Geographic Information Policy and Guidelines

of the

Ohio Department of Natural Resources

GIMS Policy & Planning Committee

Version 6.0

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INTRODUCTION

Every day, the Department of Natural Resources (DNR) must respond to a wide variety of complex issues involving geographically referenced information - that is, data related to some location. As the state agency responsible for natural resource management, DNR requires timely, efficient, and effective access to information on the state's land, water, and flora and fauna resources. Geographic information management systems (GIMS) are the spatial data tools of choice for solving such complex geographical problems.

GIMS is a term used by the Department of Natural Resources to describe a collection of related technologies used to manage geospatial data. These technologies include geographic information systems (GIS), computer-aided design (CAD) systems, automated and desktop mapping (AM) systems, remote sensing and image analysis (RSI) systems, and their related database management systems (DBMS). A GIS is a decision support system designed to collect, edit, manage, analyze and display data referenced by spatial or geographic coordinates. These systems are composed of five elements: computer hardware, software, procedures, data, and people. Geographic information systems have evolved from several related technologies, such as computer-aided design and mapping systems, and relational database management systems. GIS's, however, have several features not available in these systems. Spatial analysis, the ability to evaluate features in the context of their surroundings, is the most important of these.

GIMS technology at DNR is used to support work at four levels: policy, management, operations, and research. At the policy level, GIMS provides quality information to help address key resource issues (for example, what portions of the Lake Erie shoreline should be protected as an erosion hazard area?). On a management level, GIMS helps target areas requiring different or special management techniques (for example, what Ohio wetlands qualify under swamp-buster legislation?). At the operations level, GIMS technology assists in prioritizing activities to focus resources on the most severe potential problems (for example, how should conservation efforts for different areas within a watershed be prioritized to reduce soil erosion and deposition in a downstream reservoir?). In research, GIMS technology is used to address basic resource questions such as where, how much, or of what quality, etc. (for example, where and how extensive are the coal resources in the State of Ohio?).

The most basic goal of the GIMS program is to improve DNR's service to the public. Providing natural resource information to the public in a more efficient and effective manner is an important measure of the program's success.

Other important goals of the GIMS program include increasing the productivity of the professional staff of DNR, reducing redundancy in spatial data collection and storage, providing increased consistency and improved scientific validity in the decision making process, and promoting greater interaction and coordination between and within DNR's Offices and Divisions.

The GIMS program of the Department of Natural Resources allows the agency to effectively and efficiently employ its resources to address the many administrative, management, operation, and research responsibilities assigned to DNR, for the wise stewardship of Ohio's natural resources.

CHAPTER 1

GIMS STRATEGY at the DEPARTMENT OF NATURAL RESOURCES

Architecture

The Ohio Department of Natural Resources' Geographic Information Management System (GIMS) is designed as a distributed collection of digital spatial data created, maintained, and shared throughout the Department. The system features central management of network resources and shared databases, but distributed responsibility for data creation, capture, and maintenance, and specific applications to the divisions. Although the Department-wide system was initiated in 1992, some components have been operational since the 1970's while others are still under construction.

Key features of the Department's GIMS include:

- distributed creation and maintenance of digital spatial data,
- based on ESRI software and data structures,
- data managed by the divisions and offices according to GIMS program standards,
- operated over a sophisticated network,
- distributed responsibility for specific GIMS systems and applications,
- central responsibility for data storage and access, program coordination, standards development, funding coordination, and network infrastructure.

Implementation of a GIMS in a distributed computing environment is only possible through the use of information standards. Standards help facilitate data capture, translation, exchange, and documentation. Consistent and thorough data documentation is especially important in a Department-wide information system. To this end, the Department has developed a GIMS Metadata System. This system is used to document and query information about digital spatial data created, maintained, and disseminated by DNR. The system, available through DNR's web site, is also the access point for downloading department digital coverages. Details of the GIMS Metadata System can be found in Chapter 5 of this guidebook.

Implementation Strategy

Developed using a multiphase strategy, the first phase of the GIMS Program included installing a common infrastructure (computers, software and communication wiring) on which the program is based. In this phase a basic GIS and spatial data concepts course for DNR's GIS practitioners was developed and taught, and ArcInfo and ArcView training was provided.

The second phase consisted of developing data with the broadest impact to DNR programs, such as detailed soils, bedrock and glacial geology, floodplain and floodway maps, and DNR owned and managed property, and participation in multi-agency projects to develop complete state-wide coverage of digital 7.5 minute topoquad maps (DLGs) and digital orthophotography (DOQQs). Phase 2 also included the creation and implementation of a Department GIMS Metadata system, and the publishing of DNR's *Geographic Information Policy and Guidelines of the Ohio Department of Natural Resources.*

The third phase of the program has been the development and implementation of more specialized databases, applications and systems. Phase 3 data development included oil and gas well spot maps and attribute information, water well location and attributes, and an Ohio recreation facility inventory. Systems that were developed included the Water Well Log Image and Database System, the Risk Based Database Management System (used to store, view and analyze geologic and well production information for the regulation of the oil and gas industry in Ohio), and the Floodplain Geographic Information Management System (including applications to manage the variety of Floodplain maps and information, identify structures at risk of flooding in the state, and develop new flood studies).

Applications

Since its introduction in the Department of Natural Resources 30 years ago, GIS has been used for many applications. Samples of the variety of applications of GIS at ODNR include:

- Resource Mapping
    - Ohio's Oil and Gas Fields and Storage Areas
    - Detailed Soils
    - Land Use/Land Cover
    - National Flood Insurance Maps
    - Surficial Sediments of Lake Erie's Nearshore

- Capability Analysis
    - Ground Water Pollution Potential
    - Sanitary Landfill Suitability
    - Limitations for Wastewater Treatment Facilities
    - Low Income Housing Siting

- Decision Support

- Tracking Habitat Use for Introduction of the Sichuan Pheasant
- Pre-construction Lake Site Development Modeling
- Determining Structures At-Risk for Flooding

- Facility Planning
  - Future Land Parcel Purchase Mapping
  - State Park Future Development
  - Hunting Zones, No Wake Zone and Boat Motor Horsepower Map Updates

- Information Management
  - Floodplain Management Information System
  - Oil and Gas Well Risk-based Database Management System
  - Water Well Log Imaging and Database System

- Issue/Policy Analysis
  - Determination of the Geographic Centroid of DNR Facilities, by Division, across Ohio (used to support the decision of keeping DNR headquarters in Columbus)
  - Equine Encephalitis Outbreak Analysis

Organization Structure

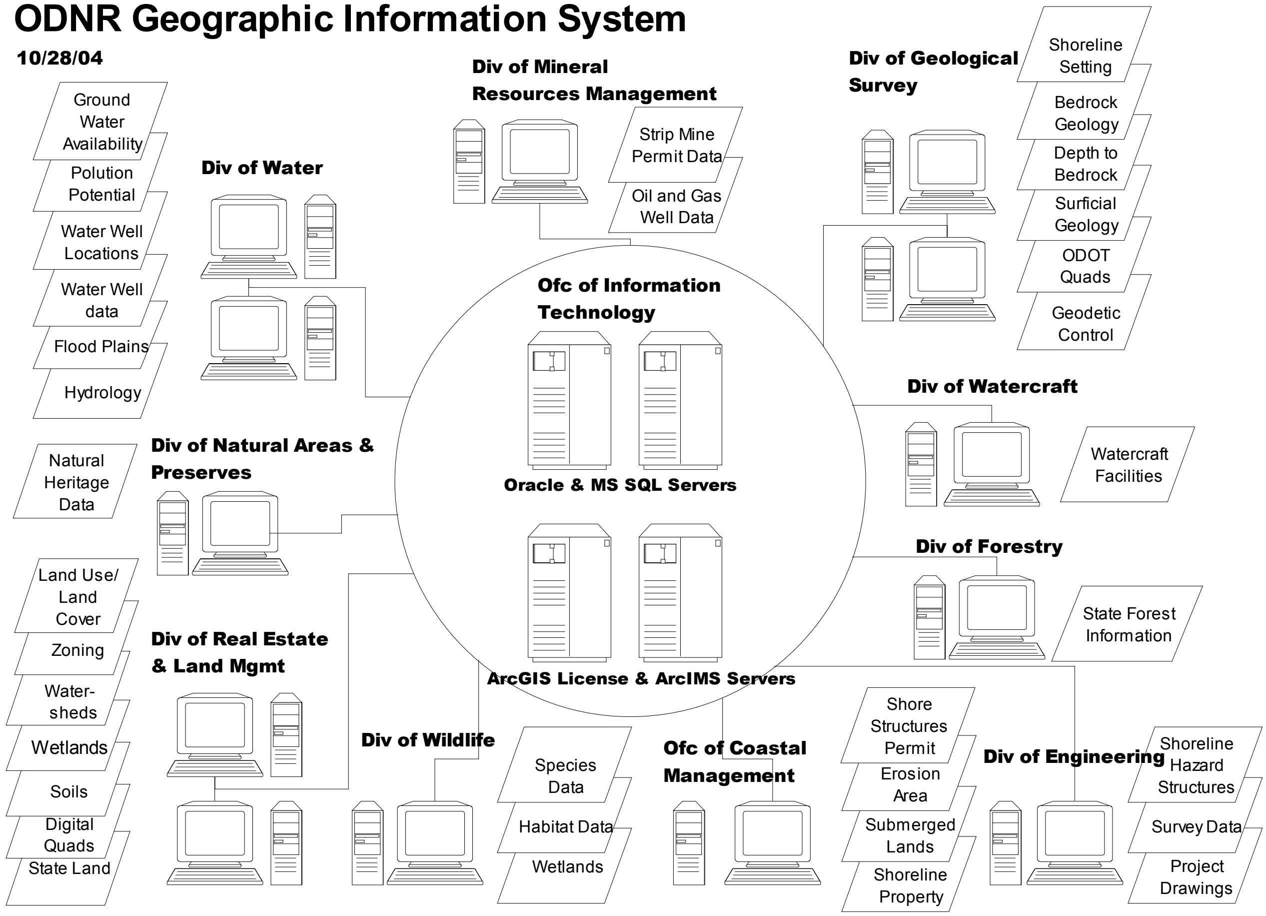
The system is coordinated and managed by the Department GIMS Administrator (DGA) in the Office of Information Technology. Program oversight is the responsibility of the GIMS Policy and Planning (P&P) Committee. The GIMS P&P Committee sets program direction, endorses standards and guidelines, and selects the division projects to be included in the GIMS Capital Budget request. This committee consists of the Chiefs of the Divisions of Real Estate and Land Management, Geological Survey, Water, Wildlife and Engineering, or their designees, and is chaired by the Department GIMS Administrator. The committee meets quarterly.

Meeting concurrently with the Policy and Planning Committee is the GIMS Advisory Committee. This committee consists of the DGA and a representative from each division and office, though usually only divisions with an active GIS program attend. The primary purpose of this committee is information exchange. It is an opportunity to disseminate information on projects, training, and other GIMS issues, and for the divisions to share their GIMS news, views, and concerns.

Finally, there is the GIMS Technical Committee. This committee meets only when there is a technical issue that must be addressed, such as the enterprise GIS system architecture or metadata database conceptual design. This committee is made up of appropriate technical staff from the major GIMS divisions, and the DGA.
The components of the implementation strategy - software, hardware, and metadata - are described in Chapters 3, 4, and 5 of this guidebook.

ODNR Geographic Information System

10/28/04



CHAPTER 2

DEPARTMENT OF NATURAL RESOURCES GIMS POLICY

The following GIMS policies have been adopted to coordinate the development of Geographic Information Management Systems (GIMS) technology within the Department of Natural Resources. They were developed from issues identified by the GIMS Policy and Planning Committee in August 1992, and are reviewed and updated annually. The purposes of these policies are:

(1) to facilitate development of efficient and cost-effective GIMS technology within DNR,
(2) to promote consistency and integration of geographic information among divisions and offices,
(3) to maximize the availability and usefulness of data,

(4) to minimize the effort required to incorporate data from one division or office into another.

These policies should serve as standards and guidelines for implementing and maintaining GIMS systems and creating geographic data. Divisions and offices, therefore, will not be developing GIMS technology in isolation, but in a consistent and coordinated manner.

POLICY I: GIMS projects must be identified and described in the division's or office's Information Technology Plan (IT Plan).

1.1 - GIMS projects developed by divisions and offices shall be included in the IT Plan and will be reviewed by the Office of Information Technology (OIT) to see that they comply with DNR standards and policies. Assistance with the development of IT Plan project write-ups is available through the Department GIMS Administrator.

1.2 - Recommended hardware specifications have been developed by Department IT Steering Committee and the GIMS Policy and Planning Committee. Hardware purchases for GIMS projects will be included in IT Plans and will be reviewed by OIT to see that they meet minimum specifications and comply with Department GIMS policies. (see Chapter 3)

1.3 - GIMS software standards have been developed by the GIMS Policy and Planning Committee. Software which deviates from the standards shall be reported in the division's or office's IT Plan and will be reviewed by OIT and the GIMS Policy and Planning Committee. (see Chapter 2)

1.4 - GIMS projects contained in a division's or office's IT Plan shall include discussions of data requirements, including data capture procedures or acquisition. Any deviation from Department GIMS standards should also be discussed and will be reviewed by the GIMS Policy and Planning Committee.

1.5 - Responsibility for the creation and maintenance of digital spatial data is determined by the division's legislated mandate and Department policy. Disputes over data responsibility will be settled by the affected divisions or offices and the GIMS Administrator, and will be reported to the GIMS Policy and Planning Committee.

1.6 - Training requirements for GIMS projects shall be included in the IT Plan. Training options available include in-house, other agencies, on-site from private contractors, or off-site from private contractors. The GIMS Administrator may work with the divisions and offices to identify and evaluate training options.

POLICY II: Department cartographic standards have been adopted and should be followed for the input, storage, and the exchange of spatial digital data. Other projections, coordinate systems, scales, etc., may be used, however, to satisfy special requirements.

2.1 - The USGS 1:24000 scale 7 1/2 minute quad map has been adopted as the consistent planimetric base map for data capture and map production. This is one of the most commonly accepted base maps, and meets most needs for scale and accuracy required by the divisions and offices. The base map is accurate for applications requiring scale of 1:24000 and smaller (e.g. 1:62500, 1:63360, 1:100000, etc.), and is useful for larger scale projects that do not require absolute spatial accuracy. Digital versions of five layers from the 1:24000 quad maps, known as DLGs, are available from the Department of Administrative Services GIS Support Center, or through DNR's GIMS Administrator.

2.2 - Latitude/Longitude (in degrees/ minutes/ seconds, or decimal degrees), is a projectionless coordinate system that may be used for the input, storage, and exchange of digital data. Although it is often used for the output of hardcopy maps, it is not structurally suited for that purpose. Latitude/ Longitude is a spherical coordinate system. A planar coordinate system, such as the Ohio State Plane Coordinate System, is needed to produce a two-dimensional map.

2.3 - Ohio State Plane Coordinate System (OSPCS 1927 datum or OSPCS 1983 datum), and Universal Transverse Mercator (UTM), are planar coordinate systems currently used by divisions and offices of DNR. These systems are recommended for the storage and exchange of previously collected digital spatial data, as well as for output of hardcopy maps. However, divisions and offices must have the capability to transform any currently used coordinate system to OSPCS (North American Datum of 1983). In addition, any new digital data collected or created after January 1st, 2000, will be input, stored, and where appropriate, exchanged in the Ohio Coordinate System of 1983, Lambert Conformal Conic projection, NAD 83, in feet.

2.4 - Since the Ohio Coordinate System of 1983 is divided into two zones for Ohio, whenever possible data should be collected, stored and exchanged in coordinates of the proper zone based on the data's location. When data are collected, stored, displayed or exchanged as a single file for the state, the Ohio Coordinate System of 1983, South Zone, NAD 83, in feet should be used. The Ohio Department of Transportation is developing a new OSPCS Unified Zone, NAD 83, which will provide a more accurate projection for statewide applications. When the National Geodetic Survey accepts this projection, it shall become the preferred projection to be used for DNR statewide data collection, storage, display and exchange.

POLICY III: Data interchange shall be accomplished in a manner that encourages the preservation of accuracy and completeness, maximizes transfer efficiency, and considers the type and intended use of the data.

3.1 - Native data interchange formats for vector and raster data should be used for transfers between like software systems.

3.2 - Intermediary exchange formats should be used when vector data interchange in native and direct exchange is not possible. ArcGIS Shape Files, GeoDatabase, or Export Files shall be used as intermediary exchange formats for Department digital geographic data. AutoCad Drawing Exchange Format (DXF) shall be used as the intermediary exchange format for Department CAD data. It is also recommended that the data interchange file generated in these formats be compressed when offered over the Internet.

3.3 - Data interchange between divisions or with the public should be accomplished via the DNR network, and/or Internet. Data exchange may also be accomplished via compact disc or other transfer media based on the considerations identified in Policy III.

3.4 - It is important that divisions and offices document digital spatial data in a consistent manner to facilitate exchange and to evaluate the fitness of the data for a specific use. The DNR metadata standard, therefore, will be used to document digital spatial data, to develop a Department data directory, and to facilitate data exchange and sharing upon its implementation. Where required by contract, the FGDC metadata standard may be used to document digital spatial data. (see Chapter 5)

The following chapters detail the software, hardware, and metadata documentation that should guide the Department in achieving its goals of information integration and cost-effective GIMS development. If divisions or offices require assistance in adhering to these policies and guidelines, the Department GIMS Administrator will be available for consultation to help determine efficient implementation strategies. The DNR GIMS Administrator can be contacted at:

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CHAPTER 3

SOFTWARE GUIDELINES

Software standards must recognize two facts:

- No single software package fully meets all GIMS application needs. All packages have particular strengths and weaknesses, and support certain applications better than others.

- Each software package to be supported requires staff resources to install, master (education and training), maintain, and troubleshoot. Therefore, budgets for support services will most likely have to be increased each time a new software package is purchased.

These countervailing forces must be carefully reconciled and balanced as part of the software selection process.

Software Categories

Currently, the Department has applications in three categories of GIMS software:

- Geographic Information Systems (GIS),
  - Vector GIS (point, line, and polygon oriented),
  - Raster GIS (grid data structure);
- Computer Assisted Drafting/Mapping (CAD/CAM),
  - engineering-oriented drafting;
- Remote Sensing and Imaging Technology (RSIT),
  - satellite image processing and analysis,
  - orthoimage production;

Based on the selection criteria and requirements outlined in Appendix A, the following software packages have been selected by the Department for each of these categories.

Approved Vector GIS Package

ArcGIS has been selected as the Department's standard vector GIS software package. Currently the Department uses version 8.3, but will be converting to version 9.0 in the first quarter of 2005. Overall ArcGIS has possibly the broadest functionality of the popular vector system, and is available on a variety of Unix and Windows NT platforms.

ArcGIS has a large number of data translators and interfaces, thereby increasing data import and export capabilities. Data sharing is a cornerstone of the Department's GIMS strategy. In addition, there is a great deal of high quality user and system documentation. Software support is very good and is mandatory after the first year (at additional cost, too.) ArcGIS can be interfaced with a variety of databases, including Oracle, MS SQL Server and Access. ESRI, the company that produces ArcGIS, has a long history of GIS innovation and strength, claiming the largest share of the GIS market nationally and worldwide. Not only is it used by the Department of Natural Resources, but also by the Departments of Administrative Services, Transportation, and Development, the Ohio Environmental Protection Agency, Ohio's Emergency Management Agency, the Public Utilities Commission of Ohio, as well as many local governmental agencies and universities around Ohio.

ArcGIS is not only the Department's standard vector GIS, but it has been selected as DNR's primary GIS software. The selection was made based on the following factors:

- ArcGIS has both vector and raster capabilities;
- Data can be easily converted within ArcGIS from the vector model to grid (raster) formats with negligible loss of information;
- ArcGIS contains a robust collection of geographic information analysis tools;
- ArcGIS is available on multiple platforms;
- ArcGIS comes complete with a large set of translation, interface, and projection/ transformation tools, which promote the wide use and exchange of data;
- ArcGIS is used extensively around Ohio, and elsewhere.

Approved CAD Software

Autodesk's AutoCAD 2005 has been selected as the Department's standard CAD software package (although versions 14 and 2000 are also in use). According to Autodesk, AutoCAD is a customizable 2D and 3D design and drafting environment toolset. With this software, architects, engineers and drafters can create, view, manage, plot and output, share, and reuse accurate, information-rich drawings. Users can use Visual LISP, VBA, ActiveX to write macros to customize menus or add functionality. AutoCAD (with add-on product ADE) also allows access to external databases such as Access, dBASE, and Oracle.

Supplemental CAD Software

Two additional CAD packages are used in the Department; Autodesk's AutoCAD LT (versions 98, 2000 and 2005) and GenericCADD v 6.1. Due to limitations of functionality and/or compatibility, these CAD packages do not meet department standards and must be approved on a case-by-case basis.

1. AutoCAD LT

Sold by Autodesk, AutoCAD LT is a low cost 2D drafting and design software that contains many of the features of AutoCAD. The differences between AutoCAD and AutoCAD LT software lie in the power, task automation, extensibility, team productivity, and smart design environment provided by AutoCAD. AutoCAD LT software focuses on making drafting more accessible to the occasional or part-time CAD user. For AutoCAD LT 2005, Autodesk suggests that as a minimum, this software should be used on a Pentium III (or later) 800MHz machine with 256MB of RAM running MS Windows XP.

2. GenericCADD

GenericCADD is a versatile low cost, DOS-based, two-dimensional CAD package that can operate on relatively low end PC's. Formally sold by Autodesk, the software is suitable for a wide variety of drafting tasks, and rivals many higher priced products in speed and power. Although not designed for network use, with some modification version 6.1 can be used over a network. Autodesk says no new versions of GenericCADD will be developed, though they do intend to continue supporting the product. GenericCADD requires 640K RAM, 2MB hard disk space (10MB recommended), and DOS 3.0 or later.

Approved Desktop Mapping or Desktop GIS Software

The Department has adopted ESRI's ArcView for desktop GIS and mapping. Currently the Department uses versions 8.3 and 3.3 (depending on the age of the application), but will be moving some applications to version 9.0 during the first quarter of 2005. Desktop GIS and mapping packages are similar to the high-end GIS software, but lack some of the more sophisticated data collection and editing, geographic analysis and map production capabilities of the larger ArcInfo product. Desktop GIS and mapping software's strength is producing intelligent maps; that is, maps with active links to relational databases. This product, and the supplemental product listed below, allows the user to visually overlay vector data with raster images.

ESRI describes ArcView as a desktop mapping and general GIS product for data visualization, query, and analysis. Built on the foundation of their larger GIS software product ArcInfo, ArcView provides a variety of spatial analysis functions, and allows tabular database queries, integration of PC and workstation geographic databases, and production of high quality maps for display or hardcopy output. ArcView operates in both stand-alone and network computing environments, on a variety of PC and workstation platforms. Although available over the DNR network, ArcView is usually used in stand-alone mode.

Supplemental Desktop Mapping Software

MapInfo is another Desktop Mapping package used in the Department. MapInfo is a geographic information visualization and query product, with limited analysis capabilities. Like other desktop mapping products, MapInfo provides extensive tools for accessing tabular data, and combining this information with graphic map data to produce quality hardcopy and softcopy output. In addition, MapInfo offers a programming language that allows users to customize the user interface, add new functionality, or connect MapInfo directly to outside applications. MapInfo also offers SQL command sets that link the software to Oracle and other relational databases. One concern is MapInfo's ability to import and export ArcGIS data; experience shows this to be difficult at best. MapInfo is available for DOS, Windows, and Macintosh PC's, and Sun or Hewlett-Packard workstations.

Approved Raster GIS Software

ARC GRID has been selected as the Department's standard raster GIS software package. Currently the Department uses version 8.3, and will be moving to version 9.0 in the first quarter of 2005. ARC GRID is a robust cell-based GIS, which is fully integrated with ArcGIS. ARC GRID offers extensive raster data management, including input, display, editing, analysis and output, and is available on a variety of Unix and Windows NT platforms.

Supplemental Raster GIS Software

Historically, within DNR there have been two additional raster GIS packages in use. The software packages were quite different in function and purpose, and each has had its own individual niche in the Department. However, due to limitations of functionality and compatibility, the use of OCAP software has been discontinued. On the other hand, due to its image processing functionality, ERDAS continues to be the only raster GIS software other than ARC GRID still in use at ODNR.

1. <u>ERDAS</u>

   The ERDAS system incorporates the functions of both image processing and raster GIS packages. These functions include the collecting, viewing, altering and analyzing of raster data sets. Common type of raster data sets used with the ERDAS software include satellite data, aerial photographs, digital topographic data, and digitized maps. Though a raster based GIS, ERDAS can use the ArcGIS data model to expand its functionality to the vector-based ArcGIS GIS. ERDAS has been used in the Department for a variety of projects, including a state wetlands determination, an abandoned mine land inventory, and a statewide land use/ land cover inventory. Within the Department, ERDAS continues to be used by the Divisions of Real Estate and Land Management, and Wildlife.

2. OCAP

The Ohio Capability Analysis Program (OCAP) was a raster based GIS package developed for and by the Department of Natural Resources. Based on the Harvard Grid model, OCAP employed a row/distance modified grid data structure. Although first deployed in 1974, the OCAP software was updated and maintained through 1997. The OCAP software has now been retired. OCAP was an integrated package of more than 30 programs that provided the wide functionality of a modern GIS. OCAP was used by the Resource Analysis Section of the Division of Real Estate for a variety of land capability and suitability studies, including sanitary landfill siting, agricultural tax assessment, and hazardous spill vulnerability analyses. Originally operating on an IBM mainframe, the OCAP was rewritten for a DEC MicroVax 3800. All data layers originally captured with OCAP software have been converted to ArcGIS Export and ArcView Shape File formats.

CHAPTER 4

HARDWARE GUIDELINES

PC Configurations

Computer Aided Design (CAD) and Desktop Mapping capabilities, for reasons of cost, are often implemented on PC-based systems. The specifications listed below are based on ODNR Class A (standard) and Class B (preferred) hardware standards in effect as of 9/27/04. When new equipment is being acquired for GIMS applications, the preferred configurations should be the Class B hardware specifications in effect at the time of the purchase, unless they are incompatible with other applications to be supported on the PC.

Video Graphics

Standard: 64MB shared memory integrated graphics adapter
Preferred: 128 MB NVIDIA Quadro FX 1300 (DVI or VGA)

Monitor

Standard: 17" color flat screen CRT (16.0 VIS 1024 x 768)
Preferred: 22" color flat screen CRT (20.3 VIS 1600 x 1200)

Processor

Standard: Pentium IV 2.8 GHz
Preferred: Pentium IV 3.0 GHz

Random Access Memory (RAM)

Standard: 512MB
Preferred: 1GB

Hard Disk

Standard: Internal hard disk, 40 GB minimum or as large as possible
Preferred: 80 GB internal hard drive or as large as can be afforded, and Ethernet card for network connection to central data storage.

CD-ROM

Standard: 48X/32X/48X CD-RW
Preferred: 16X DVD-RW

Network Connection

Standard: TCP/IP and Ethernet card (10/100 RJ45) running 10baseT
Preferred: TCP/IP and Ethernet card (10/100 RJ45) running 100baseT

Operating System

Standard**:**	MS Windows XP Professional (only)	

Printer

Standard:	Monochrome -	HP LaserJet 1300 N
Preferred:	Monochrome -	HP LaserJet 2300 N, HP LaserJet 5100 N
	Color -	HP Color LaserJet 2500 N, HP Color LaserJet 4600 N

Plotter

Standard:	HP800ps DesignJet, with a minimum 256 MB memory, HP1055cm DesignJet
Preferred:	HP5500ps DesignJet

Digitizer

Standard:	Calcomp 9500 compatible
Preferred:	GTCO AccuTab 3648

CHAPTER 5

GIMS DATA DOCUMENTATION, DATA DICTIONARY, and INDEX

Metadata

Introduction

Providing digital spatial data to users outside of DNR, and the expansion of GIS use within the Department, require an agency-wide metadata system. Metadata is a term that refers to **data about data**. Metadata standards are needed to facilitate data exchange and documentation. Without such standards it would be difficult to determine what spatial data exist, the quality of the data, the appropriateness of the data for a given use, and who to contact about the data. These issues are addressed by the Department of Natural Resources metadata system.

This chapter describes the metadata system elements used by the Department of Natural Resources. At the time of its construction, few metadata standards existed across the country. The metadata elements adopted for the DNR system were based on the minimum mandatory subset of elements under development by the Federal Geographic Data Committee (FGDC), and included additional ideas from Texas and Wisconsin metadata systems. Other elements were included to address data documentation needs unique to the department.

The web-based metadata system at ODNR includes 4 major sections; 1) Data Identification Section, 2) Projection Section, 3) Contact Section, and 4) Database/Data Set Section. These sections contain over 50 fields of information detailing the digital spatial data available from the department. Through the metadata system, users within DNR and outside of the department have access to over 1400 digital natural resources coverages.

The metadata elements described should be used to document digital spatial data for individual divisions, to develop a department data directory, and to aid in the exchange and sharing of spatial data within and outside of ODNR.

TABLE 1

ODNR METADATA ELEMENTS

IDENTIFICATION SECTION

Data Layer Classification Information
- Theme Name
- Category
- Theme Abstract/ Comments
- Cataloger
  - Telephone Number
  - E-Mail Address
- Metadata Revision Date

Location Information
- Country
- State
- County(s)
- Township(s)/ Municipality(s)
- Quadrangle(s)
- Project Area
- Bounding Coordinates
  - North
  - South
  - East
  - West

Data Format Information
- Data Type
- Digital/Paper
- Draft/Final

Software System Information
- Data File Name
- Software (including rev.)
- Transfer Format(s)
- Coordinate Precision
- Representation Model
- Resolution of Data
  - Minimum Mapping Unit
  - Cell Size
- Native Data Set Size

Data Description Information
- Data Source
  - Source Name
  - Source Scale
  - Date of Source Material
- Theme Author
- Publication Date
- Currency of Data
- Frequency of Update
- Degree of Completeness
- Data Purpose

PROJECTION SECTION

Projection Information
- Projection/Coordinate Sys Name
- Zone Name and/or Number
- Projection Units
- Horizontal Datum
- Vertical Datum
- Positional Accuracy

CONTACT SECTION

Contact Information
- Organization
- Section Name
- Contact Person
  - Name
  - Title
- Mailing Address
- Telephone
- Fax Number
- E-Mail Address

Transfer Information
- Transfer Mode
- Transfer Instructions
- Liability Statement

DATABASE/ DATA SET SECTION

Database / Data Set Information
- Database Table or Data Set Name
  - Item (Field) Name
  - Item (Field) Type
  - Item (Field) Width
  - Item (Field) Description
    - Attribute Code/ Value
    - Attribute Symbol
    - Attribute (Code/ Value) Description

DEFINITIONS

IDENTIFICATION SECTION

This section describes the general data content, location, spatial extent, generating software and source of the data.

Data Layer Classification Information

Theme Name - The theme is the lower, more specific and detailed level of a two tiered hierarchical organizational structure. It is the name of the coverage or data set. Examples include "Detailed Soils of Franklin County", or "Portage County - Ground Water Pollution Potential."

Category - The category is the higher level of the hierarchical organizational structure. The category is a summary level to which a theme can be assigned. A theme may be assigned to more than one category. Themes must be assigned to one or more of the following categories:

Administrative -	Describes features related to administrative, governmental, or regulatory boundaries.
Biologic -	Describes features related to plants, animals, and other living entities.
Cadastral -	Describes a boundary that is related to the land fabric, such as parcel ownership.
Demographic -	Describes information primarily related to human population dynamics and activities.
Geologic -	Describes surficial or subsurface features of the terrain. Included in this category is information on soils, oil and gas, and mineral resources.
Hydrologic -	Describes features that relate to water, including surface and ground water, and precipitation.
Land use/cover -	Describes features whose primary significance is to what extent they cover the surface of the earth.
Recreation -	Describes features whose primary function is to provide or support recreational activities. Recreational areas include parks, boating areas, wildlife areas, nature preserves, historic sites, etc.
Topographic -	Describes information related to elevation, such as digital elevation models and contour maps.
Transportation/ - Infrastructure	Describes features primarily related to transportation routes and utility systems, such as roads, railways, or electric transmission lines.

Theme Abstract/ Comments - This element allows the metadata cataloger to provide a description of the theme and any additional information, or comment about the theme.

Cataloger - This element contains the name of the person completing the data entry for the metadata record.

Telephone Number - The telephone number of the person completing the data entry for the metadata record.

E-Mail Address - The e-mail address of the person completing the data entry for the metadata record.

Metadata Revision Date - This element indicates the date the metadata was compiled, or last revised.

Location Information

Country - The name of the country wholly or partially containing the theme.

State - The two-letter postal codes of the state, or province, wholly or partially containing the theme.

County - The names of counties wholly or partially containing the theme.

Township/ - Municipality The names of townships and/or incorporated municipalities wholly or partially containing the theme. (optional)

Quadrangle(s)- This element lists the USGS 7.5 minute quadrangles wholly or partially containing the theme.

Project Area - This element describes the nonpolitical area wholly or partially contained in the theme. Project areas may be areas such as watersheds, wildlife refuges, or state forests. (optional)

Bounding Coordinates - The north and south latitude, and east and west longitude in decimal degrees that define a square encompassing the areal extent of the theme.

Data Format Information

Data Type - This element categorizes the format of the spatial data theme as report, map, database, publication, GIS coverage, or other.

Digital/Paper - This element categorizes the medium of the spatial data theme as digital or hardcopy (paper).

Draft/Final - This element categorizes the spatial data theme as either in final or draft form.

Software System Information

Data File Name - The name of the file or directory storing the theme. A theme may be stored in more than one file.

Software (rev) - The name and revision of the software used to create the theme.

Transfer Format(s) - The name of the transfer format(s) that may be used in the transfer of the theme (e.g. ARC/INFO Export, ASCII, DXF, DGN, SDTS).

Coordinate Precision - The precision with which coordinates are managed or maintained in the native software system and which are to be expected in the transfer. The coordinates have either single or double precision.

Representation Model - The data structure or mechanism used to represent mapped features in the theme (e.g. vector-topologic, vector- nontopologic, raster, point).

Resolution of Data - The dimension of the smallest resolvable object in the theme. The resolution is described in the following elements:

Minimum Mapping Unit - The size of the smallest area or object included in the theme (used in vector systems). (optional)

Cell Size - The x,y dimensions of the cell for data that reside in a raster format. (optional)

Native Data Set Size - The size in megabytes of the theme in its native form.

Data Description Information

Data Source - This portion of the metadata describes the source material used. The following three elements detail the data source:

Source Name - A brief descriptive name of the source material, such as "County zoning drafted by county planning agency on paper 7.5 minute quad maps."

Source Scale - Scale of source material expressed as a representative ratio, such as 1:24000 or 1:63360.

Date of Source Material - Date for which the source data is valid.

Theme Author - The name of the person responsible for the creation of the theme.

Data Purpose - The application for which the data were collected, and the intended use of the data.

Publication Date - The date when the data set was published or otherwise made available for release.

Currency of Data - The date to which the theme is current or valid.

Frequency of Update - This element describes the frequency with which the theme is updated.

Degree of Completion - An estimate of the amount of work accomplished in the series of steps required to create the digital data theme, usually expressed as a percentage.

PROJECTION SECTION

This section describes the horizontal and vertical coordinate systems, and projection used for the spatial data.

Projection Information

Projection/Coordinate System Name - The name of the projection and/or coordinate system in which the source was mapped. Examples include Geographic (latitude and longitude), State Plane - Lambert conformal conic, and Universal Transverse Mercator.

Zone Name and/or Number - The zone name or number used in the State Plane Coordinate System, the Universal Transverse Mercator System, or other coordinate system used for the theme (if the system uses zones).

Projection Units - The units in which a theme is stored. Examples include feet, meters, or decimal degrees.

Horizontal Datum - A datum is a specific set of constants defining a coordinate system used for geodetic control. Examples include the 1927 North American Datum, and the North American Datum of 1983.

Vertical Datum - Reference surface for the third (Z) component of spatial coordinates.

Positional Accuracy - A measure of positional uncertainty in units of the coordinate system. For example, "+/- 40 feet."

The following information provides the lines of reference for the listed coordinate systems.

Standard Parallel - Line(s) of latitude where the cone of projection is tangent to the spheroid of the projection. For the Ohio coordinate system (1927 and 1983) north zone, standard parallels are north latitudes 40 degrees 26 minutes and 41 degrees 42 minutes. The Ohio coordinate system (1927 and 1983) south zone standard parallels are north latitudes 38 degrees 44 minutes and 40 degrees 2 minutes.

Longitude of Central Meridian - The line of longitude that is in the center of the map from which coordinates are measured; typically the vertical line on a map drawn in a conic projection. For the two UTM zones in Ohio, the central meridian for Zone 16 is 87 degrees west and for Zone 17 is 81 degrees west.

Latitude of Projection's Origin - The line of latitude in a conic projection from which Y coordinates are measured. For the Ohio coordinate system (1927 and 1983) north zone, it is 39 degrees 40 minutes north latitude. For the Ohio coordinate system (1927 and 1983) south zone, it is 38 degrees 0 minutes north latitude.

CONTACT SECTION

This section provides point-of-contact and access information.

Contact Information

Organization - Name of organization assigned as custodian of the theme. This element is the Division or Office name (or agency other than ODNR).

Section Name-This element is the Section or Unit name within a Division (or Division name within an agency other than ODNR). (optional)

Contact Person - These two elements (Name and Title) are the name and title of the individual assigned by the Division or Section to contact regarding the theme. The Name element consists of three fields; First Name, Middle Initial, and Last Name.

Mailing Address - Mailing Address of contact person. This element consists of four fields, including Street Address, City, State, and Zipcode.

Telephone - Telephone number of contact person.

Fax Number - Fax number of the contact person.

E-Mail Address - E-mail address of the contact person.

Transfer Information

Transfer Mode - The means or media by which users may acquire the data set in a transfer format. Examples include online (Web), FTP, cartridge tape, floppy disk, or 9-track reel tape, etc.

Transfer Instructions - A specific set of instructions to be followed to obtain a copy of the data set.

Liability Statement - Statement of the liability assumed by ODNR as it applies to the spatial data distributed by the department.

DATA BASE / DATA SET SECTION

This section documents the non-graphic information associated with the theme. This information may be stored within tables of a relational database associated with a theme (herein called 'attributes') or may be stored directly within the data set, where no database is associated with the theme. This set of metadata elements can be repeated for multiple tables associated with a single theme or database.

Database Table or Data Set Name - The identity or label associated with a table in a relational database or theme.

Item (Field) Name - The name, label, or identity of the field or item in the table associated with an attribute. Examples may be "soil-code", "acreage", or "road-type".

Item (Field) Type - The type of field or item in the table associated with an attribute. Examples include numeric, character, integer, binary or date.

Item (Field) Width - The width (in bytes) of the field or item in the table associated with an attribute.

Item (Field) Description - The description or definition of an item name. An example might be "SCS soil mapping units, as shown on source map".

Attribute Code/Value* - The value, or code, of an attribute. An example might be "Zone C".

Attribute Symbol* - The alphanumeric character(s) used to depict the attribute on the initial hardcopy map. (optional)

Attribute Description* - A definition of the above attribute code or value. For the above attribute value example, an attribute description might be "Areas of minimal flooding."

(* Note - repeated for all attributes in the domain)

CHAPTER 6

CARTOGRAPHIC GUIDELINES

Standard Basemaps

Although the 1:24000 scale USGS 7.5 Minute Quadrangle series is the basemap recommended for most ODNR data collection activities, five analog basemap series are currently used in the Department for data compilation and conversion. The basemap chosen for any particular application should be based on the accuracy and resolution requirements of the application. The accuracy and characteristics of the five basemap series are discussed below.

1:24,000 USGS 7.5 Minute Quadrangles

The 7.5 minute USGS Quadrangles are the most detailed map set available for the entire state. Although the maps have not been revised since the mid-seventies (and in many cases much longer than this), the maps still provide excellent control for data compilation and conversion. Each map covers an area of approximately 57 square miles and provides information about the shape and elevation of the terrain, as well as prominent natural and cultural (manmade) features. Commonly available on paper, the maps can also be reproduced by the DNR Division of Geological Survey on mylar. A digital version of information from the quad maps, called Digital Line Graphs (DLGs), was created through a cooperative project between the State of Ohio and the USGS. The DLGs' five layers - hypsography, hydrology, transportation, political boundaries, and public lands survey - are available for download from the Department of Administrative Services (http://das.ohio.gov/ITSD/ESS/Gis/DigitalLineGraphs.htm).

1:63360, 1:62500 DOT County Road Maps

County road maps are available from the Department of Transportation at a scale of roughly one inch to the mile. These maps are compiled from data collected from the 1:24000 scale USGS 7.5 minute quad series, digitized by ODOT. No statement of positional accuracy is made.

1:100000 USGS 30' by 60' or 30' by 30' Quadrangles

USGS 1:100000 scale maps are available in printed and in digital format. The printed maps are available in a 30' by 60' format. The digital datasets, which include hydrography, transportation, land cover and boundaries, are available in 30' by 30' units from USGS or from the GIS/Remote Sensing Services Unit of the DNR Division of Real Estate and Land Management.

1:500000, 1:2 million USGS State Base Maps

These map scales are used by many agencies for compilation and presentation of statewide or multi-state information. It is best used for showing broad relationships on a statewide or multi-state basis.

Cartographic and Geodetic Control Requirements

Cartographic control should be used on GIS projects at 1:24000 or smaller scales. Cartographic control generally means that coordinate control or reference information is derived from one of the map graticules. For cartographic control, National Map Accuracy Standards should be used. This standard requires that, in a random sample of well-defined map locations, 90% will be found on the map within .02 inches of their true location on the ground. The following table illustrates the positional accuracy of 4 common scales. It should be noted, however, that the National Map Accuracy Standard is being replaced by a new National Standard for Spatial Data Accuracy.

Scale	Positional Accuracy
1:24,000	+ or - 40 feet or 12.2 meters
1:63,360	+ or - 106 feet or 32.3 meters
1:100,000	+ or - 166.7 feet or 50.8 meters
1:500,000	+ or - 833.3 feet or 254 meters

As GPS technology becomes more widely used, geodetic control will begin to replace cartographic control. With GPS, the location of data collected in the field is determined with a receiver that measures position relative to a constellation of satellites. In May 2000, Selective Availability (SA), a security measure that artificially degraded the accuracy of the GPS system, was turned off by the US military. Without SA, positional accuracy for data collected with GPS receivers can range from + or - 5 meters (16.4 feet) to better than + or - .005 meters (.2 inches), depending on the quality of the receiver and the time spent on station. For data collected before the end of SA, differential GPS processing, with a control network of basestations positioned at known locations across the state, will be required to attain these accuracies.

Projection/Coordinate Systems

Several standard projection/coordinate systems, as mentioned in Chapter One and discussed below, are used by the Department in various GIMS and traditional mapping applications. Historically, all projections have been based on the North American Datum (NAD) 1927 and the Clarke spheroid of 1866. However, since January 1 Department GIMS applications have been based on a Lambert conformal conic projection of the North American Datum (NAD) 1983, in accordance with surveying law (ORC 157). Projection parameters for each system are listed below.

Ohio State Plane Coordinate System

The Ohio State Plane Coordinate (OSPC) System is a planer Cartesian coordinate system based on a Lambert Conformal Conic projection. Developed by the U.S. Coast and Geodetic Survey (now the Geodetic Survey within NOAA), the OSPC System is designed to serve engineering, surveying, and mapping applications. Ohio has been divided into two zones, North and South, to restrict distortion to no greater than 1 in 10,000, or roughly one foot every two miles. Each county is assigned entirely to one of the two zones. Counties on either side of the zonal boundary cannot be joined with those across the line without coordinate transformation and reprojection. This coordinate system is best used for county or regional scale mapping. OSPC coordinates based on NAD27 are expressed in feet, while OSPC coordinates based on NAD83 are expressed in meters (although ODNR and ODOT continue to use feet as the unit of measure).

North Zone	OSPC of 1927	OSPC of 1983
Standard Parallels	40°26' N and 41E42' N	40°26' N and 41E42' N
Origin	82°30' W and 39E40' N	82°30' W and 39E40' N
False Easting (x)	2,000,000 feet	600,000 meters
False Northing (y)	0 feet	0 meters

South Zone	OSPC of 1927	OSPC of 1983
Standard Parallels	38°44' N and 40E02' N	38°44' N and 40E02' N
Origin	82°30' W and 38E00' N	82°30' W and 38E00' N
False Easting (x)	2,000,000 feet	600,000 meters
False Northing (y)	0 feet	0 meters

Universal Transverse Mercator

The Universal Transverse Mercator (UTM) is a planer coordinate system developed by the U.S. Army, which uses transverse Mercator cylindrical projections and a set of zones and offsets around the globe. The world is divided into 60 zones each covering six degrees of longitude. Each zone extends three degree eastward and three degrees westward from its central meridian. Most of Ohio is located within Zone 17, while the western fifth of the state is in Zone 16. With a separate projection for each UTM zone, a relatively high degree of accuracy is possible (one part in 1000 maximum distortion at the east and west edges of each zone). If a map is to be projected beyond the border of a UTM zone, the entire map may be projected for any UTM zone specified by the user. However, the maximum distortion increases with increasing distance from the specified zone's central meridian. UTM is often used for maps that have a greater north/south extent than east/west. UTM coordinates are measured in meters.

Zone 16

Central Meridian	87°00' W
Range	90°00' W to 84°00' W

Zone 17

Central Meridian	81°00' W
Range	84°00' W to 78°00' W

Latitude/Longitude (Geographic Coordinates)

If the shape of the earth were to be generalized to a sphere, Latitude and Longitude (also called geographic coordinates) can be used to describe locations on that sphere. Longitude, set by international agreement, measures the angle around the sphere from the *prime meridian*. The prime meridian is a straight line connecting the north and south poles, passing through the Royal Observatory at Greenwich, England. Latitude is the angle, measured north or south from the equator, that identifies a line parallel to the equator and perpendicular to the axis of the earth. Since Latitude/Longitude is a spherical coordinate system, it cannot be used to produce two-dimensional maps. Though some flat maps show lines of latitude and longitude, it must be remembered that these are only two-dimensional representations of the Latitude/Longitude grid *after* it has passed through the 3-D to 2-D transformation contained in the map projection.

Although latitude and longitude are not suited for 2-D maps, they can well be used to provide locational coordinates for data storage. These coordinates could then be transformed with a map projection, chosen by the user, to produce a flat map.

Ohio's General Range of Latitude and Longitude

Maximum Latitude	41°58'49" N
Minimum Latitude	38°24'01" N
Maximum Longitude	84°49'15" W
Minimum Longitude	80°30'04" W

CHAPTER 7

MAP DESIGN GUIDELINES

Introduction

Even with the explosive growth of GIMS technology and digital data in the late 1980's and throughout the 1990's, traditional cartography and paper maps continue to be of great importance to GIMS. Maps, as data source and GIMS application output, are still the best tool for summarizing and communicating complex information about spatial data. The purpose of including map design guidelines in this document is to assist those making maps in producing high quality map products. This section is not intended to be a substitute for professional judgment, either cartographic or discipline-specific, nor to be a substitute for cartographic education and training. The guidelines presented here are intended as an introduction and reference to items to consider in the map design process.

Map design requires careful consideration, systematic planning, and attention to detail if the product is to communicate effectively, meet professional quality standards and convey an appropriate impression of the Division and Department to the public. In this respect, automated mapping is similar to traditional manual cartography. The principles of good map design are independent of the tools of production.

Traditional cartography is generally viewed as having five interrelated cartographic 'areas of focus'. Good map design and production should include some attention to each area.

- A *geometric focus* considers creating a cartographic model of reality of sufficient quality to provide a basis for measurements and analyses.
- A *technical focus* which is concerned with the map-making process, or series of processes including data collection, map design, production, and reproduction.
- A *presentation focus* that emphasizes the map content, having significant concern with spatial data storage on the map, choosing what should be included on the map and what should be left off.
- An *artistic focus* where the concern is for visual presentation, including decisions on color, patterns, shapes, shades, balance and contrast.
- A *communication focus* strives for effective communication of the spatial data and for serving the users' needs.

Design Considerations and Criteria

Intended Emphasis

The informational message, what the map is attempting to convey to the users, should be a prominent component of the map. It is, after all, the purpose for creating the map. Avoidance of map "clutter" by judicious selection of base layers included on the map will help. Use of appropriate symbology will also contribute to this end.

Selection of Layers

A careful balance should be struck between the need for background, orientational and reference layers, and the thematic information presented by the map. If the base layers are too prominent, it becomes difficult to understand the thematic or statistical information the map intends to present. If contextual reference layers are inadequate, the map will lack spatial reference. A corresponding level of abstraction or generalization should be present in both. Providing a detailed base when the theme is of questionable accuracy can be deceptive and should be avoided.

Symbology

Proper use of map symbols is critical to several design components, such as: detection of objects, discrimination between objects, identification of object classes, and clarity, legibility, contrast, and hierarchical organization of map data. Symbol selection is important so as to not misrepresent the data. For example, a graduated symbol should not be used to represent nominal data. Symbols are modulated by varying seven elements: hue, value, size, shape, spacing, orientation and location.

Figure-Ground Relationship

Establishment of the figure-ground relationship is critical to effective map communication. Figure-ground is the relationship established in the viewer's mind between what is perceived as a foreground figure and its background surroundings. Care should be taken to ensure that the subject of the map be clearly dominant through the use of appropriate area and line symbology in both the figure and ground map components.

Typography

Map usability is significantly affected by the quality, design and density of the lettering. Good design makes names and other text easy to find and read. A hierarchy of sizes and selection of colors should be used to reinforce the map classes and aid in the communication objectives of the map.

Map Composition

The following discussion of map composition has been largely taken from the State of Wisconsin Department of Natural Resources *Information Management Policy, Standards and Procedures Handbook*, and noted references. Again, the purpose of including this information is to assist those making maps in producing high quality map products.

Compositional Elements: Overview

The potential inclusion, internal arrangement and content of many elements should be considered in the map design process. This step becomes more important when a series of similarly arranged maps is to be produced. The following table lists commonly used compositional elements in approximate order of importance. Specific considerations for each of the map design elements follow the list:

- The map proper: Base layer(s) and thematic information.
- Title(s) and subtitle(s).
- Map key and other content description(s).
- Explanation of spatial processing technique(s) utilized, or description of scientific model(s) employed.
- Data source(s), lineage and electronic storage locations.
- Statistical elements: data tables, frequency histograms or other graphics.
- Scale information: representative fraction, scale bar, scale factors, pixel or grid cell resolution, minimum mapping unit, etc.
- Index map(s).
- Organizational identification(s).
- Credits for data gathering, processing, compilation, funding, etc.
- Orientational elements: projection name/parameters, graticule, coordinate grid(s) tics, north arrow, etc.
- Graphical elements: neatline, etc.

1. <u>The Map Proper</u>

The map proper is the most important element of a cartographic composition. It should be positioned in a prominent position, in the visual center of the overall composition (i.e., slightly above the actual center). Map symbology should assure it a visually dominant position, but should not be emphasized to the extent that it becomes overbearing, relegating other elements to visual obscurity.

A number of issues should be carefully considered, as a lack of attention to them significantly interferes with the communication objectives of the map. These include the intended emphasis of the map; selection of base and thematic layers to be included; point, line, area and volumetric symbols; establishment of figure-ground relationship; and, typography. Each will be discussed below.

2. <u>Title</u>

It is hard to imagine a map composition that does not benefit from a title. The actual wording of the title should be carefully considered. On the one hand, a brief, succinct description of the map contents is highly desirable. On the other hand, a thorough, complete and accurate reflection of the content and purpose of the map is important. These not-quite-mutually-exclusive goals must be balanced to assure completeness without wordiness, and accuracy without resort to jargon. An incomplete or inaccurate map title is an invitation to misunderstanding and abuse of the map content and information. A complete, accurate title is insurance against such an outcome.

In general, title placement should contribute to the overall balance of the composition. Placement should usually be towards the top and center of the composition. In some cases, it may be desirable to place it as a heading on the map key. Occasionally, for reasons of format consistency or balance, it may be necessary to place the title at the bottom, center of the composition. In these cases, typographic size and style should be used to draw attention to the title.

In a location reference map, the name of the area being mapped, and the data classes emphasized are equally appropriate as title elements. Example titles:

- Major Streams in Southeast Ohio;
- Northern Ohio Fishing Lakes; and,
- Delaware County Wildlife Refuges.

In resource distribution or thematic maps, the resource mapped is relatively more important than the area of coverage. In a location reference map, these two elements were more equally weighted. Example titles:

- Migratory Waterfowl Flyways;
- Driftless Area (SW Ohio); and,
- Native Range of Northern Hardwoods.

In a statistical map, the conceptual complexity of the item being mapped is often so intense that little title "space" is available for area description. Area descriptions are, perhaps, better placed on the map itself. Example titles:

- Per Capita Arrests for Fishing Violations – 1990;
- Average Annual Permitted Volatile Organic Compound (VOC) Emissions; and,
- Percent of Land Area in Commercial Timber Types – 1980.

3. Map Key

Map keys, or legends, are critical to effective map communication. They should include explanations of all map symbols; point, line and area.

The map key or legend should contain two categories of information about map symbology: First, descriptions of the symbology used to depict the map subject; and, following, a catalog of all of the symbols used for the base layers. Furthermore, any symbol explained should appear in the legend *exactly* as it appears on the map, drawn in precisely the same size and manner.[3] Symbols for the base layers should be sorted by type (e.g., point, line and area symbols).

The legend should be placed in such a way as to contribute to a feeling of overall balance in the composition. As the second or third largest and/or visually significant element in the map, its positioning vis-à-vis the map itself and other significant elements must be carefully planned. The best position for the legend is generally in the lower left corner. Map readers often start on the left side of the map, and the legend should be in such a prominent position. If this location is not available, the lower right corner is a good alternative.

Map keys are relatively least important for simple locational reference maps. They should still be included, to assure effective map interpretation. All resource distribution and statistical maps require the use of a map key to define map symbology. While the relative gradients of range graded presentations are often intuitively obvious, the absolute quantities usually need articulation.

4. Processing Explanations

Processing explanations are used to tell the user how the data depicted in the map were processed (i.e., what models, statistical summarizations, etc. were performed upon the raw data from which the map was derived). This element is usually not necessary for location reference maps. Relevance for resource distribution or statistical maps is a function of the complexity of the processing required to create the dataset mapped. Simple distributions or volumes can often be described adequately in the map title and key. Complex distributions or statistics, or those derived from lengthy processing sequences will almost always require a text box to document the data processing methods. This is especially true where the map depicts the results of scientific spatial models.

The critical graphical element of this map component is typography. A size and style that is legible without approaching dominance is suggested. If more than half a page of text is required for this element, consideration should be given to developing a two page set of map and explanatory text, or incorporating the explanatory text into the body of the report which is to include the map.

The effect of this element on overall composition balance should be considered. Often, a box outline is useful to set off the explanation from the rest of the map and enhance its elemental identity.

5. Data Sources

Crediting data sources is more than a cartographic courtesy. It is a matter of professional ethics and “truth in labeling.” Data source crediting and lineage documentation is critical to enabling map users to judge “fitness for use” for particular applications. It is an important element in all three map classes.

It is preferable to incorporate source citations directly on the map. Where limited page space precludes the addition of source credits, such information should be placed in accompanying text, the report body, or in a footnote to the map reference in the text.

Particular care should be exercised so as not to use copyrighted materials without written permission. The exact citation should be requested from the copyright holder as part of the permission letter.

6. <u>Statistical Elements</u>

Space permitting, statistical elements should be included as integral parts of the map composition. Larger statistical elements bear more consideration in the cartographic design process. Graphical statistical elements require more attention to internal arrangement. Balance of complex statistical elements should be considered on two levels: within the composition as a whole, and within the statistical element.

As one of the larger and/or visually dominant map elements, the relative placement of statistical elements within the composition should receive some consideration. The use of rough layout sketches prior to development of computerized templates is strongly suggested. The same principal is applicable to within-element arrangement.

A number of different formats and statistical displays are available for inclusion in map statistical elements. Numeric presentation formats include listings of raw data values, where they are relatively few, and descriptive statistics, for small or large data sets. Various measures of central tendency (arithmetic average, median, modal values) and distribution (standard deviation, co-variance coefficients) are often appropriate. Where the map subject itself is statistical, presentation of higher level, multivariate statistical measures (correlations, statistical significance) is often a useful aid to map comprehension.

As the statistical measures presented become more complex, thereby requiring more explanation, the distinction between numeric statistical elements and map text begins to blur. In those cases, consolidation should be considered.

Statistical graphics can be useful adjuncts to a composition. As a map is a powerful tool for describing a *spatial distribution*, a graphic display can be an effective way of characterizing a *frequency distribution*. Many alternative chart formats are available. Histograms, or bar graphs, are useful for portraying frequencies of range graded distributions. Scatter plots are effective in describing bivariate distributions or, with the addition of a regression line, in illustrating correlations. Pie charts can be effective in displaying areal proportions of class values for discrete or range graded data.

Locational reference maps rarely benefit from the addition of statistical elements. Comprehensibility of resource distribution maps is often improved by inclusion of such components. The communication objectives of statistical maps are usually facilitated by judicious selection of appropriate, well-composed, statistical elements.

7. <u>Scale Information</u>

A scale bar is essential to conveying a map's scope and area of coverage. A scale bar should almost always be included in any map. Scale bars should be easy to understand and able to survive photo-mechanical reduction or enlargement without loss of meaning. A scale bar is a small, unobtrusive insurance policy to keep map scale in context.

The use of scale factors is most appropriate where projection characteristics are such that there is considerable scale variation over the project surface and the map is intended for metric uses. In such cases, an inset map diagram may be the best means of communicating this information without cluttering the map or losing the scale factors in the map body.

As one moves from locational reference, through resource distribution, to statistical maps, these elements become relatively less important. A locational reference map intended for professional uses such as scaling off precise distances would, for example, be incomplete without at least a representative fraction, and would probably benefit from point locations defining scale factors, if there is a range of such within the map area. A statistical map, intended for use by a general audience is, perhaps, better off unencumbered by unnecessary technical background information. The map designer should consider the relative importance and necessary level of detail of the cartographic information to be presented in light of the communication objectives of the map being designed.

NOTE: Scale information, such as the map scale (representative fraction or RF), a scale bar, or scale factors (SF) at various locations on the map are more relevant for professional, technically literate audiences than they are for the general public. For the average map reader, scale information may be more confusing than enlightening. Map designers must recognize this fact and try to keep their compositions free of unnecessary technical detail when the map's intended audience is the general public.

8. <u>Index Maps</u>

Index maps should be included wherever space is available in a composition. An index map is most critical as an accompaniment to a large scale map, and relatively less important for a smaller scale map, especially where the area of coverage is immediately identifiable (e.g., the State of Ohio). The importance of index maps is about the same with respect to each of the 3 map classes.

9. <u>Organizational Identification</u>

Inclusion of a Department logo should <u>always</u> be considered. It is required for large-sized, original compositions intended for public presentation. It should be sized so that it is readable, but not overbearing. Lower corner locations are appropriate to help assure a subordinate emphasis. Like the cliché about well-behaved children, logos "should be seen without being heard." That is, they should be visually apparent, but not compositionally dominant.

Maps that are the result of multi-agency projects should include multiple logos unless it would cause visual overcrowding. Even in such cases, other simplification methods (such as eliminating other elements) should be considered before omitting these politically important components.

Logos are relatively less important for location reference maps derived from primary sources. They are much more critical where original information is presented, as is often the case with resource distribution and statistical maps.

10. <u>Credits</u>

It is always important to "give credit where credit is due," and maps are not an exception to this rule. Acknowledgment of those involved in data gathering and processing, map design, compilation and production, and, of course, funding, is appropriate and prudent. Credit statements are equally important to each of the 3 map classes.

11. <u>Orientational Elements</u>

Orientational elements within the map proper are critical components. A graticule helps to give a sense of the projection characteristics and the global context of the map sheet, especially as the region mapped gets larger. A properly applied graticule can also strengthen the map's figure-ground relationship (i.e., a subdued graticule depicted within the "ground" portion of the map).

Projection information and coordinate grids or tics are most useful for map mensuration applications. Marginal tics are unobtrusive, useful additions to almost any map. Coordinate grids in the "figure" portion of the map should be used more carefully. They should be included only where the map is to be used for scaling coordinates, as they tend to assume a predominant position in the composition. Map projection information is critical only where data extraction or manual map overlay can be anticipated.

NOTE: North arrows are among the more abused cartographic elements.

Cutesy, gargoyle and cherub-adorned north arrows are garish. Such baroque atrocities are better suited for parodies than for serious maps. Even a simple, basic north arrow, in fact, is only needed when north is not oriented towards the top of the page. Otherwise, its only use is to fill voids or balance a composition.

A graticule is equally important to all 3 map classes. Coordinate grids and tics are most useful for locational reference maps.

12. Graphical Elements

Neat lines, dividing lines, box definitions and other similar graphic treatments can enhance or detract from good map design. Where they reinforce the identity of map elements and contribute to overall balance, they are useful. Where they could add unnecessary clutter, or be confused with other symbology (e.g., graticule lines), they should be avoided. Such graphical elements are equally important (or unimportant) to each of the 3 map classes. Importance is more a function of the individual map design than on the type of map.

One thin neat line should almost always encompass the maps and various compositional elements. Credits can be put outside this frame.

Conclusion

Cartography is both an art and a science. Good design allows the expression of both. The technical, scientific aspects, however, must be properly attended to, as described above, before the artistic expression can be "given wing." Each aspect is a necessary component of the map design process. Both are required for successful cartographic design.

References

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[2] Wood, Denis, and John Fels, "Designs and Signs/Myth and Meaning in Maps," Cartographica, Vol. 23, no. 3, Autumn 1986, pp. 54-103.

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Appendix A

Software Selection Guidelines

Department of Natural Resources
Software Selection

Selection Criteria

Several criteria were considered when evaluating alternative GIMS software packages for specific applications within the Department of Natural Resources, including:

- Functionality (Is this the best tool for your application?);
- Cost (Is this package cost efficient?);
- Data Exchange Capability (Can data be imported and exported to other Department GIMS software?);
- Documentation Quality and Quantity (Have enough written materials been provided to answer most questions thoroughly and understandably?);
- Software Support (Will there be someone available to help you?);
- Compatibility with ORACLE and ODBC (Will you be able to incorporate or use data from a Department-standard data base?);
- Platforms Supported and Hardware Requirements (What computers and peripherals can you, or must you use?);
- History of Vendor (What is their track record for enhancements or expected future ones? Will they be in business next year?); and
- Current Usage in DNR and other State Agencies (Are you going down this path alone? Are you their Guinea Pig?).

Software Evaluation

I. Vector GIS Packages

A. Requirements

1. Data Import/Export Software Requirements:

To be considered as a Department-supported vector GIS package, a system must be able to read and write the following file formats, with an acceptable level of accuracy: ARC/INFO coverage, export, geodatabase or shape format files, USGS DLG-3 (Digital Line Graphic) Standard and Optional formats, and AutoCAD DXF (Drawing Interchange Format). In addition, the software vendor must have made a commitment to support the Spatial Data Transfer Format (SDTS), and deploy a translator. ODNR is engaged in a number of Federal government contracts whereby the department may be required to deliver data in SDTS format.
Successful translation of at least six digits of precision is considered

minimally acceptable. Twelve digits of translation precision are preferred.

A second requirement relates to digitizing coordinate precision. An acceptable package must be capable of storing digitizer inches to the precision of the table (usually .001” to .005”), including tic files.

Alternatively, the digitizing software must be able to perform a bilinear or affine transformation (shift, scale, and rotate) from digitizer inches to map projection coordinates "on the fly," including tic files. Meeting either requirement is sufficient for recognition, however, digitizing in digitizer inches is preferred. It is desirable for a package to support both alternatives.

2. Cartographic Manipulation Requirements:

Only a cartographicaly functional system can be used for establishing cartographic control or changing map projections. Certification of cartographic functionality minimally includes:

a) Support for and transformation/projection capability between the following coordinate systems:

- Digitizer (map) Inches (DI)
- Latitude-Longitude (geographic) (LL)
- Universal Transverse Mercator (UTM)
- Ohio State Plane Coordinates (SPC)

b) Support for, and reprojection capability between, the following map projections:

- Lambert Conformal Conic (LCC)
- Transverse Mercator (TM)
- Geographic (latitude/longitude) (LL)
- Albers Equal Area Conic (AEAC)
- 'American' Polyconic (PC)

c) Support for, and reprojection capability between, the following datums:
- North American Datum of 1927 (NAD27)
- North American Datum of 1983 (NAD83)

The ability to transform coordinates and change projections is absolutely critical to a large area GIS. It is a potentially serious error, for example, to mosaic two adjacent maps or overlay two coincident maps drawn or created with different projections. They must first be reprojected to a common projection, and have their coordinates transformed to a common coordinate system.

The results generated by the projection software must be precise to within .001 of a foot using State Plane coordinates or within 1mm using UTM coordinates. The projection software can be tested against output from software available through the National Geodetic Survey (including the Army COE software CORPSCON) or by manually computing the results of the transformation using equations from the *U.S. Geological Survey Professional Paper 1395, Map Projections - A Working Manual*. The projection software also must use the NADCON algorithm when transforming coordinates between NAD-27 and NAD-83 datums, This is the only official method for performing this type of datum transformation.

3. Topological Structuring Requirements:

Topology describes the spatial relationships between connecting or adjacent features in the data model. Topology is required in a GIS for certain spatial modeling operations that require topological information, such as optimal path analysis or certain Boolean logic operations. Only a topologically functional system can be used for checking topological consistency. Certification of topologic functionality minimally includes approval of:

a) Automated detection and identification of unclosed polygons and unconnected lines.
b) Automated detection and identification of unlabeled polygons, lines, or points.
c) Automated intersection of lines or polygon lines digitized in "spaghetti" mode (i.e., nonintersected, nonstructured data.)

d) Creation of linked lists of:
   - Line or polyline end points (nodes)
   - Line or polyline chains (vertices) between end points
   - Polyline segments that comprise each polygon
   - Line or polyline label points
   - Map boundary or extent
   - Map reference points (tics or control points)
   - Polyline relationships to left and right polygons

4. Data Analysis Requirements:

Vector-based data analysis functions requiring topologically structured data should be performed by a topologically-intelligent system. Such analytical functions include, but are not limited to:

- Polygon overlay, with the transfer of attribute data from both parent polygons to the attribute files of each child polygon;
- Buffering functions, around points, lines, and polygons;
- Point or line in polygon overlays, with the transfer of point/line attributes to polygon attribute files and vice versa;
- Attribute modeling, with attribute files being manipulated to create new attributes that are displayed graphically.
- Networking applications, such as evaluating drainage systems upstream from some feature, route calculations, districting, etc.; and
- Proximity analysis, such as polygon adjacency, neighborhood analysis, or distance calculations.

II. CAD/CAM Software

Applications using other vector-based GIMS software packages are also found in the Department. As previously mentioned, it is important to evaluate software and select the packages that best match the requirements of an application and are consistent with the Department's computing and GIMS strategy.

A. Requirements

1. Data Input

See the above descriptions for the vector GIS software package.

2. Data Import/Export

The software must be able to Import/Export AutoCAD rev. 9 (and later) DXF files.

3. Coordinate Space

The software must be able to support double precision coordinates. This will enable the software to perform real world mapping.

III. Desktop Mapping Software (Desktop GIS)

A. Requirements

The only requirements of Desktop Mapping, or Desktop GIS software packages relate to data exchange (import and export). Consistent with the Department's enterprise-wide strategy, a package must be able to import ArcView Shape files, ArcINFO coverage, or export format files and AutoCAD DXF (Drawing Interchange Format) files to be considered for use at DNR. In addition, the software vendor must have made a commitment to support the Spatial Data Transfer Format (SDTS). Similarly, the package must be able to export files in a format acceptable to ARCGIS.

IV. Raster (Grid based) GIS Packages

A. Requirements

Although most modern GIS packages have some components of both raster and vector functionality, the distinction is found in the basic data model used by the packages. In GIS packages, the significant property that differentiates raster and vector data models is the way in which they represent spatial features. Whereas vector systems store data as a series of points that form line segments to describe spatial features (e.g. roads) or feature boundaries (e.g. watersheds), raster systems employ a grid of cells that overlay the spatial features in the area of study. Information about the spatial feature is recorded for each cell under which it lays. Each approach, raster or vector, has its advantages and disadvantages. Many of the more powerful GIS's incorporate both approaches and permit the user to move easily between one data structure to another.

Again, the only requirements of raster GIS packages relate to data exchange (import and export). Consistent with the Department's enterprise-wide strategy, a package must be able to import ArcView Shape files, ArcGIS coverage, or export format files, and AutoCAD DXF (Drawing Interchange Format) files. In addition, the software vendor must have made a commitment to support the Spatial Data Transfer Format (SDTS), and deploy a translator in the next five years. Similarly, the package must be able to export files in a format acceptable to ArcGIS and/or AutoCAD.