Tree Density
4. Beach Type
5. Boat House Type
6. Number of Boats Stored on a Given Day
7. Setback Distance of Dwelling from Lakeshore
8. Number of Personal Watercraft Stored on a Given Day

Lakeshore Parcel Maps Created for the Sustainable Lakes Project
1. Total Market Value
2. Land Market Value
3. Building Market Value
4. Tax Class
5. Date of Septic System Installation
6. Septic System Soil Suitability
7. Lawn Type
8. Slope
9. Tree Density
10. Beach Type
11. Boat House Type
12. Boat Storage on a Given Day
13. Personal Watercraft Storage on a Given Day
14. Setback Distance of Dwelling

Appendix B

Map Use in Watershed Management

The watershed maps are broken down into three categories for identifying management issues: resource characteristics, land use, and public management responsibilities.

Resource Characteristics Maps

The physical properties of watersheds define specific land areas that are most likely to contribute to water contamination. There are certain resource characteristics vulnerable to erosion, runoff, and the pollution of water including soil type, slope, residential development, and water features. The resource characteristic maps help determine likely sources of water contamination to focus attention on within a lake plan.

Resource Characteristic Map	Description/Use
1. Soils	Soil information is used to produce many of the watershed maps because they have an impact on water contamination through surface runoff and groundwater. Soils differ in size and composition making some soils more water absorbent than others. Sandy soils are relatively large with spaces between sediment particles that allow water to penetrate through at a rapid pace and enter groundwater. Clayey soils resist water drainage and are susceptible to surface water runoff, especially when found on steep slopes.
2. Slope	The *Slope* map depicts the percent slope of land areas. Steep slopes areas have a higher potential to erode than flat slopes. Steeper slopes also have desirable scenic qualities leading to a higher demand for development.
3. Erosion (Runoff) Susceptibility and Water Orientation	Residential areas, with numerous impervious surfaces (e.g. buildings and concrete slabs) do not absorb water and are susceptible to runoff. Cultivated land areas with loose topsoil and no natural vegetation on steep slopes are susceptible to runoff. This map combines the elements of poorly drained soils, steep slopes, residential, and cultivated land areas to define places most susceptible to erosion and highlights areas near water.
4. Groundwater Contamination Potential	This map ranks areas sensitive to groundwater contamination based on soil type and water table level. Well-drained soils (sands) extending from the surface to the water table level and water table levels near the surface (wetland areas) are locations where contaminants can easily enter groundwater.

5. Water Features	This map distinguishes wetland areas as lakes, marsh, swamp, and bogs. Wetlands play an important role in controlling groundwater levels and water quality, acting as nutrient absorbers digesting many nutrients that would otherwise reach lakes. They also contain fish, wildlife, and open space benefits.
6. Area Roughness	The *Area Roughness* map is created by comparing the height of land in contrast to its surroundings and depicts rolling hills as well as steep areas. Both scenic amenities, rolling hills and steep slopes are used in the production of the *Scenically Attractive Areas* map series.
7. Shaded Relief	The *Shaded Relief* map shows accentuated shaded elevation features to help viewers actualize the rise and fall of the land and determine the flow of surface water within watersheds.
8. Geomorphology	Natural resources are a function of the surrounding geology and geologic processes. Soils and vegetation, for example, are both dependent to varying degrees on the underlying geologic strata and how the landscape is shaped. The *Geomorphology* map provides geomorphic association descriptions of your watershed's landscape to better understand the landforms and processes that form those landforms within your watershed.

Land Use Maps

Natural amenities and land composition direct the location of development, recreation, and cultivation (e.g. agriculture and timber harvesting). It is important to realize preferred features for recreation and housing as well as environmental constraints related to such developments. The land Use maps will help localize present land use activities and project future recreation and development sites.

Land Use Map	**Description/Use**
9. Land Use	The *Land Use* map presents a visual representation of the land covering the watershed. It is one of the most important maps in the watershed series and is used in the production of many other maps. The map breaks down land attributes under eight categories: urban and rural development, cultivated land, hay/pasture/grassland, brushland, forested, water, bog/marsh/fen, and mining. Studying this map increases awareness of the development, activities, and natural vegetation present within the watershed.
10. Scenically Attractive Areas	Recreation and housing research identify landscape features most desirable for residential development and recreation sites. The *Scenically Attractive Areas* map combines the top three desired amenities (hilly lands, forested areas, and water

	bodies) to produce a ranking classification from least to most attractive land areas. The most attractive sites contain all three of the amenity variables while the least attractive sites are void of amenities.
11. Scenically Attractive Private Land Within ¼ Mile of Any Road	This map displays the scenically attractive classification scheme for private land areas within one-quarter mile of any road. This depiction concentrates on areas likely to be developed for residential use due to the proximity of roads and desired amenities.
12. Scenically Attractive Public Land Within ¼ Mile of Any Road	This map displays the scenically attractive classification scheme for public land areas within one-quarter mile of any road. Ideal locations for public recreational sites, such as trails and picnic areas, are in regions with natural amenities close to roads. This map can help you determine easily accessible and scenically attractive public sites desirable for recreational development.
13. Scenically Attractive Public Land Over ¼ Mile of Any Road	This map displays the scenically attractive classification scheme for public land areas over one-quarter mile of any road. Remote public lands require effort to reach and are prime locations for secluded recreational activities such as camping, cross country skiing, and biking. This map can help determine remote, scenically attractive public sites desirable for developing new and expanding existing public recreation locations.
14. Pre-settlement Vegetation	The *Pre-settlement Vegetation* map shows broad patterns of land cover during the 19th century, prior to European settlement based on General Land Office survey records of the time. This map offers a historical sense of the watershed's landscape.
15. Forest Cover	The forested classification from the *Land Use* map is extracted to produce the *Forest Cover* map. Forested areas maintain the scenic character and wildlife population of watersheds. These advantages should be considered when applying sustainable management forest practices.
16. Septic Tank Suitability	This map ranks ground area appropriateness for septic tanks based on soil permeability. Large particle soils disseminate contaminated discharge from septic tanks faster than small particle soils, but have a higher potential to hit groundwater. Septic tanks servicing lakeshore homes are often installed on large grain, sandy soils and threaten lake contamination. The *Septic Tank Suitability* map is used to determine areas prone to septic tank failure and for the consideration of septic tank compliance monitoring and mound systems.
17. USGS Topography	The *USGS Topography* map shows scanned map images of familiar looking maps often referred to as "quad sheets". Basic features such as roads, lakes, streams, urban and forested areas, and elevation contours are present as well as specific site features including schools and gravel pits. This map helps orient oneself to a particular location.

18. Aerial Photography	The *Aerial Photography* map is a digital picture rendered from a photograph taken from approximately 5,000 feet. Original photographs are manipulated to correct displacement and eliminate terrain relief. This map offers a representative picture of the land area, allowing for a unique perspective on understanding and orienting oneself with a particular land area.

Public Management Responsibilities Maps

Federal, state, and local agencies regulate planning efforts that affect various aspects of our everyday lives. Government officials are responsible for many decisions that affect watersheds, regulating both private and publicly owned lands. It is important to recognize those in decision-making positions regarding watershed activities so lake association or other lake management planning groups may approach them with the issues and concerns of the organization.

Public Management Responsibilities Map	**Description/Use**
19. Public Ownership	The *Public Ownership* map displays the State or County government sector responsible for managing public land within the watershed. Public lands are valuable land areas, occupying approximately one-quarter of the state, and provide many benefits, such as recreation areas, wildlife preserves, and parks. Public land should be managed, protected, and preserved in the best interest of the public, including lake users.
20. Government Political Boundaries	Most of the management issues affecting a lake community will be addressed by local planning entities. The *Government Political Boundaries* map delineates Minnesota cities and townships to help realize government departments that may need to be approached when acting toward the goals of the lake management plan.

Appendix C
Metadata

DLG Derived Lakes

dnr file name: lakespy2
date of data: undeterminable
originator: U.S. Geological Survey
description: 1:100,000 scale lake polygons derived from USGS Digital Line Graphs (DLGs) of the same scale. A total of 24,452 different polygons exist within this dataset, of which 3,933 have a lake name assigned.

DLG Hydrography

dnr file name: riverln2
date of data: undeterminable
originator: U.S. Geological Survey
description: 1:100,000 scale hydrography includes rivers derived from USGS DLGs of the same scale. The data includes river names for 51 rivers.

DLG Hydrography lake and wetland - lines

dnr file name: dlgstln2
date of data: undeterminable
originator: U.S. Geological Survey
description: 1:100,000 scale hydrography includes streams derived from USGS DLGs of the same scale.

Major Roads

dnr file name: majrdln3
date of data: 1996
originator: Minnesota Department of Transportation
description: This data set contains roadway centerlines for major roads found on the USGS 1:24,000 mapping series. These roadways are current through the 1994 construction season.

County Roads

dnr file name: ctyrdln3
date of data: 1996
originator: Minnesota Department of Transportation
description: This data set contains roadway centerlines for County State Aid Highway (CSAH) roads found on the USGS 1:24,000 mapping series. Those roadways are current through the 1997 construction season.

Township Roads

dnr file name: twprdln3po
date of data 1996*:*
originator: Minnesota Department of Transportation
description: This data set contains roadway centerlines for roads found on the USGS 1:24,000 mapping series designated as being administered by political township entities.

State Trails

dnr file name: gaitrln3
date of data: most 1997
originator: Minnesota DNR, Trails and Waterways Unit
description: This dataset contains trail centerlines for state trail route systems throughout the state. Data is captured from 1:100,000 scale USGS and MNDOT sources.

Watershed Basins (1995)

dnr file name: bas95py3
date of data: All but 250 of the more than 1770 quads for the state were delineated during the late 1970s. Major updates were performed in 1995 in the south central region of the state using the most recent available 1:24,000 scale quadrangle maps.
originator: U.S. Geological Survey and Minnesota DNR – Division of Waters
description: Watershed boundaries were interpreted from contours present on the original U.S. Geological Survey 7 ½ Minute Quadrangle base and manually compiled on acetate overlays. A five square mile minimum size criterion was used in the delineation process and compilations were photo-reduced and fitted to a USGS 1:100,000 scale series base.

Minor Civil Divisions

dnr file name: mcd90py2
data of data: 1990
originator: Data originated with the 1990 Census Bureau TIGER files and was processed by the Minnesota Legislative GIS Office.
description: Minor Civil Divisions display the incorporated minor civil divisions of cities and towns in urban areas and townships in rural areas.

1:250,000, 1:100,000, and 1:24,000 Digital Raster Graphics – Collars Removed

dnr file name: drgcim1, drgcim2, and drgcim3 respectively
date of data: unknown
originator: U.S. Geological Survey
description: Digital raster graphics are scanned images of USGS 7 ½ minute paper topography maps that have been transformed and georeferenced to match the UTM zone and datum of the original maps.

Digital Orthophoto Quadrangles

dnr file name: different file name for each quarter quadrangle
date of data: 02/22/1994-present
originator: U.S. Geological Survey
description: A digital orthophoto is a raster image of remotely sensed data in which displacement in the image due to sensor orientation and terrain relief have been removed. Orthophotos combine the image characteristics of a photograph with the geometric qualities of a map.

Shaded Relief

Dnr file name: shr30im3
date of data: unknown
originator: Minnesota DNR, USGS
description: This file is a product of a shaded relief process on the 30 meter resolution DEM data. This image was created using a custom AML developed by the DNR and reflects a light source in the Northwest with a sun angle of 45 degrees. The Shaded Relief dataset has a cell resolution of 30 meters and was created from the 1:24,000 DEMs created by the USGS.

Land Use/Land Cover

dnr file name: lulcmra3
date of data: The data is derived primarily from aerial photography taken between 1986 and 1996.
originator: Numerous groups worked on creating and classifying land use data in different regions of the state. Land Management Information Center (LMIC) is the depository of the data.
description: This data is a product of an effort to update Minnesota's 1969 land use inventory. The project was funded in 1989 by the State Legislature per recommendation from LCMR and required the participation of many groups over an extended period including: The International Coalition, Bemidji State University, Manitoba Remote Sensing Centre, Rochester – Olmstead Planning Department, Metropolitan Council and the University of Minnesota, Department of Natural Resources – Division of Forestry. Source photography was subjected to a variety of processes and classifications by each group before conglomerating data into eight statewide classifications.

National Wetlands Inventory Polygons

dnr file name: nwixxpy3
date of data: source aerial photography was from 1979 – 1988. Ancillary data sources had variable dates. The interpretation/automation effort began in 1991 and was completed in early 1994.
originator: U.S. Fish and Wildlife Service, National Aerial Photography Program, and the Minnesota DNR – Division of Waters
description: Wetland area features mapped as part of the National Wetlands Inventory (NWI). The National Wetlands Inventory is a national program sponsored by the U.S. Fish and Wildlife Service (USFWS). The NWI database was funded jointly between the USFWS and the State. The base data was developed through interpretation of National Aerial Photography Program (NAPP) imagery (approximately 50,000 scale) in conjunction with limited field verification studies. Ancillary data sources, particularly USGS Quadrangle Maps and soil surveys, were also used in the interpretation process. After interpreting the aerial photographs, delineations were transferred to a 1:24,000 scale orthogonal base, digitized, and coded in conformance to the

USFWS classification scheme and structured into a DLG format. The original interpretation/automation effort was performed under contract by GEONIX-MARTEL of St. Petersburg, FL. The data were delivered to LMIC, who converted it into an ARC/INFO format, and performed some additional processing to prepare it for distribution. The DNR acquired the coverages and restructured the attribute table so that the most commonly used fields were placed directly on the primary attribute table. A Circular 39 classification field was also added.

Soil Landscape Units

data name: Soils
dnr file name: 4soilpy1
date of data: 1970-1976
originator: Minnesota Land Management Information Center, Minnesota Planning
description: Soil landscape information was obtained from 1:250,000 preliminary Minnesota Soil Atlas sheets developed by the Department of Soil Science at the University of Minnesota in cooperation with the U.S. Soil Conservation Service. Soil landscape units in this dataset are groups of soils generalized into homogenous units based on four characteristics: sub-surface soil texture, surface soil texture, drainage characteristics, and surface color. The smallest area shown in the Atlas for which reliable information is available is approximately 600 acres. The MLMIS staff encoded soils information in 1976 using a grid overlay procedure. A mapograph machine was used to project soil atlas sheets onto a 40-acre grid, and the dominant soil type of each 40-acre parcel was recorded. 40- acre parcels containing water were coded according to the 100 percent rule: a cell had to be completely covered by water to be coded as such.

Geomorphology of Minnesota

dnr file name: landfne2
date of data: Data was derived from a wide variety of image and hardcopy data sources of varying vintages.
originator: University of Minnesota – Duluth Geology Department; MN Geological Survey, and the MN DNR.
description: This dataset describes the general distribution of surface sediments in Minnesota. It contains information derived from NHAP air photos (1:80,000), USGS 1:100,000, and 1:24,000 scale topographic maps and from a variety of source products related to surface geology resulting in 1:100,000 scale geomorphology data within a hierarchical classification scheme that was devised for use within Minnesota.

Vegetation at the time of the PLS Survey

dnr file name: prvegpy1
date of data: 1835 – 1905 (date of General Land Office Surveys in Minnesota). Original map created in 1930, hard copy map published in 1974, digital version distributed in 1996.
originator: **U.S. Department of Agriculture, U.S. Forest Service, and the MN DNR.**
description: This dataset was produced by digitizing the fabled Marschner map which includes 18 classes of pre-settlement vegetation as mapped by Francis J. Marschner in 1930. Marschner based his map on General Land Office Survey records from the 19th and early 20th century. The map is provided to show broad patterns of land cover in the state as it looked at the time of the PLS Survey.

Minnesota Public Lands

dnr file name: gapdipy2
date of data: 1976 – 1998 (1983 to 1985 predominately)
originator: BRW, Inc.
description: This database contains land ownership information for the entire state of Minnesota at 1:100,000 scale. Attribute fields describe ownership, administrator, and conservation management code. Ownership reflects surface features only. Ownership may only be as current as the source information and should not be considered comprehensive for the entire state. Conservation management codes are based upon the owning or administrating entity. Land interest is expressed only when some organization owns or administers more than 50 percent of a forty.

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30 Meter Digital Elevation Model

dnr file name: dem30im3
date of data: unknown
originator: U.S. Geological Survey
description: The USGS has been designated as a lead federal agency for the collection and distribution of digital cartographic data including DEM data. There are four production methods for DEM data in 7.5 minute quad form. The first is the Gestalt Photo Mapper II, which is an automated photograpmmetric system. Other methods include: manual profiling from phogogrammetric stereomodels using stereoplotters, interpolation of the elevations from the stereomodel digitized contours, interpolation from digital line graph hypsogaraphic and hydrographic data. The data were originally delivered to LMIC who produced a set of CD-ROM's to the DNR MIS Bureau, who processed the original DEM format data into an ARC GRID format.

Appendix D

Base Map (lakes, rivers, streams, major roads, county roads, township roads, state trails, cities, and minor watersheds)

lakes dataset : DLG Derived Lakes
lakes legend : A single symbol legend is used coloring the polygon data blue with a transparent outline.

rivers dataset: DLG Hydrography
rivers legend: A single symbol legend is used coloring the line data blue with a 0.1 line width.

streams dataset : DLG Hydrography lake and wetland - lines
streams legend : A single symbol legend is used coloring the line data blue with a 0.1 line width.

major roads dataset : Major Roads
major roads legend : A black, double lined, single symbol legend is used to display major roads with a 0.1 line width.

county roads dataset : County Roads
county roads legend : A single symbol legend is used coloring the line data black with a 1.5 line width.

township roads dataset : Township Roads
township roads legend : A single symbol legend is used coloring the line data black with a 0.1 line width.

state trails dataset : State Trails
state trails legend : A reddish, dotted lined, single symbol legend is used to display state trails with a 0.1 line width.

cities dataset : Minor Civil Divisions
cities legend : A single symbol legend is used to represent the point data with size 12 black circles.

minor watersheds dataset : Watershed Basins (1995)
minor watersheds legend : A single symbol legend with a transparent fill and red outline width of 5 was used to display watershed boundaries.

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