Potential of Rainwater Harvesting Systems in North Carolina

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NC STATE UNIVERSITY
Bio&Ag ENGINEERING


XFX-323

RWH & Water Conservation

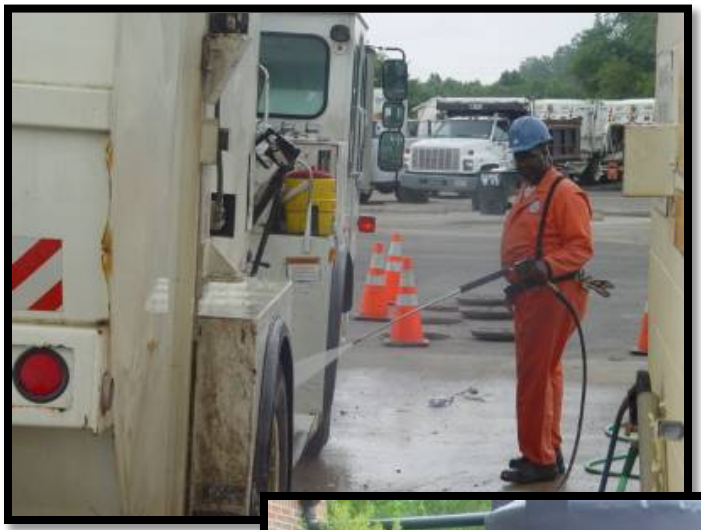
Main objective:

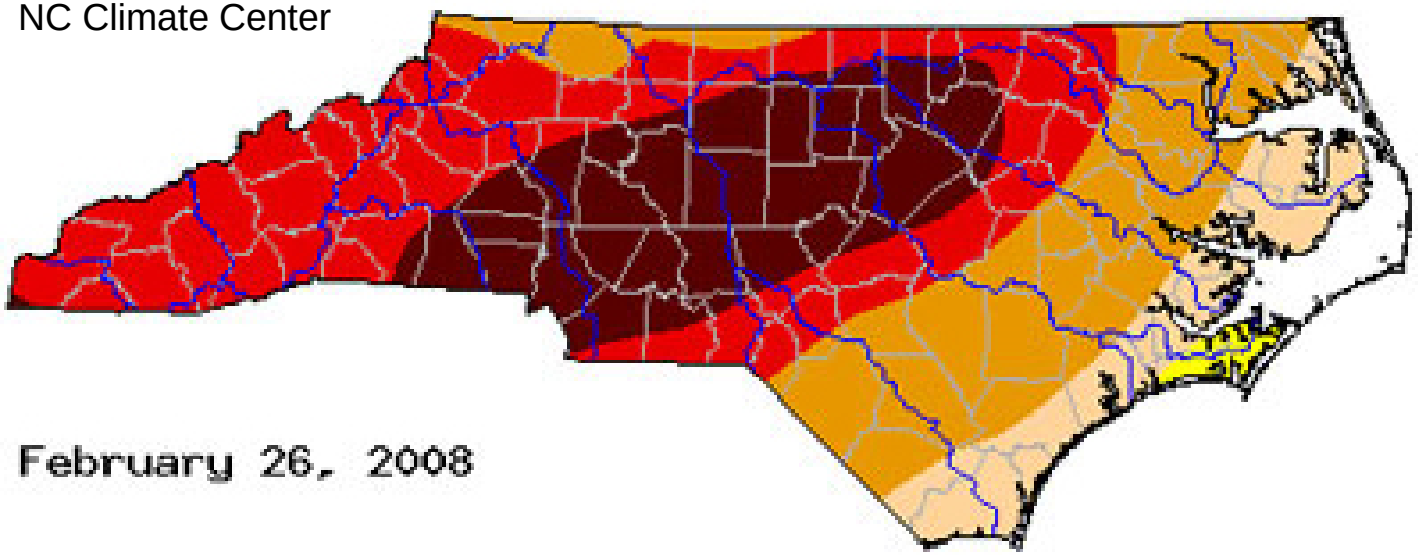
Have rainwater available to use in lieu of potable water

RWH & Stormwater Management

Main objective:
Have enough space available in the tank to capture the next storm event

Research Phase I



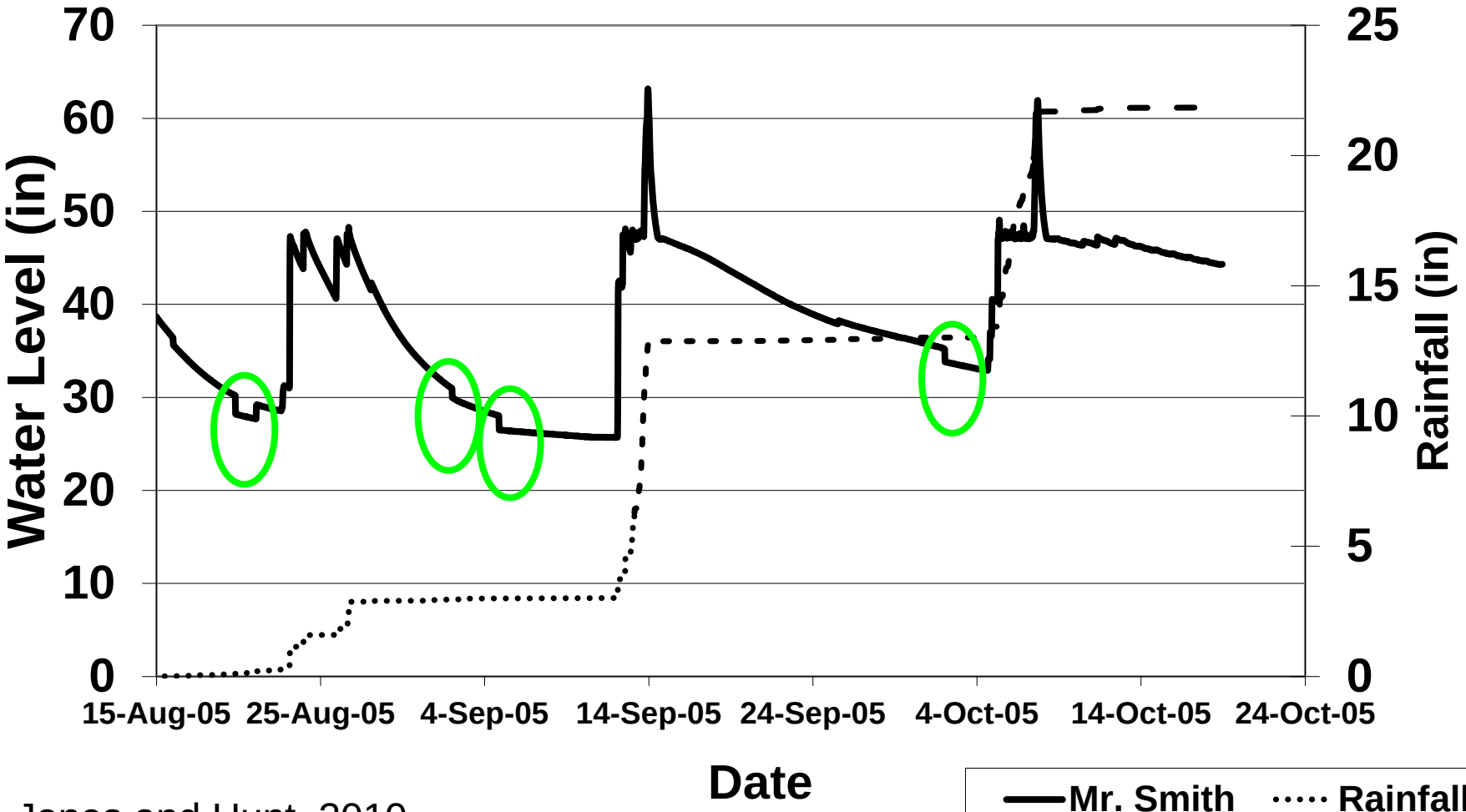


Drought Classifications

- D0 - Abnormally Dry
- D1 - Moderate Drought
- D2 - Severe Drought
- D3 - Extreme Drought
- D4 - Exceptional Drought

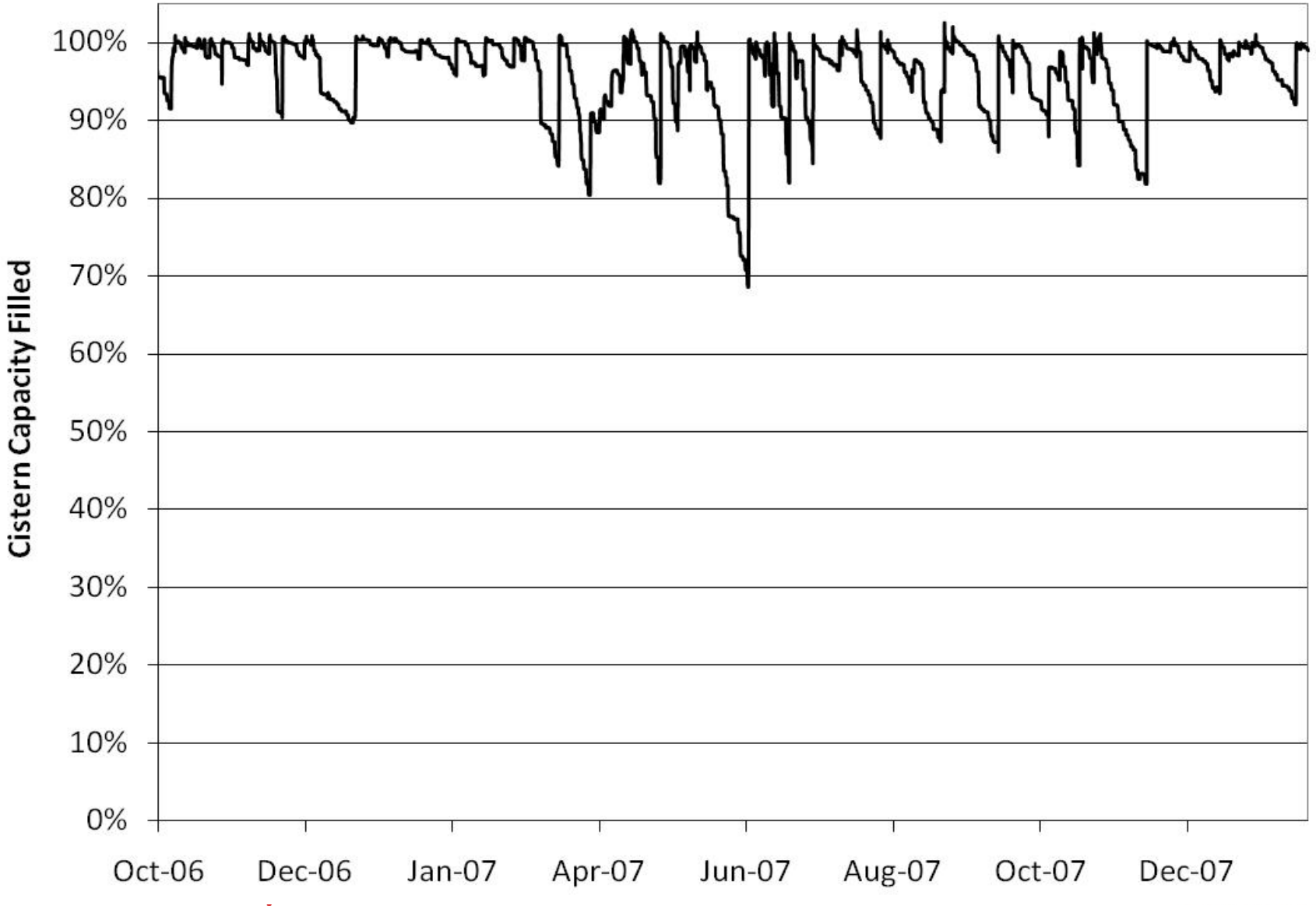
raleighnc.gov

Holden Beach: Irrigation of Garden



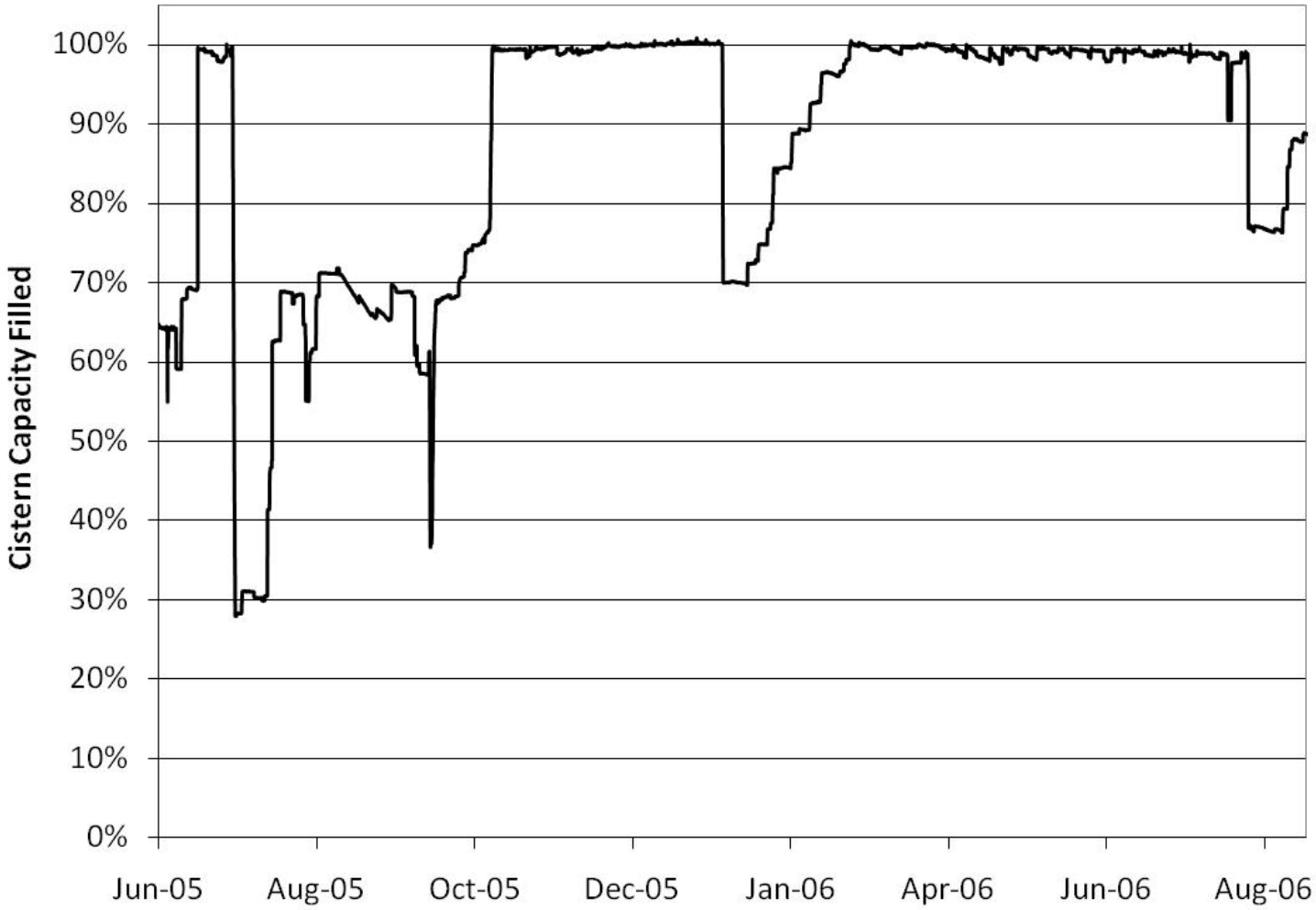
Jones and Hunt, 2010

Prairie Ridge Water Level: Toilet Flushing



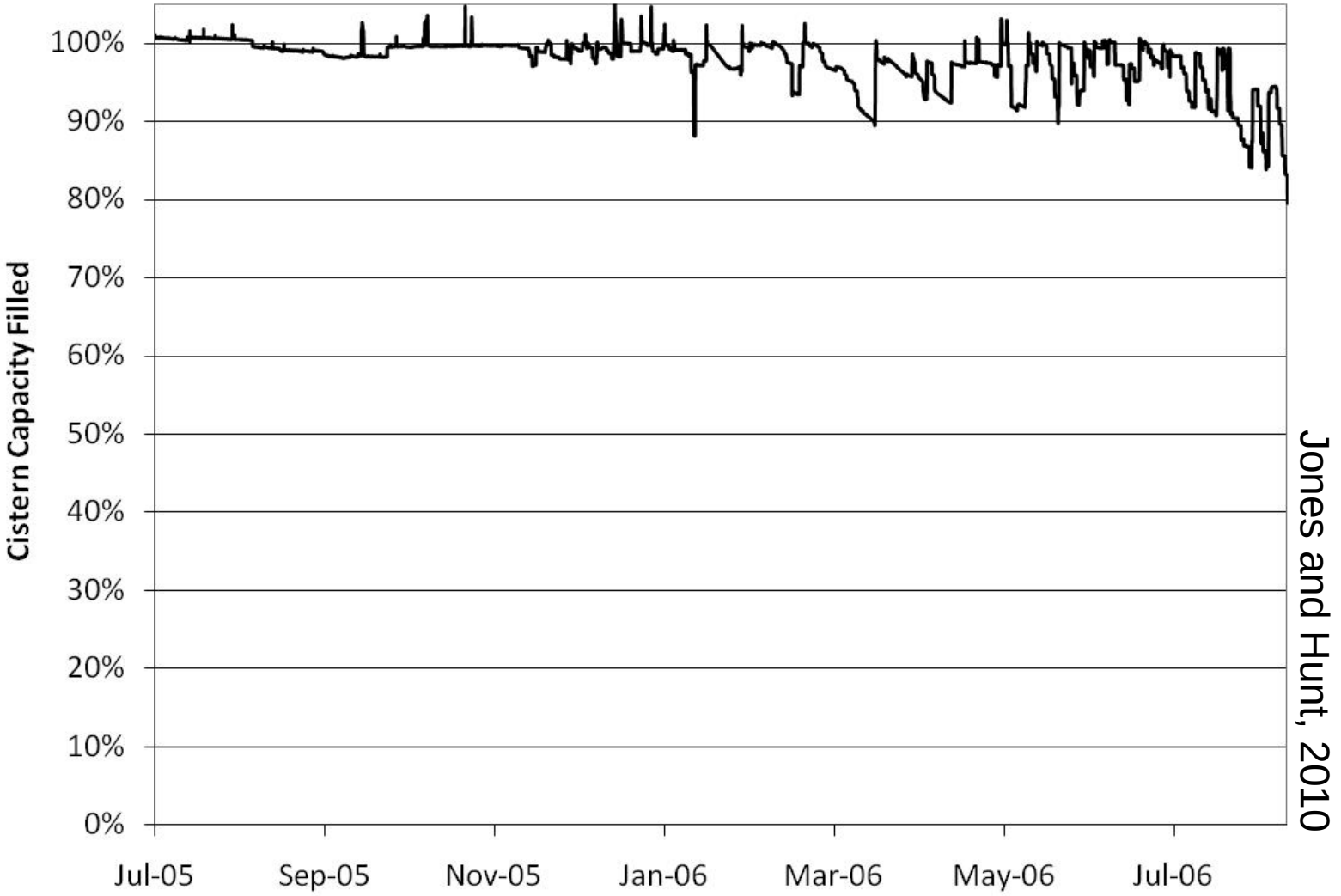
Jones and Hunt, 2010

New Bern:
Irrigation & Occasional Car Wash



Jones and Hunt, 2010

Kinston Public Services: Vehicle Washing



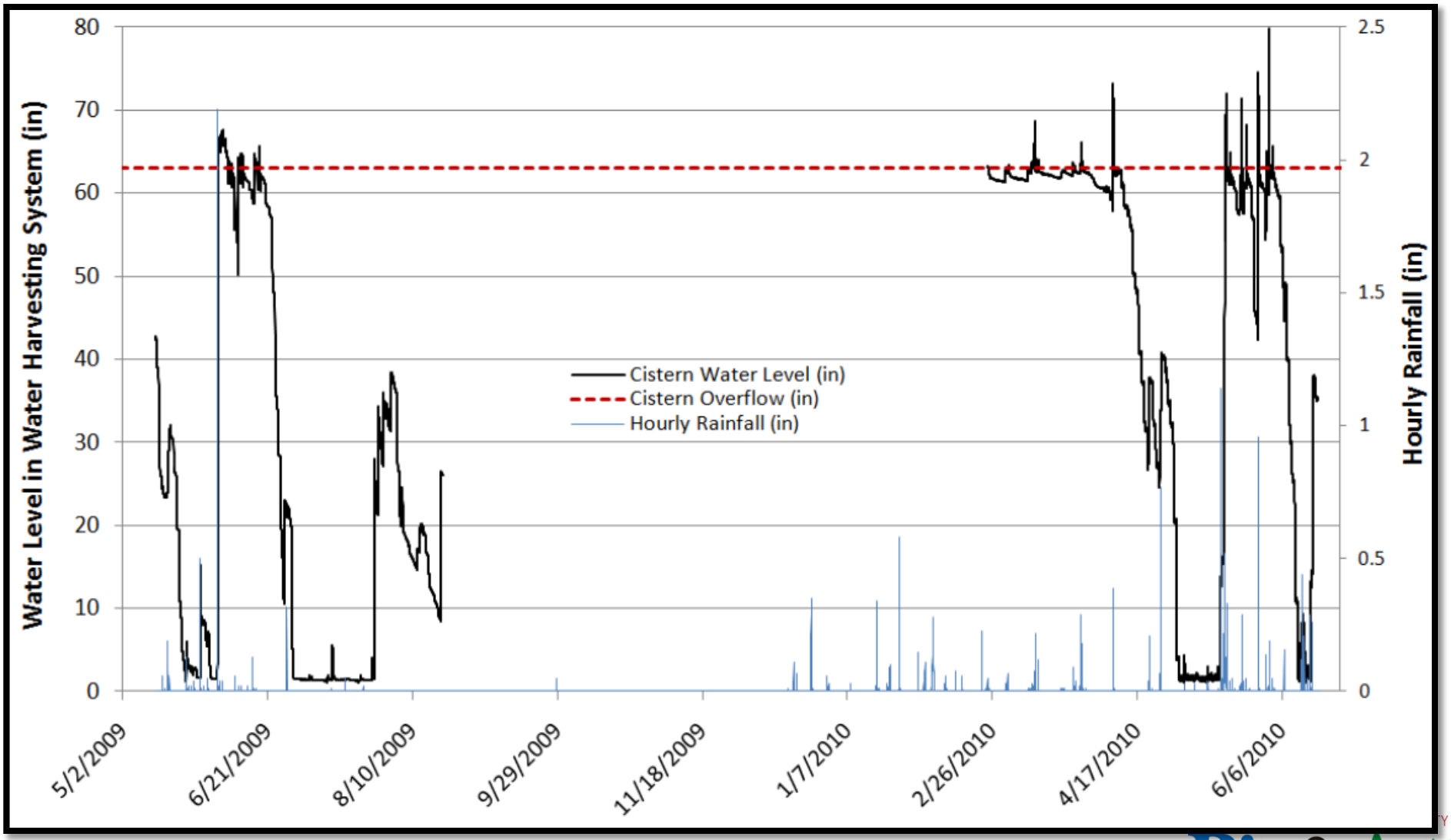
Research Phase II

- Identified designated uses
- Incorporated automation & backup water supply
- Increase education and outreach

Guilford County (Greensboro): Guilford Co. Coop. Extension Ctr.

- 4,400 gal system
- Automated system
- Backup water supply
- Water use: irrigation of community gardens

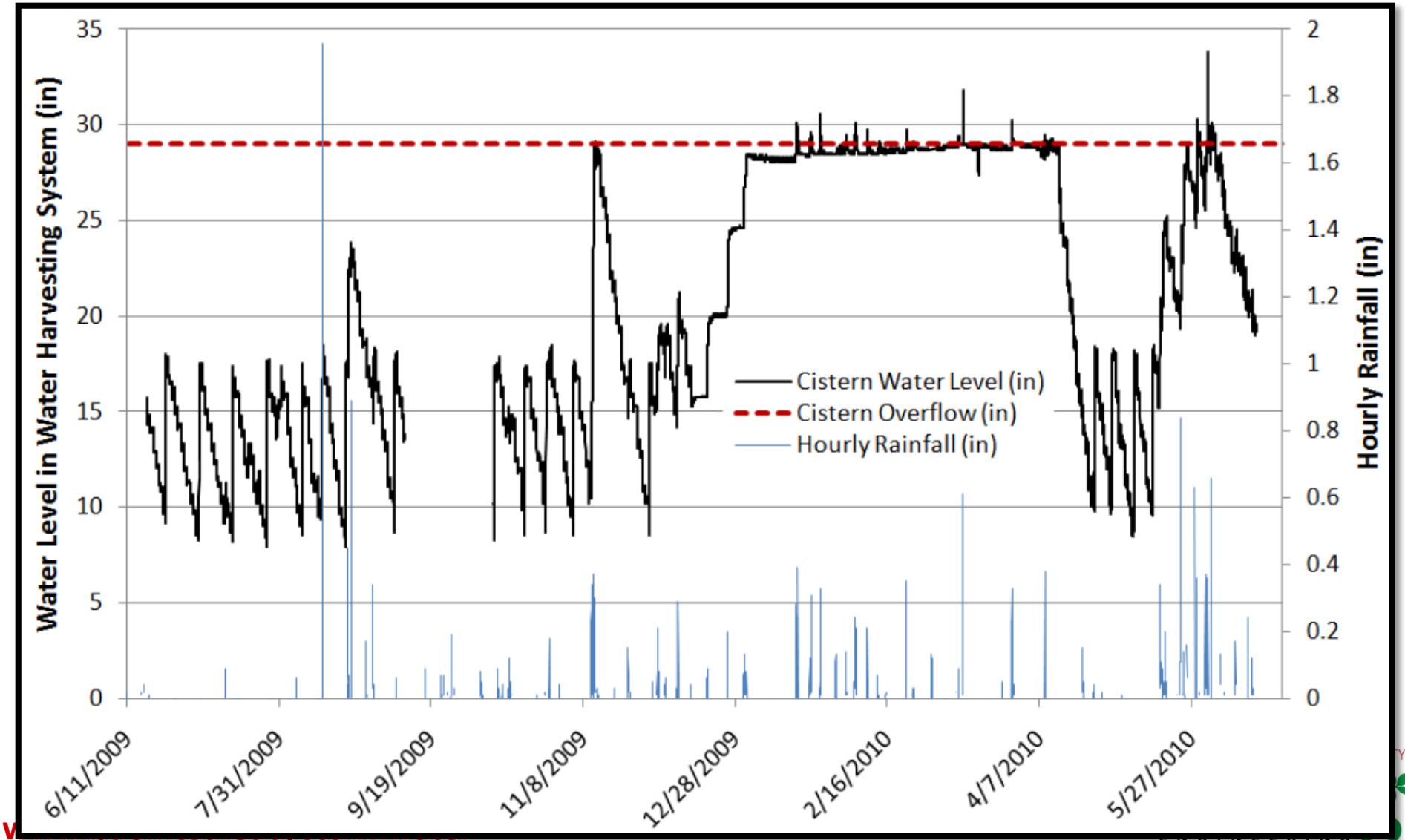
Results:
Guilford Co. Extension Center



Cumberland County (Fayetteville): Fayetteville Technical Comm. College

- 15,000 gal cistern
- Underground design
- Automated system
- Backup water supply
- Water use: irrigation of greenhouses

RESULTS – FTCC HORTICULTURE CENTER



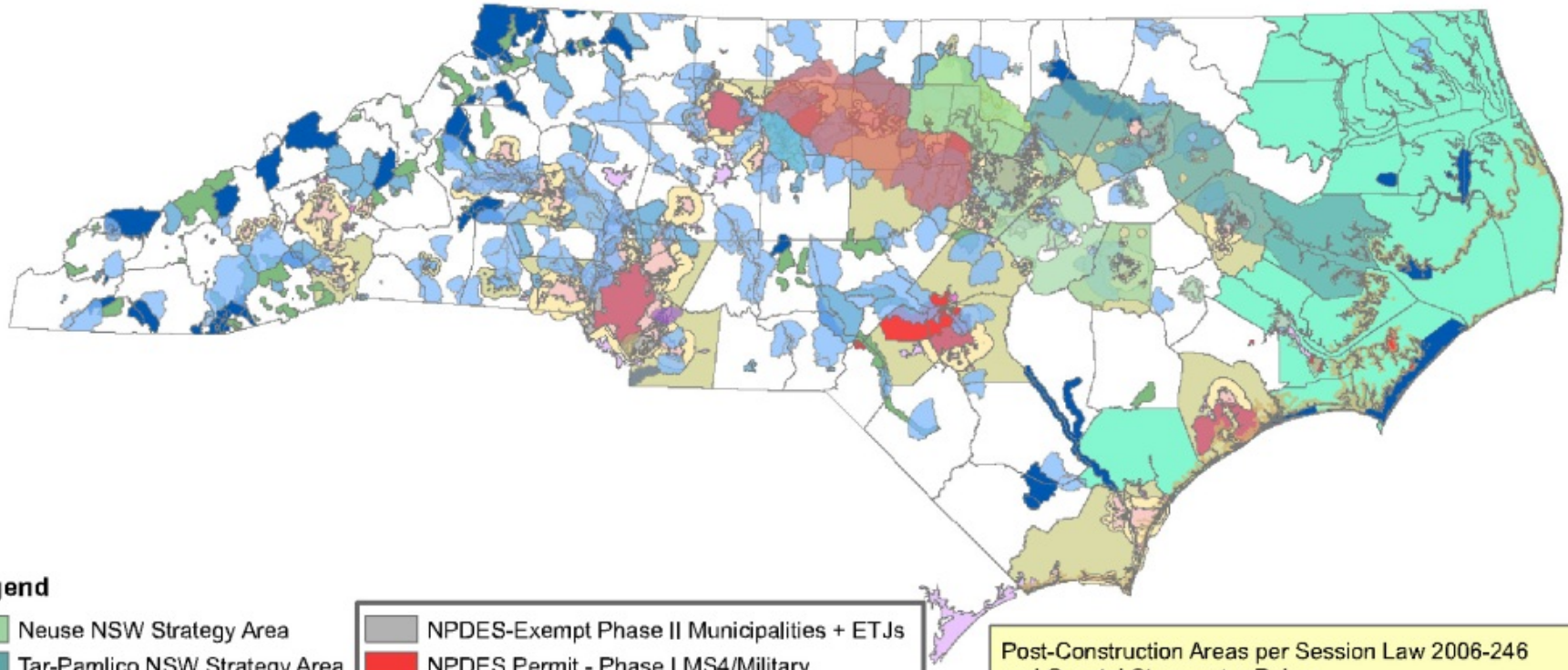
Results of Research Phase II

- Increased usage of harvested rainwater
- No usage during non-growing season
  - No stormwater benefit or mitigation
- Need to identify secondary benefits to facilitate implementation and use

DeBusk et al. (2013)

2/12/2013

Stormwater Management Program Areas in North Carolina



Legend

- Neuse NSW Strategy Area
- Tar-Pamlico NSW Strategy Area

DESCRIPT

- Falls Lake Watershed
- Goose Creek Watershed
- Jordan Reservoir Watershed
- Randleman Reservoir Watershed
- Sixmile Creek Watershed
- Waxhaw Creek Watershed
- Water Supply Watersheds
- ORW
- HQW (non-coastal)
- SA (Shellfish) Areas

- NPDES-Exempt Phase II Municipalities + ETJs
- NPDES Permit - Phase I MS4/Military
- NPDES Permitted Ph II MS4/Co
- NPDES Permitted Phase I MS4
- NPDES Permitted Phase I/II city ETJ
- NPDES Permitted Phase II MS4
- Phase II MSIs (from 2011 Boundaries)
- Designated Phase II Municipalities
- Future MSIs (2010 Delineations)
- Urbanized Areas (2000 Census)
- NEW Urbanized Areas (2010 Census)
- Phase II Tipped Counties (Post-Construction)
- Coastal Stormwater (CAMA Counties)

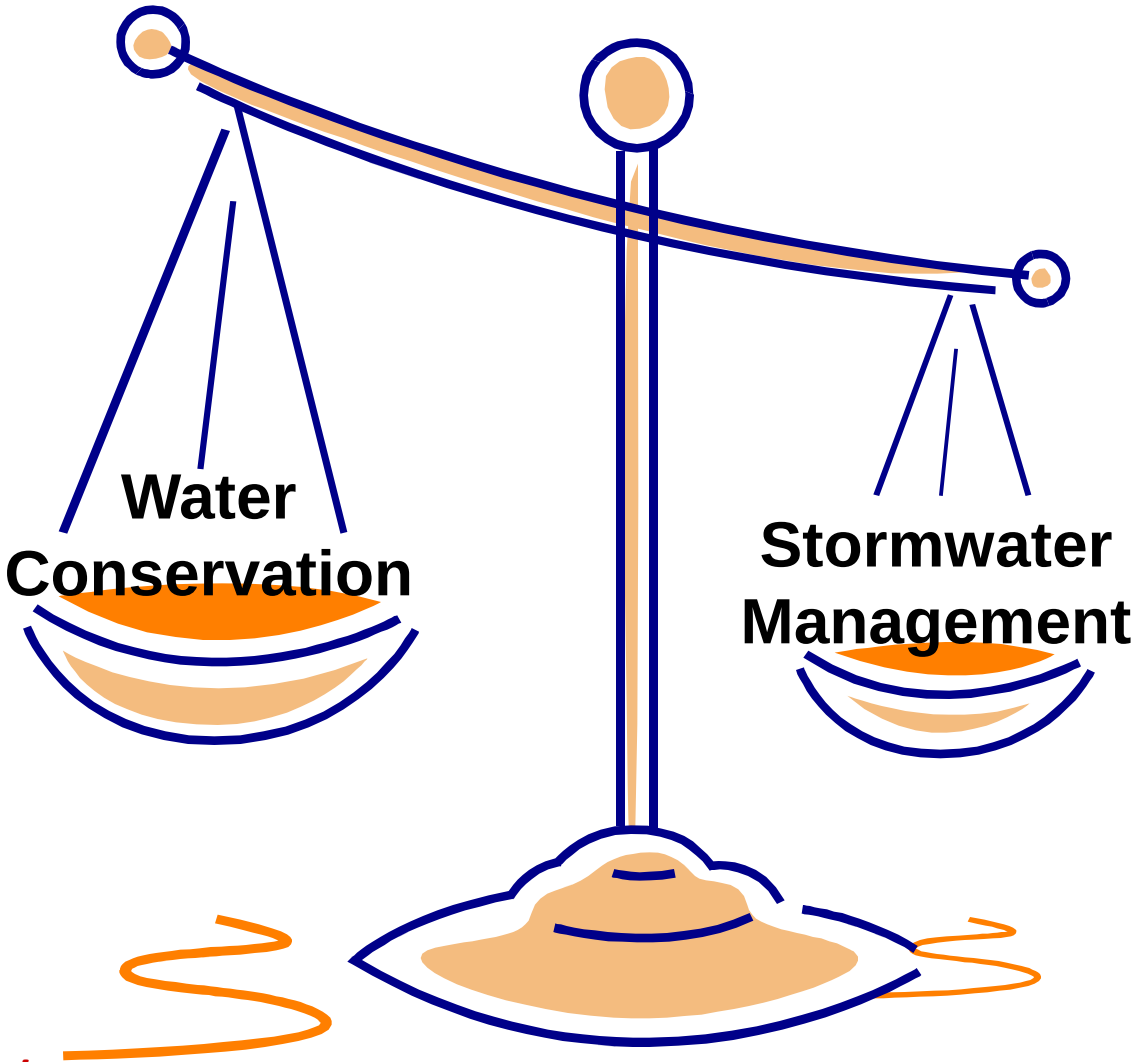
Post-Construction Areas per Session Law 2006-246 and Coastal Stormwater Rules.

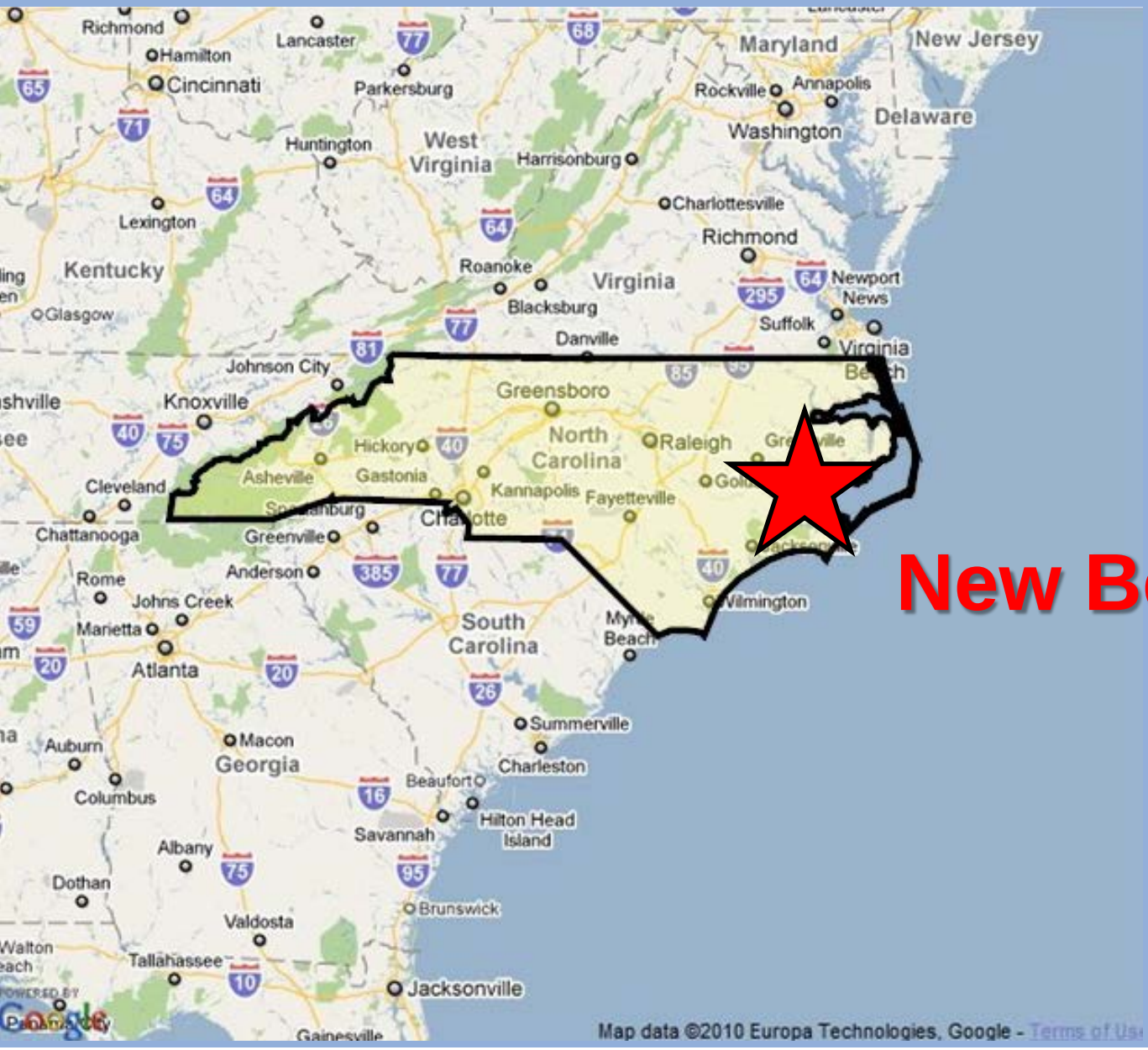
Note - Although Brunswick, New Hanover, and Onslow are Phase II Tipped Counties, projects there are subject to the Coastal Stormwater Rules.

N

0 20 40 80 Miles

How can we do both?

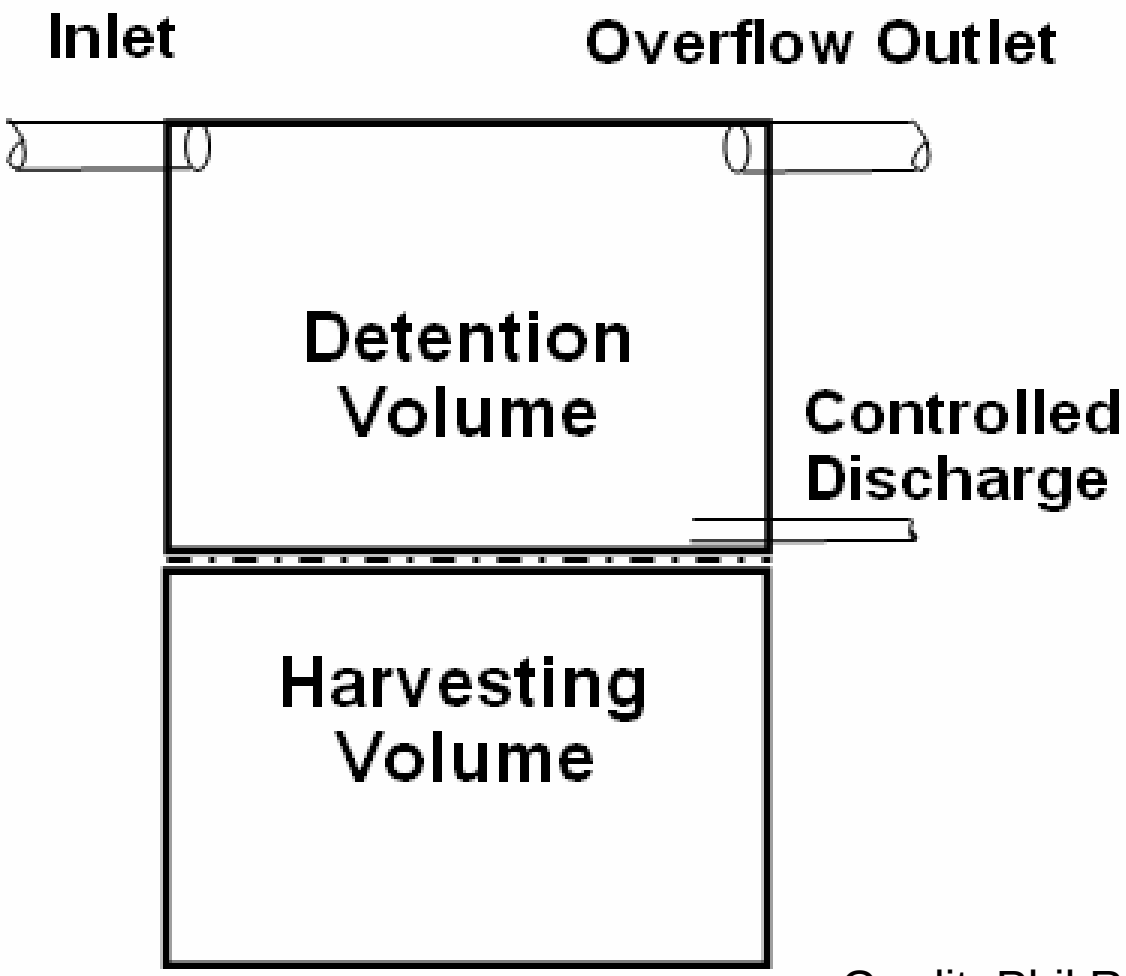



Richmond
Lancaster
Hamilton
Cincinnati
Parkersburg
Maryland
New Jersey
Rockville
Annapolis
Washington
Delaware
Huntington
West Virginia
Harrisonburg
Lexington
Charlottesville
Richmond
Kentucky
Roanoke
Virginia
Blacksburg
Newport News
Glasgow
Suffolk
Danville
Virginia Beach
Johnson City
Knoxville
Greensboro
North Carolina
Raleigh
Hickory
Asheville
Gastonia
Kannapolis
Fayetteville
Cleveland
Chattanooga
Greenville
Anderson
Rome
Johns Creek
Marietta
Atlanta
Wilmington
Myrtle Beach
South Carolina
Summerville
Auburn
Macon
Georgia
Charleston
Columbus
Beaufort
Hilton Head Island
Savannah
Albany
Dothan
Brunswick
Valdosta
Tallahassee
Jacksonville
Gainesville
Map data ©2010 Europa Technologies, Google - Terms of Use

New Bern, NC

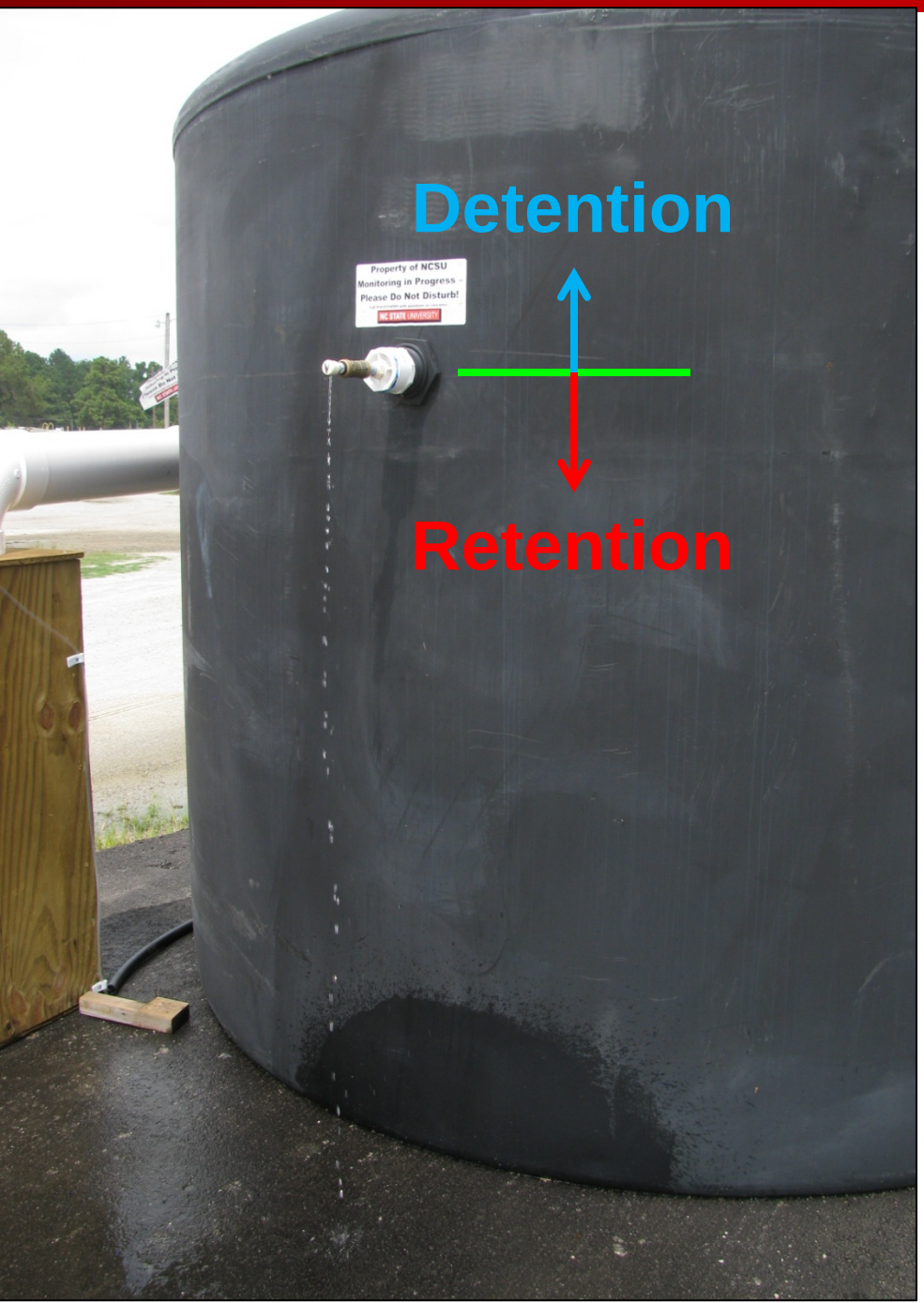
NC Department of Transportation

Passive Release Concept



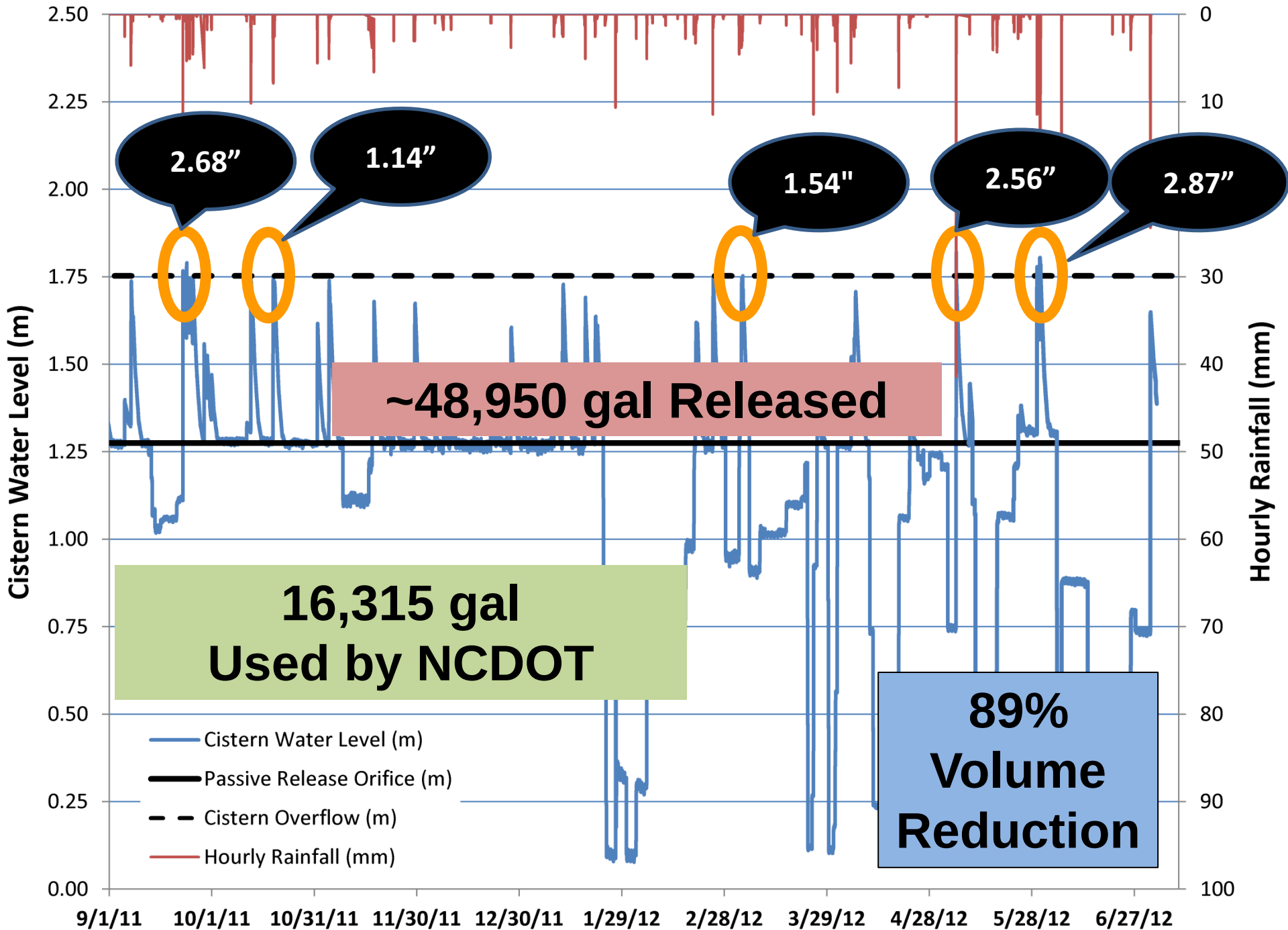
Credit: Phil Reidy

1. The cistern must be sized to treat the design rainfall (ex. 1", 1.5", 1-yr 24-hr storm) from the roof area directed to the water harvesting system. The design rainfall used shall be based on the design storm rainfall depth as specified in Session Law 2006-246 Section 9, Session Law 2008-211 and 15A NCAC 02H .1000. If all of the design volume captured cannot be used, then a scaled reduction in credit will be given. The remaining volume must be treated by a properly designed BMP. The system must be modeled using the water harvesting model developed by NCSU (http://www.bae.ncsu.edu/topic/waterharvesting/), or an equivalent model approved by DWQ, that determines the percent of the design rainfall captured in the system, percent of overflow, and the amount of roof area determined to be treated by the system.
2. A minimum factor of safety equal to 1.2 must be applied to the calculated cistern volume required.
3. All stormwater collected must have a dedicated, year-round, use to assure no overflow of the system during a design rainfall. A water balance calculation must be used to establish the dedicated use volumes and rates. The water balance calculation must demonstrate that the design volume can: (1) be drawn down (used) within 5 days to allow for available volume in the system for the next rain event to be captured and stored, or (2) have an overflow of no more than 14 percent of the annual average historic rainfall, or (3) be drawn down within 5 days and discharged to a properly designed BMP. On a case-by-case basis, reduced credit may be given if the design volume cannot be reliably drawn down within 5 days, or if a year-round reuse is not available. The dedicated water use system must be automated to insure that the water will be used at the rate and volume designed. DWQ may require a meter on the cistern outlet to determine if the water is actually being used at the design dedicated volume



- Detention volume = 600 gal (~1.1”)
- Retention volume = 1600 gal
- Drawdown time = 3 days
- Water quality volume


Property of NCSU
Monitoring in Progress –
Please Do Not Disturb!
NC STATE UNIVERSITY


2.68”
1.14”
1.54"
2.56”
2.87”
~48,950 gal Released
16,315 gal
Used by NCDOT
89%
Volume
Reduction
Cistern Water Level (m)
Passive Release Orifice (m)
Cistern Overflow (m)
Hourly Rainfall (mm)
Cistern Water Level (m)
Hourly Rainfall (mm)
2.50
2.25
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
0
10
30
40
50
60
70
80
90
100
9/1/11
10/1/11
10/31/11
11/30/11
12/30/11
1/29/12
2/28/12
3/29/12
4/28/12
5/28/12
6/27/12

Passive Release Conclusions

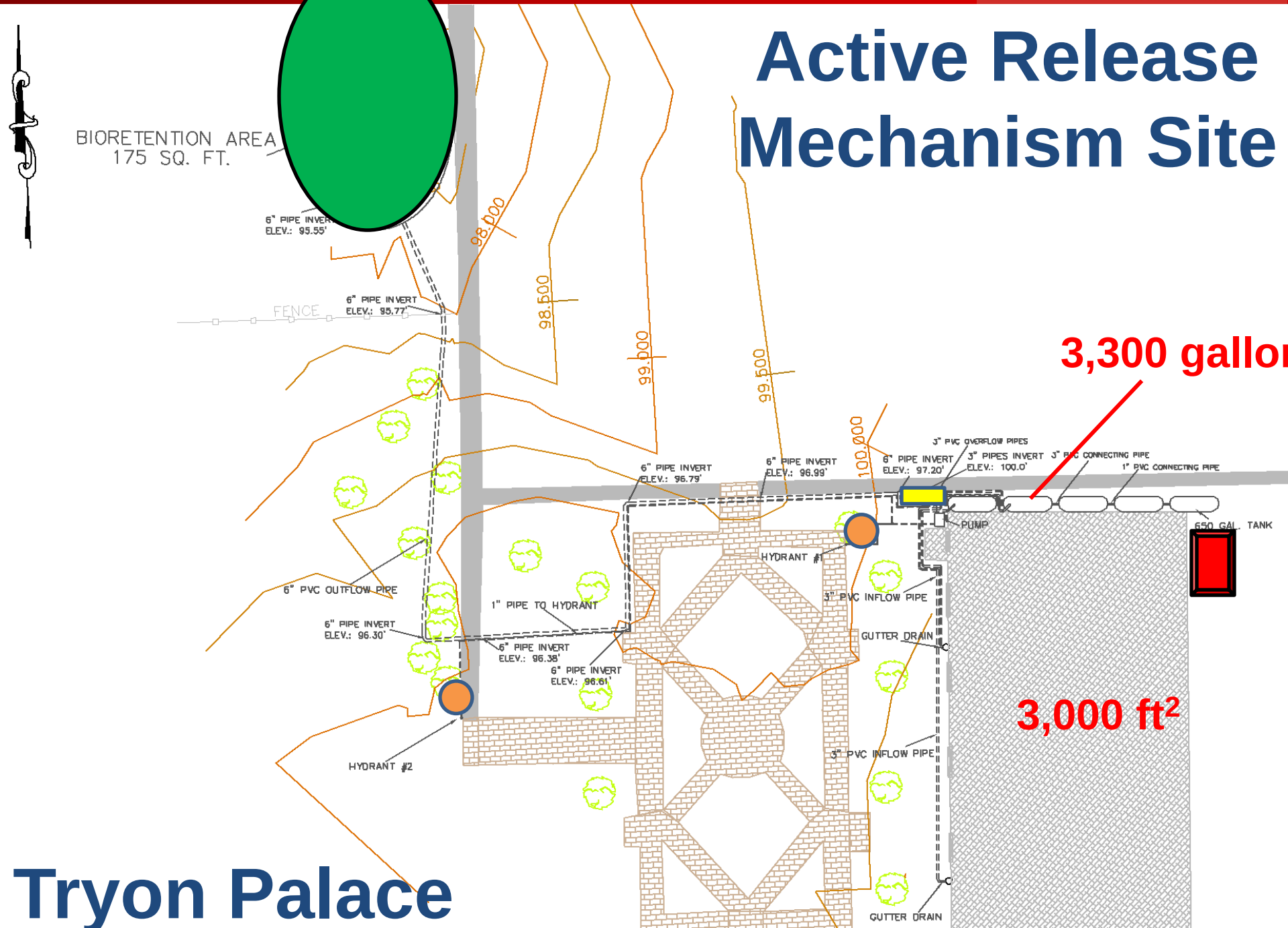
- Significant potential for meeting stormwater management regulations
- Easy to retrofit existing systems
- Maintenance free
- Coincides well with existing North Carolina stormwater regulations

Active Release Mechanism

- Uses NWS forecast to 'prepare' system for rain by releasing water
- Releases up to 3.8 cm event volume (1.5")

Geosyntec consultants

Active Release Mechanism Site

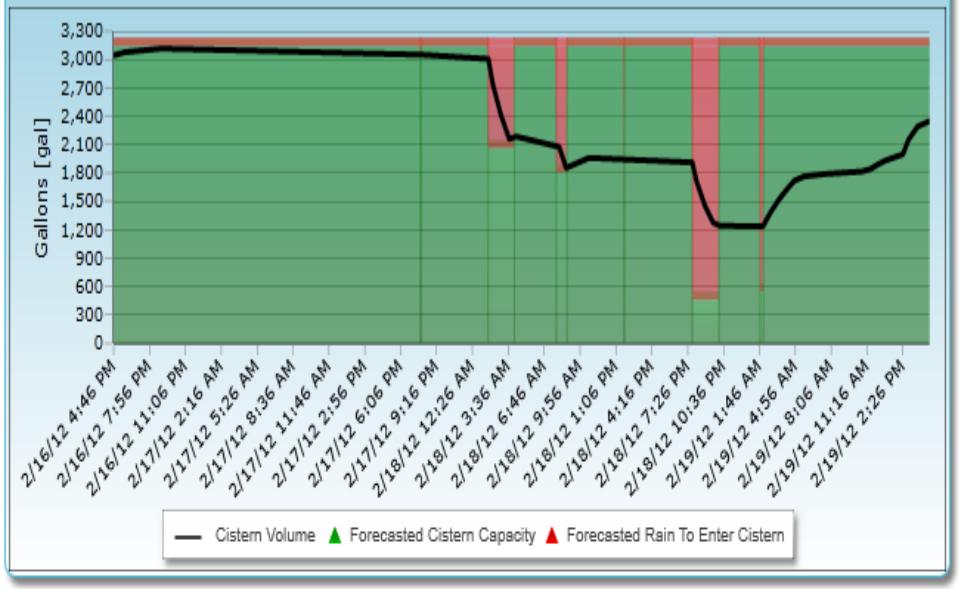


Tryon Palace

Decision Analysis On Cistern

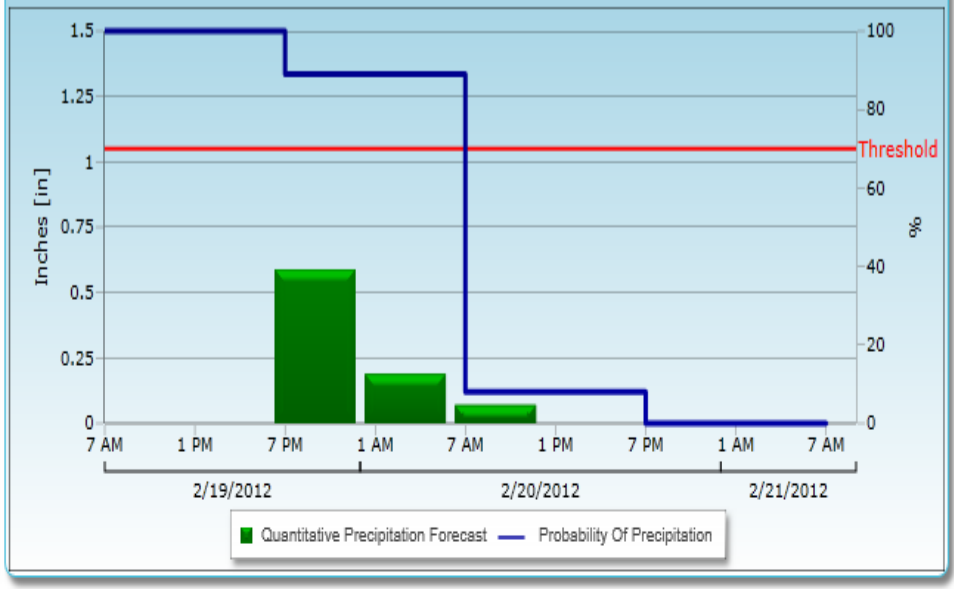
Past 24 Hours. Latest record at 4:46:23 PM

export | 1d | 3d | 7d



NWS Forecast as of 2/19/2012 7:00:00 AM

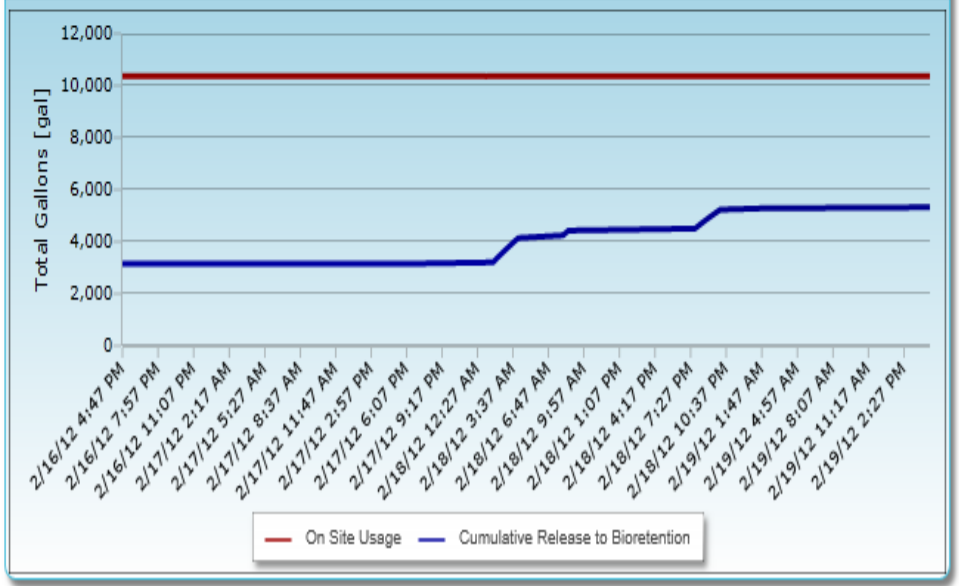
2 Day Forecast. Latest record at 4:47:20 PM



Water Usage Time Series

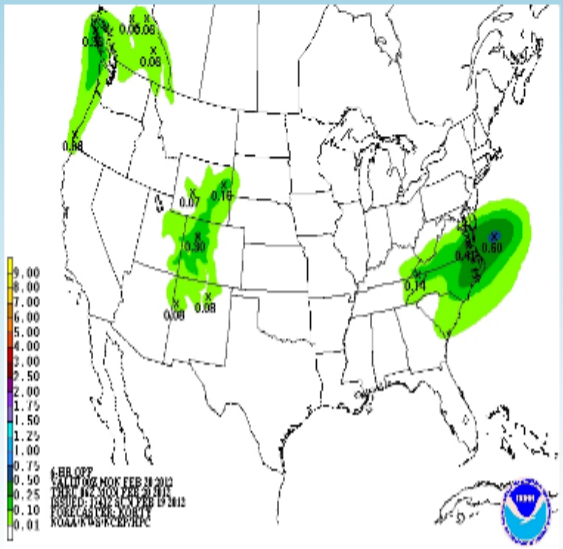
Past 24 Hours. Latest record at 4:47:19 PM

export | 1d | 3d | 7d

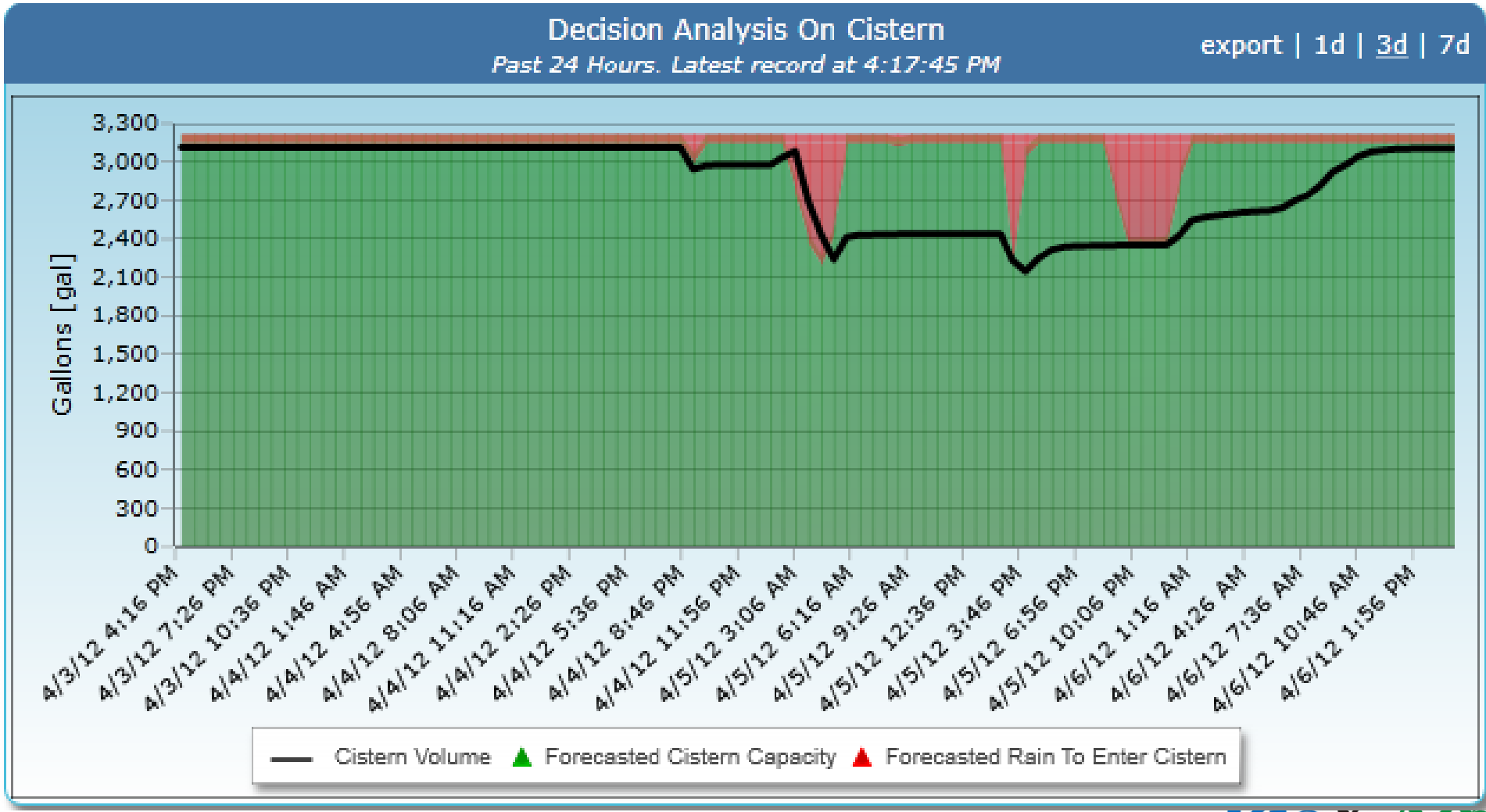


US NOAA Image

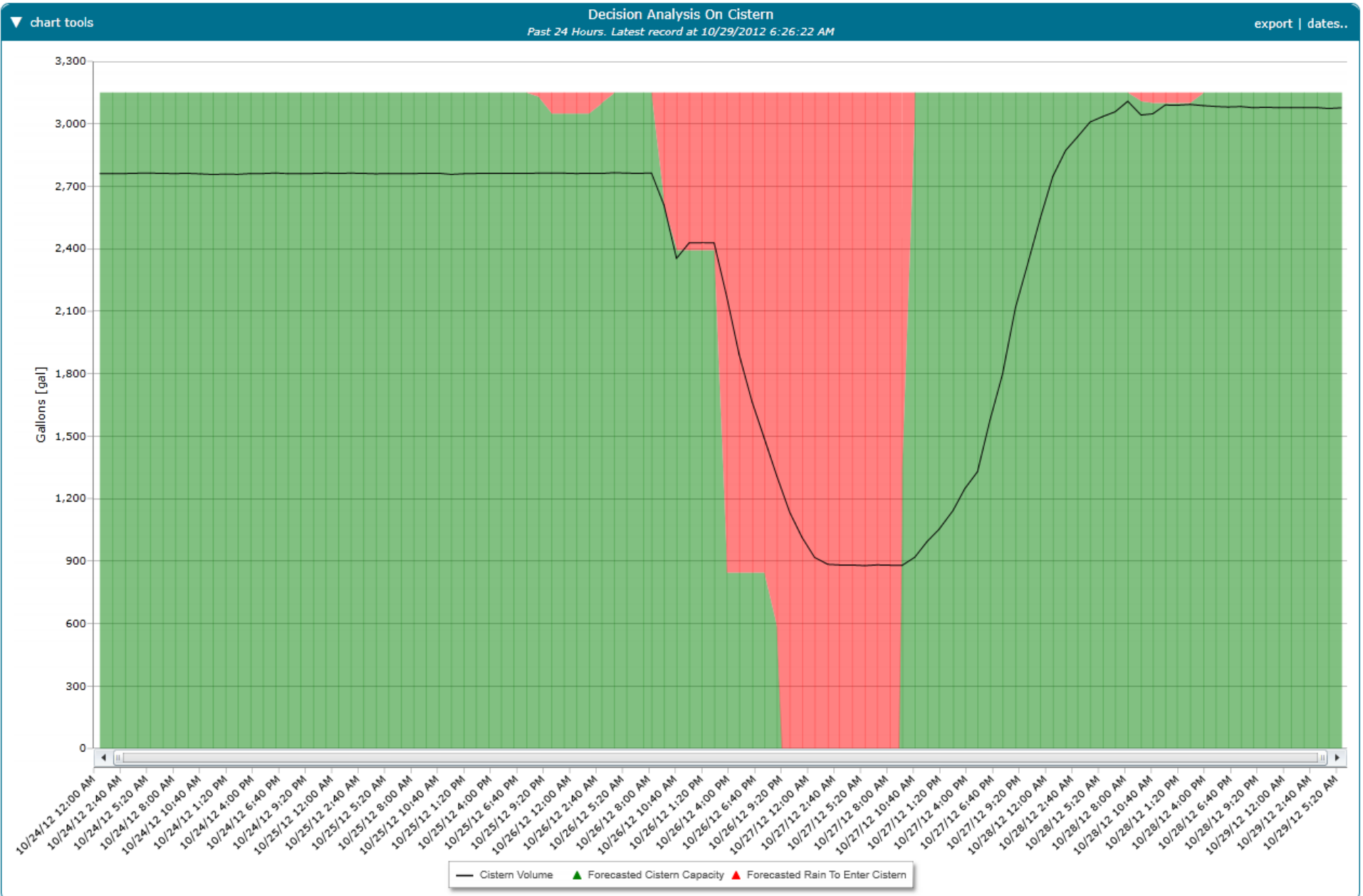
6 Hour Forecast



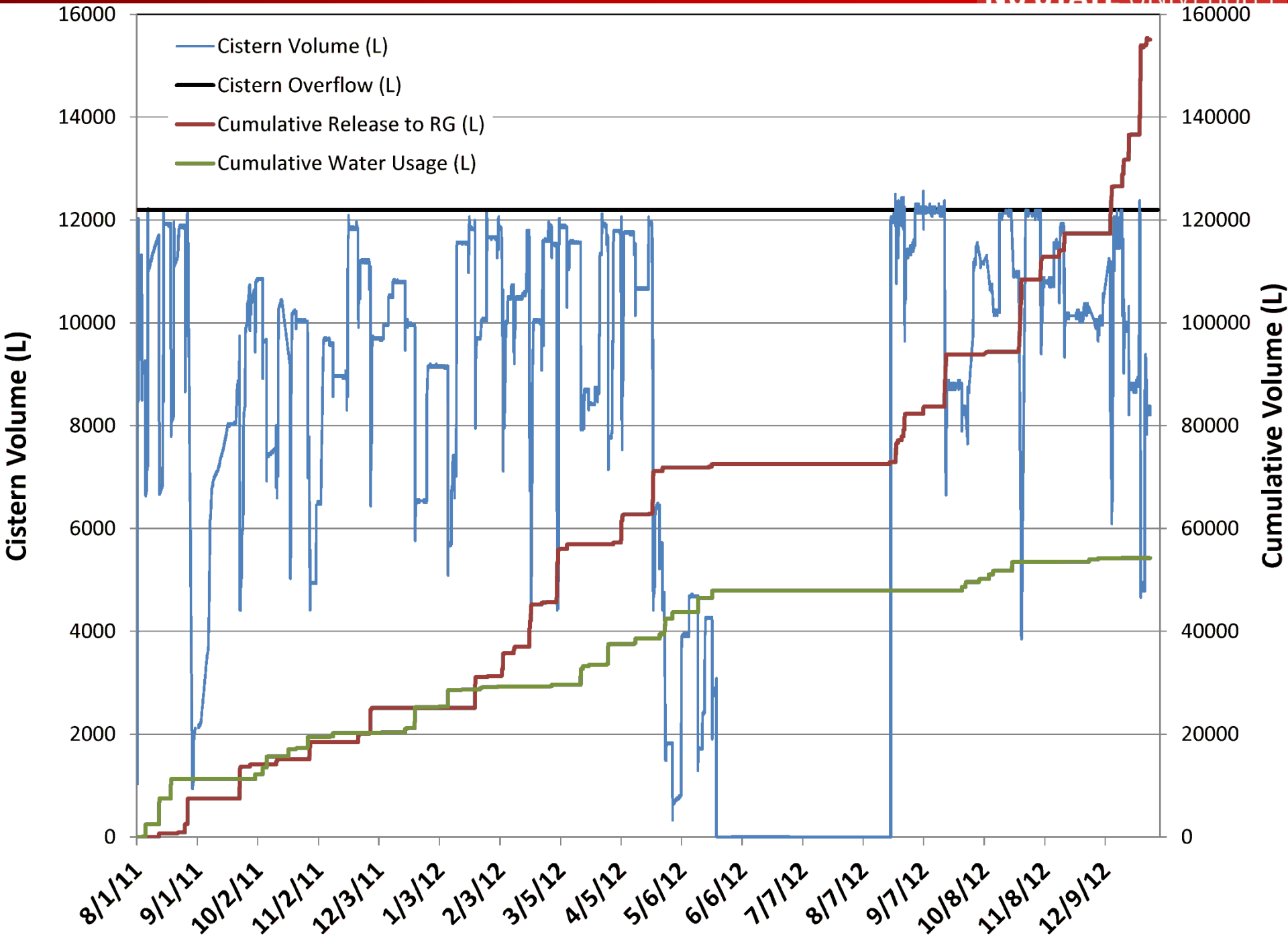
April 5, 2012


Decision Analysis On Cistern
Past 24 Hours. Latest record at 4:17:45 PM
export | 1d | 3d | 7d
Gallons [gal]
3,300
3,000
2,700
2,400
2,100
1,800
1,500
1,200
900
600
300
0
4/3/12 4:16 PM
4/3/12 7:26 PM
4/3/12 10:36 PM
4/4/12 1:46 AM
4/4/12 4:56 AM
4/4/12 8:06 AM
4/4/12 11:16 AM
4/4/12 2:26 PM
4/4/12 5:36 PM
4/4/12 8:46 PM
4/4/12 11:56 PM
4/5/12 3:06 AM
4/5/12 6:16 AM
4/5/12 9:26 AM
4/5/12 12:36 PM
4/5/12 3:46 PM
4/5/12 6:56 PM
4/5/12 10:06 PM
4/6/12 1:16 AM
4/6/12 4:26 AM
4/6/12 7:36 AM
4/6/12 10:46 AM
4/6/12 1:56 PM
Cistern Volume
Forecasted Cistern Capacity
Forecasted Rain To Enter Cistern

Hurricane Sandy (10/29/12)




16000
14000
12000
10000
8000
6000
4000
2000
0
Cistern Volume (L)
0
10
20
30
40
50
60
70
80
Hourly Rainfall (mm)
8/1/11
9/1/11
2/9/12


Cistern Volume (L)
Cistern Overflow (L)
Cumulative Release to RG (L)
Cumulative Water Usage (L)
Cistern Volume (L)
Cumulative Volume (L)
16000
14000
12000
10000
8000
6000
4000
2000
0
160000
140000
120000
100000
80000
60000
40000
20000
0
8/1/11
9/1/11
10/2/11
11/2/11
12/3/11
1/3/12
2/3/12
3/5/12
4/5/12
5/6/12
6/6/12
7/7/12
8/7/12
9/7/12
10/8/12
11/8/12
12/9/12

Results

Inflow Volume (L)	124,500
Water Used (L)	14,335
Released to RG (L)	40,975
Volume Reduction (%)	44.4%

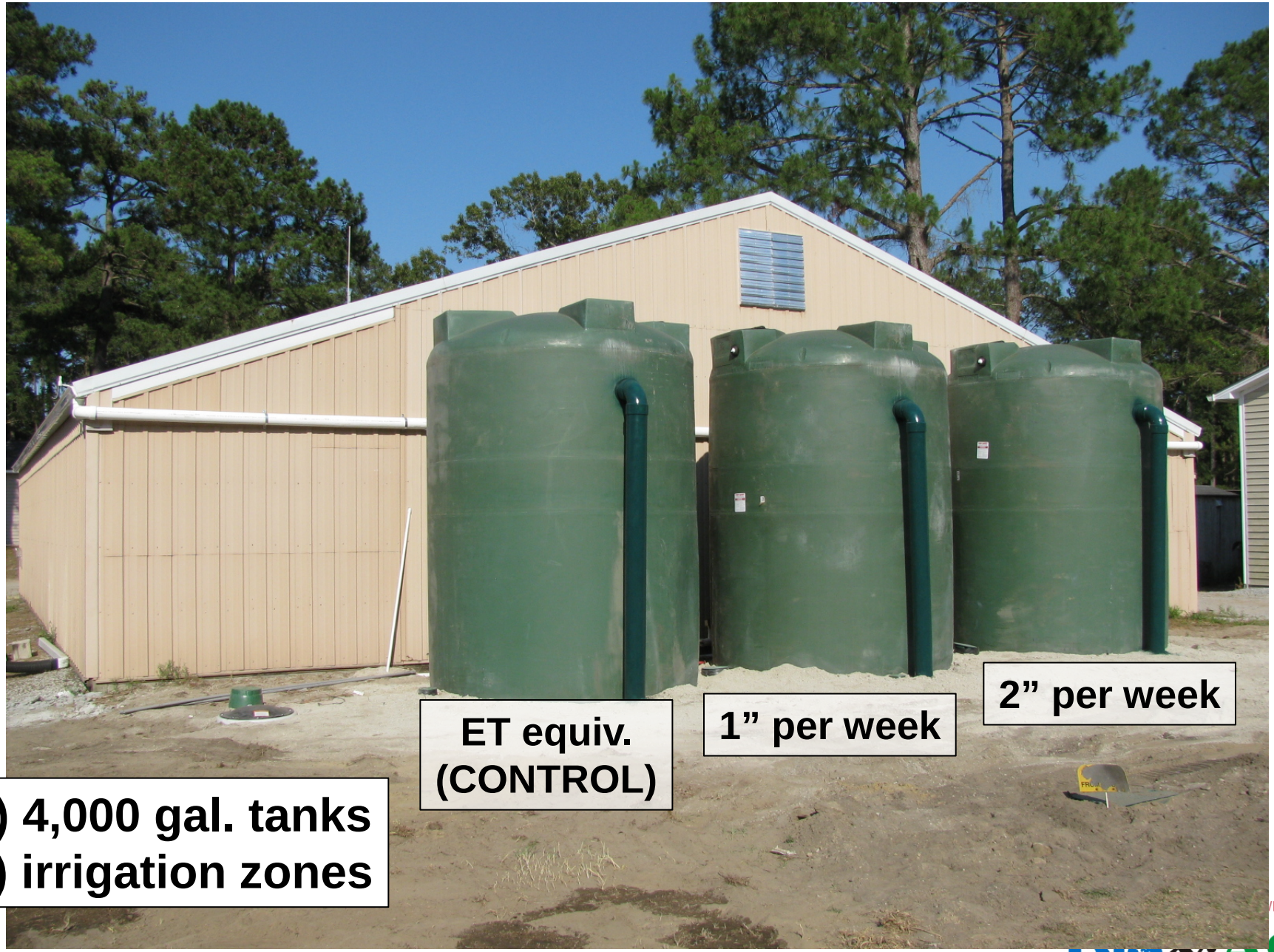
July 1, 2011 – January 3, 2013

Active Release Conclusions

- Preserves the water conservation benefits of the system while adding stormwater management benefits
- Excellent potential for meeting stormwater management regulations
- Resource intensive (electricity, internet, oversight)

What can we do for irrigation-based systems?


0 20 40 80 120 160
Feet
N



(3) 4,000 gal. tanks
(3) irrigation zones

Preliminary Results
October 24, 2011 – June 12, 2012

	ZONE 1 (control/ET)	ZONE 2 (1” per week)	ZONE 3 (2” per week)
Inflow Volume (gal)	134,600	134,600	155,600
Water Used (gal)	17,400	43,480	80,195
Volume Reduction (%)	12.9%	32.3%	51.5%

*October 24, 2011 – June 12, 2012

Preliminary Results

- Big difference in stormwater runoff volume reduction between all 3 zones
  - Noticeable reduction in flooding
  - Tank watering the most runs out of water more quickly than the others – problematic during drought
- No difference in runoff production, turf quality or soil nitrate among the 3 zones
- LOTS of water saved (over 140,000 gallons!!!)

Over-Irrigation Conclusions

- Substantial potential in meeting both water conservation and stormwater management goals
  - Craven County goal: reduce groundwater consumption by 20% by 2020
  - New stormwater fees in place – potential credit?
- Contradicts intuition…. Wasting water?
- Will need some kind of backup supply

In Summary…


Property of NCSU
Monitoring in Progress –
Please Do Not Disturb!
NON-POT
WATER

Passive Release: Advantages

- Cheap
- Easy to install
- “Guaranteed” stormwater management
- No electricity or human input required

Passive Release: Disadvantages

- Semi-permanent
- Prone to freezing
- “Wasted” water

Active Release: Advantages

- Optimal stormwater management
- No ‘wasted’ water
- No contribution to stormflows
- Maximizes usable water volume

Active Release: Disadvantages

- Expensive
- Requires electricity, internet and data storage
- Requires extensive knowledge & tech support
- Something can always go wrong…

Over-Irrigation: Advantages

- A consistent, dedicated use of large volumes of non-potable water
- A lot of infrastructure/resources are already in place
- Utilizes a de-facto treatment method (infiltration)

Over-Irrigation: Disadvantages

- Usually requires a tremendous amount of contributing drainage area and storage
- Necessary controls can be expensive, complicated

What Does This Mean for the Stormwater World?

- "Double-dipping"
  - Water conservation incentives/benefits + stormwater management credit
  - Economic advantages to installing RWH systems
- Increased water conservation
  - Supports sustainability concepts and environmental awareness
- Potential for substantial Combined Sewer Overflow (CSO) improvements
- Mutually beneficial solutions for land/property owners and the environment
  - Contributes to widespread water reuse solutions (over-use of aquifers, saltwater intrusion, etc.)
  - "Off the grid"

Other Aspects to Consider

- Social (cultural, historical, habitual) influences on the use of systems
  - Location, access, potable water system, pressure
- Environmental impacts associated with rainwater harvesting systems
  - Energy use
  - Carbon footprint
  - Ecotoxicity
- Economics of implementation in various locations
- Gateway drug?

Final Thoughts

- Each approach has substantial potential in meeting both water conservation and stormwater management goals
- Cost, size of the system and return of investment will decide between different mechanisms
- All systems will contradict public intuition

Final Thoughts

- It will be a balancing act that will probably require some fine tuning
- Automation is essential in insuring use, but users/owners should make sure system is operating as intended on a regular basis
- Sell the less-than-obvious benefits of RWH (less flooding, ‘cleaner’ water, stormwater credit, etc.)

Acknowledgements

- Dr. Bill Hunt
- Mitch Woodward
- Ryan Winston & Shawn Kennedy
- Jim Hoffman (River Bend Country Club)
- David Adams (Lawnscapes of New Bern)
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- NCSU Stormwater Team

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N.C. Clean Water Management Trust Fund


Thank you!