Combining precipitation and surface runoff using NEXRAD and USGS streamflow.

2015 ESRI International User Conference

by Marlio Lesmez, Ph.D., P.E.
Michigan Department of Environmental Quality
Water Resources Division
Hydrologic Studies and Dam Safety Unit

Department of Environmental Quality

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- Macomb County awarded $1 million brownfield loan
- Science advisory panel to hear public input June 25 on net-pen aquaculture in Great Lakes
- New water quality testing to begin at Michigan beaches
- DEQ announces 30-year vision for water
- DEQ looking for local partners to help educate boaters about invasive species
- DEQ, Great Lakes Commission award stream monitoring grants
- DEQ awards 10 water quality grants

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Great Lakes
Groundwater Discharge
Groundwater Modeling

WATER

The DEQ ensures Michigan's water resources remain clean and abundant by establishing water quality standards, overseeing public water supplies, regulating the discharge of industrial and municipal wastewaters, monitoring water quality and the health of aquatic communities, developing policy, and fostering stewardship. Water-related program staff provide for the protection, restoration and conservation of Michigan's Great Lakes, inland lakes and streams, wetlands, and groundwater.

- Michigan's Water Strategy
- Water Quality News and Announcements
- Michigan Surface Water Programs

Quicklinks

- Clean Water Revolving Fund - SRF, SWQIF, SAW
- Groundwater Discharge
- MDEQ/USACE Joint Permit Application
- MiWaters Information
- Part 5 Rules: Spillage of Oil/Polluting Materials
- Total Maximum Daily Load (TMDL) Assessments
- Water Resources Division Enforcement
- Water Use Program
- Water Withdrawal Assessment Tool

Great Lakes | Drinking Water | Lakes & Streams | Wastewater | Wetlands | Permits

Michigan's Great Lakes

- Michigan's Great Lakes

  The Great Lakes are known for their beauty and the wealth of resources within and around them. The combined lakes contain one-fifth of the

+ Explore the Lakes
+ Protection and Restoration
+ Coastal Resources &

Hydrologic Data Collection & Analysis

The Hydrologic Studies Program of the Water Resources Division calculates flood and low flow discharges and conducts other types of hydrologic analyses in support of the department's water-related programs.

This page can be accessed as www.mi.gov/hydrology.

Information

- Presentations from the 2006 MSFA Conference
- Introduction to Hydrology
- The Hydrologic Cycle
- Glossary
- Michigan's Major Watersheds
- Frequently Asked Questions - Hydrologic Studies
- Relevant Laws and Rules
- Drought Flow Fact Sheet
- NFIP Flood Insurance Study Updates
- Storm Water Management Guidebook, with other Newsletters and Guidebooks
- Nonpoint Source Hydrologic Analysis
- Miscellaneous Discharge Measurements

Reports

- Computing Flood Discharges for Small Ungaged Watersheds

Online Services

- Request a Flood or Low Flow Discharge Form

Quick Links
- Contact Information for Hydrologic Data Collection & Analysis
- Current river stages

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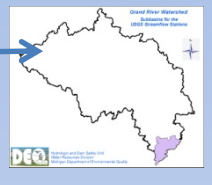
Problem: Provide precipitation distribution and surface runoff for the analysis of flood flows.

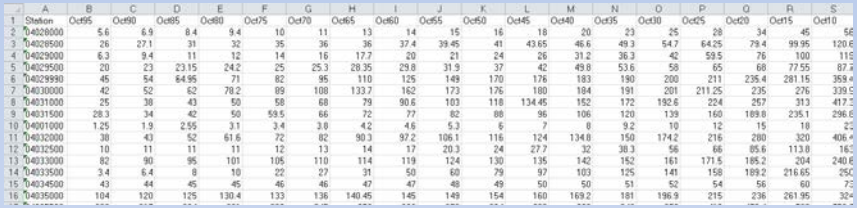
Solution: Develop a combined Access and ArcMap application to generate and visually see the storm event and the resulting surface runoff.

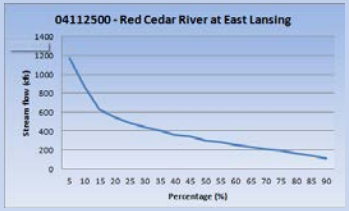
Spatial and Tabular Elements needed

1. Shapes – Point & Polygons ⟷ Precipitation Stations, Watersheds - Basins



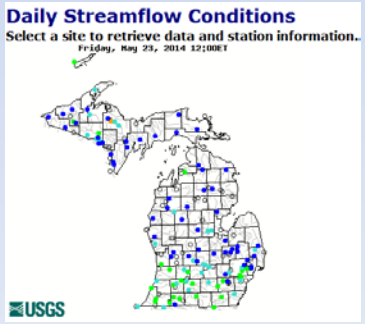
2. Historical Data ⟷ Data Base, Spread Sheet – Exceedance or flood frequency curves

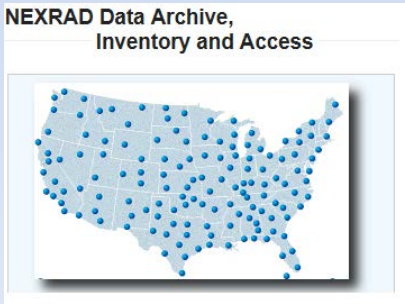




3. Data ⟷ Stream flow data: Real Time/ 15/30 minutes daily/monthly/yearly

NOAA COOP Stations 5 minutes/hourly/ daily
NEXRAD 16/256

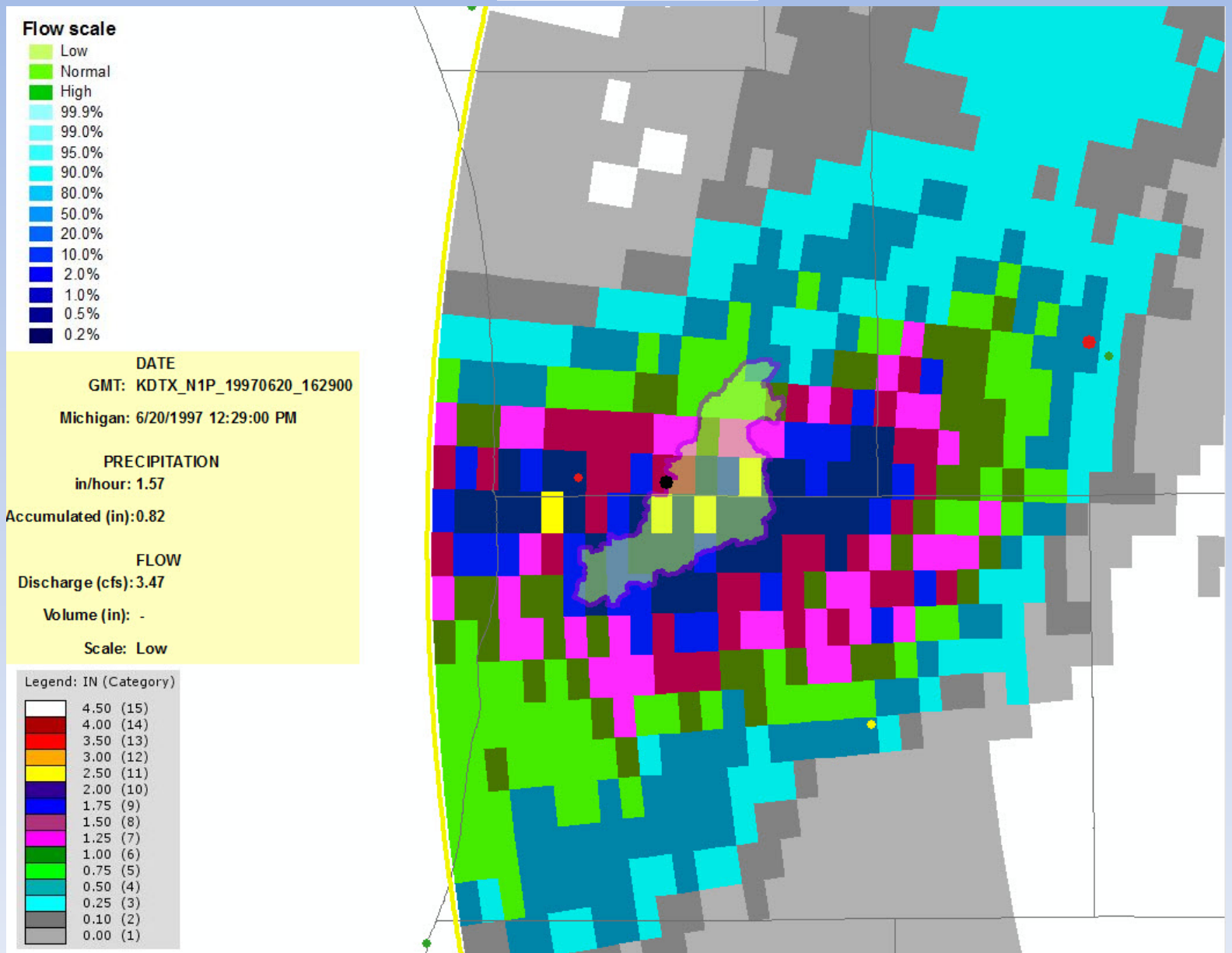




Date	Discharge	Code
2012.08.01	32	
2012.08.02	30	
2012.08.03	28	
2012.08.04	26	
2012.08.05	25	
2012.08.06	23	
2012.08.07	22	
2012.08.08	20	
2012.08.09	25	
2012.08.10	56	
2012.08.11	67	

COOP	WBAN	GHCND	STAtion_name	Time_Collec	rDATE	rVALUE
202392	99999		EAST LANSING 1	99	4/1/1863	0
202392	99999		EAST LANSING 1	99	4/2/1863	0
202392	99999		EAST LANSING 1	99	4/3/1863	0
202392	99999		EAST LANSING 1	99	4/4/1863	0
202392	99999		EAST LANSING 1	99	4/5/1863	0
202392	99999		EAST LANSING 1	99	4/6/1863	0.12
202392	99999		EAST LANSING 1	99	4/7/1863	0
202392	99999		EAST LANSING 1	99	4/8/1863	0
202392	99999		EAST LANSING 1	99	4/9/1863	0
202392	99999		EAST LANSING 1	99	4/10/1863	0
202392	99999		EAST LANSING 1	99	4/11/1863	0.28
202392	99999		EAST LANSING 1	99	4/12/1863	0
202392	99999		EAST LANSING 1	99	4/13/1863	0
202392	99999		EAST LANSING 1	99	4/14/1863	0
202392	99999		EAST LANSING 1	99	4/15/1863	0
202392	99999		EAST LANSING 1	99	4/16/1863	0
202392	99999		EAST LANSING 1	99	4/17/1863	0
202392	99999		EAST LANSING 1	99	4/18/1863	0

Result


Flow scale
Low
Normal
High
99.9%
99.0%
95.0%
90.0%
80.0%
50.0%
20.0%
10.0%
2.0%
1.0%
0.5%
0.2%
DATE
GMT: KDTX_N1P_19970620_162900
Michigan: 6/20/1997 12:29:00 PM
PRECIPITATION
in/hour: 1.57
Accumulated (in): 0.82
FLOW
Discharge (cfs): 3.47
Volume (in): -
Scale: Low
Legend: IN (Category)
4.50 (15)
4.00 (14)
3.50 (13)
3.00 (12)
2.50 (11)
2.00 (10)
1.75 (9)
1.50 (8)
1.25 (7)
1.00 (6)
0.75 (5)
0.50 (4)
0.25 (3)
0.10 (2)
0.00 (1)

Spatial and Tabular Elements needed

1. Shapes – Points and Polygons that represent weather stations and watersheds or basins

What is a Watershed?
A watershed is the area of land where all of the water that is under it or drains off of it or goes into the same place.

http://water.epa.gov/type/watersheds/whatis.cfm

Water Resources Division
Michigan's Major Watersheds
Lake Superior
Watersheds
N
0 20 40 Miles
14 Grand
14A Red Cedar
14B Looking Glass
14C Maple
14D Thornapple
14E Flat
14F Rogue
Newaygo
Mecosta
Isabella
Midland
Oceana
Muskegon
Montcalm
Gratiot
Saginaw
Ottawa
Kent
Ionia
Clinton
Shiawassee
Allegan
Barry
Eaton
Ingham
Calhoun
Jackson
Van Buren
Kalamazoo
Berrien
Cass
St. Joseph
Branch
Hillsdale
Lenawee
www.michigan.gov/hydrology

Spatial and Tabular Elements needed

2. Historical data that represent current or past conditions of the stream flow stations with respect to the period of record.

Exceedence Flows

"Exceedence" is a way to describe the percentage of time for which an observed stream-flow is greater than or equal to a defined stream-flow.

http://www.idwr.idaho.gov/waterboard/WaterPlanning/nezperce/exceedence_flows.htm

Spatial and Tabular Elements needed

Annual Exceedance Probability

The Annual Exceedance Probability is the chance or probability of a natural hazard event (usually a rainfall or flooding event) occurring annually and is usually expressed as a percentage. Bigger rainfall events occur (are exceeded) less often and will therefore have a lesser annual probability.

Example 1:
2% exceedance probability rainfall event: A 2% Annual Exceedance Probability rainfall event has a 2% chance of occurring in a year, so once in every 50 years.

Example 2:
20% exceedance probability rainfall event: A 20% Annual Exceedance Probability rainfall event has a 20% chance of occurring in a year, so once in every 5 years.

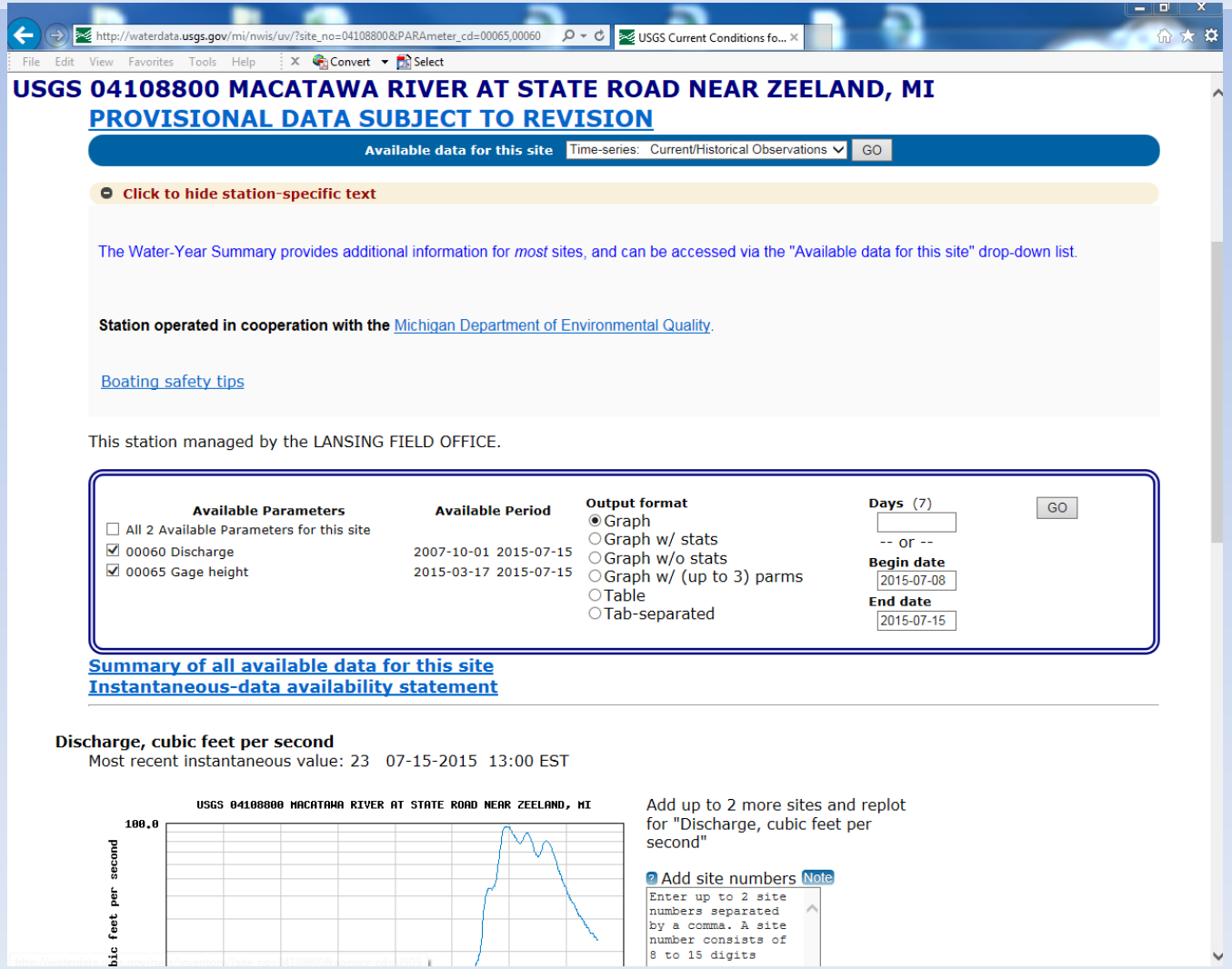
Table:

1% AEP = 1 in 100 year event Greater rainfall event
2% AEP = 1 in 50 year event
5% AEP = 1 in 20 year event
10% AEP = 1 in 10 year event
20% AEP = 1 in 5 year event
50% AEP = 1 in 2 year event
100% AEP = Happens every year Lesser rainfall event

Source: http://ecan.govt.nz/quick-answers/Pages/what-does-annual-exceedance-probability-or-aep-mean.aspx

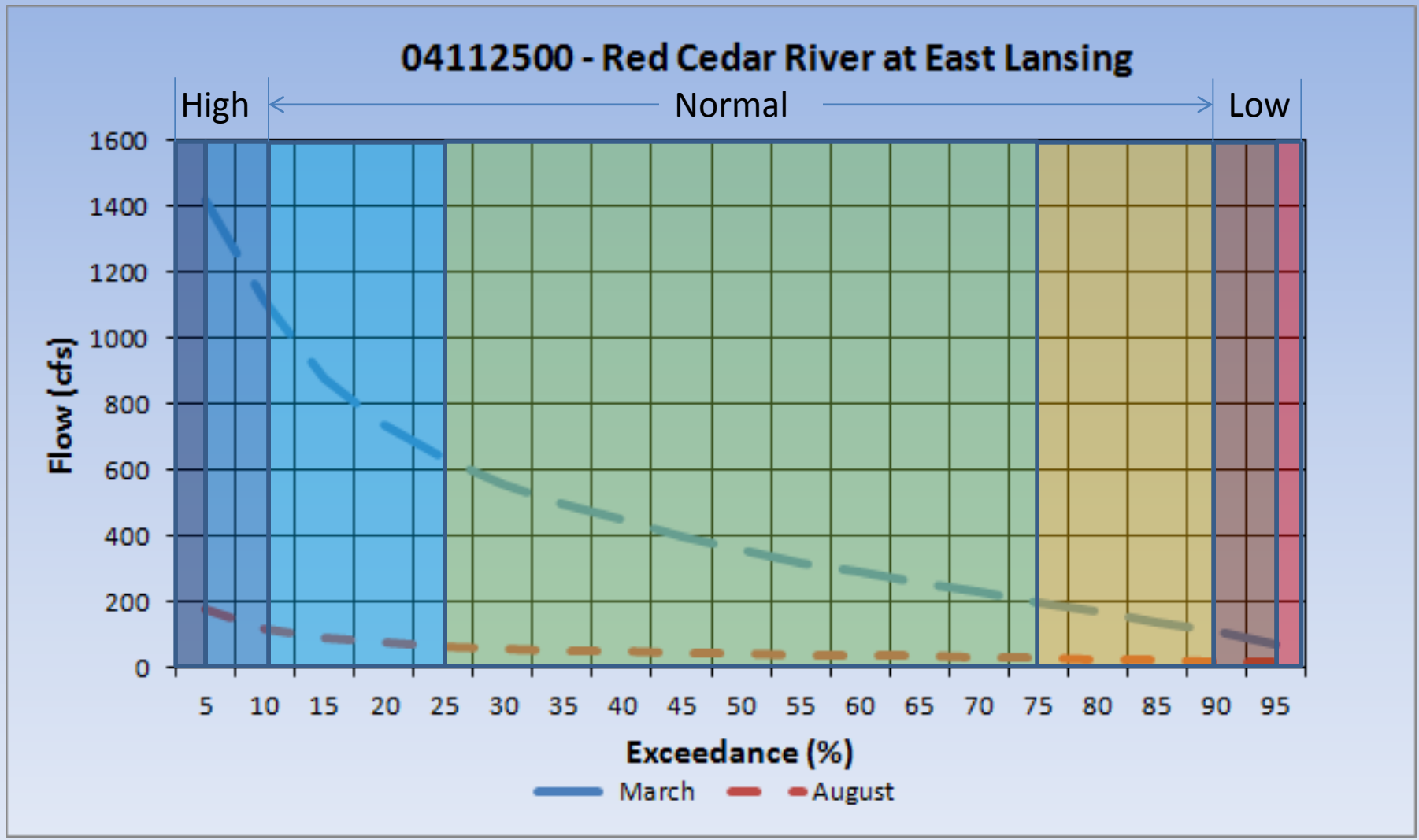
Spatial and Tabular Elements needed

Streamflows by USGS Instantaneous Data



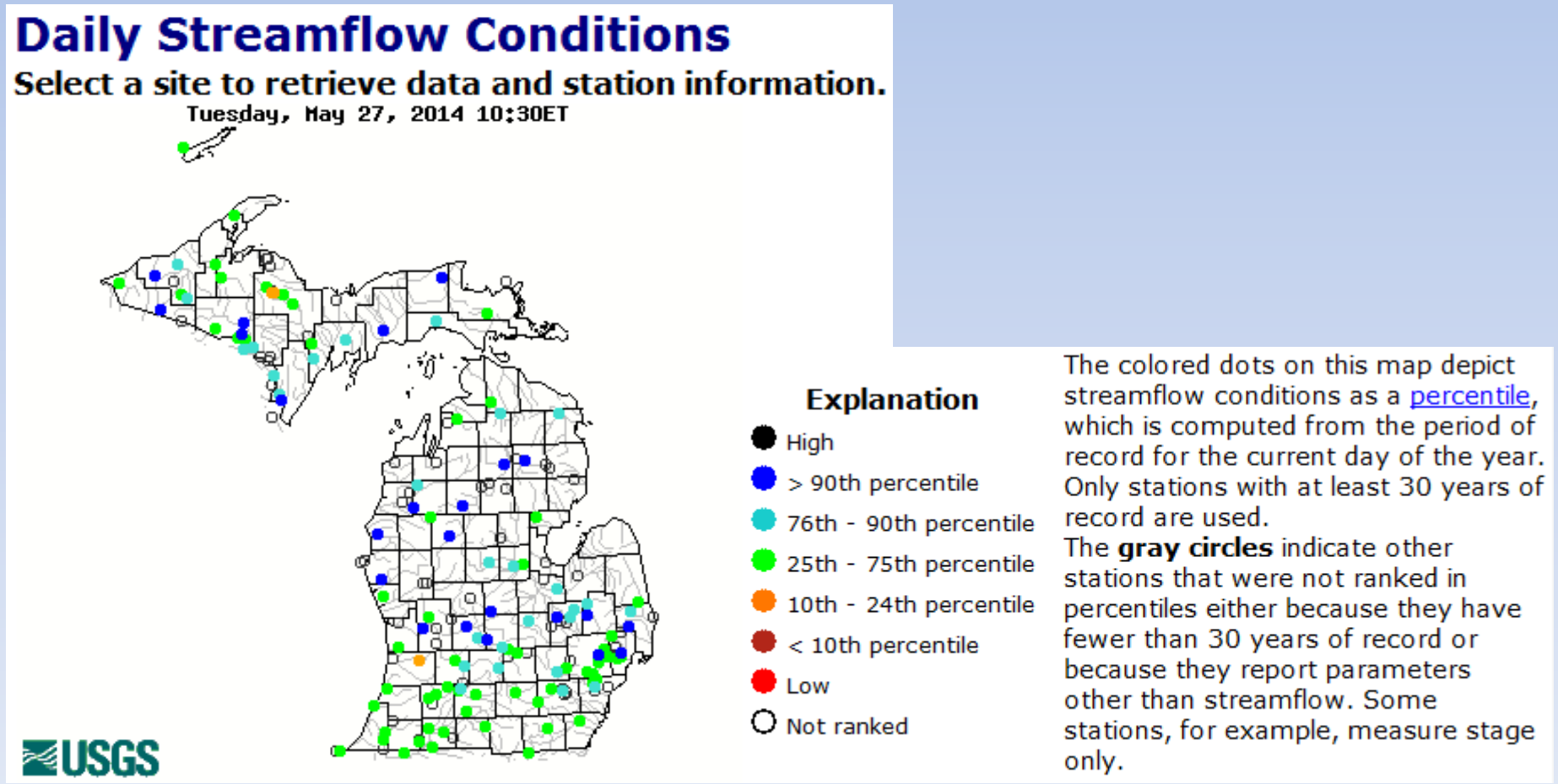
Spatial and Tabular Elements needed

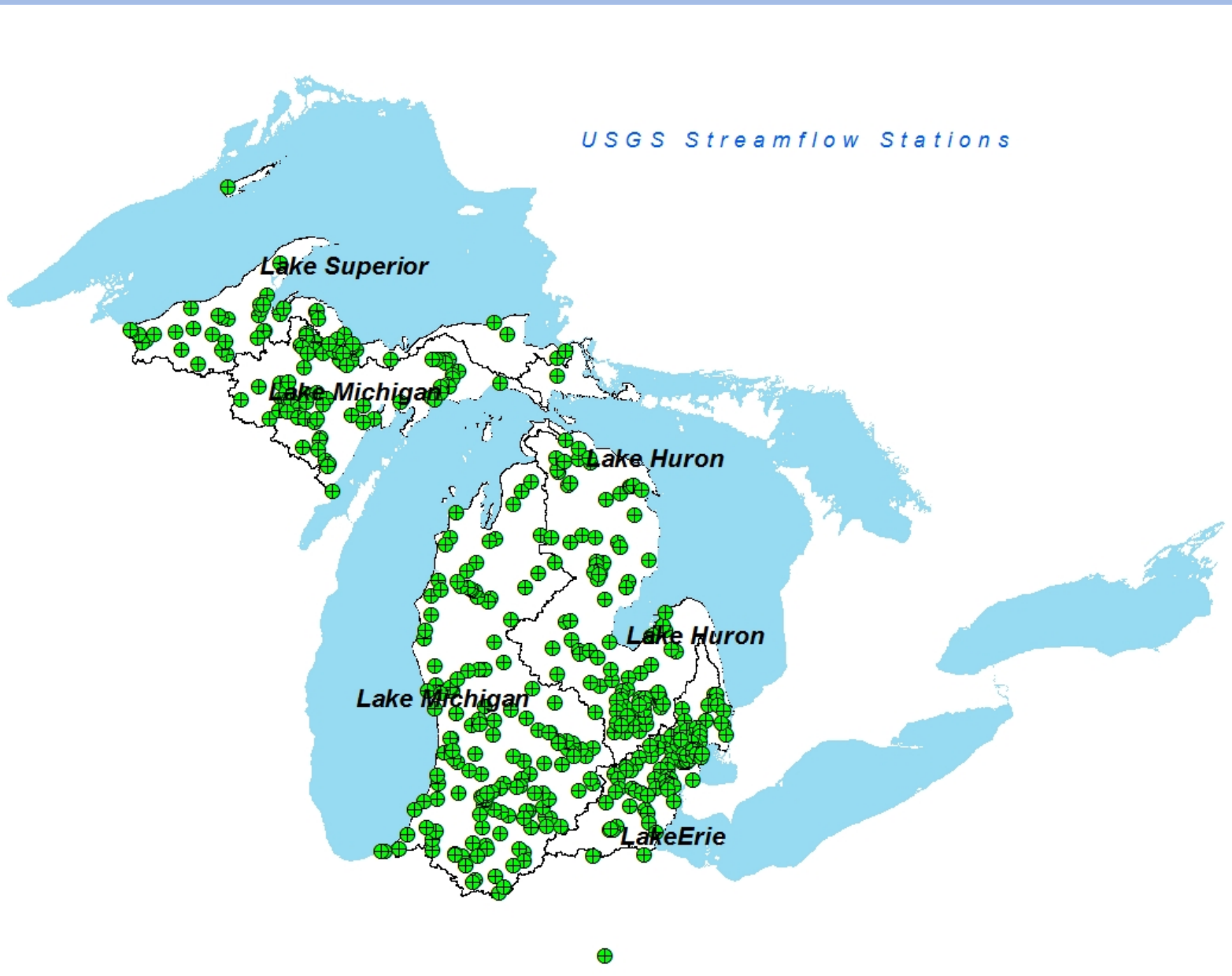
2. Historical data: Exceedance Curve



Spatial and Tabular Elements needed

3. Data - Stream flow data: Real time or instantaneous (15-30 minutes)/daily/monthly/yearly.




USGS Streamflow Stations
Lake Superior
Lake Michigan
Lake Huron
Lake Huron
Lake Michigan
LakeErie

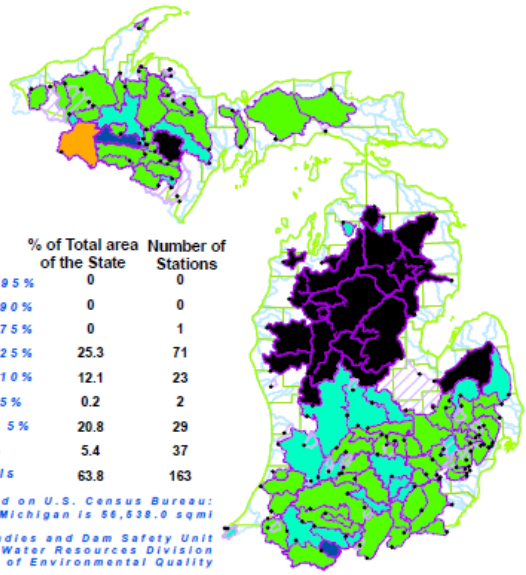
Exceedance Map

Flood Flow Map

Michigan's Current Streamflow Conditions based on USGS Real Time Stations

April, 16 2014 08 AM

"Exceedance" is a way to describe the percentage of time for which an observed streamflow is greater than or equal to a defined stream flow. For example, the 80% exceedance flow of a stream is 25 cubic feet per second (cfs) for the month of June. An 80% exceedance flow means that the median June flow will be equal to or greater than 25 cfs 8 days out of 10. Or 24 days in the month of June.



Classes		% of Total area of the State	Number of Stations
Low	below 95%	0	0
Much below normal	95% - 90%	0	0
Below normal	89% - 75%	0	1
Normal	74% - 25%	25.3	71
Above normal	24% - 10%	12.1	23
Much above normal	9% - 5%	0.2	2
High	above 5%	20.8	29
Station not operating	N/A	5.4	37
	Totals	63.8	163

Based on U.S. Census Bureau:
Total area of Michigan is 56,538.0 sqmi

Hydrologic Studies and Dam Safety Unit
Water Resources Division
Michigan Department of Environmental Quality

The streamflow conditions are normal for 25.3% of the State, or 14,304 square miles.

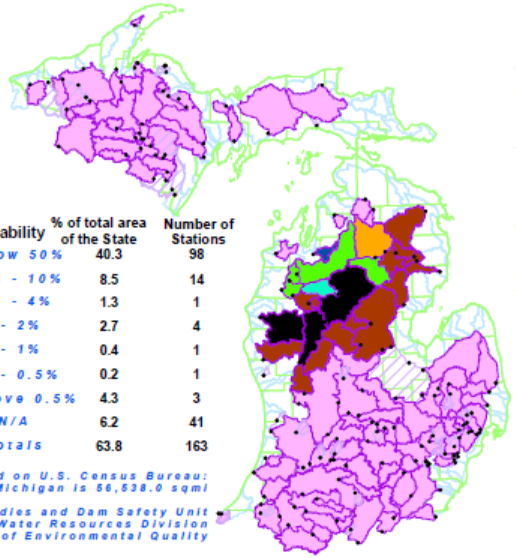
The USGS has 163 streamflow stations that cover 63.8% of the State, or 36,072 square miles.

These are streamflow conditions at the USGS stations. Streamflows may be different at other locations within the watersheds.

Michigan's Current flood flows based on USGS Real Time Stations

April, 16 2014 08 AM

The 2-year flood has a 1 in 2 chance of being equaled or exceeded in any one year. It has a 50-percent chance of occuring in any giving year. It has an average recurrence interval of 2 years.



Classes			% of total area of the State	Number of Stations
Years		Probability		
Below the 2-year		below 50%	40.3	98
Between the 2-year and 10-year		50% - 10%	8.5	14
Between the 10-year and 25-year		10% - 4%	1.3	1
Between the 25-year and 50-year		4% - 2%	2.7	4
Between the 50-year and 100-year		2% - 1%	0.4	1
Between the 100-year and 200-year		1% - 0.5%	0.2	1
Above the 200-year		above 0.5%	4.3	3
Station not operating		N/A	6.2	41
		Totals	63.8	163

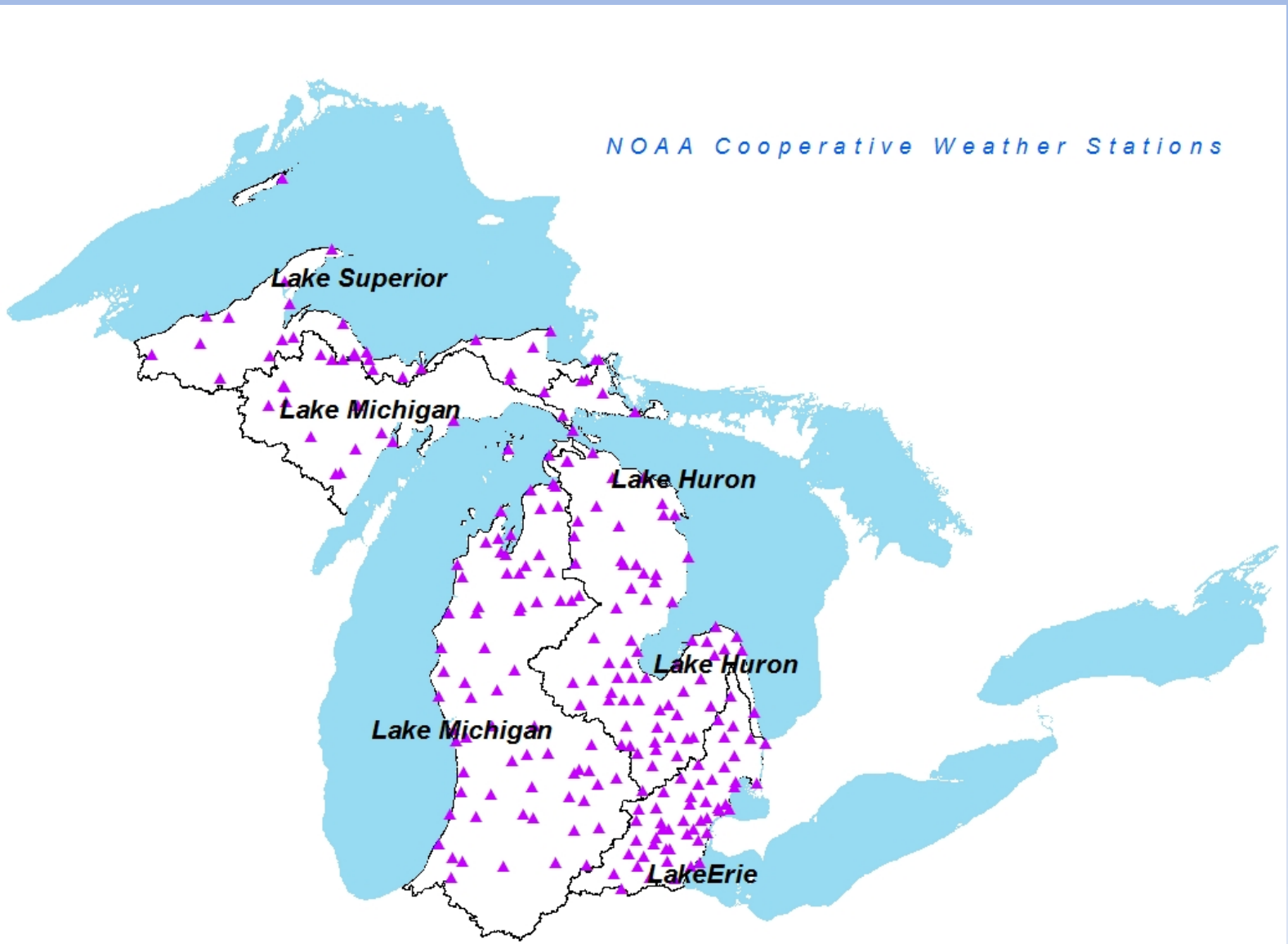
Based on U.S. Census Bureau:
Total area of Michigan is 56,538.0 sqmi

Hydrologic Studies and Dam Safety Unit
Water Resources Division
Michigan Department of Environmental Quality

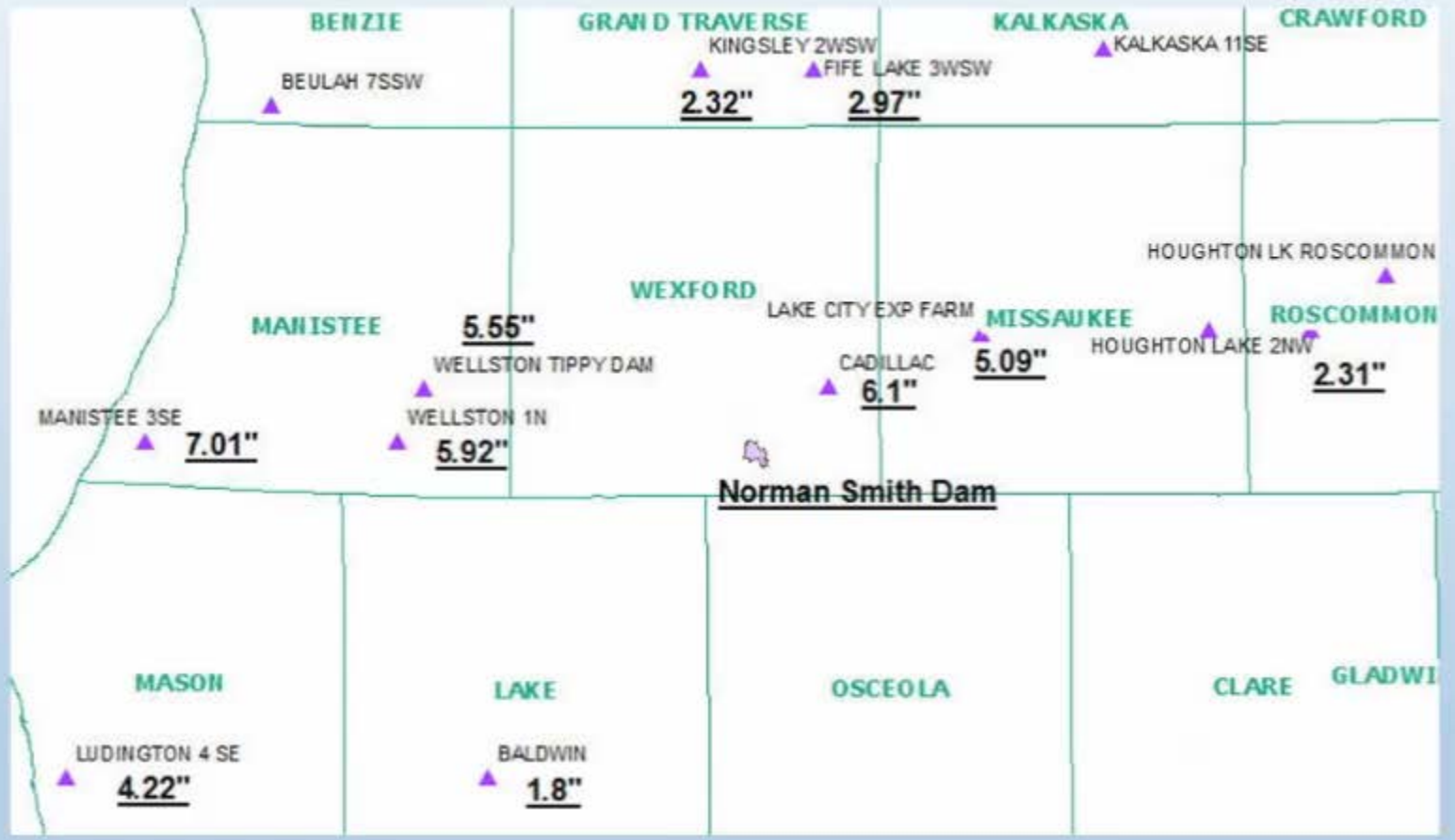
The streamflow conditions are below the 2-year for 40.3% of the State, or 22,785 square miles.

The USGS has 163 streamflow stations that cover 63.8% of the State, or 36,072 square miles.

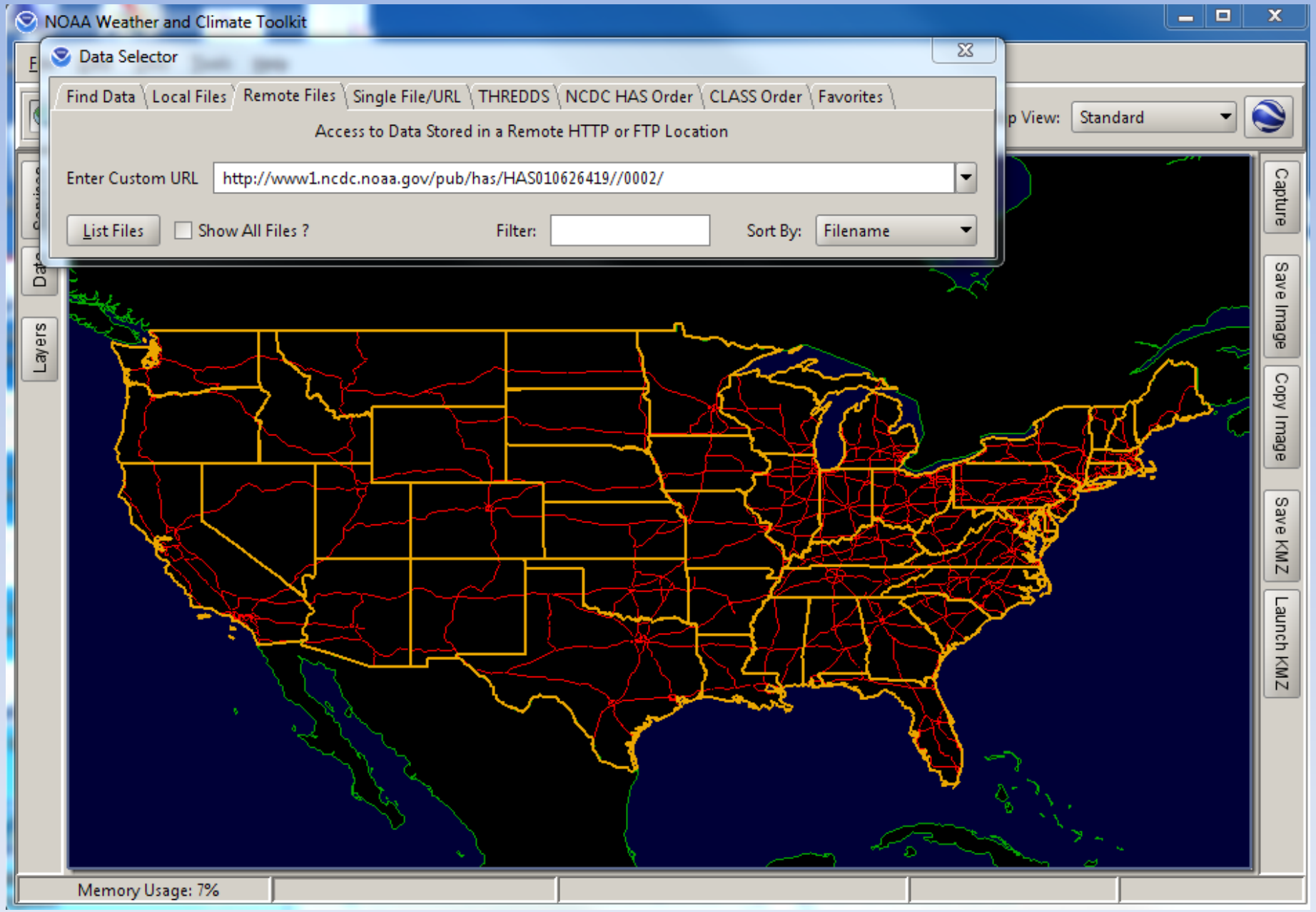
These are streamflow conditions at the USGS stations. Streamflows may be different at other locations within the watersheds.


NOAA Cooperative Weather Stations
Lake Superior
Lake Michigan
Lake Huron
Lake Huron
Lake Michigan
LakeErie

NOAA Weather Station Data for June 13, 2008



NEXRAD Images



NEXRAD Images

NOAA NATIONAL CLIMATIC DATA CENTER
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

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NCDC > Radar Data > NEXRAD Inventory

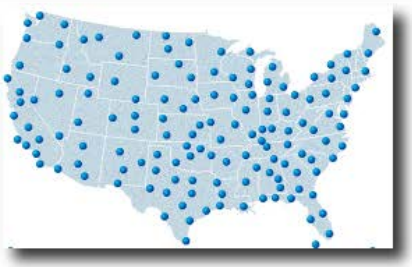
NEXRAD Archive Access

Data Access
- Home
- Select By Map
- Select By List
- Select By County, City, Zip Code (Climate Data Online)
- Historical Reflectivity and Coverage Maps
- Select By Archive File (Bulk Order)

Documentation
- Archive and Access Statistics
- Overview, History
- NEXRAD Product List
- Network Metadata
- Radar Operations Center

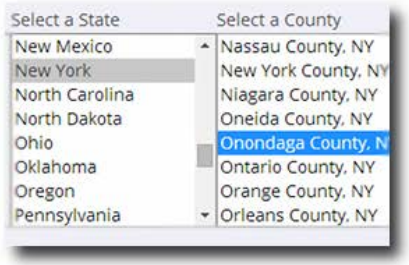
External Resources
- NOAA/NWS Current Radar
- NOAA Training (WDTB)

NEXRAD Data Archive, Inventory and Access



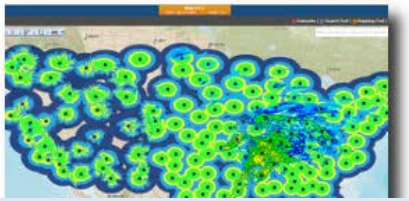
Select By Map
(Single Site and Day)

Select By Site List
(WSR-88D and TDWR sites)



Select by County, City, Zip Code
(Multiple Sites and Days)

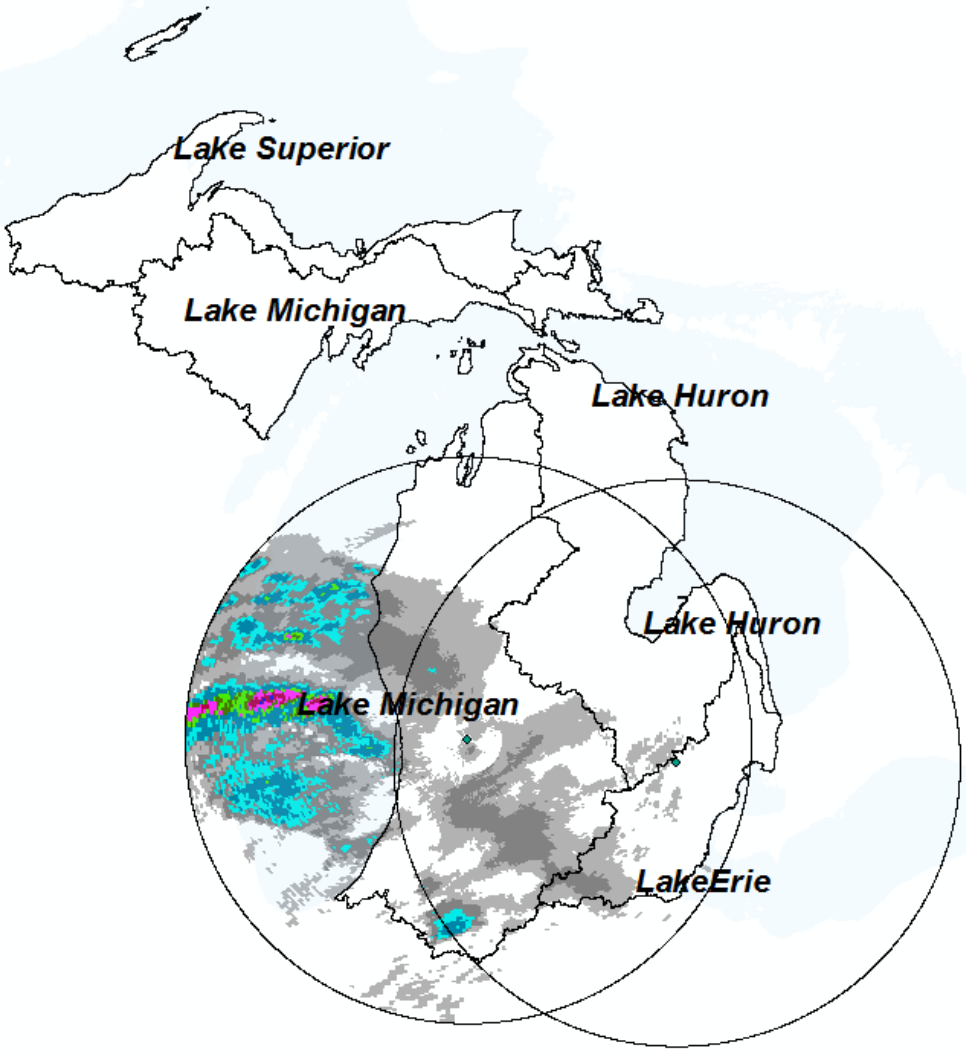
Select by Archived File
(Generic Access to the NCDC Archive.
Useful for Bulk Orders and Advanced Users)



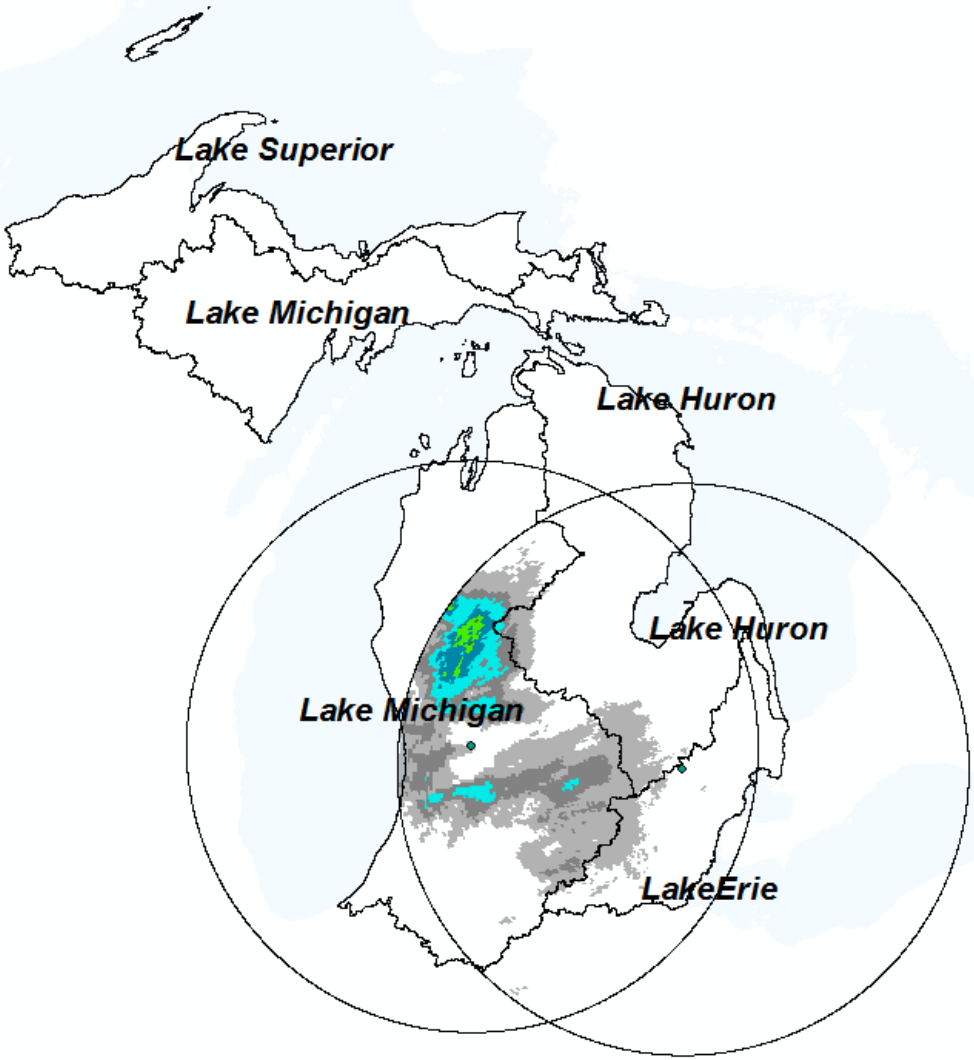
/nexradinv/choosesite.jsp

NEXRAD Images

NEXRAD Images



NEXRAD Images



Application - Access

frmDailyRainStations

Date or Date Range: 6/6/2008-6/17/2008

Description of location of interest: MacatawaRiver2008

Location of Interest: Latitude 42.779167 Longitude -86.018333

Distance from location of interest: 40 miles

Load Stations | Create Shape File | delete files | Generate 5 minutes Point | Generate 5 minutes Watershed

Rainfall Stations:

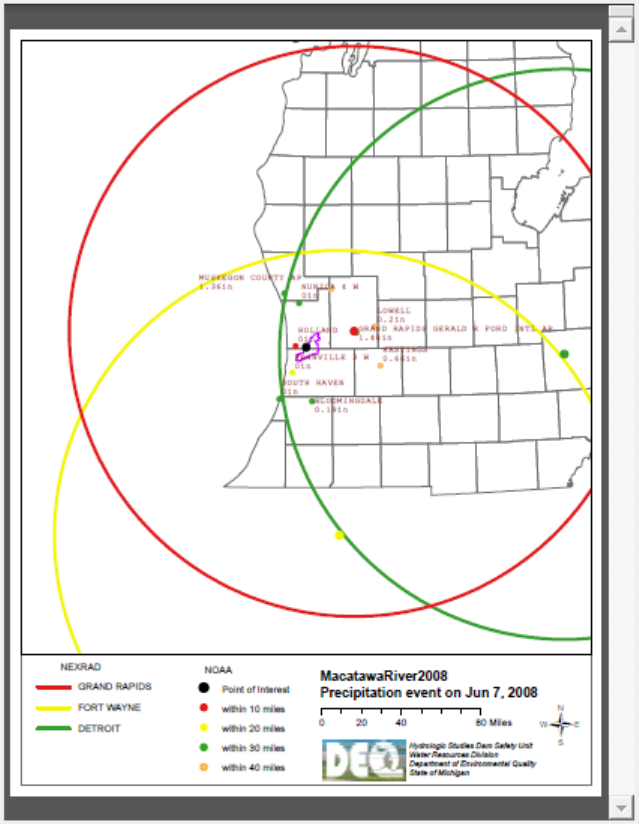
NEXRAD Stations:

View Map

Dates: 6/7/2008

Large

Small



Record: 1 of 1 | No Filter | Search

Computer
WS_FTP Pro
HIRPart21_8
Buffer
Alcona_200...
Recycle Bin
convert
TriCountyC...
Rainfall_Ba...
Adobe Acrobat...
Capture
content
Buffer
Working
USGS Location-1
Invitation to NHRS
HLocation... Copy
ASCII TABLE
dams2002
USGS Location-2
Grapher6
Converted...
WRD Database
DCDS
Untitled
Converted...
CompLowF...
ESRI ArcGIS Explorer
Book1
Converted...
Rainfall
MapImage_... ProViewer
Capture7
Quick Data View _ Clim...
NMS3
Wesco_Kis...
MMI
POI Scan
HIRPart21
Converted...
ArcGIS®
ArcMap™
10.1
Loading Document...
esri
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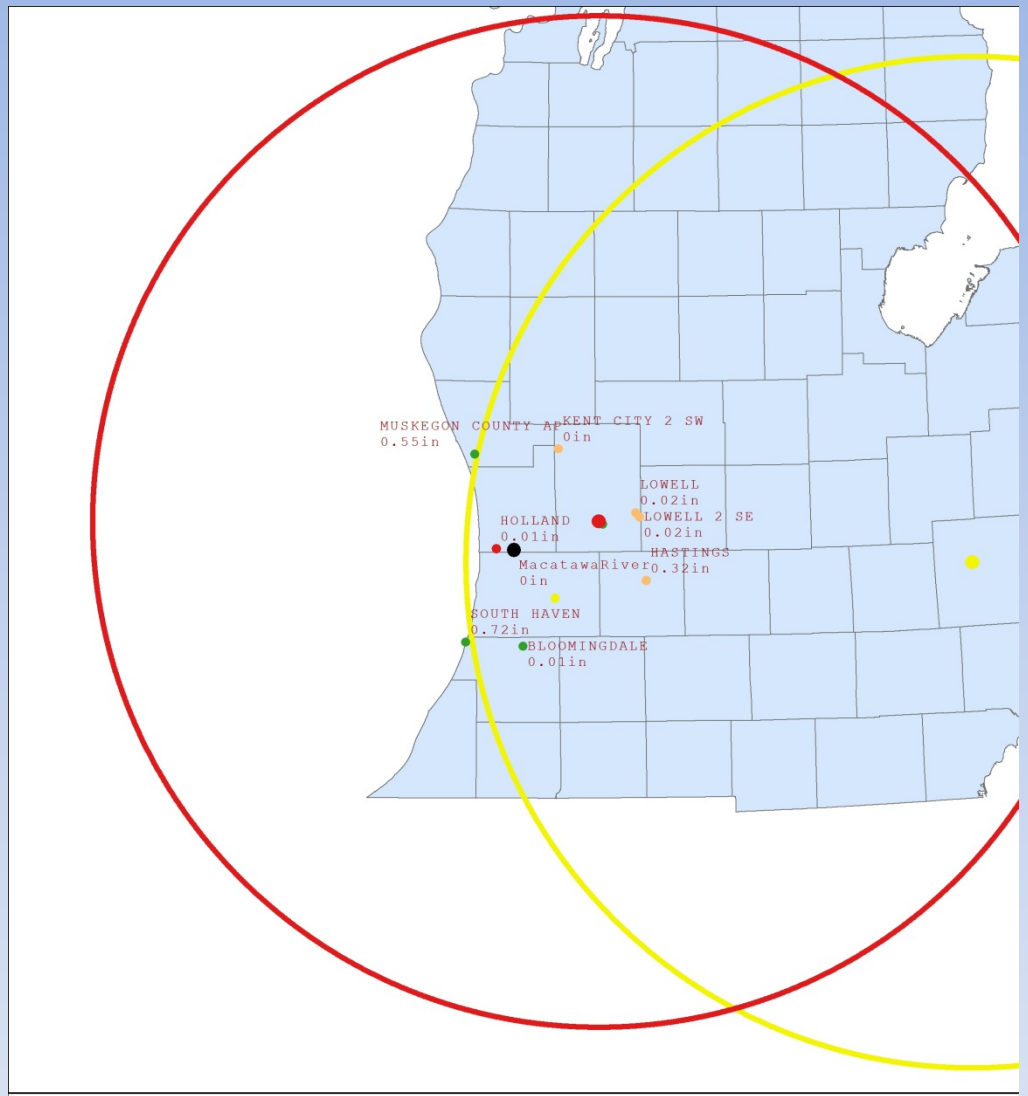
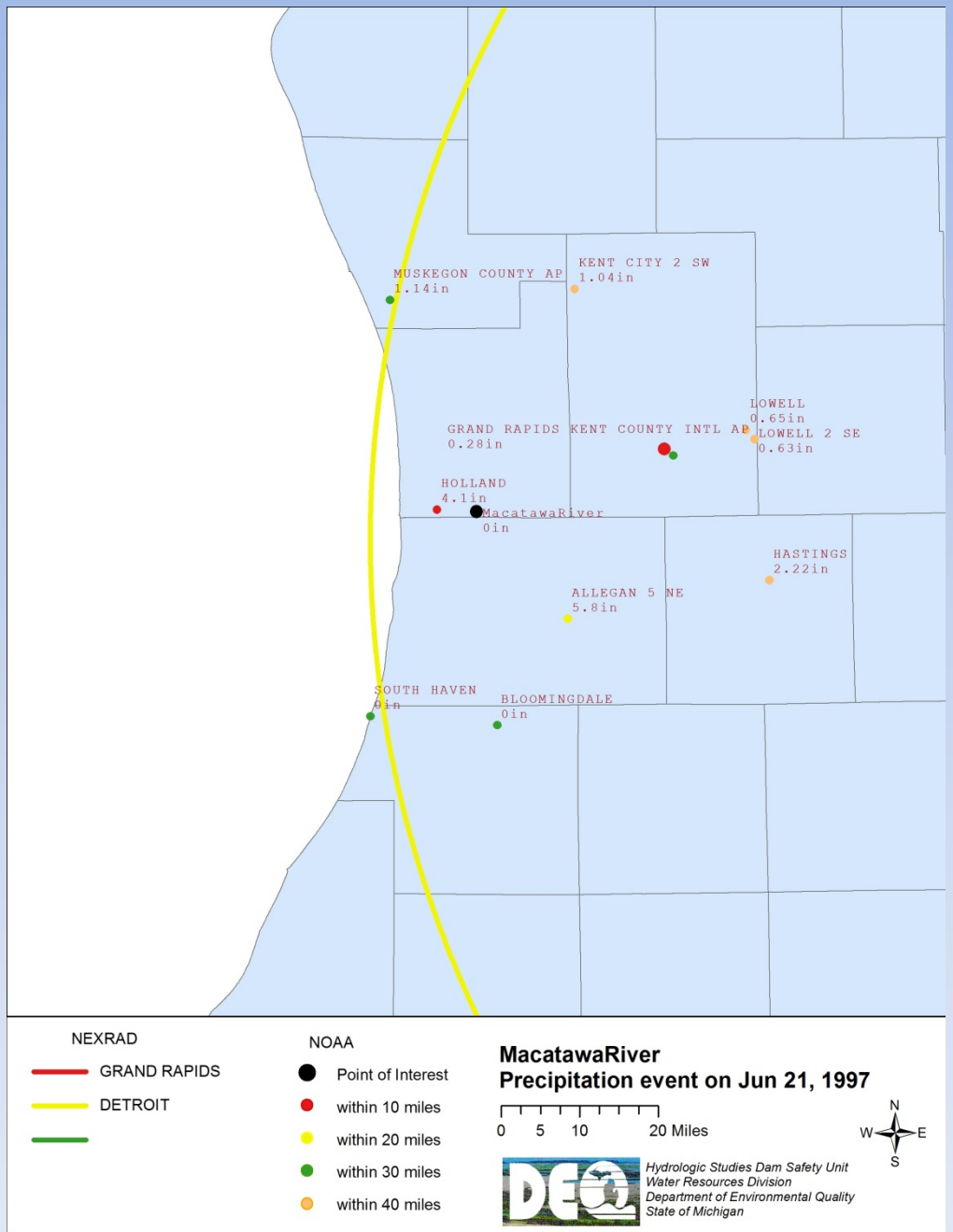
10:53 AM
7/16/2015

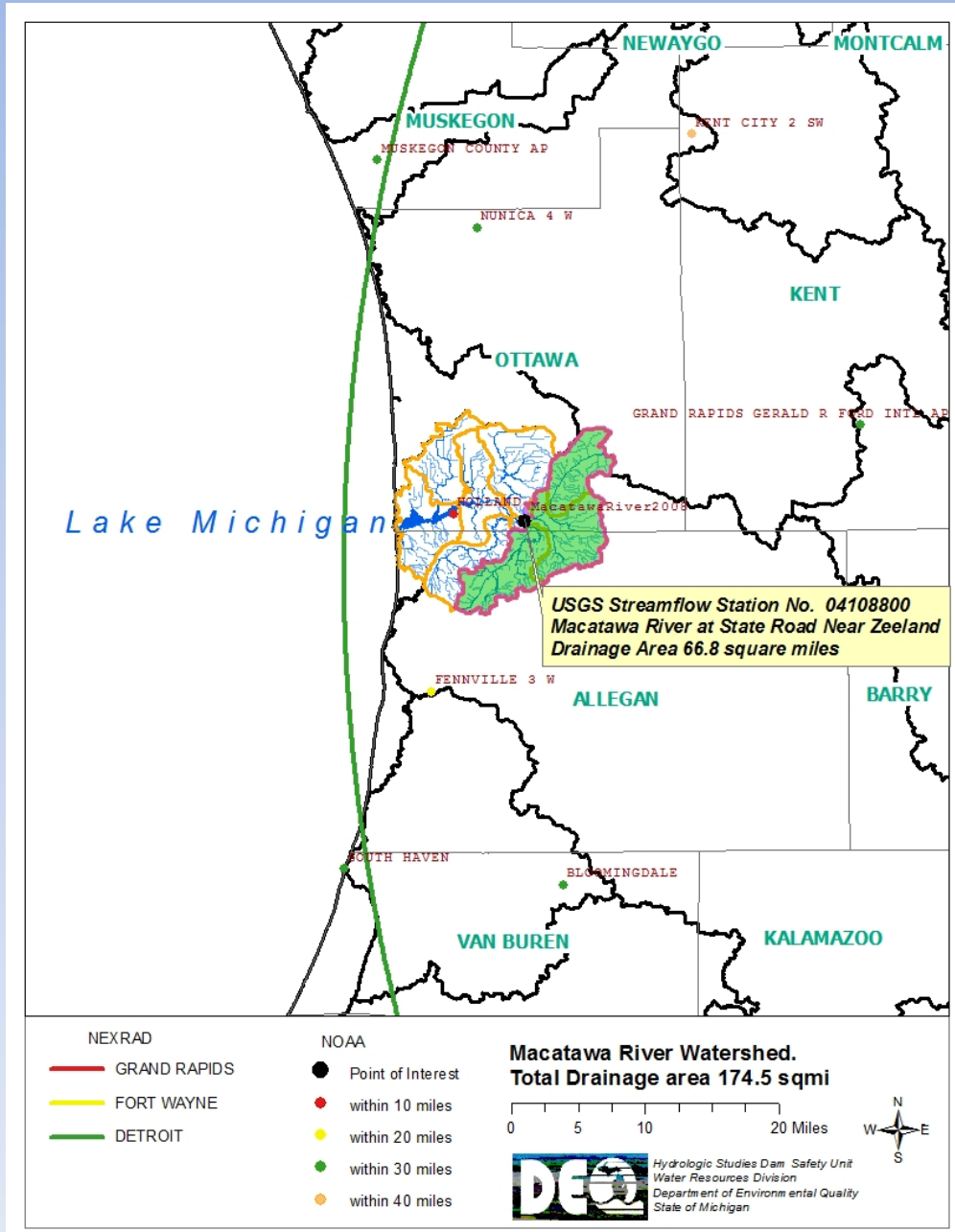
Application - ArcMap

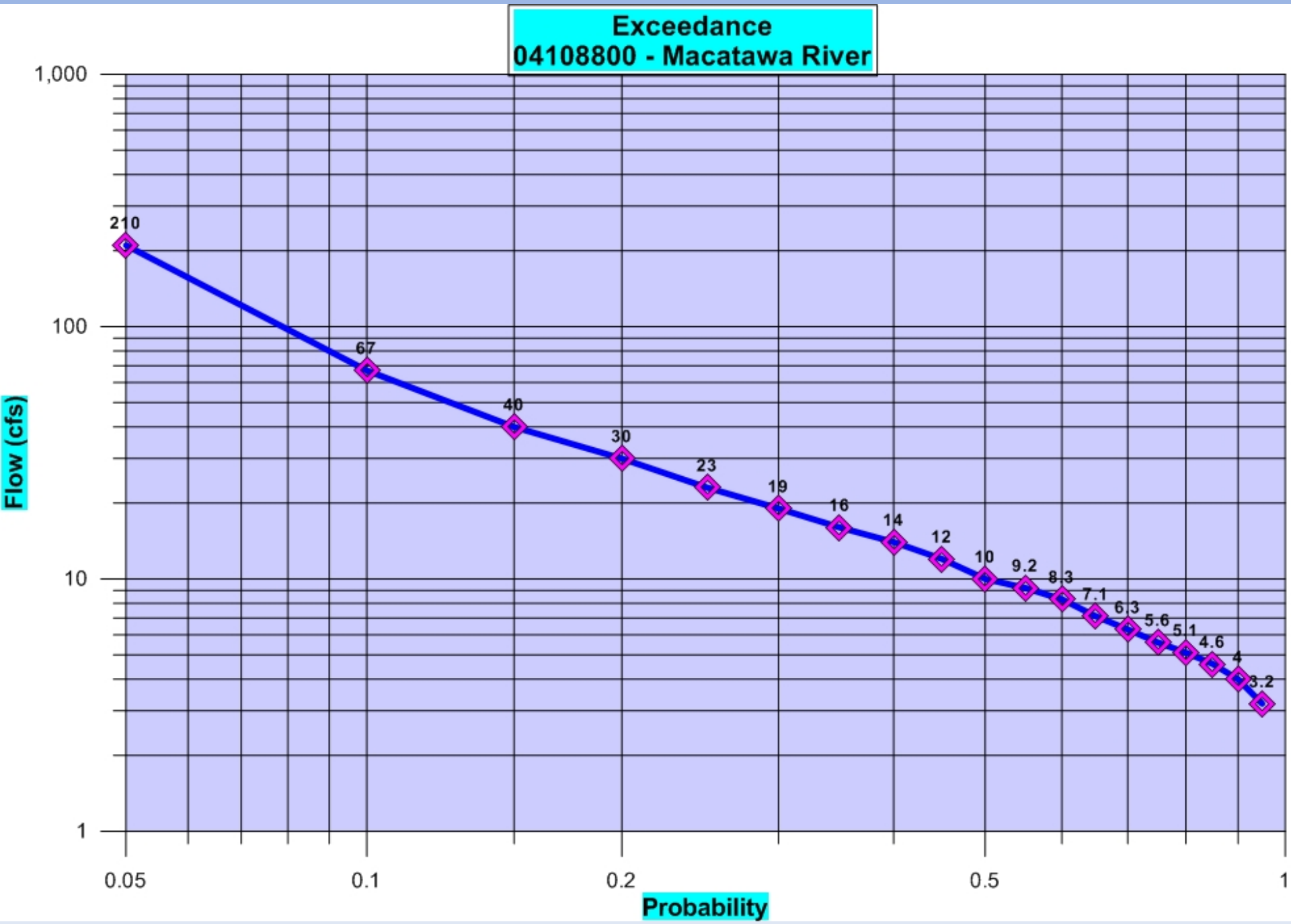


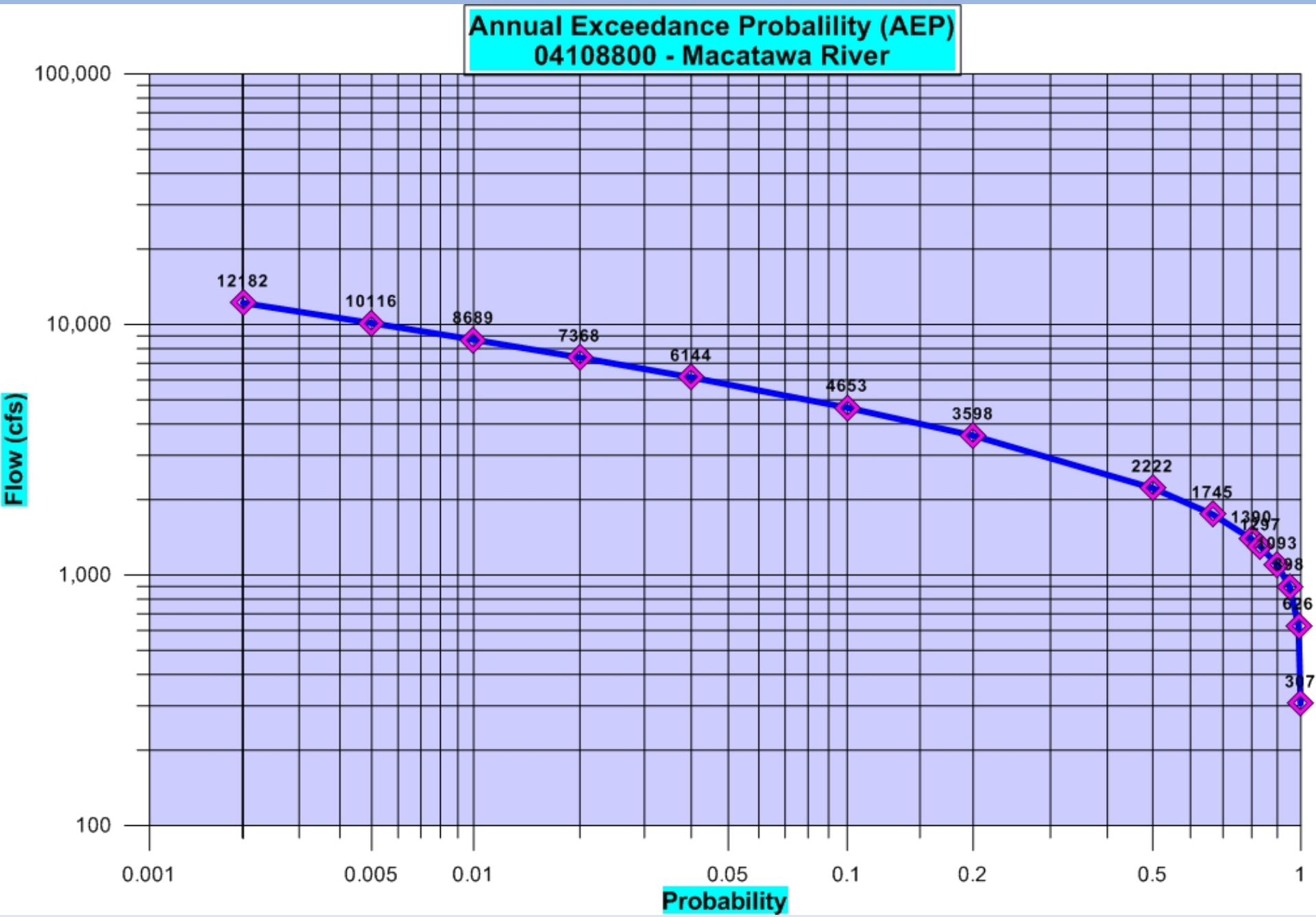
Application - ArcMap



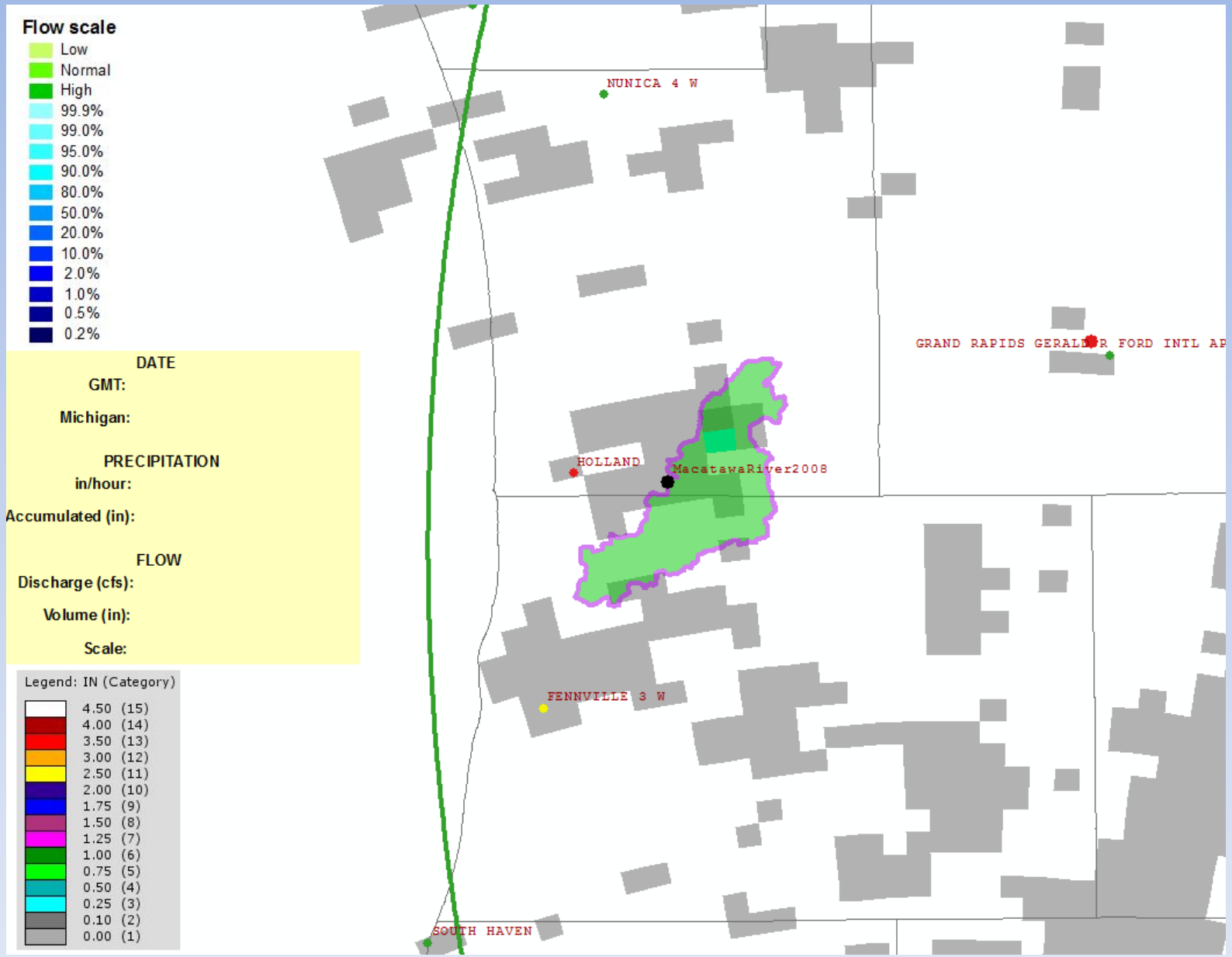
Application - ArcMap



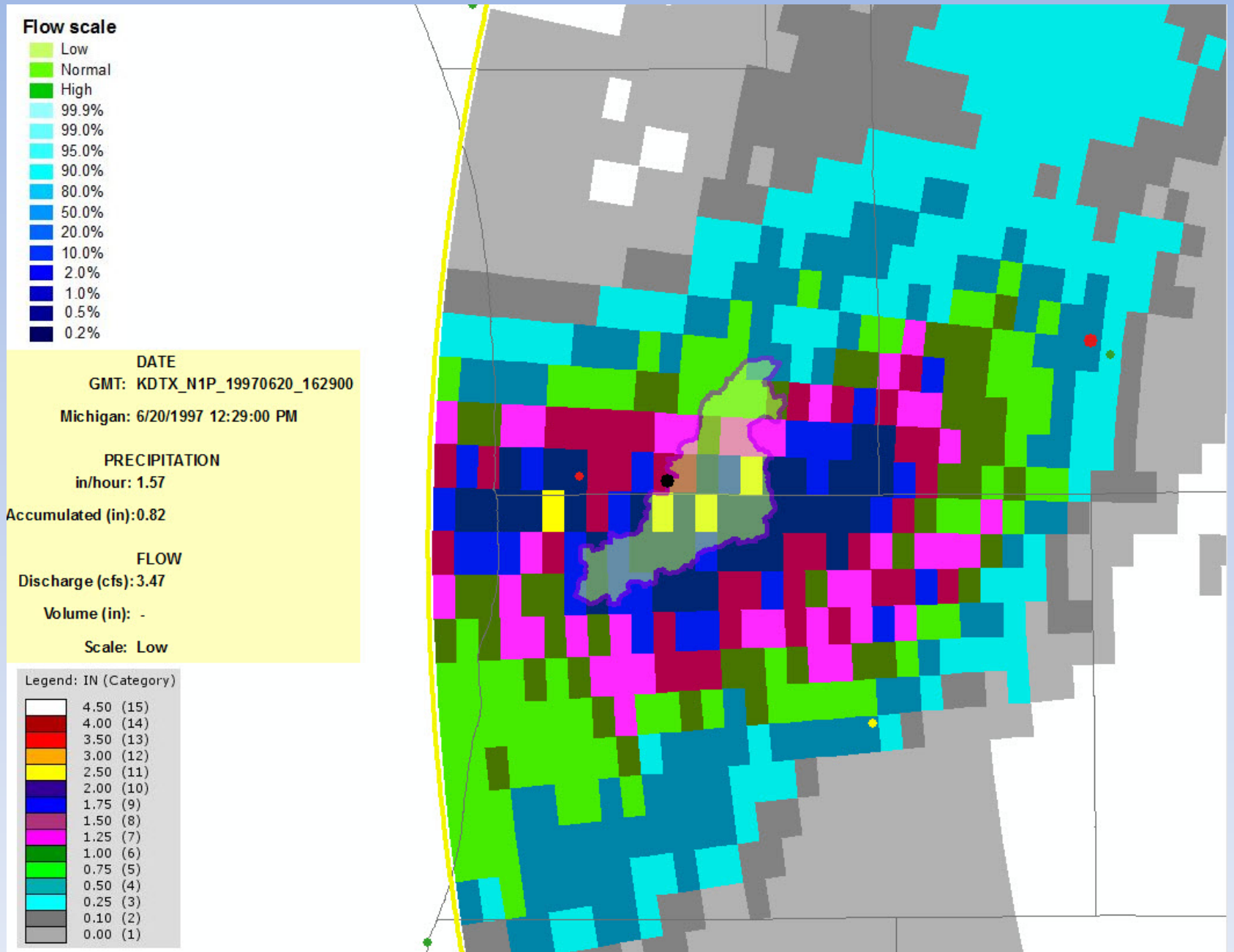

Exceedance
04108800 - Macatawa River
1,000
100
10
1
Flow (cfs)
210
67
40
30
23
19
16
14
12
10
9.2
8.3
7.1
6.3
5.6
5.1
4.6
4
3.2
0.05
0.1
0.2
0.5
1
Probability


Annual Exceedance Probalility (AEP)
04108800 - Macatawa River
100,000
10,000
1,000
100
Flow (cfs)
12182
10116
8689
7368
6144
4653
3598
2222
1745
1390
1297
1093
898
626
307
0.001
0.005
0.01
0.05
0.1
0.2
0.5
1
Probability

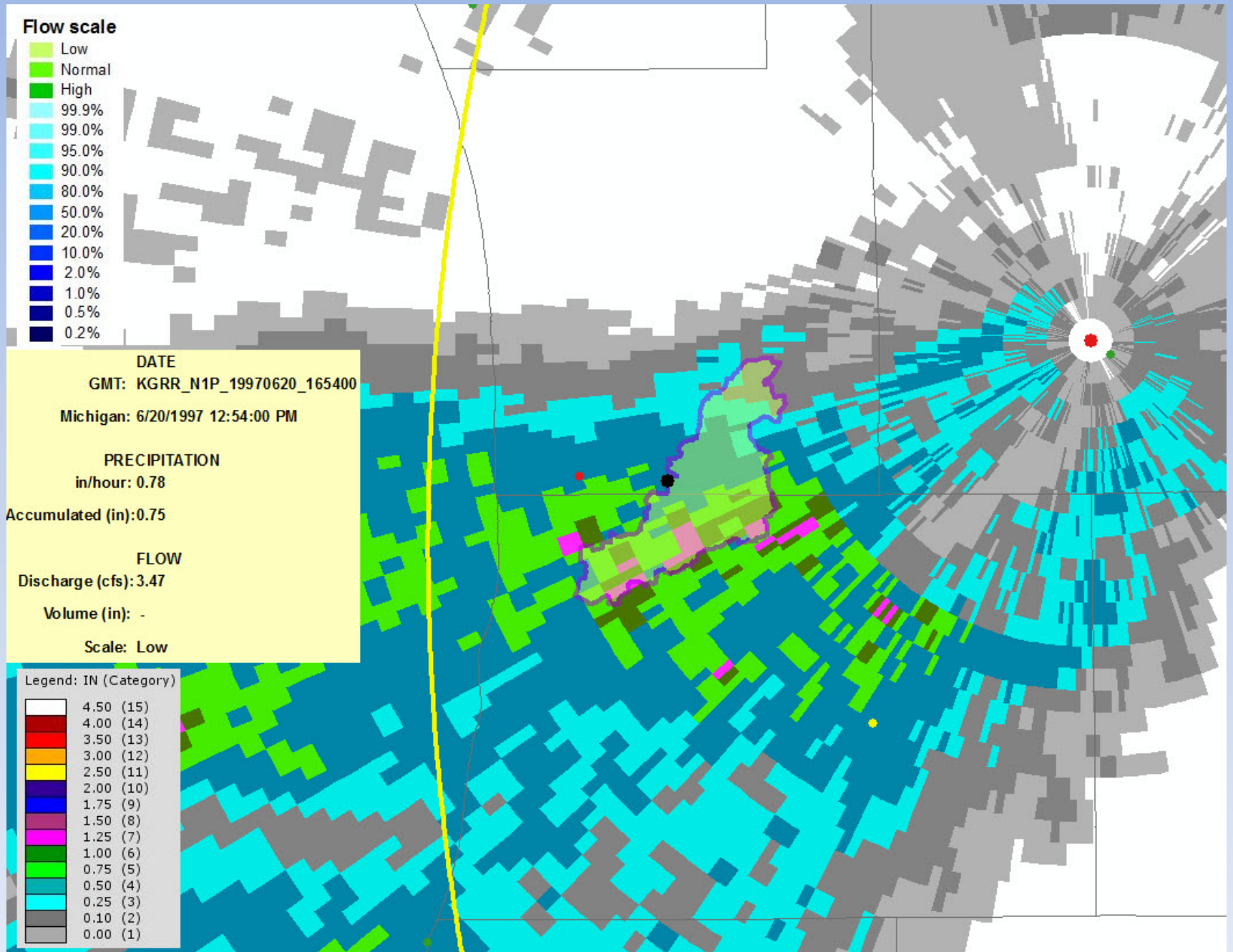
Application - ArcMap

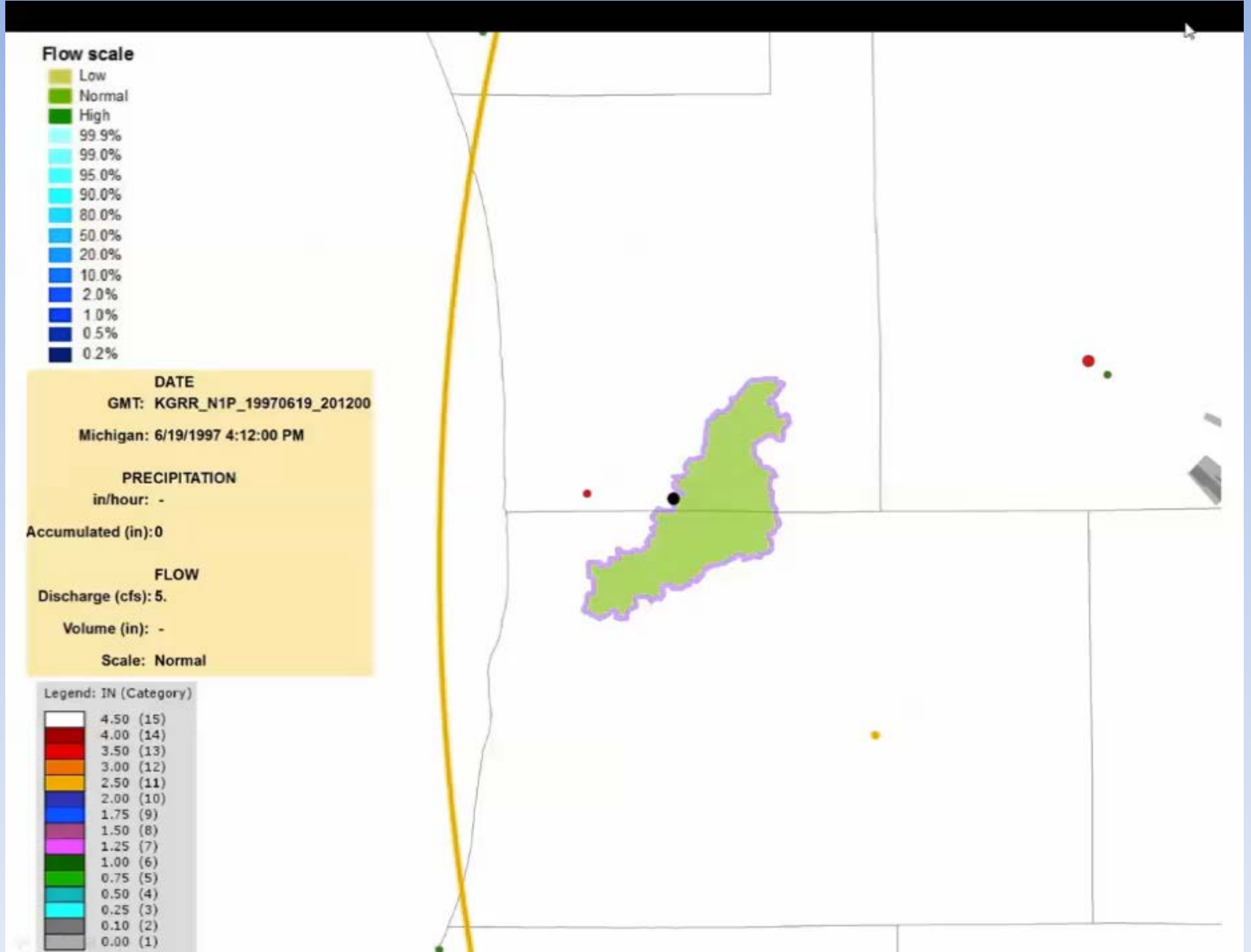


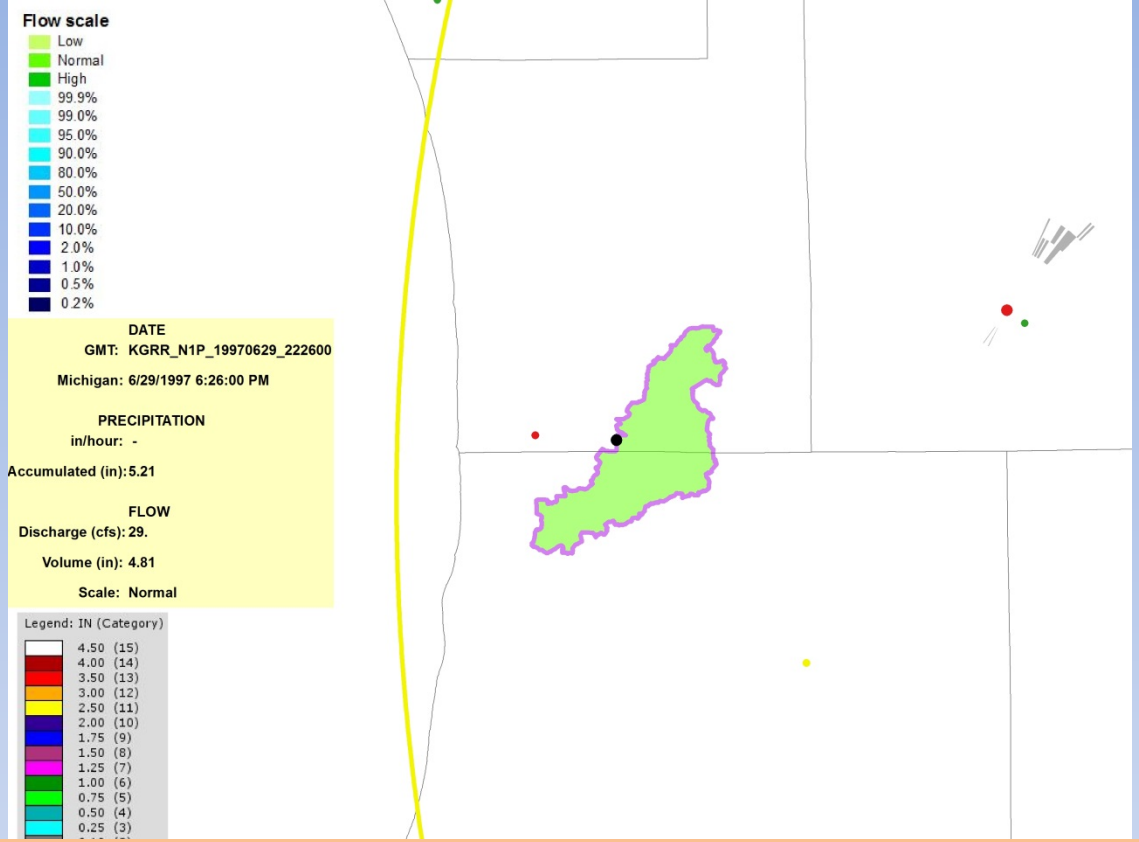
Application - ArcMap

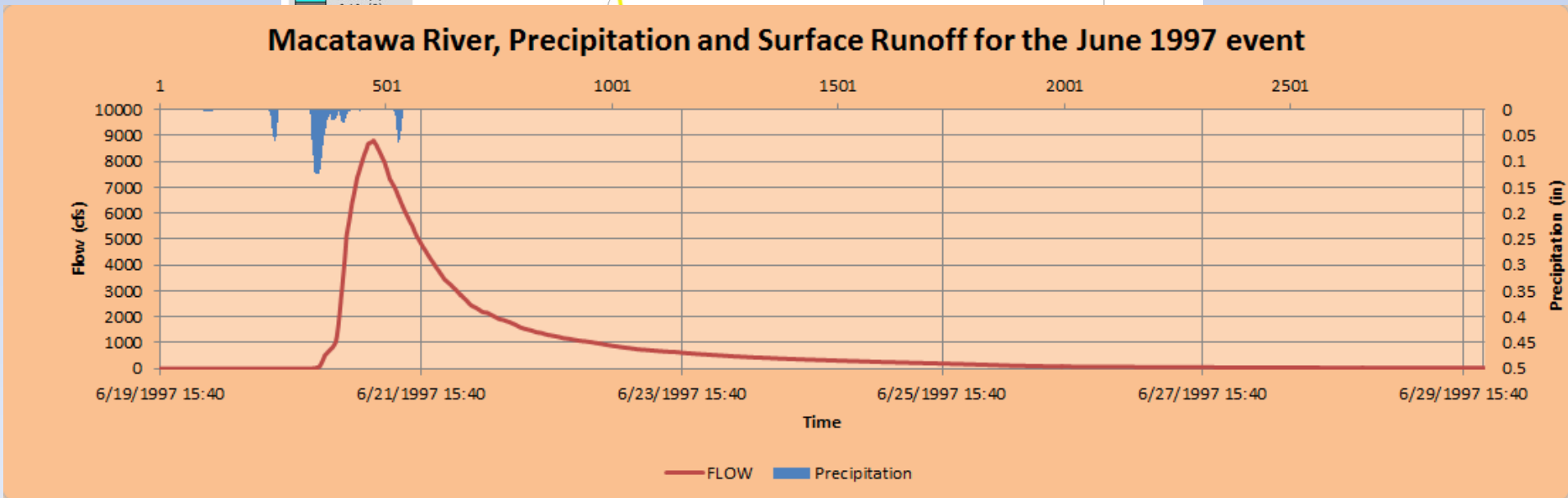


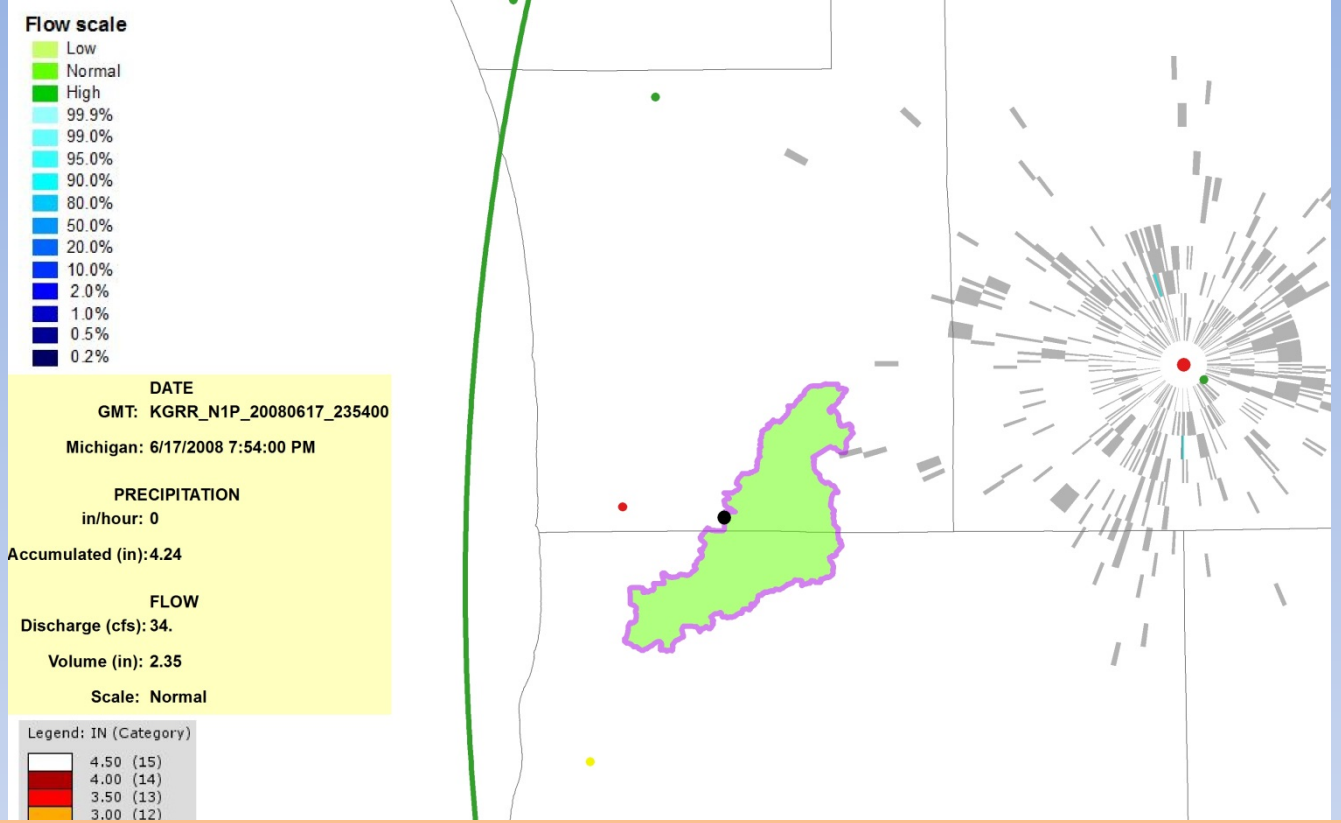
Application - ArcMap

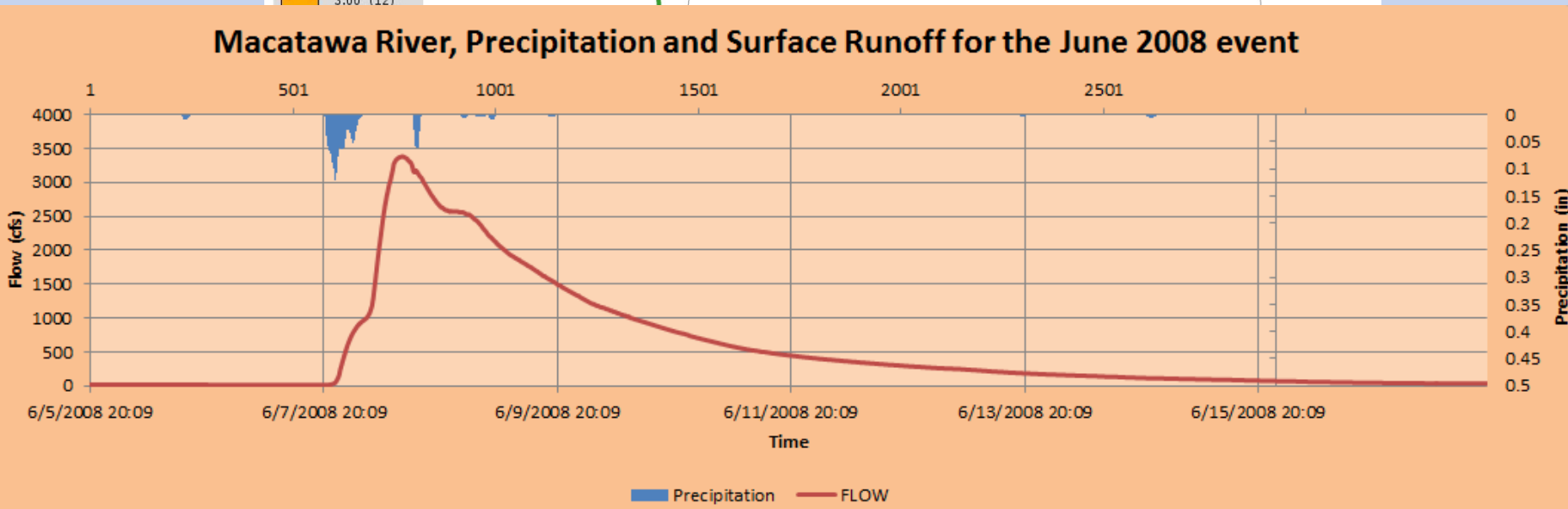


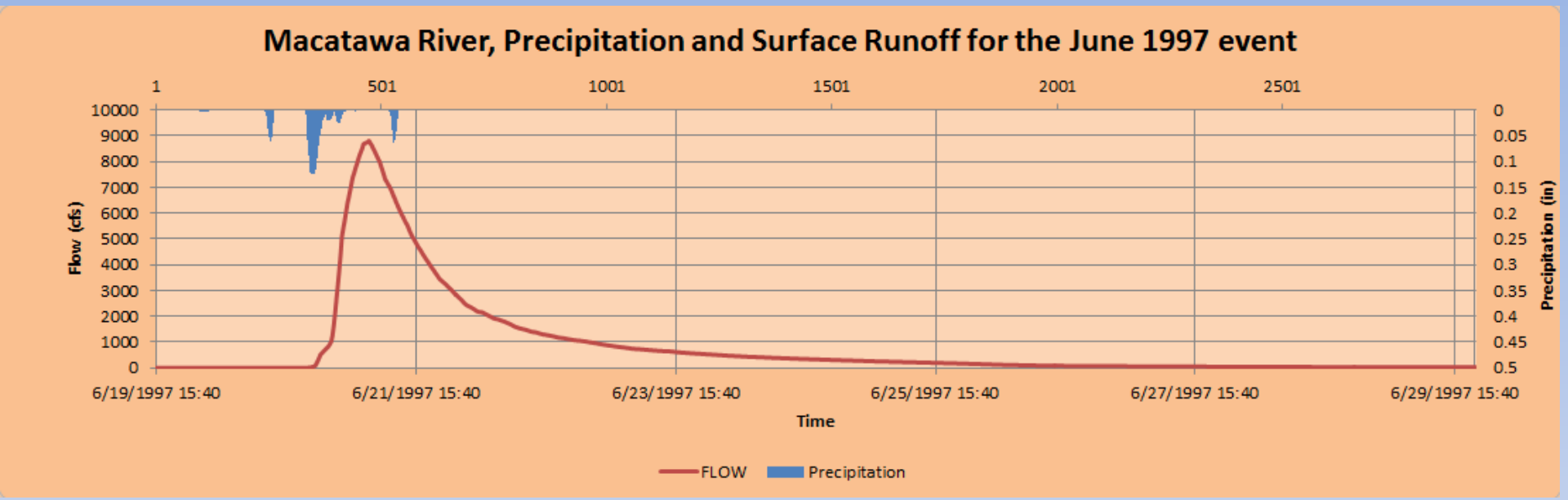

Flow scale
Low
Normal
High
99.9%
99.0%
95.0%
90.0%
80.0%
50.0%
20.0%
10.0%
2.0%
1.0%
0.5%
0.2%
DATE
GMT: KGRR_N1P_19970619_201200
Michigan: 6/19/1997 4:12:00 PM
PRECIPITATION
in/hour: -
Accumulated (in): 0
FLOW
Discharge (cfs): 5.
Volume (in): -
Scale: Normal
Legend: IN (Category)
4.50 (15)
4.00 (14)
3.50 (13)
3.00 (12)
2.50 (11)
2.00 (10)
1.75 (9)
1.50 (8)
1.25 (7)
1.00 (6)
0.75 (5)
0.50 (4)
0.25 (3)
0.10 (2)
0.00 (1)

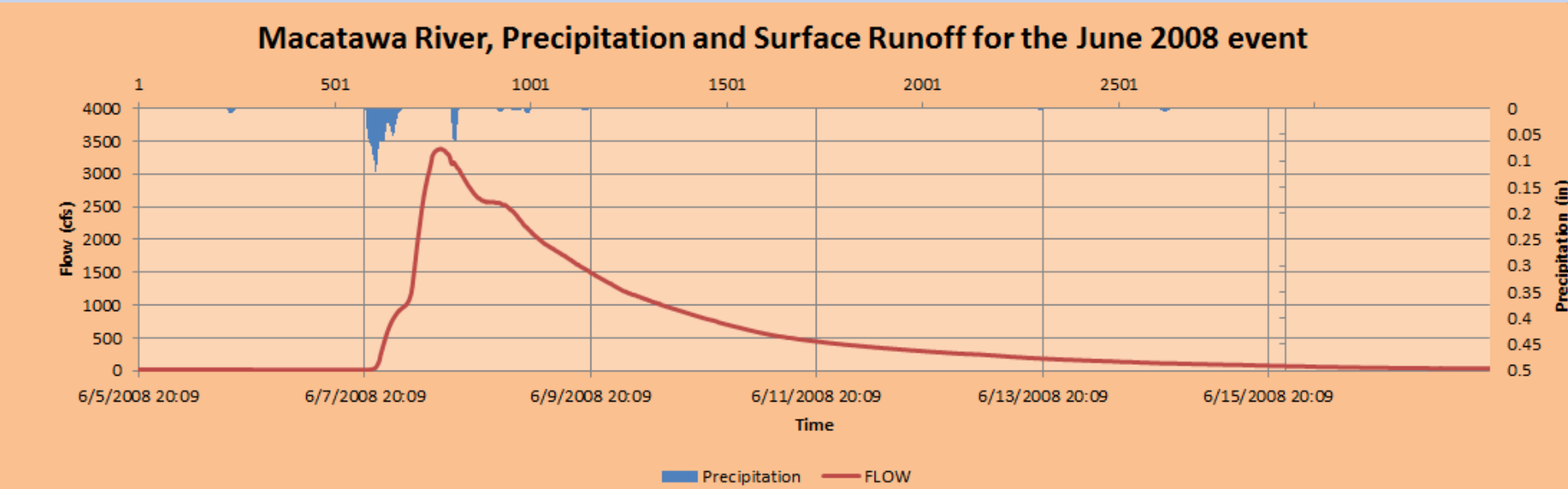

Flow scale
Low
Normal
High
99.9%
99.0%
95.0%
90.0%
80.0%
50.0%
20.0%
10.0%
2.0%
1.0%
0.5%
0.2%
DATE
GMT: KGRR_N1P_19970629_222600
Michigan: 6/29/1997 6:26:00 PM
PRECIPITATION
in/hour: -
Accumulated (in): 5.21
FLOW
Discharge (cfs): 29.
Volume (in): 4.81
Scale: Normal
Legend: IN (Category)
4.50 (15)
4.00 (14)
3.50 (13)
3.00 (12)
2.50 (11)
2.00 (10)
1.75 (9)
1.50 (8)
1.25 (7)
1.00 (6)
0.75 (5)
0.50 (4)
0.25 (3)


Macatawa River, Precipitation and Surface Runoff for the June 1997 event
1
501
1001
1501
2001
2501
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
Flow (cfs)
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0.5
Precipitation (in)
6/19/1997 15:40
6/21/1997 15:40
6/23/1997 15:40
6/25/1997 15:40
6/27/1997 15:40
6/29/1997 15:40
Time
FLOW
Precipitation


Flow scale
Low
Normal
High
99.9%
99.0%
95.0%
90.0%
80.0%
50.0%
20.0%
10.0%
2.0%
1.0%
0.5%
0.2%
DATE
GMT: KGRR_N1P_20080617_235400
Michigan: 6/17/2008 7:54:00 PM
PRECIPITATION
in/hour: 0
Accumulated (in): 4.24
FLOW
Discharge (cfs): 34.
Volume (in): 2.35
Scale: Normal
Legend: IN (Category)
4.50 (15)
4.00 (14)
3.50 (13)
3.00 (12)


Macatawa River, Precipitation and Surface Runoff for the June 2008 event
1
501
1001
1501
2001
2501
4000
3500
3000
2500
2000
1500
1000
500
0
Flow (cfs)
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0.5
Precipitation (in)
6/5/2008 20:09
6/7/2008 20:09
6/9/2008 20:09
6/11/2008 20:09
6/13/2008 20:09
6/15/2008 20:09
Time
Precipitation
FLOW


Macatawa River, Precipitation and Surface Runoff for the June 1997 event
1
501
1001
1501
2001
2501
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
Flow (cfs)
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0.5
Precipitation (in)
6/19/1997 15:40
6/21/1997 15:40
6/23/1997 15:40
6/25/1997 15:40
6/27/1997 15:40
6/29/1997 15:40
Time
FLOW
Precipitation


Macatawa River, Precipitation and Surface Runoff for the June 2008 event
1
501
1001
1501
2001
2501
4000
3500
3000
2500
2000
1500
1000
500
0
Flow (cfs)
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0.5
Precipitation (in)
6/5/2008 20:09
6/7/2008 20:09
6/9/2008 20:09
6/11/2008 20:09
6/13/2008 20:09
6/15/2008 20:09
Time
Precipitation
FLOW

Questions?