Watershed Based Nutrient Management

New England Water Environment Association
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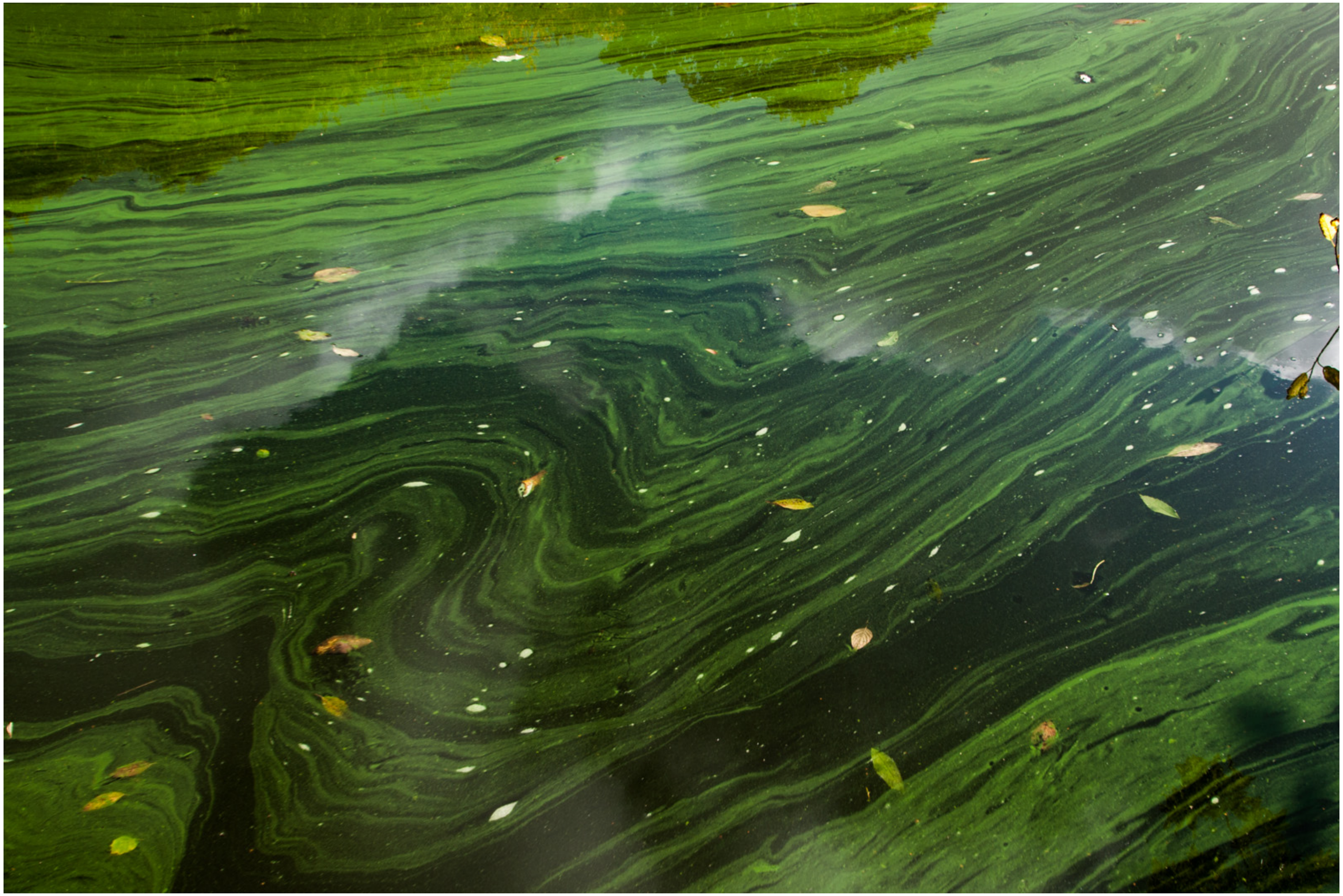
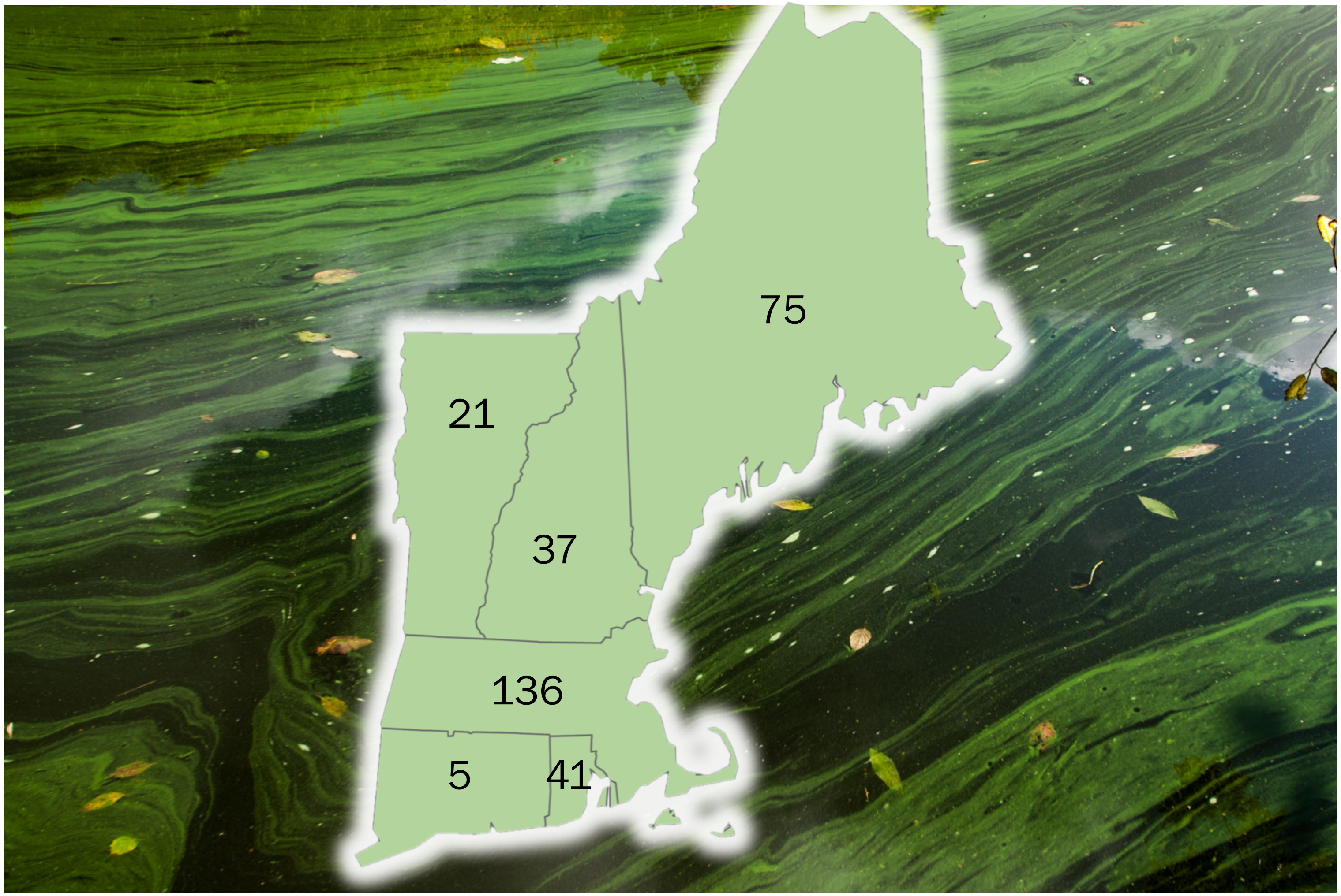
Matt Davis, P.E.
Jeff Herr, P.E., D.WRE

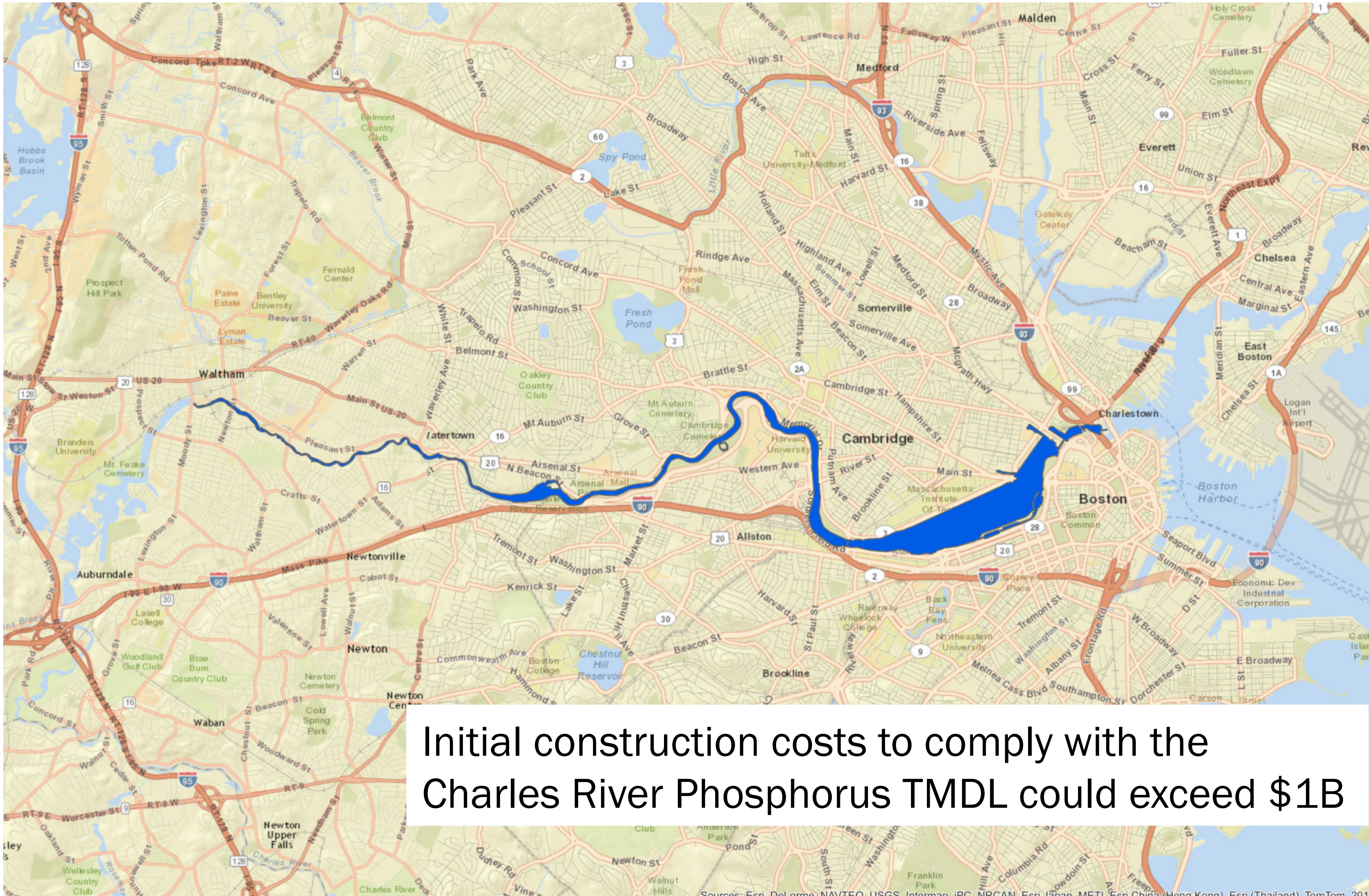
Nutrients – too much of a good thing is not a good thing



New England nutrient TMDLs



TMDL compliance can be expensive



Initial construction costs to comply with the Charles River Phosphorus TMDL could exceed $1B

How to minimize the cost of nutrient control while protecting water quality?

- **Scientific study**
  - Work alongside or ahead of regulators
  - Evaluate water quality
  - Assess and quantify factors impacting water quality
    - Nutrients
    - Light transparency
    - Turbidity
    - Circulation
  - Investment is typically small and can potentially result in substantial savings in overall compliance
- Develop/implement solutions in an efficient manner through **Integrated Planning**

Integrated Planning

- Holistic approach to watershed management
  - Include different types of sources
  - Address most serious water quality issues first
  - Find most cost effective/beneficial solutions
- EPA onboard with approach
  - Final Framework released in June 2012
  - Status memo to EPA Regions January 2013
- Potential features
  - Adaptive management
  - Increasing reliance on Green Infrastructure (sustainability)
  - Pollutant trading
- Driven by local governments – early adopters – Baltimore, Seattle, Columbus OH

Regulatory Framework for Integrated Planning

- NPDES Permit
- Regulatory action (Administrative Order or Consent Order)

Step 1. Understand Nutrient Loading – Surface Water Response

Nutrient loadings are only one factor in the TMDL equation.

Only some forms of P (dissolved OP/SRP) and N (NOx and NHx) are bioavailable. TP and TN less important.

Increased nutrient loadings do not necessarily cause impairment or poorer water quality.

Many other factors such as light transparency, turbidity, residence time and circulation also play important roles.

Step 2 - Accurately Quantify Nutrient Loads in the Watershed

Point Sources

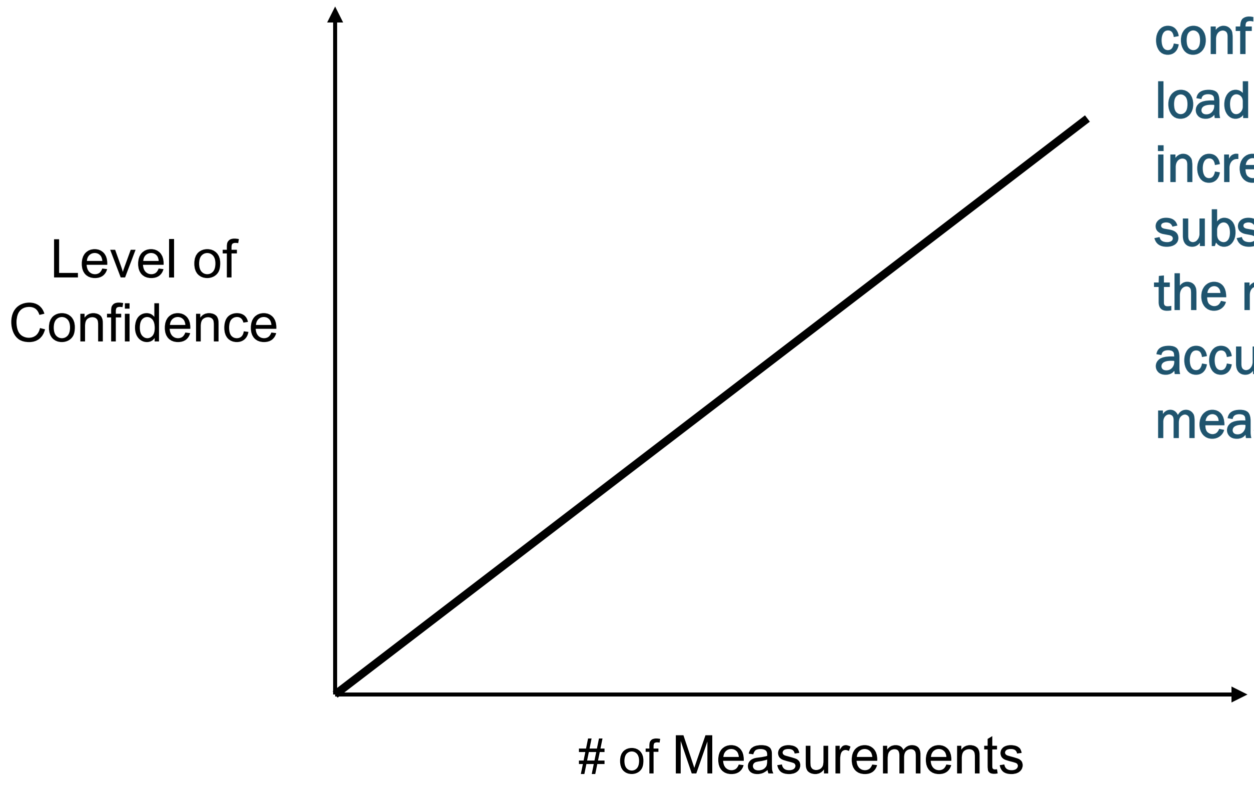
- Wastewater discharges
- Industrial discharges
- Combined wet weather discharges
- Sanitary sewer overflows
- Stormwater discharges

Non - Point Sources

- Septic systems
- Groundwater seepage
- Agricultural discharges
- Atmospheric deposition (primarily N)
- Bird, pet, wildlife waste
- Fertilizer
- Internal nutrient recycling from water bottom sediments

How Do We Estimate Nutrient Loadings?

1. Perform Measurements
2. Estimate Using Models



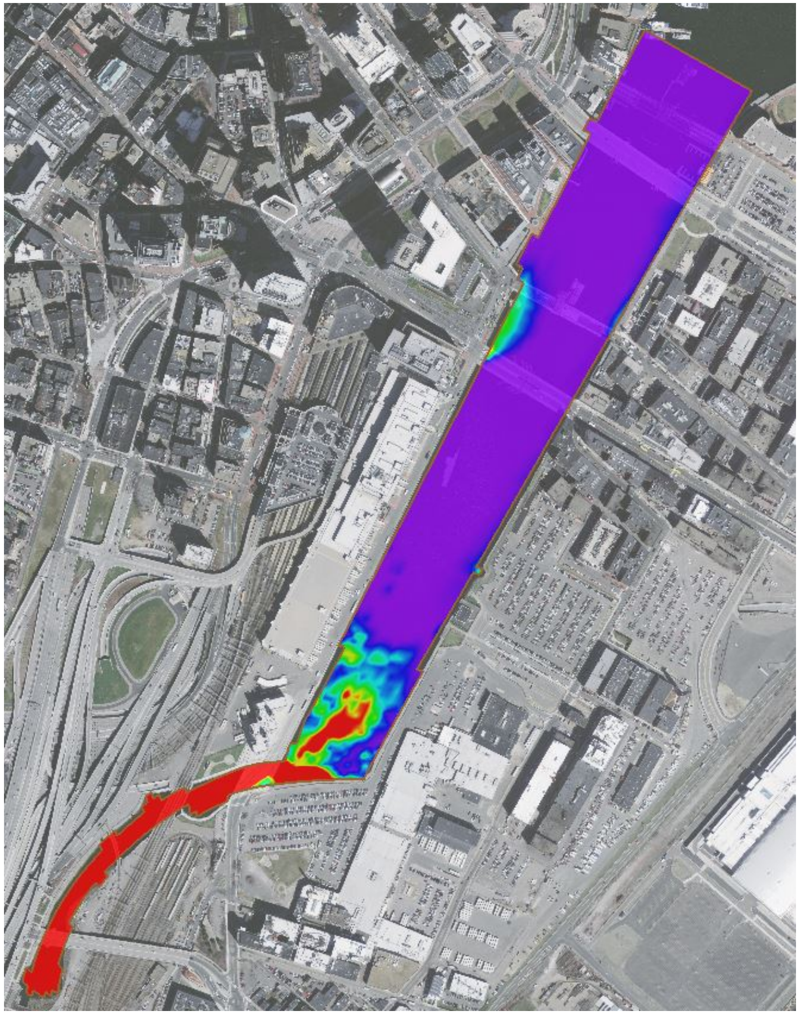
Our level of confidence in loading estimates increases substantially with the number of accurate measurements.

Monitoring is Essential

Calibration of monitoring data to models is essential for building confidence in the model

Models can be Useful Tools in Developing Management Strategies

- Typical model functionality
  - Generation of nutrients at source locations
  - Transport of nutrients through conveyance infrastructure, surface runoff and groundwater
  - Transport and fate in receiving water
- Powerful tools for extrapolating to potential future conditions
- Typical models
  - USGS regression
  - HSPF/Basins
  - GWLF
  - SWMM
  - WinSLAMM
  - SPARROW
  - QUAL2E



Step 3 – Evaluate Potential Point Source Solutions

- Biological and/or chemical treatment unit processes
- Membranes
- Wetland treatment
- Reduce volume thru infiltration or reuse
  - nitrogen is mobile in groundwater

Limits of technology: ~0.8 mg TN/L and 0.05 mg TP/L

Very expensive to reach low levels.

Typically cost effective to 5 mg/L TN and 0.3 - 0.5 mg/L TP.

Step 4 - Evaluate Potential Surface Water Solutions - Lake (if applicable)

- Sediment removal
- Inactivation of P using a coagulant
- Floating treatment islands
- Recirculation treatment system
- Aeration/destratification
- Hypolimnetic oxygenation
- Treat surface water inflows

Step 4 - Evaluate Potential Surface Water Solutions - Stream (if applicable)

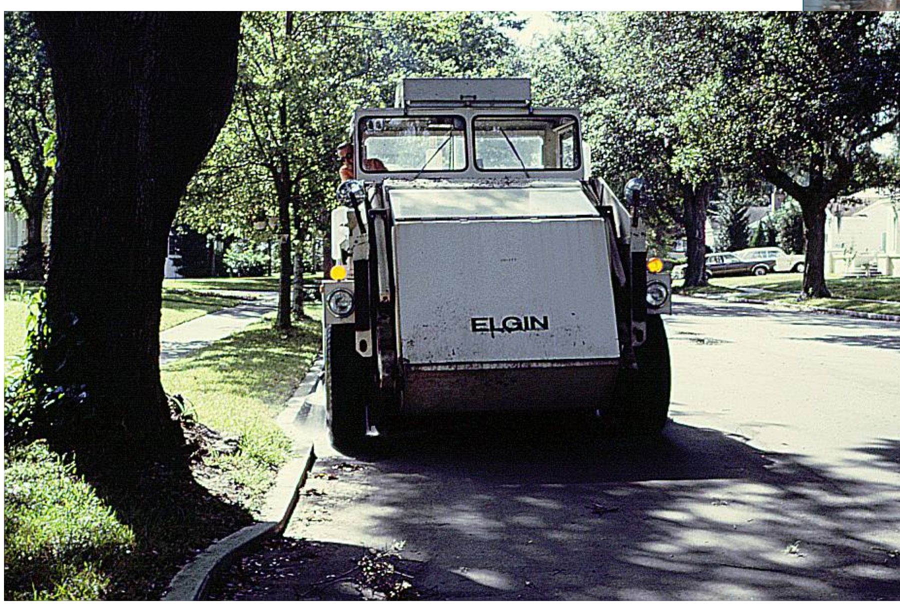
- Restore creek natural hydrology
- Reconnect creek to wetlands/floodplains
- Improve creek riparian buffers
- Repair/restore degraded creek/tributary segments
- Modify or remove in-stream structures
- Sediment removal
- In-stream aeration
- Alter channel water depth/width/velocity
- Contain/clean-up point waste sources
- Treat surface water inflows from tributaries

Step 5 - Evaluate Potential Non-Point Source Practices

- Public education (pet waste, lawn clippings fertilizers, etc.)
- Non-structural practices - sweeping, lead pickup,inlet inserts, etc
- End-of-pipe treatment for gross solids, sediment
- Traditional treatment practices – ponds, basins
- Chemical and wetland treatment
- Green Stormwater Infrastructure practices – reduce runoff volume (infiltration and reuse)

Maximize Implementation of Non-Structural BMPs

Nutrient Management
Street Sweeping
Catch Basin Cleanout
Material Storage



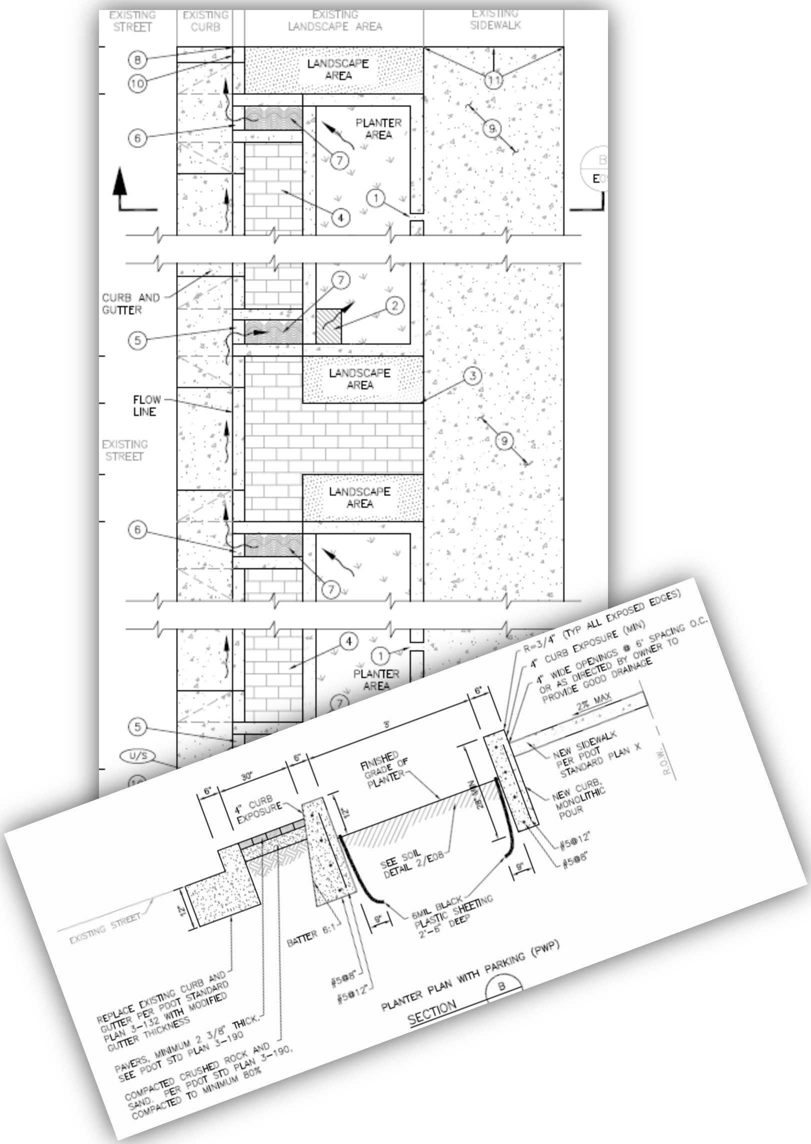
Typically cost effective pollutant load reduction

Permeable Pavers and Porous Pavement

Subgrade and proper material installation critical to success. Maintenance required.

Bioswales

Sidewalk Planter



Chemical Treatment

- Achieves significantly higher removal efficiencies than traditional treatment methods for many pollutants; **80-90% TP, 99.9% pathogen removal**
- Requires significantly less land than traditional methods
- Typically has the lowest life cycle cost per mass TP and pathogen removed
- Improves receiving surface water quality for aesthetics, recreational use or public health
- Provides source water protection and controls growth of algae and bacteria (including blue-green algae)

Largo Central Park

1200 acre watershed treated using 3 acre pond, floc pumped to SS
Construction cost = $1,000,000
Annual O&M cost = $50,000

Step 6 – Manage Watershed

- Integrate solutions for a watershed considering point and non-point sources, structural and non-structural controls
- **Identify the solutions with the lowest life cycle cost per mass pollutant removed**
- **Evaluate pollutant trading/offsets**
- **Implement best triple bottom line solutions**
- Meet project regulatory requirements
  and watershed improvement objectives

Questions

NEWEA Annual Conference
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Matt Davis, P.E.
mdavis@brwncald.com

Why Pursue Trading/Offset? Generally . . .

Trading Programs Offer Specific Benefits

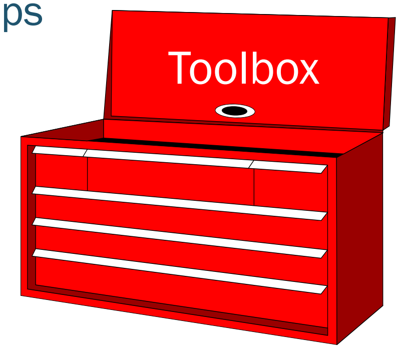
- ***Cost effective***
- Incentive to go beyond minimum requirements
- ***Promotes flexibility/innovative approaches***
- Offsets increased discharges from growth
- ***Addresses nonpoint sources***
- Reductions, sooner, to improve water quality
- Promoted watershed approach
- ***Greater environmental benefit***

Treatment Train - Implementing Cost Effective BMPs For Non-Point Source Management

Runoff & Load Control → Conveyance and Pretreatment → Additional Treatment & Attenuation → Final Treatment and Attenuation

Runoff & Load Control	Conveyance and Pretreatment	Additional Treatment & Attenuation	Final Treatment and Attenuation
Regulations	Swales	Detention	Retention
Public education	Catch Basins	Wetland	Detention
Erosion control	Inlets filters	Storage	Wetland
Roof runoff	Oil/water separators	Sediment sump	Chemical
Disconnect IA	Trash/sediment traps		Ozone
Landscaping			UV
Pervious paving			Reuse
Pavement cleaning			End of pipe

GI



End of Pipe Stormwater Treatment

- Typically for gross solids and sediment removal but new medias effective for removing other pollutants
- Used extensively for removal of primary pollutants
- Minimal land required
- Relatively inexpensive
- Can be implemented relatively quickly

BC Design for CalTrans

Baffle Box
CDS Unit
Vortechnics
Stormceptor
Many others

Second Generation Baffle Box

Suntree Technologies

Installed Cost

$30,000 - $150,000/unit

Comparison of BMP Treatment Efficiencies for Primary Pollutants

Type of BMP	Estimated Removal Efficiencies (% Load Reduction)			
	TN	TP	TSS	BOD
INFILTRATION/REUSE 1.00” VOLUME 1.50” VOLUME	 80 90	 80 90	 80 90	 80 90
WET DET (14-21 day WSRT)	25-35	60-70	90	50-70
WET DET/FILTER	0-10	50	85	70
DRY DETENTION	10-20	20-40	20-60	20-50
DRY DET/FILTER	(-)-20	(-)-20	40-60	0-50
CHEMICAL TREATMENT	20-40	80-90	>90	30-60
WETLAND TREATMENT	(-)-90	(-)-90	50-90	(-)-50

Volume Reduction

No volume = no load
Also reduces conveyance requirements and cost.

Disconnect Impervious Areas

Rainwater Harvesting and Reuse

Stormwater Storage and Reuse

Low Impact Development
and Infiltration Practices
(permeability of native soils critical)

Permeable Pavers and Porous Pavement

Subgrade and proper material installation critical to success. Maintenance required.

Rainwater Harvesting and Reuse
(relatively clean water)

1-inch of runoff over 3,000 sf = 1,870 gallons.

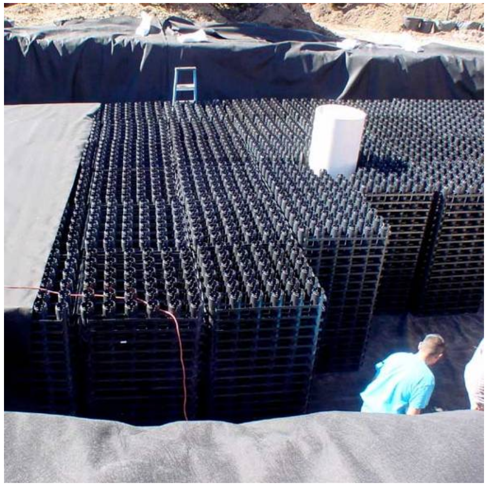
55 gallon rain barrels provide minimal storage for a typical single family home.

HDPE Tanks ~ $1/gallon storage

Stormwater Reuse

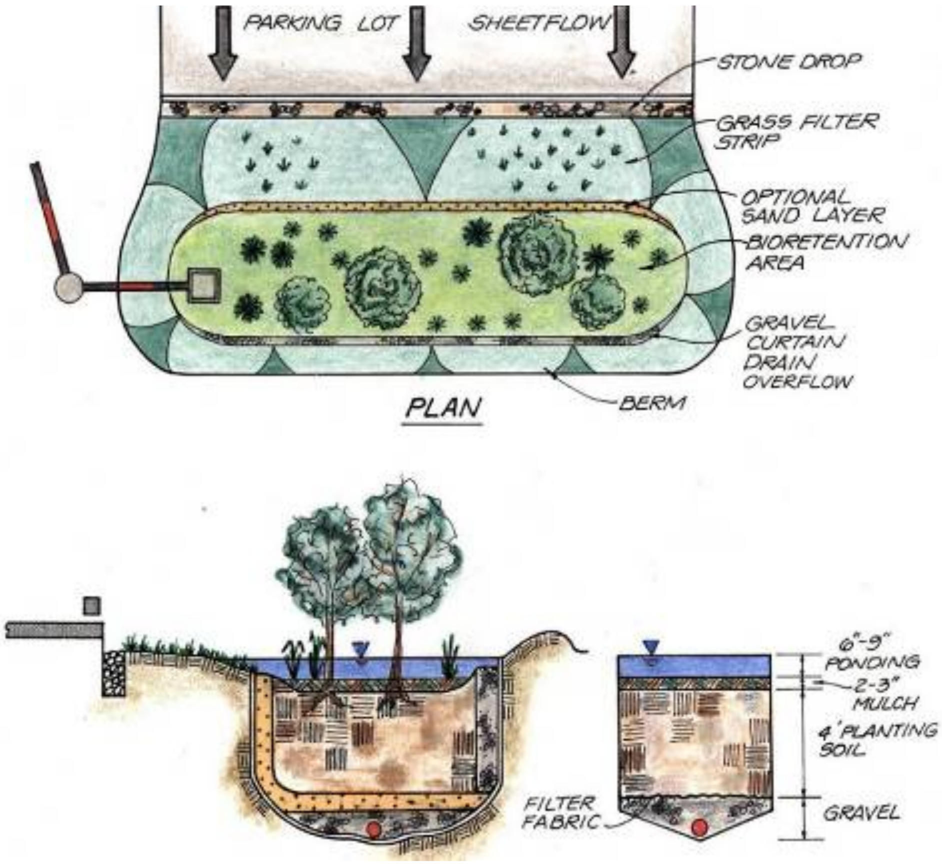
Reduces runoff volume and pollutant load and reduces potable water demand.

Higher concentrations of pollutants than rainwater but can be used for irrigation and gray water.



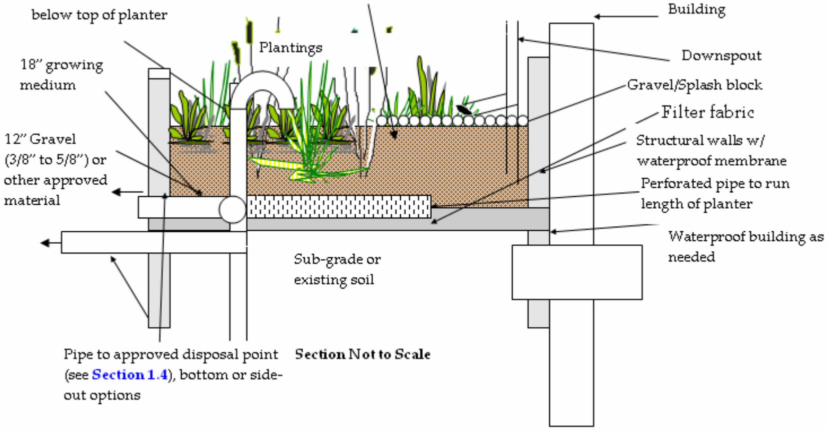
Must have sediment removal element prior to any underground storage with ability to remove sediment.

Bioretention Area (different than biofiltration)



Research to improve TP and TN removal.
Aluminum precipitates for TP (4-5x).
Anaerobic zone for denitrification.

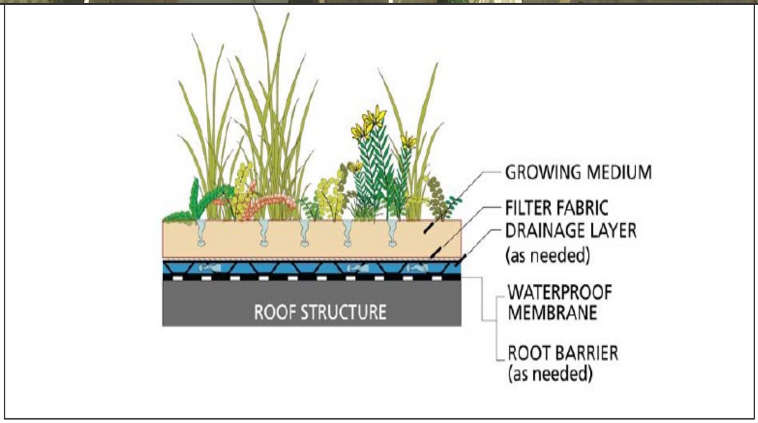
Biofiltration/Biodetention



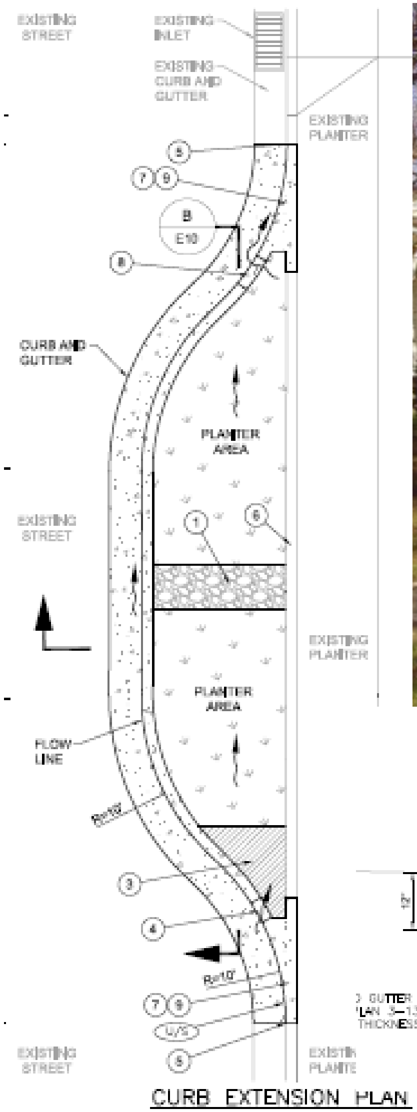
Much lower volume reduction than bioretention
but can achieve substantial pollutant concentration reduction.
Dense vegetation is the key.

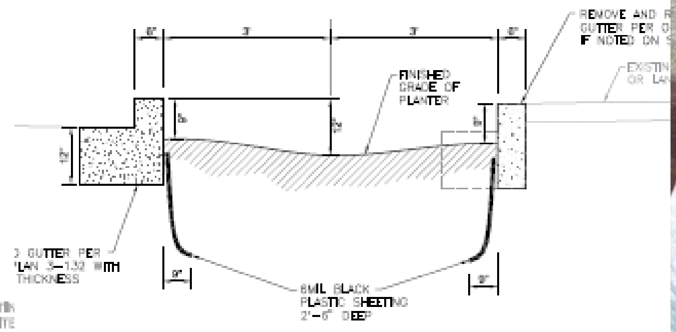
Bioswales

Blue/Green Roof



Curb Extension





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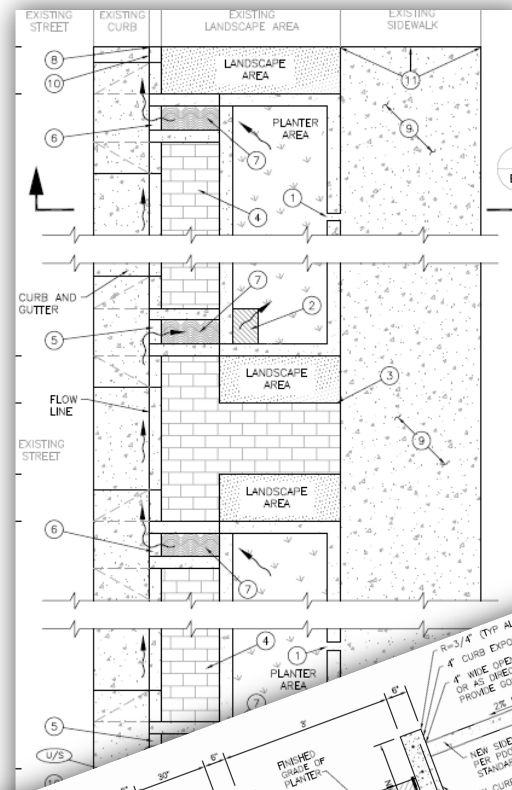

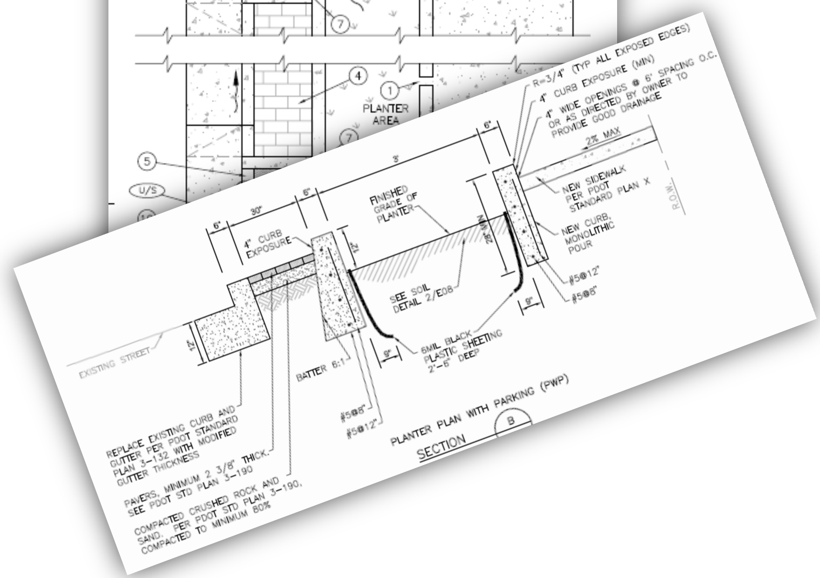

Wet Detention and Wetland Treatment

PPV and residence time key factor for wet detention effectiveness (21+ days)

Significant land area required for wetlands, efficiencies highly dependent on influent concentrations and hydraulic loading rate, plan for future maintenance.

- emergent marsh w/ open water pools
- submerged aquatic vegetation (SAV)
- hardwood elements
- design to minimize short circuiting


15 Acre SAV/Wet Detention System treats 600 acres
Construction cost $1M
Annual O&M cost $20,000
Property owned by FDOT

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LCWA Nutrient Reduction Facility

Treats flows up to 300 cfs and 50,000 ac-ft of water per year from a 60,000 ac watershed. Meets P TMDL requirements for entire watershed.
Construction Cost $7.5M
Annual O&M Cost $1M

Enhanced Wetland Treatment System to Meet TMDL

6500 acre watershed treated
Flows up to 100 cfs diverted

Construction cost = $2,000,000
Annual O&M cost = $75,000

Reduces chemical requirements; wetland alone achieves desired TP reduction during lower flows.

Dewatered alum floc used to amend constructed wetland treatment soils to bind P

Annual load reductions = 2,000 kg TP, 1,300 kg TN, 18,000 kg TSS

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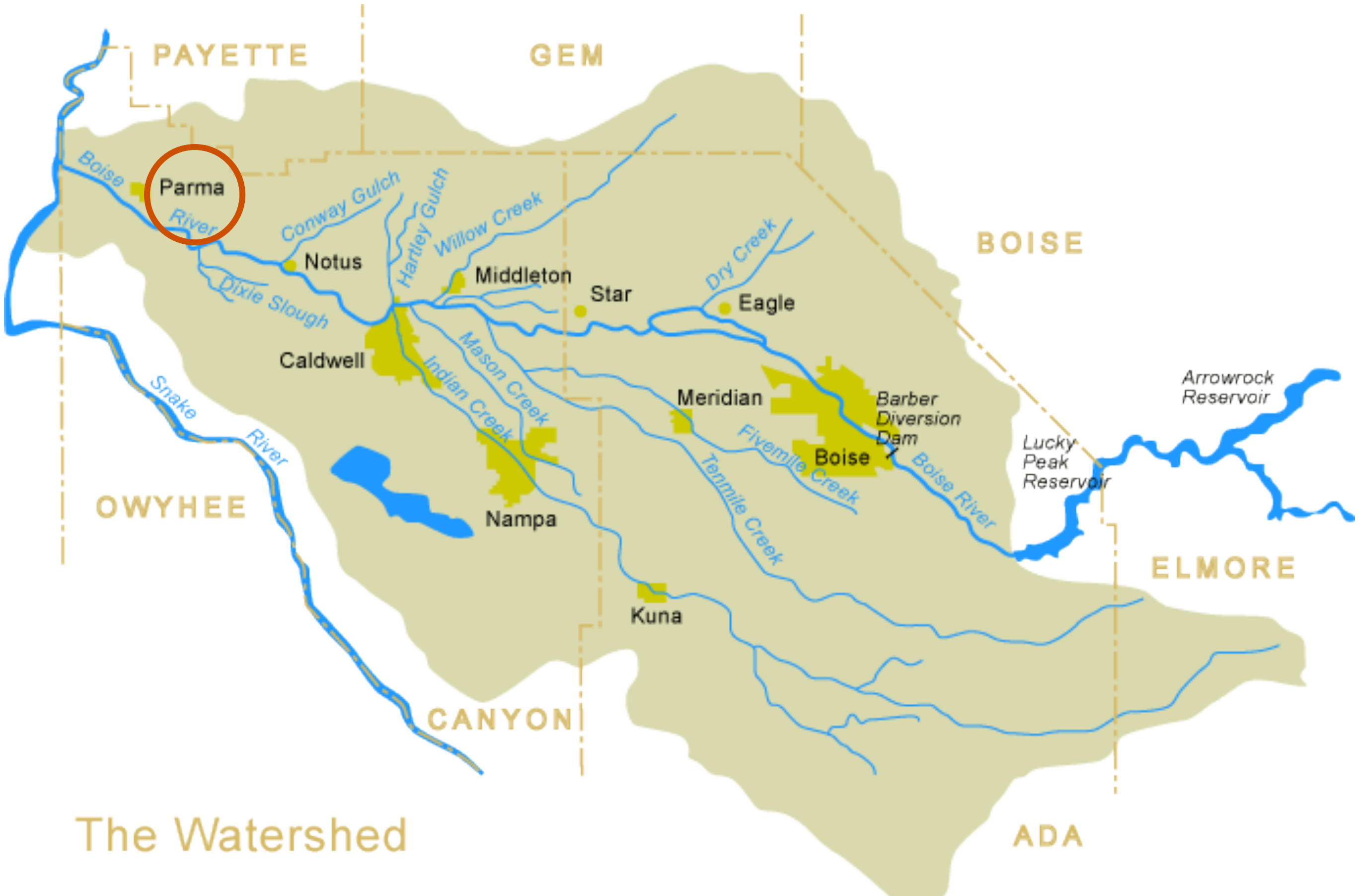
City of Boise Nutrient Offset Case Study

- Trades must be implemented so that the overall water quality of the watershed is protected
  - Equivalency
  - Mass Ratios
  - Local Impacts

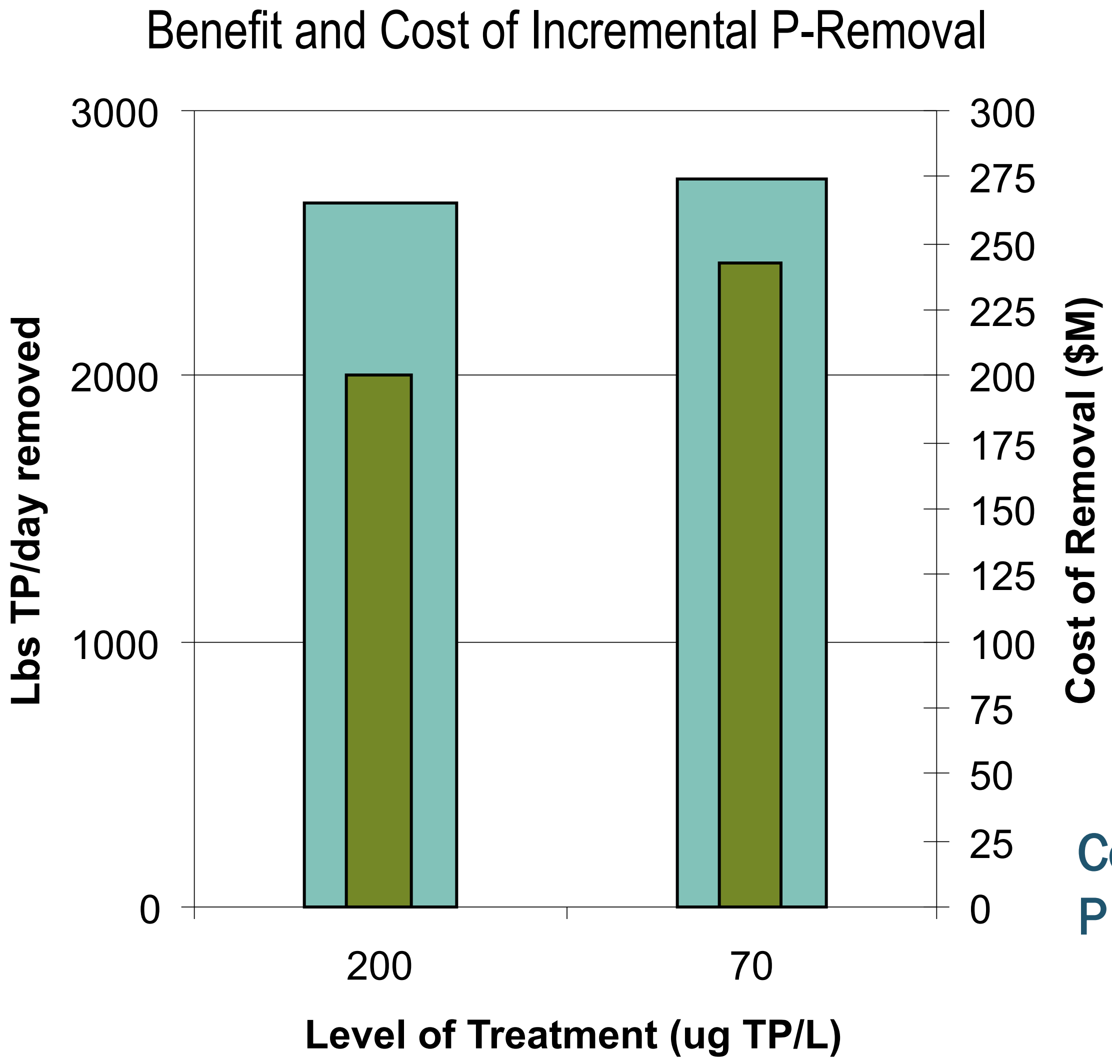


Trading/Offset Offers an Alternative to Advanced and Expensive Processes

- EPA proposes point sources implement “limit of technology” treatment
  - .05 mg/L to .07 mg/L TP levels within 5 to 7 years
- Lower limit results in 3% decrease in lbs removed/day

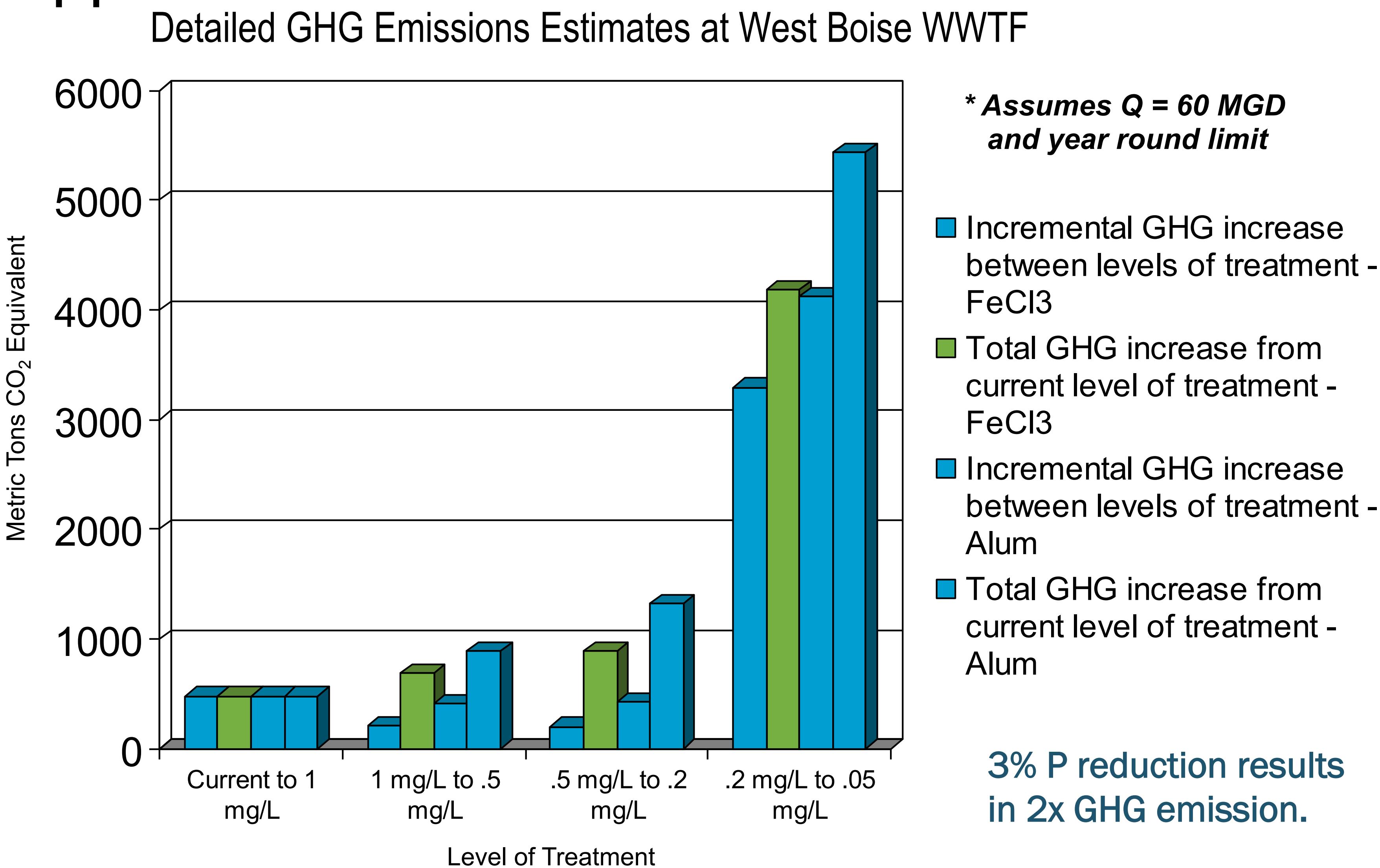
	Current TP Emissions	At .2 mg/L, lbs TP removed/day	At .07 mg/L, additional lbs TP removed/day
Lander St	4.9 mg/L	2,352	75
West Boise	2.6 mg/L	300	19
	Totals	**2,652**	**94**

Trading/Offset Can Offer Significant Cost Benefits



Cost for additional 3% P reduction ~ $40M.

Trading May Offer a More Sustainable Approach



Assumes Q = 60 MGD and year round limit

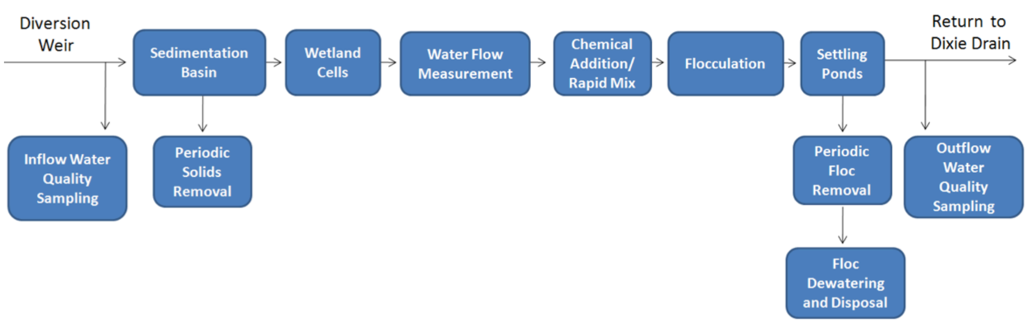
3% P reduction results in 2x GHG emission.

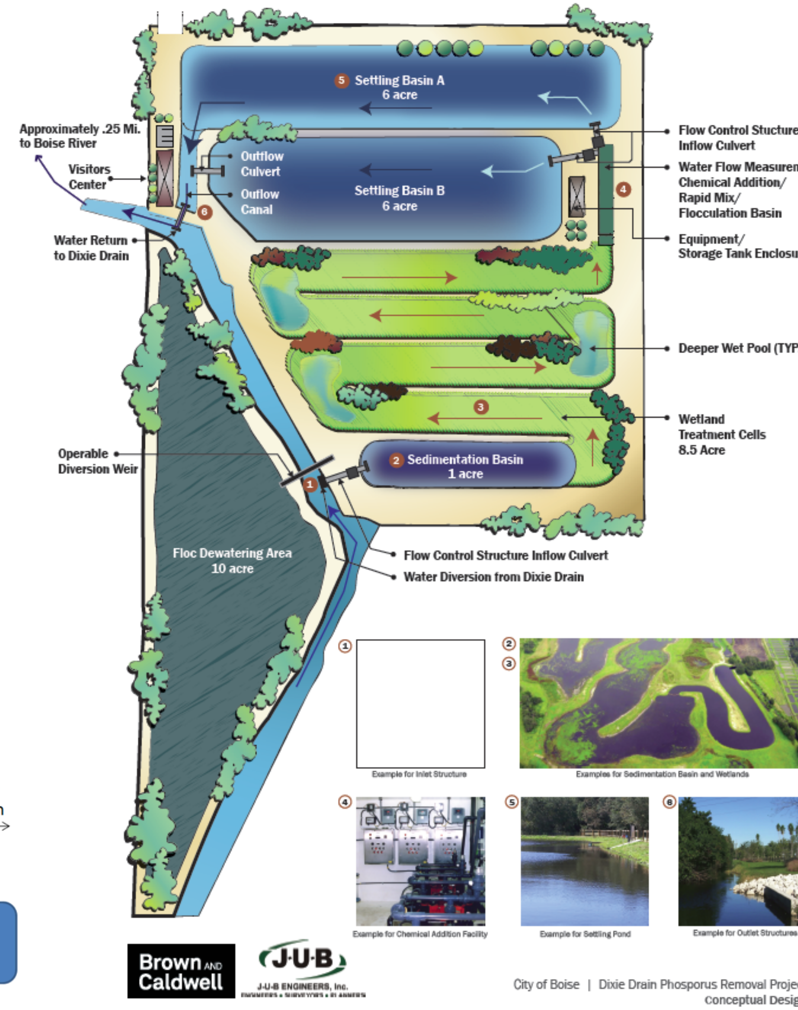
Overview of Potential Offset Options for Boise

- Purchase of Agricultural Lands/Conversion to forest
- Partnership to Reduce Ag Fertilizer Application
- Partnership to Construct Agricultural BMPs
- Wastewater Reuse
- Regional Chemical Treatment of Agricultural Drains
- Regional Constructed Wetlands Treatment of Agricultural Drains
- Regional Enhanced Wetland Treatment of Agricultural Drains

Enhanced Wetland Treatment System

Dixie Drain Enhanced Wetland Treatment Process Flow Diagram





Life Cycle Cost = $48/lb TP

Don’t Overcommitt Without Reliable Information. What Do You Really Know?

- Point source pollutant loadings
- Rainfall volume
- Pollutant loadings from atmospheric deposition
- Pollutant loadings increase significantly with development
- Surface water runoff volume is highly dependent on Directly Connected Impervious Area (DCIA)
- **Determine what you don’t know and generate necessary information**

BMP Life Cycle Cost Comparisons are highly variable

Retrofit BMP	Life Cycle Cost per kg TP removed ($)	Life Cycle Cost per kg TN removed ($)
Pet Waste Education	150 - 300	20 - 40
Second Generation Baffle Box	400 – 1,600	250 - 500
Wet Detention Pond	200 - 2,400	100 - 1,000
Dry Detention Basin	1,500 - 7,000	1,250 - 2,500
LID - Bioretention	1,000- 40,000	500 - 5,000
Stream Restoration	1,000 - 4,000	300 - 600
Chemical Treatment	90 - 180	50 - 100
Enhanced Wetland Treatment	100 - 200	100 - 200

Education is very cost effective.
Larger - regional systems tend to have significantly lower life cycle costs per mass of TP and TN removed than many smaller systems.
LID for new construction is more cost effective.

Questions

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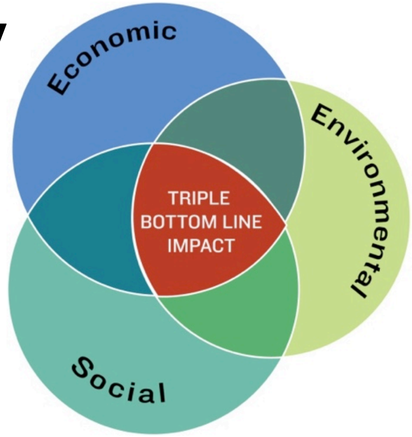
Matt Davis, P.E.
National Stormwater Leader
jherr@brwncald.com

Brown AND Caldwell

Integrated Watershed Approach to Nutrient Load Reduction

- Holistic evaluation considering all pollutant sources and loads
- Evaluate life cycle cost per mass pollutant removed
- Triple bottom line analysis – environmental, economic, social

Step 1 – Develop specific and measurable goals and objectiv



Sediment and Groundwater Seepage Testing Critical for Lakes (streams)