Michigan Association of County Drain Commissioners (MACDC)

Business Plan for NHD Implementation

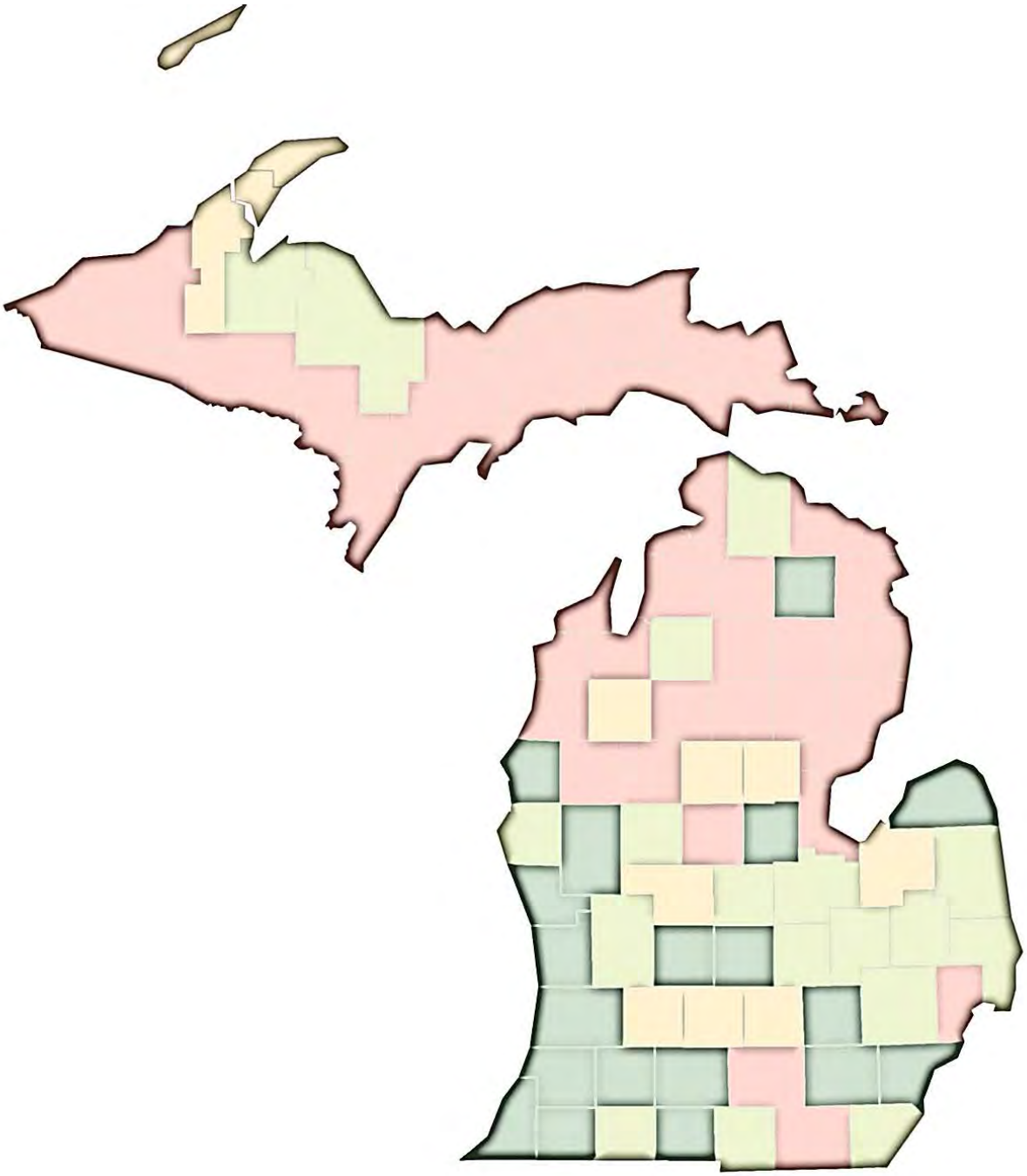


Table of Contents

List of Figures 4
List of Tables 5
List of Acronyms 6
Executive Summary 7
1. Introduction 10
2. Background 11
2.1 MACDC Organization & Mission 11
3. National Hydrological Dataset 12
3.1 NHD Applications 12
3.1.1 StreamStats 12
3.1.2 National Fish Passage Program 12
3.1.3 SPARROW 13
3.1.4 WATERS (Watershed Assessment, Tracking & Environmental ResultS) 13
3.2 NHD Tools & Utilities 13
3.2.1 NHD Tools 14
3.2.2 NHD Utilities 15
3.3 NHD Stewardship 16
3.3.1 NHD Community of Users 17
3.4 Benefits of the NHD 18
3.5 Architecture of NHD 24
3.6 Maintenance of the NHD 27
3.7 NHD Issues 27
3.8 NHD Road Ahead 28
4. Assessment 29
4.1 Data Inventory 29
4.1.1 Overview 29
4.1.2 Participation 31
4.1.3 Findings 31
4.1.4 Drain Commissioner Business Processes 36
4.2 Business Case Studies 36

4.2.1 Clinton County, Population ~75k (Minimal drain integration) 36
4.2.2 Livingston County, Population ~ 180k (Partial drain integration) 38
4.2.3 Kent County, Population ~ 600k..... 39
5. Return on Investment..... 40
5.1 Benefits to MACDC..... 40
6. Action Plan..... 42
6.1 Implementation Options..... 43
6.2 Workflow..... 43
7. Next Steps..... 45
Appendix A – MACDC Contacts 47
Appendix B – Survey Results (2013) 49

List of Figures

Figure 1 - SPARROW Screen capture 13
Figure 2 - Layering of data facilitates analysis 18
Figure 3 - Hydrological units and subbasins 19
Figure 4 - The National Hydrography Dataset (NHD) Model (v2.0) 20
Figure 5 - Flow direction providing intelligence to the data. 21
Figure 6 - Leveraging the NHD Flow Network 22
Figure 7 - Linear Referencing along a stream 23
Figure 8 - Events identified by segment or points on a flowline 23
Figure 9 - Integrated view of data layers 24
Figure 10 - Snapshot of common NHD layers 26
Figure 11 - Harmonizing data across borders 27
Figure 12 - Survey Responses for 2013 and 2010 31
Figure 13 - Data Accessibility 31
Figure 14 - Data Format and Extensiveness 32
Figure 15 - Drain Count and Stationing 34
Figure 16 - Clinton County 36
Figure 17 - Clinton County; contaminated waters 37
Figure 18 - Livingston County 38
Figure 19 - Kent County 39
Figure 20 - Benefits Roadmap for NHD 41

List of Tables

Table 1 - Counties Data Accessibility 32
Table 2 - Synopsis of counties with GIS, CAD, Drains 33
Table 3 - Counties with Hard Copy or CAD Only 33
Table 4 - Data with Unknown Accessibility 33
Table 5 - Synopsis of Drain Count /Stationing 34
Table 6 - Drain Count and Stationing Unknown 35

List of Acronyms

3DEP- 3D Elevation Program
DEQ – Department of Environmental Quality
DNR – Department of Natural Resources
EPA – Environmental Protection Agency
GIS - Geographic Information Systems
HEM - Hydrography Event Management
IMAGIN - Improving Michigan's Access to Geographic information Networks
MACDC – Michigan Association of County Drain Commissioners
MDOT – Michigan Department of Transportation
MDARD - Michigan Department of Agriculture and Rural Development
MICAMP - Michigan Communities Association of Mapping Professionals
MSU – Michigan State University
NFPP - National Fish Passage Program
NRCS - Natural Resources Conservation Service
NHD - National Hydrography Dataset
SPARROW - Spatially Referenced Regressions On Watershed attributes
USACE – United States Corps of Engineers
USDA – United States Department of Agriculture
USGS - United States Geological Survey
USFS- United States Forestry Service
WATERS - Watershed Assessment, Tracking & Environmental Results System
WBD – Watershed Boundary Dataset

Executive Summary

The survival and success of an organization depends on many variables as the counties in Michigan strive to become as efficient as possible. GIS has emerged as a technology that the counties of Michigan are looking towards to create these efficiencies and facilitate solutions. This business plan is proposed for adoption by the Michigan Association of Drain Commissioners (MACDC) for the exploration and implementation of the National Hydrography Dataset (NHD) for the state of Michigan. The plan addresses:

- Findings from the November 2013 MACDC GIS Survey (i.e. issues and concerns with the adoption of the NHD)
- Stewardship and maintenance of the NHD
- Long term plans for improvement and adoption of the NHD.

The U.S. Geological Survey (USGS) has recently awarded a grant to the MACDC to develop a business plan for collection of hydrographic data within the office of Michigan's primary stormwater management entity. The USGS maintains the NHD, which is currently the largest single database related to surface hydrology in Michigan. In order to continue to build a more robust model, the USGS is interested in the capture of information related to subsurface stormwater conveyance in Michigan, which are not currently incorporated as part of the NHD. Consequently, a grant opportunity was created to develop a business plan for the eventual collection of this data from all of Michigan's 83 counties.

Michigan's Drain Commissioners have primary responsibility to maintain legally established drain infrastructure in order to protect agricultural lands and other properties from inundation. The NHD has significant potential to provide Drain Commissioners with the data necessary for modeling efforts as part of their maintenance activities, as well as to provide a significant basemap for developing GIS programs in the various counties. This plan will document the current state of drain information across the state as provided by the November 2013 MACDC GIS Survey and identify challenges that exist related to the data collection and costs associated with the adoption of the NHD.

The NHD is a comprehensive digital spatial data schema of surface water features such as lakes, ponds, streams, rivers, canals, dams and stream gages for the United States (US). The NHD is used to represent surface water on maps and perform geospatial analysis. It is designed for use by Geographic Information Systems (GIS) facilitating the ability to analyze how water flows throughout the US. NHD provides benefits to those that adopt it. At a high level it allows the counties of Michigan to leverage the following capabilities:

- Contains a flow-direction network that traces the water downstream or upstream.
- Uses an addressing system to link specific information about the water such as water discharge, water quality, and fish population.
- Includes more than 50 types of surface water features found on USGS topographic maps.
- Provides links to the NHD Viewer, pre-staged sub-regions, and dataset extracts by state.

GIS technologies take advantage of the attributes imbedded in the NHD to generate specialized information that are possible because the NHD contains a flow network that allows for tracing water downstream or upstream. Using basic NHD features like flow network, linked information, and other characteristics, it is possible to study cause and affect relationships, such as how a source of poor water quality upstream might has affects downstream. Having this capability would be a primary interest for several counties in Michigan.

The goals of this plan are to:

1. Identify what data the drain commissioners have today
2. Identify gaps in data that exist
3. Identity the benefits of implementing the NHD
4. Evaluate the NHD for meeting current processes of the drain commissioners.
5. Propose a plan for the adoption and implementation of the NHD.

GIS are an indispensable tool in providing timely and accurate information necessary for making excellent water resources decisions. Emerging technologies in data collection, information management, web and cloud services, and visualization have opened up significant new avenues for sharing solutions across local, state, federal, and international levels.

Successful NHD implementation will depend heavily on the development of sustainable partnerships. Communication will be employed to maximize external participation.

The MACDC will lead this effort by:

- Guaranteeing statewide data completeness, consistency, and accuracy;
- Conducting geographic analysis, remote-sensing research, and cartographic and geographic information science research;
- Organizing the awareness, availability, and utility of the NHD;
- Act as the catalyst and collaborator for creating and stimulating partnerships;
- Developing geospatial data standards among the counties of Michigan;
- Integrating and certifying basic hydrological geospatial data from users; and

- Assuming ownership and producer of hydrological data when no other data sources exist.

1. Introduction

The Drain Code of 1956 is the primary statute that mandates the responsibilities of the county drain commissioner and provides for the creation and maintenance of county drains. Each drain has a contributing area (similar to a watershed) called a drainage district. A drainage district is a public corporation that is legally and financially responsible for maintaining the functioning of the drain. All costs are paid for by drain assessments. The drain commissioner acts as a steward for each drainage district. The drain commissioner keeps the historical, financial, and easement records; schedules maintenance; responds to service requests; requires permits for activities affecting the drain; borrows funds to pay for costs; and assesses the costs back to the landowners, transportation authorities, and municipalities, according to their estimated benefit.

2. Background

2.1 MACDC Organization & Mission

Drain Commissioners and their staff are responsible for many aspects of surface water management. The Drain Commissioner develops design standards for storm water runoff management in new developments, and is involved in agricultural, commercial, and residential drainage; storm water management; lake levels; soil erosion; water supplies and sewer systems. Water management infrastructure is managed by the Drain Commissioners. For Michigan, water drains across key agricultural areas requiring proper drainage. Michigan instituted the drain code in 1956 that provided uniform guidelines and procedures for draining land and the system to administer them. The DC is an elected official and represents the people of Michigan.

Drain commissioners must be consistently monitor drain effectively and repair and clean drains as necessary. Drain commissioners perform maintenance efforts and new construction projects to continue drainage operations.

Drainage systems have a direct effect on community concerns such as the ability to provide unhindered emergency response services when needed, erosion control, wastewater management, monitoring lake levels, managing aquatic weed control and dredging.

3. National Hydrological Dataset

The National Hydrography Dataset (NHD) is the surface water component of The National Map containing over 7.5 million mile stream network. The NHD is a digital vector dataset used by geographic information systems (GIS). Development of the NHD was driven primarily by three Federal agencies: the USGS, the EPA and the USDA Forest Service. During the data development process a great number of state and local partners were brought on board and these partnerships remain today in the form of a diverse user community. The data model and production process was crafted by many contributors, but in the end, was guided and managed by the USGS. Today the USGS continues to be the final source of NHD data and standards. As the NHD has evolved and become more widely used and the USGS has shifted away from a strict top-down data management focus, it has become increasingly apparent that there exists a need for local stewardship of NHD data. These intermediary data stewards play a crucial role in temporally maintaining the NHD's geographic and attribute accuracy. To facilitate engagement with the NHD the USGS developed a data editing tool and data model for use by the NHD data steward. In addition the USGS developed a very general outline of the editing and maintenance process.

The NHD has achieved the following:

1. Developing a standardized data model almost everyone can agree to.
2. Creating a fundamental framework to serve as an application foundation.
3. Developing a robust solution that will advance the science.
4. Making the solution simple enough to be implementable.
5. Creating a national partnership to pool resources.
6. Actually building the national dataset.
7. Creating a stewardship community and process to enhance and maintain the data.

3.1 NHD Applications

3.1.1 StreamStats

StreamStats has the ability to analyze the stream network upstream and downstream from a user-selected point and to identify and provide information for other points of interest that are located along the network. This functionality is known as "stream-network navigation" or "network tracing."

3.1.2 National Fish Passage Program

The National Fish Passage Program (NFPP) is a voluntary, non-regulatory effort launched by the U. S. Fish and Wildlife Service and managed by the Service's Fisheries Program. It provides financial and technical assistance to our partners for the removal or bypassing of barriers that impede the movement of fish and other aquatic species. The mission of

the NFPP is to restore aquatic species to self-sustaining levels by reconnecting habitats that have been fragmented by barriers.

3.1.3 SPARROW

Spatially Referenced Regressions On Watershed attributes (SPARROW) is a modeling tool for the regional interpretation of water-quality monitoring data. The model relates in-stream water-quality measurements to spatially referenced characteristics of watersheds, including contaminant sources and factors influencing terrestrial and aquatic transport. SPARROW empirically estimates the origin and fate of contaminants in river networks and quantifies uncertainties in model predictions.

Figure 1 - SPARROW Screen capture

3.1.4 WATERS (Watershed Assessment, Tracking & Environmental ResultS)

The Watershed Assessment, Tracking & Environmental Results System (WATERS) unites water quality information previously available only from several independent and unconnected databases.

EPA gathers water quality information to address public concerns such as:

- How healthy is my watershed?
- Can I drink the water?
- Can I eat the fish?
- Is it safe to swim in the water?

3.2 NHD Tools & Utilities

The USGS has provided tools to assist in the use of NHD data. No special tool is needed to display or work with the NHD other than a GIS. The NHD is a GIS dataset available in a shapefile format. Any GIS that can read shapefiles can be used to display the NHD. Some features of the NHD, such as geometric navigation, only work within the Esri

ArcMap software. An alternative to working with a GIS is to display the NHD in The National Map Viewer on the web.

3.2.1 NHD Tools

NHD GeoConflation Tool: The GeoConflation Tool is one of several methods available to update the National Hydrography Dataset (NHD). The tool automates the NHD Create Process used to generate the high resolution (24K) NHD data from the medium resolution (100K) data. NHD conflation is the integration of two datasets into one. The basic goal of conflation is to conserve ReachCodes and ComID's by duplicating them from the original dataset to the modified or target dataset whenever possible. This allows the history of the ReachCodes, and by association any information tied to the ReachCode, to be preserved.

One way to think of the process is "change detection". There are two inputs to the tool: the original NHD subbasin and the newly created or updated geometry called the target subbasin. The source NHD subbasin is then compared to the target subbasin. Where the geometries of flowlines and/or waterbodies match within specified tolerances, ReachCodes and ComIDs are automatically transferred from the source NHD to the target dataset. Close matches are flagged for closer review by the user to determine if there is an actual match or not. If the feature exists in the original, but not in the target, a "delete feature" is automatically generated. In the alternative circumstance where the feature exists in the target but not the source, a new ReachCode and ComID is applied to the feature and a "create new feature" is automatically generated.

As in any update process the results are only as good as the input data. The updates or target data must have *FTypes*, *FCodes*, connectivity, and be in correct the NHD schema. In addition, the target data must pass all QA/QC checks required before any data is integrated into the NHD. The end result of the conflation process is a "new" dataset consisting of the new geometry complete with ReachCodes and ComIDs. All changes have been tracked. The updates are then uploaded to the database. In the near future, the new *PermID* and Crosswalk tables will be incorporated into the tool.

USFS Reprojection Tool (Version 2.0): The USFS Reprojection Toolbar changes geographic projection and can transform datums using all available ESRI ArcObjects algorithms. It was developed by the USDA-Forest Service for the National Hydrography Dataset (NHD) *NHDinGEO* format, but can function on any personal or file geodatabase. This is an add-on toolbar written for ESRI's ArcGIS 9.2, 9.3, and 10. The advantage is that it reprojects whole personal and file geodatabases at once, and updates the metadata at both the Geodatabase, Dataset, and Feature class levels in both the Data Quality and

Spatial Reference sections of standard FGDC metadata--or creates its own metadata if there is none. Version 2.0 works on ArcGIS 9.2 while version 2.1 works on ArcGIS 9.3, 2.2 works on ArcGIS 10.

Hydrography Event Management Tool: The Hydrography Event Management (HEM) Tool provides full functionality for adding and editing events in the NHD. Events are informational data that are linked to the NHD using a linear referencing system on *NHDFlowlines*. The use of events is a key characteristic of the NHD by allowing vast amounts of scientific information to be linked to the NHD while keeping the design simple and by making advanced analysis techniques possible. The HEM tool handles all the linear referencing mechanics to make working with events easy. It works on point, line, and area events and allows events to be located interactively, imported, or calculated. An I.D. value is created that provides the link between the event location and the informational data tied to the location. It also creates metadata linked to the event. The tool also provides network measuring to determine distances through the flowline network. The HEM tool was developed by the Department of the Interior - Bureau of Land Management.

3.2.2 NHD Utilities

Note: NHD Utilities for 32-bit machines is not currently available for ArcGIS Version 10.1

Geographic Names Information System (GNIS): GNIS was developed by the USGS in cooperation with the U.S. Board on Geographic Names, contains information about physical and cultural geographic features in the United States and associated areas, both current and historical (not including roads and highways). The database holds the federally recognized name of each feature and defines the location of the feature by state, county, USGS topographic map, and geographic coordinates. Other feature attributes include names or spellings other than the official name, feature designations, feature class, historical and descriptive information. The database assigns a unique feature identifier, a random number that is a key for accessing, integrating, or reconciling GNIS data with other datasets. The GNIS is our Nation's official repository of domestic geographic feature names information.

This utility provides access to the GNIS to check, submit new, or make changes to names in GNIS.

NHD Build Flow: The NHD Build Flow utility requires the input of an NHD subbasin personal or file geodatabase. The tool builds a geometric network using the NHDFlowline feature class within the geodatabase. Each node within the geometric network represents a confluence of two or more hydrography features less than 40 feet wide. The Build Flow utility then uses these nodes to

populate the NHDFlow table with in and out flow directions for each node, based off the FlowDir attribute within the NHDFlowline feature class. The result is a populated NHDFlow table that shows the flow of water throughout the subbasin.

NHD Network Builder: After reprojecting NHDinGEO data, it is necessary to re-build the network(s) to restore flow and directionality to your network data. Network_PGDB_S0_FL.exe is a tool that rebuilds a network and sets the flow direction within the context of the geometric network based on the flowdir attribute. The tool does not rebuild or update the NHDFlow table.

MValue Utilities: The MValue Utility builds MValues on NHD reached flowlines. Each reached flowline feature will have MValues associated with it. The MValue provides the networked location of a point event or the extent of a linear event along a reach.

PGDB2Shp: Converts NHD ESRI personal or file geodatabases to a shapefile.

Shp2PGDB: Converts an NHD Shapefile to an ESRI file geodatabase.

XML2GDB: Used in the process for NHD Conflation.

XMLExtract: Used in the process for NHD Conflation.

NHD Merge Tool: The Merge program was developed to join two or more NHD file geodatabases and generating one file geodatabase as the output. The program will also remove duplicated features between input files.

NHD Watershed Tool: The NHD Watershed Tool is an extension that allows users to delineate a watershed from any point on any NHD reach in a fast, accurate, and reliable manner.

3.3 NHD Stewardship

Maintaining the NHD requires an extensive partnership, and is accomplished by those closest to the hydrography data. These users are motivated to ensure the accuracy data and are willing to use the NHD to meet their business needs and are ideally suited to become the stewards of hydrography data.

The national NHD community is active, well organized, and experienced. This community will prove to be a valuable resource as the Michigan NHD Stewardship program matures.

Though it is not an exhaustive list, the USGS defines the following responsibilities to the data steward:

- Guarantee that updated NHD data pass all validation tests.

- Assure that the core content (features, attributes and relationships identified in the NHD standards) is included.
- Keep the data current.
- Consider any change submitted and decide authoritatively if it will be accepted or not. (Some changes can have significant impacts, and it is essential that any changes made to the NHD are valid.)
- Report the decision publicly.
- Respond to proposed changes within some agreed upon reasonable time.
- Provide publicly available information on status of data development and updating.
- Maintain awareness of activities by other agencies and groups.

For Michigan these are the following POCs:

USGS Region III Point of Contact (Michigan)
Name: Joel Skalet
E-mail: jjskalet@usgs.gov
Phone: 608-238-9333 x-152
Organization: USGS National Geospatial Technical Operations Center - Denver

Michigan Geospatial Liaison
Name: Charles Hickman
E-mail: chickman@usgs.gov
Phone: (614) 430-7768
Organization: USGS Geospatial Liaisons

Michigan Principal Steward
Name: Everett Root
E-mail: roote@michigan.gov
Phone: 517-373-7910
Organization: Michigan - Center for Geographic Information

Each person identified plays a role in the management of the hydrological activities within the state. The United States Geological Survey (USGS) will facilitate the overall process, providing national management, coordination, tools, standards, documentation, training, quality assurance, data archival, and data distribution. The maintenance will be performed by that agency or other agencies in the state. Updates to the NHD will be made by the stewards, transmitted to the USGS, processed, and made available in the national dataset distribution.

3.3.1 NHD Community of Users

For the NHD Stewardship Program to be successful, a community of users must be established. This community will support and organize data in support of the NHD implementation for Michigan. Establishing this community will be the first step towards

achieving long term goals for the state where hydrographic data is integrated with the USGS. This group is addressed in the Action Plan section of this document.

3.4 Benefits of the NHD

The NHD, facilitated by GIS technologies take advantage of a rich set of features and attributes that comprise the NHD data model allowing the generation of specialized information. The ability to perform analysis on these data is possible because the NHD contains a flow network that allows for tracing water downstream or upstream. It also uses an addressing system based on reach codes and linear referencing to link specific information about the water such as water discharge rates, water quality, and fish population. Using basic NHD features like flow network, linked information, and other characteristics, it is possible to study cause and affect relationships, such as how a source of poor water quality upstream might affect a fish population downstream. A few additional benefits to the implementation and use of the NHD are as follows:

- The NHD can be enhanced by linking other data and/or data themes such as elevation, boundaries, and transportation to provide enhanced analytical capabilities.

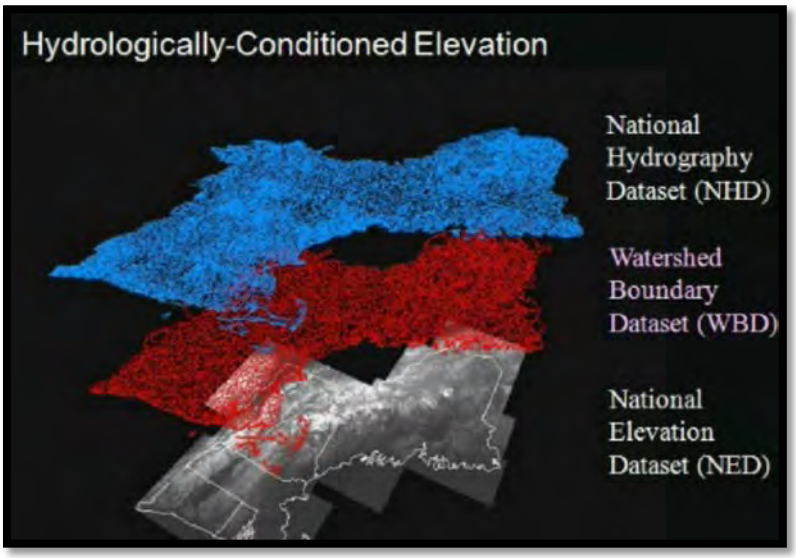


Figure 2 - Layering of data facilitates analysis

- The NHD presents a holistic view of all the Michigan County's associated hydrography layers integrating hydrological units that cross county boundaries – providing one contiguous data set for the state and country.
- Standardization of data features and attributes such as:
    - A data dictionary that provides details on all feature classes and attribute tables found in the NHD. The figure below provides a diagram of the

tables, the table items, the item definitions, and the relationships between the tables in the NHDinGEO data model.

- Data is organized into hydrological units and from these units into subbasins.

Figure 3 - Hydrological units and subbasins

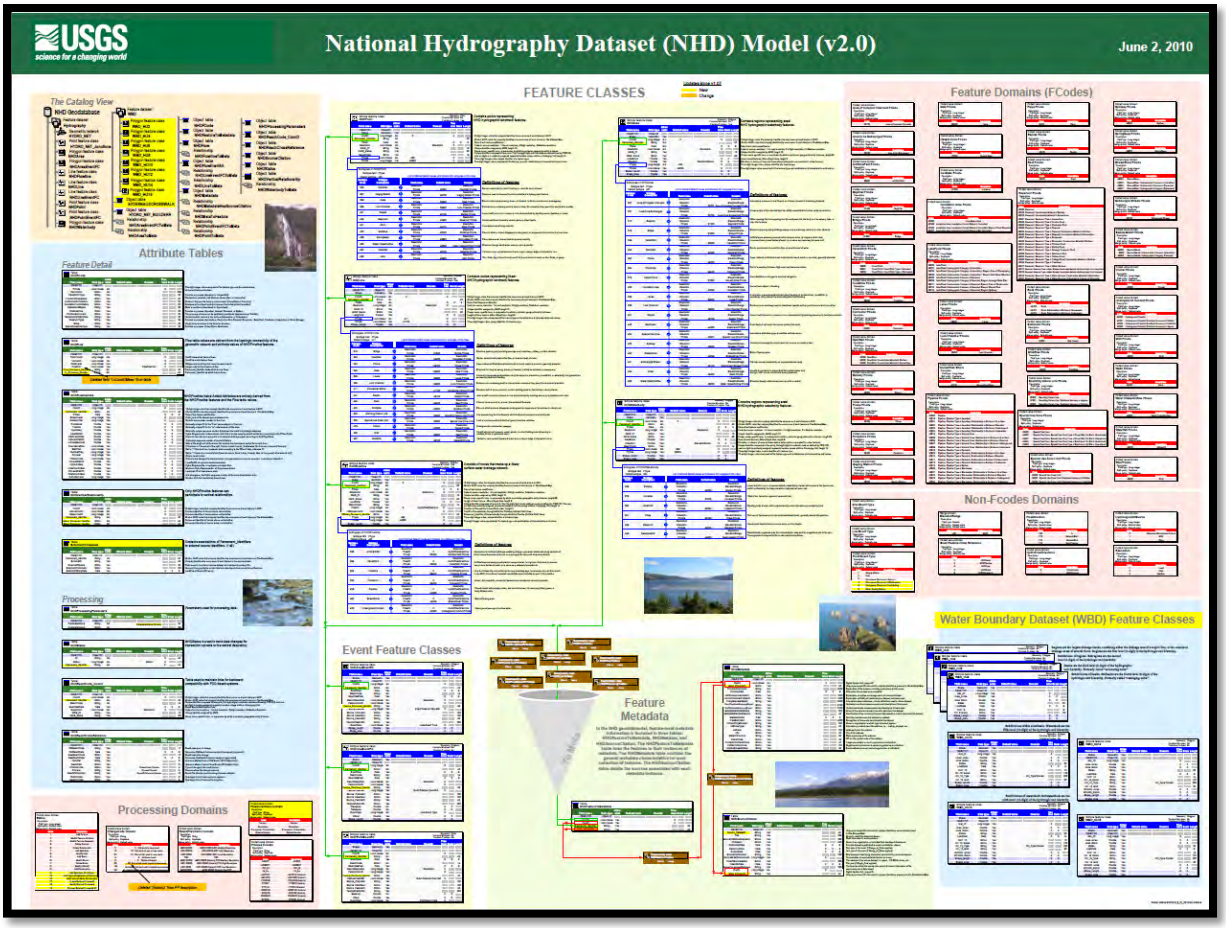


Figure 4 - The National Hydrography Dataset (NHD) Model (v2.0)

- Reach codes that are permanent, tracked, multi-scale, and form the basis of a controlled linear referencing system.
- The common identifier (ComID) is a 10-digit integer value that uniquely identifies the occurrence of each NHD feature (including reaches). Each value occurs only once throughout the Nation. Once assigned, the value is associated permanently with its feature. When features are deleted or split or merged, their ComIDs are retired. The common identifier is stored in a data element named "COM_ID". ComIDs are different between medium resolution and high resolution. Changes to common identifiers are not tracked.
- Permanent Identifiers (PermIDs) store registry style strings consisting of 36 characters enclosed in curly brackets. These strings uniquely identify a feature or table row within a geodatabase and across geodatabases. PermIDs allow features to be tracked in one-way and two-way geodatabase replication.
- Conventions that provide unique and logical naming for streams country-wide.

    - Network framework that provides address on the hydrological network that creates intelligence on the network.
- A flow network that allows users to tracing water downstream or upstream promoting analytical activities.

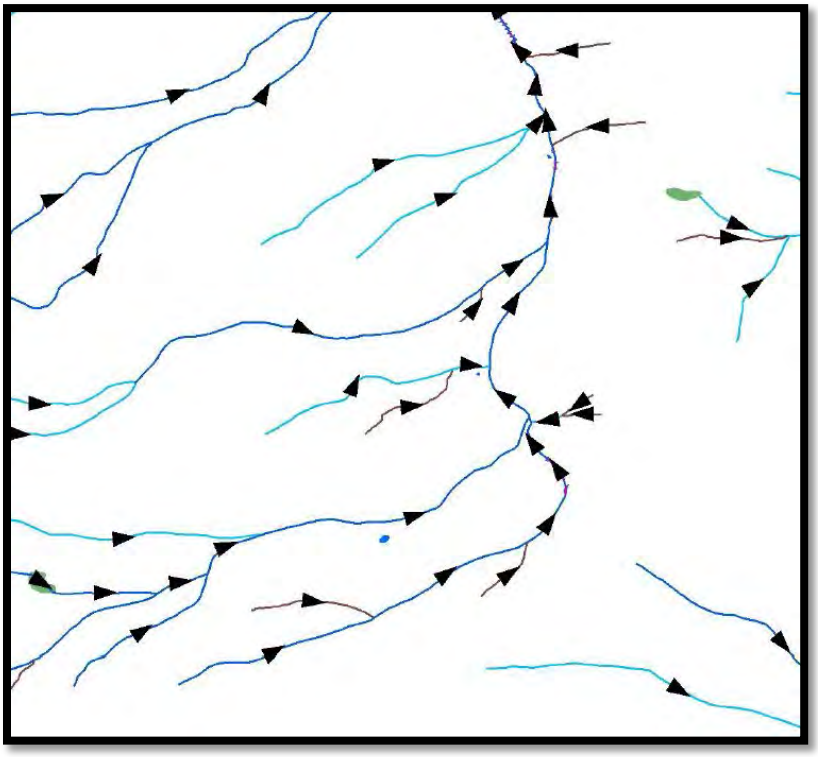


Figure 5 - Flow direction providing intelligence to the data.

- Ability to study cause and affect relationships based on navigation, such as how a source of poor water quality upstream might affect a fish population downstream. Reference the hypothetical scenario presented below:

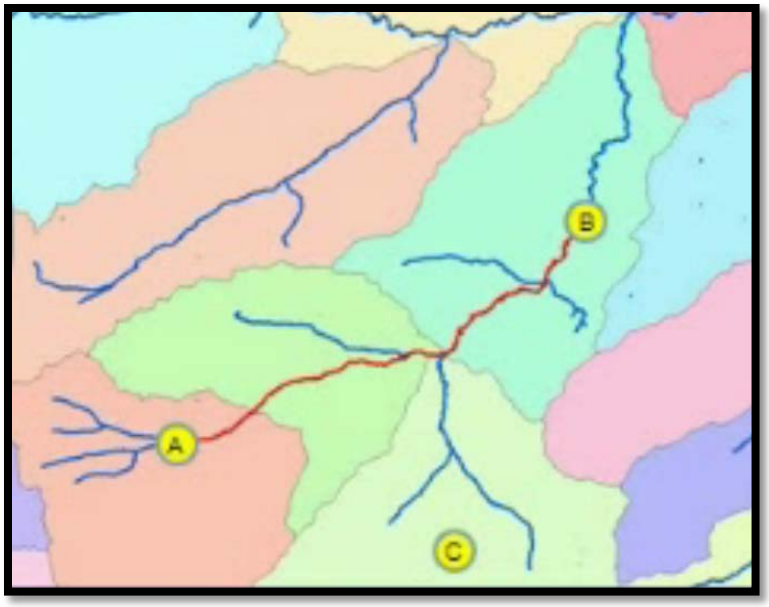


Figure 6 - Leveraging the NHD Flow Network

A= Industrial discharge point
B= Drinking water uptake
C= Pesticide application

A is upstream of B based on the flowlines of the NHD dataset. C is upstream of B so that we know that A and C affect the drinking water of uptake point B.

- An addressing system that can be leveraged to extract specific information about the water such as water discharge rates, water quality, and fish population allows users to solve problems by generating 'what if' scenarios. In addition, users can analyze how points along the network relate to each other.
- Tools and utilities that facilitate the use of the NHD. In addition, a map portal to login and update hydrography layers is made available.
    - StreamStats that allows you to pick any point along a river and determine stream flow of that location, drainage information, 100 year flood intervals, etc.
    - Access to stream gage data that adds intelligence to associated features such as:
        - How much water is in the river
        - Name of the stream/river
        - What is downstream
        - Upstream
        - Location of dams, reservoirs
        - Acres of feet in a reservoir

- Diversion of water (cubic feet/second)
- Miles of perennial, intermittent, ephemeral stream
- Drainage area, etc.

o Linear referencing reach codes divide into units between 0 – 100 that allows you to identify the location of any point along that feature.

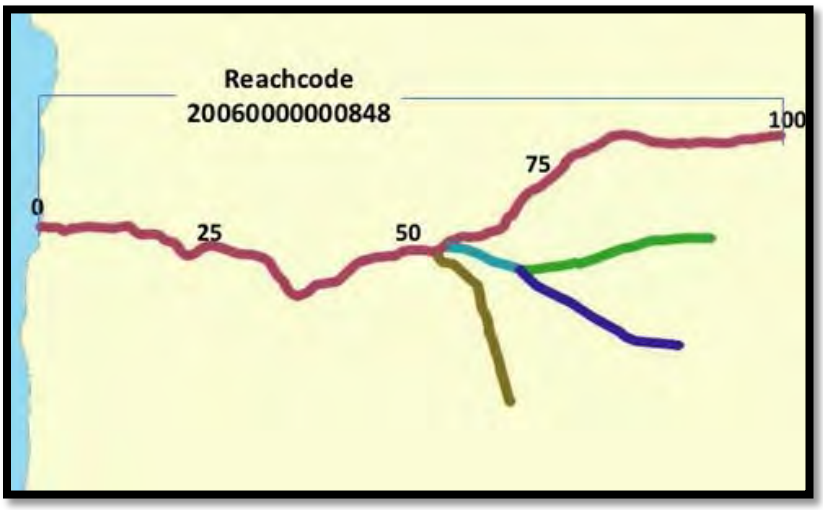


Figure 7 - Linear Referencing along a stream

o Identifying events that describe stretches or segments of a flowline. These events can be used as a layer within the NHD to provide additional information and/or data.

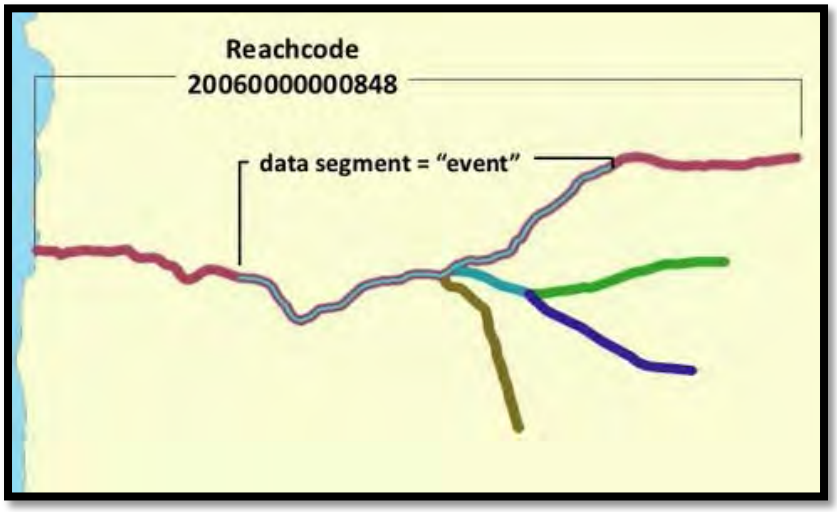


Figure 8 - Events identified by segment or points on a flowline

- Allows the user to take advantage of NHD Features and Functions such as:
    - Add the NHD Service to any map viewer and allows the user to add their services to the NHD Viewer.
    - Add map annotation
    - Save and send a map.

3.5 Architecture of NHD

The NHD integrates information from many resources to provide a holistic view of water information.

- ✓ Data is linked and overlaid with other data within the structure.
- ✓ Relationships between features are determined by spatial proximity.
- ✓ Analysis is more powerful and effective.

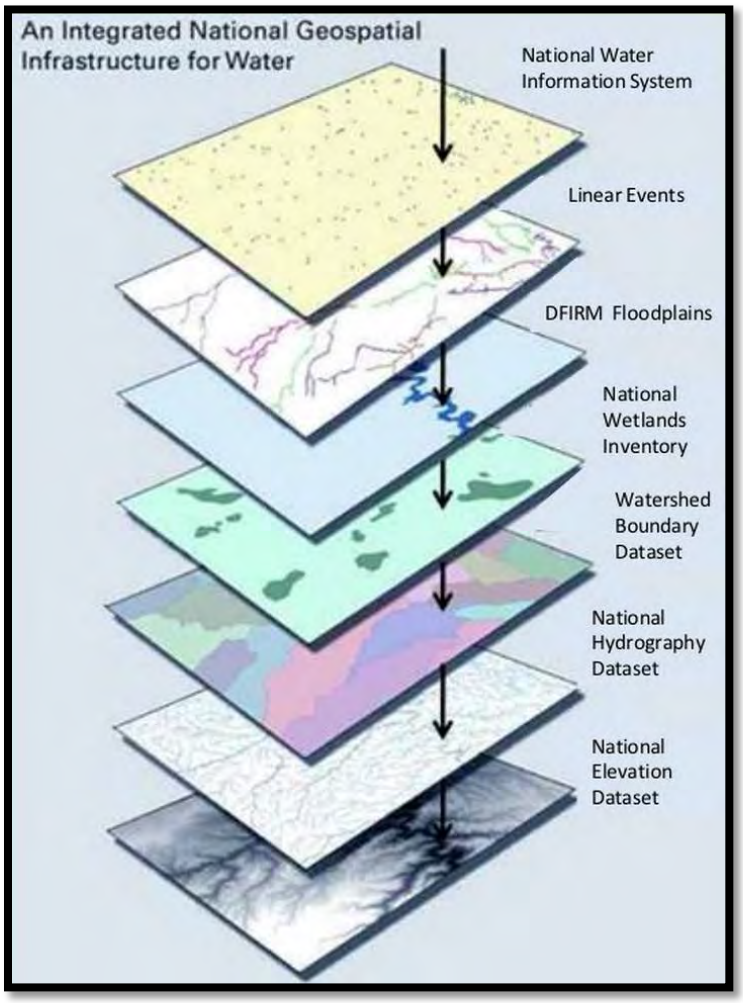


Figure 9 - Integrated view of data layers

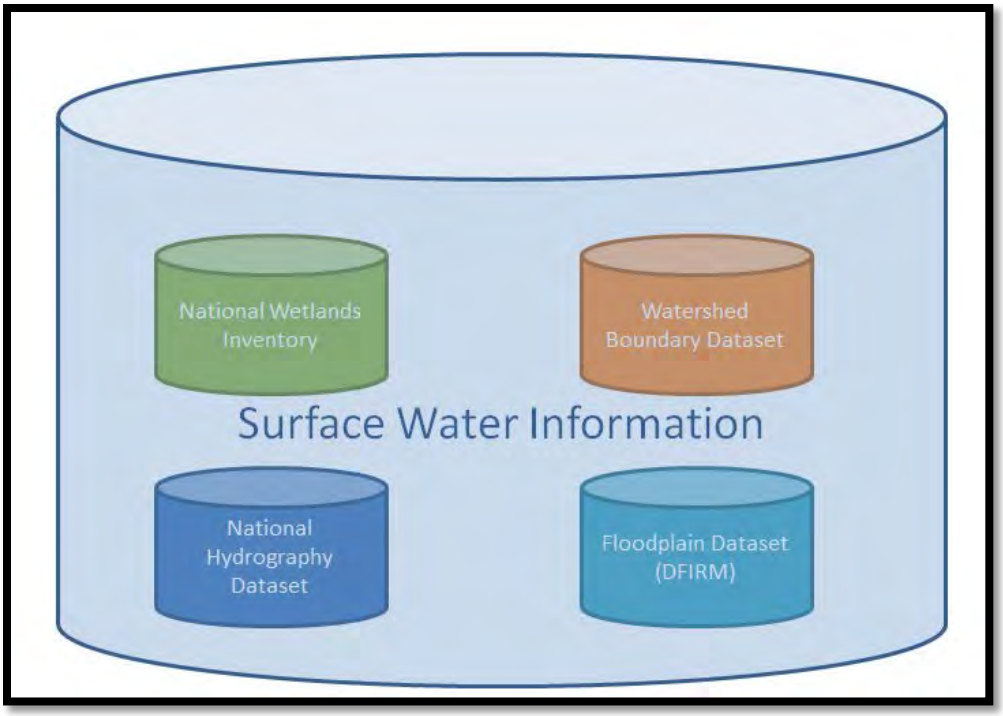

National Wetlands Inventory
Watershed Boundary Dataset
Surface Water Information
National Hydrography Dataset
Floodplain Dataset (DFIRM)

Figure 10 - Snapshot of common NHD layers

By using modeling techniques predict how much water each stream segment will have.

Improve understanding of diversion of water and the affects it has.

Link water discharge permits to the NHD.

Look at water contamination at a certain point and over a period of time. (i.e. peak concentration, threat passed, etc.) Facilitates the work of emergency responders.

Fish barriers status, complete, partial and potential barriers.

Canada and Mexico are also building hydrological data sets. NHD is harmonizing this data.

Figure 11 - Harmonizing data across borders

3.6 Maintenance of the NHD

Maintaining the NHD is reliant upon the partnerships established across the nation and those closest to the data. Local users are motivated to ensure the accuracy of the NHD meet their own business needs and those of the county and state. The USGS facilitates the overall process by providing management of the overall process, coordination, tools, standards, quality assurance. Updates to the NHD will be made by the stewards and transmitted to the USGS for processing. Data are then made available in the national dataset.

3.7 NHD Issues

In the past various conferences and NHD panels have illustrated a number of similar and disparate situations faced by the states that have implemented the NHD. The data steward's role becomes critical in these situations to bring a voice to the challenges faced in hydrography stewardship. Networking among the representatives is a key component to uncovering current issues and resolving some with lessons learned by peers.

Two primary issues that Michigan will face are the following:

1. Keeping up with the changing features in the NHD.

2. Streams changing courses, etc.
3. The model is built, how can the model accommodate appended data? The board is open to what people want.
4. Mobile devices but not there yet.

3.8 NHD Road Ahead

The ability of the stewardship community to work together is an important element in the success of stewardship since many states encounter issues and ideas that have already been addressed by other states. The NHD community continues to address issues as they arise and leverage conferences and other gatherings as a means to foster these relationships and identify solutions.

The NHD plans to move forward with the following options:

- Continuing to build the baseline, developing and maturing the 24K-5K NHD/Water Boundary Dataset (WBD) and 10m-1m 3D Elevation Program (3DEP).
- Continue to leverage LiDAR to produce new data.
- Continue to mature tools leveraged by the data stewards.
- Continue to build resolution within the NHD.
- Develop mobile solutions that will facilitate integration and collections.

4. Assessment

To determine the best course of action for the MACDC, an evaluation of the current state of the data and processes was captured. This was completed through capturing feedback from the drain commissioners via an online survey and comparison of that data to a survey completed in 2010. Follow up, when required was completed via phone interviews.

4.1 Data Inventory

4.1.1 Overview

This plan provides a road map for the best means for adopting the NHD. Several artifacts generated over the past few months are used to support a thorough understanding of the county-level business processes. These artifacts have been developed from an online survey of Michigan's 83 counties. The plan will communicate the objectives and strategy required for NHD adoption as well as recommendations for where modifications to the NHD data model should be considered.

What is the business value of adopting GIS and the NHD? While many counties have implemented GIS for focused projects and areas of operations, they can derive maximum benefits by leveraging GIS and the NHD to enhance their business workflows. Many users have realized greater success rates by developing a solid foundation of data and services to apply across their organizations to solve an array of problems. With solid foundational data, the counties of Michigan can build on itself, and the benefits will spill over from department to department, sector to sector, and county to county.

The case studies that will be presented in Section 4.2 show how GIS technology has become ingrained into daily activities and leveraged to solve problems and communicate solutions.

To encourage adoption of the NHD data model the business plan will provide approximately 6 examples of how digital management of data has presented cost and time savings.

Two individual surveys were sent out via email in October, 2013. A shorter, eight-question survey went out to all County Drain Commissioners with the purpose of collecting high-level responses to increase the overall response rate. The shorter survey collected the following information:

- How drains are managed (GIS, CAD, or Hard Copy)
- Status of GIS
- Portion of County drains within GIS
- How GIS has improved operations and/or saved money

- Count and linear footage of County drains
- Drain stationing
- Data accessibility

A more comprehensive survey went out to ten targeted Counties. The purpose of this survey was to collect more in-depth data in order to create case studies to help demonstrate to the benefits of GIS to other Counties. Counties were selected to provide a cross-section of Michigan Counties as a whole. The following counties were selected for the targeted survey:

Rural (Low population density)

- Newago- Population ~ 50k
- Ionia- Population ~ 60K
- Clinton- Population ~ 75k

Suburban (Medium population density)

- Livingston- Population ~ 180k
- Allegan- Population ~ 110k
- Kalamazoo- Population ~ 250k

Urban (High population density)

- Wayne- Population ~ 2M+
- Oakland- Population ~ 1M+
- Kent- Population ~ 600k
- Washtenaw- Population ~ 350k

The targeted survey collected the following information:

- How drains are managed (GIS, CAD, or Hard Copy)
- Status of GIS
- Portion of County drains within GIS
- How GIS is used by Drain Commissioner
- How GIS has improved operations and/or saved money
- Future value of GIS
- Challenges adopting/using GIS
- GIS layers maintained
- Count and linear footage of County drains
- Drain stationing
- Data accessibility
- NHD layer usage
- Value and challenges in using NHD

4.1.2 Participation

The blanket survey was sent to all 83 counties, and of them, 30 counties (36%) responded. The targeted survey was sent out to 10 counties, and of them, 7 counties (70%) responded. When the results are combined with the 2010 GIS survey, 47 counties (56%) are represented.

4.1.3 Findings

4.1.3.1 Data accessibility

County Drain Commissioners were asked the following question: "How accessible/available to you is your County drain data?" An answer of "Very" indicates records are maintained within the Drain Commissioner's office. An answer of "Mostly" indicates records are maintained by at least one other department but are accessible to the Drain Commissioner. An answer of "Somewhat" indicates records are maintained by another department within the County and the Drain Commissioner has limited access to these records. An answer of "Not at all" indicates that the County has a GIS not the Drain Commissioner currently has no access to it.

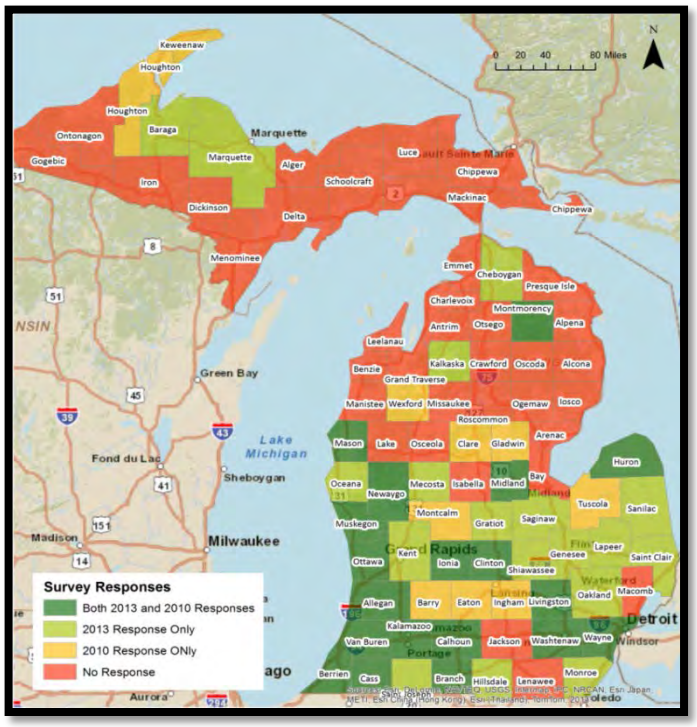


Figure 12 - Survey Responses for 2013 and 2010

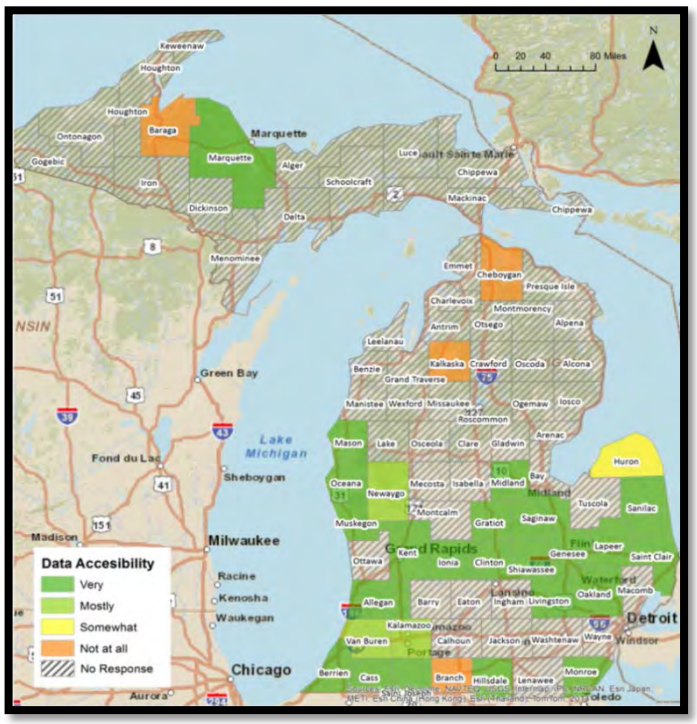


Figure 13 - Data Accessibility

Table 1 - Counties Data Accessibility

Counties with 'very' accessible data						
Allegan	Berrien	Cass	Genesee	Clinton	Gratiot	Hillsdale
Ionia	Kent	Lapeer	Livingston	Mason	Marquette	Midland
Monroe	Muskegon	Oakland	Oceana	Saginaw	Saint Clair	Saint Joseph
Sanilac	Shiawassee					

Counties with 'mostly' or 'somewhat' accessible data			
Kalamazoo	Newaygo	Van Buren	Huron

Counties with 'not at all' accessible data			
Baraga	Branch	Cheboygan	Kalkaska

Data accessibility status unknown						
Alcona	Alger	Alpena	Antrim	Arenac	Barry	Bay
Benzie	Calhoun	Charlevoix	Chippewa	Clare	Crawford	Delta
Dickinson	Eaton	Emmet	Gladwin	Gogebic	Grand Traverse	Houghton
Ingham	Iosco	Iron	Isabella	Jackson	Keweenaw	Lake
Leelanau	Lenawee	Luce	Mackinac	Macomb	Manistee	Mecosta
Menominee	Missaukee	Montcalm	Montmorency	Ogemaw	Ontonagon	Osceola
Oscoda	Otsego	Ottawa	Presque Isle	Roscommon	Schoolcraft	Tuscola
Washtenaw	Wayne	Wexford				

4.1.3.2 Data Format & Extensiveness

County Drain Commissioners were asked the following question: "How do you manage your drains?" Of the 83 counties, 40 counties responded to this question. 7 counties (9%) manage their drains using GIS, CAD, & hard copy. 1 county (1%) uses GIS & CAD. 15 counties (18%) use GIS & hard copy. 6 counties (7%) use GIS only. 1 county (1%) uses CAD & hard copy. 11 counties (13%) use hard copy only. 42 counties (51%) did not respond.

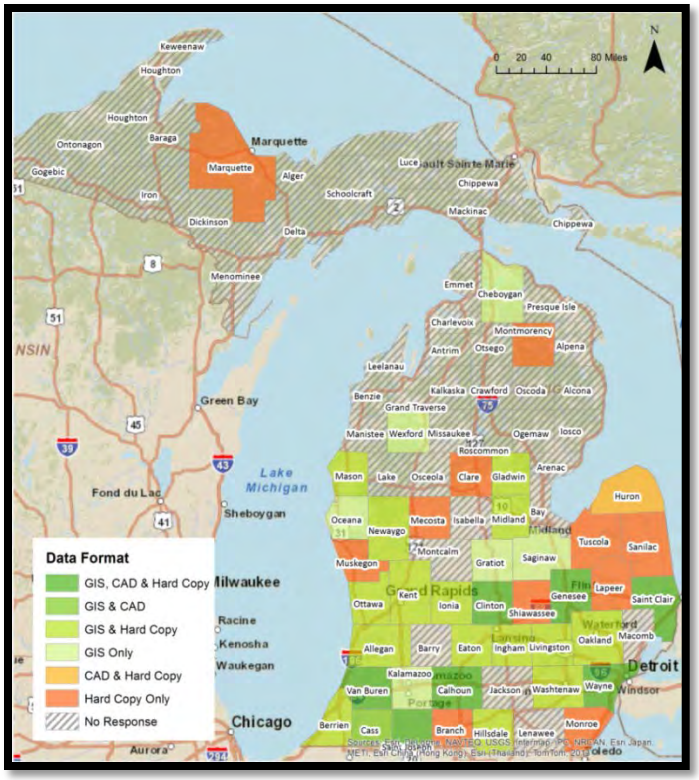


Figure 14 - Data Format and Extensiveness

Table 2 - Synopsis of counties with GIS, CAD, Drains

	GIS	CAD	Hard Copy	Portion of Drain included in GIS
Clinton	X	X	X	All
Van Buren	X	X	X	All
Wayne	X	X	X	All
Berrien	X		X	All
Eaton	X		X	All
Ionia	X		X	All
Livingston	X		X	All
Ottawa	X		X	All
Cheboygan	X			All
Gratiot	X			All
Kalamazoo	X			All
Allegan	X		X	Most
Gladwin	X		X	Most
Midland	X		X	Most
Newaygo	X		X	Most
Oakland	X		X	Most
Washtenaw	X		X	Most
Oceana	X			Most
Saginaw	X			Most
Wexford	X			None
Calhoun	X	X	X	Some
Genesee	X	X	X	Some
Saint Clair	X	X	X	Some
Saint Joseph	X	X	X	Some
Cass	X	X		Some
Ingham	X		X	Some
Mason	X		X	Some
Hillsdale	X		X	Unknown
Kent	X		X	Unknown

Table 3 - Counties with Hard Copy or CAD Only

Counties with 'Hard Copy' or 'CAD' only (No GIS)						
Huron	Branch	Lapeer	Marquette	Mecosta	Monroe	Montmorency
Muskegon	Sanilac	Shiawassee	Baraga	Kalkaska	Clare	Tuscola

Table 4 - Data with Unknown Accessibility

Data Accessibility Status Unknown						
Alcona	Alger	Alpena	Antrim	Arenac	Barry	Bay
Benzie	Charlevoix	Chippewa	Crawford	Delta	Dickinson	Emmet
Gogebic	Grand Traverse	Houghton	Iosco	Iron	Isabella	Jackson
Keweenaw	Lake	Leelanau	Lenawee	Luce	Mackinac	Macomb

Drain Count and Stationing

County Drain Commissioners were asked to provide a rough count of county drains along with drain stationing- whether upstream to downstream or downstream to upstream. Of the 83 counties, 37 counties (45%) provided a rough count of their County drains and 31 counties (37%) provided their drain stationing. Of the 31 counties, 6 counties (19%) use "Upstream to Downstream" stationing and the remaining 25 counties (81%) use "Downstream to Upstream" stationing.

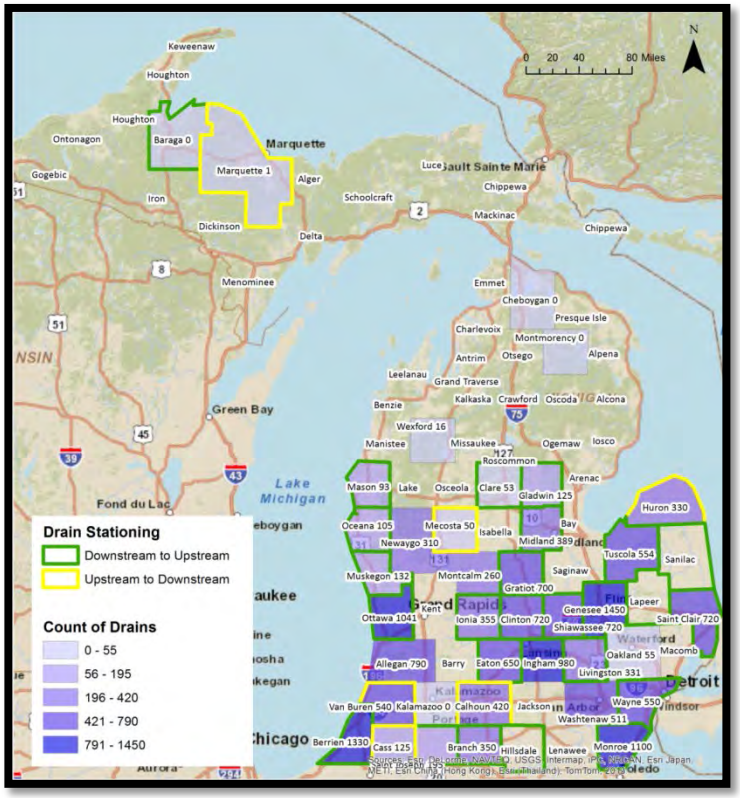


Figure 15 - Drain Count and Stationing

Table 5 - Synopsis of Drain Count /Stationing

County	Open Drains Count	Closed Drains Count	Total Drains	Dams Count	Open Drains LF	Closed Drains LF	Stationing
Cheboygan	0	0	0	0	0	0	-
Baraga	0	0	0	0	0	0	Down to Up
Montmorency	-	-	0	-	-	-	-
Kalamazoo	-	-	0	-	-	-	-
Marquette	1	0	1	0	16200	0	Upstream to Downstream
Wexford	-	-	16	-	-	-	-
Mecosta	36	14	50	0	-	-	Up to Down
Clare	-	-	53	-	-	-	Down to Up
Oakland	49	4	55	0	1103427	9749	-
Mason	-	-	93	-	-	-	Down to Up
Oceana	100	5	105	2	5963301	40000	Down to Up
Cass	100	25	125	15	1584000	21120	Upstream to Downstream

Gladwin	-	-	125	-	-	-	Down to Up
Muskegon	131	1	132	0	695579	1931	Down to Up
Saint Joseph	187	8	195	6	3949440	2100	Down to Up
Montcalm	-	-	260	-	-	-	-
Newaygo	290	20	310	2	1584000	158400	-
Huron	320	10	330	0	5800000	53000	Up to Down
Livingston	-	-	331	-	-	-	Down to Up
Branch	200	150	350	9	3168000	2640000	Down to Up
Ionia	-	-	355	-	-	-	Down to Up
Midland	246	143	389	0	3652492	446477	Down to Up
Calhoun	-	-	420	-	-	-	Up to Down
Washtenaw	-	-	511	-	-	-	-
Van Buren	450	90	540	25	3696000	580800	Up to Down
Wayne	-	-	550	-	-	-	Down to Up
Tuscola	-	-	554	-	-	-	Down to Up
Eaton	-	-	650	-	-	-	Down to Up
Gratiot	500	200	700	0	6864000	3168000	Down to Up
Saint Clair	375	30	720	1	4884000	660000	Down to Up
Shiawassee	412	203	720	4	13200000	-	Down to Up
Clinton	-	-	720	-	-	-	Down to Up
Allegan	-	-	790	-	-	-	-
Ingham	-	-	980	-	-	-	-
Ottawa	-	-	1041	-	-	-	Down to Up
Monroe	900	200	1100	0	5280000	-	Down to Up
Berrien	400	400	1330	-	1848000000	1.85E+09	Down to Up
Genesee	550	900	1450	9	3696000	3960000	Down to Up
Lapeer	260	-	-	-	2640000	-	Down to Up
Hillsdale	283	-	-	-	1230240	1188000	Down to Up
Sanilac	-	-	-	0	7814400	10560	Down to Up

Table 6 - Drain Count and Stationing Unknown

Drain Count and Stationing Unknown						
Alcona	Alger	Alpena	Antrim	Arenac	Barry	Bay
Benzie	Charlevoix	Chippewa	Crawford	Delta	Dickinson	Emmet
Gogebic	Grand Traverse	Houghton	Iosco	Iron	Isabella	Jackson
Kalkaska	Kent	Keweenaw	Lake	Leelanau	Lenawee	Luce
Mackinac	Macomb	Manistee	Menominee	Missaukee	Ogemaw	Ontonagon
Osceola	Oscoda	Otsego	Presque Isle	Roscommon	Saginaw	Schoolcraft

4.1.4 Drain Commissioner Business Processes

Identify business processes that fall outside of the current NHD and identify what changes need to be made to meet the needs of the Drain Commissioner. The survey will capture business processes associated with the daily operations of the drain commissioners' offices. These results will be analyzed to understand and define the activities completed, identify inefficiencies and make recommendations for improvement.

4.2 Business Case Studies

Time and budget constraints do not allow for detailed data collection and refinement beyond the survey collection method. To mitigate this constraint, GISi will complete three (3) case studies of drain commissioner offices of varying program maturity. The candidate offices selected for the case studies will be used to ensure the business plan addresses the varying needs of the offices.

4.2.1 Clinton County, Population ~75k (Minimal drain integration)

Protect people, wildlife, and plants

Clinton County is a rural county north of the City of Lansing. Clinton County uses GIS, CAD and hard copies to manage their county drains. Currently, the county has minimal integration of drain records into GIS and only uses it to store features and their associated attributes. Their CAD based mapping process is very efficient, and they struggle to see how adopting GIS can create useful results.

Figure 16 - Clinton County

Clinton County, being 60% agriculture, has agricultural drains and likely a lot of drainage runoff. One way Clinton County could take advantage of the NHD is to examine water tracing, discharge rates, water quality, and fish population in order to protect its residents and wildlife from such runoff.

Without incorporating county drains into this analysis, GIS hydrologic analysis is limited to lakes, rivers and streams. Once the drains are integrated, Clinton County, and organization that rely on accurate NHD data to perform sophisticated GIS analysis, can be assured they are seeing the whole picture. Water quality organizations such as BASINS, SPARROW, and NRIS leverage the NHD for their water quality analysis.

When Clinton County integrates their data to the NHD, Clinton County and/or other organizations can use network tracing from hydrology features the EPA considers "impaired." Impaired waters are defined as "waters that are too polluted or otherwise degraded to meet the water quality standards set by states, territories, or authorized tribes." Network tracing from these impaired features can help drain commissioners and other organizations better locate the cause of a problem. Accurate and current drain data for Clinton County and neighboring counties is imperative for this type of exercise.

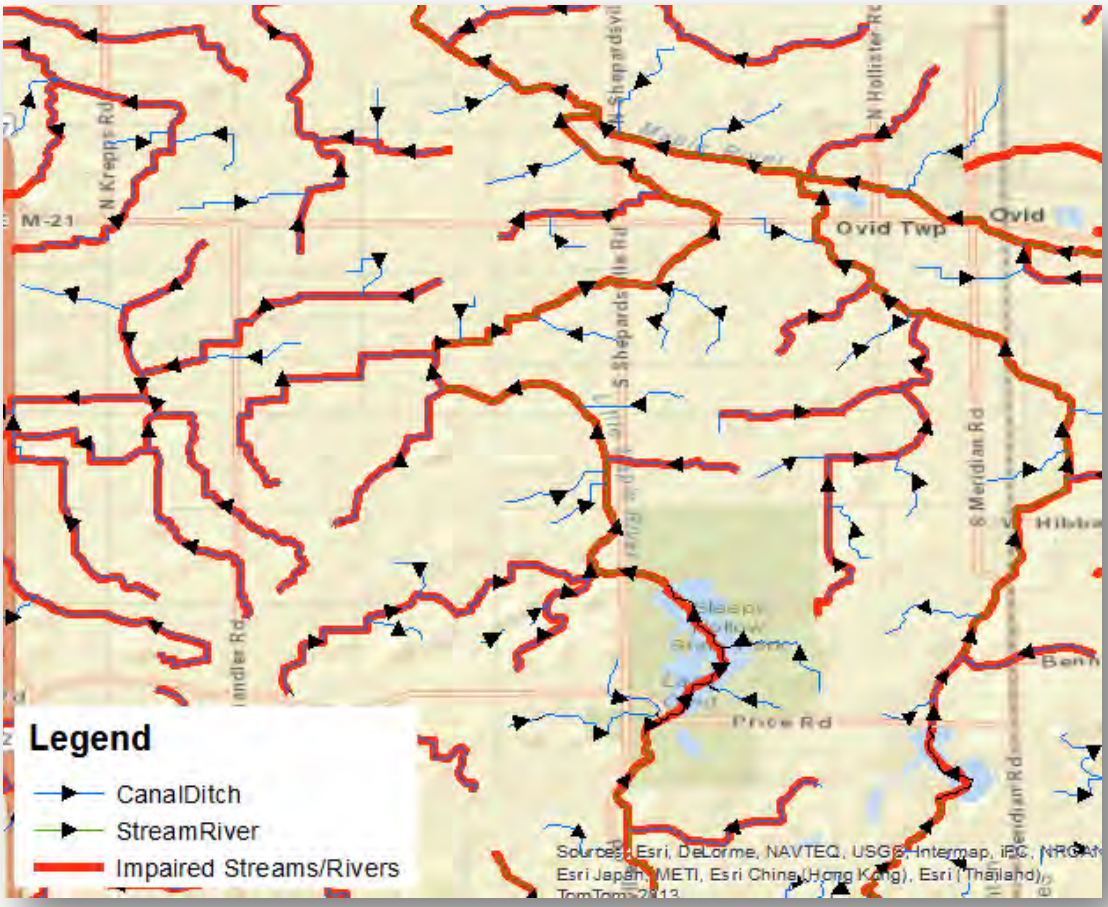


Figure 17 - Clinton County; contaminated waters

4.2.2 Livingston County, Population ~ 180k (Partial drain integration)

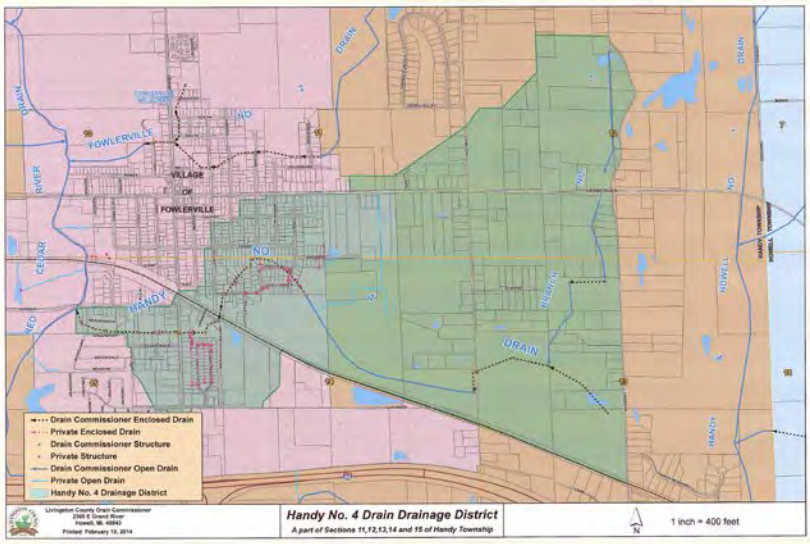
Save money and operate more effectively

Livingston County is a suburban county of Detroit. Livingston County's drain records are partially integrated into their GIS with most of the County Drains covered by their GIS. They currently leverage GIS to store features and associated attributes, create thematic maps, and to buffer features in order to determine proximity to drainage features.

Figure 18 - Livingston County

Their biggest challenge to expanding GIS and adopting the NHD at this time is lack of resources at the local level.

One way GIS has helped Livingston County reduce effort and save money is through the increased efficiencies GIS offers during an assessment process. Before leveraging GIS for assessing, the amount of time involved in a typically assessment year is approximately 1000 - 1200 engineering hours. Using GIS, the same assessment rolls with a greater level of accuracy can be created in roughly 300 hours. Without GIS, every parcel of property bisected by the district boundary would require the land area to be hand calculated, taking an enormous amount of time. That same task can be accomplished with increased accuracy in just a few minutes with the GIS.



The contrast is just as stark when you consider the ability to layout maintenance projects and in stationing drains. In some instances, the time commitment without GIS on a large district is in the order of a couple of weeks. That involves a significant amount of field time, hand measurements, and pacing distances to develop a basic blueprint of the construction requirements. In these instances, horizontal accuracy can be off by

more than 20 or 30 ft. Even then, a detailed plan and profile isn't often produced. GIS allows Livingston County to develop a comprehensive plan and profile with horizontal accuracy that doesn't exceed 6 inches. As an example, stationing can be done for the entire length of the drain in just a few minutes instead of days. Keep in mind that a great deal of data entry goes into establishing these districts, but once this is done, the time savings are pretty spectacular.

There are a lot of variables in estimating time savings, but overall, Livingston County estimates around a **75% time savings**, on average, for activities using GIS, compared to the old methods of hand calculation and field measurement.

4.2.3 Kent County, Population ~ 600k

Better prepare for flood events

Kent County is an urban county that contains Michigan's second largest city, Grand Rapids. The Kent County Drain Commissioner's office can be considered one of the most advanced in GIS as compared to other counties in Michigan. Most of Kent County's drains are integrated into their GIS and they use GIS beyond storing data and associated attributes. Kent County creates maps with their GIS data, uses buffering to locate other GIS features within proximity to drain features, leverages digital elevation models analyze runoff, and impervious area calculation is taken into consideration for storm water billing. Kent County has 25+ GIS professionals and they consider GIS indispensable to their daily operations.

Figure 19 - Kent County

Kent County can benefit from the NHD by having a more complete view of their hydrology features. Incorporating drains into the existing river/stream network and leveraging features from neighboring counties can provide for much more reliable analysis. In other words, the more features that are captured in the NHD, the more accurate the analysis is.

One such form of analysis Kent County can benefit from is improved flood maps developed either internally or by FEMA leveraging USGS data. During a significant weather event, the drainage system may exceed its built capacity and surrounding low-lying areas may flood. This flooding can cover roads and wash out bridges-potentially restricting emergency vehicles from entering an area. Any evacuation

routes or roads that are necessary for emergency vehicles to travel during a crisis that intersect a flood zone could pose a significant problem during an emergency. Hydrologic flood maps can be improved by incorporating local County drain data into the NHD. Once the data from all sources is merged, the County, FEMA, and/or other organizations can leverage ESRI's Hydrologic analysis to create more accurate and helpful flood maps. Determining which roads intersect potential areas of flooding can help a County and its communities develop better emergency preparedness plans.

Hydrologic tools leveraging the NHD and supporting data (such as elevation data, soil types, etc.) can be used to help Kent County understand and map flood events- such as the one that occurred in Grand Rapids in 2013.

5. Return on Investment

5.1 Benefits to MACDC

Although a formal Benefits Study has not been completed, there are benefits and by extension a great return on investment for implementing an enterprise GIS that is spearheaded by the implementation of the NHD. High level benefits are as follows:

- Save time and increase efficiencies.
- Increase data accuracy and definition.
- Increase productivity through communication and collaboration.
- Potentially generate revenue
- Support decision-making for all counties and the state holistically.
- Facilitate budgeting along with improved and/or automated workflows.
- Build a state repository for hydrological data
- Facilitate the management of resources and finally,
- Reduce costs and save money through these efficiencies.

The following figure depicts what this might look like for Michigan.

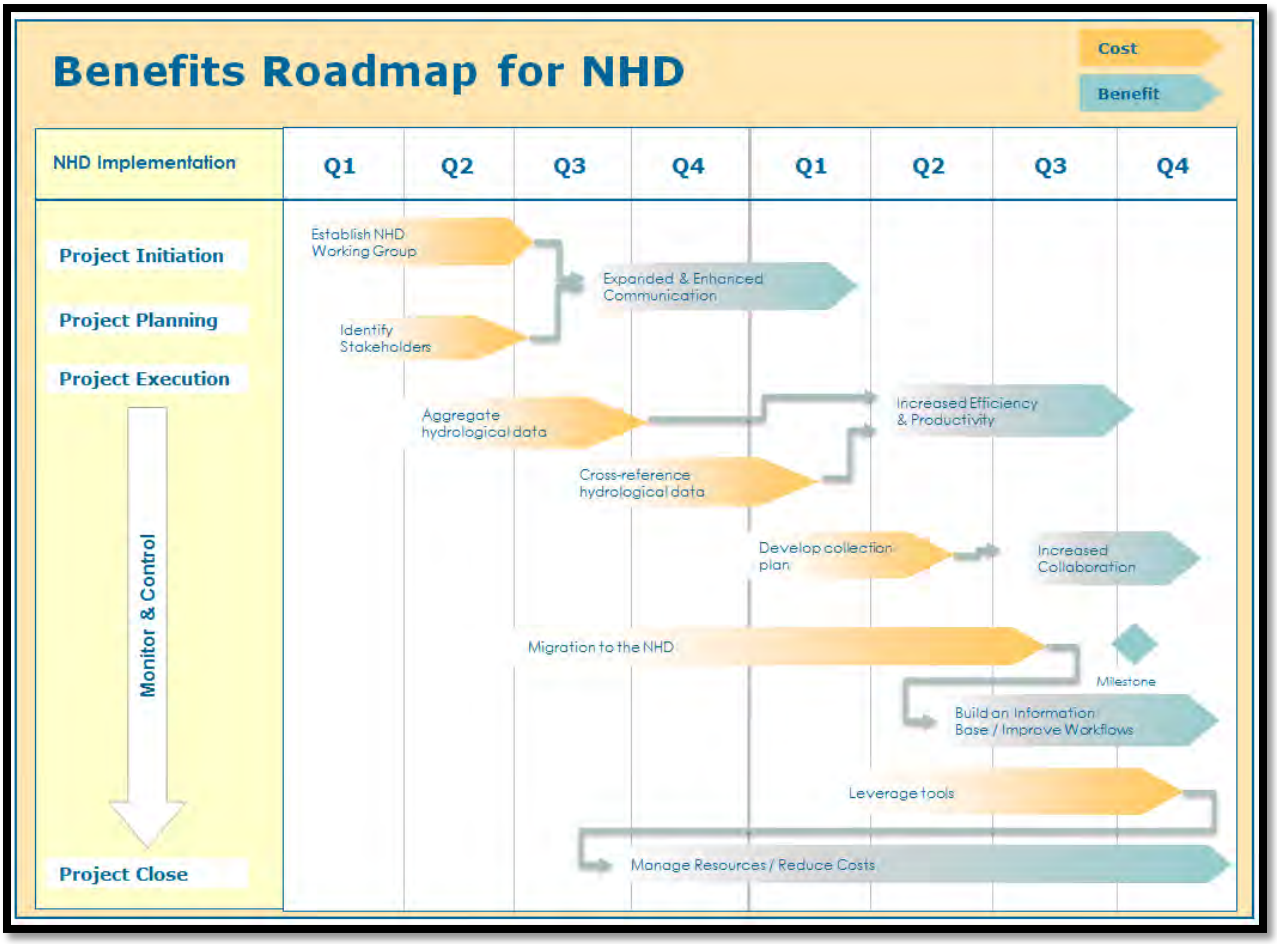


Figure 20 - Benefits Roadmap for NHD

If the MACDC were to adopt enterprise GIS practices, MACDC would reduce costs through efficiency and effectiveness. Efficiency and effectiveness benefits are realized when GIS is used to reduce costs of a task that, in the absence of GIS, would be handled by some other method or organization such as the NHD. The NHD has a model that will meet the near term needs and facilitate this task. It is envisioned that by implementing the NHD, MACDC would realize significant improvement over existing processes. This translates into tangible savings most likely decreasing costs, conserving time spent (i.e. man hours).

In addition to realizing efficiencies through the implementation of GIS and NHD, there is also another benefit to consider; cost avoidance. MACDC may be able to leverage technologies and repositories that the USGS has in place to build from; at least initially. This may present an opportunity to the MACDC to eliminate the need to purchase new hardware and software in the near term.

Finally, the advantages gained under intangible benefits are those that are harder to quantify. Intangible benefits can be measured in terms of strategic benefits such as increased involvement, communication and collaboration among the members of the MACDC.

6. Action Plan

This section of the document communicates a draft of the tasks and associated projects the MACDC plans to engage in for Fiscal Year 2014. This section provides a tentative framework for the pursuit and implementation of the NHD.

1. Establish a working group for Michigan that partners like agencies and users that maintain, create and monitor hydrological data. This group will promote the advancement of GIS and leverage data that has been collected that can be harmonized with the NHD data model.
    a. Provide an organization structure to the group.
    b. Draft a charter that will identify the group's purpose, to include goals and mission of the group. This will identify how the group is managed and define the roles and responsibilities of its members.
    c. This group will provide recommendations and changes to the NHD to ensure that the NHD is meeting the needs of the counties of Michigan.
    d. This group will contain members from: Michigan - Center for Geographic Information, MACDC Drain Commissioners, DNR, USGS, USDA USFS, US EPA, DEQ, IMAGIN, MiCAMP, MSU (Hydrology & Water Resources), MDOT, MDARD, USDA NRCS, , as well as others that can be decided upon a later date.
2. Identify the user or stakeholder that will assume responsibility for aggregating the hydrological data of Michigan.
3. Aggregate hydrological data from all working group members and store copies of this data in an accessible, centralized repository.
4. Cross-reference, map, and migrate existing data into the NHD data model.
5. Perform a gap analysis that will target the data that is missing from the group's collective data repository.
6. Establish a collection plan prioritizing data that has been identified in the gap analysis as needed.
    a. Identify how data is going to be collected and how it will be stored (i.e. metadata)
7. Migrate new collections into the NHD data model.
8. Leverage tools and utilities to enhance current business processes of the MACDC Drain Commissioners.

There are several options for successfully implementing these steps. They are identified in the section below.

6.1 Implementation Options

6.1.1 Option 1

The MACDC targets an independent, secondary data steward to partner with the data steward to reach out to all counties, consolidate and push data to the USGS servers. There may be potential grants available for this work.

6.1.2 Option 2

The MACDC identifies a tech savvy person or team to act as sub-steward(s) who will partner with the data steward, reach out to all counties, consolidate and push data to the USGS servers. This will be assigned as an additional duty.

6.1.3 Option 3

The MACDC Drain commissioners will operate and participate independently complying with the NHD data model and processes. Each drain commissioner will gain the benefits of the NHD that they find of most use to their business needs.

6.2 Workflow

In general, the workflow for engagement with the NHD remains similar across the options.

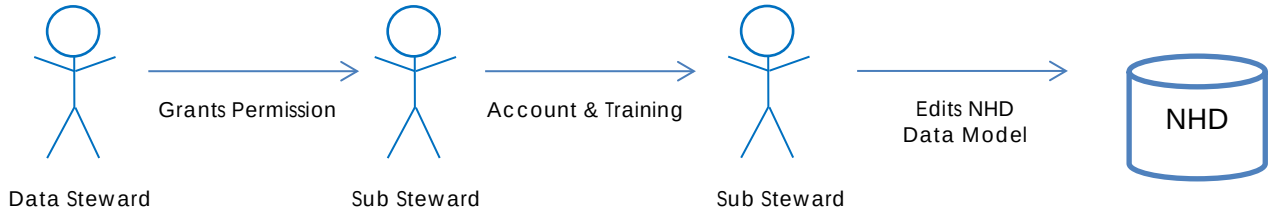


Figure 21 – Access to NHD Data Model

Figure 22 – Download NHD Data, Tools, Utilities and Applications.

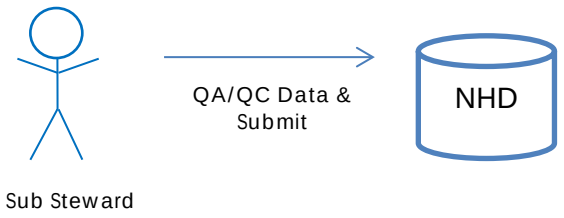


Figure 23 – QA/QC NHD data and submit back to USGS

Figure 24 – Submit change requests to the NHD Committee

7. Next Steps

To proceed with the implementation of the NHD, it is recommended that the MACDC discuss the benefits of the NHD and what it will mean for each county individually and then what it will mean for the entire state of Michigan. Subsequent to this internal meeting of the MACDC Drain Commissioners, it would be beneficial to reach out to the following points of contact (from the NHD Stewardship section):

USGS Region III Point of Contact (Michigan)
Name: Joel Skalet
E-mail: jjskalet@usgs.gov
Phone: 608-238-9333 x-152
Organization: USGS National Geospatial Technical Operations Center - Denver

USGS Regional Point of Contact for NHD and Water Resources
Name: David Nail
E-mail: dnail@usgs.gov
Phone: 317-600-2722
Organization: USGS Community of Use (COU) Liaison: Water Resources

Michigan Geospatial Liaison
Name: Charles Hickman
E-mail: chickman@usgs.gov
Phone: (614) 430-7768
Organization: USGS Geospatial Liaisons

Michigan Principal Steward
Name: Everett Root
E-mail: roote@michigan.gov
Phone: 517-373-7910
Organization: Michigan - Center for Geographic Information

Collectively, this meeting should discuss key players, options for implementation and who should be included in future efforts. An annual plan should be drafted that will identify the goals for the upcoming year. Items that should be discussed and planned for are as follows:

- Resource(s) identified to evaluate current data collections for fitness for use within the NHD data model structure.
- A gap analysis will identify where data does not meet the data model structure and/or not exist.
- All data that can be used will be migrated into the NHD data model format; collection of missing data will be initiated.
- A maintenance routine will be established for QA/QC of the data and the time frame for the data to be re-evaluated (i.e. quarterly, semi-annually, or annually)

- Tools will be downloaded and used to analyze data; becoming part of the drain commissioner's routine processes.
- Enhance data with edits and/or updates by other entities (i.e USFS, USDA, US EPA, etc.)

Appendix A – MACDC Contacts

County	Name	Email	Phone
Alcona	Jesse Campbell	Alcona01@chartermi.net	989.736.8168
Alger	Doug Miron	acrc@jamadots.com	906.387.2042
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Oscoda	Ron Bruner	rbruner@oscrc.org	989.826.3218
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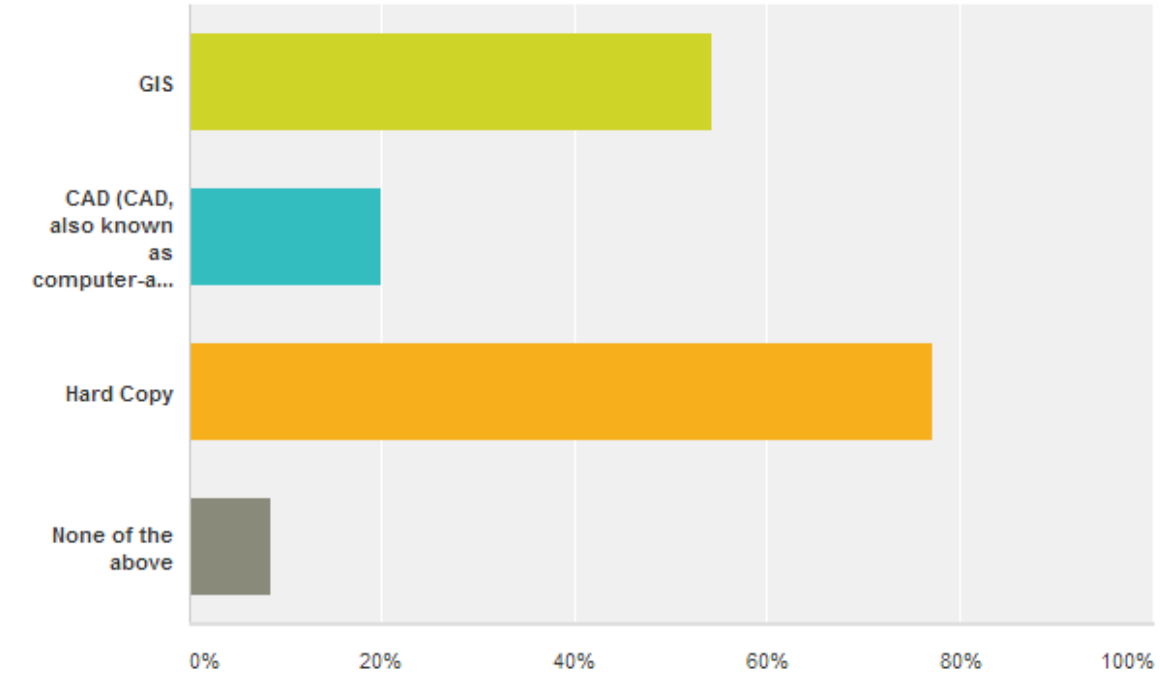
Appendix B – Survey Results (2013)

How do you manage your drains? (Select all that apply)

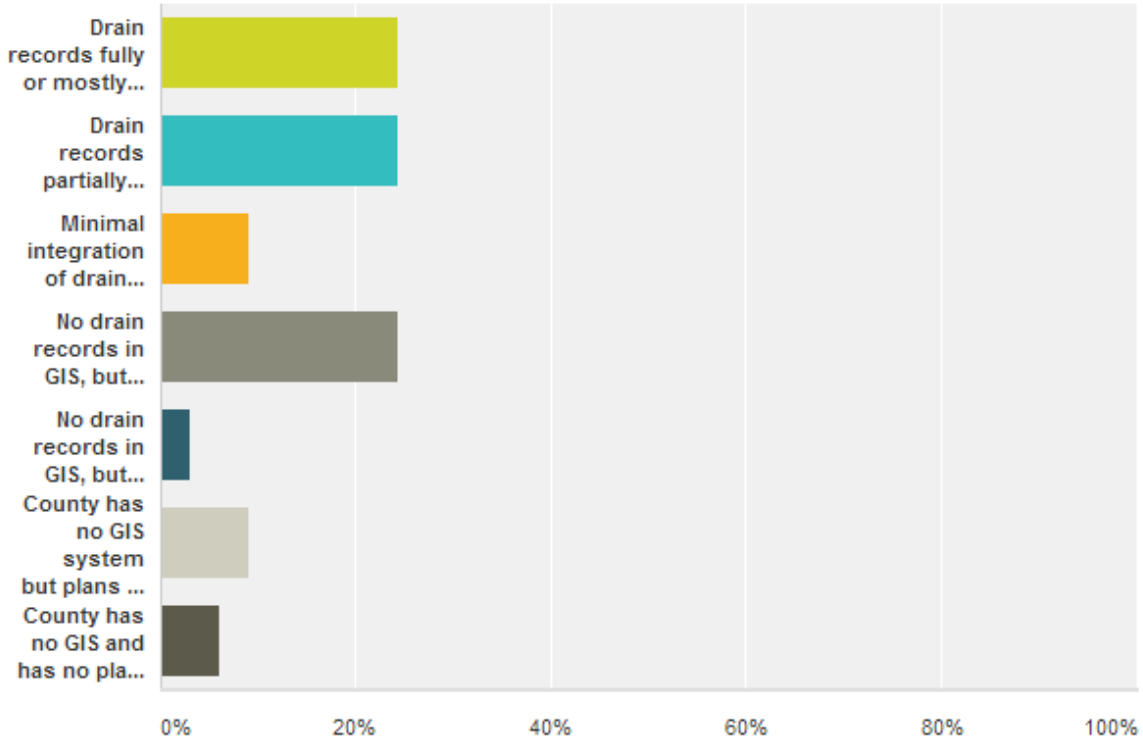
Answered: 35 Skipped: 0



Answer Choices	Responses	
GIS	54.29%	19
CAD (CAD, also known as computer-aided design and drafting (CADD), is the use of computer technology for the process of design and design-documentation. CAD software is a type of computer program that replaces tedious manual drafting with an automated process)	20%	7
Hard Copy	77.14%	27
None of the above	8.57%	3
Total Respondents: 35		

What is the status of your GIS?

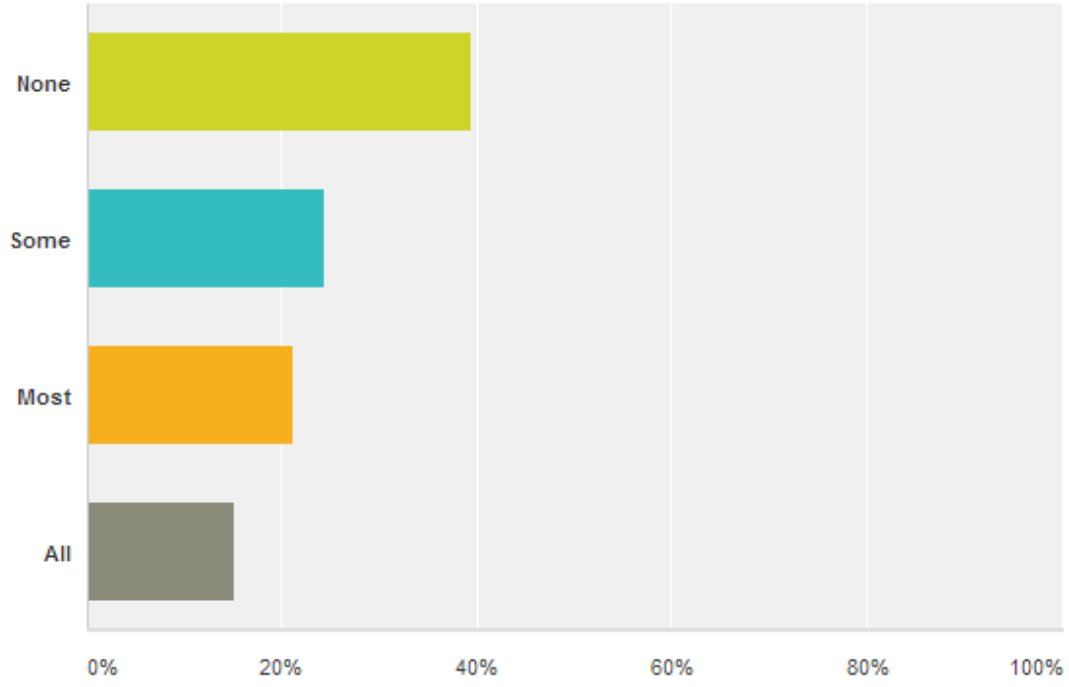
Answered: 33 Skipped: 2



Answer Choices	Responses	
Drain records fully or mostly integrated into GIS	24.24%	8
Drain records partially integrated into GIS	24.24%	8
Minimal integration of drain records into GIS	9.09%	3
No drain records in GIS, but County has a GIS	24.24%	8
No drain records in GIS, but County is currently developing a GIS	3.03%	1
County has no GIS system but plans on implementing	9.09%	3
County has no GIS and has no plans to implement	6.06%	2
Total		33

What portion of your County drains are covered by GIS?

Answered: 33 Skipped: 2



Answer Choices	Responses	
None	39.39%	13
Some	24.24%	8
Most	21.21%	7
All	15.15%	5
Total		33

Free Text Responses:
Easy to See
Rough measurements from the office, reduces notice mailing size (maintenance crew can point out where work is to be done), can often avoid trips out to the field when landowners have concerns, and it helps improve speed and accuracy of assessments.
Huge time savings in accessing drain information when responding to drainage complaints, preparing drain district maps, accessing property owner data within drainage district for notification purposes, preparing assessment rolls just to name a few. GIS has also been very helpful with our Phase II stormwater permit requirements.

GIS has allowed us to define and share information. We have a computerized maintenance management system that incorporates our GIS data. As a whole, our office uses GIS for many reasons.
Being able to look up a complaint or investigation from the computer without having to go through drawers of hard copies (AS-Builts) has increased speed and service to the residents. If I can look it up while I am talking to them I do not have to call them back
GIS is used to map drainage districts and create assessment rolls from the maps.
Increased speed of applying special assessments within a drain district
It has saved on time and labor during assessment time for referencing maps. In addition, it has saved money from hiring outside staff to manually creating a drainage district boundary line or confirming drain route.