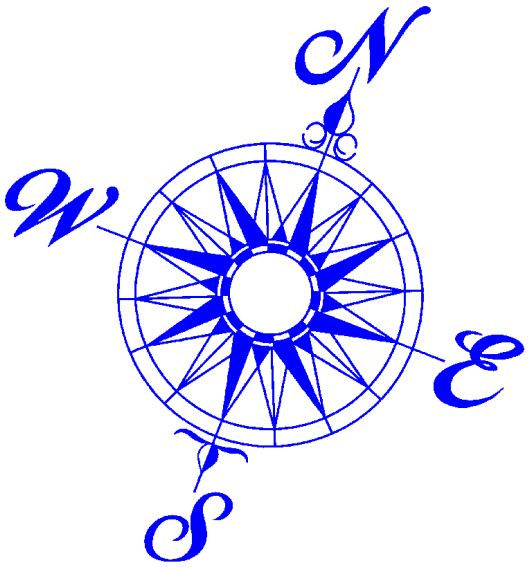
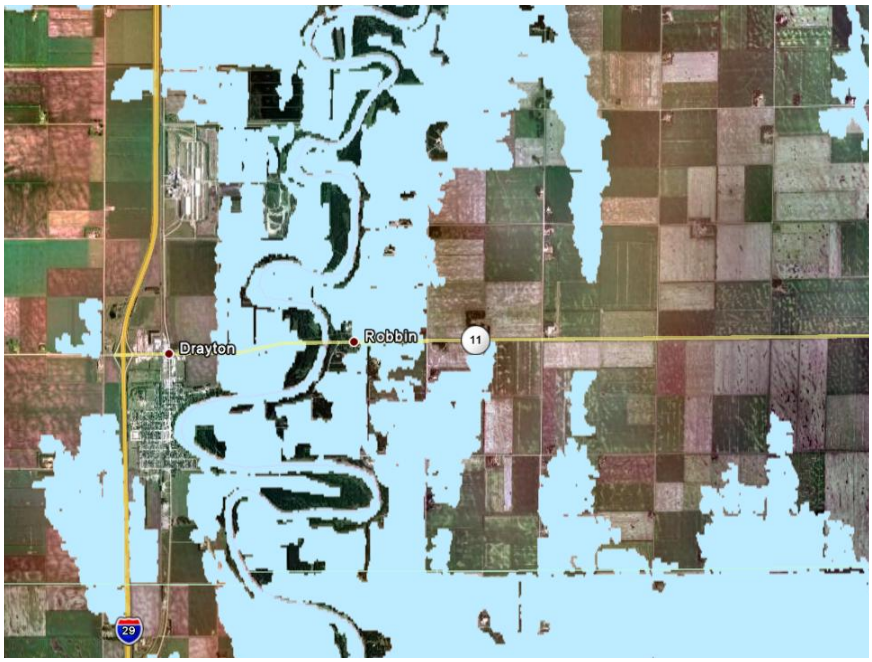
The 2009 Red River Flood Geospatial After Action Report



Final Report
March 11, 2010

Emergency Preparedness Committee (EPC)
Minnesota Governor's Council on Geographic Information (GCGI)
Now the MnGEO Statewide Geospatial Advisory Council (SGAC)



Top image: Looking east at the Welcome to Minnesota Sign on State Hwy 11 with a home heating fuel oil tank at the sign's base. April 17, 2009.

Bottom image: Corresponding Radarsat Flood extent map for April 17, 2009. The sign is located where the "R" is for the town of Robbin on Hwy 11.
(Google Earth & Canadian Center for Remote Sensing)

Cover photo: Panoramic tile mosaic of the Minnesota State Highway 11 and bridge to North Dakota over the flooding Red River. April 17, 2009.

Cover image and inside cover image credits: Brian Huberty, U.S. Fish & Wildlife Service.

2009 Red River Flood
Geospatial After Action Report October 20, 2009

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Executive Summary

This document is the after action report (AAR) for the flood event in the Red River basin beginning March 2009 in northwest Minnesota. The weather events prompted the Minnesota Governor's Council of Geographic Information's Emergency Preparedness Committee to organize its volunteer membership to assist local, state, and federal agencies by providing geospatial products throughout the entire event. This report provides an analysis of the GCGI EPC response activities, with particular focus on support to local emergency response agencies and the Minnesota Division of Homeland Security and Emergency Management.

This analysis is intended to improve performance during future events. The information for the analysis was collected through responder testimonials via emails, a debriefing "hotwash", and comments made on the Emergency Preparedness Committee's Sharepoint web site.

Brief Overview

When the Red River began to flood this year, GIS responded. This groundbreaking effort is the first time that a group of GIS volunteers came together on this scale in a collaborative web environment to provide geospatial support to an emergency. This effort was facilitated by the organizational framework of the Emergency Preparedness Committee (EPC), which was part of the Minnesota Governor's Council on Geospatial Information (GCGI), and is now part of the Statewide Geospatial Advisory Council (SGAC) for the Minnesota Geospatial Information Office (MnGeo). Map products included aerial photography, contours, weather, US National Grid, simple maps to get around, and much more. Maps were posted in PDF format to a public web site for responders to browse and download. In addition to map products, there were online map viewers, forecast tools, and a robust communications channel. The EPC also provided auxiliary support to the SEOC during the event.

The EPC began organizing efforts in advance of the event, and began making map products on March 23, 2009. The effort started with one person, and swelled to include 59 individuals from around the state as the event unfolded, working together from their own homes and offices. Leveraging lessons learned from participation in the Republican National Convention (RNC) security effort, the EPC deployed an array of tools that allowed volunteers from around the state to work collaboratively in a virtual production environment. Some of those tools included a Microsoft SharePoint for exchanging administrative files and information; Jabber Instant Messaging Service for dynamic group awareness and coordination; high capacity, high speed, redundant servers for storage of standardized maps; and a GeoMoose-driven web interface (SharedGeo) for distribution of product.

Major Strengths

The volunteers for this effort were knowledgeable and eager to help. The EPC had been preparing for response to an emergency event, through meetings, training, and standing up websites and spatial data. EPC volunteers used the online tools above in combination with "On the Job Training" to create templates and approaches that delivered 10 KM U.S. National Grid (10x10 kilometers in extent, 1:24,000-scale) maps for the entire Red River Valley, and 1 KM maps (1:6,000-scale) for populated areas. Of particular note, the combination of standardized maps that could be updated as new information came in, along with web access via the SharedGeo interface,

provided responders with 24-hour access to the most current map products available. Furthermore, this approach allowed the EPC and the Land Management Information Center to collaboratively produce, in a matter of hours, over 200 1 KM USNG maps that Minnesota Homeland Security and Emergency Management used to conduct the state's official damage assessment for this federally declared disaster.

Opportunities for Improvement

This event revealed many opportunities for improvement in five key areas, partnerships, technical, technological, organizational, and procedural. The complete findings and recommendations are detailed later in this report.

In the area of **partnerships**, we found that there were a number of contacts that had not been established prior to the event, particularly with Federal agencies. Among other things, this made it difficult to obtain some remote sensing data. We also found that the situation reports in the SEOC were lacking maps depicting the extent of the event and key issues.

Technical issues included the lack of best practices, and standard naming and symbolization conventions. There were some problems with different file formats and versions. We found that data licensing can be a roadblock, and that the number of spatial data sources and products out there can make it difficult to find the right information quickly. There was a lack of simple basemaps which could have been made prior to the event.

Opportunities to improve our systems, **technological** issues, included the way that we deliver the maps. Some responders did not have access to large format plotters to print the maps made by the team. Establishing deployable plotters, such as those in the DNR Mapmobile, would help alleviate this issue. Sharepoint and Jabber worked well for communication, providing a virtual work environment and dynamic communication. Some government agencies were not able to utilize Jabber due to security restrictions, while other agencies allowed use for this event. Jabber history was critical to keeping volunteers updated and for tracking events as they happened.

Because the role of the organization unfolded through time and need, so did the **organizational** structure itself. Creating an official, documented ICS structure for geospatial responders, as well as creating an official resource type for GIS professionals would help the organization and response effectiveness of the EPC. It is also important that GIS responders are able to use the emergency response tools (such as Jabber and Sharepoint) in their everyday work, so that they can utilize it more effectively in an emergency. And it is important emergency response personnel receive training in the availability and use of geospatial tools.

There appears to be no authoritative template anywhere in the nation for a GIS emergency response, and **procedural** issues had not been addressed prior to this event. There is no official documentation on how to operate, no standard operating procedure (SOP) for GIS response or involvement. There are no agreements or Memorandums of Understanding as to what the GIS community in Minnesota is able to provide to an emergency situation.

Introduction

The Red River basin of northwest Minnesota and eastern North Dakota experienced significant flooding for several weeks beginning in March 2009, resulting in two separate crests of the Red River. This event continued into late-April as the crests moved north towards Canada. This major flooding event prompted response and recovery operations from the state and federal governments in concert with local government agencies. This was event was very similar to the 1997 flood which devastated Grand Forks.

Assisting in government efforts were geospatial professionals from across Minnesota, volunteering their time and energy from computer terminals throughout the state to provide geospatial technical assistance for the duration of the event. This team worked together in a "virtual office" to collaboratively create map and information products in response to the flooding.

This after action report (AAR) is authored by the Minnesota Governor's Council of Geographic Information's Emergency Preparedness Committee and provides an analysis of its geospatial response and recovery activities.

Its key objectives are to document this effort, to identify strengths and weaknesses of the response, and to provide suggestions on how response can be improved for future events. *It is not the intent of this document to place blame, but rather analyze weaknesses for future improvements.*

Events

This was the first time the EPC had been fully engaged in an emergency event, taking a proactive approach in order to provide maps and geospatial information. The EPC did play a part during the last National Special Security Event, the 2008 Republican National Convention, staffing the State Emergency Operations Center (SEOC) and the Multi Agency Communication Center (MACC) and providing support to the National Geospatial Intelligence Agency (NGA). However the EPC participation for the RNC pales in comparison with the efforts for the Red River event.

EPC Co-Chair Steve Swazee began organizing volunteers for this effort in advance of the event. The Go Team was already established, and members were available if needed to staff the SEOC. Other EPC members came forward and a Map Production Team was established. Led by Randy Knippel and his Dakota County staff, the Map Production Team began making preliminary map products March 23.

On Thursday, March 26, Randy Knippel contacted Shelly Sentyrz to participate on the Map Production Team. SharePoint and the Dakota County FTP site had already been established by Randy and his Dakota County employees. They shared datasets, example map products, and the contact information, and then spoke about immediate mapping needs. Shelly began work on a TownMap product.

By Friday, March 27, map production went into full swing. More volunteer names were funneled through Randy to Shelly during the day, as Randy took the role of Team Leader while Shelly assumed the role of Assistant Team Leader. There were eight volunteers at that point who worked late into the night to produce a 1k, 10k, 100k, and Town Map series and uploaded them onto a single, organized FTP site that anyone could access 24/7. Shelly established a twice-daily email

brief to the Map Production Team and assumed 80% role of managing Sharepoint due to Randy's time constraints.

On Saturday March 28, Jabber became fully functional. A heavy day of map production and standardization followed, and individuals were assigned to be Product Manager of individual products. The Map Production Team began to plan for adding new volunteers to the mix, and began developing a file naming convention.

On Sunday, March 29, map production was carried out at a fast and furious pace, though was slowed in the waiting for remotely sensed imagery to be flown that never materialized. A simple "web presence" was established by the Map Production Team on the FTP site so people could browse more easily. Bob Basques and Jim Klassen (City of St Paul Public Works) eventually linked the interactive mapping site www.sharedgeo.org to the FTP site, and built crawlers from the sharedgeo.org site to the FTP site inventory of products. The Map Production Team also changed the file naming convention.

With the growing number of volunteers, it was clear that a separate person would be needed just to coordinate volunteers. EPC Education Work Group Co-Chair Joella Givens was assigned to be the volunteer coordinator, and assumed that role on Monday, March 30.

Joella received initial volunteer information from Steve, and created a master spreadsheet in Microsoft Excel for the effort. This spreadsheet had a tab for each team: Administrative Support, Map Production, Go Team, SharedGeo/Common Operating Picture, Local Distribution, Remote Sensing, LMIC, and Deployable. Joella checked with each team leader to see if they needed additional volunteers. All of the teams were set with the exception of the Map Production Team, which did request additional volunteers.

As volunteers came forward, Joella first made sure they had access to the Dakota County Sharepoint site. If a volunteer did not already have access, Joella could request that Khai Lee, Dakota county employee and administrator of Sharepoint, create a temporary account. This account was established specifically for this event, and was turned off when the event was over.

Once a volunteer had access to Sharepoint, Joella gave them a quick orientation to the site if needed, and directed them to become familiar with the page dedicated to the Red River event. On this Sharepoint page were instructions for getting a SharedGeo account, installing a jabber client, and accessing jabber through a web client (www.meebo.com).

Joella also determined the level of GIS experience for volunteers, and made sure they had access to ArcGIS. Once a volunteer had access to Sharepoint and Jabber, and had ArcGIS, Joella assigned them to the mapping team. This was the handoff to Randy and Shelly, leaders of the mapping team. Randy and Shelly then provided an orientation to the map production process, standards, data and map products, and assigned work.

By Monday, March 30, map production eases a bit with the first crest having been reached and a snowstorm moving into the Red River Basin, slowing the overland flow. Joella, in her role as Volunteer Coordinator, forwarded additional volunteers to Randy and Shelly, who then provided product orientation and assignments.

With mapping production slowing a bit, Tuesday, March 31 was a day of everyone was able to get caught up on "normal" work and regroup. New volunteers were assigned to products, and new incoming data was assessed by the Map Production Team. LMIC's John Hoshal assumed the role as Liaison between SEOC and Go Team.

During the time period of Wednesday, April 1, and Monday, April 13, the Map Production Team continued to perfect maps, as well as research and development of new products. The team had a total of 21 volunteers at this point.

Several Go Team members were also assigned to the Map Production, with the understanding that they would be pulled back to the SEOC if the Go Team was activated. There was a Go Team availability calendar on SharePoint, and team members indicated their availability for SEOC shifts.

By Tuesday, April 14, the Map Production Team began preparing for the second crest. This was lower than expected and adds no further burden to the effort by Friday, April 17. No response work was requested. With no word from Randy, Shelly assumes map production leadership responsibilities in his absence.

On April 15, in anticipation of the second crest, the Go Team was activated. John Hoshal from LMIC spoke with Joella about the need for volunteers to supplement the LMIC staff at the SEOC. Joella called Gordon Chinander, Go Team Lead, to activate the team. The plan was to schedule volunteers for four eight hour shifts Friday through Monday. However the next day the SEOC activation was reduced due to favorable conditions and the Go Team was not needed.

While the map production team took center stage, the other volunteer teams were also providing support and preparedness. The SharedGeo team gathered and assembled relative data into a common operating picture. Local distribution efforts relayed the maps to the folks on the scene. The remote sensing team arranged for data to be collected and available for use in this event. The LMIC team worked shifts at the SEOC and coordinated map and data requests from responders. The administrative support team included web support for the Sharepoint site (Khai Lee), official historian to create the After Action Report (Dan Anderson), a timekeeper to track volunteer hours (Nancy Read), and leadership positions (Steve and Joella).

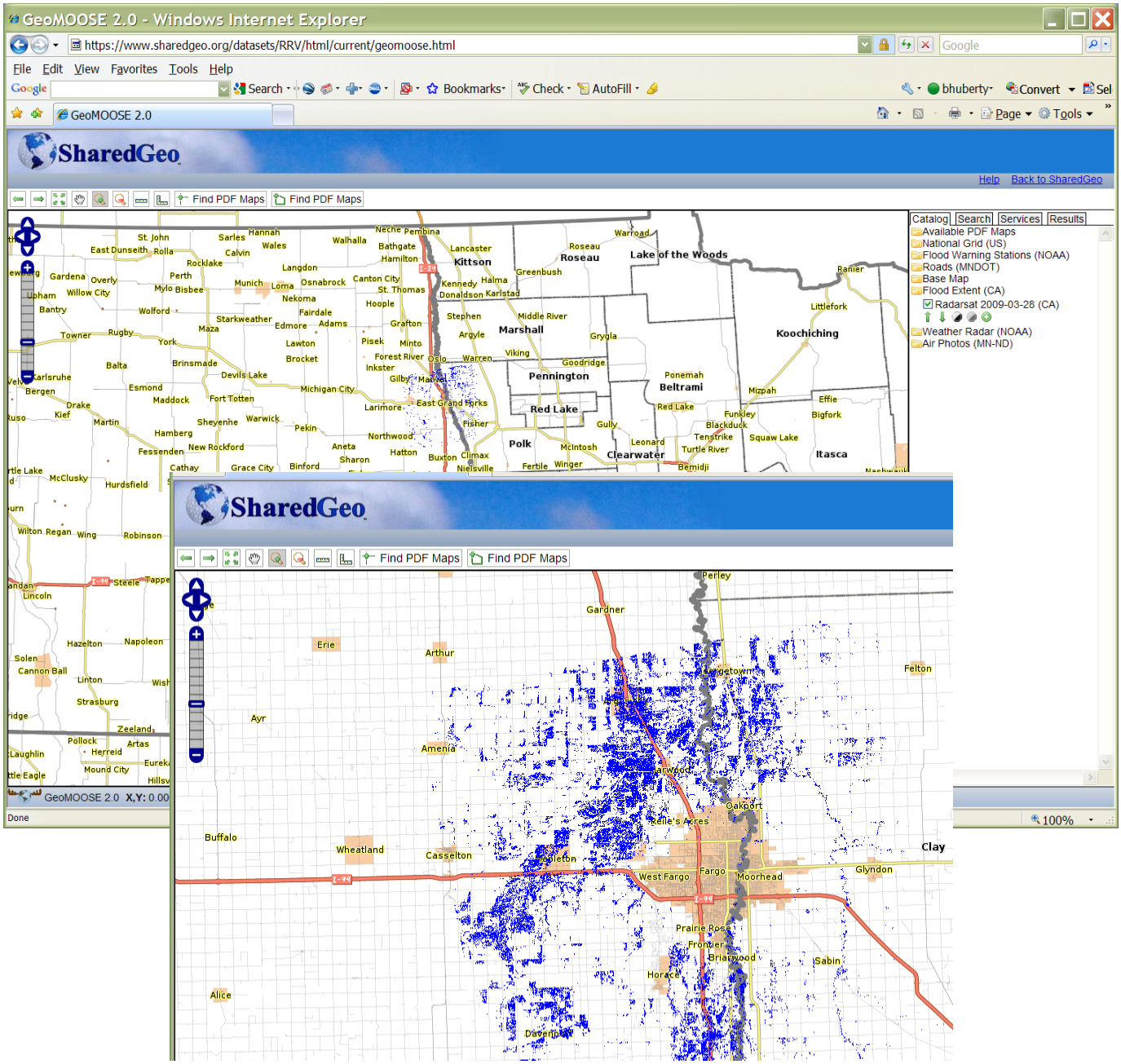
On Monday, April 20, Shelly begins organizing the map production team volunteers to clean up and package their products. Steve says that no more map production work to be done, and asked everyone involved to add Lessons Learned to Sharepoint. Shelly then organizes group to demobilize. See Appendix B for the list of volunteers. See Appendix C for a list of maps products and sample maps.

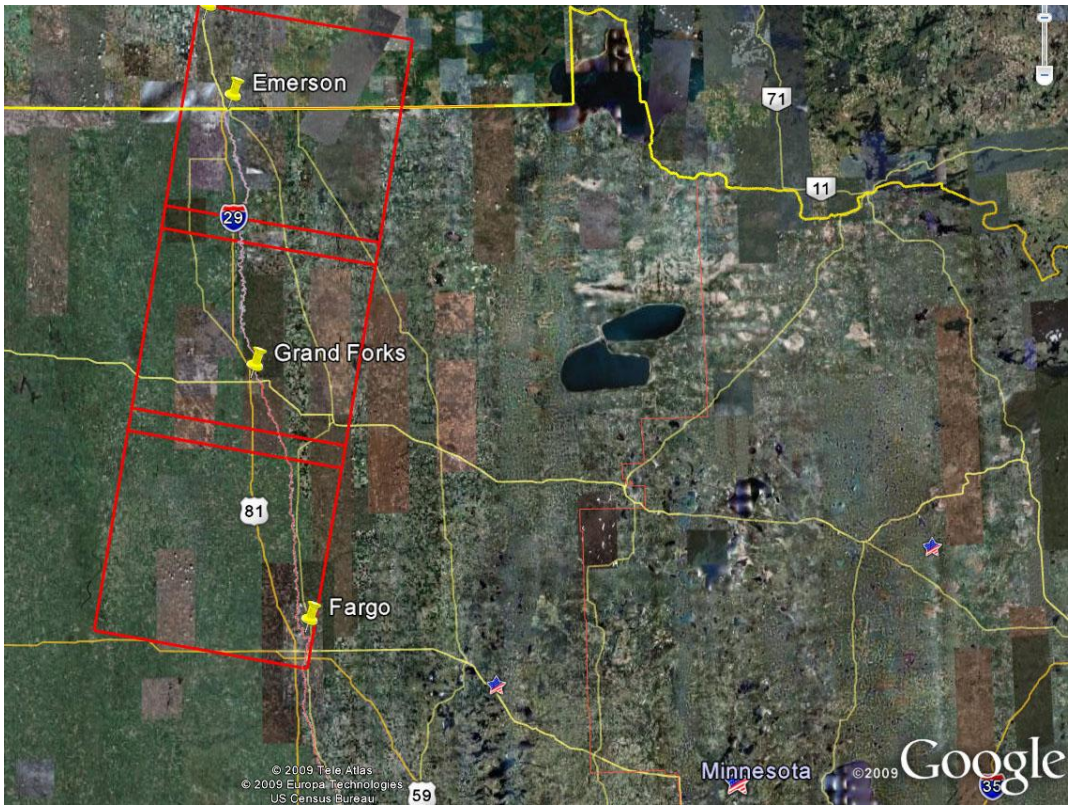
Remote Sensing

Key to any emergency is knowing where the disaster is, and what is the extent of the damage. Remote sensing through the use of aerial and satellite imagery fills this void. Satellite radar imagery is needed to see through clouds to map the flooded areas. Digital near-real time optical stereo imagery is needed to show detail views of damage.

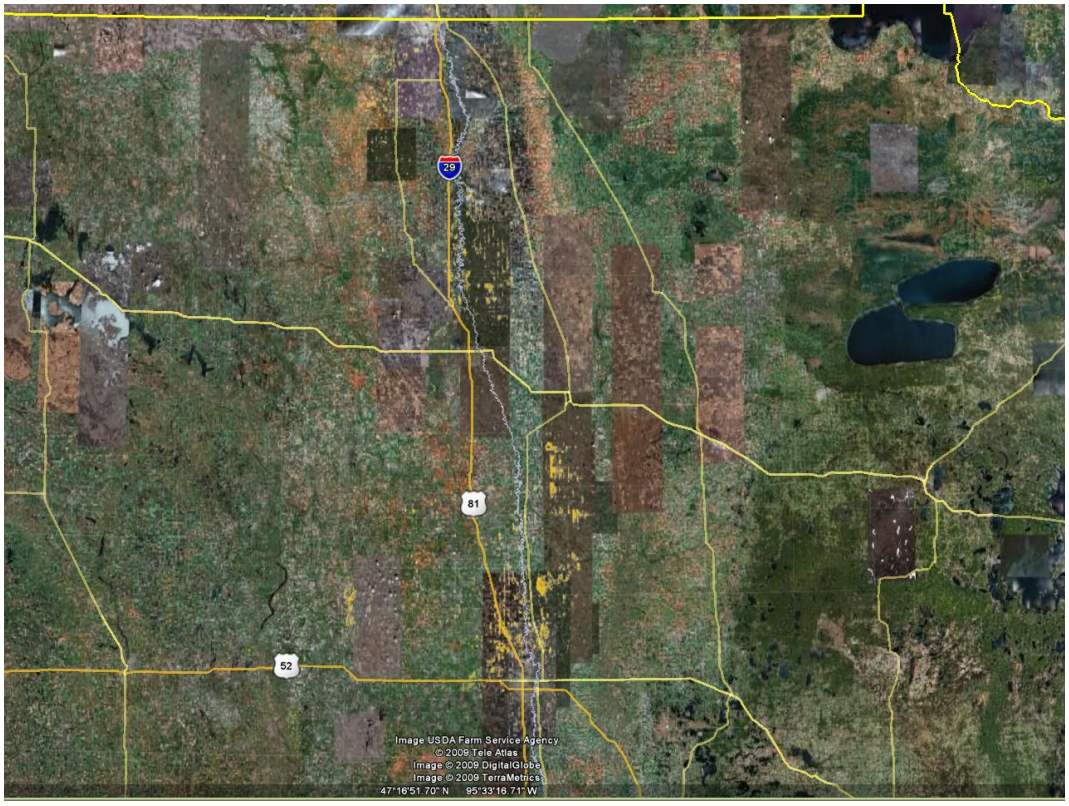
Radar Imagery

The SharedGeo site served a variety of data, including NOAA Flood Warning Stations and weather radar, Radarsat, and air photos. In the image below, the blue speckled pattern around Fargo on this SharedGeo map of the region is one of the first flood extent flood maps served up using Radarsat Imagery.

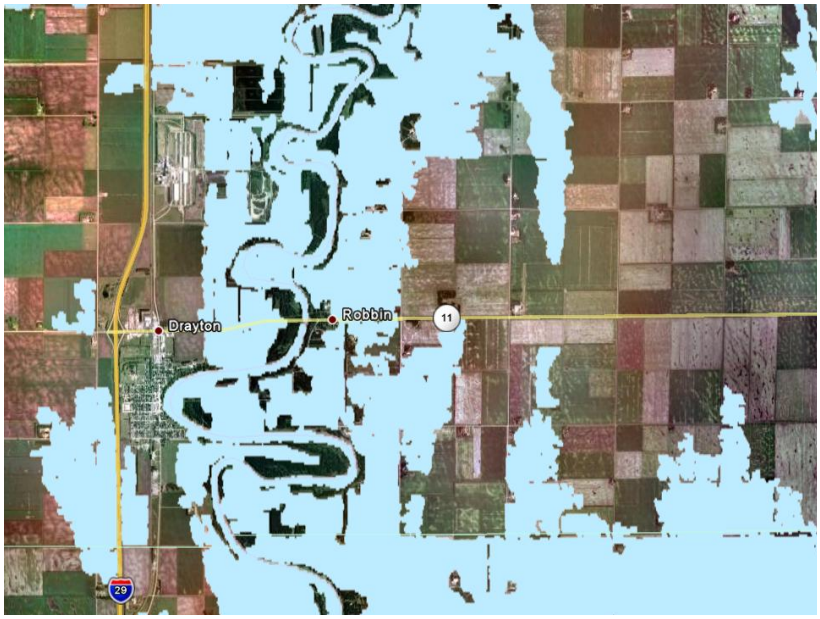




The top image shows Radarsat image scene coverage areas for the Red River Valley on one day. Given there are two Radarsat satellites in orbit, flood extent mapping coverage was possible about every other day. The bottom image shows the flooded areas in yellow, derived from the Radarsat images. (Courtesy of Google Earth and the Canadian Center for Remote Sensing.)



Radarsat

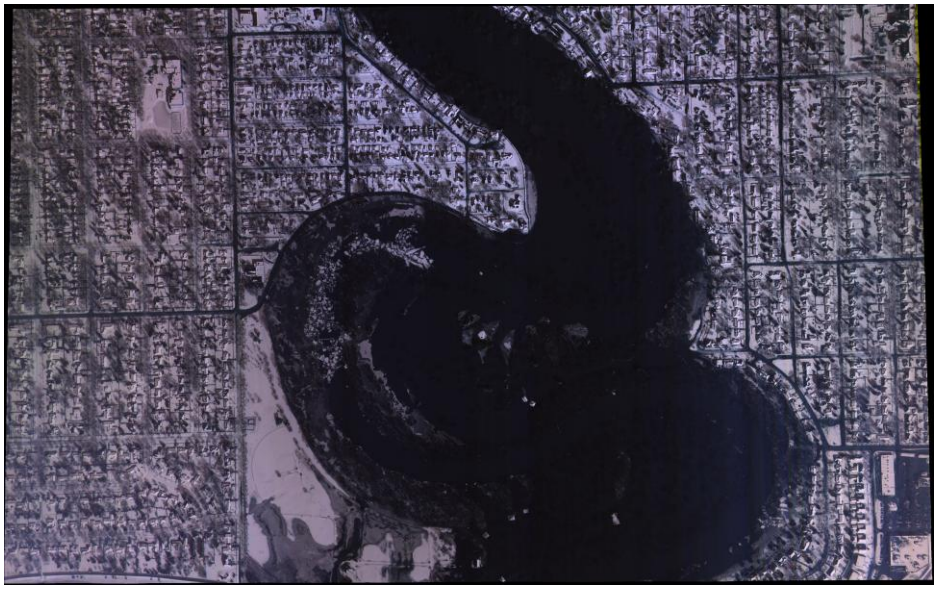


This is Drayton, ND showing the flood extent for April 17, 2009 with Radarsat Imagery.

Aerial Imagery

Airborne Data Systems (ADS) from Redwood Falls, MN was tasked by the North Dakota Water Commission to fly aerial imagery during the peak flood event for Fargo on March 28, 2009. All 300+ square miles (nearly a terabyte of imagery) was processed on Sunday and served up on Monday, March 30, 2009 by Agriimagis out of Fargo, ND. This amount and area of aerial imagery has never been processed and served up as fast as this event… ever… globally! The images would have been served up by Agriimagis on Sunday but everyone was busy sandbagging around their homes! A few days later, the same imagery was up on Google Earth.

Horizons (out of Rapid City, SD) and the North Dakota DOT also flew engineering level high resolution imagery for this event. Unfortunately, these systems are not designed for rapid response and require extra weeks for processing. However, they are being used for the post analysis of the flood for USACE.



Source: Airborne Data Systems, Fargo, ND. Moorehead, MN Peak Flood, Saturday, March 28, 2009, .5 meter resolution, full multi-band, multi-spectral stereo imagery.

Oblique Imagery

ND CAP March 19, 2009 Ice Jam near Fargo

ND CAP April 2, 2009, Railroad crossing, Moorehead, MN

Pictometry imagery of Fargo, ND. March 29, 2009

Customs Border Patrol: Predator UAS imagery. Note that there is no date on the imagery, just location and direction of the imagery. Predator imagery was useful to determine areas of inundation, ice jams and location of water in relation to critical infrastructure. It was not used for mapping due to its low resolution and lack of control. Oblique imagery taken by Pictometry, MN DNR, CAP and Border Patrol all provide a nice bird's view of the area.

Roles

The following are the roles of some of the state agencies involved in the event.

Land Management Information Center

The Land Management Information Center (LMIC – now called MnGeo) provided GIS support at the request of Minnesota Homeland Security and Emergency Management (HSEM), and as part of the Minnesota Department of Administration's role in the State's Emergency Operations Plan (MEOP). This was the second time LMIC had been requested to attend an actual event at the State Emergency Operations Center (SEOC); which also staffed the GIS desk at the SEOC during the Republican National Convention (RNC). LMIC is also under contract with HSEM to provide GIS support for the Radiological Emergency Preparedness (REP) program. These efforts have also provided opportunities to prepare the SEOC GIS PC for a wider variety of potential disasters. The RNC and REP activities included federally mandated exercises and training.

During the Red River event, and while at the SEOC, LMIC operated under the direction of the Operations Section. Three LMIC staff covered the GIS desk via split five hour shifts with a 30 minute overlap between shifts for knowledge transfer. One person worked the entire shift when the schedule switched to an eight hour day.
The GIS support staff responsibilities included:

- Create, update and display an overview map of the event in the SEOC via a projector (projector eventually failed during this event).
- Monitor and respond to SEOC GIS staff email.
- Monitor and respond to SEOC GIS staff DisasterLAN account.
- Provide the Minnesota Deptartment of Administration staff with Situation Report information.
- Fill map requests approved by the Operations Section. About 60 maps (drafts & finals) were created by staff for this event.
- Take part in briefing updates.

In addition, LMIC had several staff members working back at the office to coordinate data and map requests with FEMA, and perform data research and development at the request of several state agencies and the Minnesota Army National Guard.

Minnesota Department of Transportation

Mn/DOT helped support the Red River flooding emergency by collecting and disseminating road closure information through the creation of hardcopy and electronic maps, and web map services. This effort involved nine GIS staff, working shifts at the SEOC or in their Mn/DOT offices.

Previous experience with similar events helped Mn/DOT prepare for this event. Mn/DOT provided GIS staff to the SEOC when it was activated, and additional editors back in the Mn/DOT offices. Shifts varied as the incident ramped up and then scaled back down, with Mn/DOT staff generally providing coverage from 8:00 AM to 6:00 PM, with some weekend coverage as needed. During the peak, all nine Mn/DOT GIS staff were focused on flood activities and provided up to 16 hours per day of coverage. Mn/DOT staff provided nearly 1000 hours of support to this effort. In addition to

paid work time, several Mn/DOT employees provided volunteer support to this effort 'off the clock'.

Mn/DOT staff worked with ESRI (Environmental Systems Research Institute) to set up an interactive routing application for the Red River area. This application was originally developed to route people around the I-35W bridge collapse, and was used later that same year for flooding issues in southeastern Minnesota. The application was dusted off and put into place quickly. It allowed Mn/DOT staff to enter road closures onto a secure web map interface. A second application then provided closure and routing information to a public web map interface. The public could zoom in and pan to their area of interest, and could see the road closures. Additionally, citizens could click on the map to enter a point of origin and a destination. The map would then provide a blue line showing the route around the closures, and a turn-by-turn narrative describing how to get there. This is very much like a Google service, except this map was able to take into account the most current road closures.

Initially a GIS staff person was assigned to be the contact person each shift. This person generally worked from the SEOC when state agencies were staffing. Otherwise this was done from the Mn/DOT office. Each of the 21 counties and two Mn/DOT Districts, in the affected area were contacted to obtain changes to road closure information. Some counties had GIS maps showing road closures and indicating which had changes. Other counties had maps, but no information as to what had changed. Some counties had road closures listed as text on their web site, with some indicating change dates or when the list was last updated. These sites were checked at least once per day, sometimes more if there was a lot of activity in that county. For counties with no web information, the designated contact person sent an e-mail to the county contact, or in some cases called them. Additionally, available information regarding road incidents for North Dakota was reviewed and incorporated as necessary.

Road condition changes were sent to the editor(s) for updating. When there were a significant number of changes or updates, additional editors were assigned to enter the changes. Editing was performed in the Mn/DOT office to take advantage of better network speed. Editors were also responsible for updating the map products that were shared with other agencies and organizations. Mn/DOT divided the affected region into five overlapping areas, and produced an updated map for each area, one or two times each day. These 34" by 44" maps were posted as GeoPDFs to the web, and were printed to display on the walls at the SEOC. Mn/DOT continued to monitor road closures and update the web site until the situation stabilized.

Minnesota Department of Natural Resources

The Minnesota DNR MapMobile was not used for this event. It was readied by the MN DNR Resource Assessment Unit (RAU) in anticipation it would be called up to help provide support. This resource could be utilized to provide on-site maps in future events. Sidenote: The MapMobile was sent to New York to provide maps and imagery the next day after 9/11. It was the ***only*** mobile GIS vehicle in the entire country at that time to provide emergency support.

Mike Hoppus, Remote Sensing lead for the MN DNR RAU did provide oblique imagery which was vital for the Canadian Center for Remote Sensing to use in order to calibrate their flood extent maps derived from Radarsat Satellite Imagery.

Source: Mike Hoppus, MN DNR April 14, 2009

Source: Mike Hoppus, MN DNR April 14, 2009

Methods

Information for this report was gathered using email surveys and online testimonials placed on the GCGI EPC Sharepoint website, as well as an April 30, 2009, debriefing phone conference meeting of those who provided GIS products for the event.

This After Action Report was distributed in draft form to all pertinent players in order for them to supplement and correct the original text. Considerable thought and effort was put into refining and editing this document.

Findings & Recommendations

Those responding identified several key areas, or "lessons learned" on which to improve, along with some suggested improvement actions. These are grouped into five major categories: partnerships, technical, technological, organizational, and procedural.

Partnerships

Partnerships with local, state, and federal partners, though improving, still prove to be a challenge.

Finding: It was initially difficult to establish Federal contacts.
At the beginning of the event, it was unclear who each agency's contacts were. FEMA, the state agencies, and the local agencies were equally confused as to who they should be in contact with at the other agencies. The learning curve was universal, though over time this resolved itself. Contacts were made, and working relationships forged for mutual benefit.

In the past, and for this event, HSEM has had neither the staff to fully utilize GIS, nor the understanding of its full benefits. Through no real fault of their own, they simply haven't realized that there is a need. Simply put, they don't know what they're missing.

FEMA had a difficult time initially understanding who to make contact with in the GIS community, though they eventually were able to liaise with John Hoshal and LMIC. FEMA's need for local data was pretty specific, and was based on FEMA's need to gather information in order to plan for resource utilization. This flood covered large areas of Minnesota, North Dakota, and Manitoba, as well as two FEMA regions, adding to the confusion.

Recommendation: Continue to establish Federal contacts before the next incident.
Getting HSEM and the SEOC to understand FEMA's GIS needs is crucial. If FEMA's liaison to the SEOC asks for certain GIS data, then the need is there for the SEOC to utilize its relationships with its GIS partners.

Preplanning activities pave the way for this to happen. All partners need to continue to build the relationships created with this event.

Finding: The SEOC Situation Reports currently do not include maps.
Textual descriptions are not the best way to communicate certain information. The situation reports did not include depicting the extent of the event and key issues. Emergency responders need to be able to answer the basic question "Where is the disaster and its extent?"

Recommendation: Develop standard maps for situation reports.
Work with SEOC leadership to identify the importance of and suggest the inclusion of maps as part of the Sit Reps. Work more closely with partners to demonstrate the value of geospatial products for emergency response and let them know about the geospatial resources available. The addition of simple maps to the situation reports would help in understanding of the event. By including maps showing critical issues such as the current and predicted flood extents and ice jams, the situation is communicated clearly and concisely. A picture is truly worth a thousand words.

Finding: It was difficult to obtain some needed remote sensing data.
Remote sensing imagery is critical in a disaster like this in order to define the extent of the damage. No one in Minnesota was delegated and trained to request remote sensing imagery support through the International Disaster Charter.

Recommendation: Develop a procedure to acquire remote sensing imagery.
Develop agreements with aerial imagery providers to acquire photography throughout the affected area before, during, and after an event. Delegate and train someone to request remote sensing imagery support through the International Disaster Charter.

Technical

It is widely known that no matter what the incident, operations are usually hampered by interoperable communications issues. In a GIS emergency response, technical issues are no different. Technical issues may plague any GIS emergency response, but like other emergency responders who confront interoperable communications issues, we must begin and continue the process of confronting technical issues.

Finding: There was a lack of base maps.
In the early stages of the event, sometimes all that is needed is simple navigation, or a general understanding of an area that a base map can provide. Many of the maps available were out-of-date and inaccurate. Because of time constraints, responders didn't have time to wade through all the free data or web mapping service (WMS) data available. Even though high resolution terrain maps (one foot DEMs) were acquired recently for a central portion of the Red River corridor, the rest of the basin was not funded to be mapped

Recommendation: Create base maps for future responses.
The EPC needs to come up with standardized base data layers that can be shared on Go Team portable hard drives. These layers can also be served out on a WMS for use by GIS emergency responders remotely. As well, premade hard copy county, city, and thematic state maps would benefit personnel staffing the SEOC.

A standard set of PDF basemaps founded on the United States National Grid (USNG), with the ability to add layers of additional data sets, should be created for the State. GIS responders often spend a great deal of time re-creating the basic elements of a map in order to add more or different information. Providing a standard basemap as a starting point would provide consistency across maps and the ability to quickly create custom maps specific to a given situation.

Finding: The use of different file formats was problematic.
Using commonly used file formats is critical for passing information from one user to another. There were a few cases where Microsoft Word documents couldn't be opened because they were created in a newer version of Office. The National Geospatial-Intelligence Agency (NGA) delivered .nitf format images which are unreadable by most civilian agencies.

Recommendation: Create best practices and standards for file formats.
Standards for file formats need to be created, taking into account a practical "lowest common denominator" of software and hardware being used.

Continued use of shapefiles is a good idea since they are an "open" standard and can be used by most GIS software.

Also, converting documentation into Adobe Acrobat PDF files would be useful. Adobe Acrobat Reader is free and widely installed on most computers.

Finding: There were so many available remote sensing products methods that keeping track of them was a challenge.
Several remote sensing products from several different organizations were available for this event, making it difficult to keep track of all of them. This led to confusion and lost time.

Recommendation: Document all remote sensing products available.
Those who use remote sensing products will meet at length in the future on how to address this problem. Basically they will create a spreadsheet which lists the different types of remote sensing products in use, and make that list available to emergency responders.

Finding: So many sources of data makes it problematic to find the right data quickly.
There were a variety of systems and data producers available, and during the incident it was difficult to find what was needed quickly and easily.

Recommendation: Identify common data sets and make them readily available.
Create an index of common data sets that could be used in an emergency event. Provide education to GIS responders as to what data is available and where it is located. Develop a web-based common storefront for access to spatial data and information related to emergency management. Create statewide basemaps that hold common layers as a starting point for mapping.

Finding: Data licensing can be a roadblock. Licensing of some GIS data and remote sensing imagery made it difficult to deliver much needed information.

Recommendation: Establish data access protocols and licenses.
Establish these prior to an emergency so that geospatial data and products are available when the emergency happens. Also continue to develop statewide emergency management related data sets that can be distributed without license restrictions.

Finding: Standard Naming and Symbolization Conventions are critical.
Having predefined naming and symbolization conventions are critical. A lot of time was spent coming up with a good naming convention for the maps. Eventually it was worked out but if it were predefined it would reduce the amount of time.

Recommendation: Create a standard for naming and symbolization.
A naming and symbolization standards document is currently being developed.

Technological

Different from technical issues that deal with aspects of dealing with data, technological issues are those that deal with systems.

Finding: Having a single FTP site for data storage works well.

During this incident the National Interagency Fire Center housed an FTP site used by GIS volunteers for data storage and transfer. Although NIFC will allow the FTP site to be used for any future incidents, perhaps it would be better if there was a dedicated "all-hazards" FTP site.

Also note that varying formats of FTP made access confusing and sometimes impossible for some people. Firewalls also impeded some data transfers.

Recommendation: Establish one FTP site to use during future incidents.
The NIFC site can be used as long as needed for any future event. However, some GIS emergency responders feel the need for one national "incident response" site, one that is easy to use and consistent, with clear instructions. This site should be located outside of agency firewalls for best access.

Finding: Jabber history is a critical piece of any event record.
Early on it was discovered that the Jabber server installed on SharedGEO did not provide a way to access a chat room's history as had been the case during the Republican National Convention. Past history has demonstrated the premium value of being able to leave Jabber, but return later and understand events by reviewing past history. In response, a self-standing workaround was created. However some agencies did not allow access to jabber from within their network.

Recommendation: Promote and standardize an integrated secured messaging system.
If Jabber is used in the future, the Jabber server needs to have the history module activated from the start of the event.

Also, there is the bigger issue of information technology protocol that does not allow instant messaging in some workplaces. Jabber, or other integrated secured messaging systems like it, is needed for future incidents. It is an important piece that needs to be developed as a collaborative effort, along with the GIS and situational awareness pieces.

Finding: Working remotely with one map plotting/distribution site works well.
Modern technology makes it possible for an actual GIS emergency response to happen hundreds of miles from the event. This was utilized well during this incident by the creation of a 'virtual office'. The collection of web tools and procedures allowed volunteers from across the state to contribute when and where they had time, without traveling to the event site or a common location.

Recommendation: Continue to support working remotely; yet improve the ability to deliver those maps in hard copy form to the jurisdiction or in the field.
Much of the work done by a Go Team member can be done in their current work area or from home. However, in order to do this, Information Technologies issues arise.

The Go Team needs to establish baseline technical requirements for participating in the mapping effort. Requirements like Virtual Private Network access, remote desktop, and Jabber should be understood as basic requirements for doing business as a Go Team member.

There will always be a need to plot hard copy maps locally. Deployable plotters may need to be an option, or utilization of the DNR GIS trailer or perhaps FEMA GIS assets.

Also continue to enhance the SharedGeo.org website for sharing data and communicating in future emergencies.

Organizational

Because the role of the organization unfolded through time and need, so did the organizational structure itself. What started out as a small need for some GIS volunteers turned into a need to track the volunteers themselves, the time they put in, and what they achieved. A total of 59 GIS responders and administrative support staff, working at city, county, and state government offices, in private industry, and from their homes, worked more than 2,500 hours in the effort.

Because of lessons learned, and now with the support of the local, state, and federal agencies we will serve in the future, our approach will be more structured for future incidents.

Finding: This can be done and done well!
We have proved to ourselves that teamwork and organization brought a completely nonexistent product into a functional, effective, and necessary resource in a very short period of time.

Recommendation: Find ways to make the skills and tools GIS responders used at this incident perpetually sustainable by incorporating them into everyday use.
In reality, now that this is all in place it never really has to be put away. The key to this is to find a way to make this sustainable by using in our everyday work. Using Jabber and Sharepoint on a daily basis and not just during an incident constantly exercises our new emergency response skills while maintaining relationships built during this and future responses.

Also train emergency response personnel in the use of geospatial products and tools, incorporating geospatial education into standard emergency management curriculum.

Finding: The Chain of Command was not documented.
GIS Emergency Responders were at times confused as to who was in charge, what other people did, or why the responder should or shouldn't be talking to someone. A centrally posted organizational chart would have solved this basic communications challenge. Sharing activity summary reports with all responders is important.

Recommendation: Institute the use of the Incident Command System at the onset of an event, and use throughout the event.
Having never responded to an incident of this magnitude, it was impossible to know how to expand an appropriate organization beyond the Go Teams. The obvious answer now is the use of the Incident Command System. However, the initial concept of the Go Teams was that they be inserted into other agencies Incident Command Systems. Never did it occur to us that we would be dealing with an event large enough for us to initiate our own.

However, that's exactly what happened. It eventually grew into nine operational and administrative teams under the guidance of EPC Co-chair Steve Swazee. (See Appendix A) In retrospect, a full Incident Command System, expanded and contracted through the lifespan of the incident and exercising a manageable span of control, would have been more appropriate.

Despite this, or operations response was coordinated and our objectives were met. But having an ICS in place would have addressed some basic Planning, LoGIStics, and Finance needs. By establishing an ICS, the following would have been completed:

- Establish an **Operations Section**.
    - Secure mapping team structure and make them part of the Operations Section. The mapping team structure worked very well. This structure needs to be kept intact, though folded into the Operations Section.
    - Establish one person/site to receive incoming incident data – By establishing a Planning or LoGIStics Section, with a Chief, incoming data could have been received and catalogued for future use.
    - Operations Section Chief would be in charge of establishing the incident objectives each operational period so that they align with the objectives of the GIS emergency responder partner agencies.

- Establish a **Finance Section**, with a Chief, that would have been in charge of gathering all cost and time data to be used for reimbursement of responders and any expendables. All costs were reimbursable through FEMA because this was a Presidentially Declared Disaster. However volunteers for this effort were not able to receive payment as protocols for this were not put into place before the incident.

- Establish a **Planning Section**, with a Chief, that would have been in charge of documenting the entire incident for this after action report, as well as establishing an Incident Action Plan. As well, the Planning Section is responsible for collecting ongoing situation information for use within the ICS.

- Establish a **LoGIStics Section**, with a Chief, that would have been in charge of gathering and tracking volunteers as well as establishing and maintaining the lines of communication used by GIS emergency responders. These include Jabber, Sharepoint, phone conferences, video conferences, etc.
    - Establish one person to receive/distribute product orders. Orders for products would then be tasked to the appropriate Operations team.

- Establish a **Command Section**, with an Incident Commander, to oversee the entire operation. The Incident Commander would need to assign the following positions:
    - Public Information Officer – this person would have been in charge of gathering information for general public and industry specific media.
    - Liaison Officer – official EPC representatives to FEMA, HSEM, etc.

Procedural

Currently there is no authoritative template anywhere in the nation for a GIS emergency response. Much of what we have learned thus far is truly “lesson’s learned” in that much of what we encountered haven’t been encountered at this level before. This particular event was multi-city, multi-county, multi-state, and multi-country in scope. It was local, state, federal, tribal, and international. Procedures are currently nonexistent, though before the Red River flooded where we only had ideas, we now have the base experience to create procedures that will most likely the first of their kind in the nation.

Finding: There's no documentation on how to operate.
Having a single source of information in a document would be useful to understand how GIS resources activate and operate. Nothing like this currently exists.

Recommendation: Create a Standard Operating Procedure for disaster response.
Given our recent experience, the value of a GIS Standard Operating Procedure has once again been validated. One of the big lessons learned from the RNC experience was the need for a document to be used by GIS emergency responders during a disaster. There currently is an effort by an EPC "Tiger Team" to do just this. Such a document should include things like:

- Situations and Assumptions in activating GIS resources
- Initial steps to be taken to begin the effort
- Organizational steps to be taken as the incident expands or contracts
- Product production and standards
- Node protocol
- Management of the product request process

Finding: FEMA did not understand what GIS assets and data were available in Minnesota before the incident.
Without this type of awareness in place, there is no real clarity concerning the required expenditures and corresponding methods to recover state and local costs.

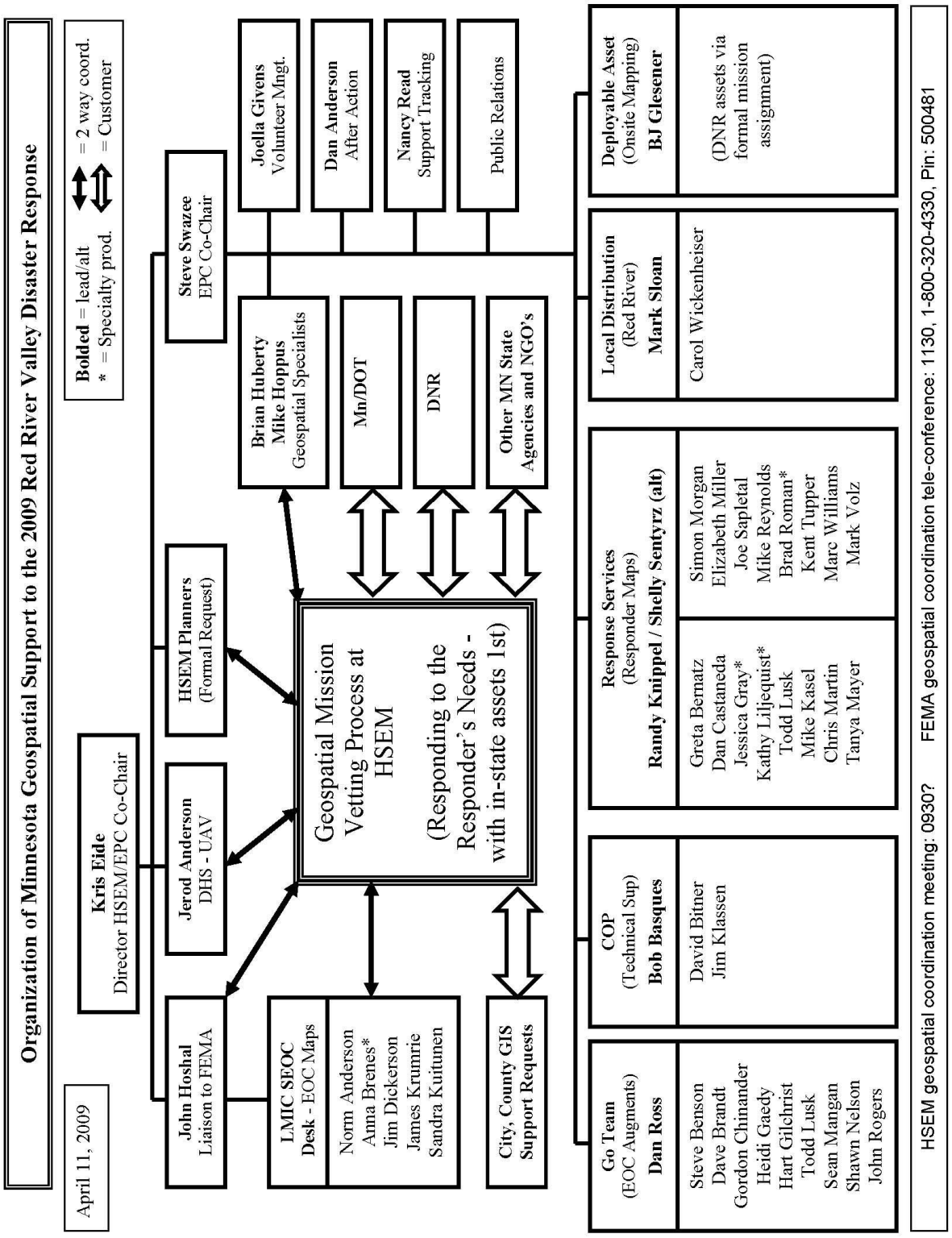
Recommendation: We need to establish before an event what FEMA expects the Minnesota GIS community to provide.
GIS partners will dedicate time to future discussions. Perhaps through Memorandums of Understanding or similar documents, the Minnesota GIS community can define a shopping list of products and support that define the state's contribution for a disaster.

Conclusion

The 2009 Red River Flood response is an example to learn from in order to improve how we define and respond to future disasters. The key questions of "Where is the disaster?" and "What is damaged?" remain to be better addressed in the future. The findings and recommendations that are outlined in this report need to be addressed in order to minimize the loss of life and property in future disasters. The geospatial and remote sensing components are foundational elements to aid victims and emergency responders in any emergency.

Appendix A: Organizational Chart

Geospatial Support Structure



Appendix B: Volunteers List

EPC Volunteers for the Geospatial Response to the 2009 Red River Flooding

Dan Anderson
Norm Anderson
Bob Basques
Steve Benson
Greta Bernatz
Dave Bitner
David Brandt
Anna Brenes
Dan Castaneda
Gordon Chinander
Jim Dickerson
Lanny Faleide
Dave Fuhr
Heidi Gaedy
Jessica L. Gary
Pete Giencke
Hart Gilchrist
Joella Givens
BJ Glesener
Mike Hoppus
John Hoshal
Brian Huberty
Katherine D. Hurley
Adam Julson
Mike Kasel
Jim Klassen
Randy Knippel
Greg Koeln
Jim Krumrie
Sandi Kuitunen
Robert Landry
Bob Lease
Khai Lee
Stuart J. Lien
Kathy Liljequist
Dan Little
Todd Lusk
Sean Mangan
Chris Martin
Tanya Mayer
Elizabeth Miller
Simon Morgan
Shawn Nelson
Don Raymond
Nancy Read
Mike Reynolds
John Rogers
Brad Roman
Joe Sapletal
Shelly Sentryz
Mark Sloan
Steve Swazee
Mark Volz
Carol Wickenheiser
Marc Williams
Chet Wilberg
Brenda Zachman

Appendix C: Maps

Field Map Product List

Initial creation	Map product	Paper size	Average file size	Orientation	Map scale	Short description
3/27/09	Town_Maps/11x17	11x17	8 Mb	Landscape	varies by town	2008 FSA photo background, general map of MN towns in Red River Basin inlcuding transportation, hydro, boundaries, USNG
3/27/09	Town_Maps/42x48	42x48	3 Mb	Landscape	1:3,000, 1:7,500, and 1:12,000 depending on town size	2008 FSA photo background, general map of MN towns in Red River Basin inlcuding transportation, hydro, boundaries, USNG
3/23/09	RedRiverIndex.pdf	8x11	0.1 Mb	Portrait	1:500,000	Overview of entire basin with USNG
3/23/09	1k	8x11	1 Mb	Portrait	1:6,000	2008 FSA, USNG
3/23/09	10k/Floodplain	22x24	30 Mb	Portrait	1:24,000	Clay County Floodplain, 2008 FSA photo background, USNG
3/25/09	10k	22x24	0.5 Mb	Portrait	1:24,000	2008 FSA photo background, USNG
3/27/09	SmallScaleMaps/50k	34x48	3 Mb	Portrait	1:50,000	2008 FSA photo background, USNG, MnDOT roads
3/28/09	10k	22x24	0.5 Mb	Portrait	1:24,000	roads, USNG, 1997 flood area, 41-43' flood prediction area
3/28/09	100k/A-size	8x11	0.3 Mb	Portrait	1:600,000	1997 Flood, USNG
3/28/09	100k/E-size_150k_scale	34x48	1.5 Mb	Portrait	1:150,000	USNG, 1997 flood area, 41-43' flood prediction area, roads, lines only
3/28/09	100k/E-size_150k_scale	34x48	2 Mb	Portrait	1:50,000	USNG, levees and sandbags, 1997 flood area, 41-43' flood prediction area
3/28/09	100k/E-size_150k_scale	34x48	1.9 Mb	Portrait	1:24,000	USNG, levees and sandbags, 1997 flood area, 41-43' flood prediction area
3/28/09	100k/E-size_150k_scale	34x48	1.5 Mb	Portrait	1:12,000	USNG, levees and sandbags, 1997 flood area, 41-43' flood prediction area
3/31/09	1k/A-size	8x11	1.5 Mb	Portrait	1:6,000	Damage Report Maps for Breckenridge, East Grand Forks, Moorhead, and Oslo
3/30/09	City	24x34	0.4	Landscape	varies	MnDOT city highway maps
3/30/09	County	24x34	1.5 Mb	Landscape	1:80,000	MnDOT county highway maps
4/02/09	County	8x11	0.4 Mb	Portrait	1:40,000	MnDOT county road closure maps

1000-m GRID, US NATIONAL GRID
NORTH AMERICAN DATUM 1983
GRID ZONE DESIGNATION 14T
100,000-m SQUARE IDENTIFICATION: PT

U.S. National Grid
100000m Square ID
PT
Grid Zone Designator
14T

Scale: 1 inch = 250 feet (print size 8.5"x11")

Feet: 0, 100, 200, 300, 400, 500

Meters: 0, 100, 200

PREPARED BY: BEN OCCHIPO, MARCH 20, 2008 1200 HRS
CORRECTIONS AND ADDITIONS SHOULD BE BROUGHT TO THE ATTENTION OF CLAY COUNTY GIS
PHONE: (218) - 299 - 5000 GIS@co.clay.mn.us
This map was created using the FGDC Standard for the U.S. National Grid
FGDC-STD-011-2001

For additional information
see http://www.fgdc.gov/usng

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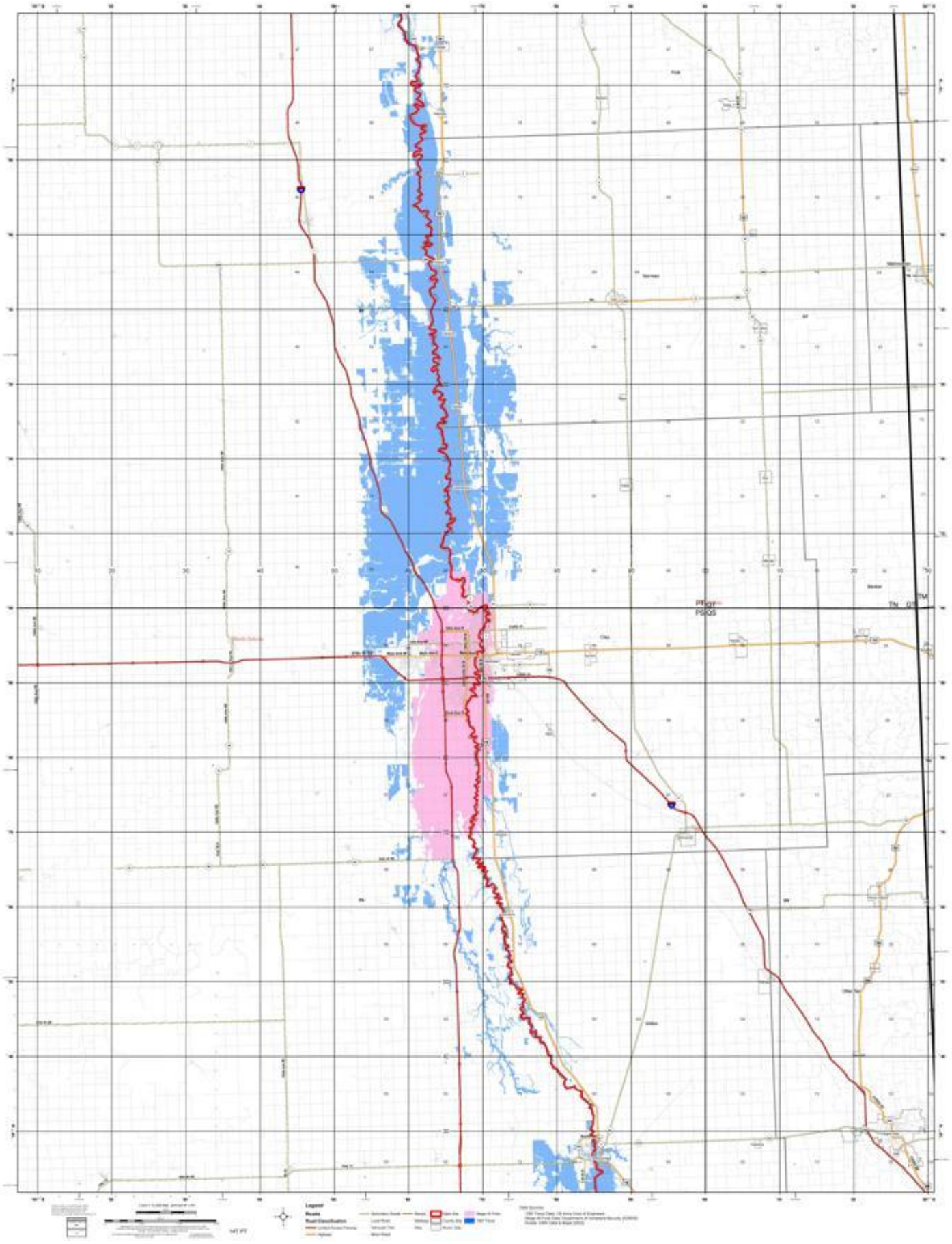
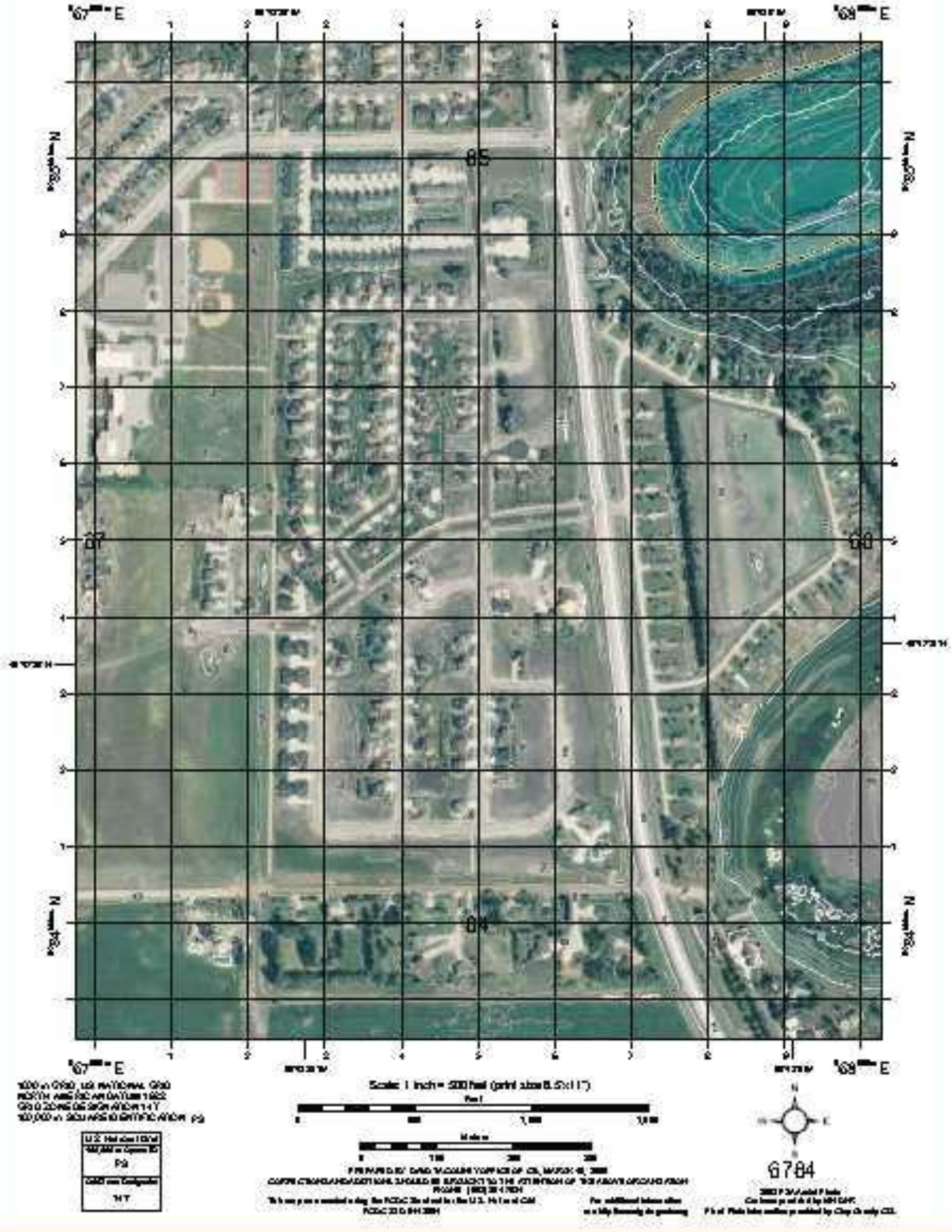
COMMAND POST - WARD1

2005 FSA Aerial Photo
Contours provided by MN DNR
Flood Plain information provided by Clay County GIS

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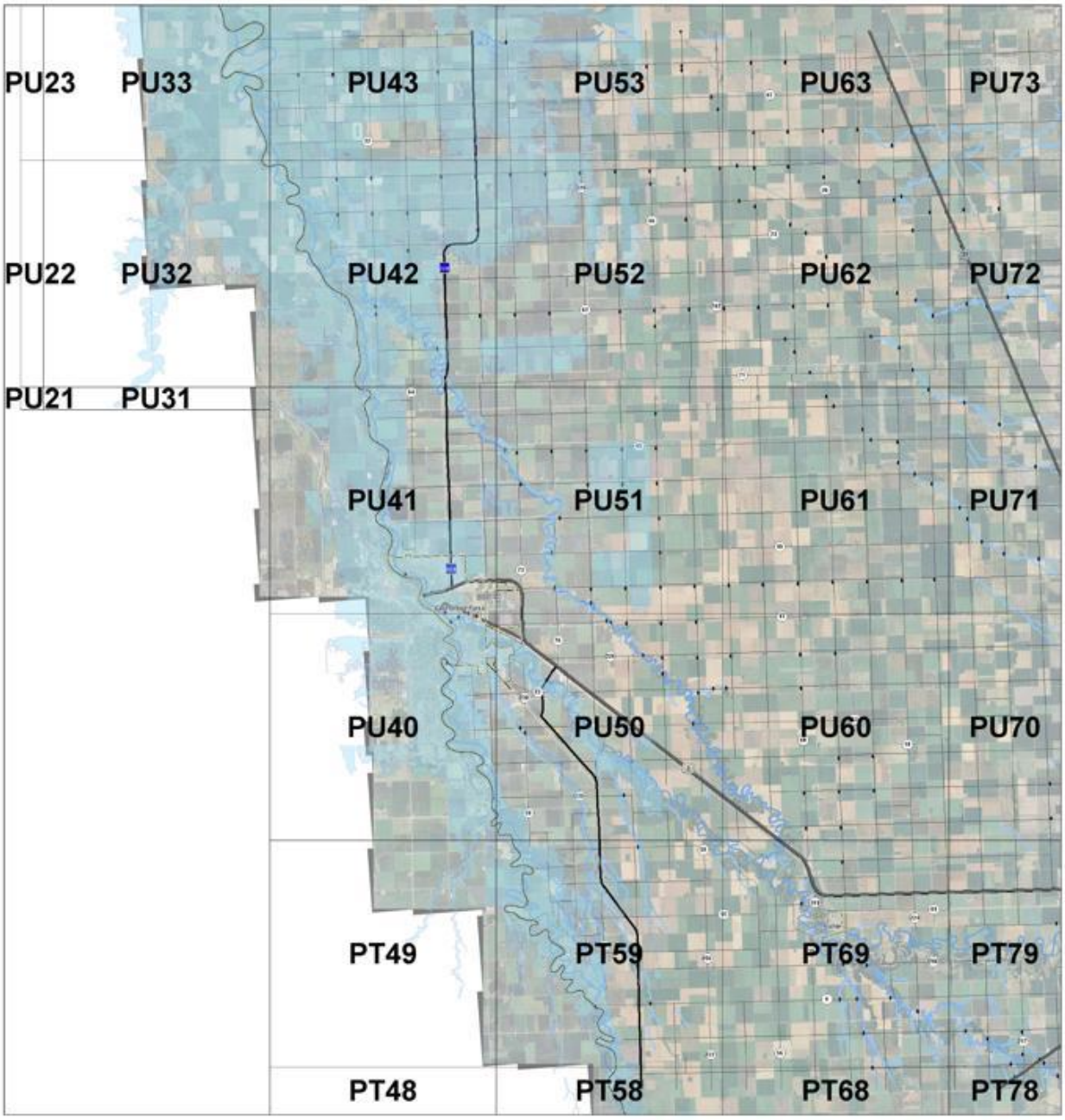
6784

RED RIVER REPSONE



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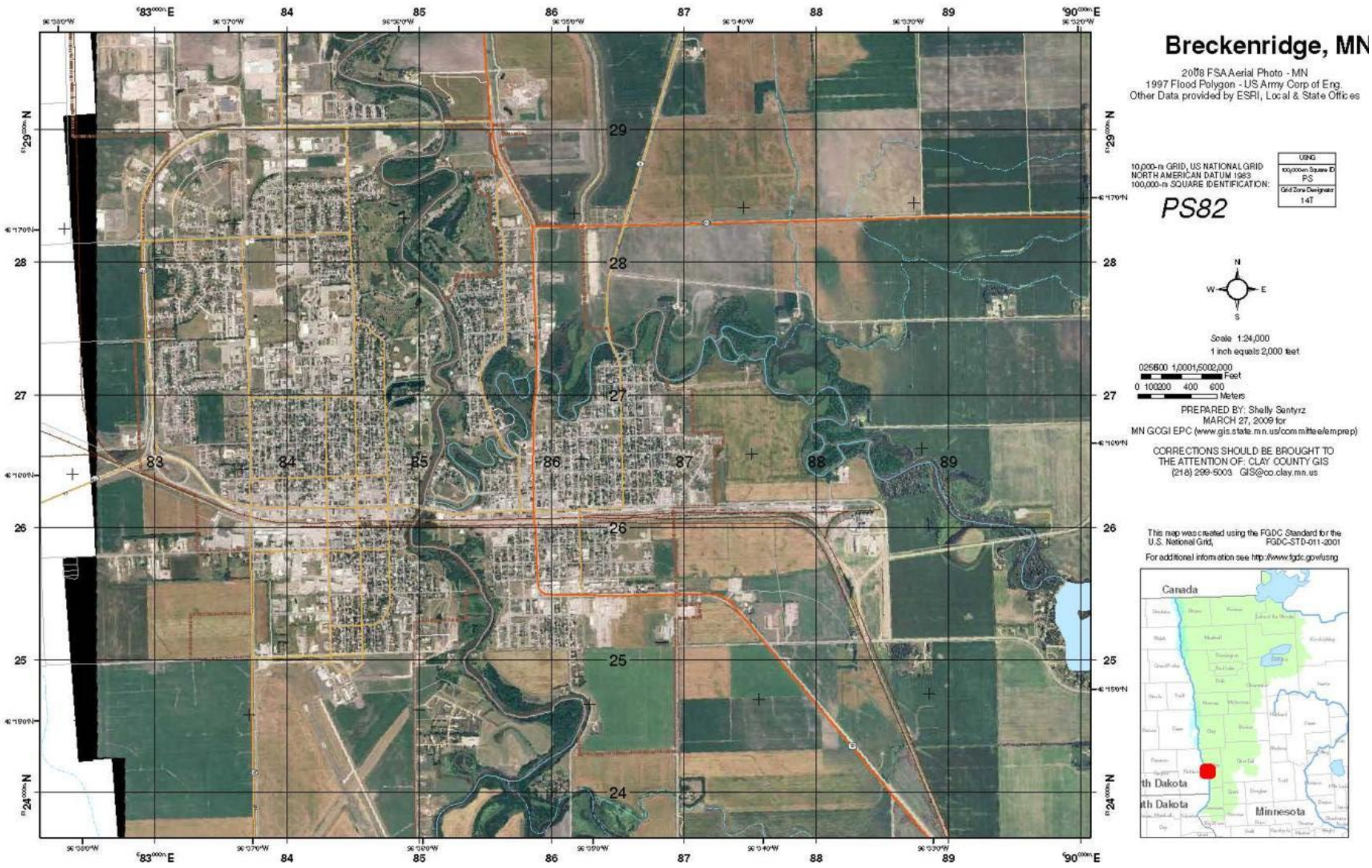
PREPARED BY: MN GCGI EPC (http://www.gis.state.mn.us/committee/emprep).
CORRECTIONS AND ADDITIONS SHOULD BE BROUGHT TO THE ATTENTION OF CLAY COUNTY GIS
PHONE : (218) 299-5003 or EMAIL : GIS@co.clay.mn.us

RED_RIVER_RESPONSE_V1

2008 FSA Aerial Photo
Contours provided by MN DNR
Flood Plain information provided by Clay County GIS

This map was created using the FGDC Standard for the U.S. National Grid
FGDC-STD-011-2001

For additional information
see http://www.fgdc.gov/usng


Breckenridge, MN
2008 FSA Aerial Photo - MN
1997 Flood Polygon - US Army Corp of Eng.
Other Data provided by ESRI, Local & State Offices
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NORTH AMERICAN DATUM 1983
100,000-m SQUARE IDENTIFICATION:
PS82
USNG
100,000m Square ID
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Grid Zone Designator
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Scale 1:24,000
1 inch equals 2,000 feet
0 2,500 5,000 10,000 Feet
0 1,000 2,000 3,000 Meters
PREPARED BY: Shelly Sentyrz
MARCH 27, 2009 for
MN GCGI EPC (www.gis.state.mn.us/committee/emprep)
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THE ATTENTION OF: CLAY COUNTY GIS
(218) 299-5003 GIS@co.clay.mn.us
This map was created using the FGDC Standard for the U.S. National Grid, FGDC-STD-011-2001
For additional information see http://www.fgdc.gov/usng
Canada
Minnesota
83
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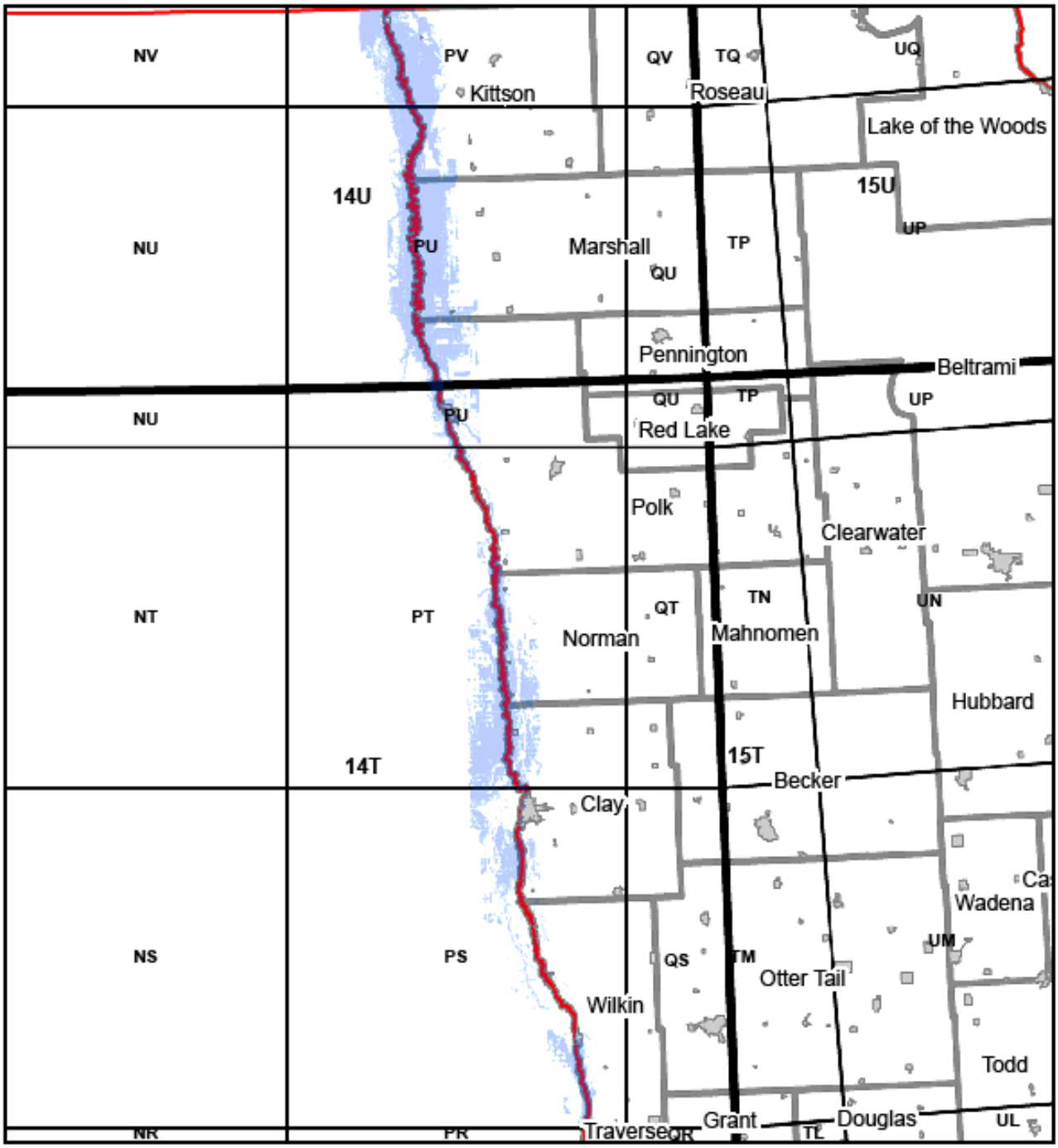
29

USNG Map Samples



Legend

- 1997 Flood
- Munic. Bdy.
- County Bdy.

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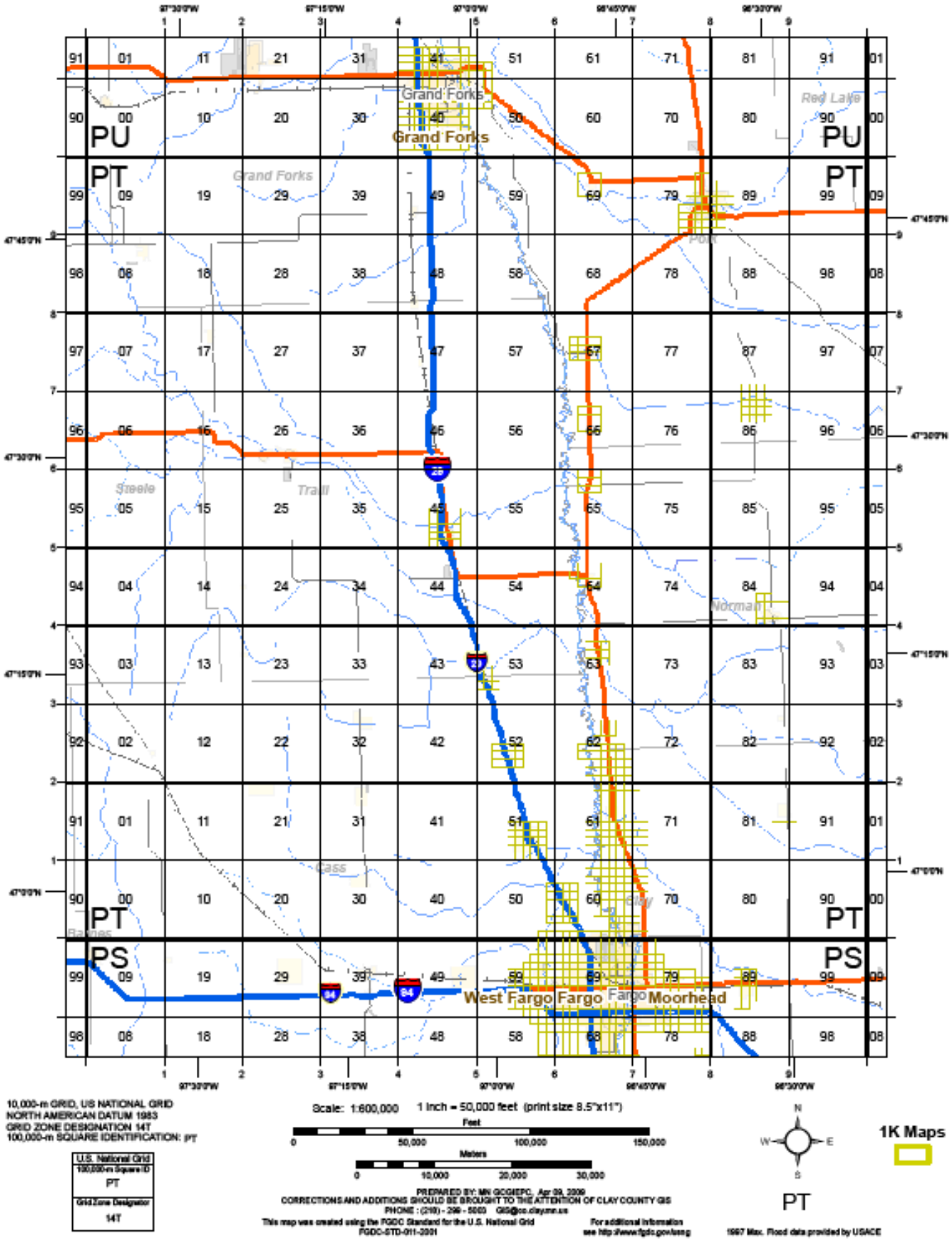
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Scale: 1:600,000
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Grid Zone Designator
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PREPARED BY: MN GIC/EPC, Apr 09, 2009
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PHONE : (218) - 299 - 5003 GIS@co.clay.mn.us
This map was created using the FGDC Standard for the U.S. National Grid
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For additional information
see http://www.fgdc.gov/usng
1997 Max. Flood data provided by USACE
1K Maps
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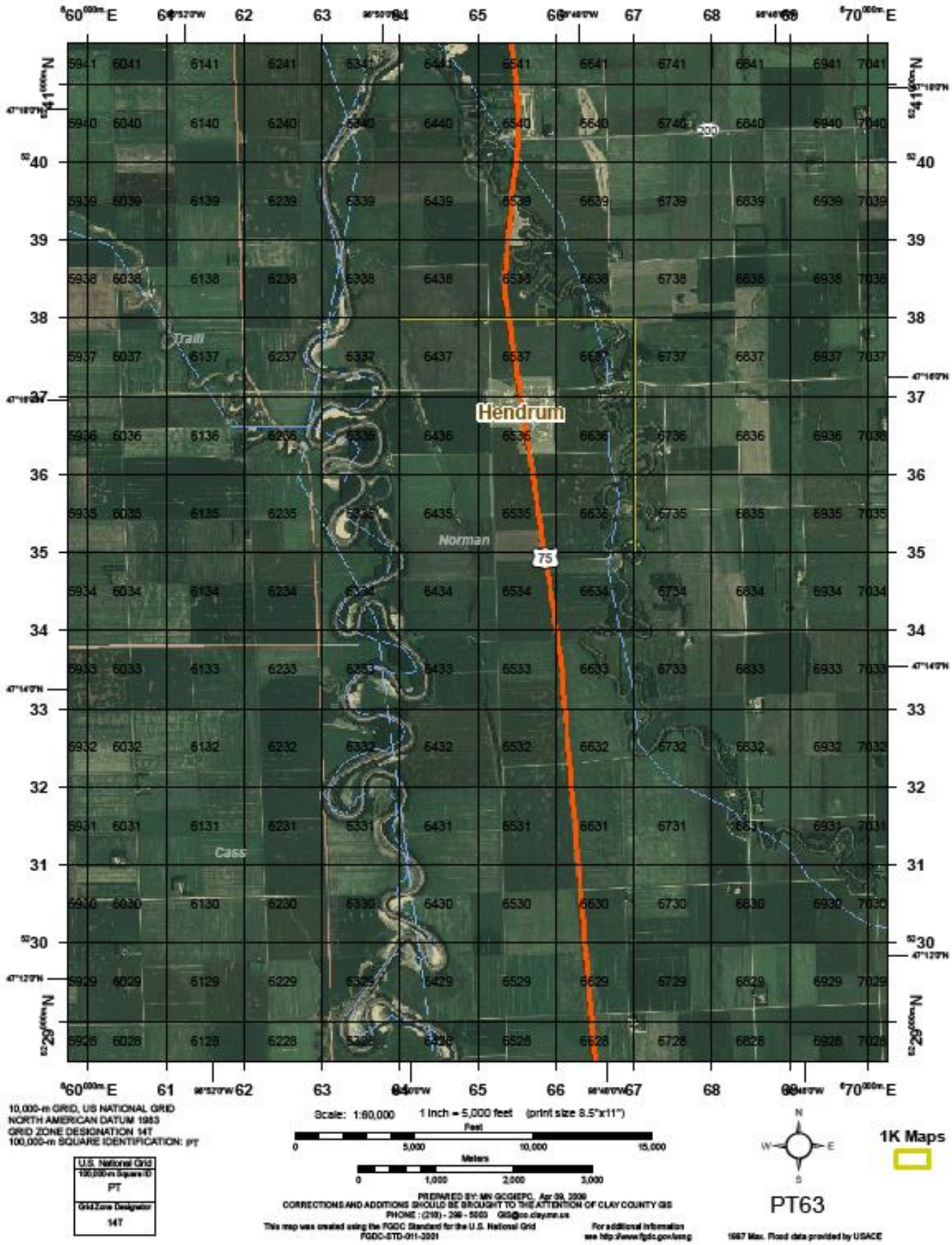
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PT63
PREPARED BY: MN GC/GIEPC, Apr 09, 2009
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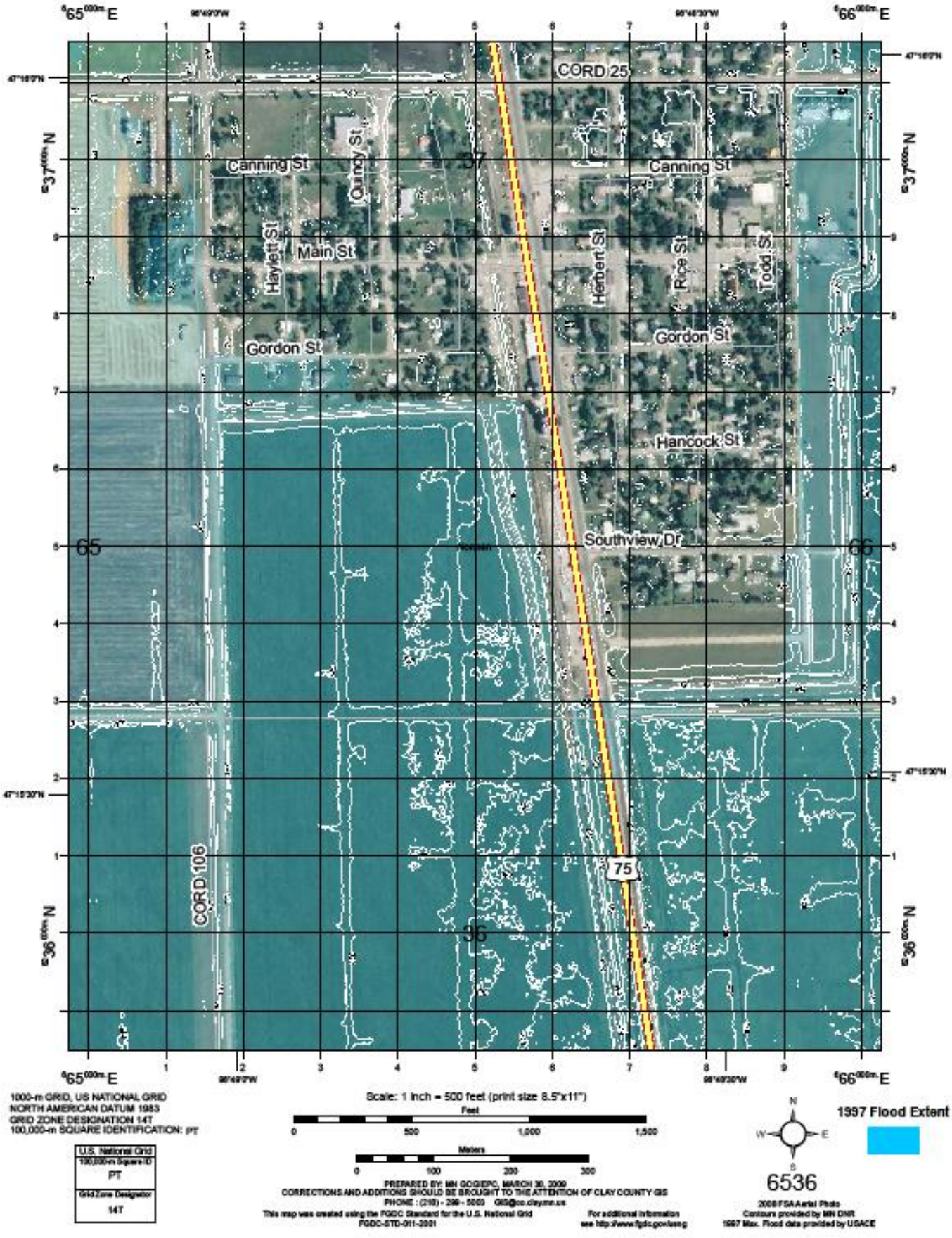
This map was created using the FGDC Standard for the U.S. National Grid
FGDC-STD-011-2001
For additional information
see http://www.fgdc.gov/usng
1997 Max. Flood data provided by USACE


CORD 25
Canning St
Quincy St
Hayett St
Main St
Herbert St
Rice St
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Gordon St
Hancock St
Southview Dr
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NORTH AMERICAN DATUM 1983
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1997 Flood Extent
6536
PREPARED BY: MN GCGIEPC, MARCH 30, 2009
CORRECTIONS AND ADDITIONS SHOULD BE BROUGHT TO THE ATTENTION OF CLAY COUNTY GIS
PHONE : (218) - 299 - 5003 GIS@co.clay.mn.us
This map was created using the FGDC Standard for the U.S. National Grid
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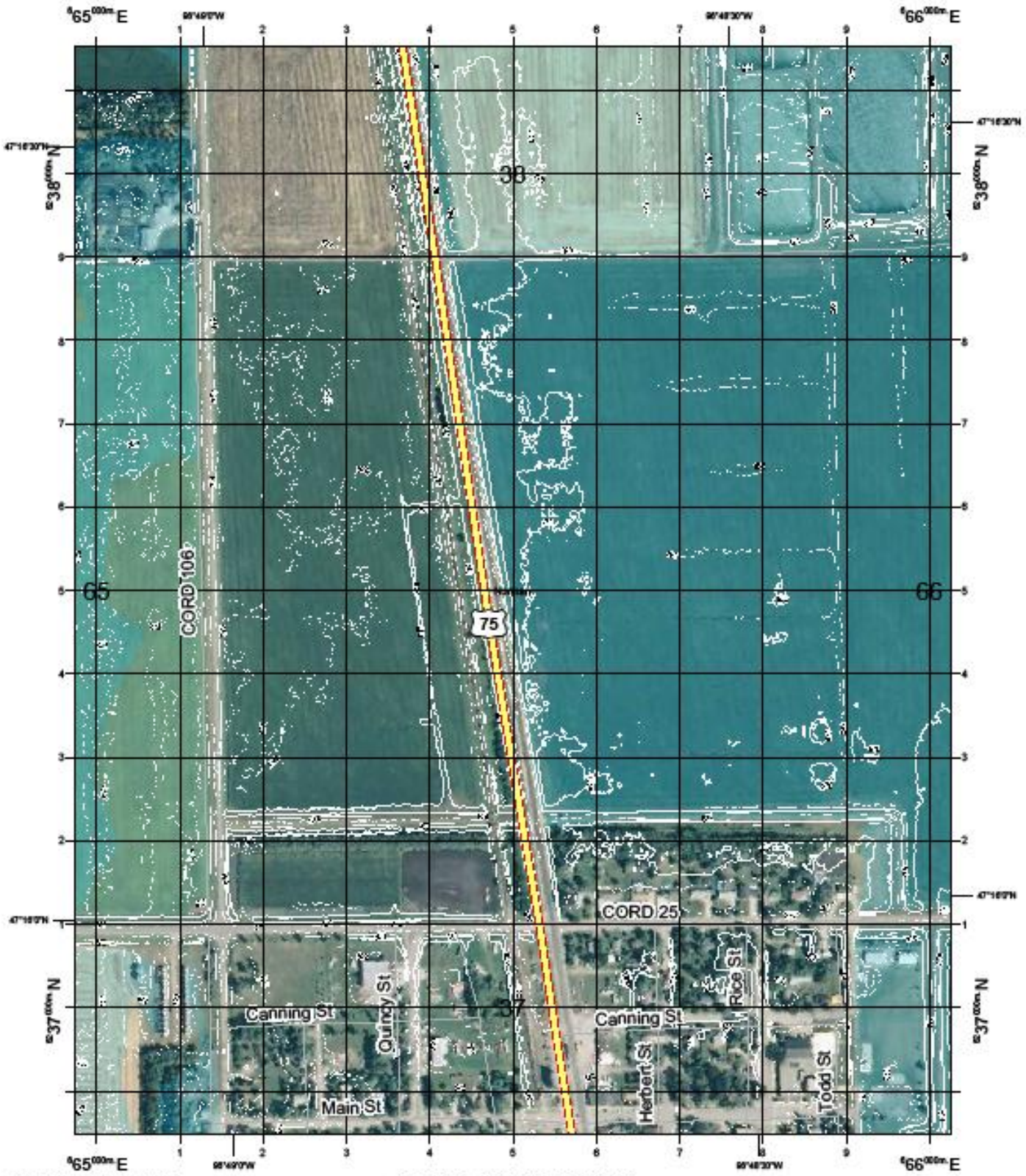
For additional information
see http://www.fgdc.gov/usng
2008 FSA Aerial Photo
Contours provided by MN DNR
1997 Max. Flood data provided by USACE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1000-m GRID, US NATIONAL GRID
NORTH AMERICAN DATUM 1983
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U.S. National Grid
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Grid Zone Designator
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PREPARED BY: MN GCG/EPC, MARCH 30, 2009
CORRECTIONS AND ADDITIONS SHOULD BE BROUGHT TO THE ATTENTION OF CLAY COUNTY GIS
PHONE : (218) - 299 - 5003 GIS@co.clay.mn.us
This map was created using the FGDC Standard for the U.S. National Grid
FGDC-STD-011-2001
For additional information
see http://www.fgdc.gov/usng
N
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1997 Flood Extent
6537
2008 FSA Aerial Photo
Contours provided by MN DNR
1997 Max. Flood data provided by USACE

Mn/DOT Road Closure Map Sample