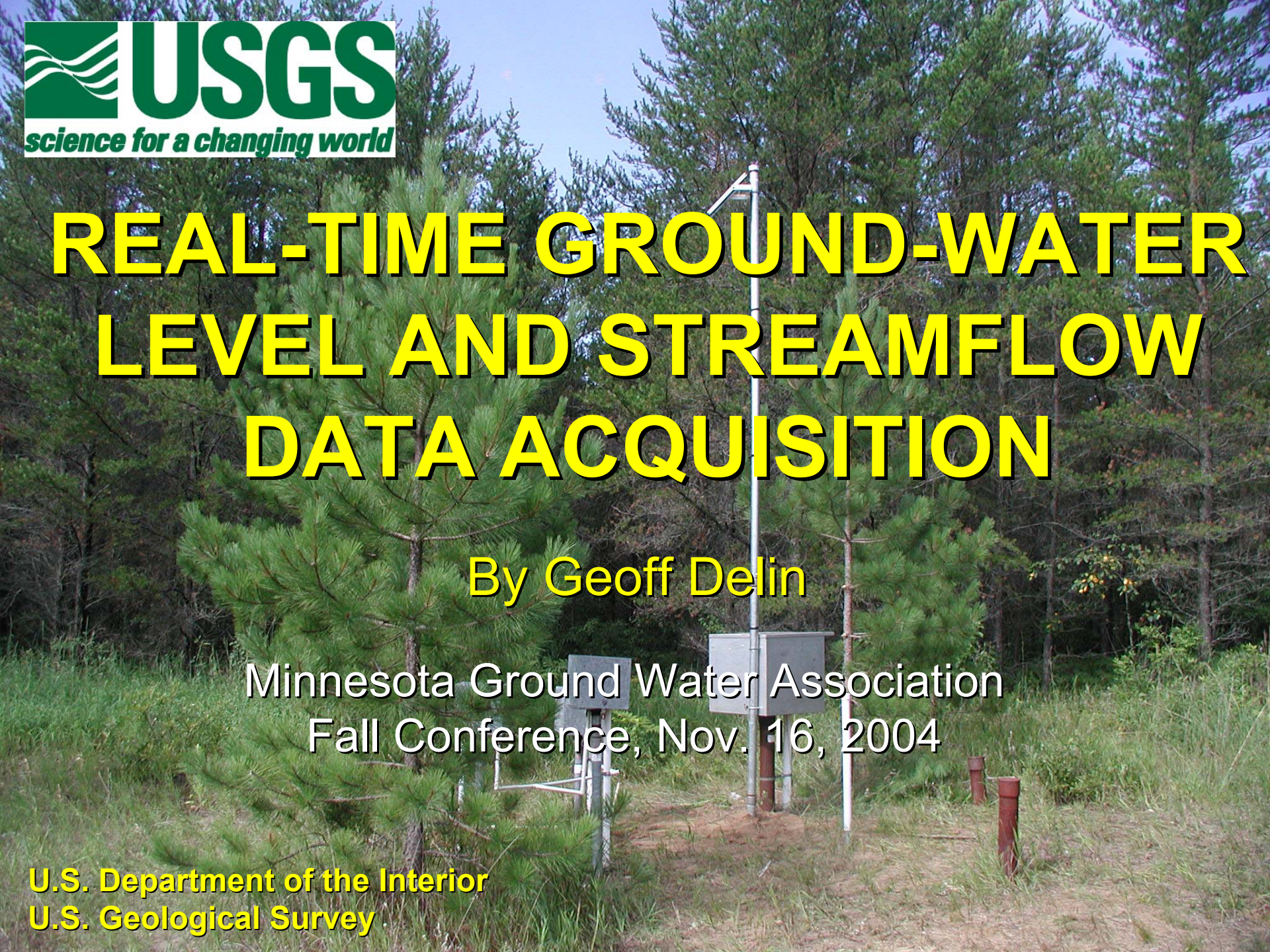


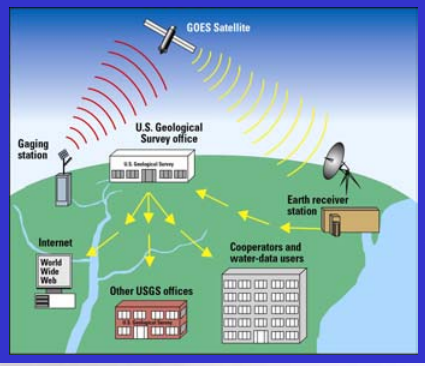
USGS
science for a changing world

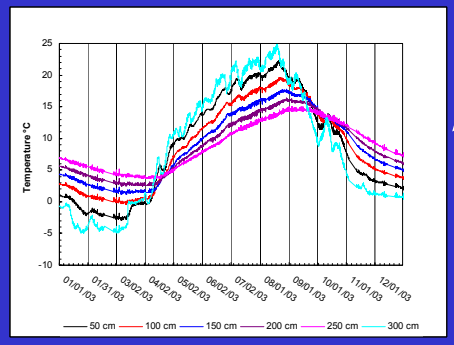
REAL-TIME GROUND-WATER LEVEL AND STREAMFLOW DATA ACQUISITION

By Geoff Delin

Minnesota Ground Water Association
Fall Conference, Nov. 16, 2004

U.S. Department of the Interior
U.S. Geological Survey



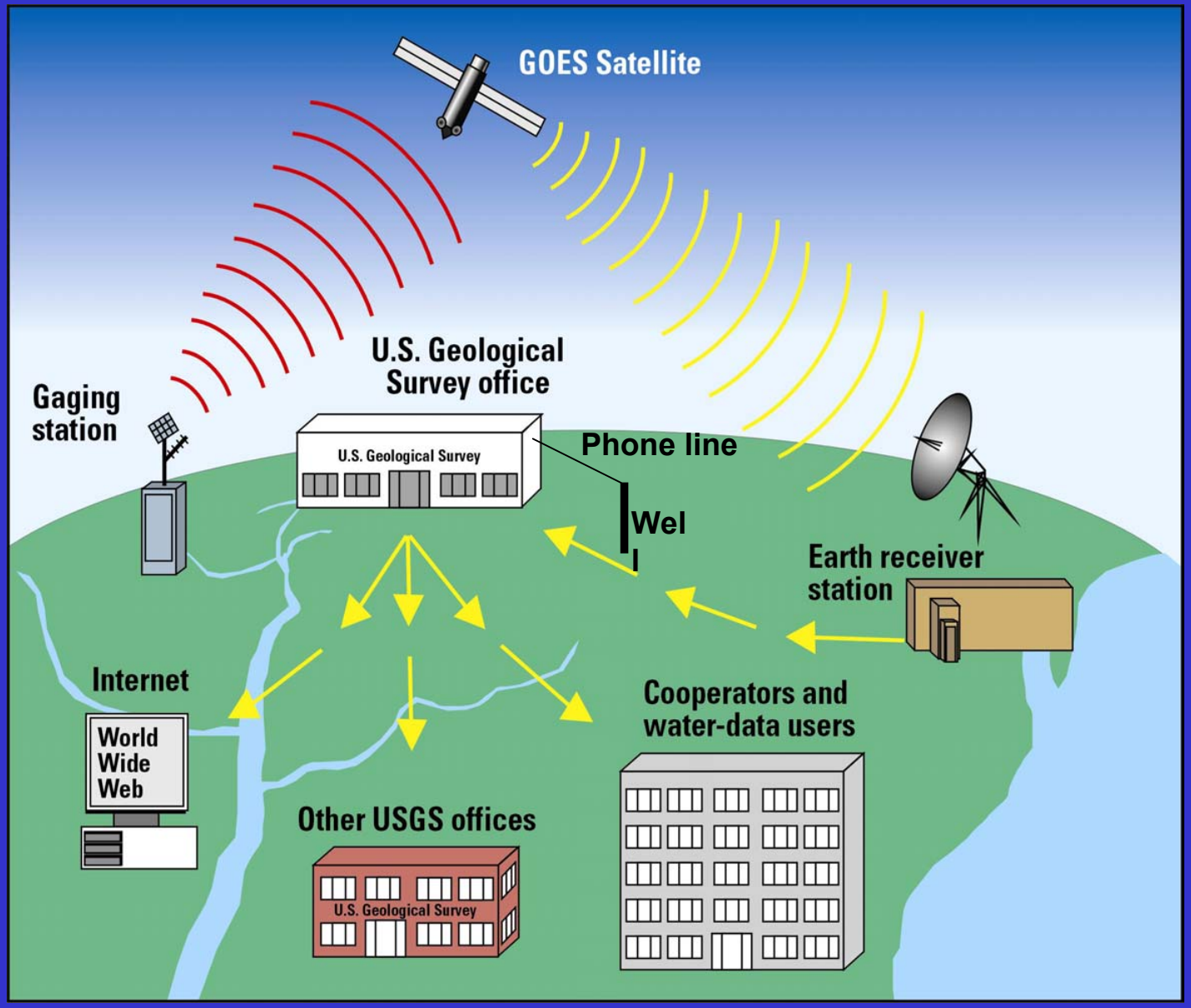


Outline

- Overview
- USGS real-time streamflow data acquisition
- USGS real-time ground-water level data acquisition and example applications
- Future plans for USGS real-time monitoring in Minnesota
- Summary and benefits

USGS

Real-Time Data Acquisition



USGS

What do we mean by "Real-Time"?

- The data are measured every 15 minutes to once per hour in the field
- The data are uploaded and delivered to the Web every one to four hours

USGS

USGS Real-Time Streamflow Data Acquisition

Snake River gage
near Alvaredo

USGS

Real-Time Data for the Nation - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Back Search Favorites

Address http://waterdata.usgs.gov/usa/nwis/rt Go Links

USGS
science for a changing world

District Access
Water Resources

Data Category: Real-time
Geographic Area: United States
go

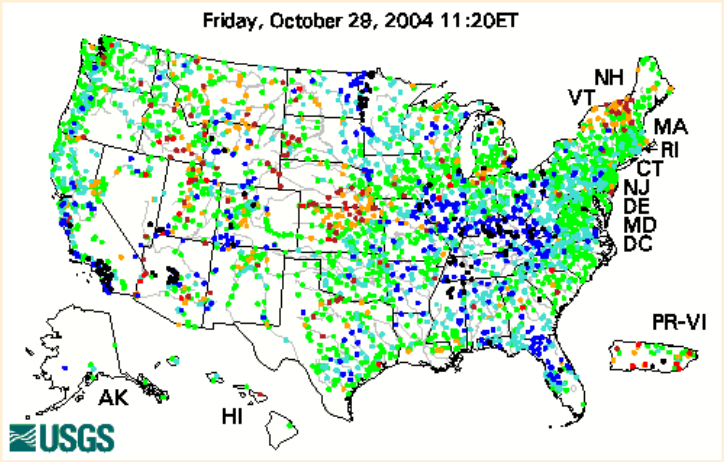
Real-Time Data for the Nation

--- Predefined displays --- Introduction
Group table by – no grouping –
Select sites by number or name
GO

Daily Streamflow Conditions

Select a state to view real-time information for that state

Friday, October 28, 2004 11:20ET



Explanation

- High
- ≥ 90th percentile
- 75th - 89th percentile
- 25th - 74th percentile
- 10th - 24th percentile
- < 10th percentile
- Low
- Not ranked

The colored dots on this map depict streamflow conditions as a percentile, which is computed from the period of record for the current day of the year. Only stations with at least 30 years of record are used. The **gray circles** indicate other stations that were not ranked in percentiles either because they have fewer than 30 years of record or because they report parameters other than streamflow. Some stations, for example, measure stage only.

Statewide Streamflow Table

Real-time data typically are recorded at 15-60 minute intervals, stored onsite, and then transmitted to USGS offices every 1 to 4 hours, depending on the data relay technique used. Recording and transmission times may be more frequent during critical events. Data from real-time sites are relayed to USGS offices via satellite, telephone, and/or radio and are available for viewing within minutes of arrival.

All real-time data are provisional and subject to revision.

Build Table	Build a custom summary table for one or more stations.
Build Sequence	Build a custom sequence of graphical or tabular data for one or more stations.

Done Internet

USGS Real-Time Stream-flow Data Acquisition Network

Data stored in USGS database

http://waterdata.usgs.gov/nwis/rt

USGS

Real-Time Data for Minnesota - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Back Search Favorites

Address http://waterdata.usgs.gov/mn/nwis/rt Go Links

USGS
science for a changing world

District Access
Water Resources

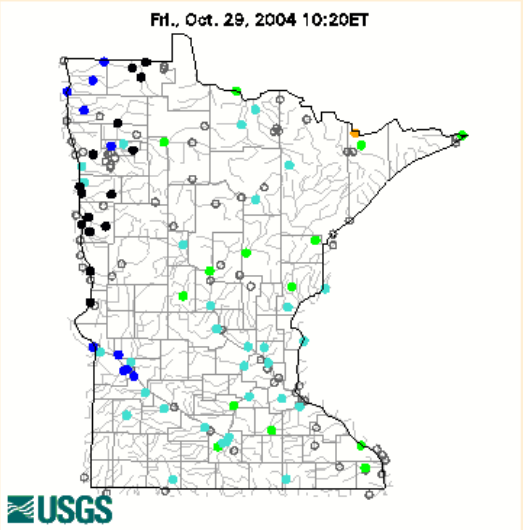
Data Category: Real-time
Geographic Area: United States
go

Real-Time Data for Minnesota

--- Predefined displays --- Introduction
Group table by – no grouping –
Select sites by number or name GO

Daily Streamflow Conditions

Select a site to retrieve data and station information.



Explanation

- High
- ≥ 90th percentile
- 75th - 89th percentile
- 25th - 74th percentile

The colored dots on this map depict streamflow conditions as a percentile, which is computed from the period of record for the current day of the year. Only stations with at least 30 years of record are used.
The **gray circles** indicate other

Statewide Streamflow Table

Statewide Precipitation Table

Statewide Ground-Water Table

Real-time data typically are recorded at 15-60 minute intervals, stored onsite, and then transmitted to USGS offices every 1 to 4 hours, depending on the data relay technique used. Recording and transmission times may be more frequent during critical events. Data from real-time sites are relayed to USGS offices via satellite, telephone, and/or radio and are available for viewing within minutes of arrival.

All real-time data are provisional and subject to revision.

Build Table	Build a custom summary table for one or more stations.
Build Sequence	Build a custom sequence of graphical or tabular data for one or more stations.

Internet

Minnesota USGS Real-Time Stream-flow Network

90 real-time gaging stations in MN

http://waterdata.usgs.gov/mn/nwis/rt

USGS

Real-time data for USGS 05345000 VERMILLION RIVER NEAR EMPIRE, MN - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Back Search Favorites

Address http://waterdata.usgs.gov/nwis/uv?05345000 Go Links

USGS

District Access
Water Resources

Data Category: Real-time | Geographic Area: United States | go

Rescheduled - The nwis.waterdata.usgs.gov server will be undergoing maintenance Monday, November 8, 2004 from 9:00 AM until 12:00 PM EDT and will not contain the latest real-time data during this time period. All real-time data will continue to be available at http://waterdata.usgs.gov/nwis.

USGS 05345000 VERMILLION RIVER NEAR EMPIRE, MN

PROVISIONAL DATA SUBJECT TO REVISION

Available data for this site: Real-time | GO

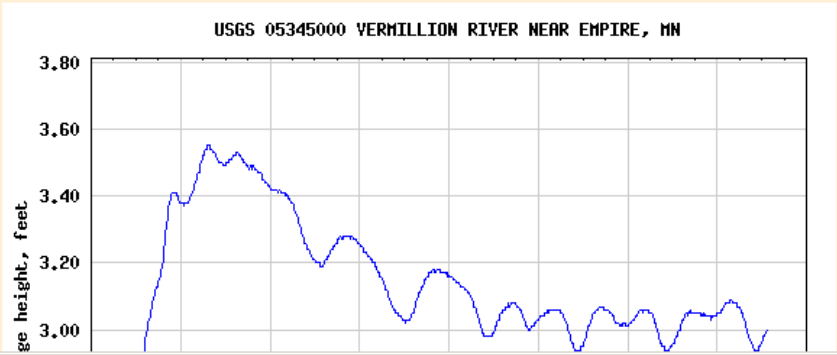
DNR Waters

Operated in cooperation with the Minnesota Department of Natural Resources - Division of Waters.

Available Parameters	Output format	Days	
All 5 parameters available at this site 00065 Gage height (DD 11) 00060 Discharge (DD 12) 70969 DCP battery voltage (DD 13)	Graph	7 (1-31)	get data

Gage height, feet

Most recent value: 3.00 11-04-2004 13:30



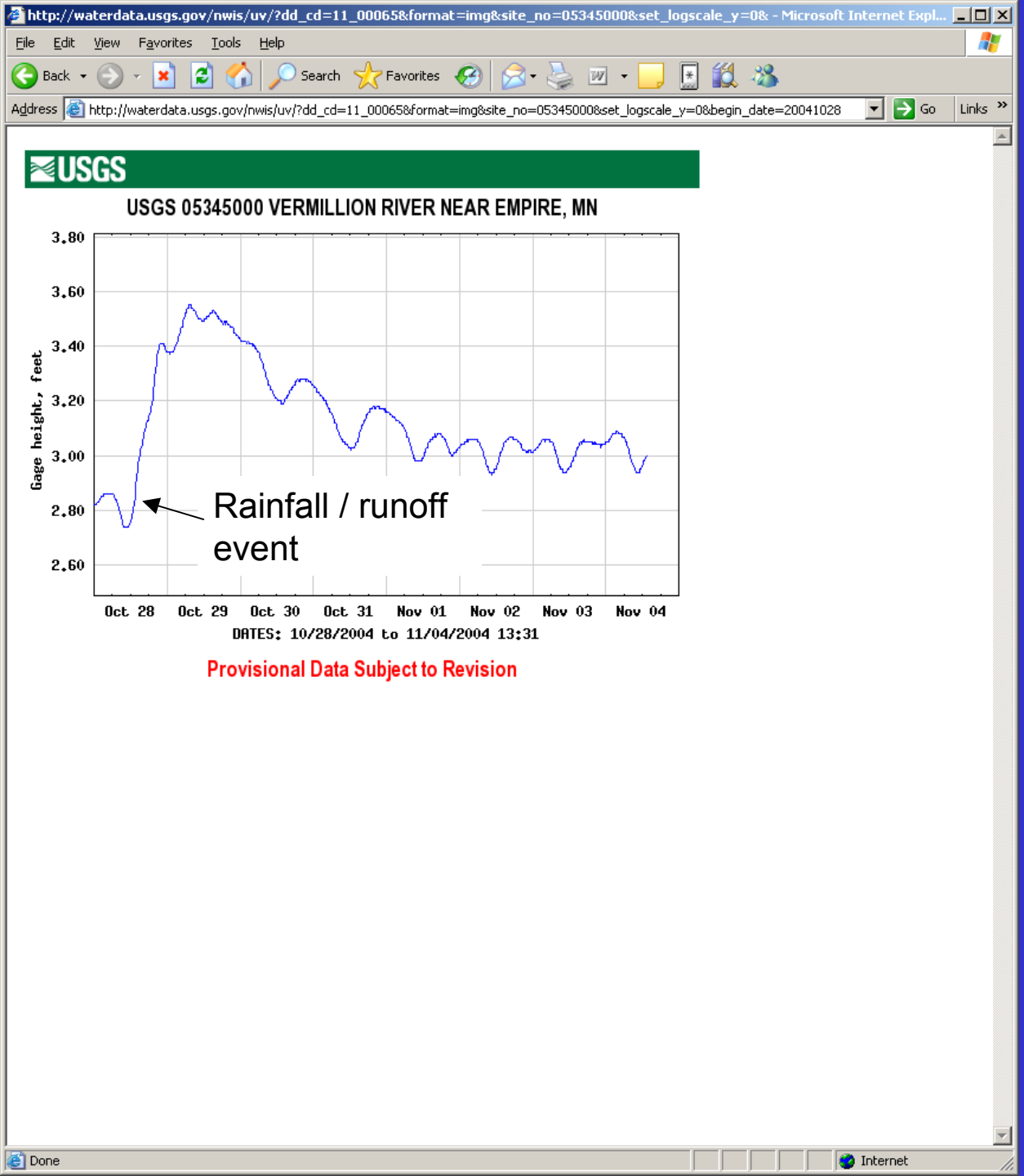
Internet

Vermillion River near Empire, MN USGS Station

Cooperative funding with MDNR

http://waterdata.usgs.gov/mn/nwis/rt/uv?05345000

USGS



Full View of Stage for Vermillion River near Empire

USGS

Real-Time Stream Water-Quality Data Served to Web

Shingle Creek, at Queen Ave. in Minneapolis example

Real-time data for USGS 05288705 SHINGLE CREEK AT QUEEN AVE IN MINNEAPOLIS, MN - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Back Search Favorites

Address http://waterdata.usgs.gov/mn/nwis/uv?dd_cd=05&format=gif&period=7&site_no=05288705 Go Links

USGS

District Access
Water Resources

Data Category: Real-time
Geographic Area: Minnesota
go

Rescheduled - The nwis.waterdata.usgs.gov server will be undergoing maintenance Monday, November 8, 2004 from 9:00 AM until 12:00 PM EDT and will not contain the latest real-time data during this time period. All real-time data will continue to be available at http://waterdata.usgs.gov/nwis.

USGS 05288705 SHINGLE CREEK AT QUEEN AVE IN MINNEAPOLIS, MN

PROVISIONAL DATA SUBJECT TO REVISION

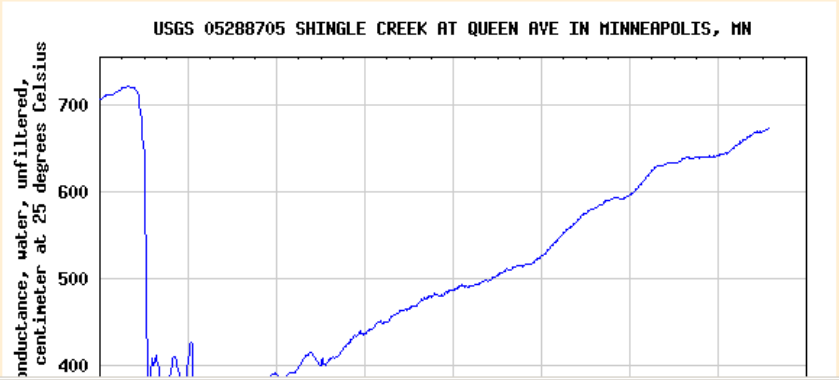
Available data for this site: Real-time GO

Operated by the USGS as part of the National Water-Quality Assessment Program (NAWQA) and National Streamflow Information Program (NSIP). Continuous specific conductance and water temperature monitors operated in cooperation with the Shingle Creek Watershed Commission.

Available Parameters	Output format	Days	
All 7 parameters available at this site 00065 Gage height (DD 01) 00060 Discharge (DD 02) 00010 Temperature, water (DD 04)	Graph	7 (1-31)	get data

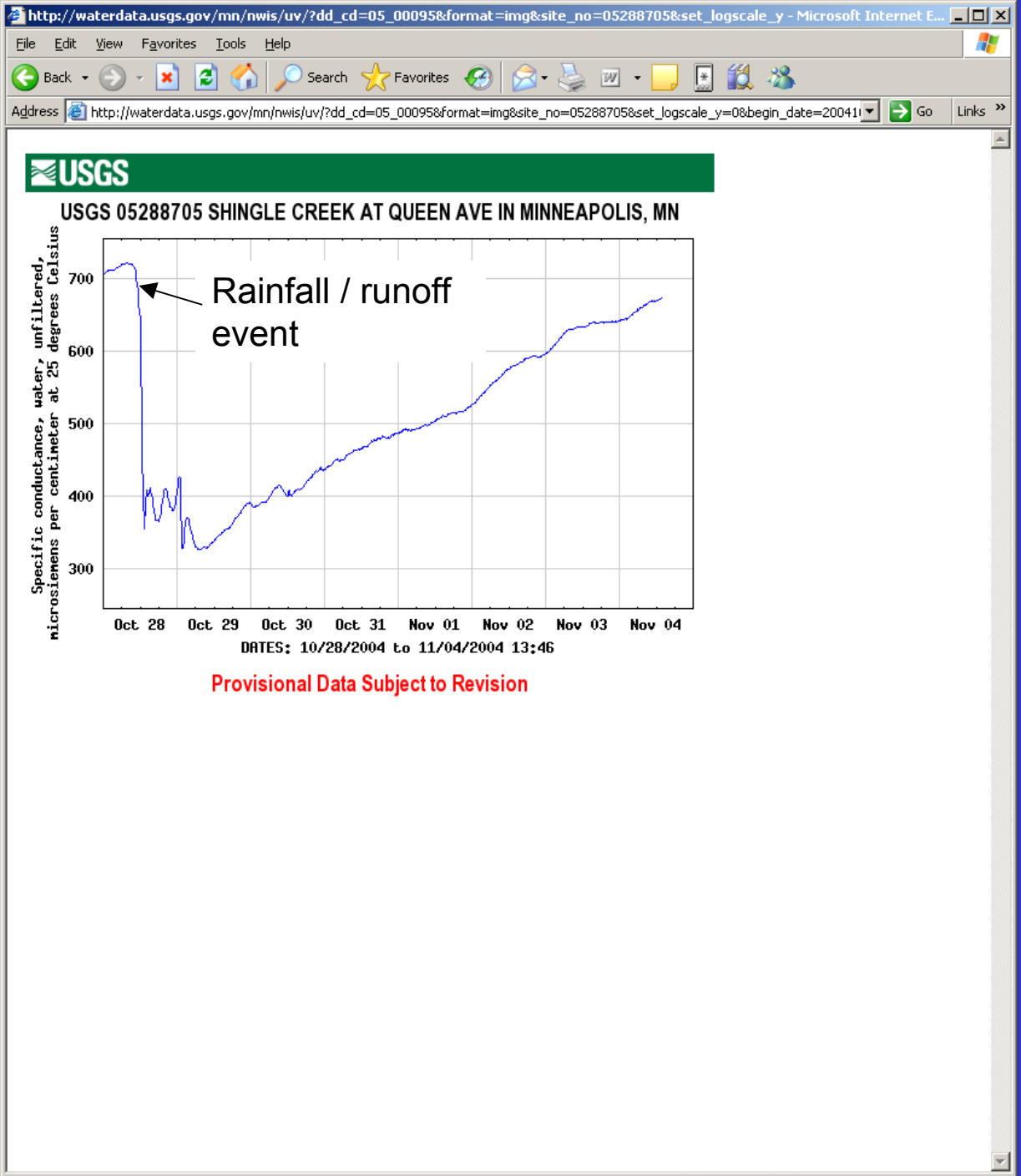
Specific conductance, water, unfiltered, microsiemens per centimeter at 25 degrees Celsius

Most recent value: 674 11-04-2004 13:45



Done Internet

USGS

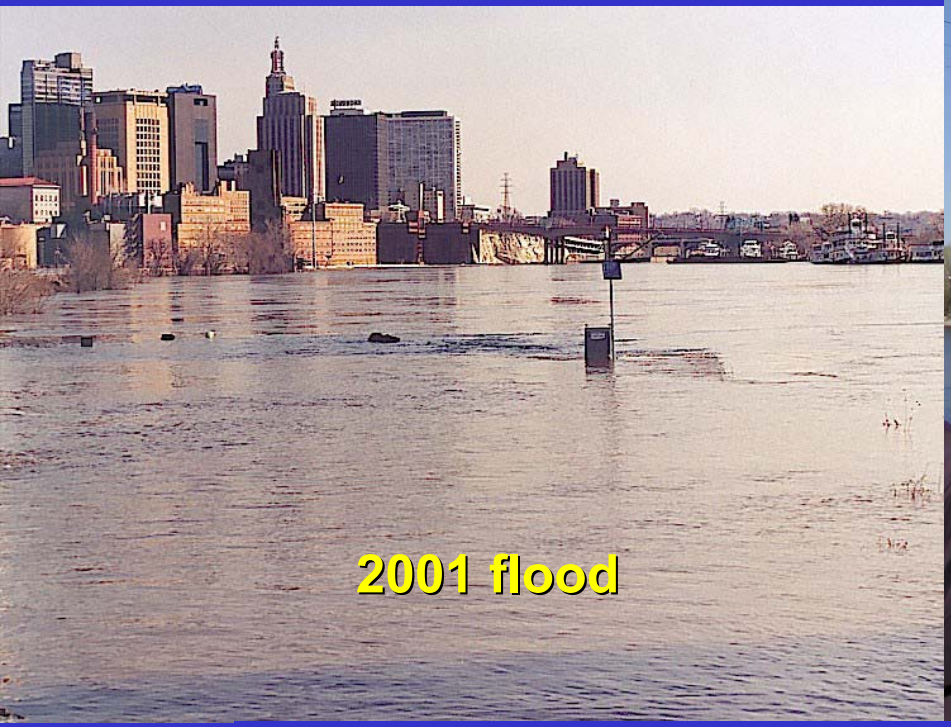


Full view of Shingle Creek Graph of Specific Conductance

Conductance varies inversely with stream flow

USGS

Example Stream Gaging Site on Mississippi River at St. Paul



2001 flood

Site gaged since 1867

USGS

Some Uses of USGS Real-Time Streamflow Data

- Water recreation activities
- Flood warning and forecasting
- Prediction of droughts
- Water-quality assessments
- Reservoir operation
- Discharge regulation
- Flood plain regulation
- Stream waste load determination
- Design of bridges and flood control structures
- Water supply development and management

Millions of hits per day on our web sites

USGS

USGS Real-Time Ground-Water Data Acquisition

USGS Real-Time Ground-Water Level Data Acquisition

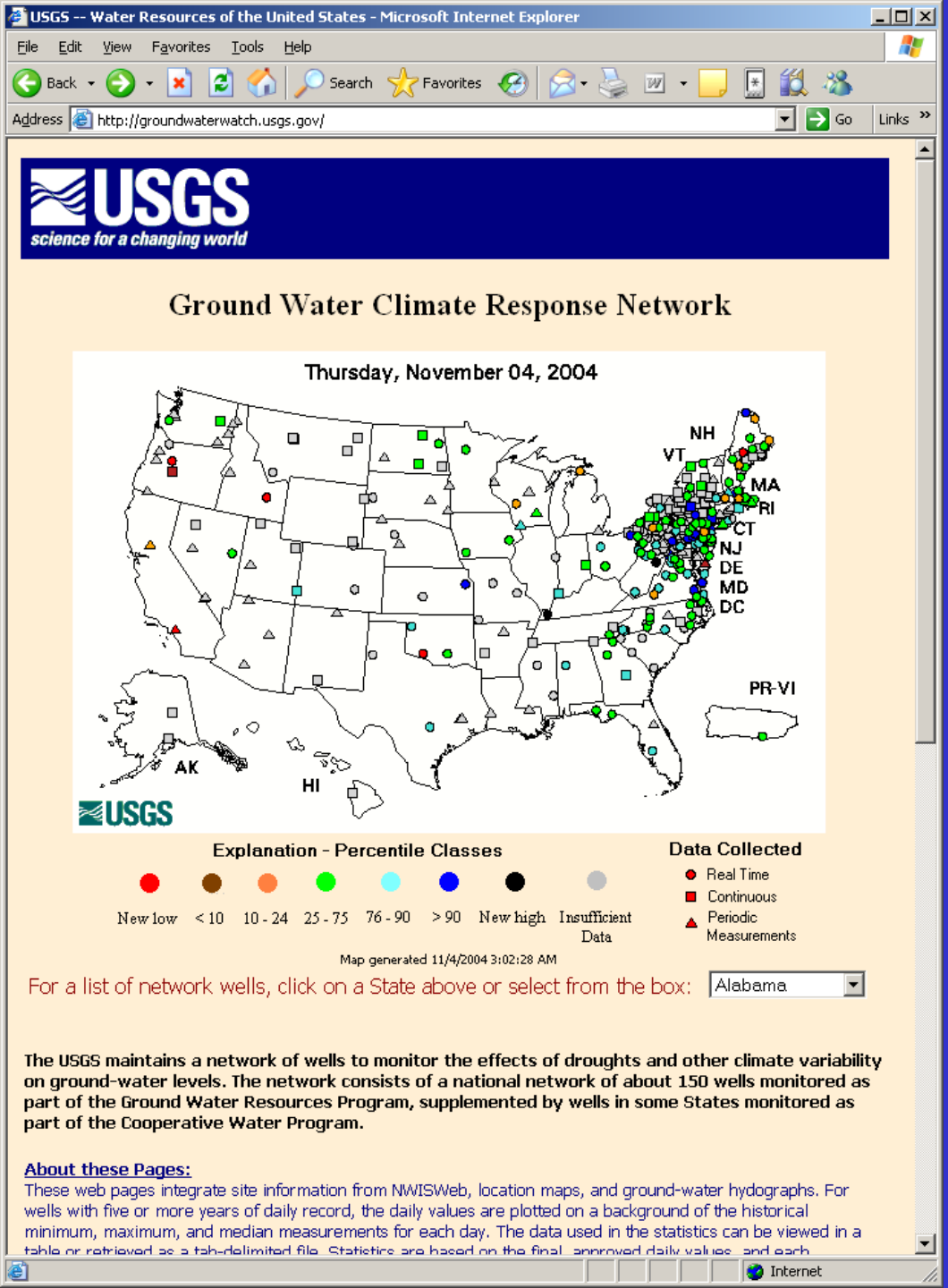
- Two USGS real-time networks
  - Climate response network (nationwide)
  - Minn. real-time monitoring network (currently working with the MDNR and other agencies)
- All data served to Web
- Measurements made hourly
- Data other than water levels recorded (e.g. – precipitation)

USGS

Purposes of Climate Response Network

- Increase public awareness of changes in ground-water storage as related to the effects of droughts and other climate variability factors, and
- To provide water managers and the public with GW level data that can be utilized for a variety of planning activities

USGS

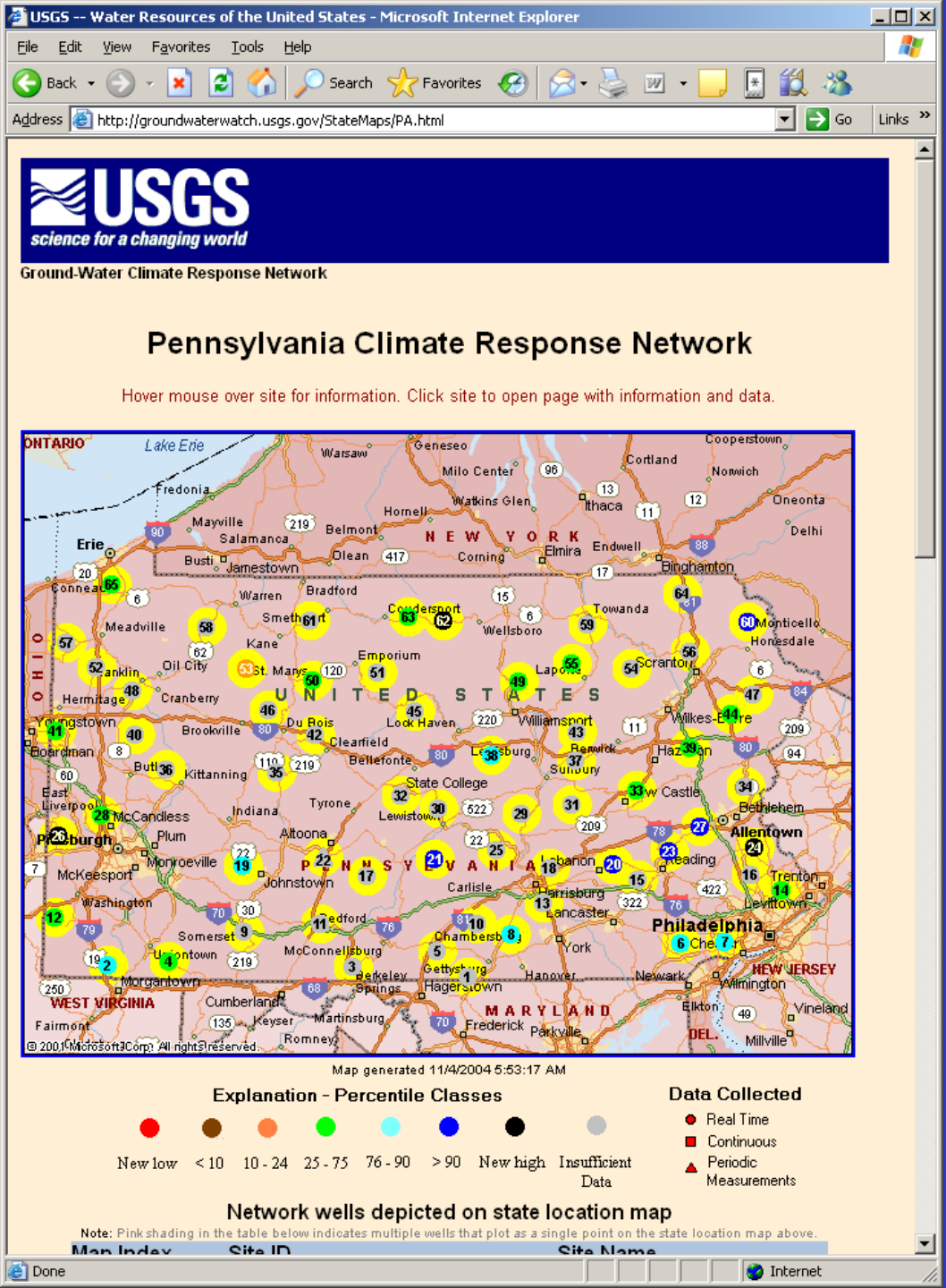


Real-Time Ground-Water Level Climate Response Network

150 wells nationwide

http://groundwaterwatch.usgs.gov

USGS



Pennsylvania Climate Response Network

Jointly funded by USGS and State agencies

USGS

USGS -- Water Resources of the United States - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Back Search Favorites

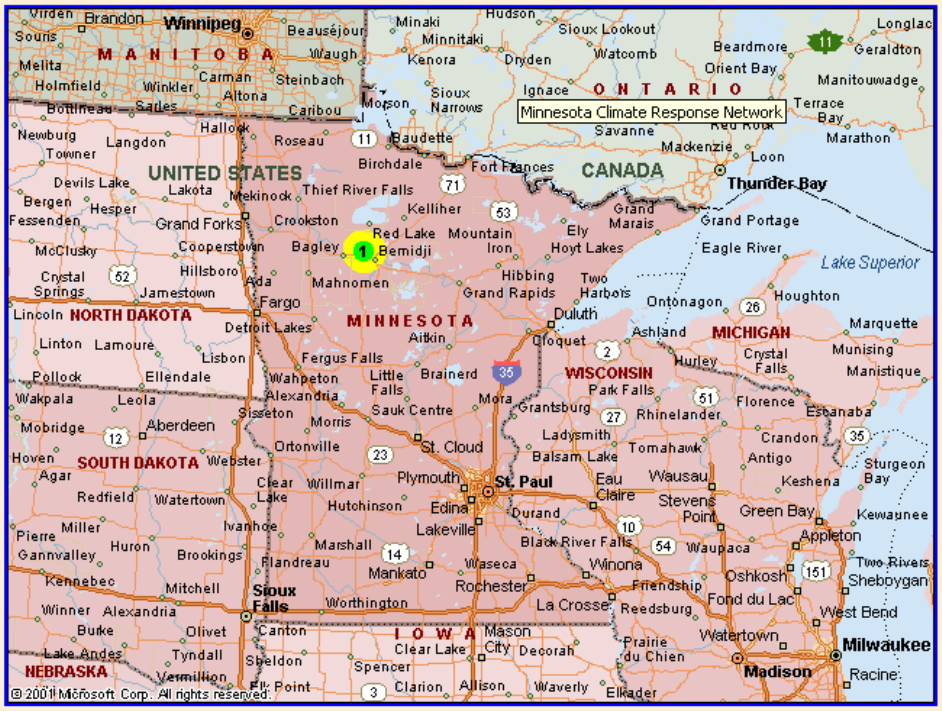
Address http://groundwaterwatch.usgs.gov/StateMaps/MN.html Go Links

USGS science for a changing world

Ground-Water Climate Response Network

Minnesota Climate Response Network

Hover mouse over site for information. Click site to open page with information and data.



Map generated 11/4/2004 5:43:27 AM

Explanation - Percentile Classes

New low | < 10 | 10 - 24 | 25 - 75 | 76 - 90 | > 90 | New high | Insufficient Data

Data Collected

- Real Time
- Continuous
- Periodic Measurements

Network wells depicted on state location map

Note: Pink shading in the table below indicates multiple wells that plot as a single point on the state location map above.

Map Index Site ID Site Name

Done Internet

Minnesota Climate Response "Network"

Funded entirely with USGS $$

USGS

USGS -- Water Resources of the United States - Microsoft Internet Explorer

File Edit View Favorites Tools Help

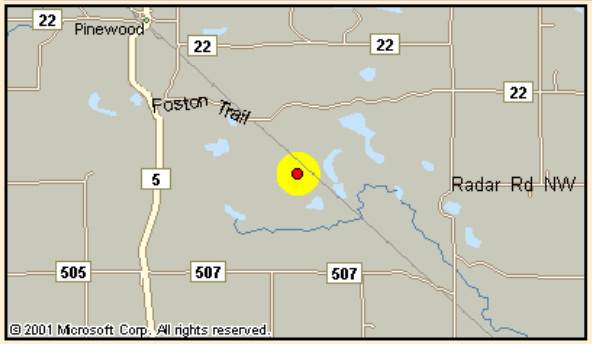
Back Search Favorites

Address http://groundwaterwatch.usgs.gov/CRNSites.asp?S=473423095053301 Go Links

USGS
science for a changing world

Ground-Water Climate Response Network.

Site Number: 473423095053301 - 147N35W02CDCBDD Bemidji 310d



LOCATION
Latitude 47°34'23", Longitude 95°05'33" NAD27,
Beltrami County, Minnesota , Hydrologic Unit 07010101

WELL DESCRIPTION
The depth of the well is 34.83 feet below land surface.Altitude of land surface datum 1,420.45 feet above sea level NGVD29.The depth of the hole is 110 feet below land surface.
This well is completed in OUTWASH DEPOSITS (112OTSH)

AVAILABLE DATA:

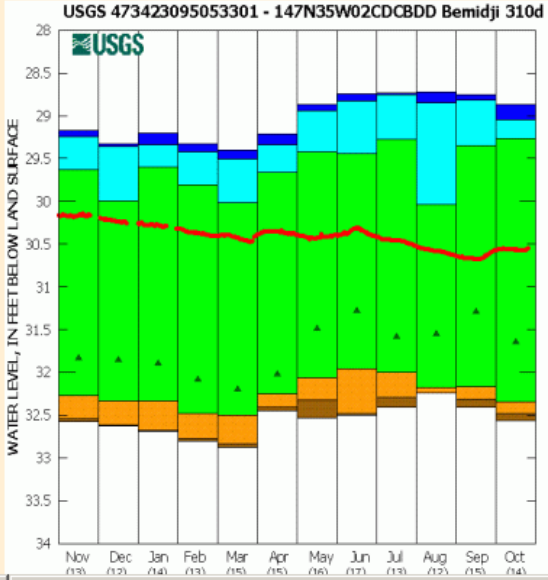
Data Type	Begin Date	End Date	Count
Real-time	This is a real-time site		
Ground-water levels	1983-05-25	2003-09-24	267

OPERATION:
Record for this site is maintained by the USGS office in Minnesota

CONTACT INFORMATION
Email questions about this site to Water Webserver Team

Site Statistics

USGS 473423095053301 - 147N35W02CDCBDD Bemidji 310d



Period of Record Monthly Statistics
Water Level, Feet Below Land Surface

	High	90th %ile	75th %ile	50th %ile	25th %ile	10th %ile	Low
Jan	29.20	29.34	29.60	31.88	32.33	32.68	32.69
Feb	29.33	29.42	29.81	32.07	32.48	32.77	32.80
Mar	29.40	29.51	30.02	32.19	32.50	32.83	32.87
Apr	29.21	29.34	29.66	32.01	32.25	32.41	32.45
May	28.87	28.94	29.42	31.48	32.06	32.32	32.53
Jun	28.74	28.83	29.44	31.27	31.96	32.48	32.50
Jul	28.73	28.76	29.28	31.57	32.00	32.29	32.41
Aug	28.72	28.85	30.04	31.54	32.18	32.24	32.24
Sep	28.75	28.82	29.35	31.28	32.16	32.31	32.41
Oct	28.87	29.05	29.27	31.63	32.34	32.48	32.56
Nov	29.17	29.24	29.63	31.82	32.27	32.54	32.57
Dec	29.33	29.36	30.00	31.84	32.33	32.61	32.62

Statistics Options

Internet

Bemidji Real-Time Ground-Water Level Station

USGS

Real-time data for USGS 473423095053301 147N35W02CDCBDD Bemidji 310d - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Back Search Favorites

Address http://waterdata.usgs.gov/nwis/uv?site_no=473423095053301 Go Links

USGS

District Access
Water Resources

Data Category: Real-time
Geographic Area: United States
go

Rescheduled - The nwis.waterdata.usgs.gov server will be undergoing maintenance Monday, November 8, 2004 from 9:00 AM until 12:00 PM EDT and will not contain the latest real-time data during this time period. All real-time data will continue to be available at http://waterdata.usgs.gov/nwis.

USGS 473423095053301 147N35W02CDCBDD Bemidji 310d

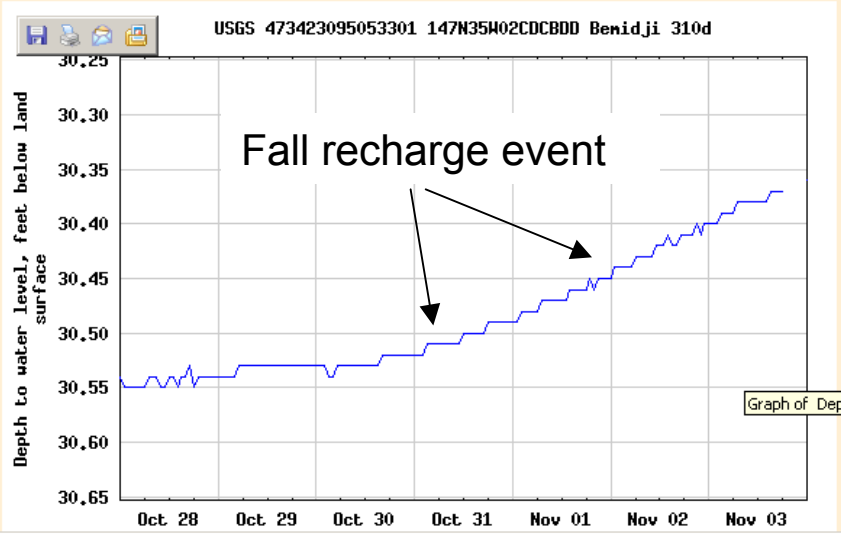
PROVISIONAL DATA SUBJECT TO REVISION

Available data for this site: Real-time GO

Available Parameters	Output format	Days	
All 2 parameters available at this site 72019 WaterLevel, BelowLSD (DD 01) 70969 DCP battery voltage (DD 02)	Graph	7 (1-31)	get data

Depth to water level, feet below land surface

Most recent value: 30.36 11-04-2004 00:00



Done Internet

Graph of Most Recent Real-Time Data

USGS

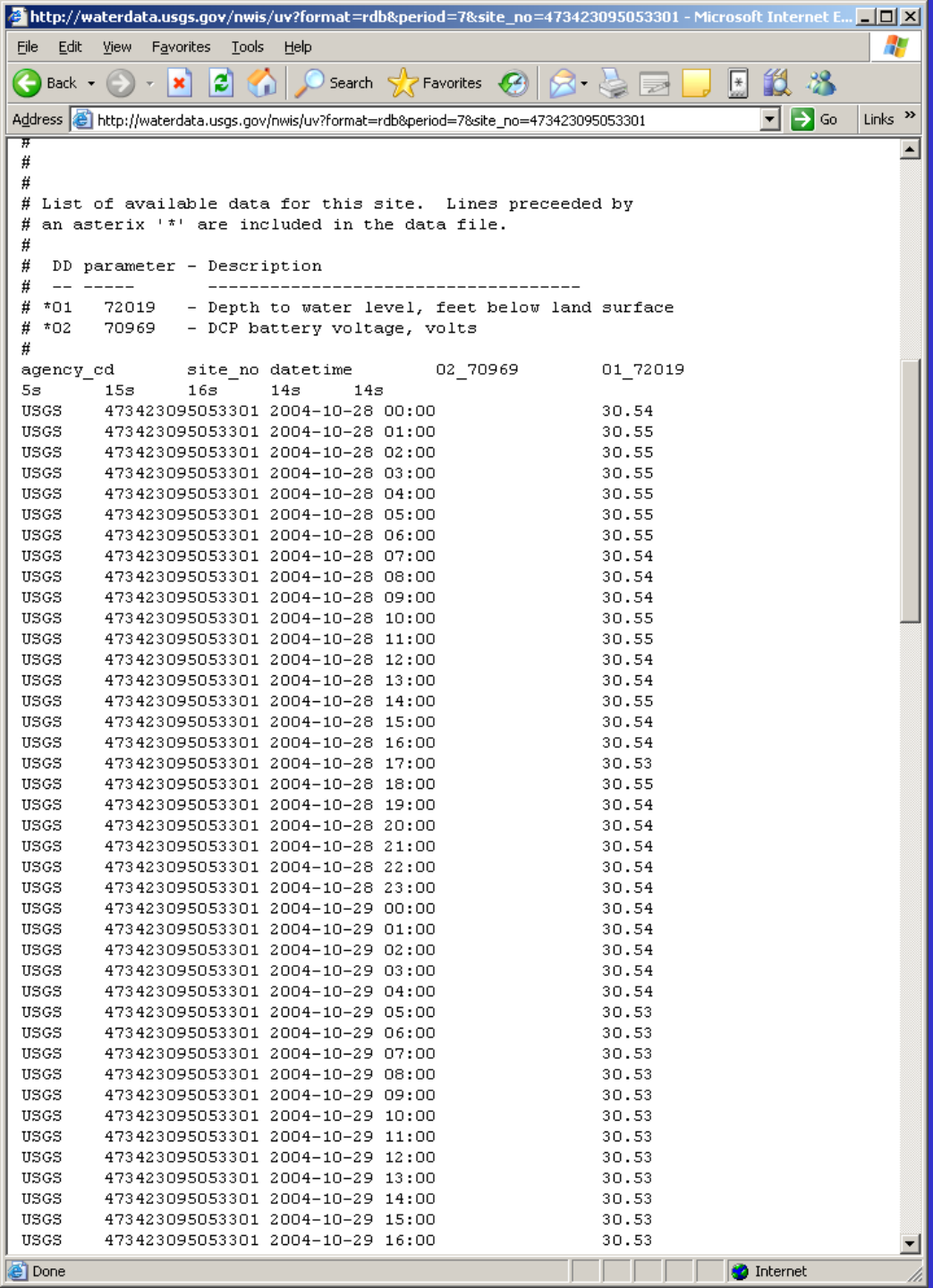


Table of Most Recent Real-Time Data

USGS

USGS Research Site near Bemidji

Bemidji Ground Water Climate Response Well

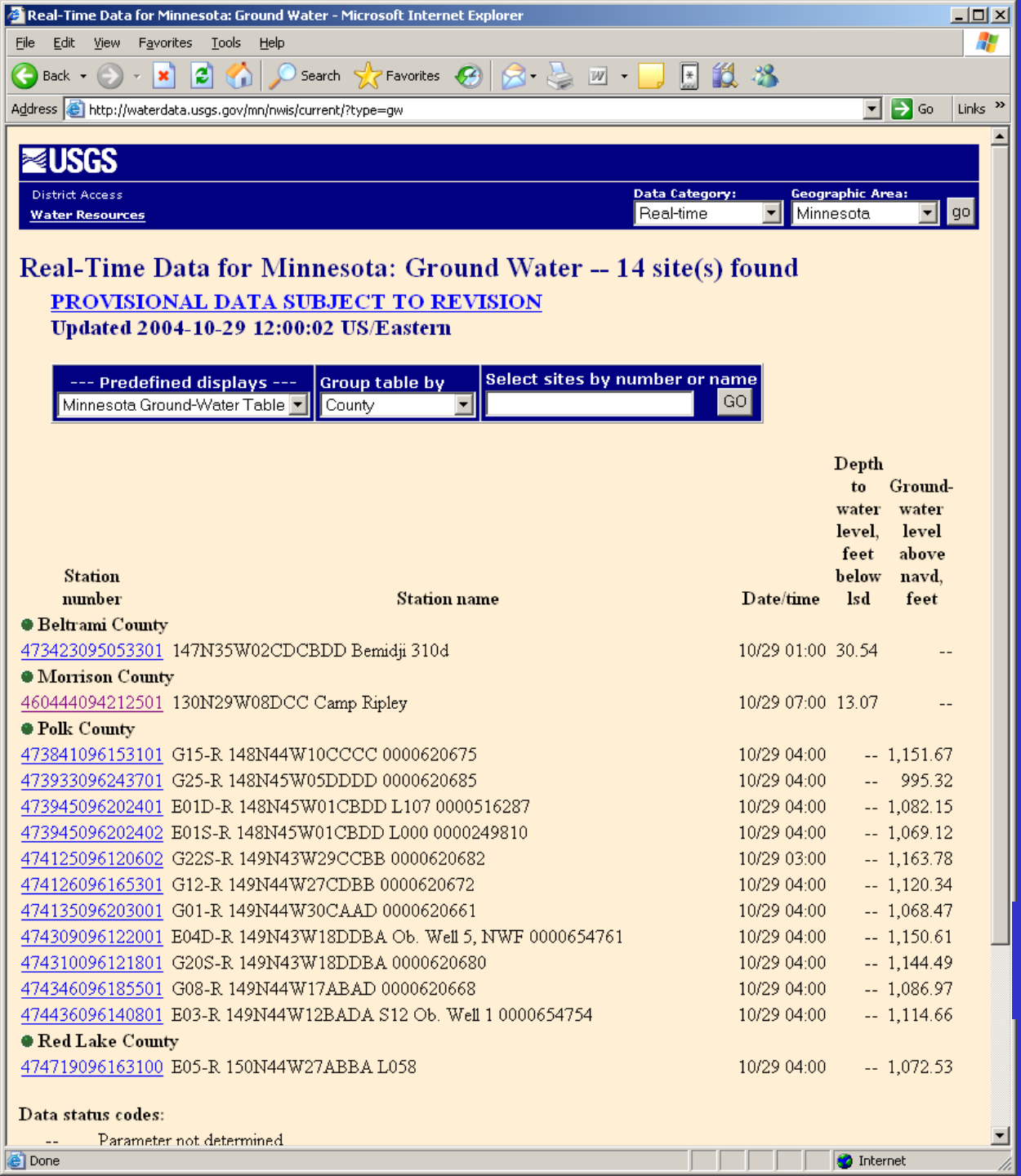
USGS

Purposes of Minnesota Real-Time Ground-Water Level Network

- To provide high-frequency data to the Web
- To provide water managers and the public with GW level data that can be utilized for a variety of planning activities, such as:
- To monitor the effects of natural processes (e.g. recharge, ET, GW/SW interaction)
- To monitor aquifer stresses related to human activities (e.g. pumping, urbanization)

Real-time wells in other states

USGS



Minnesota Real-Time Ground-Water Level Monitoring Sites

13 wells in network

USGS

Real-time data for USGS 473841096153101 G15-R 148N44W10CCCC 0000620675 - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Back Search Favorites

Address http://waterdata.usgs.gov/mn/nwis/uv/?site_no=473841096153101&PARAmeter_cd=72019,62611 Go Links

USGS

District Access
Water Resources

Data Category: Real-time Geographic Area: Minnesota go

Rescheduled - The nwis.waterdata.usgs.gov server will be undergoing maintenance Monday, November 8, 2004 from 9:00 AM until 12:00 PM EDT and will not contain the latest real-time data during this time period. All real-time data will continue to be available at http://waterdata.usgs.gov/nwis.

USGS 473841096153101 G15-R 148N44W10CCCC 0000620675

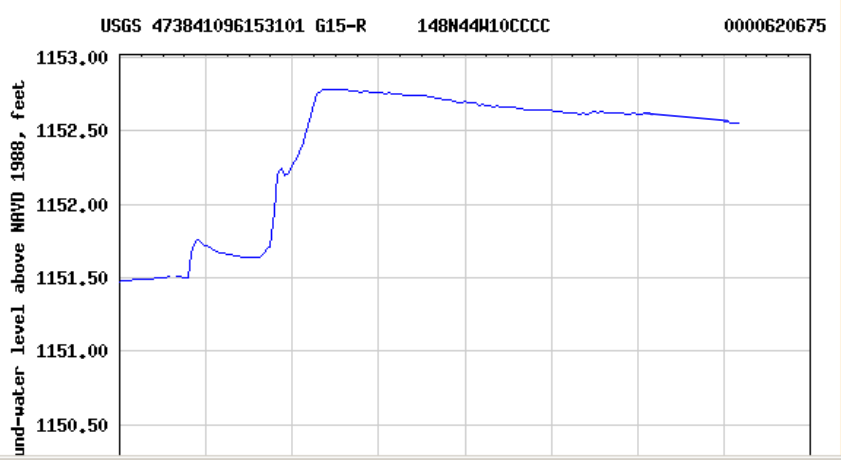
PROVISIONAL DATA SUBJECT TO REVISION

Available data for this site Real-time GO

Available Parameters	Output format	Days	
All 5 parameters available at this site 62611 Water level, NAVD (DD 01) 00010 Temperature, water (DD 02) 70969 DCP battery voltage (DD 03)	Graph	7 (1-31)	get data

Ground-water level above NAVD 1988, feet

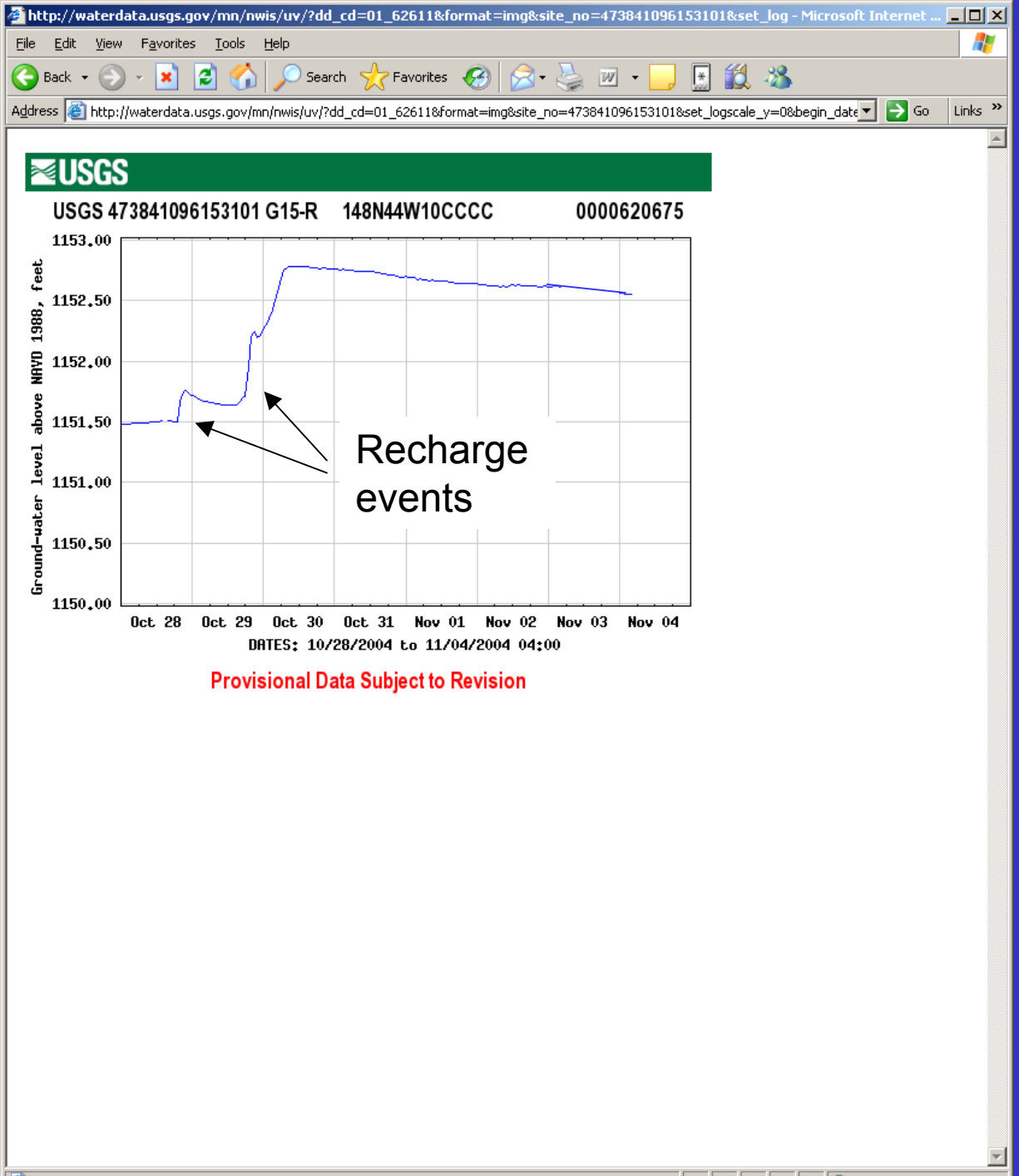
Most recent value: 1,152.55 11-04-2004 04:00



Done Internet

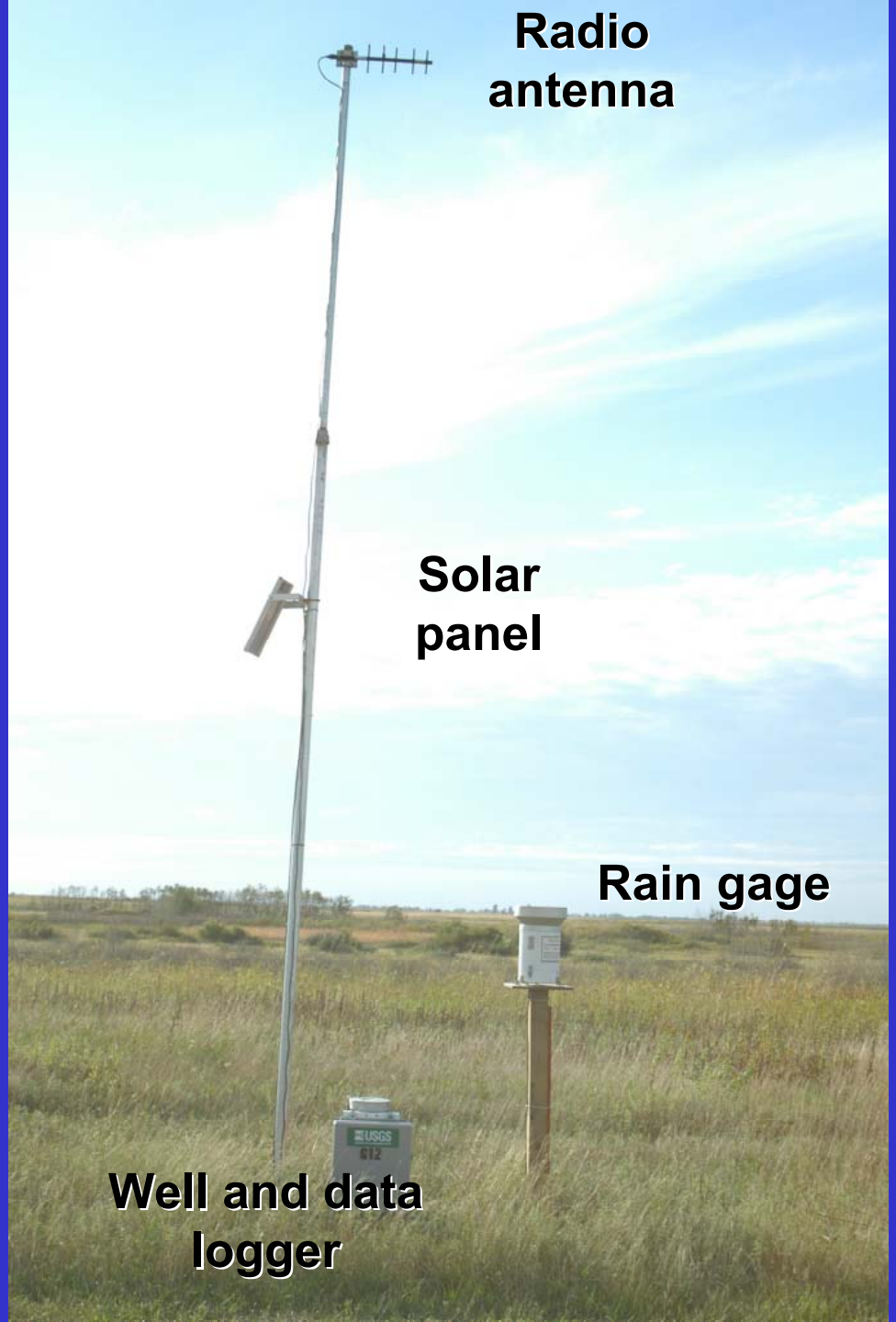
Glacial Ridge Project Monitoring Site well G15

USGS



Full View of Glacial Ridge Well G15 Hydrograph

USGS



Example Real-Time Ground Water Instrumentation

Glacial Ridge study: Ten well transmitter stations within 10 miles of each other

USGS


Real time monitoring of well with water level above land surface

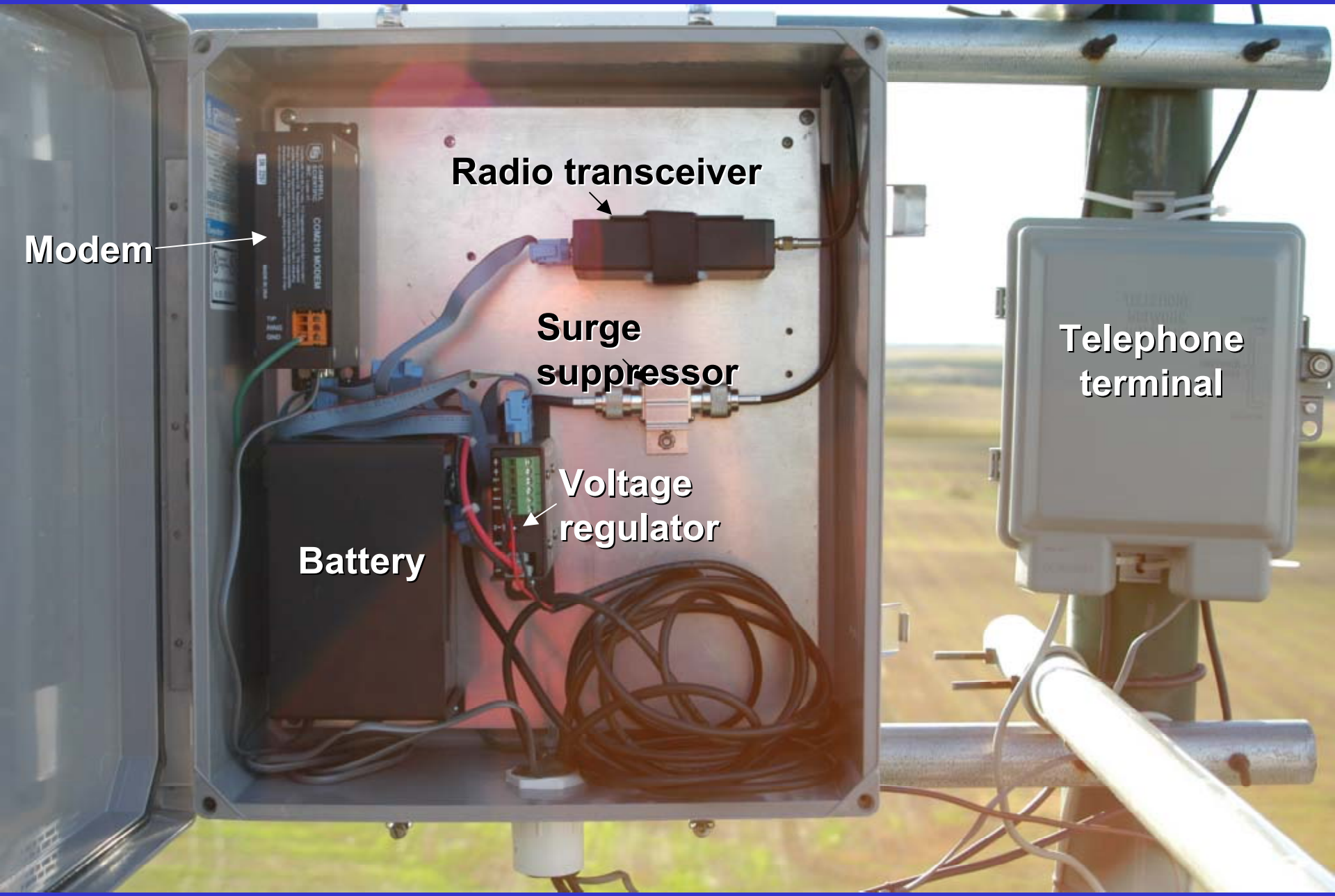
Inside of data logger shelter

USGS

Data from all ten stations transmitted to this receiver tower

USGS did not build this tower

USGS



Radio receiver equipment and modem

USGS

Why would anyone measure ground-water levels continuously?

Why would they do it hourly?

USGS

One use of continuous ground-water level measurements:

Accurate estimation of recharge

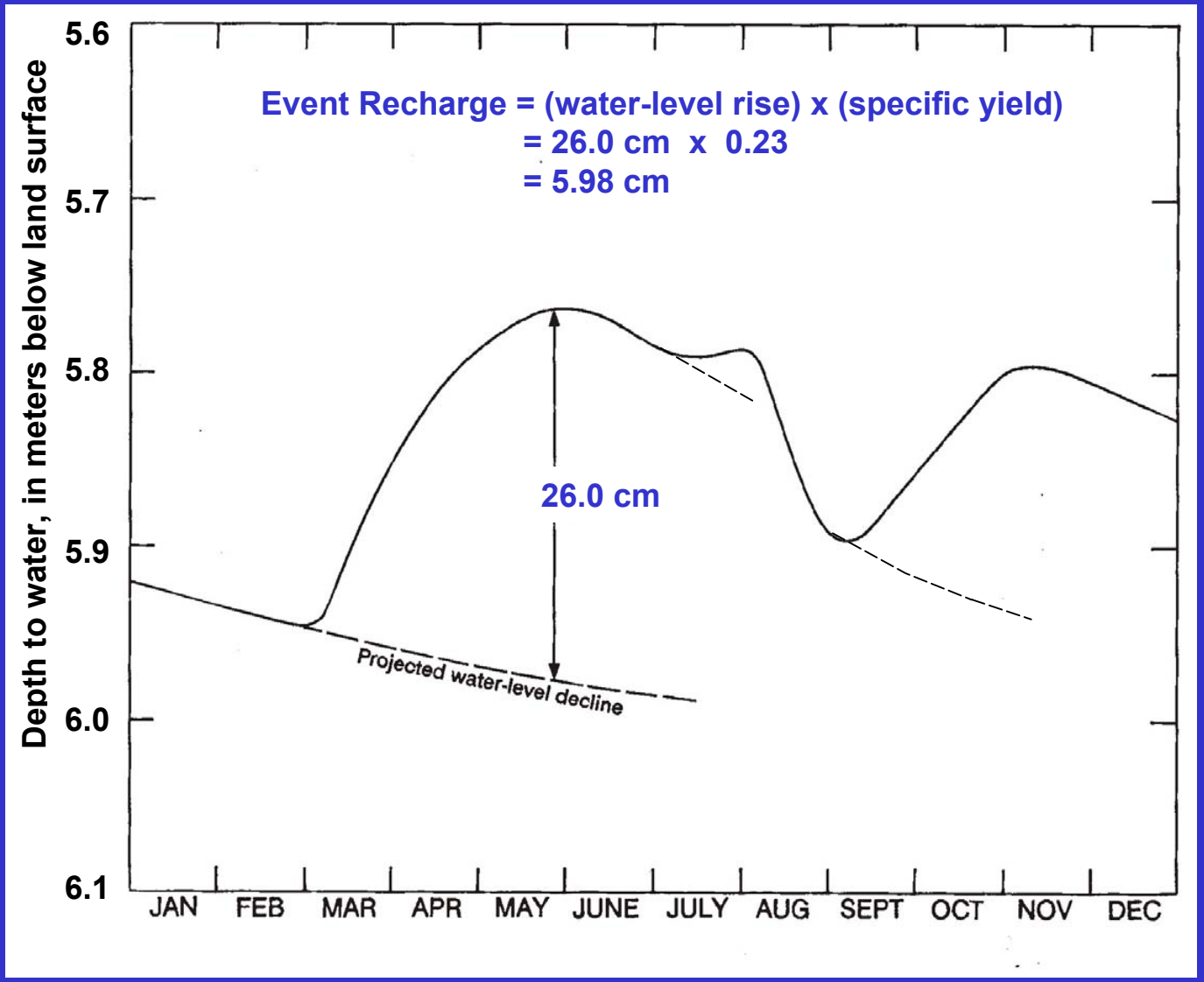
USGS

Ongoing USGS study estimating recharge throughout Minnesota

- Using multiple methods, including water-table fluctuations (WTF)
- Applied WTF method to 38 wells instrumented with data loggers

USGS

Recharge Based on Water-Table Fluctuations



Example graph from Delin (1990)

Graphical WTF approach (shown) and others used

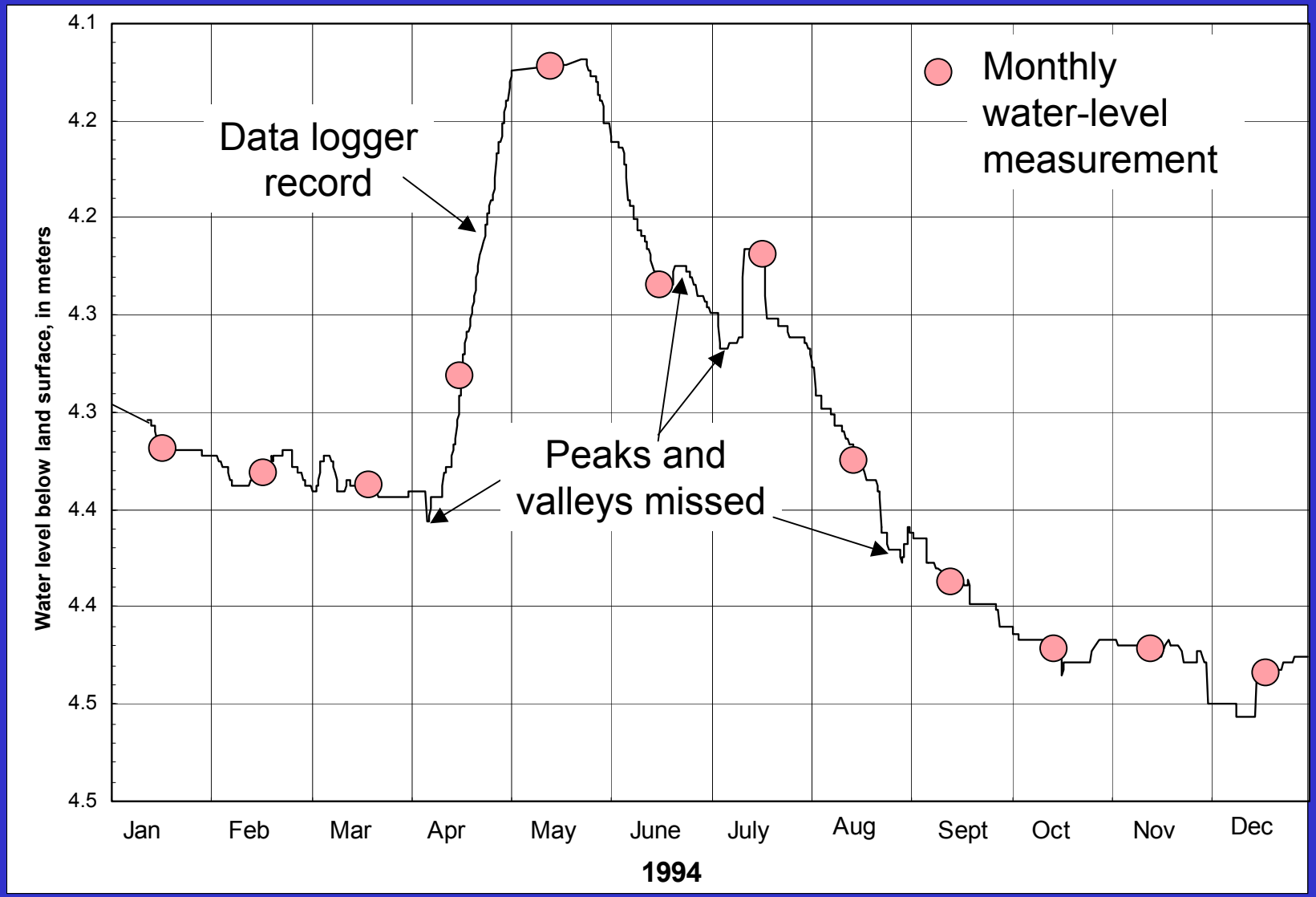
USGS

Effects of Water-Level Measurement Frequency on Recharge – an example

- Agricultural chemical, farming systems effects on water quality site near Princeton, MN
- Research by USGS, USDA-ARS, UofM Soils Dept. (MSEA study)
- Sand plain with rapid recharge and high hydraulic conductivity
- Data collected from 1992-95

USGS

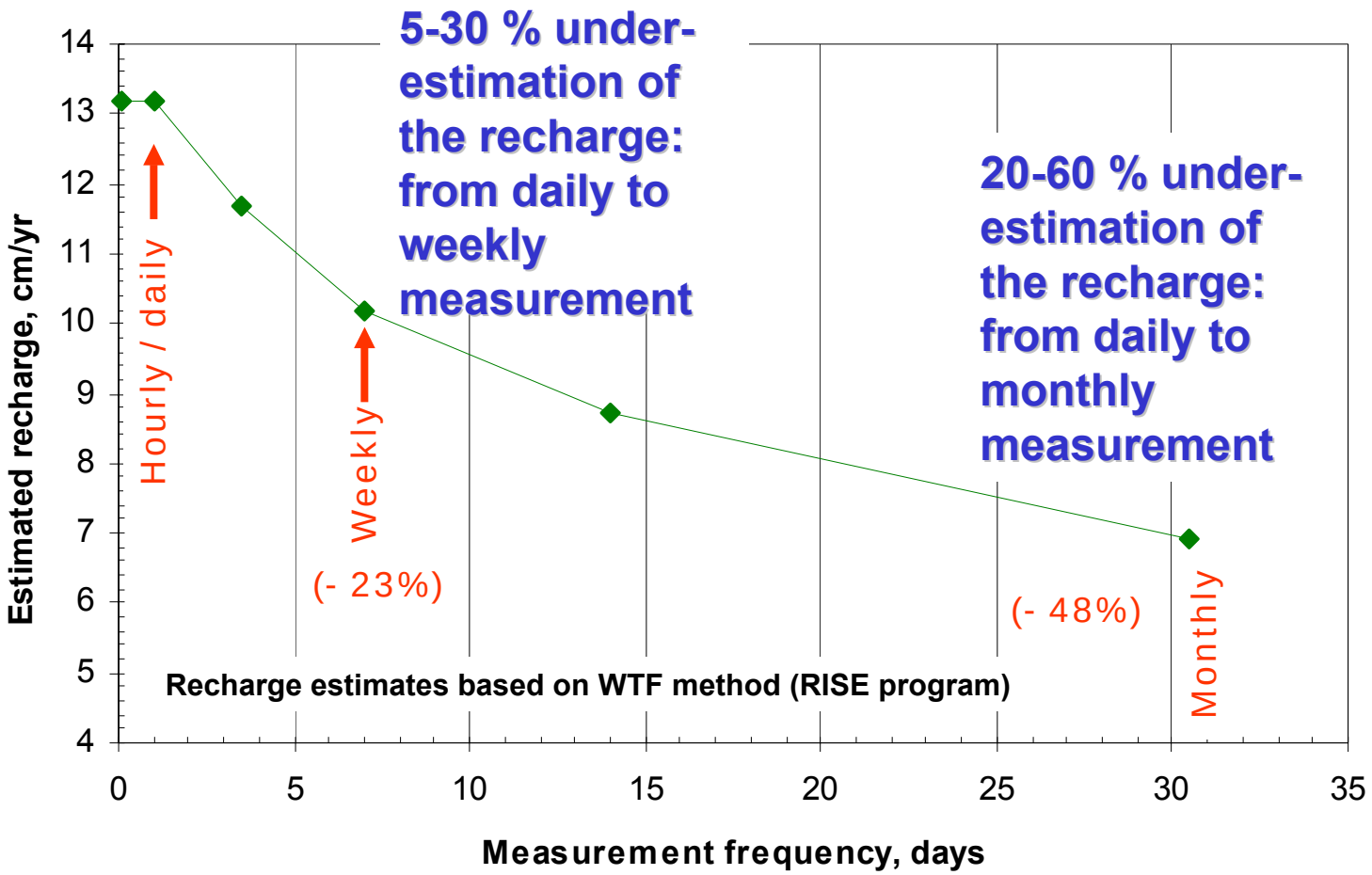
MSEA Well R2 – 1994 water levels



USGS

Effects of Measurement Frequency on Recharge Estimates

No change in estimated recharge going from hourly to daily measure



MSEA well R2 near Princeton, MN: 1994 data

USGS

Accurate Recharge Estimates are Critical in Most Water Resource Investigations

- GW flow simulations
- Aquifer vulnerability to contamination
- Chemical flux estimates and contaminant transport evaluations (e.g. – MSEA)
- Ground-water supply and water budget analyses
- Wellhead protection studies
- Well interference issues
- GW/SW interaction studies
- Etc., etc., etc.

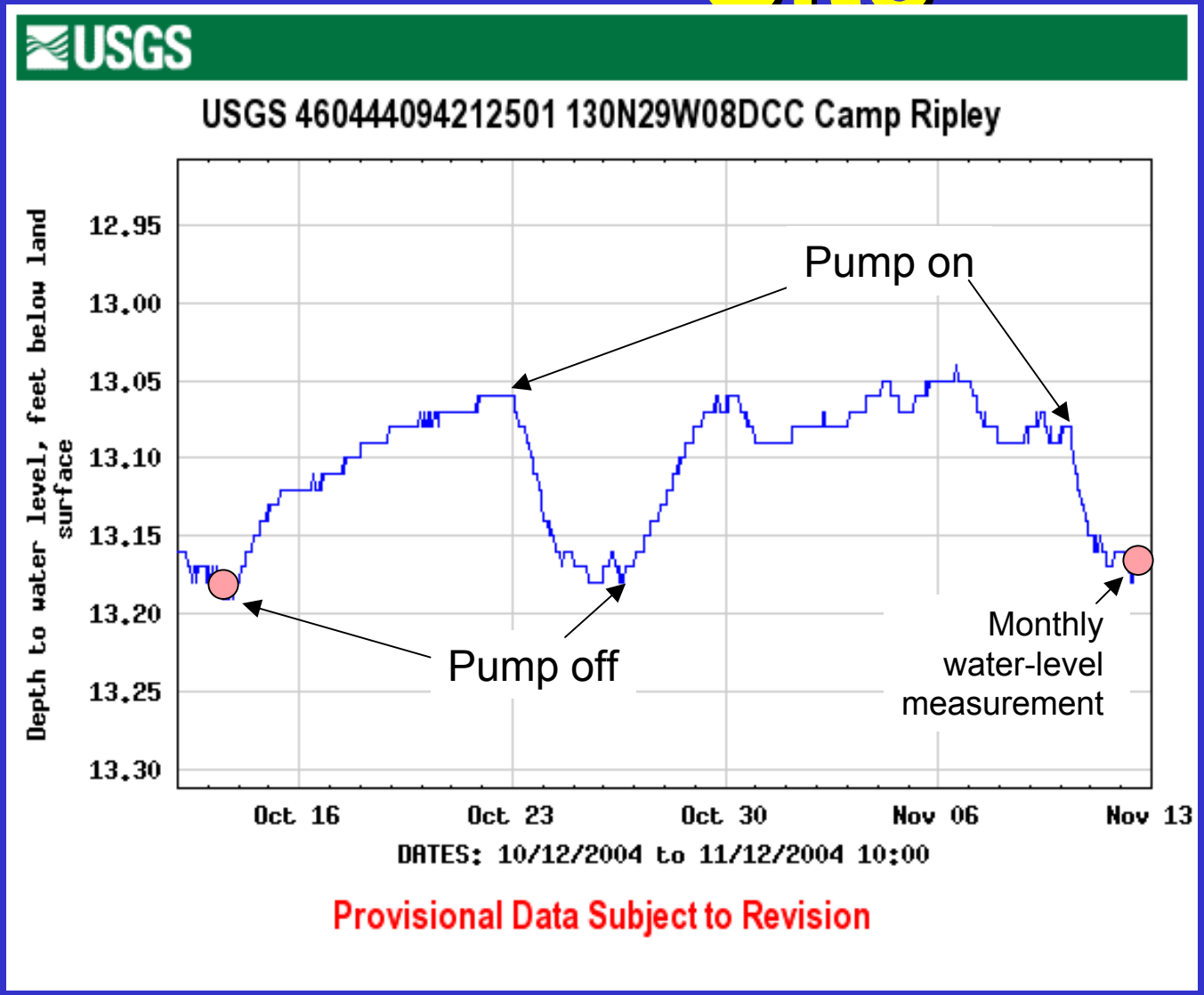
USGS

Another use of continuous ground-water level measurements:

Monitoring the effects of pumping

USGS

Camp Ripley Real-Time Site



Pumping well ~400 feet away

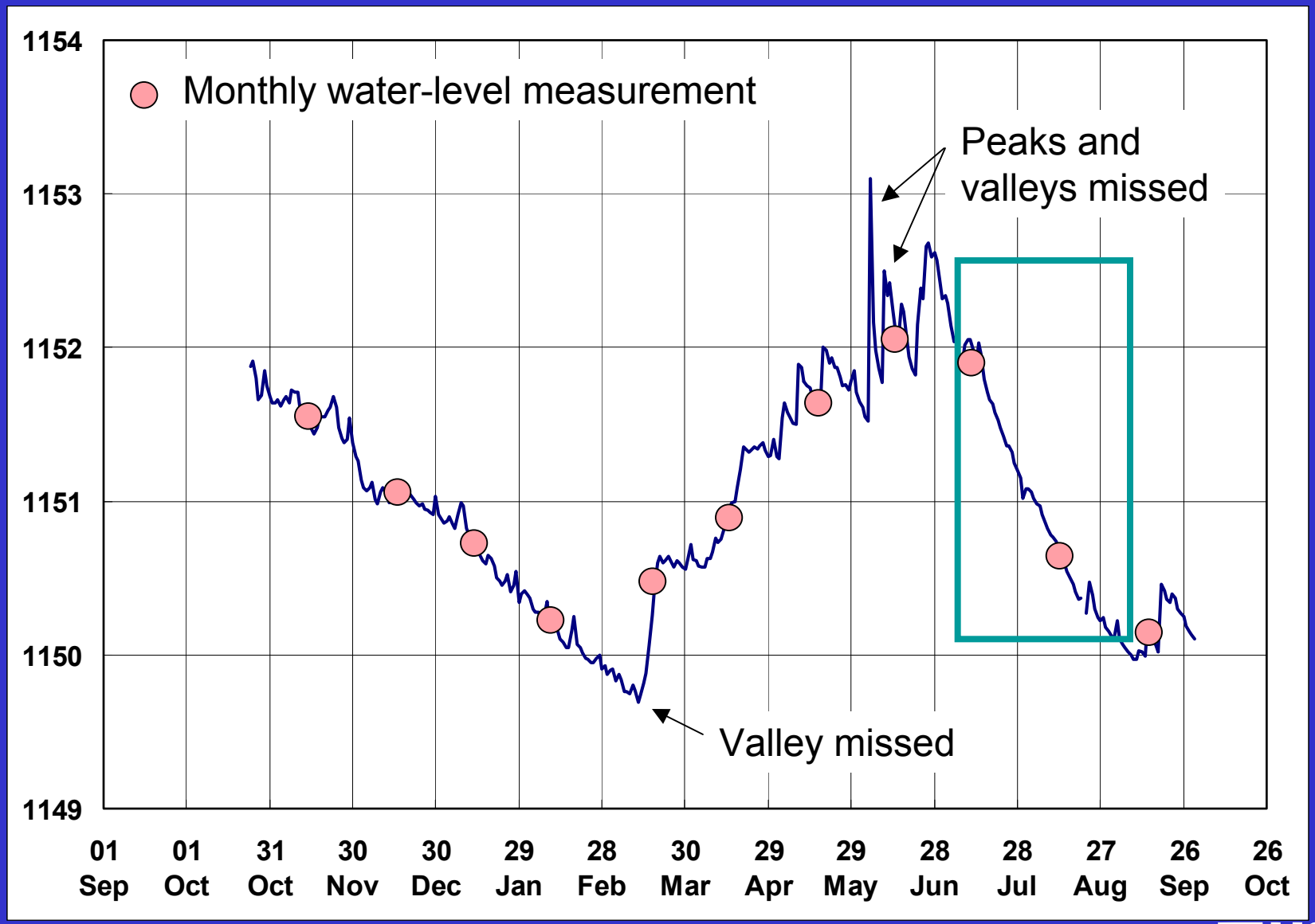
USGS

Another use of continuous ground-water level measurements:

Evaluate the effects of evapotranspiration

USGS

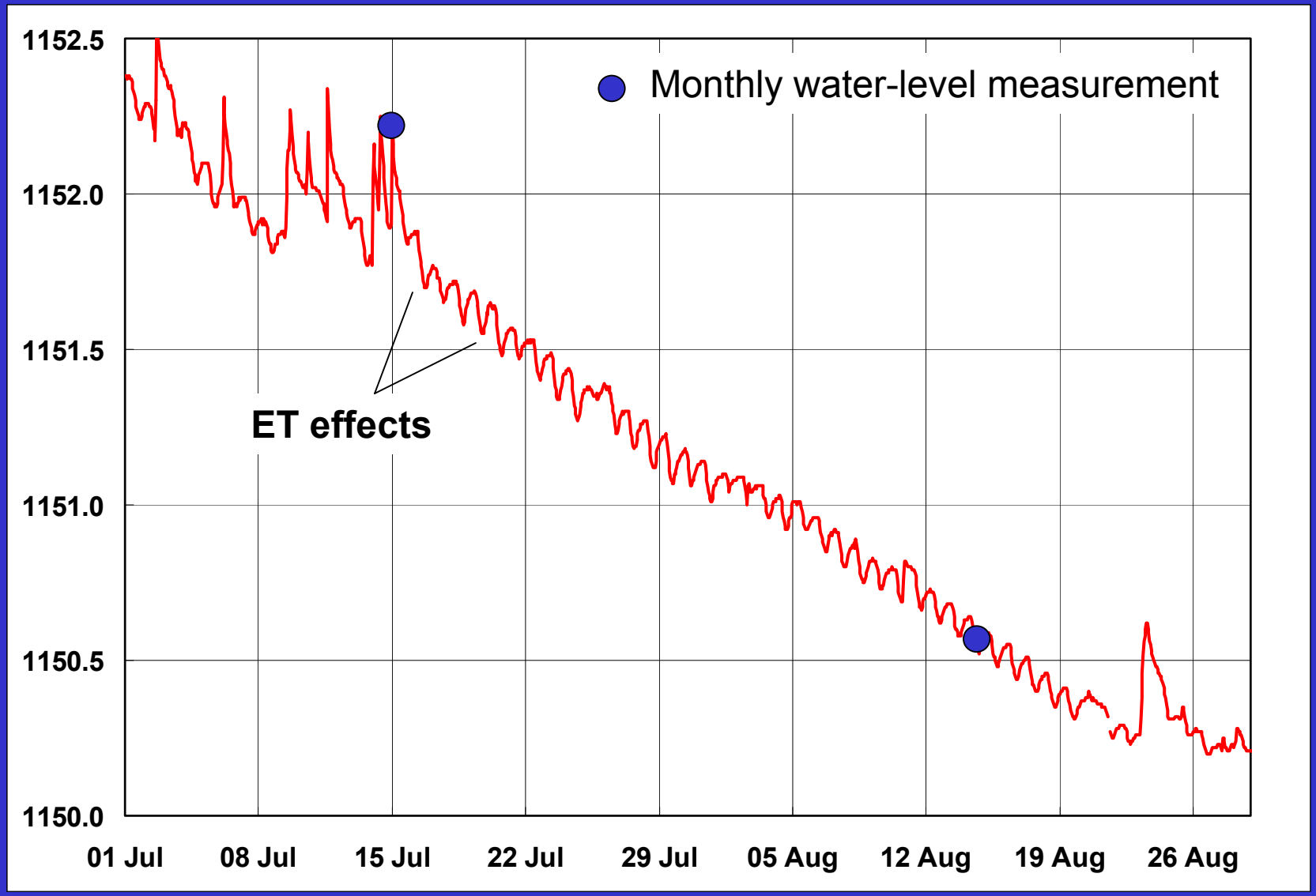
Well G15 Water Levels



Oct. 2003 – Sept. 2004

USGS

Well G15 — July & August 2003 hourly values



Depth to water table: ~ 3 feet

USGS

Prairie wetland near well G15

Depth to water table: ~ 3 feet

USGS

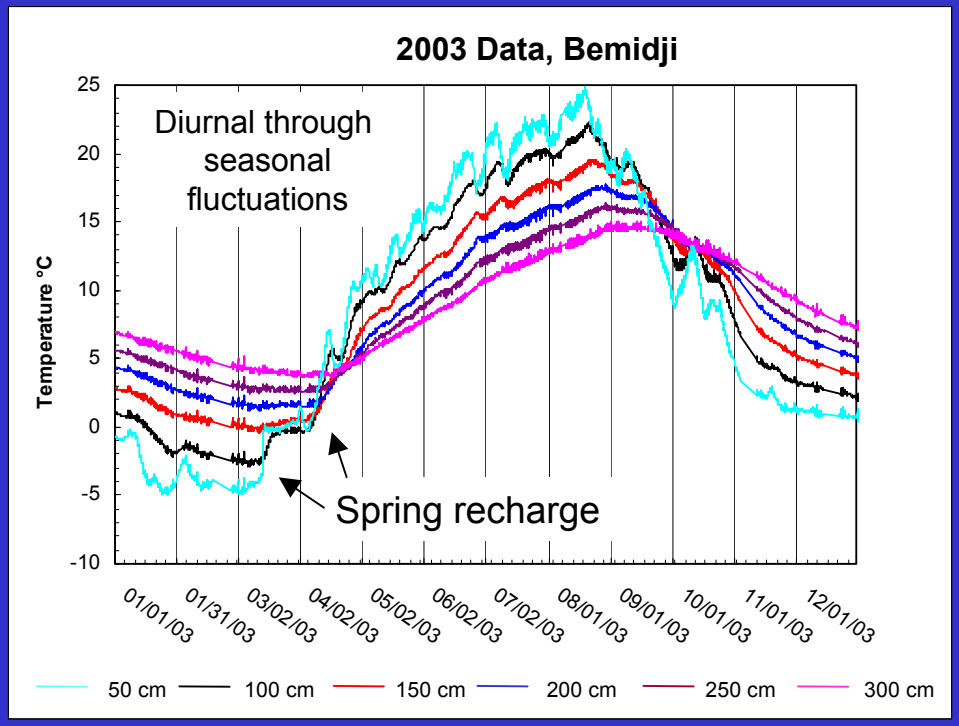
Future Plans for USGS Real-Time Monitoring in Minnesota

- Expand USGS climate response network
- Work with cooperating agencies to monitor ground water of interest
- Add at least one new well to network for each new cooperative ground water study
- Selected sites may include soil moisture, soil temperature, and precipitation

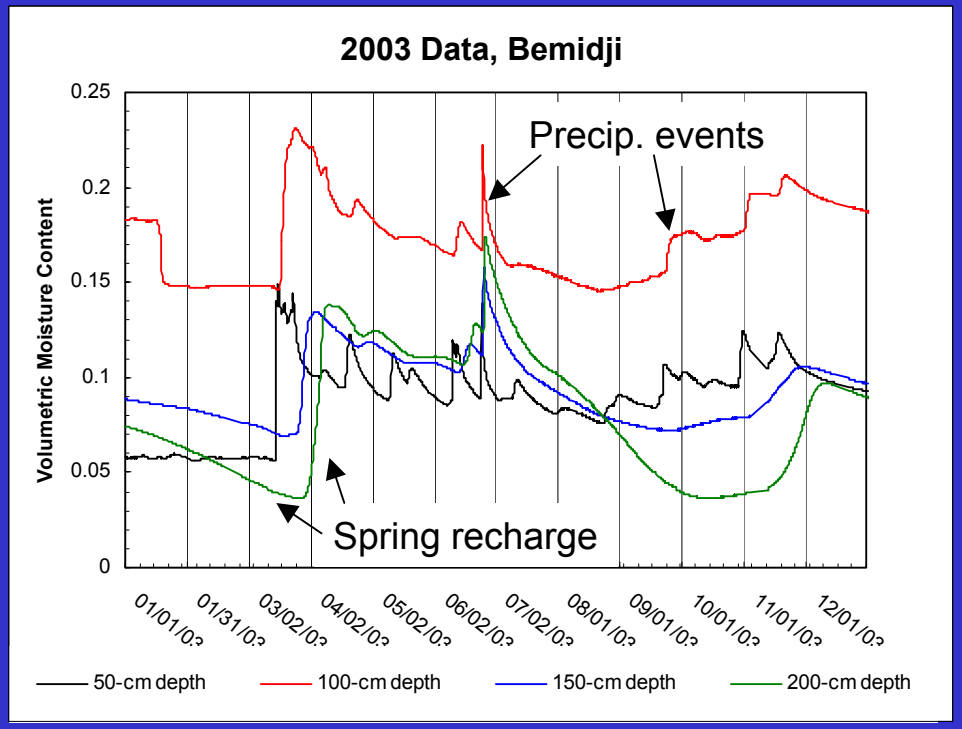
USGS

Future Data Collection Examples

Soil Temperatures



Soil Moisture



Unsaturated zone data

USGS

Summary & Benefits of Ground Water Real-Time Monitoring

- Accurately estimate recharge
- Estimate evapotranspiration
- Effects of climate change
- Real-time serving of data to web; can be easily downloaded
- More complete record than hand measurements
- Tend to look at data more frequently because it's easily accessible on the web, which improves quality assurance

USGS

Benefits – continued

- Data loggers can be remotely reprogrammed
- Costs are similar to conventional methods over the long run but quality and quantity of data are greatly increased
- Monitoring of municipal pumping effects
- Monitoring of irrigation effects

USGS

Questions?

USGS Fact sheets

Real-Time Web Information

- **USGS Real-Time Stream Flow web site: http://waterdata.usgs.gov/usa/nwis/rt**
- **Minnesota Real-Time Ground-Water Data web site: http://waterdata.usgs.gov/mn/nwis/gw**
- **USGS Real-Time Climate Response web site: http://groundwaterwatch.usgs.gov**

USGS