

Making Green Work, and Work Harder

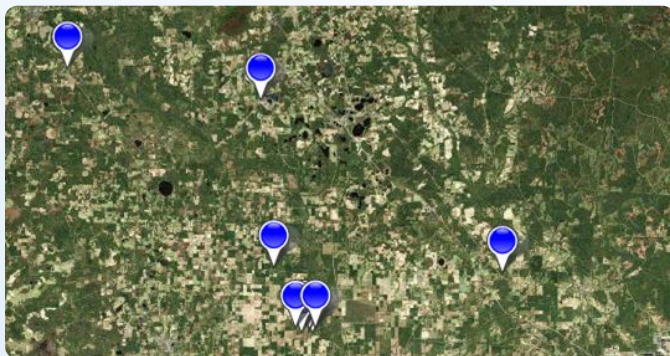
Andrea Braga, P.E., CPESC, Geosyntec

- *Outline*
 - *Real-Time Controls and Monitoring*
 - *Varying BMP Applications*
 - *Performance Results*

Highly Distributed Real-Time Monitoring and Control (DTRC)



OptiRTC featured in **FAST COMPANY**
HOW THE "INTERNET OF THINGS" IS TURNING
CITIES INTO LIVING ORGANISMS



"Ecosystems" of smart environmental infrastructure

- Platforms that **interact and scale**
- Disparate data sources can be combined for visualization, analysis, and system control
 - Access field and web-based data
 - Interface with other systems
 - Complex algorithms
 - Specified data can be made available to the public
 - Data access and user experience is user/group specific

DRTC Platform Overview

Internet Based Weather
Forecast or other internet
data sources
(Web service API)

Azure Tables/Blobs

OptiRTC Data Aggregator
and Decision Space

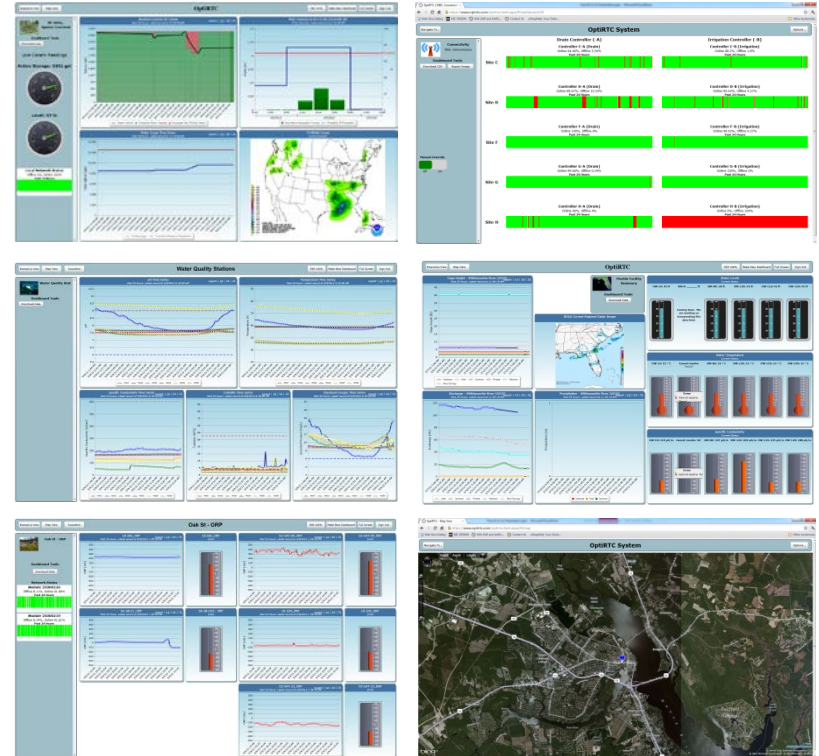
Data Logging and Telemetry
Solutions

Field Monitoring and Control
(Sensors, Gauges, and Actuators)

Rapid Deployment Field "Kits"
With Wireless Sensors



User Interface Web Services and
User Dashboards



Alerts
Email
Tweet
SMS
Voice Autodial



DRTC Examples 2013

- Seattle University
Smart Detection System
- Retrofit of Detention
 - CSO area



- University of Chicago North Sciences Quad
Advanced Rainwater Harvesting System
- 102K Gallons Detention
 - 89,760 Gallons of Integrated Active Onsite Use



- Route 44 Site, Taunton, MA
Ozone Injection System Monitoring
- 40 Wells

- Denver Green School
Advanced Rainwater Harvesting System
- 3,000 Gallon Cistern



- Whittaker
Real-time Groundwater Monitoring
- 12 wells
 - 1 flow meter



- Public Safety Building Omaha, NE
Porous Pavement Retrofit
- Smart Under Drain Control
 - CSO Area



- St. Joseph, MO
Smart Pond Control
CSO Flow Mitigation

- Austin and Pflugerville, TX Two Projects
Twin Oaks Library Advanced Rainwater Harvesting System
- Retrofit of 5000 Cisterns
 - Pflugerville Detention Retrofit
 - Smart Outlet Control
 - Water Quality Retrofit



- MBS - St. Louis, MO
Advanced Rainwater Harvesting Systems
- Ranging from 10K to 20K Gallons
 - Used for Irrigation



- SAP, Newtown Sq., PA
Green Roof Irrigation Control System
- Water Level Control
 - Forecast Integration



- DDOE, Washington, DC
Two - Advanced Rainwater Harvesting Systems at Fire Houses
- 5,000 Gallon Cisterns
 - EPA Headquarters, Washington, DC
 - Retrofit of Cisterns



- NCState Pilot, New Bern, NC
Advanced Rainwater Harvesting System
- 3,300 Gallons Fully Active System



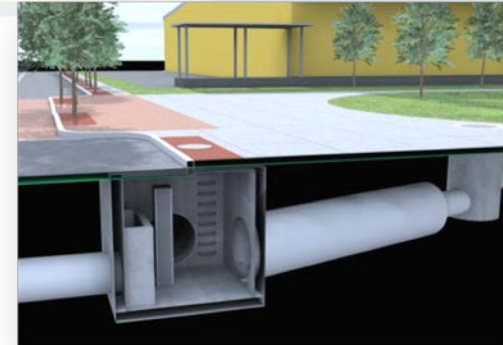
- Dalton Landfill, Dalton, GA
Leachate Monitoring System
- Leachate Force Main
 - Wet Well
 - Six Side Slope Risers



- Nestle Water
Well Field/Weather/Stream Monitoring System
- 15 Wells at 3 Sites
 - USGS Gauges
 - NWS Forecasts
 - WMD Feeds

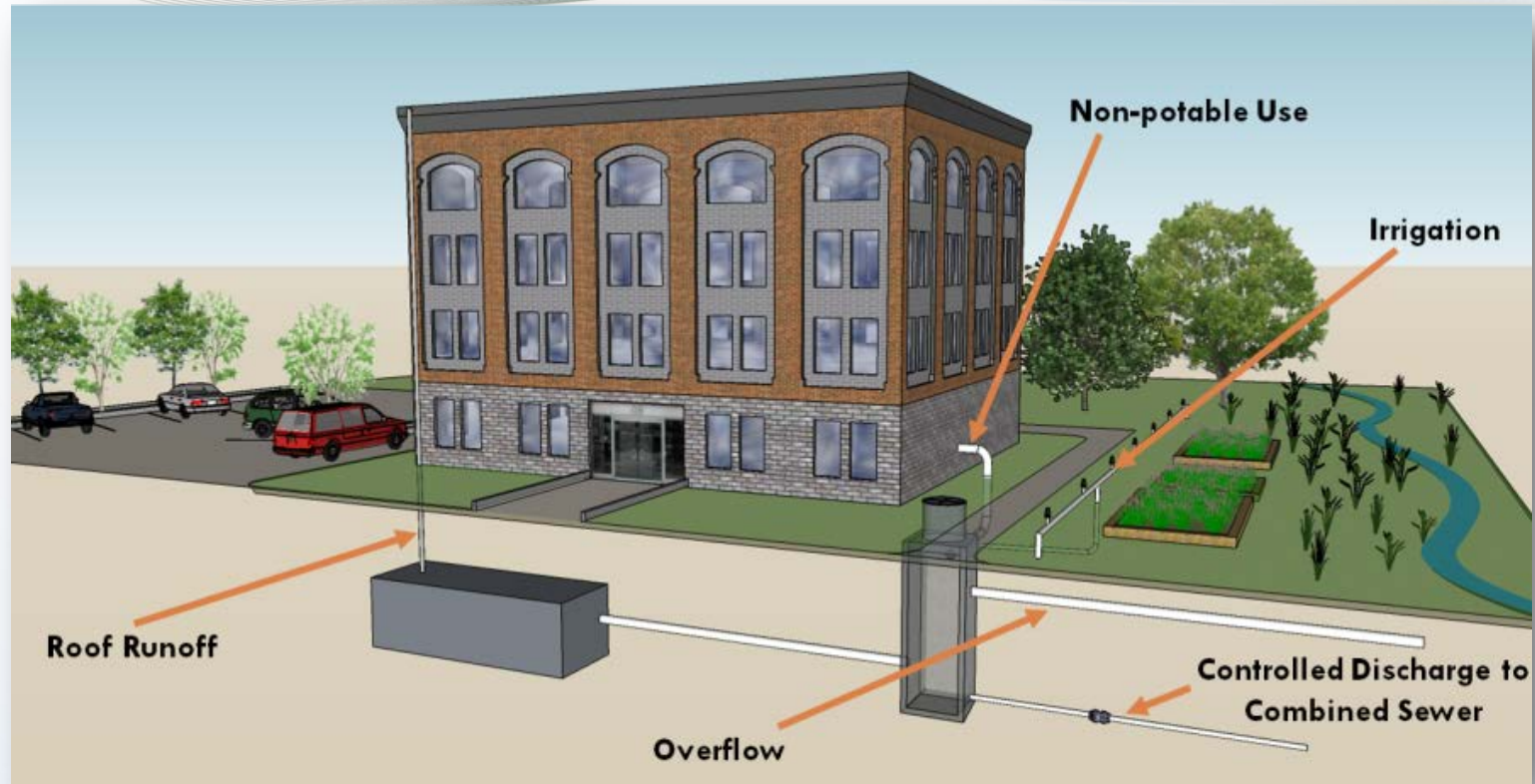
Adaptive Surface Water Management Using DRTC

- **Advanced rainwater harvesting**
- Predictive retention and detention systems using precipitation forecasts
- Controlled under drain bioretention
- Active porous pavement systems
- Active blue and green roofs



Technology Application: Advanced Rainwater Harvesting System

Advanced Rainwater Harvesting System Concept

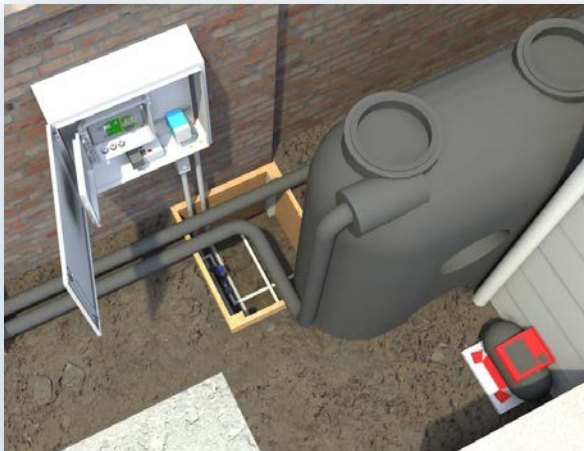


- Goal: Storage for both effective wet weather control and on-site use

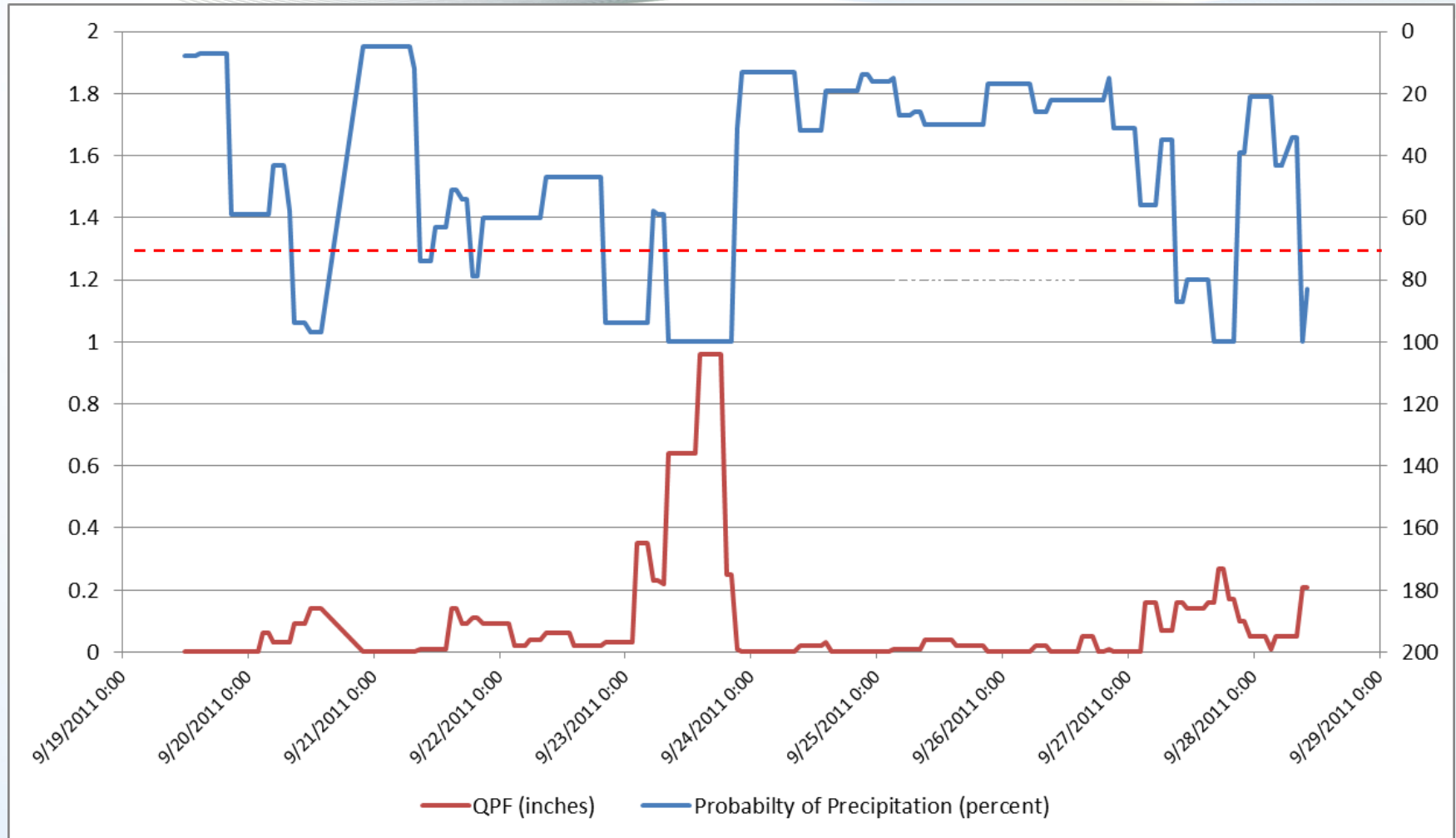
Case Study: Advanced Rainwater Harvesting System North Carolina

System Description

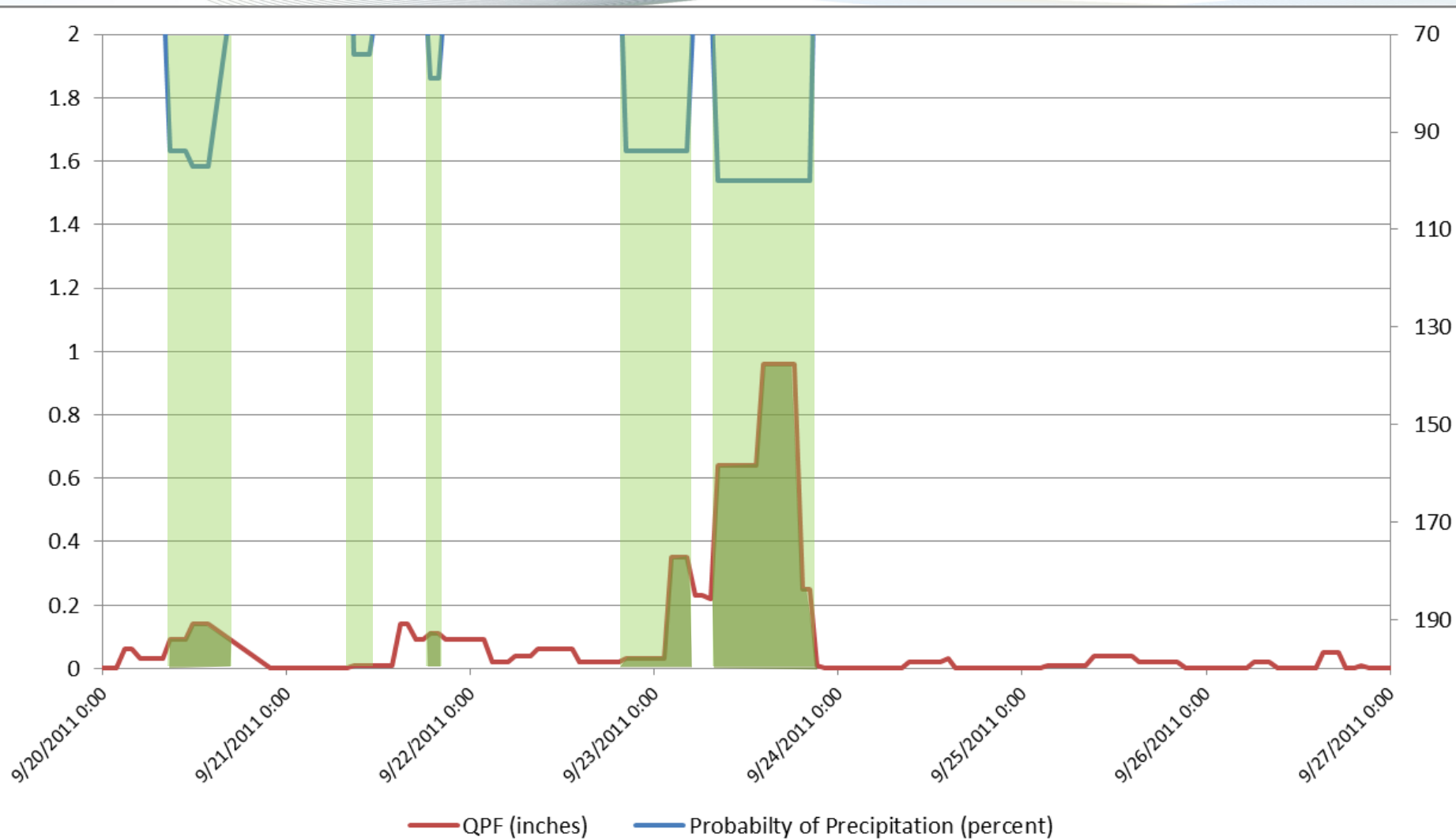
- Cistern installed to store runoff and make available on-site
- Web-based precipitation forecasts are used to automatically control releases to combined sewers or downstream BMPs (e.g., infiltration/bioretention)



NC State Pilot System Behavior Week of 9/20/2011 Forecast Datastream



NC State Pilot
System Behavior Week of 9/20/2011
QPF and POP Forecast Datastream (Threshold of 70%)



NC State Pilot – Dashboard (1-min refresh)

System Behavior Week of 4/5/2012 11:52 AM

Executive View Map View

OptiRTC

Edit XAML Make New Dashboard Full Screen Sign Out

NC State,
System Overview

Dashboard Tools

Download Data

Live Cistern Readings

Active Storage: 2431 gal

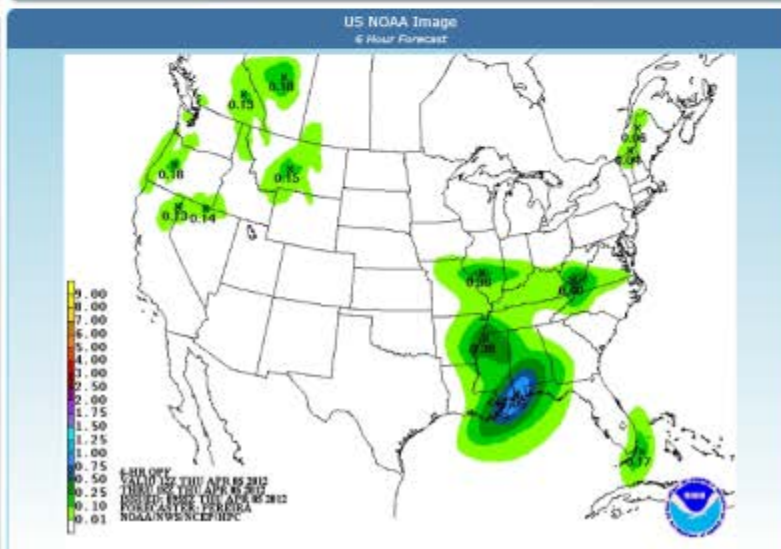
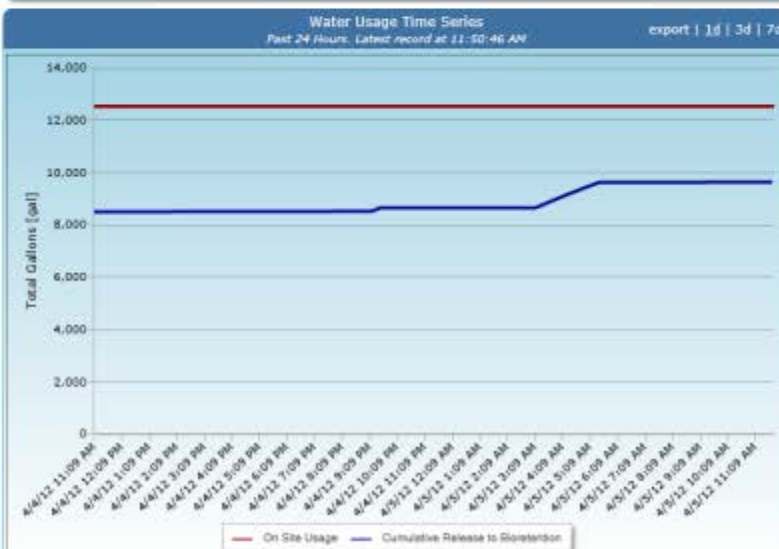
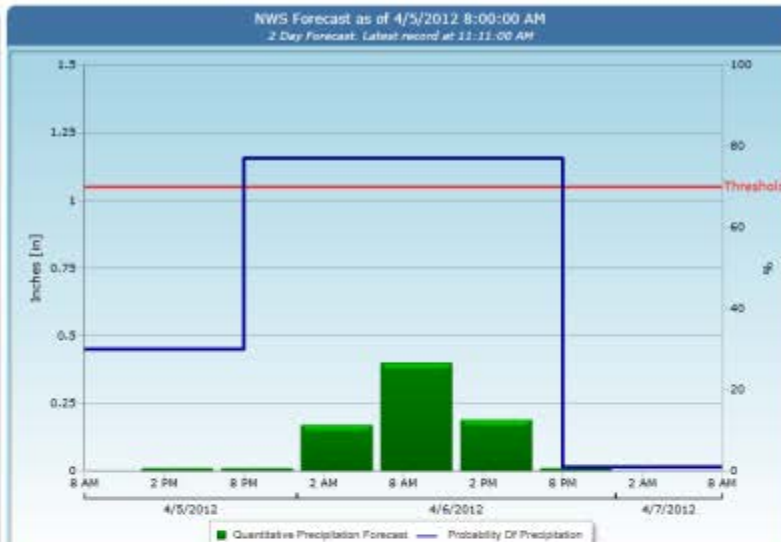
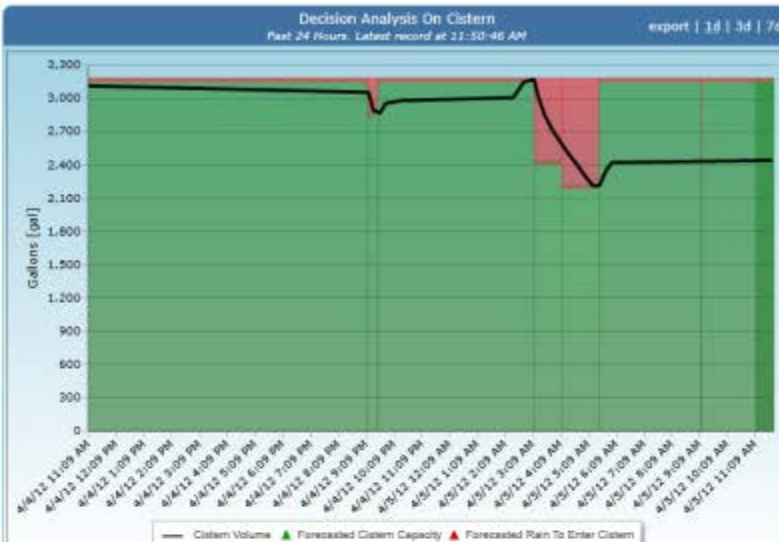


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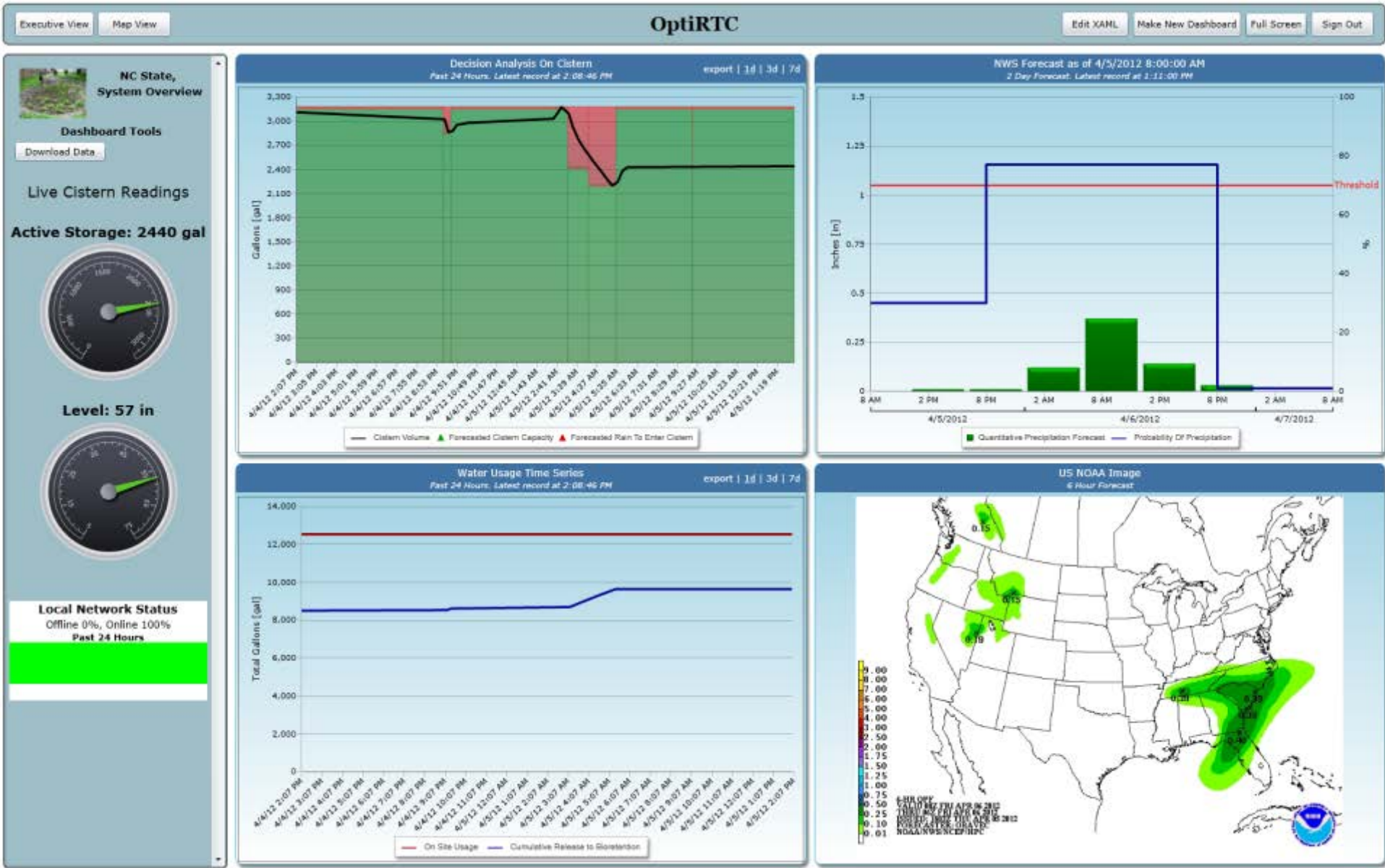


Local Network Status

Offline 0%, Online 100%
Past 24 Hours



NC State Pilot – Dashboard (1-min refresh) System Behavior Week of 4/5/2012 2:06 PM



NC State Pilot – Dashboard (1-min refresh)

System Behavior Week of 4/6/2012 12:14 AM

Executive View

Map View

OptiRTC

Edit XAML

Make New Dashboard

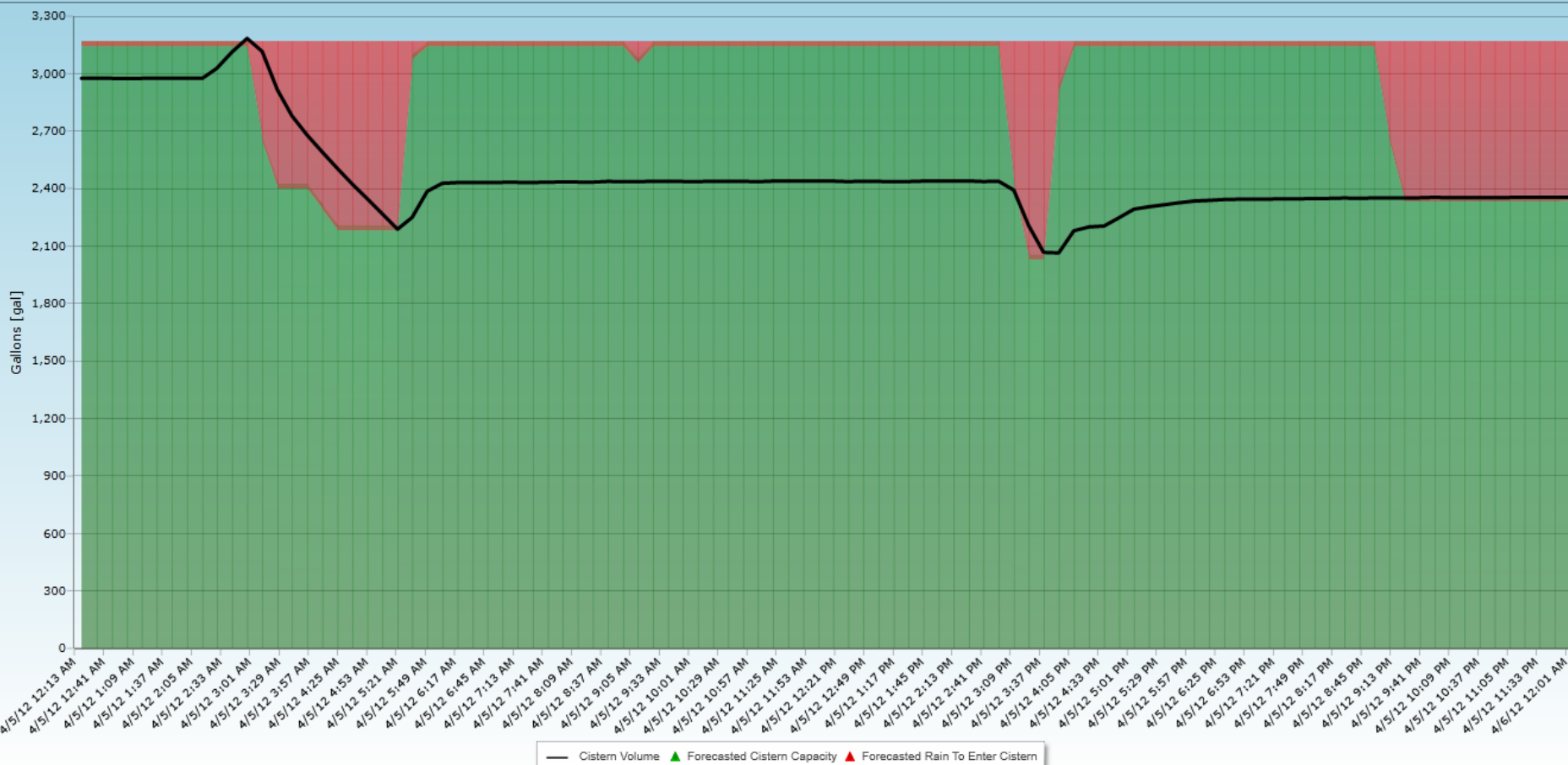
Full Screen

Sign Out

Decision Analysis On Cistern

Past 24 Hours. Latest record at 12:12:52 AM

export | 1d | 3d | 7d



NC State Pilot – Dashboard (1-min refresh) System Behavior Week of 4/6/2012 12:14 AM

Executive View

Map View

OptiRTC

Edit XAML

Make New Dashboard

Full Screen

Sign Out



NC State,
System Overview

Dashboard Tools

Download Data

Live Cistern Readings

Active Storage: 2355 gal

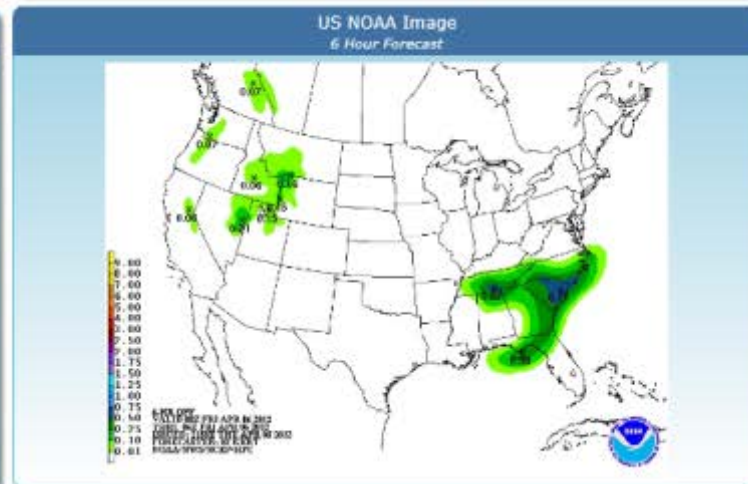
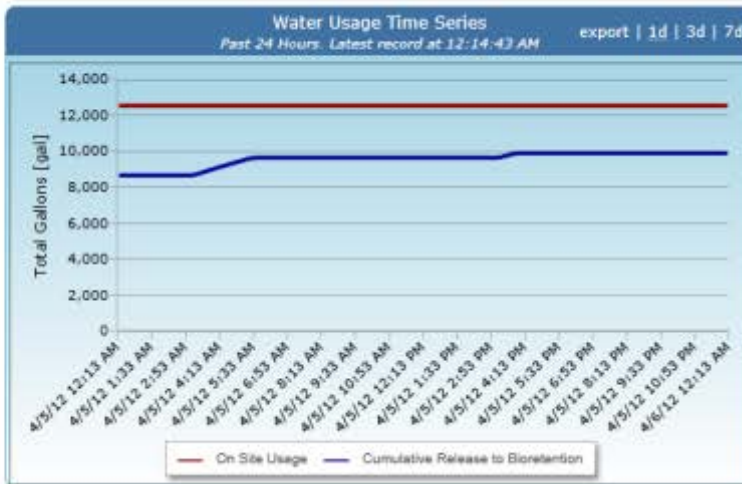


Level: 55 in



Local Network Status

Offline 0%, Online 100%



NC State Pilot – Dashboard (1-min refresh)

System Behavior Week of 4/6/2012 8:38 AM

Executive View Map View

OptiRTC

Edit XAML Make New Dashboard Full Screen Sign Out

NC State,
System Overview

Dashboard Tools

Download Data

Live Cistern Readings

Active Storage: 2788 gal



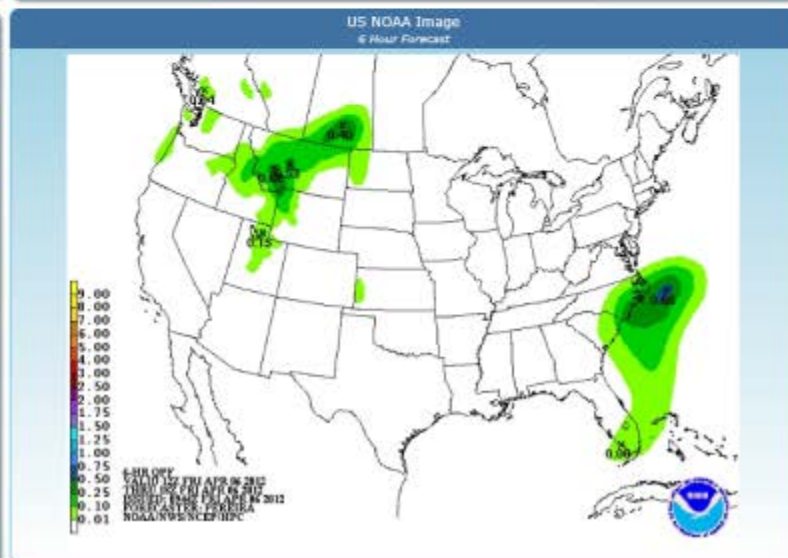
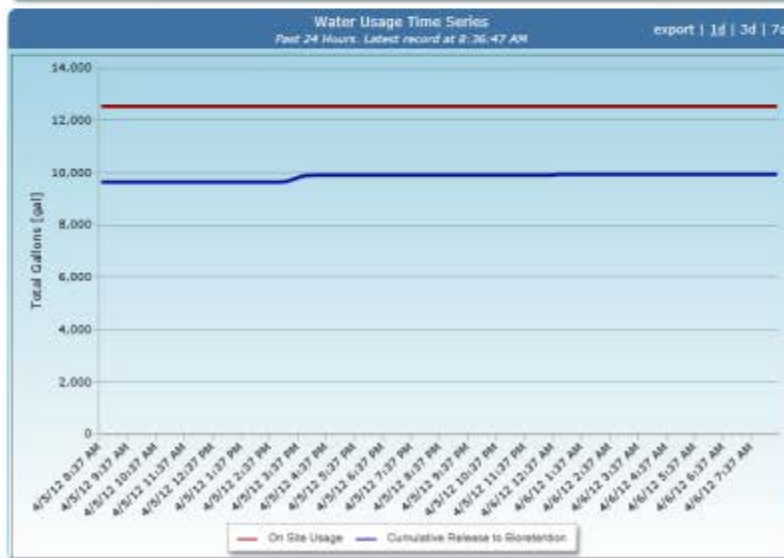
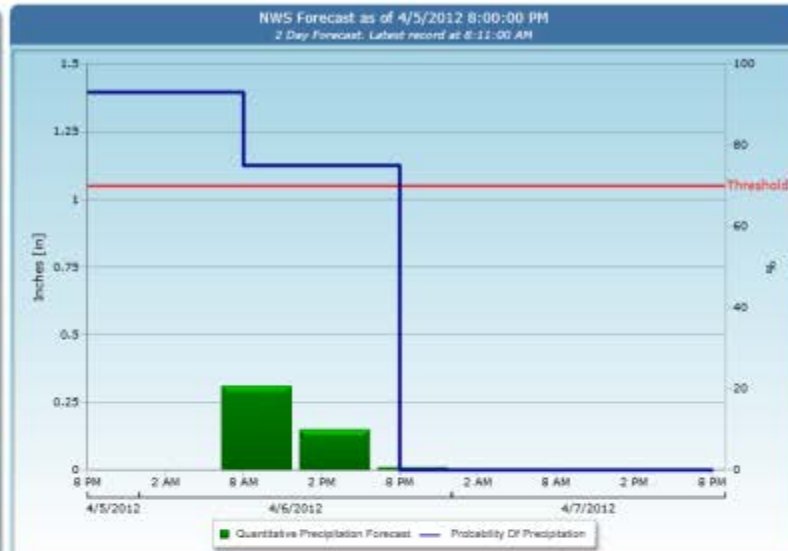
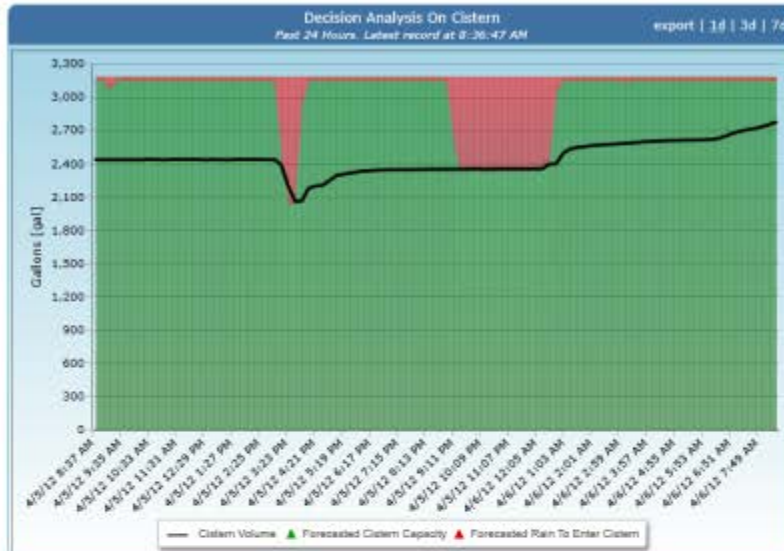
Level: 65 in



Local Network Status

Offline 0%, Online 100%

Past 24 Hours



NC State Pilot – Dashboard (1-min refresh)

System Behavior Week of 4/6/2012 3:34 PM

Executive View Map View

OptiRTC

Edit XAML

Make New Dashboard

Full Screen

Sign Out



NC State,
System Overview

Dashboard Tools

Download Data

Live Cistern Readings

Active Storage: 3102 gal



Level: 72 in



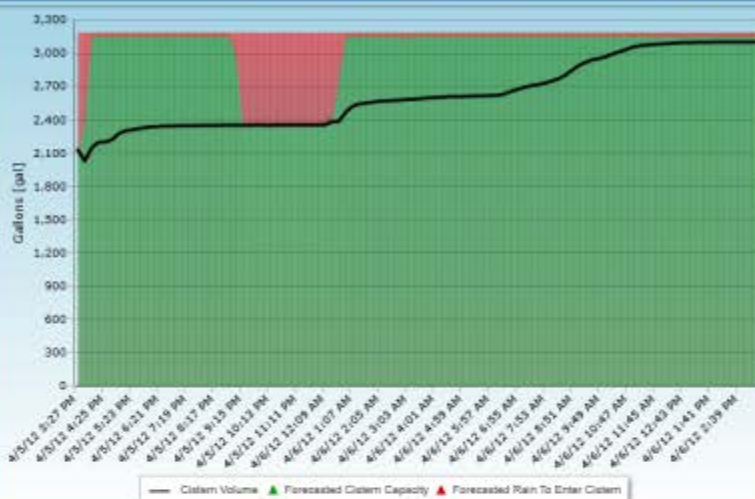
Local Network Status

Offline 0%, Online 100%
Past 24 Hours

Decision Analysis On Cistern

Past 24 Hours. Latest record at 3:32:56 PM

export | 1d | 3d | 7d



NWS Forecast as of 4/6/2012 8:00:00 AM

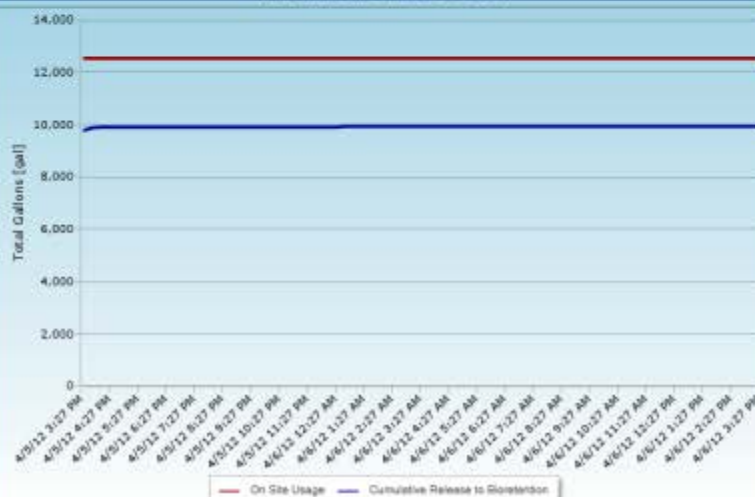
2 Day Forecast. Latest record at 3:11:00 PM



Water Usage Time Series

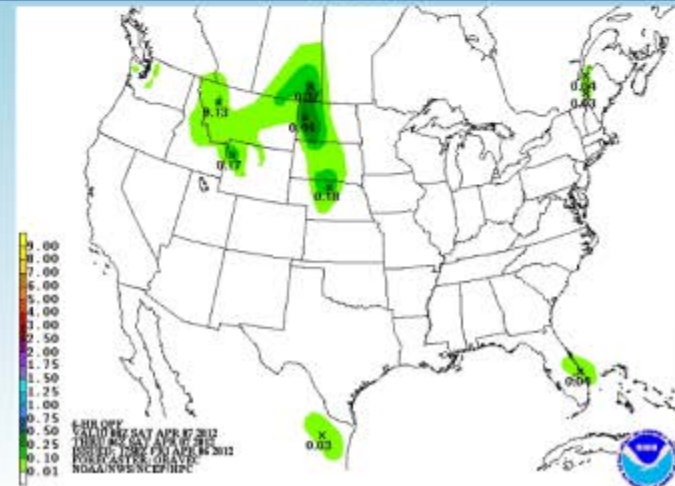
Past 24 Hours. Latest record at 3:32:56 PM

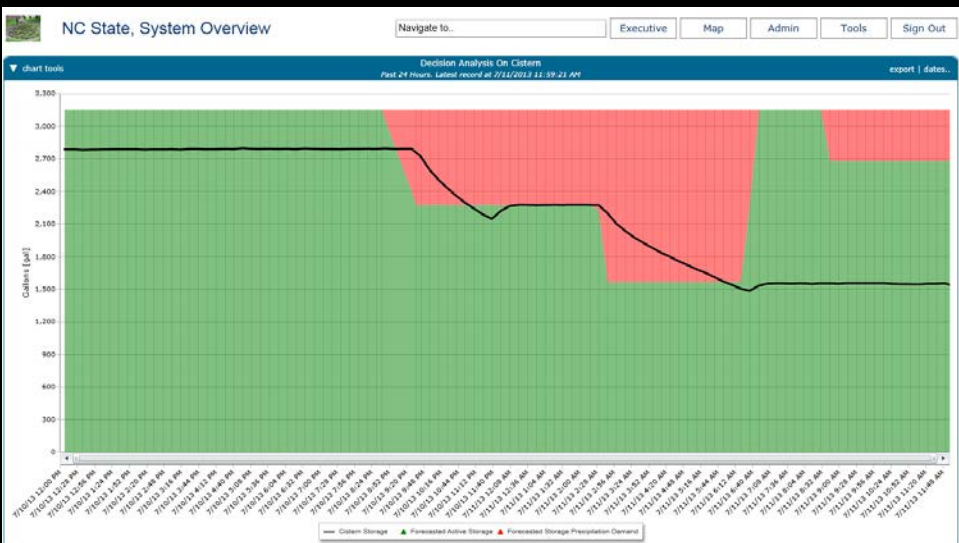
export | 1d | 3d | 7d



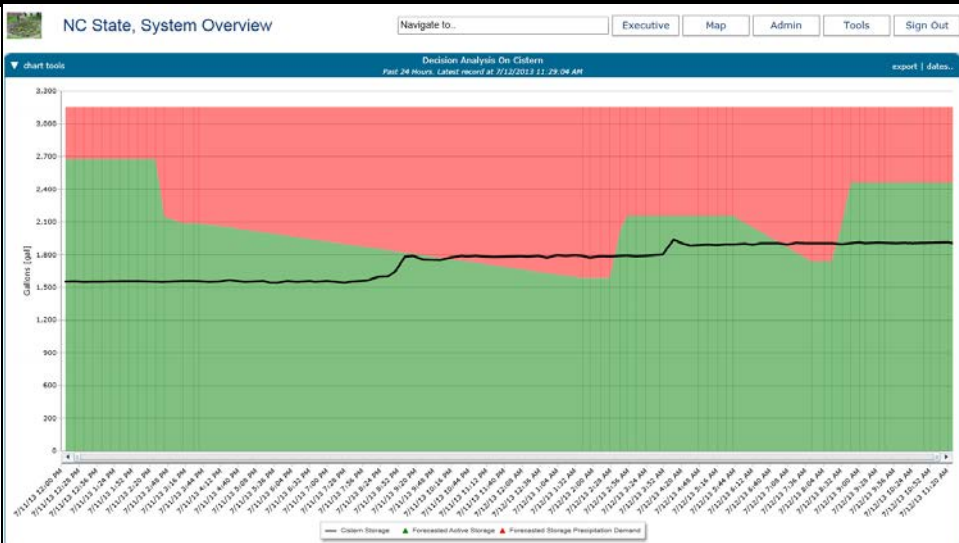
US NOAA Image

6 Hour Forecast

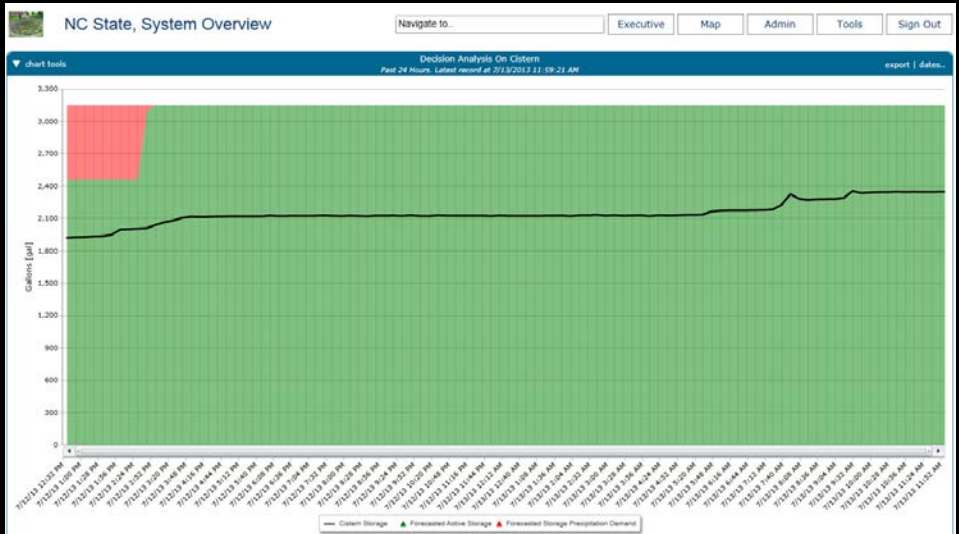




7/11/13 12:00 pm



7/12/13 12:00 pm



7/13/13 12:00 pm



7/14/13 12:00 pm

Executive View

Navigate to..

Executive

Map



































































































































Admin

Tools

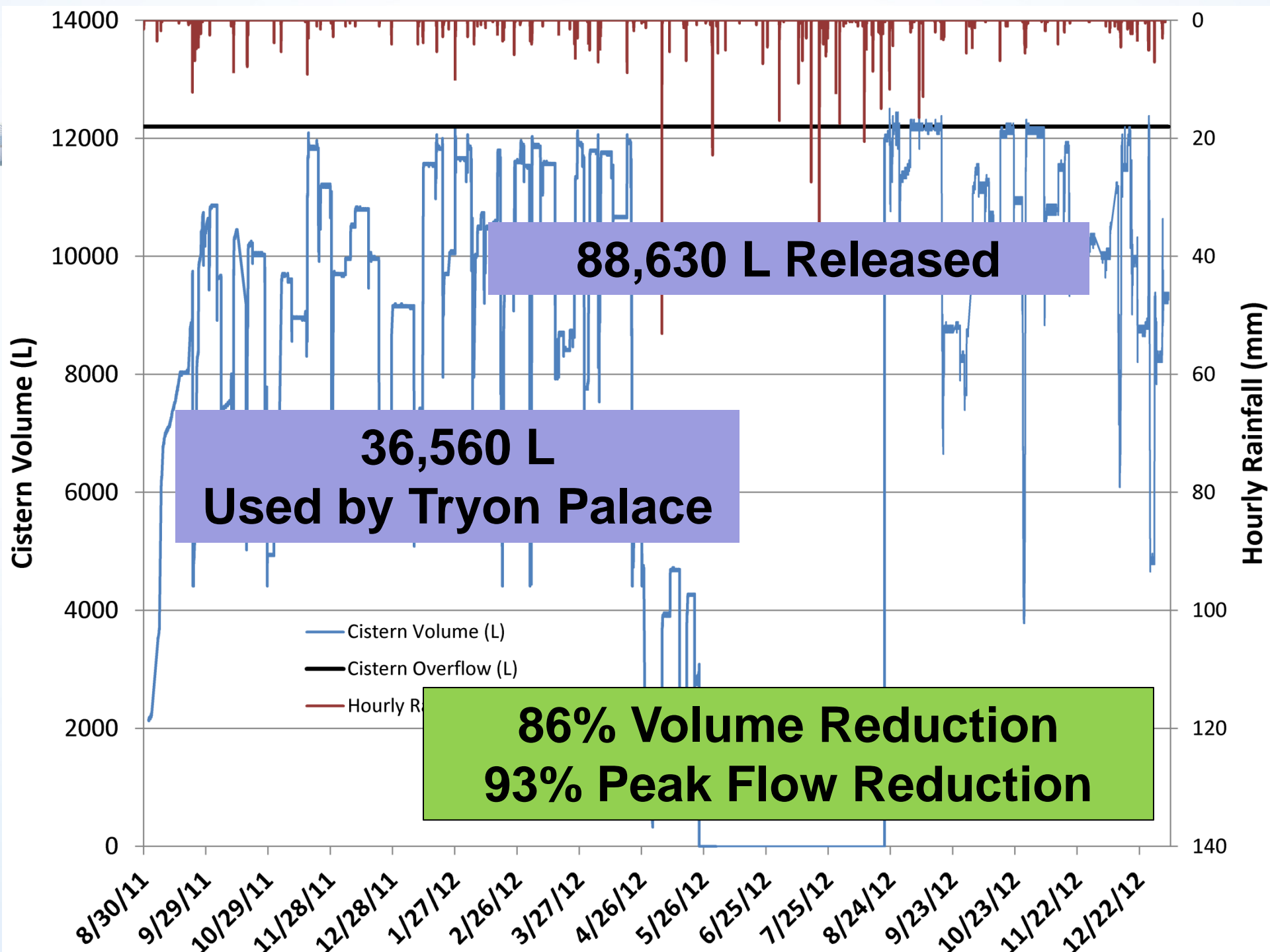
Sign Out

Visibility to Clients: Visible to Clients >

Sort: Client ▾      

Clear All 		RSCE1680	RSCE1671	RSCE1662	RSCE1689	RSCE1716	RSCE1707	RSCE1698	RSCE1617	RSCE1608	RSCE1599	RSCE1626	RSCE1653	RSCE1644
Search... 		RSCE1635	RSCE1725	RSCE1815	RSCE1806	RSCE1797	RSCE1824	RSCE1851	RSCE1842	RSCE1833	RSCE1752	RSCE1743	RSCE1734	RSCE1761
Client		RSCE1788	RSCE1779	RSCE1770	MD-16D	MD-16B	MD-16A	MD-17A	MD-18A	MD-17D	MD-17C	MD-14D	MD-14C	MD-14B
Sort: Quantity		MD-15A	MD-15D	MD-15C	MD-15B	MD-18B	RSCE1554	RSCE1545	RSCE1537	RSCE1563	RSCE1590	RSCE1581	RSCE1572	MD-19C
<input type="checkbox"/> Center Hill Dam 209		MD-19B	MD-19A	MD-19D	RSCE1530	RSCE1521	RSCE1512	RSCE2202	RSCE2193	RSCE2184	RSCE2211	RSCE2238	RSCE2229	RSCE2220
<input type="checkbox"/> Dalton-Whitfield Solid Was 8		RSCE2139	RSCE2130	RSCE2121	RSCE2148	RSCE2175	RSCE2166	RSCE2157	RSCE2247					
<input type="checkbox"/> MBS St. Louis 8								Headwater	Tailwater	Tailwater/H Headwater	RSCE1941	RSCE1932	RSCE1923	RSCE1950
<input type="checkbox"/> Nestle 7		RSCE1977	RSCE1968	RSCE1959	RSCE1878	RSCE1869	RSCE1860	RSCE1887	RSCE1914	RSCE1905	RSCE1896	RSCE1896	RSCE2076	RSCE2067
<input type="checkbox"/> Geosyntec 1941 6		RSCE2058	RSCE2085	RSCE2112	RSCE2103	RSCE2094	RSCE2013	RSCE2004	RSCE1995	RSCE2022	RSCE2049	RSCE2040	RSCE2031	MD-14A
<input type="checkbox"/> Whittaker 6		VWP-8	VWP-7-3	VWP-9	LA-2	LA-1	VWP-7-2	VWP-5-2	VWP-5-1	VWP-5-3	VWP-7-1	VWP-6	LA-3	C-7
<input type="checkbox"/> DDOE 2		C-5	C-10	C-12	C-11	C-3	LA-6	LA-4	LA-7	C-2	C-1			
<input type="checkbox"/> NC State 2						MD-17B						VWP-3-2	VWP-3-1	VWP-3-3
<input type="checkbox"/> Port of Pittsburgh Commiss 2		VWP-4-1	VWP-2-2	VWP-1-1		VWP-1-2	VWP-2-1	VWP-1-3	C-19	LRM-24	LRM-22	LRM-25	LRM-27	LRM-26
<input type="checkbox"/> City of Austin Twin Oaks Lib 1		LRM-21	C-277R	C-265R	C-281R	LRG-11	LRG-01	MD-12A	MD-11	MD-12B	MD-12D	MD-12C	MD-10	MD-3
<input type="checkbox"/> City of Omaha 1		LRM-28	MD-4	MD-9	MD-7	C-264	DX-12	C-58	DX-13	C-46E	C-37	C-56	C-23	C-20
<input type="checkbox"/> Geosyntec Acton Office 1		C-26	C-54	C-42	C-79R	C-75R	C-80R	C-263R	C-82R	C-74R	C-51	C-261R	C-52BE	C-72R
<input type="checkbox"/> Invensys 1		C-68R												
<input type="checkbox"/> NYC Parks Department 1														
<input type="checkbox"/> Seattle University 1														
<input type="checkbox"/> University of Texas 1														
<input type="checkbox"/> WERF Denver 1														
User Group														
Dashboard Name														
Visibility to Clients 														

NCState System



How Much of a Difference Did it Make?

	Observed (With DRTC)	Modeled (Without DRTC)
Overall Wet Weather Volume Reduction	86%	21%
Mean Peak Flow Reduction	93%	11%
Overflow Frequency	18%	58%
Dry Rain Tank Frequency	0%	0%

NC State, System Overview

Navigate to..

Executive

Map

Admin

Tools

Sign Out

Current Status

Active Storage: 3089 gal



Manual Override Control



Current State: OFF

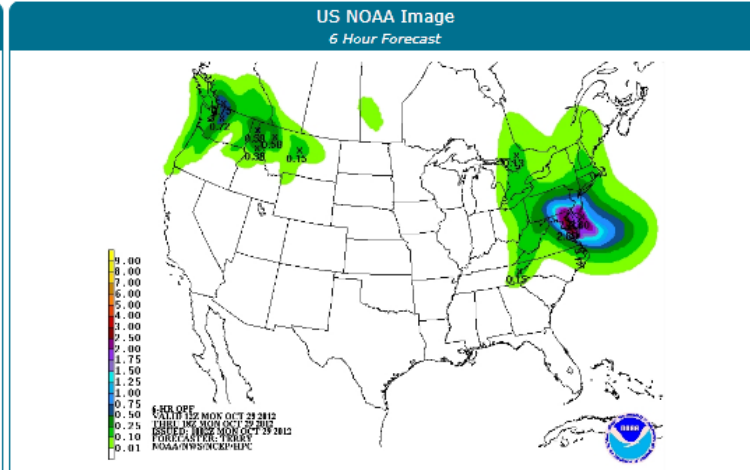
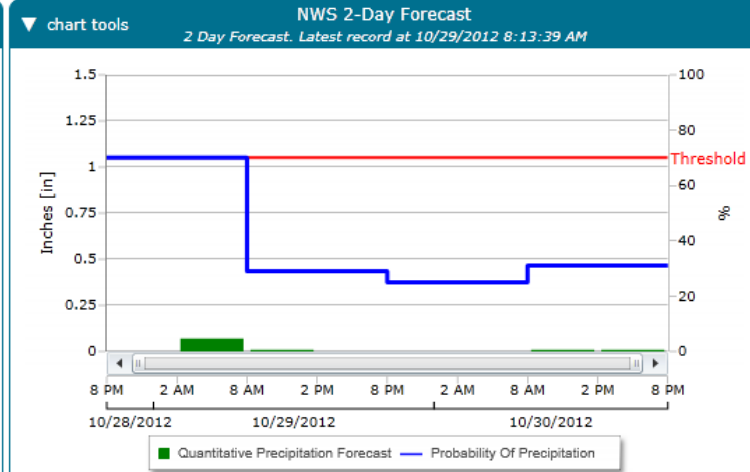
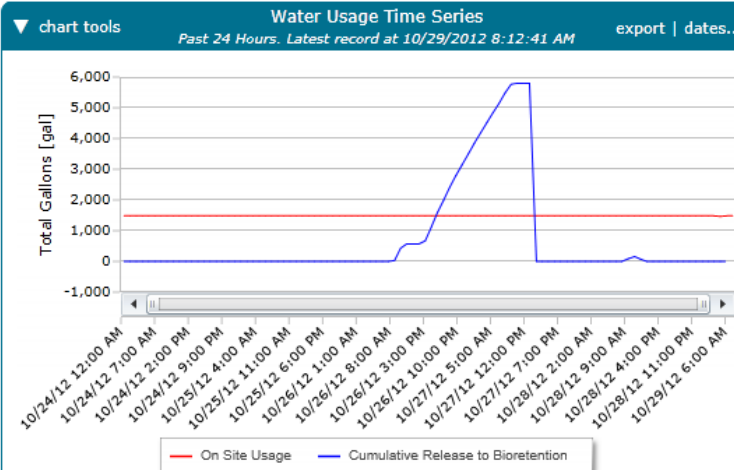
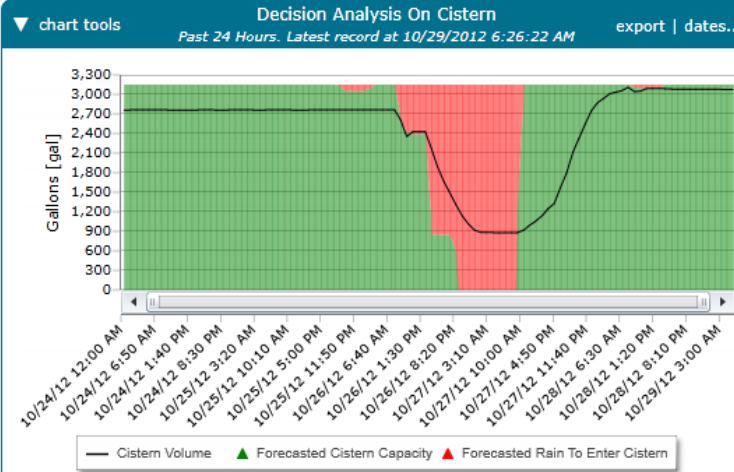
Switch to ON

Recent Status

Local Network

Offline 0%, Online 100%

Past 24 Hours

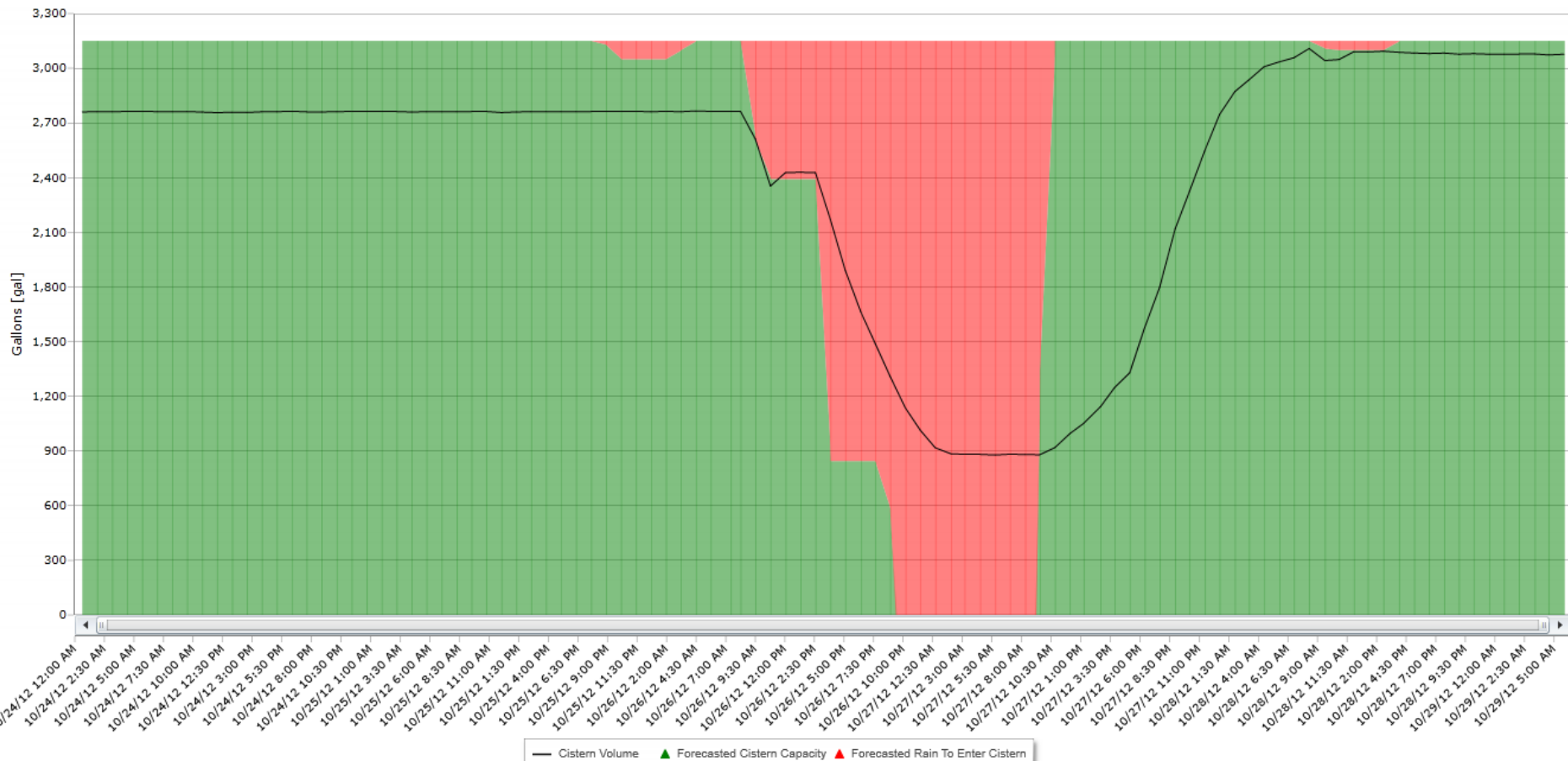


▼ chart tools

Decision Analysis On Cistern

Past 24 Hours. Latest record at 10/29/2012 6:26:22 AM

export | dates..



Technology Application: Advanced Rainwater Harvesting Systems

Other Installations

Twin Oaks Library - Austin



Twin Oaks Library: Remote Reality Interface



Controlled Release
to Bioretention





Twin Oaks Advanced Rainwater Harvesting System

Executive

Map

Admin

Tools

Sign Out

1359 gallons

Operation Mode

Current state is Manual Override

Automatic

Manual Override

Local State

Current state is Closed

Closed

Open

Local Network Status

Offline 9%, Online 91%

Past 24 Hours

Operation Mode

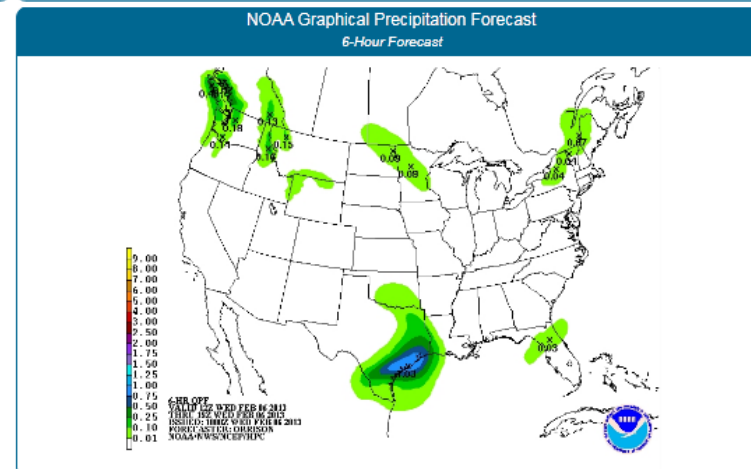
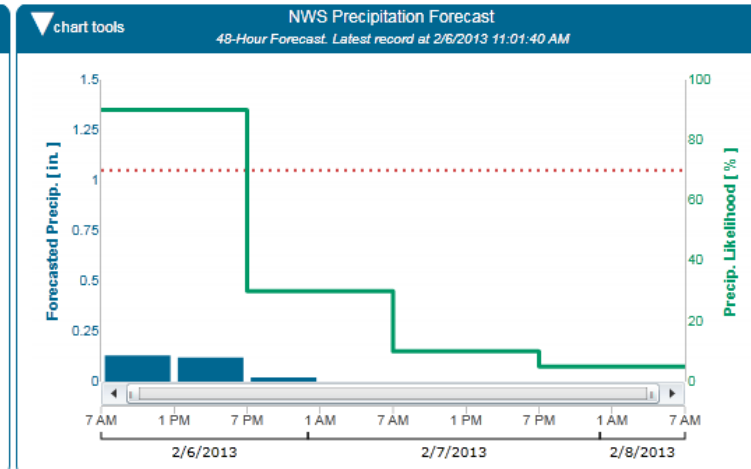
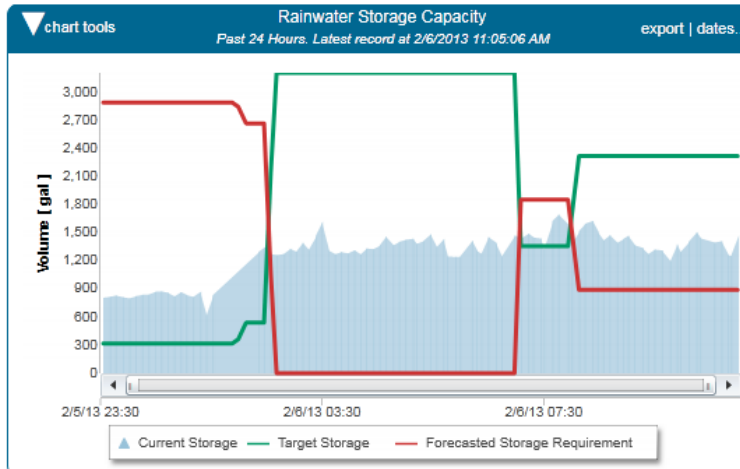
Automatic 63%, Manual Override 37%

Past 24 Hours

Local State

Closed 100%, Open 0%

Past 24 Hours



Pilot Site: Washington, DC Engine House #3











CLEAR FLOW PRECAST
CF

AMERICAST

A. J. JONES
CONTRACTORS SUPPLY
& SERVICES
800.555.7888







Engine House 3 Operations

Navigate to..

Executive

Map

Admin

Tools

Sign Out



Engine House 3 Operations

Dashboard Tools

Download Data

Network Status-Drain

Offline 0%, Online 100%

Past 24 Hours

Network Status-Treatment

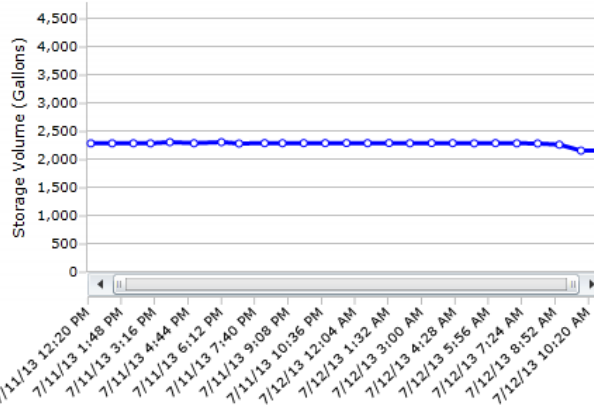
Offline 0%, Online 100%

Past 24 Hours

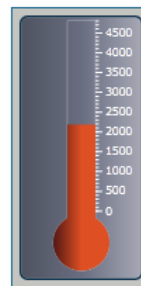
Cistern Storage Time Series

Past 24 Hours. Latest record at 7/12/2013 11:23:46 AM

export | dates..



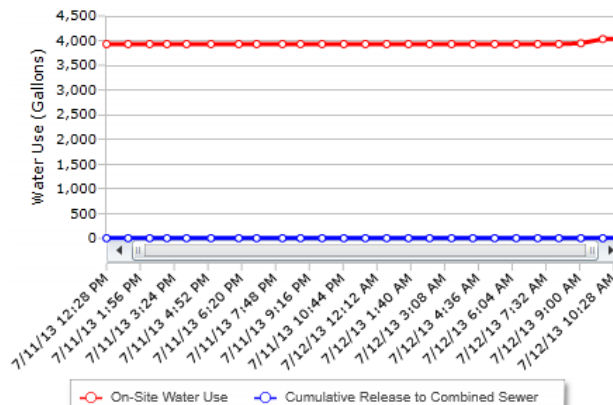
Storage for On-Site Use (Gallons)



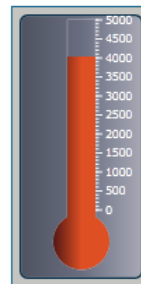
Water Usage Time Series

Past 24 Hours. Latest record at 7/12/2013 11:23:46 AM

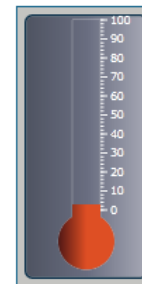
export | dates..



On-Site Water Usage (Gallons)

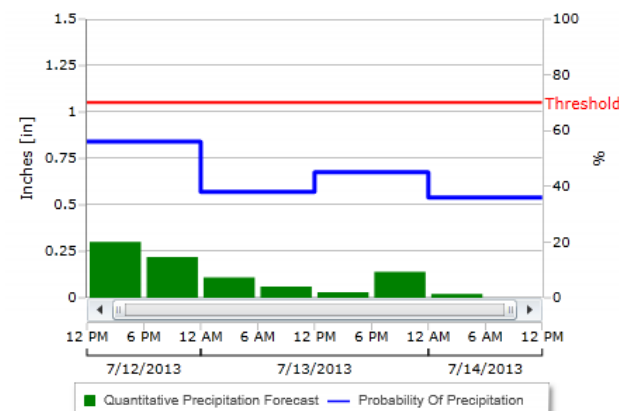


Release to Combined Sewer (Gallons)



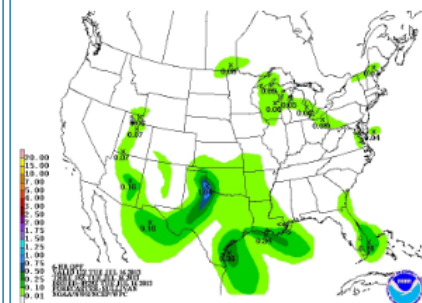
NWS 2-Day Forecast

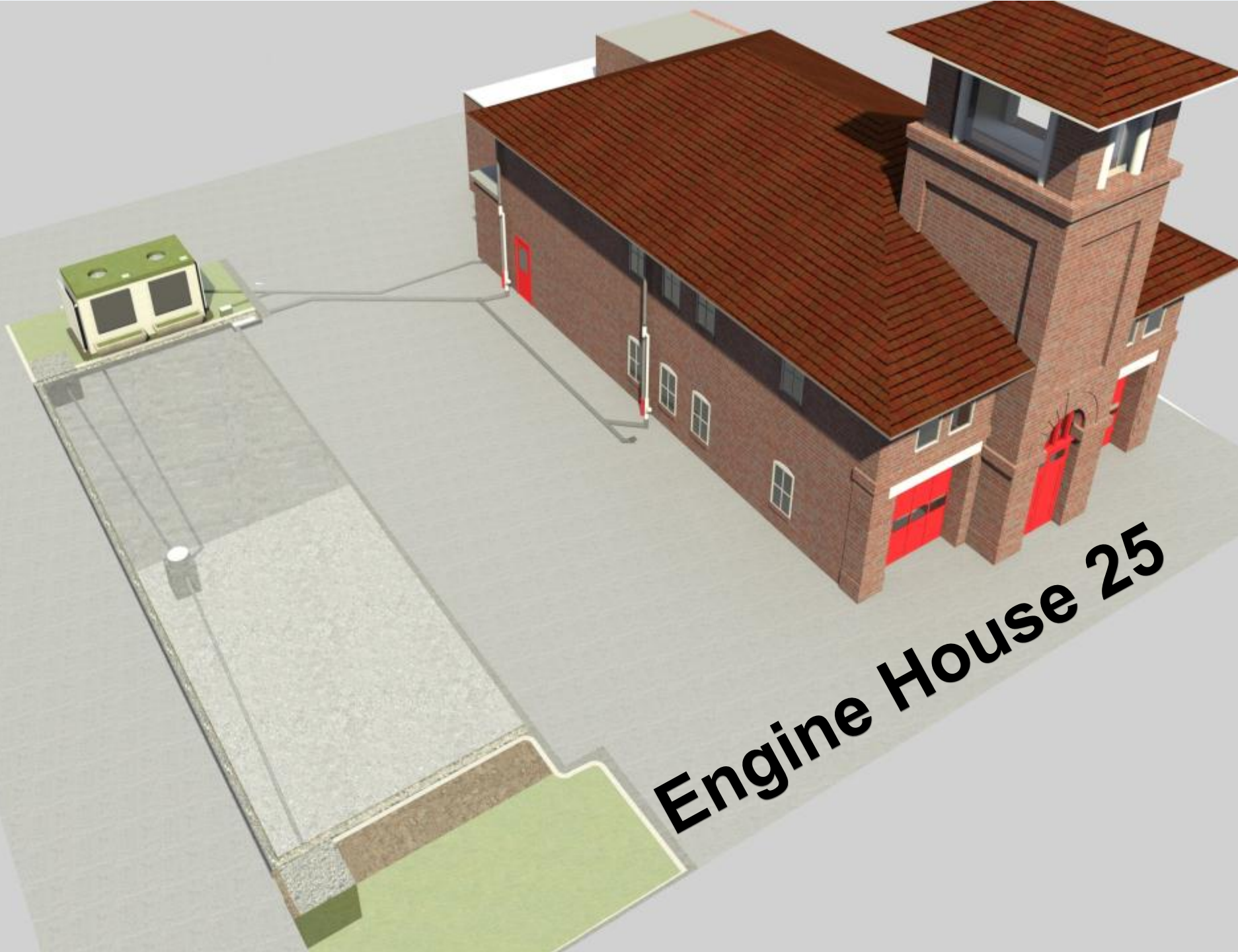
2 Day Forecast. Latest record at 7/12/2013 11:40:00 AM



US NOAA Image

6 Hour Forecast





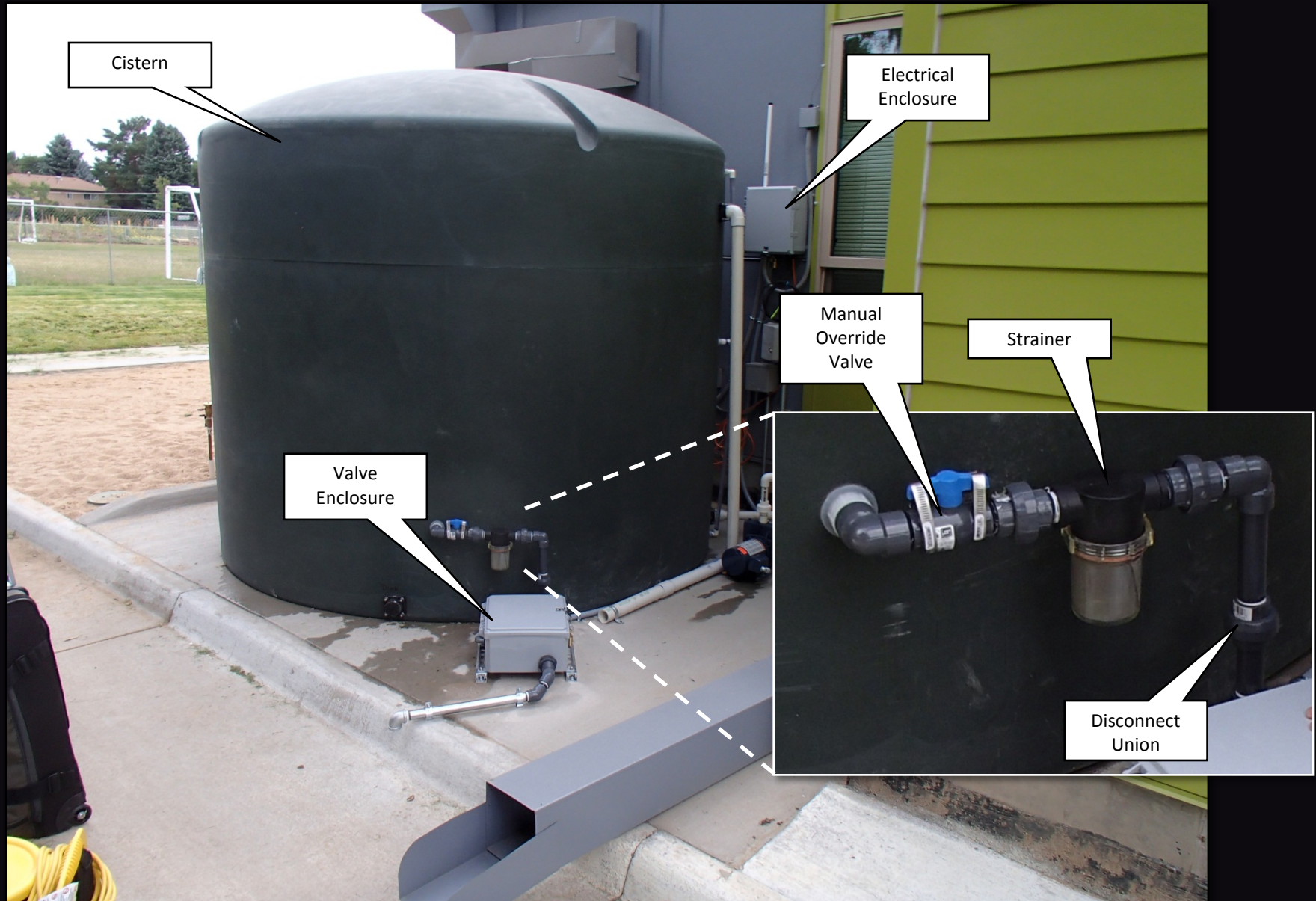
Engine House 25



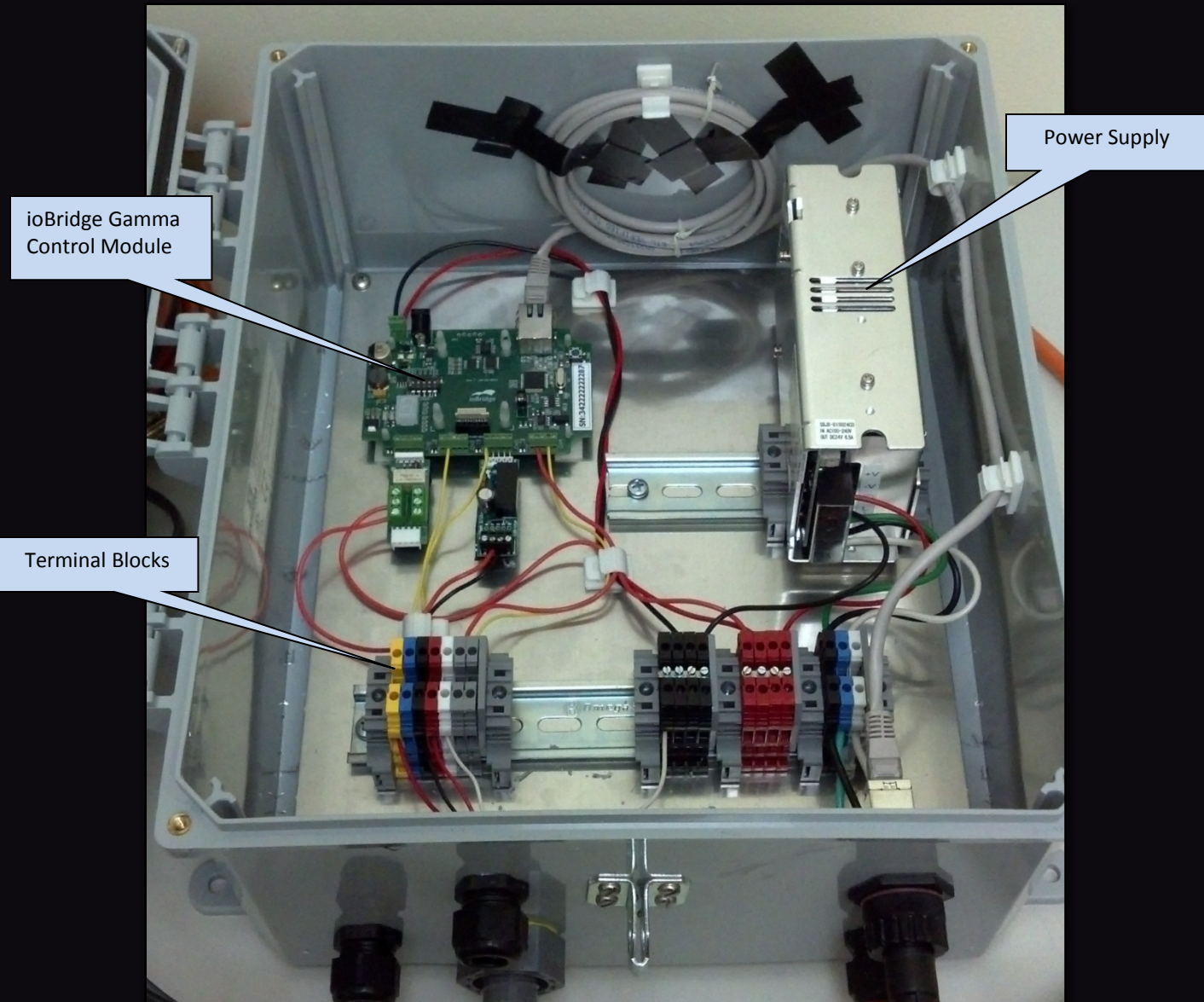
Urban Drainage and Flood Control District: Advanced Rainwater Harvesting System Installation at Denver Green School



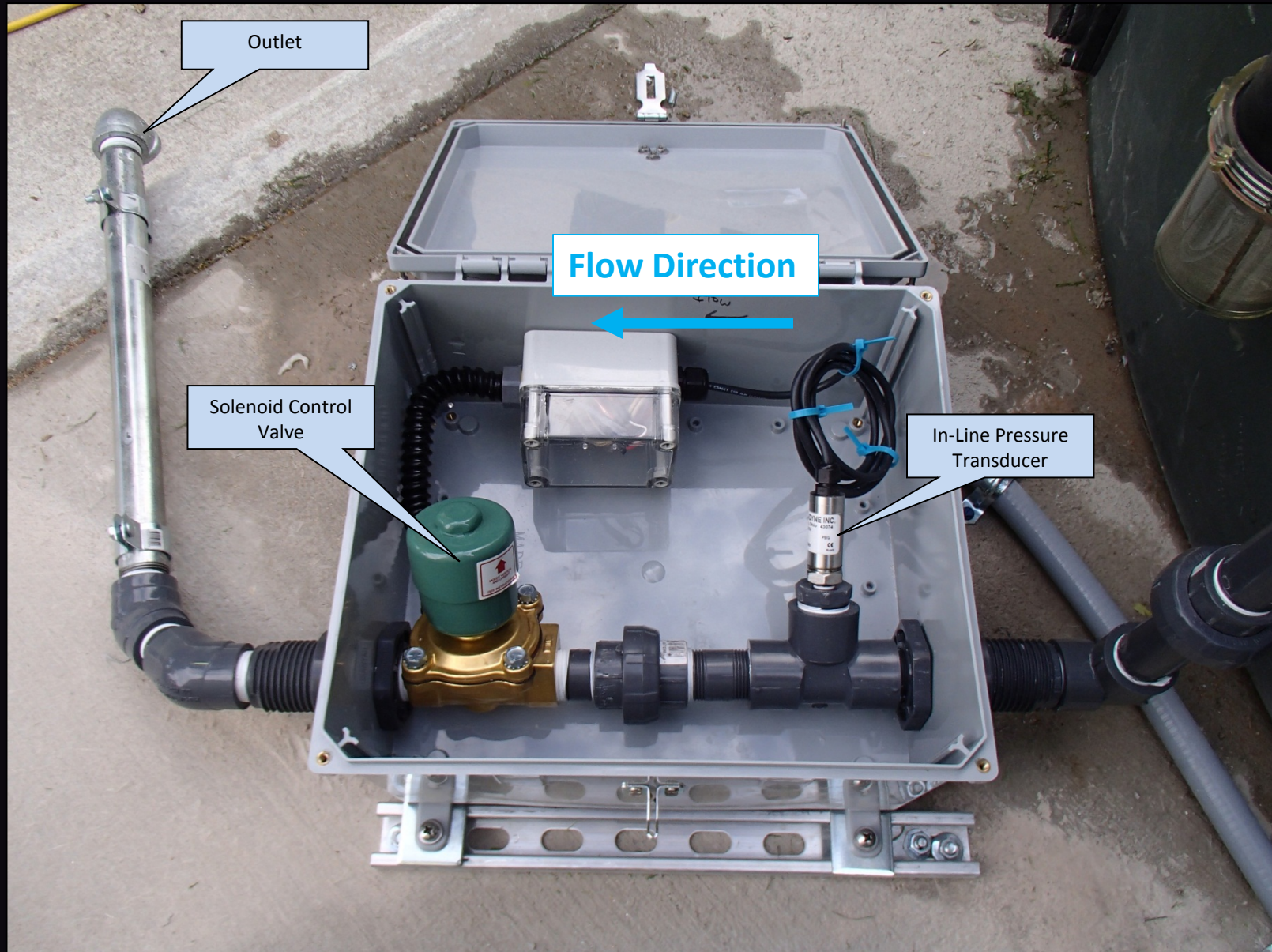
UDFCD – System Overview



UDFCD – Electrical Enclosure (in office)



UDFCD – Valve Enclosure



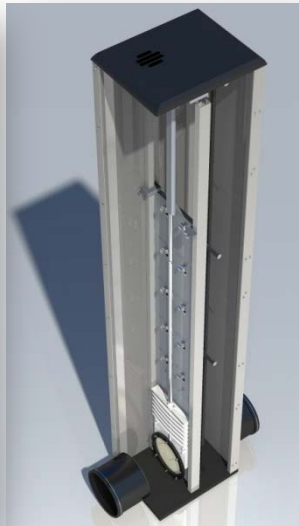
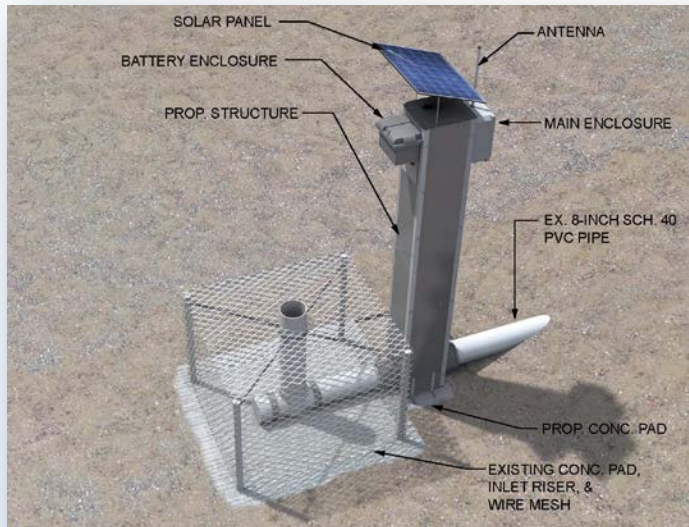


EPA Headquarters Building Cisterns Retrofit
Washington, DC – In Progress

Technology Application: Smart Detention/Retention/Flood Control Retrofits

Case Study: TX, Pond/Flood Control Retrofit

- Outlet Control Structure Retrofit for Water Quality Enhancement
- Balance Flood Control and Water Quality





Gilleland Creek Detention Pond

Navigate to..

Executive

Map

Admin

Tools

Sign Out

Operation Mode

Current state is Manual Override

Automatic

Manual Override

Local State

Current state is Opened

Close

Open

Valve Status

Open 100%, Closed 0%
Past 24 Hours

Local Network Status

Online 100%, Offline 0%
Past 24 Hours

chart tools

Pond Water Level

Past 4 Days. Latest record at 4/6/2013 11:58:40 PM

export | dates..

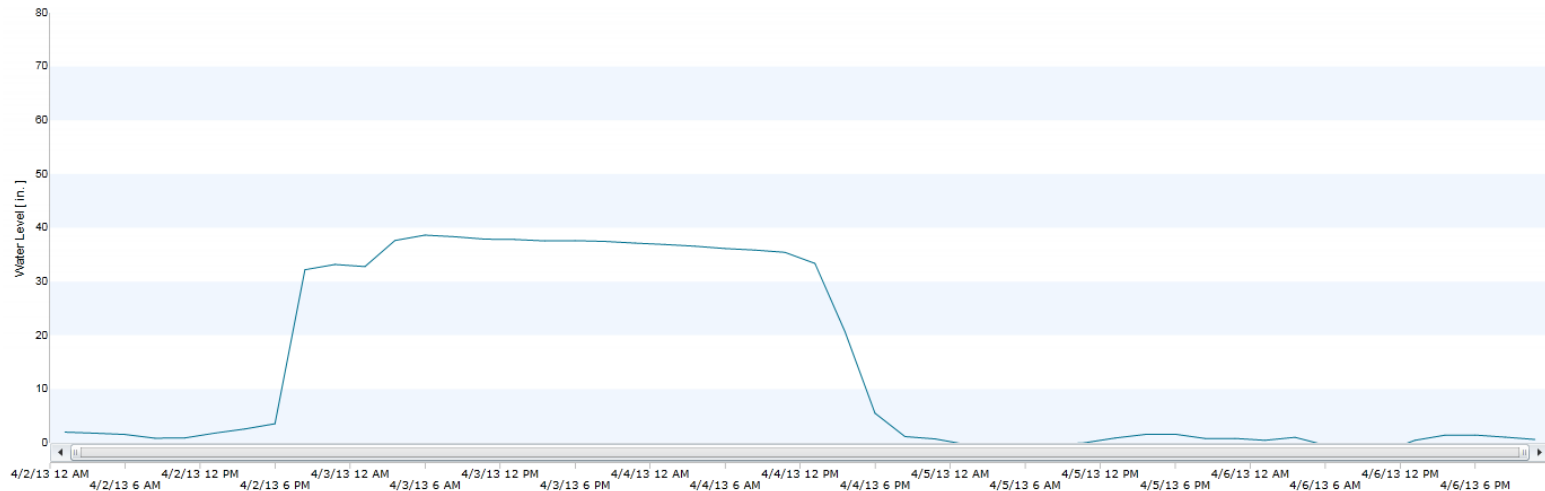
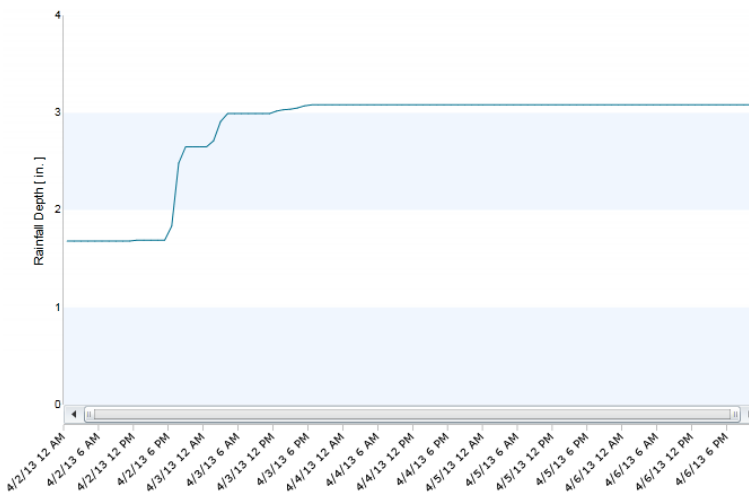


chart tools

Cumulative Rainfall

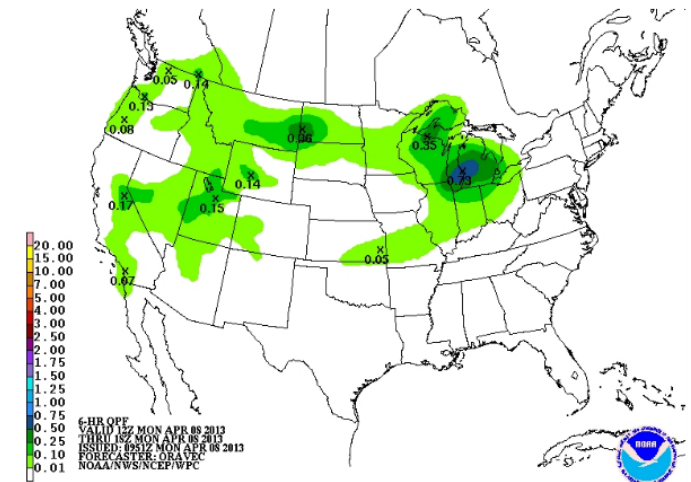
Past 4 Days. Latest record at 4/6/2013 11:58:40 PM

export | dates..



NOAA Graphical Precipitation Forecast

6-Hour Forecast

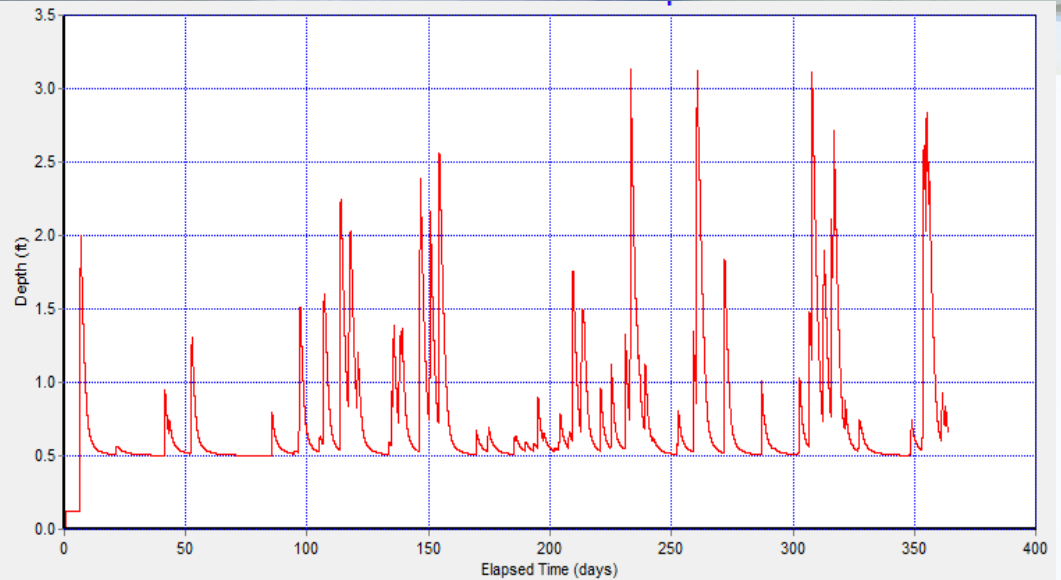


Technology Application: Modeled Wetland Pond/water Feature Retrofits

North Carolina Design (collaboration with Bill Hunt)

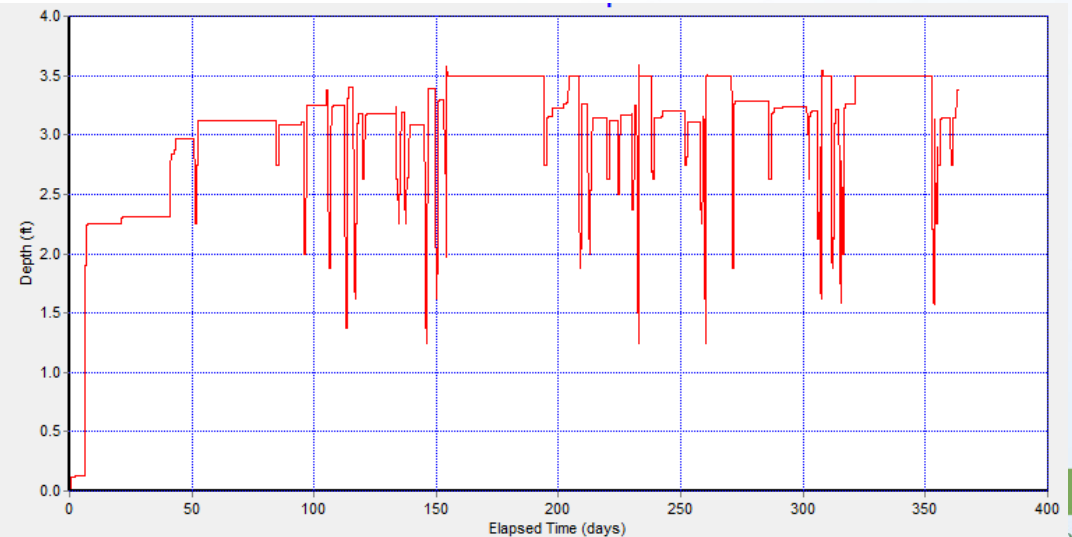
Depth Time Series and Average Hydraulic Residence Time for Passive Outlet

**Average Hydraulic
Residence Time
13 days**



Depth Time Series and Average Hydraulic Residence Time for Actively Controlled Outlet

**Average Hydraulic
Residence Time
24 days**



Brooklyn Botanical Garden – Pond Control for CSO Mitigation

Water Level Sensor



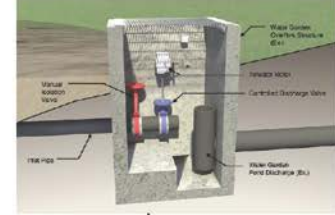
Site Water Controller



Tipping Bucket Rain Gauge



Water Garden Outlet Control Structure



Technology Application: Controlled Underdrain Bioretention

Case Study: Controlled Bioretention Underdrain



Bioretention site rendering



Maximize Infiltration, minimize bypass, and achieve
water quality targets

Technology Application: Active Porous Pavement

Actively Controlled Porous Pavement City of Omaha, NE



Control plate height
is variable and
serves as overflow
when closed

Control Box

Pressure
Transducer

Actuator

Trash Screen

Slide Gate

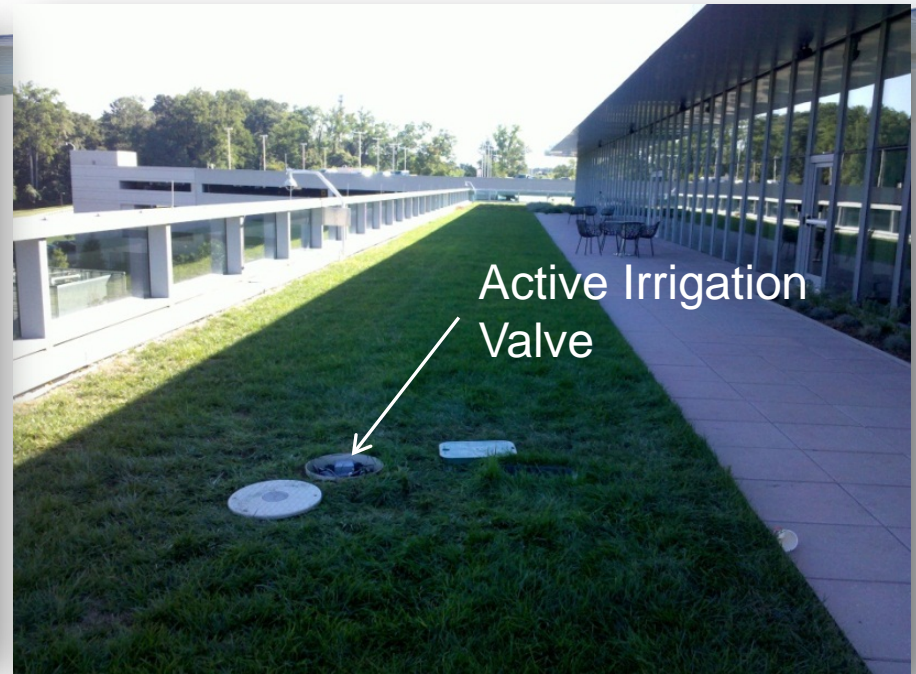
Control Plate with Actuated Slide Gate (Open)

Technology Application: Active Green Roofs

Case Study: Active Green Roof, Pennsylvania



Green Roof Project Site



SAP HQ, Green Roof

Navigate to..

Executive

Map

Admin

Tools

Sign Out

Recent Status

Liquid Level Sensor

Above Sensor 2%, Below Sensor 98%

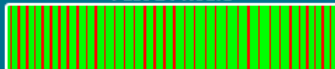
Past 24 Hours



Irrigation Valve

Valve Closed 77%, Valve Open 23%

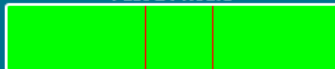
Past 24 Hours



Local Network

Offline 1%, Online 99%

Past 24 Hours



Automation Mode

Manual 0%, Automatic 100%

Past 24 Hours



Controller State

DATING-OPEN 13%, HOLD-OPEN 9%, V

Past 24 Hours

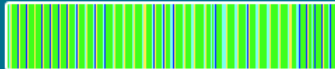


chart tools

Green Roof Operations

export | dates..

Past 24 Hours. Latest record at 7/16/2013 2:41:40 PM

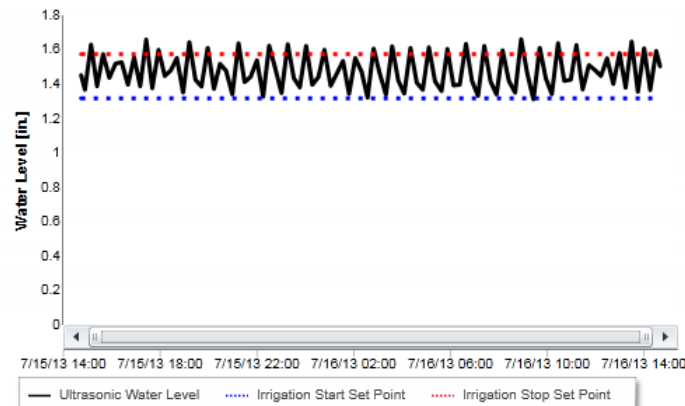


chart tools

Irrigation Consumption Meter

export | dates..

Past 24 Hours. Latest record at 7/16/2013 2:41:40 PM

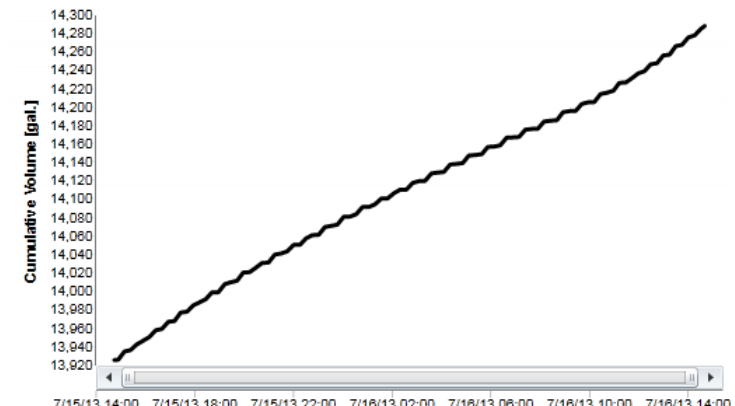
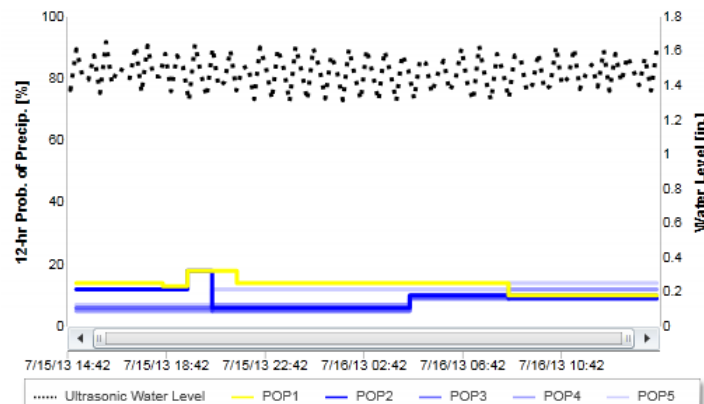


chart tools

Forecast Time Series

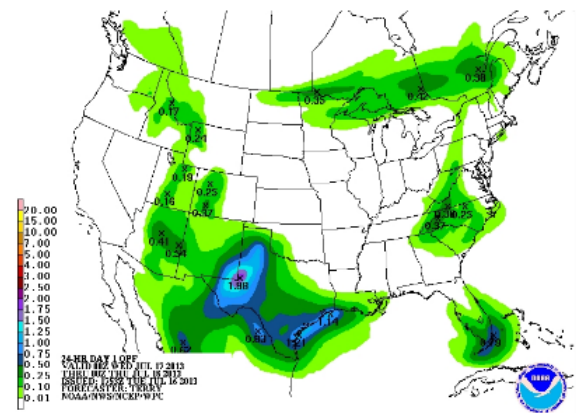
export | dates..

Past 24 Hours. Latest record at 7/16/2013 2:41:40 PM



US NOAA Image

24 Hour Forecast



Dashboard SAP Green Roof – 7/11/13



SAP HQ, Green Roof

Navigate to..

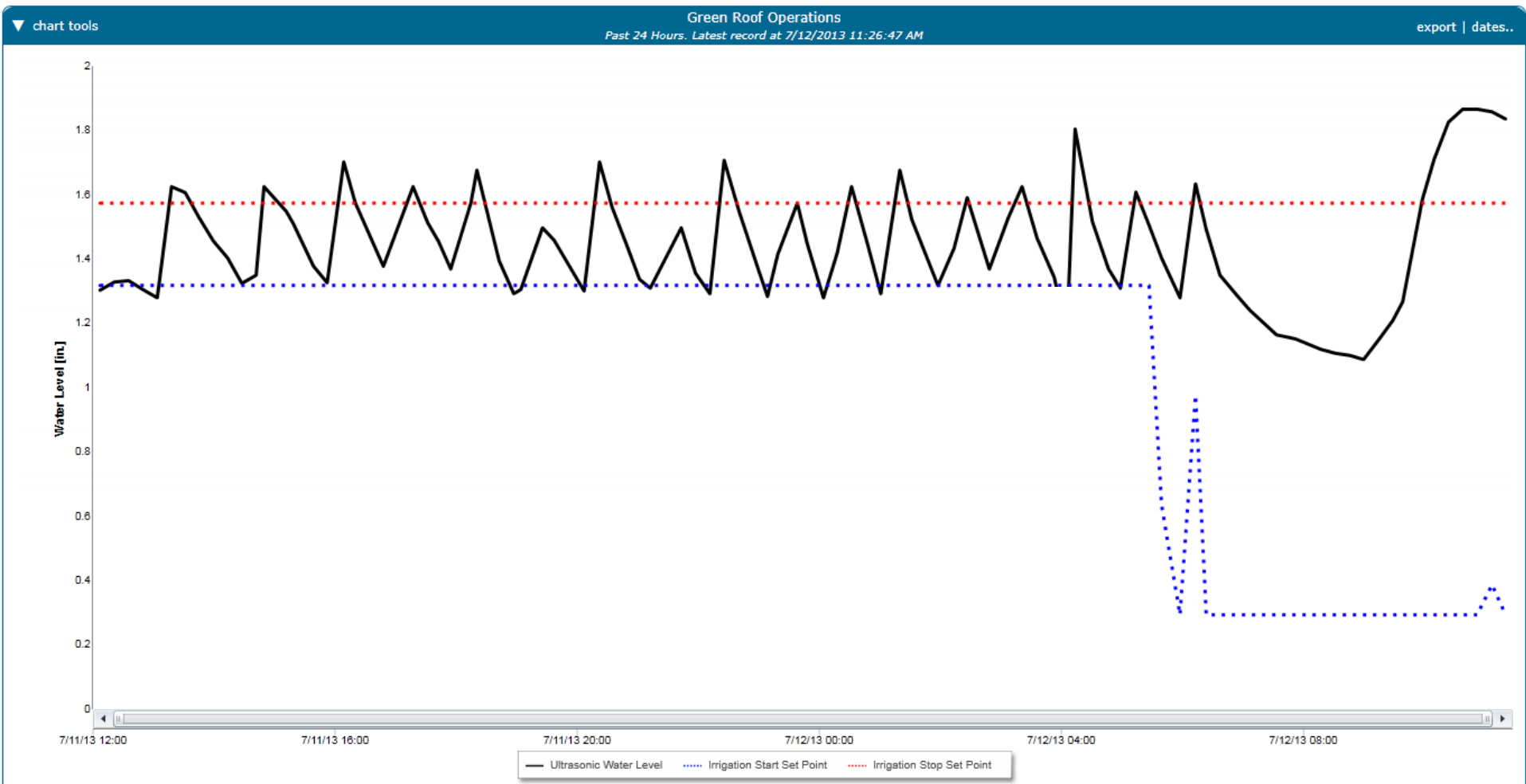
Executive

Map

Admin

Tools

Sign Out



- Merging of information technology and infrastructure will increasingly be important if not critical.
- Low cost, reliable, and highly functional sensors and sensor platforms will change everything we know about how we currently regulate, enforce, and understand environmental systems.
- Be creative, explore the possibilities, the future is blindingly interesting.