MS4 Compliance thru Nature-based Infrastructure



A Turnkey Implementor's Perspective, Case Studies and Creative Partnerships

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Restoring a resilient earth for a modern world

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Agenda

- Why are we talking about stormwater, thru lens of TMDL/ MS4/ CSO compliance, water quality BMPs, green vs. gray infrastructure, etc.?
- Let's talk about procurement
  - "Full-delivery", "Turnkey", "Performance-based" terminology
- MS4 (stormwater-pollution) approach in Pennsylvania
- Case studies
  - MS4 'credits' for PennDOT, state's largest MS4 permittee
  - CSO Greened Acres 'credit' example

DISCLAIMER: While many PA examples shared, every state/community is unique (context is key), and will tackle stormwater in their own unique way!

Why are we here again?

- Since European settlement of North America, thru the development of the United States, **we have 're-plumbed' our watersheds** and covered **much of the landscape with impervious or 'less-pervious'** (lawn, row-crops, etc) surfaces, exasperating stormwater runoff challenges
- Modern society faces **unprecedented challenges** associated with clean **air**, clean/available **water**, habitat modification, and loss of floral and faunal **biodiversity**
- Modern society will need to address these challenges, in order to maintain our current quality of life, thru **evolving regulatory programs**:
  - Compensatory mitigation 'now' required to **offset** (hopefully better) unavoidable **'new' impacts**
  - MS4/TMDL/CSO programs **addressing legacy impacts** to watersheds

Land Use Change & Hydromodification, Pre-Industrial Era



Pennsylvania State Archives

Deforestation & Logging Roads



University of Minnesota Extension

Tillage



"The heroic effort it took to finally drain the Black Swamp merited a state historical marker, which is located at Archbold. Ditching and tiling helped transform the 1,500 square miles of swamp into productive farmland."



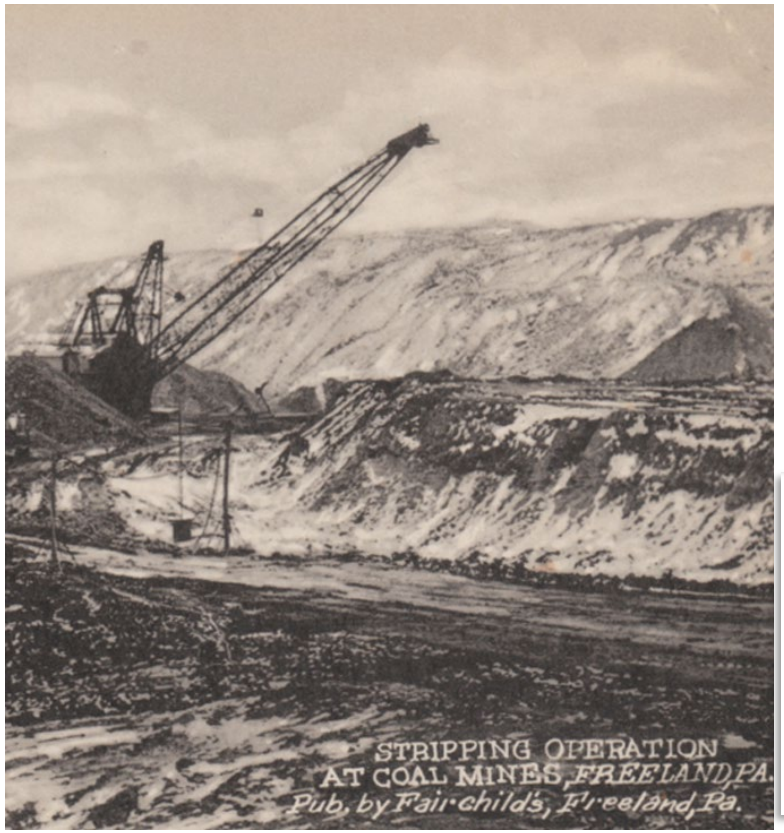
HISTORIC WETLANDS	AREA IN ACRES	DATE DRAINED	SOURCE
Black Swamp	3,072,000	1859–1885	Ohio Dept. Nat. Res., 1988
Pickaway Plains	4,800	1821	Gordon, 1969
Scioto Marsh	16,000	1859, 1883	Gordon, 1969
Other marshes, Hardin County	9,000	1860's	Howe, 1900
Hog Creek Marsh	8,000	1868–1874	Gordon, 1969
Cranberry Marsh	1,000	Unknown	Gordon, 1969
Lake Erie Marshes	300,000	1936–1974	Bednarik, 1984
Dougan's Prairie	Unknown	1827	Middleton, 1917
	TOTAL 3,410,800		

National Water Summary on Wetland Resources
United States Geological Survey Water Supply Paper 2425

Ven Wert, Ohio Times Bulletin

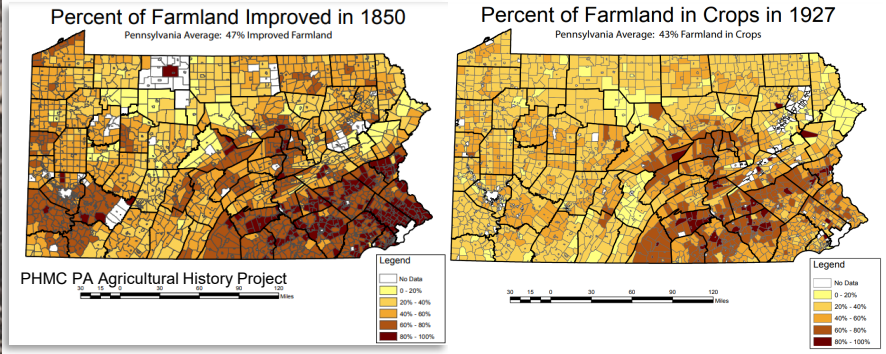
Ditching & Drainage

Land Use Change & Hydromodification, Industrial Era



Tillage, Erosion, & Sedimentation





Pennsylvania State Archives

Extractive Industries



Drainage & Channelization

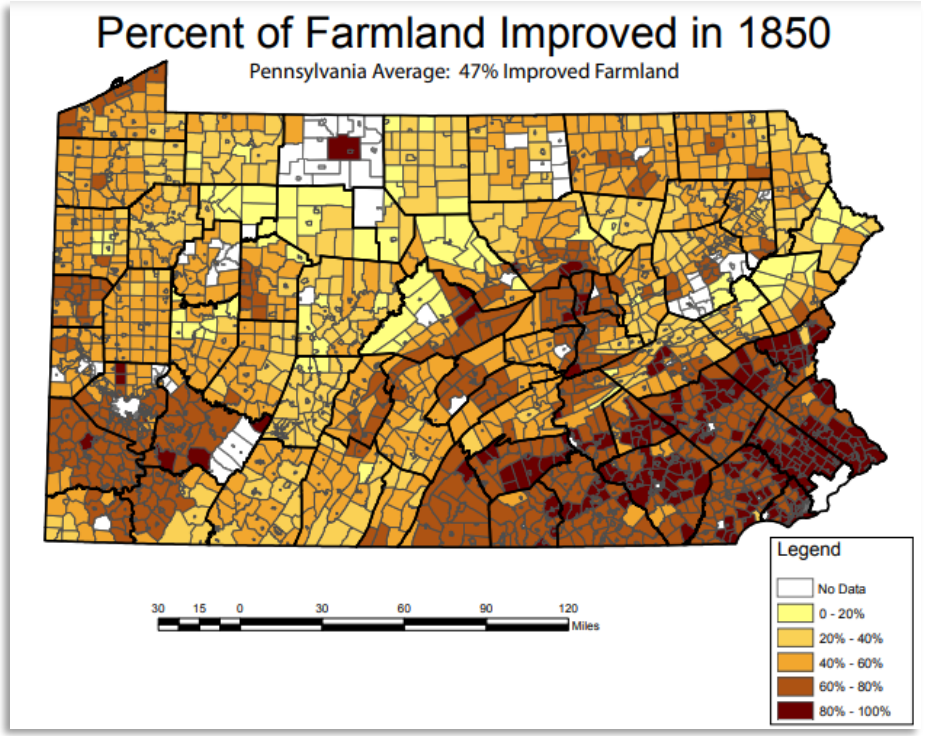
Land Use Change & Hydromodification, Modern Realities

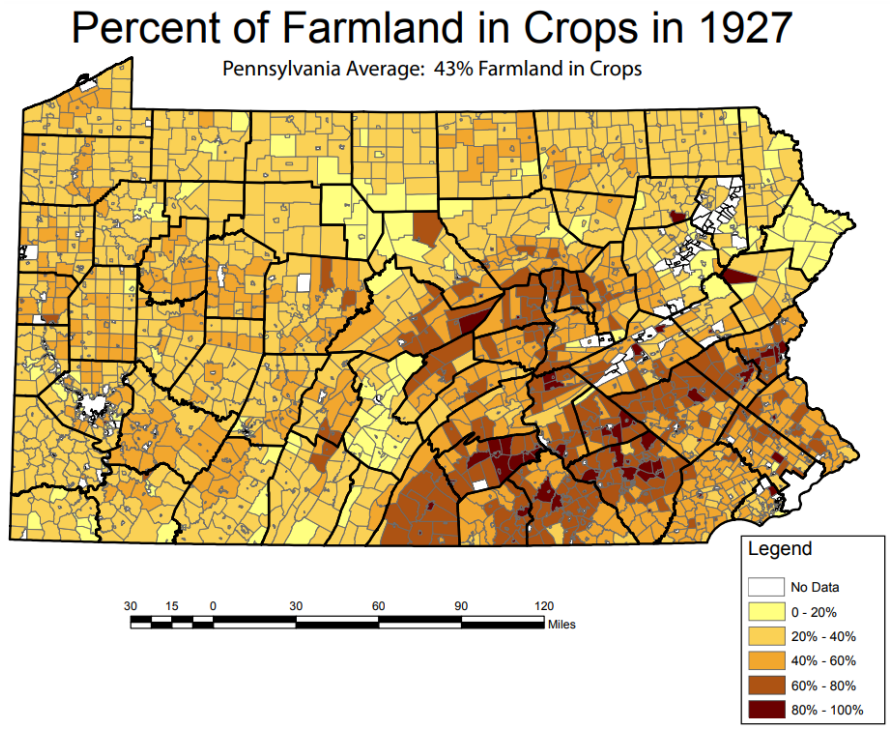




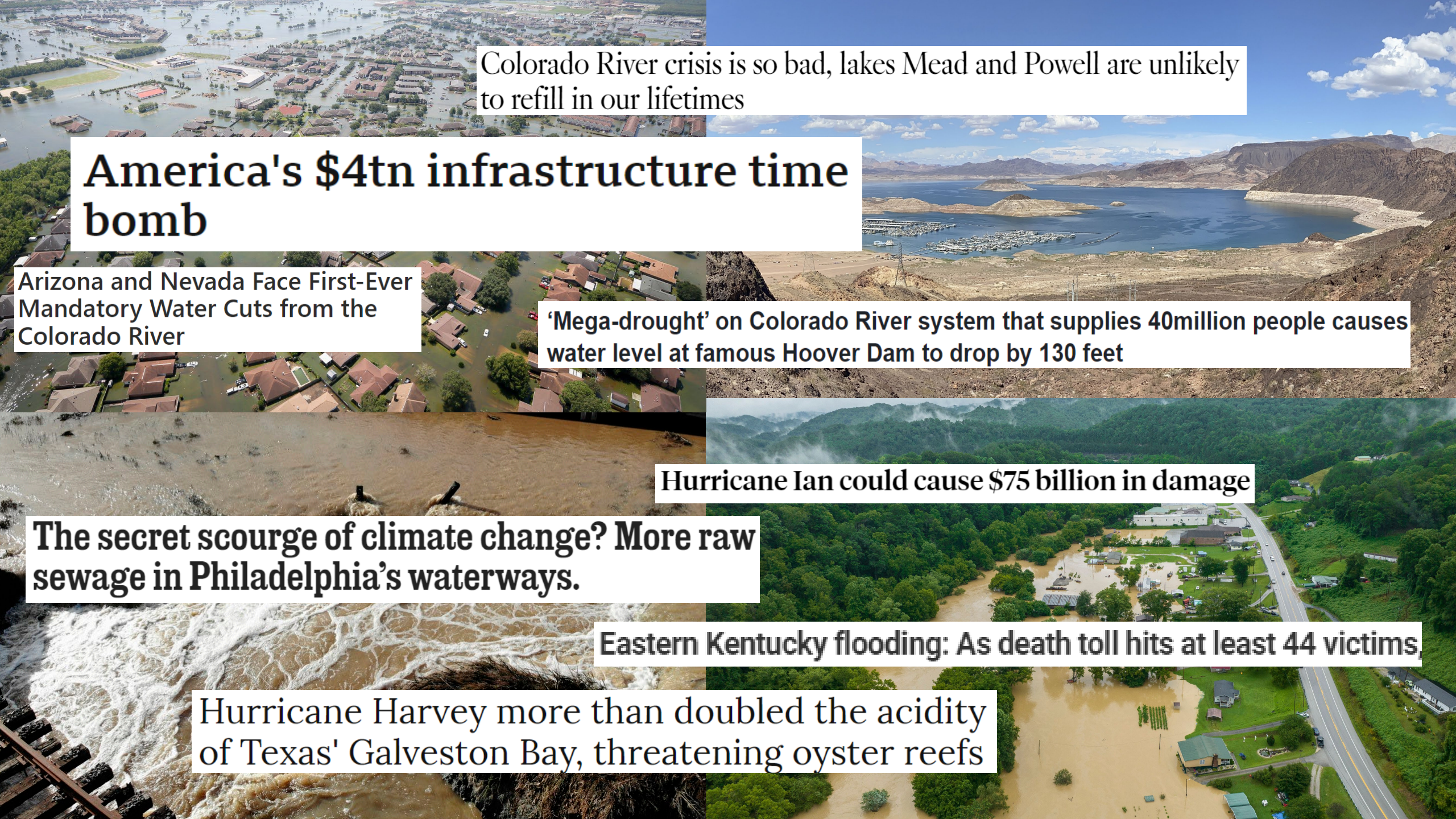


How did we get here again? Land use history in PA…





- We turned the woodlands and wetlands into farms, the **streams became the stormwater (and wastewater) conveyance**
- Where did the wetlands and streams go? (They're under our homes, our roads, our stores)
- Our watersheds are starting to unravel, and the **eroding stream banks** are now **the source of sediment-pollution in PA**


Colorado River crisis is so bad, lakes Mead and Powell are unlikely to refill in our lifetimes
America's $4tn infrastructure time bomb
Arizona and Nevada Face First-Ever Mandatory Water Cuts from the Colorado River
'Mega-drought' on Colorado River system that supplies 40million people causes water level at famous Hoover Dam to drop by 130 feet
Hurricane Ian could cause $75 billion in damage
The secret scourge of climate change? More raw sewage in Philadelphia's waterways.
Eastern Kentucky flooding: As death toll hits at least 44 victims,
Hurricane Harvey more than doubled the acidity of Texas' Galveston Bay, threatening oyster reefs

What are we doing about this?

- Society is realizing **we need to act now**, to preserve our quality of life
- State and federal regulations are requiring **better water and resource-management** when building new projects, CSO, **MS4** and TMDL regulations are working to address these legacy challenges
- Funding will include a mix of local, state, federal funding, and different forms of 'impact-fees' (**stormwater taxes**)
- **Trillions of $ will be spent** in the next few decades to rebuild our nation, in a better, more holistic manner (job security if you're in the infrastructure business)
- **Economic development** for myriad of staff across the project-life cycle (planners, engineers, construction, GIS, ecologists, attorneys, laborers, etc), and there may not 'be an app for that', IE technology will be critical, but we still need to build stuff
- **Best answer: Progressive procurement**, to invest in large (watershed-scale) projects, will be key to using infrastructure funds most wisely. **Nature-based infrastructure** projects address multiple issues (water quantity, water quality, pollinator habitats, bio-diversity), stretching public-investment dollars further.

Let's talk procurement

- **Design–Bid–Build**
  - Traditional project delivery with multiple contracts = intense administrative effort = higher costs
- **Design–Build & Engineering–Procurement–Construction (EPC)**
  - Separate contracts for land acquisition, design/construction, and operations
  - Can accelerate the project development phase
- **Full-Delivery**
  - A single contract to acquire the real estate (site), develop, and operate the project up to a future regulatory closeout
  - A "product" is delivered, in the form of a measure of performance
  - Guaranteed regulatory compliance, transfer of liability
  - Typically ***includes 5-10 years (or more) of guaranteed performance***

Full-Delivery Progressive Procurement is also referred to as:

- "Turnkey"
- **"Design, Build, Operate, Maintain (DBOM)"**
- "Pay for Performance"
- "Performance Based"

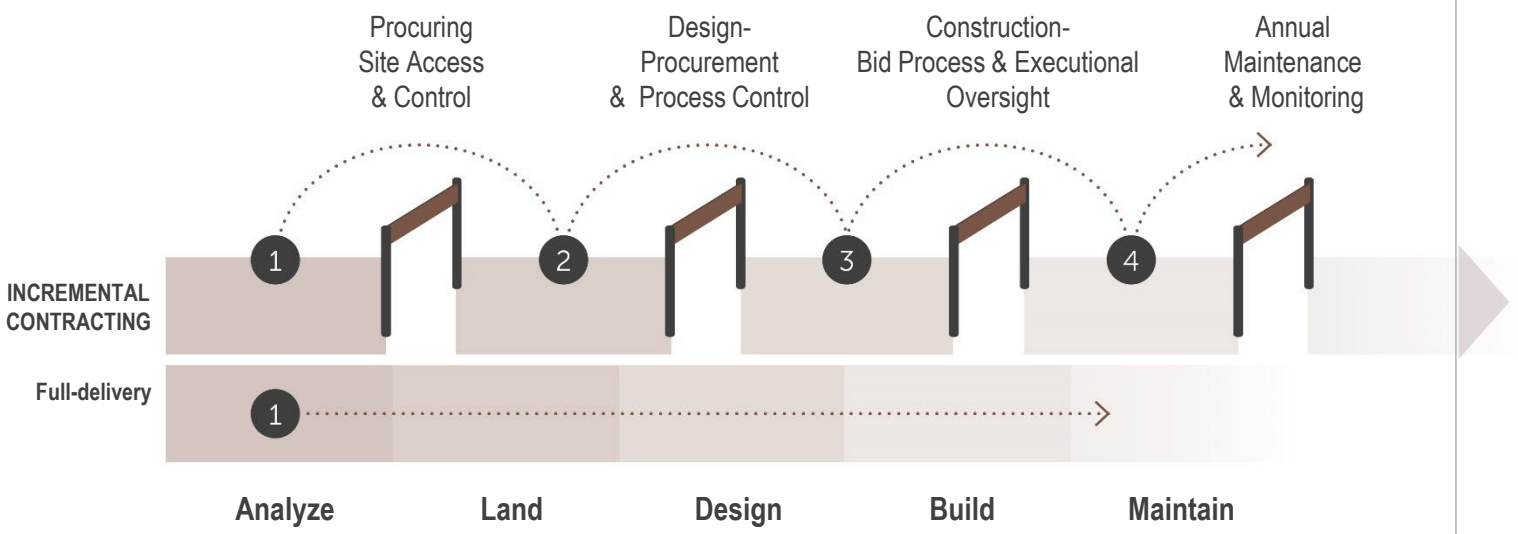
Change is hard; 21st Century Challenges Require 21st Century Solutions

The Power of Full-delivery (Progressive) Procurement

Transfer of Financial and Regulatory Risk

- Single contract **responsible for all phases**
- **Guarantee delivery**, of the 'product', on time, on budget
- **Save 20-30%** of capital project life-cycle costs

Each 'hurdle' adds cost and opportunity for error



Buy the outcome!!! Make the implementor figure it out!

Results= Top-notch Restoration on the Ground

- **Better** work, done by experts
- **Faster** implementation
- **Cheaper,** incl. much less **administrative costs/effort**

Why Procurement Matters?

- **Compensatory Mitigation: North Texas Freshwater Reservoir**
  - 17,000 acres of aquatic and terrestrial resource mitigation
  - Value-engineer, build, monitor and maintain for 20 years, with liability transfer thru surety bonding
  - Quote from District: "***With the switch in delivery method, we realized about $100 million in contract savings***"

- **Water Quality Trading: Virginia Center for Transportation Innovation & Research**
  - Cost-comparison of VDOT participating in water quality trading (WQT, or 'Full-delivery' approach) vs constructing onsite BMPs
  - **Cost savings of 5% to 75%, with an average cost savings of 51%** using WQT
  - VDOT's commitment to WQT **spurred economic development in eco-restoration**, to meet VDOT and other market demands

- **PennDOT MS4 Program-wide using DBOM**
  - **Initially estimated MS4 compliance at $50M, currently expecting closer to $10M,** with minimal staffing
  - Collaborating with municipal partners to procure DBOM TSS credits to **reduce cost for local taxpayers**

Progressive (alternative) procurement saves $Millions over traditional

Ecological offset markets already using full-delivery



Compensatory Mitigation Requirements

"Classic" wetland, stream, endangered species offsets for project impacts **(offsetting 'new impacts')**



Environmental Lawsuits

Regulatory and/or legal settlements for compliance and enforcement actions



Water Quality/ Stormwater Offsets

Restoration to satisfy **governmental (and DOT's) compliance** for TMDL's, CSO Consent Decrees, **MS4**, etc.

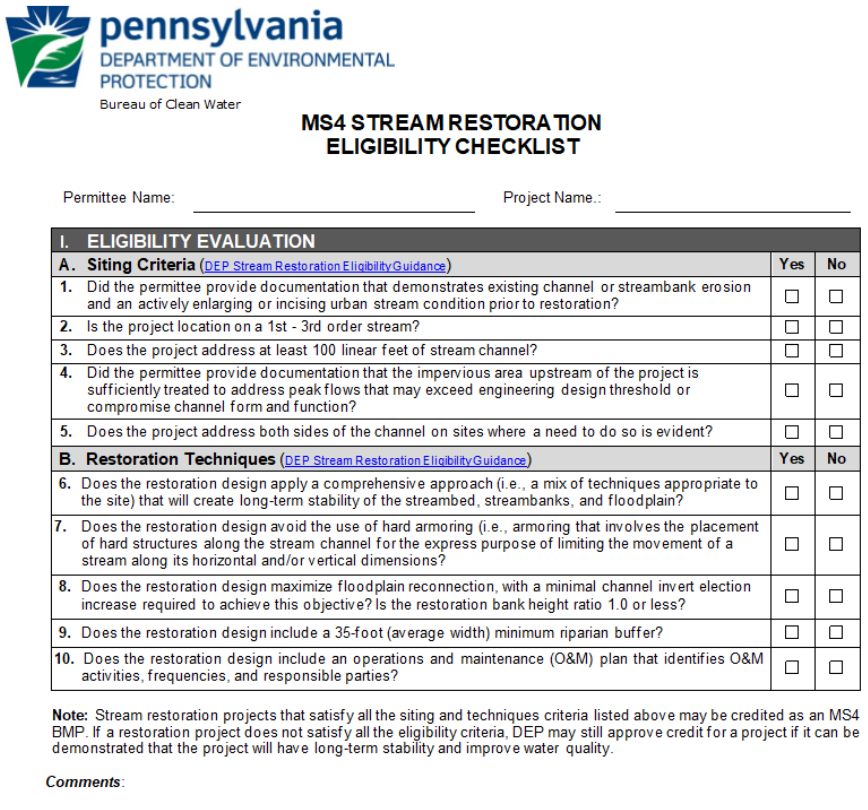


Corporate Sustainability

Private companies (**including tech**) engaging in voluntary restoration for greater public good, creating positive environmental benefits, often with performance 'scores' from investors

Case Study MS4 Program Overview

- Regulatory Framework
  - Focus on watershed impairment, **tied to stormwater pollution**
  - 5-year permit cycles
    - Mapping, planning, implementing
    - Ultimately getting to a Pollution Reduction Plan (IE what are you doing to reduce pollution?)
  - BMP Project Checklists
  - Established methodologies or protocols for specific BMP types
  - Why stream (**more importantly, floodplain**) restoration, using these protocols?
    - Removes the eroding stream banks
    - Re-established floodplain wetlands to capture sediment and nutrients



pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION
Bureau of Clean Water

MS4 STREAM RESTORATION ELIGIBILITY CHECKLIST

Permittee Name: _____ Project Name.: _____

I. ELIGIBILITY EVALUATION		
A. Siting Criteria (DEP Stream Restoration Eligibility Guidance)	**Yes**	**No**
1. Did the permittee provide documentation that demonstrates existing channel or streambank erosion and an actively enlarging or incising urban stream condition prior to restoration?	☐	☐
2. Is the project location on a 1st - 3rd order stream?	☐	☐
3. Does the project address at least 100 linear feet of stream channel?	☐	☐
4. Did the permittee provide documentation that the impervious area upstream of the project is sufficiently treated to address peak flows that may exceed engineering design threshold or compromise channel form and function?	☐	☐
5. Does the project address both sides of the channel on sites where a need to do so is evident?	☐	☐
B. Restoration Techniques (DEP Stream Restoration Eligibility Guidance)	**Yes**	**No**
6. Does the restoration design apply a comprehensive approach (i.e., a mix of techniques appropriate to the site) that will create long-term stability of the streambed, streambanks, and floodplain?	☐	☐
7. Does the restoration design avoid the use of hard armoring (i.e., armoring that involves the placement of hard structures along the stream channel for the express purpose of limiting the movement of a stream along its horizontal and/or vertical dimensions?	☐	☐
8. Does the restoration design maximize floodplain reconnection, with a minimal channel invert election increase required to achieve this objective? Is the restoration bank height ratio 1.0 or less?	☐	☐
9. Does the restoration design include a 35-foot (average width) minimum riparian buffer?	☐	☐
10. Does the restoration design include an operations and maintenance (O&M) plan that identifies O&M activities, frequencies, and responsible parties?	☐	☐

Note: Stream restoration projects that satisfy all the siting and techniques criteria listed above may be credited as an MS4 BMP. If a restoration project does not satisfy all the eligibility criteria, DEP may still approve credit for a project if it can be demonstrated that the project will have long-term stability and improve water quality.

Comments:

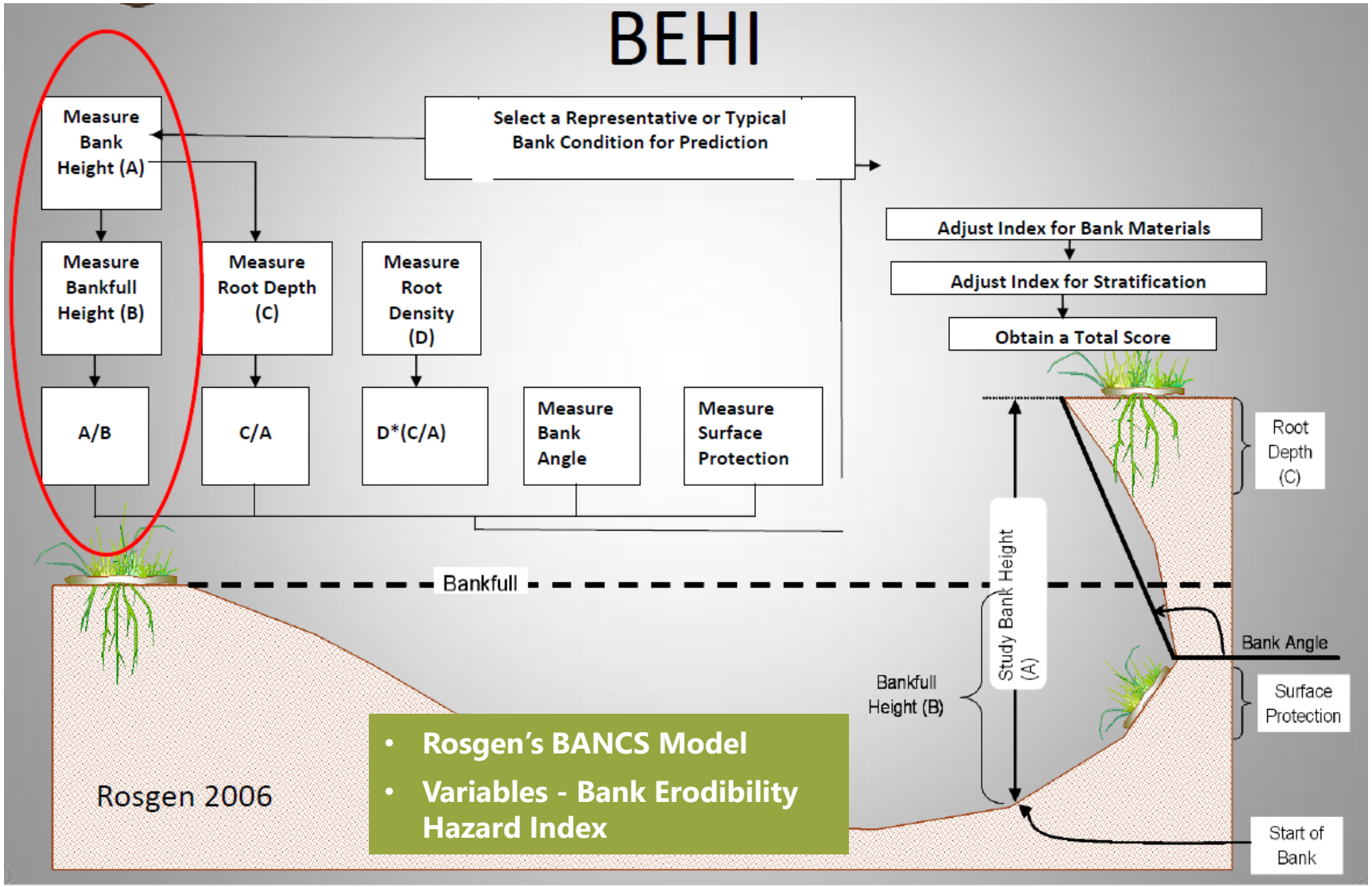
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Why ‘stream restoration’? BMP Cost-comparison

Project	BMP Type	Pounds	Cost	$/Pound
Shope Gardens	Rain Garden	1,500	$160,000	$106.00
Greenfield	Detention Basin Retrofit	4,500	$120,000	$27.00
Cicada Hill	Detention Basin Retrofit	9,100	$110,000	$12.00
Konhaus North	Detention Basin Retrofit	2,400	$130,000	$54.00
Konhaus South	Detention Basin Retrofit	3,800	$103,000	$27.00
Township Building	Detention Basin Retrofit	900	$5,000	$6.00
Deer Run	Stream Restoration: one-off	483,000	$2.5M	$5.18
PennDOT Ohio	Stream Restoration: large-scale	484,485	$1.73M	$5.21
PennDOT Paxton	Stream Restoration: large-scale	573,066	$2.0M	$3.49
PennDOT Delaware	Stream Restoration: large-scale	1,013,650	$4.0M	$2.05
PennDOT Ches. Bay	Stream Restoration: large-scale	1,282,051	$2.5M	$1.95

When you need 1 million pounds, you want to buy $2 pounds!!!

Site Selection for Stream Restoration BMPs





Site Selection for Stream Restoration BMPs

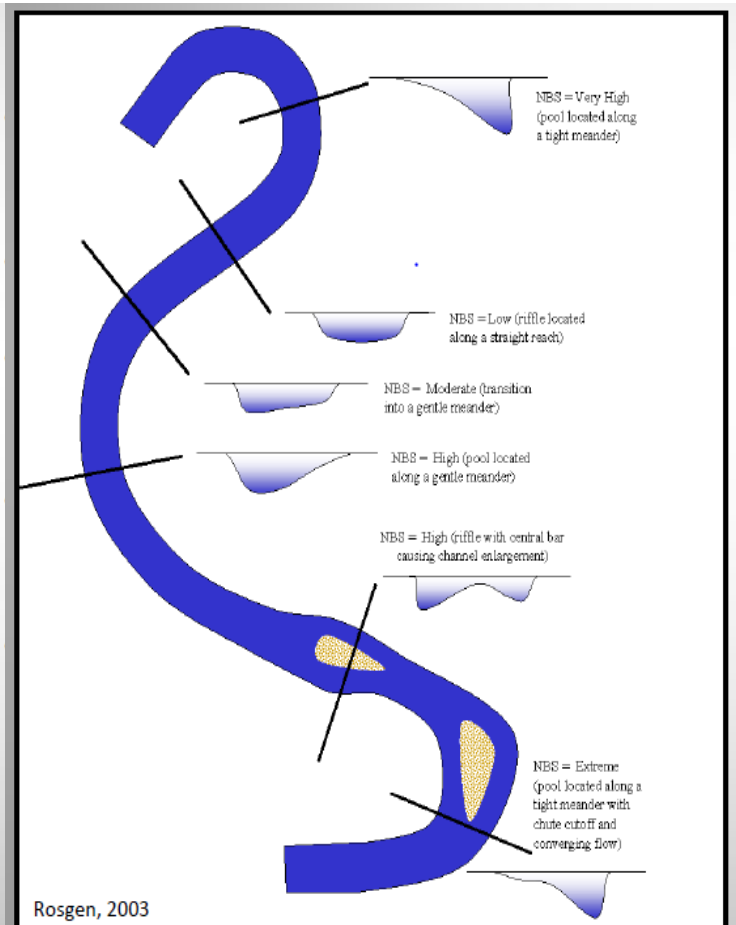
- Protocols utilized to assess near bank stress
- Estimation of bank stress associated with bankfull flows
- Method depends on site-specific conditions, IE **site-selection is very critical** to BMP/ unit-cost

Methods for Estimating Near-Bank Stress (NBS)

(1) Channel pattern, transverse bar or split channel/central bar creating NBS								Level I	Reconaissance	
(2) Ratio of radius of curvature to bankfull width (R_c / W_{bkf})								Level II	General prediction	
(3) Ratio of pool slope to average water surface slope (S_p / S)								Level II	General prediction	
(4) Ratio of pool slope to riffle slope (S_p / S_{rif})								Level II	General prediction	
(5) Ratio of near-bank maximum depth to bankfull mean depth (d_{nb} / d_{bkf})								Level III	Detailed prediction	
(6) Ratio of near-bank shear stress to bankfull shear stress (τ_{nb} / τ_{bkf})								Level III	Detailed prediction	
(7) Velocity profiles / Isovels / Velocity gradient								Level IV	Validation	
Level I	(1)	Transverse and/or central bars-short and/or discontinuous.....NBS = High / Very High Extensive deposition (continuous, cross-channel).....NBS = Extreme Chute cutoffs, down-valley meander migration, converging flow.....NBS = Extreme								
Level II	(2)	Radius of Curvature R_c (ft)	Bankfull Width W_{bkf} (ft)	*Ratio* R_c / W_{bkf}	Near-Bank Stress (NBS)					
	(3)	Pool Slope S_p	Average Slope S	*Ratio* S_p / S	Near-Bank Stress (NBS)					
	(4)	Pool Slope S_p	Riffle Slope S_{rif}	*Ratio* S_p / S_{rif}	Near-Bank Stress (NBS)					
Level III	(5)	Near-Bank Max Depth d_{nb} (ft)	Mean Depth d_{bkf} (ft)	*Ratio* d_{nb} / d_{bkf}	Near-Bank Stress (NBS)					
	(6)	Near-Bank Max Depth d_{nb} (ft)	Near-Bank Slope S_{nb}	Near-Bank Shear Stress τ_{nb} (lb/ft^2)	Mean Depth d_{bkf} (ft)	Average Slope S	Bankfull Shear Stress τ_{bkf} (lb/ft^2)	Ratio τ_{nb} / τ_{bkf}	Near-Bank Stress (NBS)	
Level IV	(7)	Velocity Gradient (ft / sec / ft)	Near-Bank Stress (NBS)							

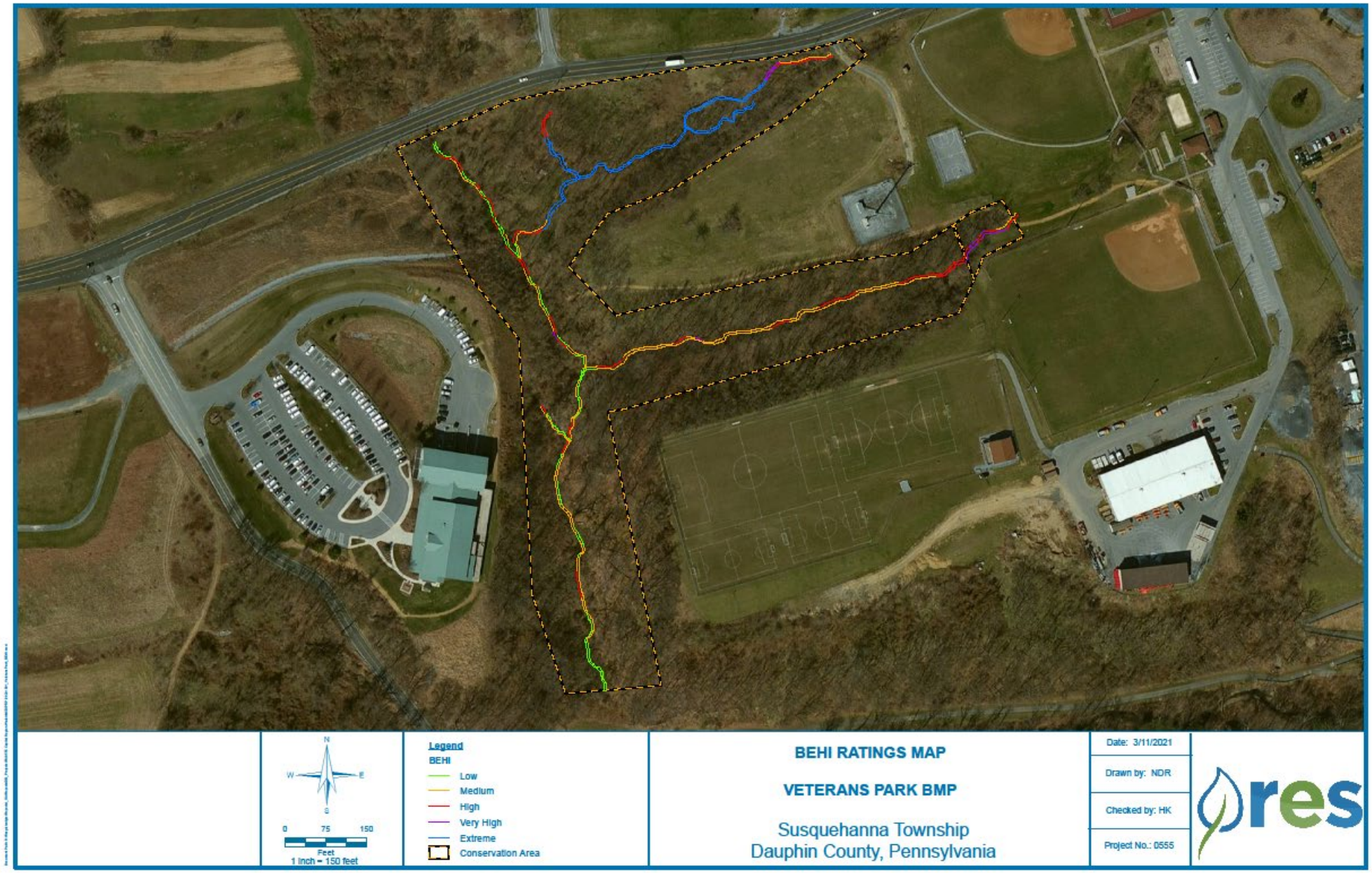
Dominant Near-Bank Stress

Rosgen, 2006



Rosgen, 2003

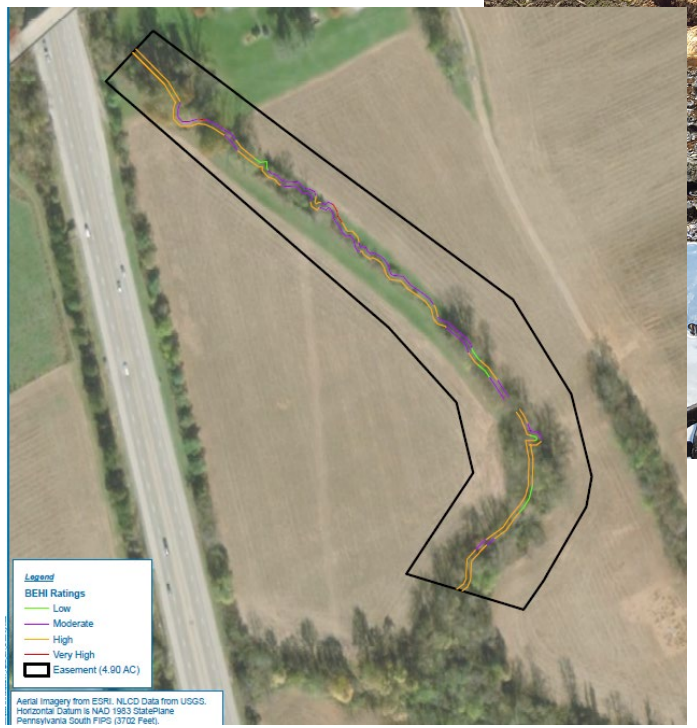
Heat-map for Site-specific Sediment Loading



Case Study 1: PennDOT Sinking Springs MS4 BMP

- "Design-build-operate-maintain" contract 167,000 lbs. sediment reduction **= full-delivery approach**
- Proposed unit costs ranged from $4.48/lb to $29.99/lb, with RES the low-bid **(yes, you can competitively bid this!)**
- RES acquired rights on **private land** to build and maintain project
- RES' scope; siting, design, permitting, acquisition of property interests, construction, inspection, operation, maintenance and post-construction
- Shared with York County Planning Comm.
- Contracted late 2018
- **Designed/permitting/constructed in 2019**
- Post-construction (1-yr) reductions validated December 2020





PennDOT Sinking Springs MS4 BMP

Pre-construction





PennDOT Sinking Springs MS4 BMP

Post Construction- December 2019



April 2020



PennDOT Sinking Springs MS4 BMP

September 2021





PennDOT Sinking Springs MS4 BMP

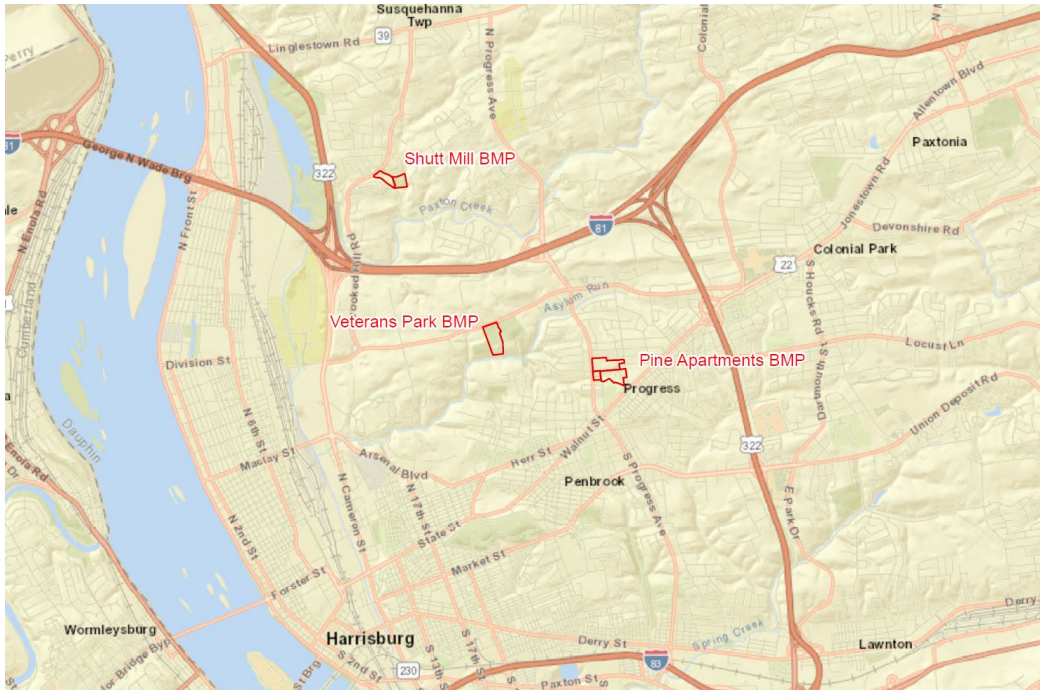
September 2021 (bottom of project, looking at restored vs un-restored)





Case Study 2: Paxton Creek Municipal Partnership

- "Design-build-operate-maintain" contract seeking most lbs of sediment reduction for $2M contract value
- Proposed unit costs ranged from $3.49/lb to $12.77/lb, with RES the low-bid (equating to 573,066 lbs)
- Funded by PennDOT and three municipal partners (Susquehanna and Lower Paxton Townships, and Capital Region Water)
- Contracted September 2020
- **Designed/permitting/constructed in 2021**



Paxton Creek Municipal Partnership

- Three different BMPs
- One township park, one private HOA within a townhome community, one combo township park/state-owned property (different landowner-agreements for each)
- Aggregating all three projects under one contract lead to volume-savings/cost-efficiencies
- **Partnership matters**!!!! The municipal partnership was started years in advance, leading to great efficiencies on the part of all parties
- First time a MS4 contract was co-funded by multiple municipal partners and PennDOT, with PennDOT facilitating the contracting and procurement



Veterans Park MS4 BMP

Pre-Construction





Veterans Park MS4 BMP

December 2021



August 2023



Veterans Park MS4 BMP

Post-construction





Case Study 3: Chesapeake Bay MS4 BMP (Before-After)

March 2022



April 2024



Chesapeake Bay MS4 BMP (Nature-based Results)

Today's biomass



Tomorrow's biomass



Chesapeake Bay MS4 BMP (But the streams?)

EPT taxa (minus P, yet)



Predators!!



CSO/ Urban Case Study: Darien Crossing Stormwater Retrofit

- RES was awarded a Greened Acre Retrofit Program (GARP) grant thru PWD's innovative Green City, Clean Waters Program (**progressive procurement**)
- Largest Greened Acre project (67) to date in Philadelphia, to help meet its goal of 10,000 Greened Acres (**unit of measurement**)
- Removed portion of vacant warehouse, to install retrofit underground, with parking facility on top for beneficial use of parcel
- 2018-2020 (Design and Construction)
- 2021- 2065 (Operations and Maintenance Period)
- The "wins", lower admin-effort (one large project vs 67 small ones), delivered on-time, on-budget (**no changeorders**), for 47-year long project



Key Topics for Full-delivery BMPs

- What are you paying for? Scope (fixed-cost guaranteed outcomes vs. services)
- Public vs. private land
  - Goal= most cost-effective BMP
- Know the life-cycle of the BMP
- Know your regulatory methodology (super critical)
- Financial assurances
- Provisions for long-term maintenance
  - Can you include 5, 10, 20+ years of O&M upfront?



Top "Why" Statements

- **Why Progressive Procurement Matters!**
  - Progressive procurement saves 10-30% over traditional design-bid-build
  - Buy the outcome (not the planning, engineering, constructing…)
- **Why Partnership and Collaboration Matters!**
  - Multi-municipal partnerships focused on watersheds vs. individual municipal can help identify the most cost-effective projects, share the cost, share the credit
  - Leads to larger-scale projects, and larger-scale = lower costs
- **Why Focus on Nature-based Infrastructure (and we really like floodplain wetlands)!**
  - Gray infrastructure needs to be replaced vs green (build it one time)
  - Get 'free' co-benefits!
    - Flood-resiliency, biodiversity, environmental justice, education

Creative MS4 Partnership Ideas

- **Your DOTs!**
  - They are the state's largest MS4 permittees (every watershed, every municipality)
  - They may be able to help with progressive procurement
  - RES DBOM contracts in the Chesapeake Bay now include nearly a dozen "municipal partners"
- **Each other!**
  - Multi-municipal partnerships focused on watersheds vs. individual municipal can help identify the most cost-effective projects, share the cost, share the credit
  - Can be formal partnerships with Joint PRPs, or can be project (BMP) specific
- **Others (though the two above are the best we're aware of)**
  - Farmers and other landowners doing something else water-related (farm pond example)
  - Touchy one, but developers? Yes, this could work. Solar is planting a lot of trees? Developers may be willing to 'over-manage' stormwater with post-construction BMPs that mimic MS4 BMPs
  - Other environmental offset programs, including ESG/CSR for large organizations, many of which have 'water' related initiatives
  - Collaboration with other infrastructure owners (besides DOTs)

One more example… Jon's Pet Project…

- Early-stage water-quality project (likely MS4 collaboration with water utility and my city)
- Focused on sediment and nutrient reduction potential upstream from public water reservoir
- Funding justification: hog the sediment out of the reservoir and chemical treatment vs keeping sediment and nutrients out (could an ounce of prevention offset a pound of treatment?)
- Jon is paying $400/month (or more) for public drinking water from this reservoir. Can we fix this?





The "Why" again? For our children/ future

(they're drinking that water, and will be paying for it)

Question and Answer

Why that location/project for the Pilot Project?
What's the largest area of risk for a full-delivery implementor?
Full-delivery procurement and traditional municipal procurement challenges?
Questions from the audience?

THANKS FOR YOUR TIME!!!!

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