

iUTAH Cyberinfrastructure to Support Data Collection and Management for the GAMUT Monitoring Network



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USU Spring Runoff Conference
4-10-2013

Support:
EPS 1208732



innovative Urban Transitions and Aridregion Hydro-sustainability (iUTAH)

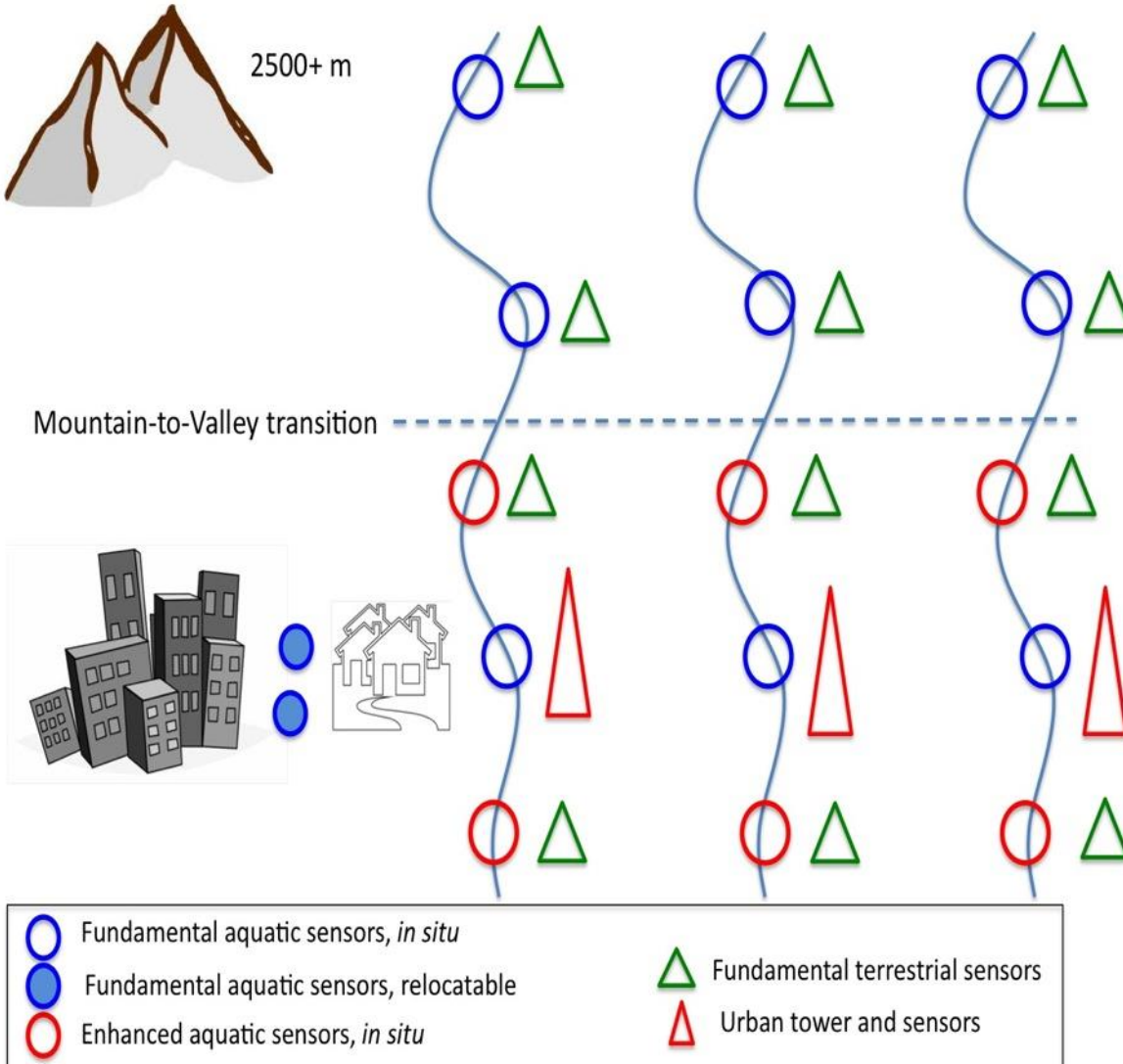
- Statewide effort
- \$20 million competitive award from NSF EPSCoR
- Research capacity building
- Interdisciplinary and multi-institution
- Focused on sustainable management of Utah's water resources



Support:
EPS 1208732

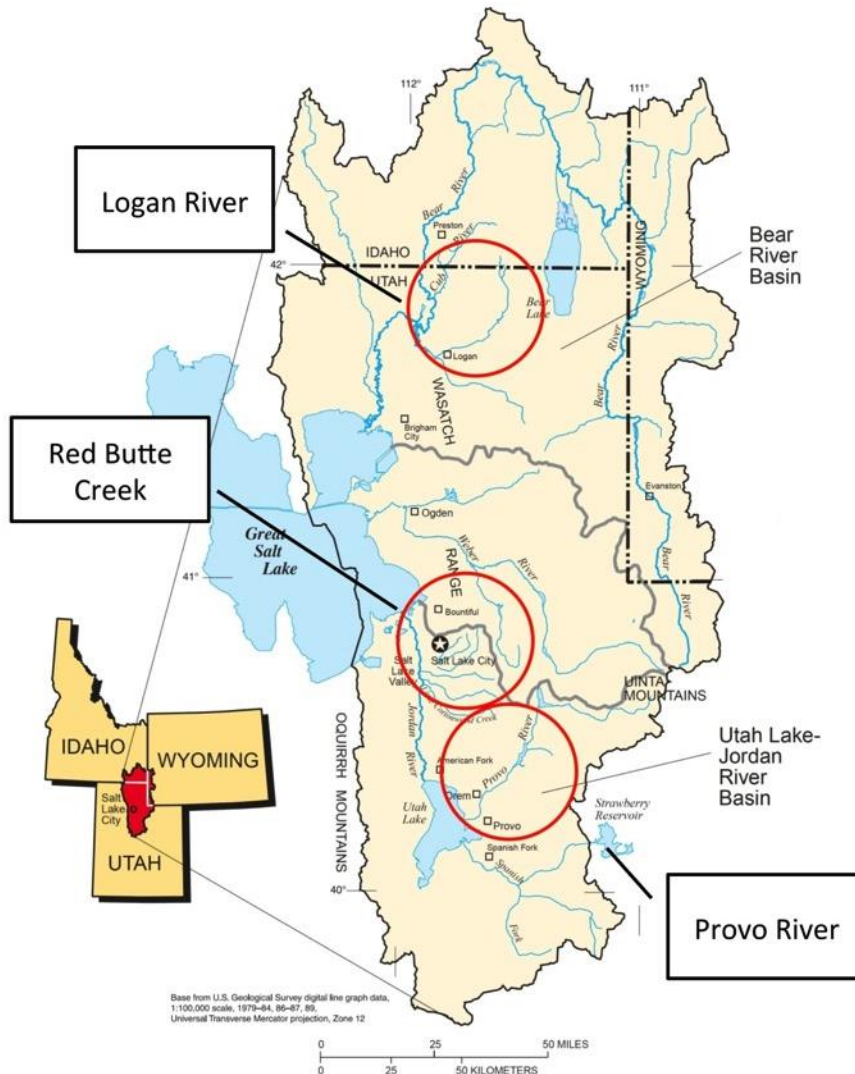
A screenshot of the iUTAH website. The header includes the iUTAH logo (a stylized mountain and cityscape) and the EPSCoR logo. The main title is "Preserving Utah's Water Resources" with the subtitle "innovative Urban Transitions and Aridregion Hydro-sustainability". Navigation links include "Home", "Team", "Reporting Sign In", "iUTAH Offices", and "Contact Us". Below the title is a green bar with links: "About iUTAH", "Research Focus Areas", "Education & Outreach", "Data & Modeling", and "Resources". The "Opportunities" section features a blue header and a large image of two people in red jackets working with a water pump. Text on the left states: "iUTAH will have opportunities, resources and project activities available to support the involvement of students, teachers and researchers at all academic levels." with a "Learn More" button. Below this are three columns of news and announcements: "News & Announcements" (Rain Barrel Project, NOAA's 11th Annual Climate Prediction Applications Science, Utah EPSCoR eligibility update), "Highlights & Upcoming Events" (WATERSHED Screening - April 9, 2013, March iUTAH Newsletter, Natural History Museum of Utah takes Learning Outdoors with...), and "Opportunities" (Utah EPSCoR Undergraduate Summer Internships, USU opens assistantships for PhD students, Doctoral Research Fellowship Hydrologic Modeling of Coupled Human Natural Systems Utah State University, Other iUTAH Fellowship Opportunities, Other Related Opportunities).

Gradients Along Mountain to Urban Transitions (GAMUT) Network



- Sensor network developed between USU/UofU/BYU
- Mix of aquatic and terrestrial *in situ* and re-locatable sensors
- Measure aspects of water inputs and outputs and water quality over gradient
- Deployed in three watersheds

Gradients Along Mountain to Urban Transitions (GAMUT) Network



- 3 watersheds have similar water source (high elevation snow) but different land use transitions
- Logan River: irrigated agriculture transitioning to moderate density urban at moderate pace
- Red Butte Creek: highly urbanized
- Provo River: irrigated agriculture transitioning to low density urban at rapid pace

Gradients Along Mountain to Urban Transitions (GAMUT) Network



Table 1. Parameters to be measured by the iUTAH Climate and Ecohydrology Sensor Network.

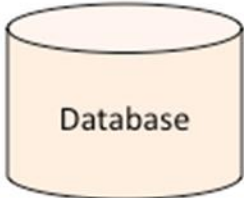
	Fundamental Suite	Enhanced/Urban Suite
Terrestrial Sensors	Barometric pressure Wind speed and direction Air temperature Relative humidity Precipitation Snow depth Soil temperature, moisture, conductivity Solar radiation (net radiation and PAR)	Barometric pressure Wind speed and direction Air temperature Relative humidity Precipitation Snow depth Soil temperature, moisture, conductivity Solar radiation (net radiation and PAR)
Aquatic Sensors	Stream stage Temperature Electrical Conductivity pH Dissolved oxygen Turbidity	Stream stage Temperature Electrical Conductivity pH Dissolved oxygen Turbidity Total algae (chlorophyll a + phycocyanin) fDOM Nitrate

Cyberinfrastructure

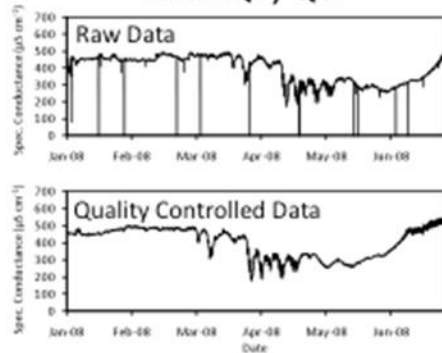
Tier 3: Data Storage, Processing, and Analysis

Data Storage

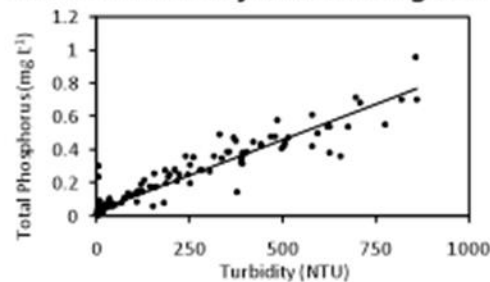
- Data Loading
- Data Manipulation
- Data Publication



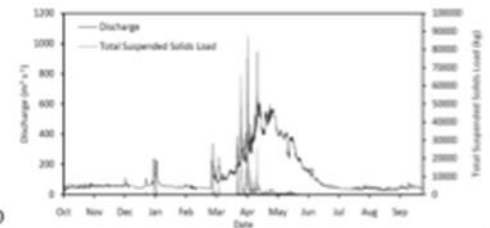
Data QA/QC



Estimation of Discharge and Concentration from Surrogates



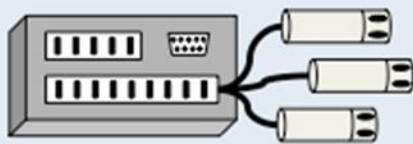
Data Visualization and Analysis



Tier 1: Sensors and Monitoring

Sensor Nodes

- Stream gauging
- Surrogate observations

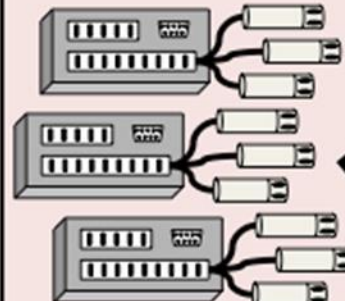


Periodic Monitoring

- Water quality sampling
- Discharge measurements



Tier 2: Communication



Sensor Nodes



Radio

Telemetry Network

Base Station Computer



- Monitor Sensor Node Status
- Retrieve Data

Challenges to Managing Sensor Data

- Volume of data
- Data heterogeneity
- Multiple watersheds
- Multiple institutions
- Scale
- Synchronize timing, data access, equipment tracking
- Standardize data editing

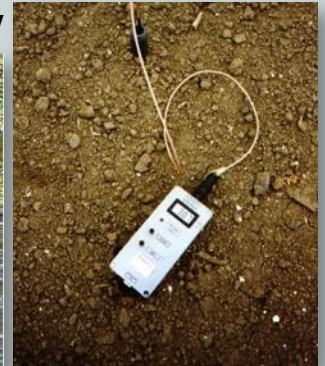
Rainfall and Meteorology



Water quantity



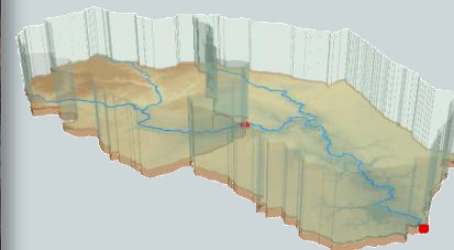
Soil water



Water quality



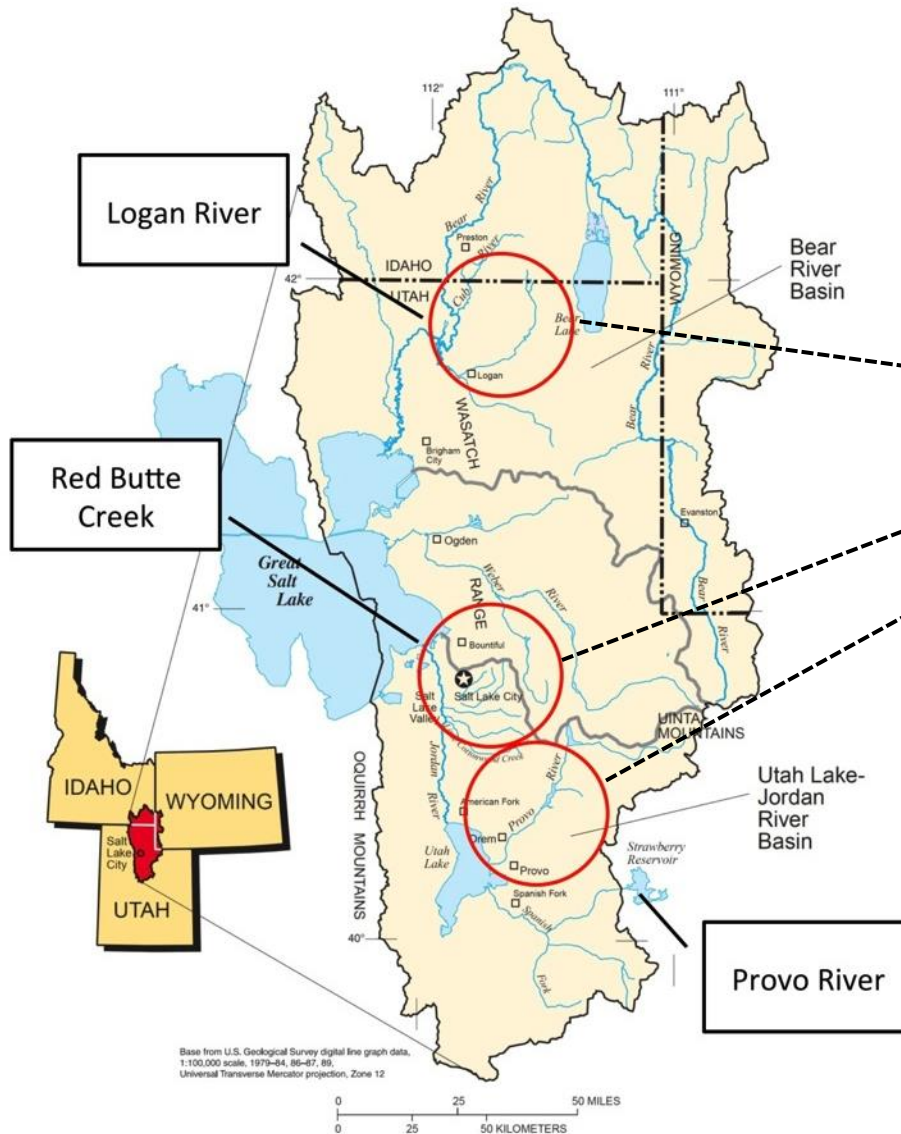
GIS



Groundwater

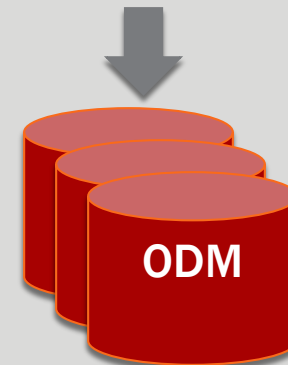


Data Loading and Storage



iUTAH Modeling and Data
Federation Facility

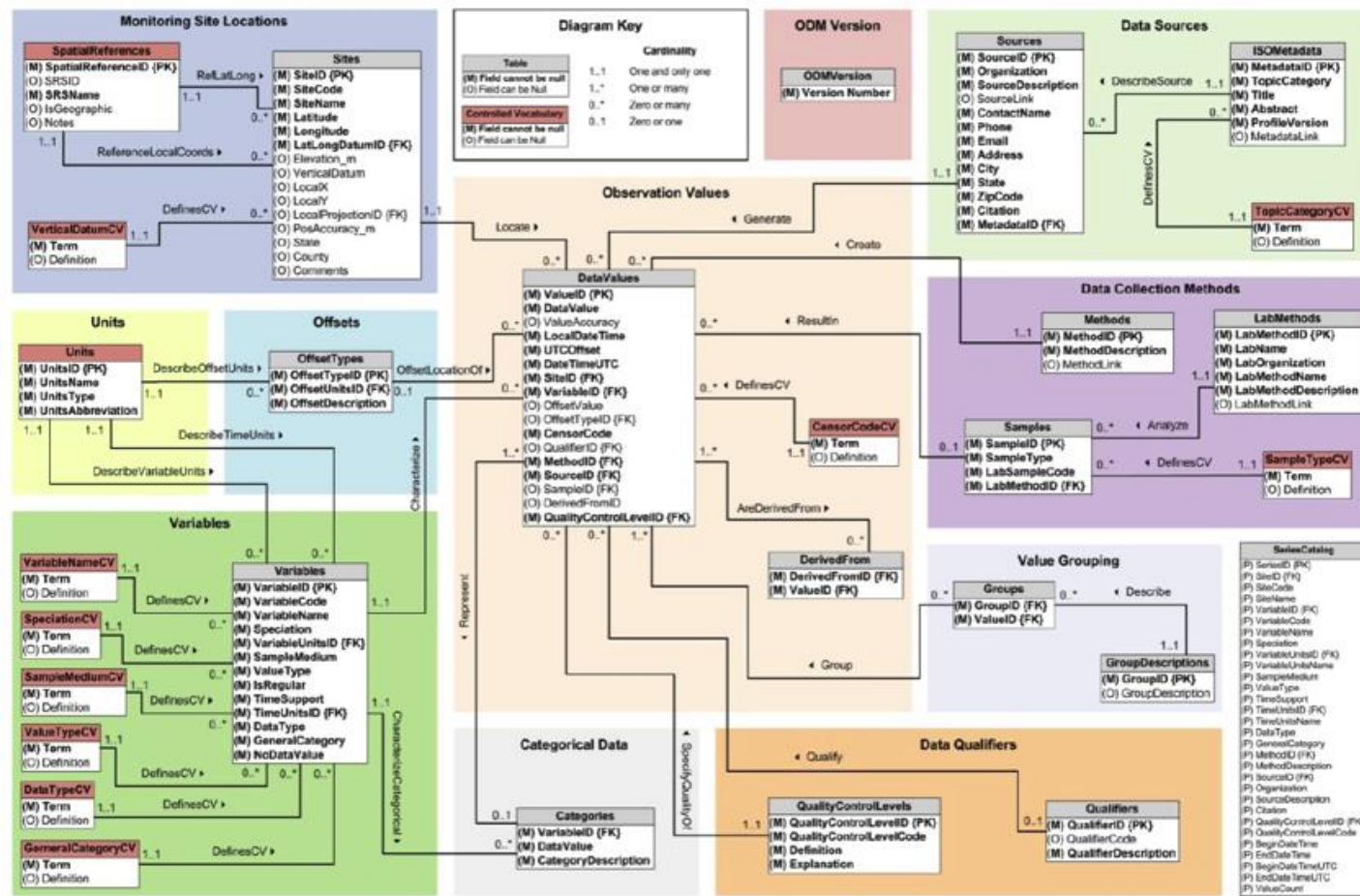
Primary Databases at USU



Backup Databases at UofU

Data Loading and Storage

- **Observations Data Model (ODM):** relational database at the single observation level
- **Metadata** for unambiguous interpretation
- **Traceable heritage** from raw measurements to usable information
- **Promote syntactic and semantic consistency**
- **Cross dimension retrieval and analysis**



Horsburgh, J. S., D. G. Tarboton, D. R. Maidment, and I. Zaslavsky (2008), A relational model for environmental and water resources data, *Water Resources Research*, 44, W05406, doi:10.1029/2007WR006392.

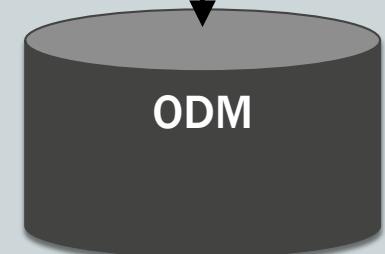
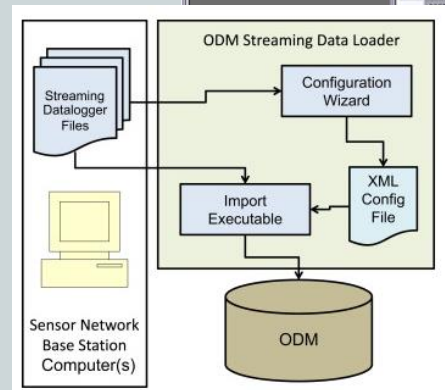
Data Loading and Storage



The screenshot shows the 'ODM Streaming Data Loader' window. It has a table with columns: ID, Server Address, Database Name, File Location Type, File Location, Schedule Period, Schedule Beginning, and Last Update. Below this is an 'Add New File' section with a table of timestamps and various sensor readings.

ID	Server Address	Database Name	File Location Type	File Location	Schedule Period	Schedule Beginning	Last Update
1	(local)	MudLakeOD	Local	C:\Working\Proj...	1 hours	7/18/2007 3:00...	8/27/2007 10:59...
3	(local)	MudLakeOD	Local	C:\Working\Proj...	1 hours	7/31/2007 5:00...	8/27/2007 11:09...
4	(local)	MudLakeOD	Local	C:\Working\Proj...	1 hours	7/18/2007 3:00...	8/27/2007 11:13...
5	(local)	MudLakeOD	Local	C:\Working\Proj...	1 hours	7/18/2007 3:00...	8/27/2007 11:18...
6	(local)	MudLakeOD	Local	C:\Working\Proj...	1 hours	8/27/2007 11:00...	8/28/2007 12:06...
7	(local)						

TIMESTAMP	RECORD	Bat_Volt_Avg	Turb_Avg	Turb_Vis	Turb_Med	Turb_RES
2007-06-08 13.0	0	13.37478	5.5	0.0963	5.44	5.48
2007-06-08 13.1	1	13.37625	5.25	0.0614	5.23	5.24
2007-06-08 14.0	2	13.30762	5.37	0.0784	5.32	5.33
2007-06-08 14.3	3	13.31614	5.4	0.0722	5.37	5.38
2007-06-08 15.0	4	13.32022	5.62	0.0623	5.57	5.58
2007-06-08 15.3	5	13.37645	5.47	0.064	5.44	5.45
2007-06-08 16.0	6	13.35044	5.55	0.0618	5.54	5.53
2007-06-08 16.3	7	13.29565	5.66	0.064	5.62	5.62
2007-06-08 17.0	8	13.34624	5.47	0.0434	5.44	5.44
2007-06-08 17.3	9	13.36051	5.91	0.1418	5.86	5.86
2007-06-08 18.0	10	13.39325	6.06	0.1145	6.05	6.05
2007-06-08 18.3	11	13.39744	6.09	0.1119	6.08	6.09
2007-06-08 19.0	12	13.25306	6.25	0.0535	6.24	6.24
2007-06-08 19.3	13	13.24299	6.65	0.0505	6.63	6.65



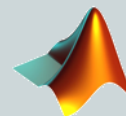
Data Access and Publication

■ Publish data and register with CUAHSI HIS

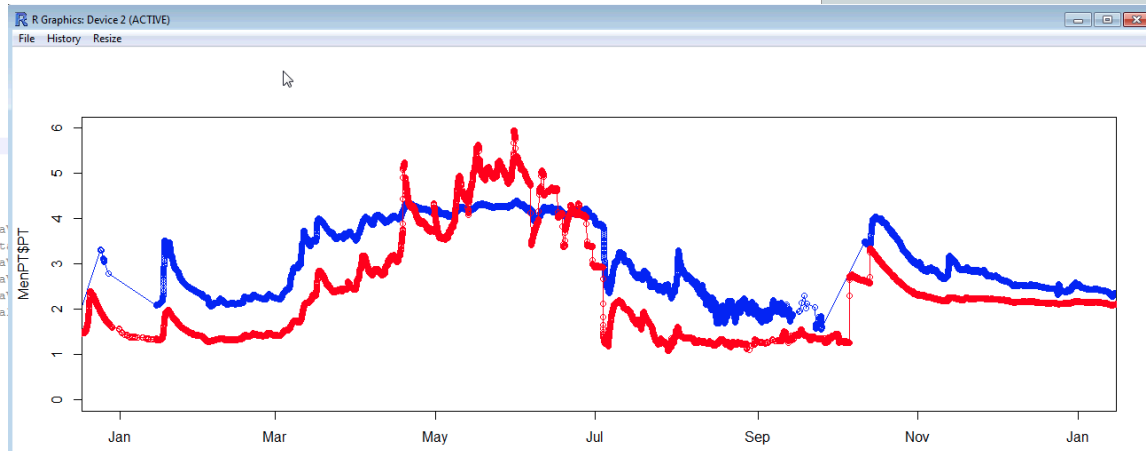
- Discoverable and available nationally
- Published data citable

■ Data Accessed via

- Web services
- iUTAH Modeling and Data Federation (data.iutahepscor.org)
- Direct database connection: using ODM Tools and/or preferred software



```
1 #Load the required libraries
2 #-----
3 library(RODBC)
4
5 #Specify the database connection information
6 #-----
7 database <- "LBRQC"
8 userID <- "Amber"
9
10 #Open a channel to the database using odbcConnect
11 #-----
12 channel <- odbcConnect(database,userID)
13
14 #Get QC Level 1 stage data for all sites
15 #-----
16
17 MenPT = sqlQuery(channel, paste("SELECT LocalDateTime AS DATE, DataValue AS PT FROM Data")
18 WellPT = sqlQuery(channel, paste("SELECT LocalDateTime AS DATE, DataValue AS PT FROM Data")
19 ConPT = sqlQuery(channel, paste("SELECT LocalDateTime AS DATE, DataValue AS PT FROM Data")
20 LsfPT = sqlQuery(channel, paste("SELECT LocalDateTime AS DATE, DataValue AS PT FROM Data")
21 UsfPT = sqlQuery(channel, paste("SELECT LocalDateTime AS DATE, DataValue AS PT FROM Data")
22 ParH = sqlQuery(channel, paste("SELECT LocalDateTime AS DATE, DataValue AS H FROM Data")
23
24 MenPT$DATE <- as.POSIXct(MenPT$DATE,tz="MST")
25 WellPT$DATE <- as.POSIXct(WellPT$DATE,tz="MST")
26 ConPT$DATE <- as.POSIXct(ConPT$DATE,tz="MST")
27 LsfPT$DATE <- as.POSIXct(LsfPT$DATE,tz="MST")
28 UsfPT$DATE <- as.POSIXct(UsfPT$DATE,tz="MST")
29 ParH$DATE <- as.POSIXct(ParH$DATE,tz="MST")
30
31
32 #Compare Wellsville and Mendon, adjust dates as desired
33 #-----
34 plot(MenPT$DATE, MenPT$PT, col = "blue", type = "o", xlim = as.POSIXct(c("2011-01-01","2012-01-01")), ylim = c(0,6))
35 points(WellPT$DATE, WellPT$PT, col = "red", type = "o")
```



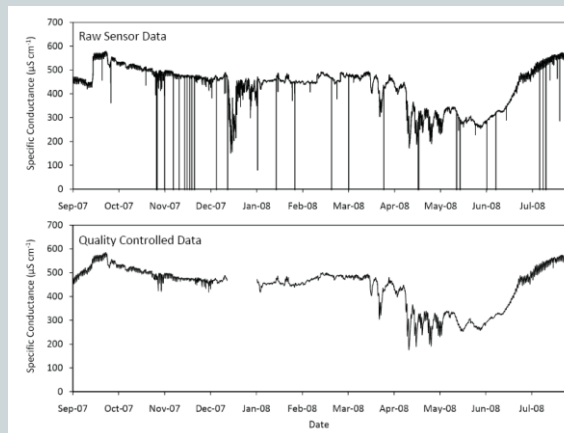
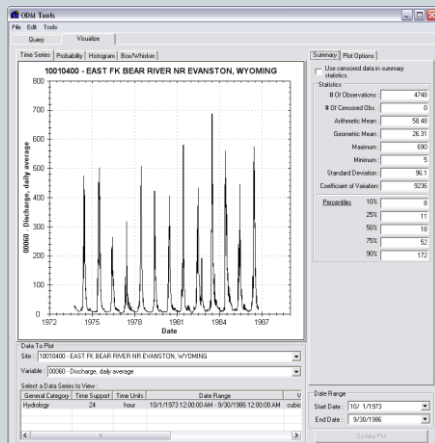
Data Visualization and Management

iUTAH Modeling and Data Federation Facility

ODM

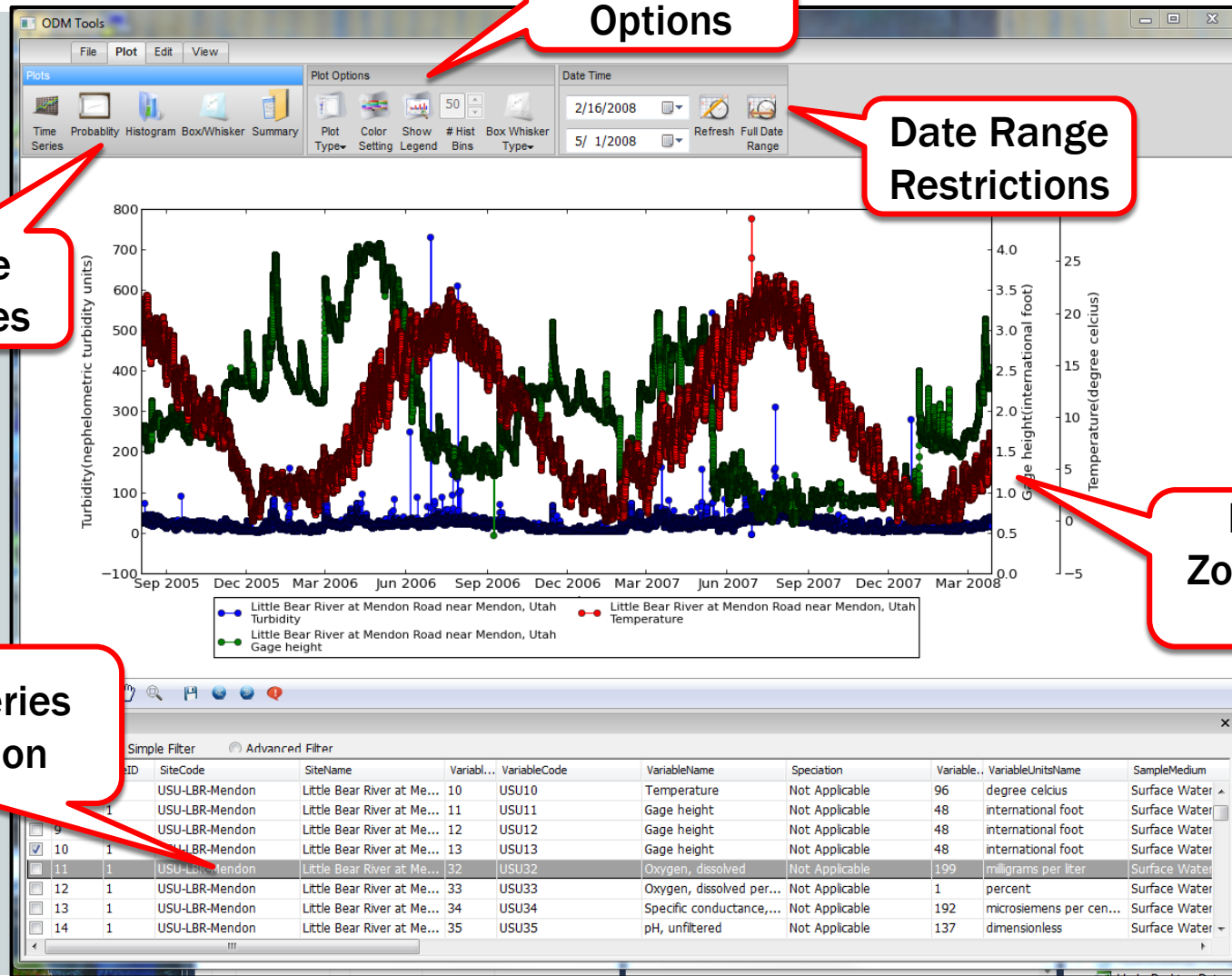


Remote Data Managers

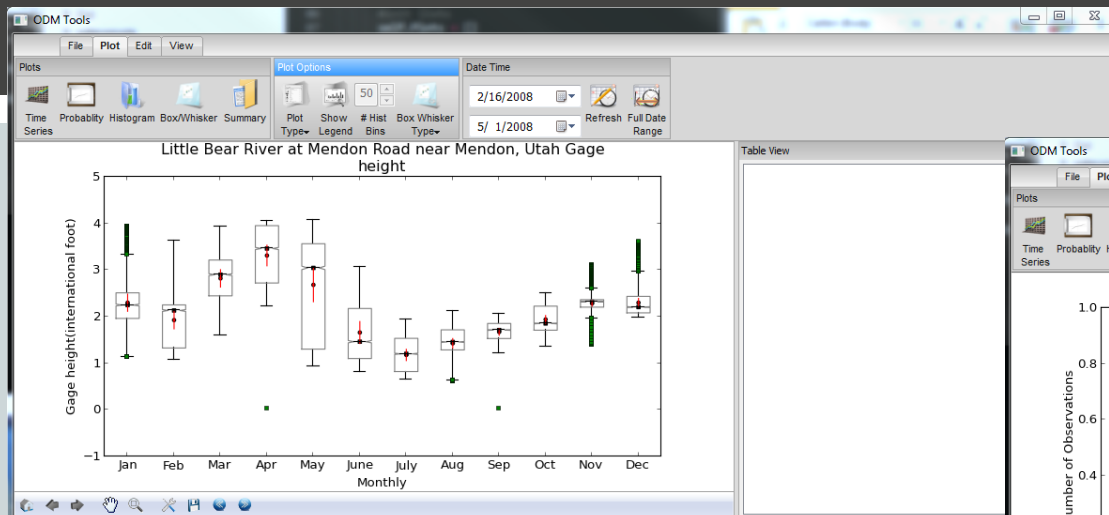


Development of and Support for Data Management Tools

Data Visualization and Management



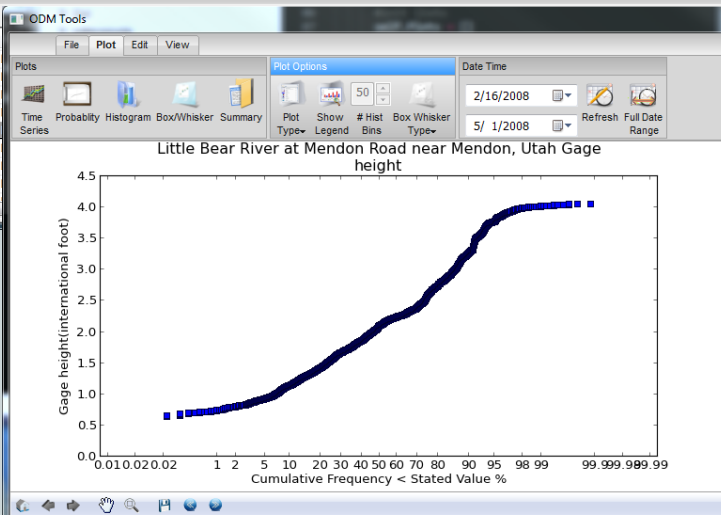
Data Visualization and Management



Series Selector

All Simple Filter Advanced Filter

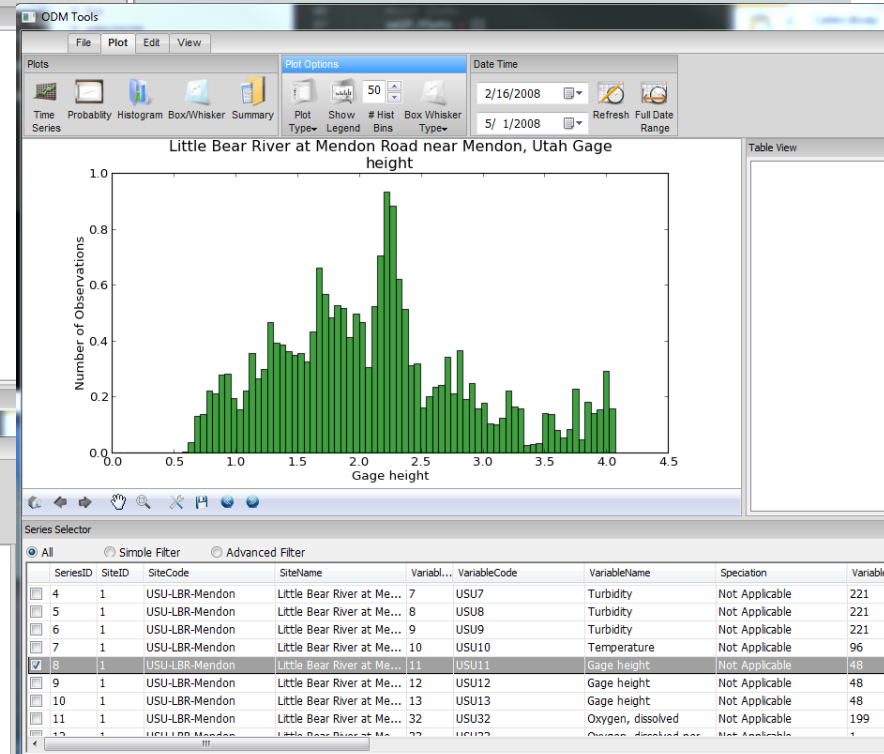
SeriesID	SiteID	SiteCode
<input type="checkbox"/> 4	1	USU-LBR-Mendon
<input type="checkbox"/> 5	1	USU-LBR-Mendon
<input type="checkbox"/> 6	1	USU-LBR-Mendon
<input type="checkbox"/> 7	1	USU-LBR-Mendon
<input checked="" type="checkbox"/> 8	1	USU-LBR-Mendon
<input type="checkbox"/> 9	1	USU-LBR-Mendon
<input type="checkbox"/> 10	1	USU-LBR-Mendon
<input type="checkbox"/> 11	1	USU-LBR-Mendon
<input type="checkbox"/> 12	1	USU-LBR-Mendon



Series Selector

☒ All ☐ Simple Filter ☐ Advanced Filter

	SeriesID	SiteID	SiteCode	SiteName	Variable...	VariableCode	VariableName	Speciation	Variable...	VariableUnitsName	SampleMedium
<input type="checkbox"/>	4	1	USU-LBR-Mendon	Little Bear River at Me...	7	USU7	Turbidity	Not Applicable	221	nephelometric turbidi...	Surface Water
<input type="checkbox"/>	5	1	USU-LBR-Mendon	Little Bear River at Me...	8	USU8	Turbidity	Not Applicable	221	nephelometric turbidi...	Surface Water
<input type="checkbox"/>	6	1	USU-LBR-Mendon	Little Bear River at Me...	9	USU9	Turbidity	Not Applicable	221	nephelometric turbidi...	Surface Water
<input type="checkbox"/>	7	1	USU-LBR-Mendon	Little Bear River at Me...	10	USU10	Temperature	Not Applicable	96	degree celcius	Surface Water
<input checked="" type="checkbox"/>	8	1	USU-LBR-Mendon	Little Bear River at Me...	11	USU11	Gage height	Not Applicable	48	international foot	Surface Water

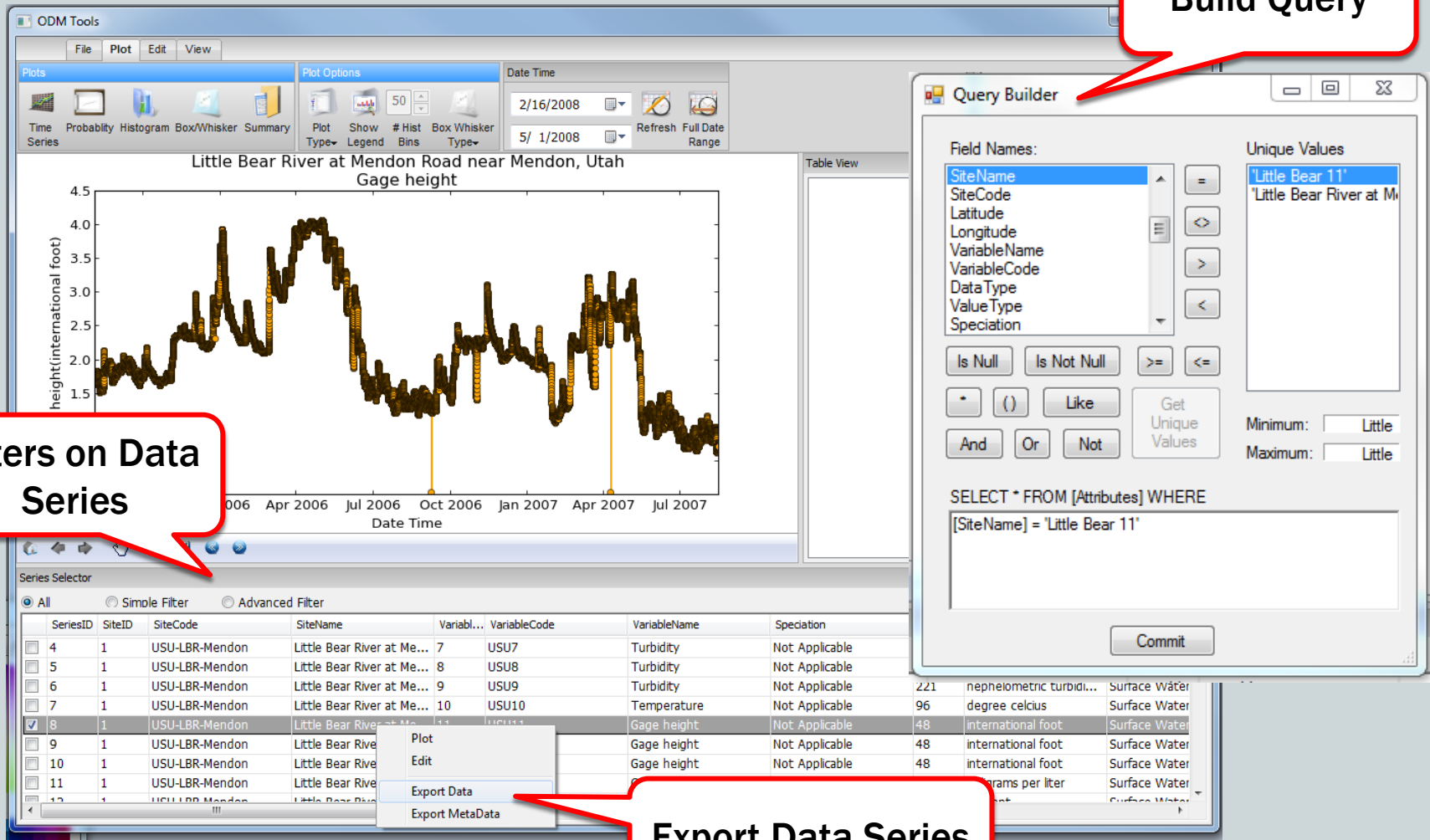


Data Visualization and Management

Build Query

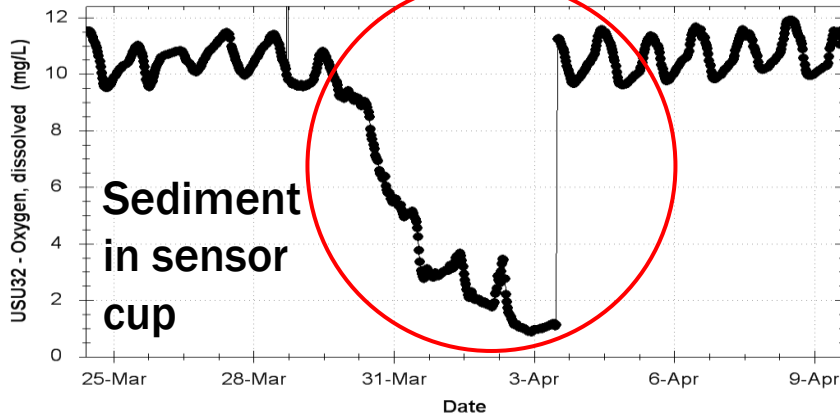
Filters on Data Series

Export Data Series

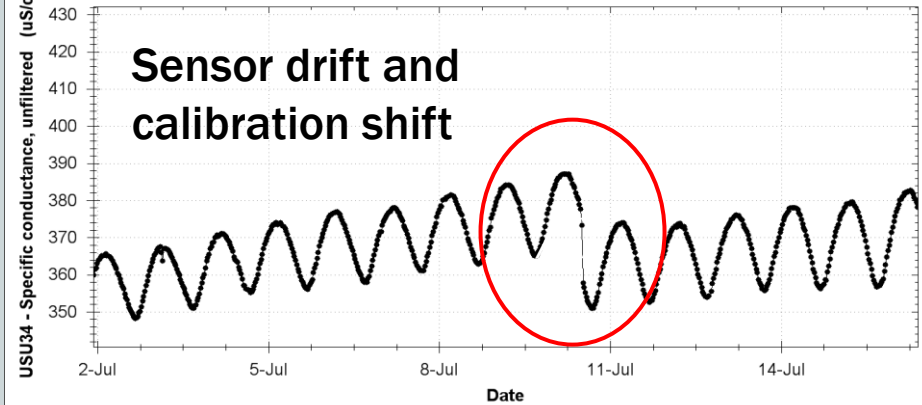


Sensor Data Quality Control

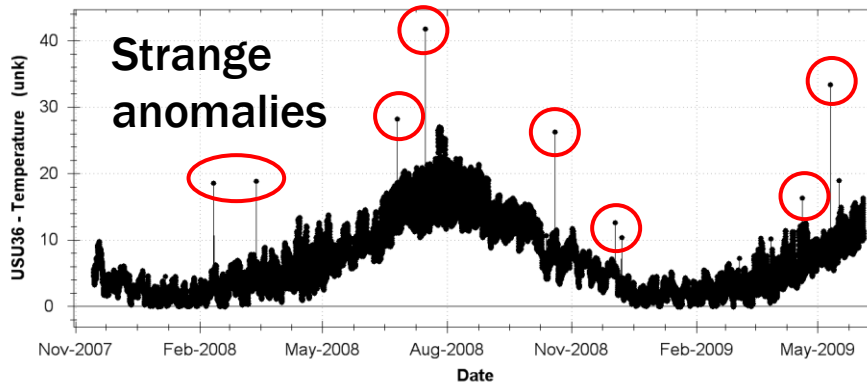
USU-LBR-Paradise - Little Bear River at McMurdy Hollow near Paradise, Utah



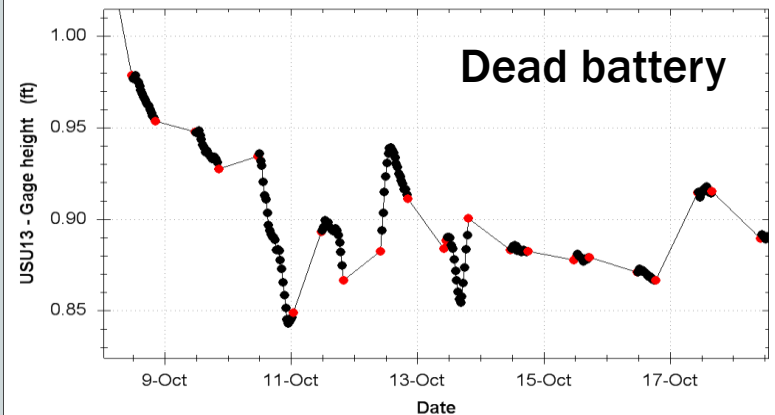
USU-LBR-SFLower - South Fork Little Bear River below Davenport Creek near Avon, Utah



USU-LBR-Confluence - Little Bear River below Confluence of South and East Forks near Avon, Utah



USU-LBR-Mendon - Little Bear River at Mendon Road near Mendon, Utah



Sensor Data Quality Control

The screenshot displays the ODM Tools software interface, which is used for sensor data quality control. The interface is divided into several sections:

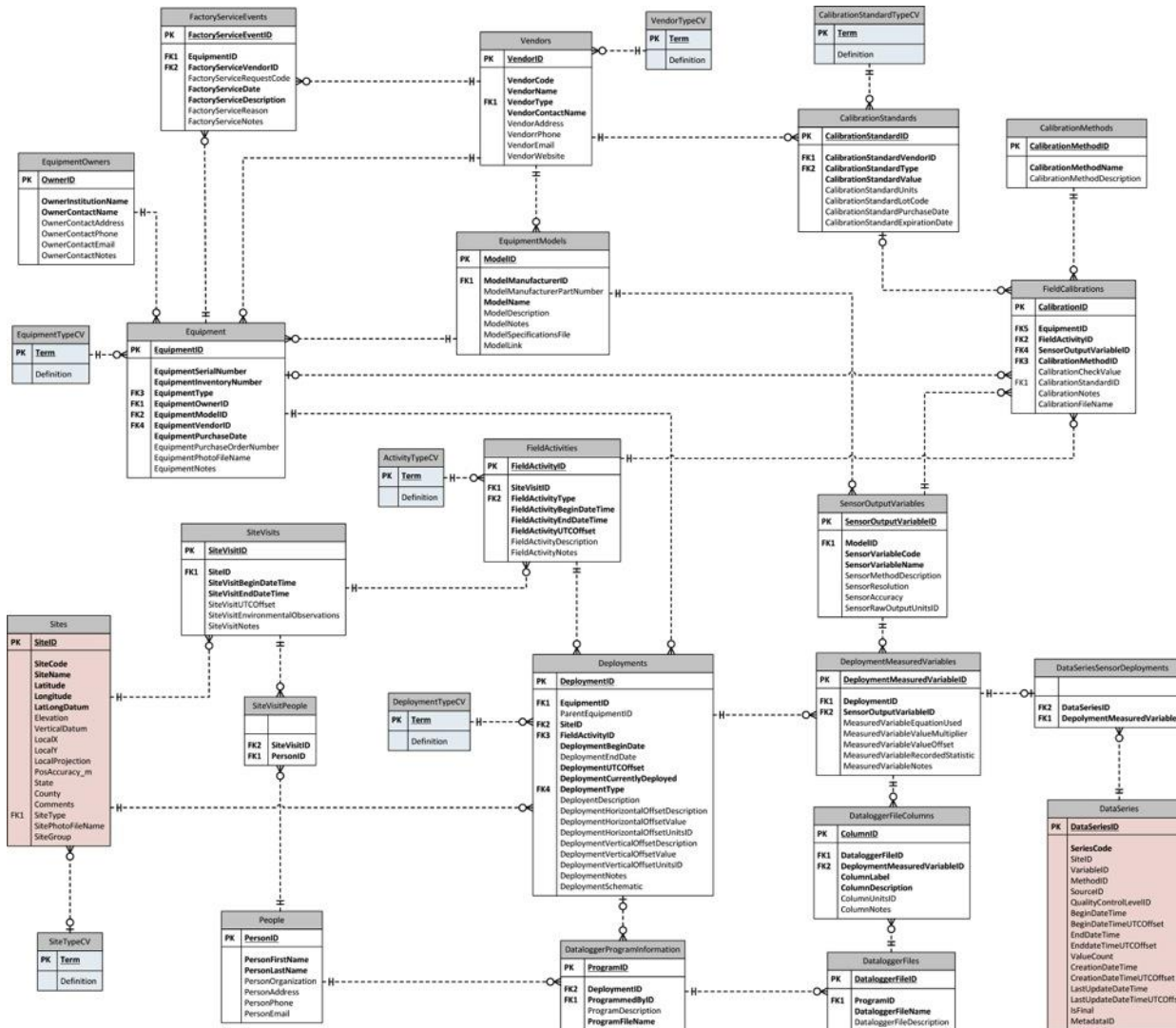
- Data Editing Tools:** A toolbar at the top left contains various icons for editing data, including 'Edit Series', 'Derive New Series', 'Restore', 'Save', 'Filter Points', 'Change Value', 'Interpolate', 'Flag', 'Add Point', 'Delete Point', and 'Record'.
- Dynamic Data Editing Display:** A plot titled 'Little Bear River at Paradise, Utah Gage height' showing 'Gage height(international foot)' on the y-axis (ranging from 4 to 10) and 'Date Time' on the x-axis (ranging from Dec 22 2007 to Apr 12 2008). The plot shows a series of data points with a significant spike in late March 2008, highlighted by a red box.
- Python Code Console:** A window on the right side of the interface showing a Python console with the following code:

```
>>>
>>> from odmservices.edit_service import EditService
>>> series = EditService(series_id= 171,
... connection_string =
... 'mssql+pyodbc://ODM:odm@(local)/LittleBear11')
>>> series.filter_value(8, '>')
>>>
>>> series.get_active_points()
[(2766974, 9.04, datetime.datetime(2008, 3, 2, 11, 30)), (
2766975, 9.04, datetime.datetime(2008, 3, 2, 11, 45)), (2766976
, 9.04, datetime.datetime(2008, 3, 2, 12, 0)), (2766977, 9.04,
datetime.datetime(2008, 3, 2, 12, 15)), (2766978, 9.04,
datetime.datetime(2008, 3, 2, 12, 30)), (2766979, 9.04,
datetime.datetime(2008, 3, 2, 12, 45)), (2766980, 9.04,
datetime.datetime(2008, 3, 2, 13, 0)), (2766981, 9.04, datetime
.datetime(2008, 3, 2, 13, 15)), (2766982, 9.05, datetime.
datetime(2008, 3, 2, 13, 30)), (2766983, 9.06, datetime.
datetime(2008, 3, 2, 13, 45)), (2766984, 9.06, datetime.
datetime(2008, 3, 2, 14, 0)), (2766985, 9.08, datetime.datetime
(2008, 3, 2, 14, 15)), (2766986, 9.09, datetime.datetime(2008,
3, 2, 14, 30)), (2766987, 9.1, datetime.datetime(2008, 3, 2, 14
, 45)), (2766988, 9.1, datetime.datetime(2008, 3, 2, 15, 0)), (
2766989, 9.1, datetime.datetime(2008, 3, 2, 15, 15)), (2766990,
9.1, datetime.datetime(2008, 3, 2, 15, 30)), (2766991, 9.1,
datetime.datetime(2008, 3, 2, 15, 45)), (2766992, 9.09,
```
- Python Script Editor:** A window at the bottom right showing a Python script editor with the following code:

```
1 from odmservices.edit_service import EditService
2 series = EditService(series_id= 171,
3 connection_string = "mssql+pyodbc://ODM:odm@(local)/Lit
4 series.filter_value(8, '>')
5
```

The bottom of the interface features a 'Series Selector' table with columns: SeriesID, SiteID, SiteCode, SiteName, VariableCode, VariableName, Speciation, VariableUnitsName, and SampleM. The table lists several series, including 'Little Bear River below...' and 'Little Bear River at Pa...'. The selected series is 171, which is 'Gage height' at 'Little Bear River at Pa...'.

Equipment Management



- Track physical infrastructure: sensors, data loggers, batteries, etc.
- Track events: deployments, calibrations, site visits, factory servicings, etc.
- Connects to ODM where streaming data is stored
- Web interface

Sites

Manage Sites

Site Visits

Manage Visits

Equipment

Manage equipment

Reports

Generate Reports

Equipment Details

| View full equipment details

Edit Description

Delete

Equipment Description

Equipment ID: 99999999999

Serial Number: 99999999999

Model Name: DTS-12

Description: Forest Technology Systems DTS-12 Digital Turbidity Sensor

Purchase Date: 1/20/2013

Notes: Measures water turbidity and water temperature.

Link: <http://www.ftsenvironmental.com/products/sensors/dts12/>

Owner Institution: Utah State University

Owner Contact: Michelle Baker

Owner Address: 5305 Old Main Hill, Logan, UT 84322-5305

Owner Phone: 1.435.797.7131

Email: michelle.baker@usu.edu



Manufacturer

Vendor Name: Forest Technology Systems

Contact Name: Someguy Thatworksthere

Address: 1123 Fir Avenue, Suite C., Blaine, WA,

98230**Phone:** 1.800.548.4264

Email: sales@ftshydrology.com

Web Address: <http://www.ftsenvironmental.com/>

Vendor

Vendor Name: Forest Technology Systems

Contact Name: Someguy Thatworksthere

Address: 1123 Fir Avenue, Suite C., Blaine, WA, 98230

Phone: 1.800.548.4264

Email: sales@ftshydrology.com

Web Address: <http://www.ftsenvironmental.com/>

View Deployment History

View Factory Service History

View Calibration History

Sites

Manage Sites

Site Visits

Manage Visits

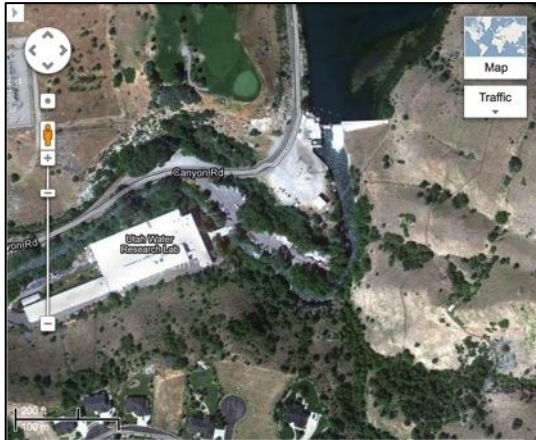
Equipment

Manage equipment

Reports

Generate Reports

Site Visit Details | [View full site visit details](#)

[Edit Description](#)
[Delete](#)
[View Full Site Visit History for this Site](#)


Site Visit Location

Site Code: USU-LR-UWRL

Site Name: Logan River at the Utah Water Research Laboratory

Latitude: 43

Longitude: -111

Elevation: 4355 m

Site Visit Description

Crew: Jeff Horsburgh, Amber Jones

Begin Date Time: 2/22/2013 1:00 PM MST

End Date Time: 2/22/2013 2:00 PM MST

Environmental Observations: The weather was sunny. The river was low. Water was clear.

Site Visit Notes: None.

Field Activities Performed (click the activity type to view details)

Activity Type	Begin Date/Time	End Date/Time	Description	Notes
Calibration	2/22/2013 1:00 PM MST	2/22/2013 1:10 PM MST	Sensor Calibration	None
Deployment	2/22/2013 1:30 PM MST	2/22/2013 2:00 PM MST	Sensor Deployment	None

**Sites**

Manage Sites

Site Visits

Manage Visits

Equipment

Manage equipment

Reports

Generate Reports

Calendar | Click on activities to view details

February ▼

2013 ▼

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
			Logan River Site1			
	Red Butte Creek Site3	Logan River Site2	Red Butte Creek Site1			
			Provo River Site1	Logan River Site3		
	Red Butte Creek Site2		Provo River Site1			

Display: ☒ Site Visits ☐ Factory Service Events

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This material is based upon work supported by the National Science Foundation (NSF) under Grant No. XXXXXXXX.

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Deluge of Data

- Tools for:
 - Storage
 - Publication
 - Access
 - Processing
 - Equipment Tracking
- Fulfill Needs of iUTAH researchers
- Cyberinfrastructure is research, too!





Support:
EPS 1208732



Questions?

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Jeff Horsburgh
jeff.horsburgh@usu.edu