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Natural Solutions for Stormwater

We can't solve problems
with the same kind of
thinking we used when we
created them.

-Albert Einstein

- Mechanical PE in Fluids systems
- Stormwater Engineer with Martin County Since 2017

- Likes challenges
- Learning from Nature



Vegetation

- Requires Maintenance
- Impacts Flood Control
- Nuisance vegetation:
Noxious weeds or any plant that is highly destructive, competitive, or difficult to control.



Vegetation

- Constant & Costly
- We need smart solutions
- Beneficial use ?



Smart Solutions

- Not obvious
- Complex
- Need the right tools!



What's our Responsibility

- Federal Clean Water Act (CWA) 1972
- F.S. 369.20 Florida Aquatic Weed Control Act
- F.S. 369.22 Florida Aquatic Plant Management Act
- F.S. 373 Part IV Management and Storage of Surface Waters
- Florida Rules
 - Chapter 62-302 State Water Quality Standards
 - Chapter 62-304 Total Maximum Daily Loads

- According to FEMA “ Nature-based solutions are sustainable planning, design, environmental management, and engineering practices that weave natural features or processes into the built environment to promote adaptation and resilience.”
- Florida DEP Green Infrastructure initiative
- FEMA BRIC Technical Evaluation Criteria
Priority goal to Incorporate nature-based solutions - 10% of application score for nature-based solutions



Maintain Vegetation

- Common Public Concern
- Mechanical or Chemical
- Constant and costly
- Martin County maintains approximately 450 miles



Dealing with Erosion

- Damages Property
- Impacts to Water Quality
- Impacts to Flood Control & Maintenance
- Costly



Uphold Water Quality

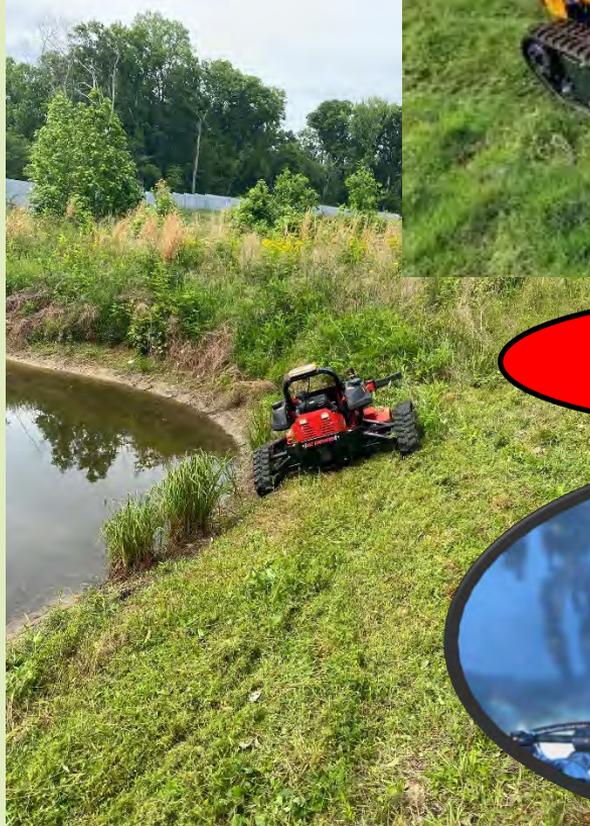
- State requirements and BMAP targets
- Chapter 62-304 (TMDL's)
- New Infrastructure is expensive
- Can we be more cost effective?



How do we solve the problem?

Robots

- Robots!
- Cost effective?
- Public Opinion?



My CPU is a
neuro-net processor



Chemical Spraying

- Public Opinion
- Bad Press...
- Cost effective
- Environmentally concerning

The screenshot shows a news website with a top navigation bar for CNN US, including links for Crime + Justice, Energy + Environment, and More. Below the navigation is a carousel of video thumbnails with titles such as "Florida's war on weeds is killing fish, supercharging red tide," "Passenger who landed plane describes moment he took action," "Supreme Court sides with Cruz in campaign finance case," "CNN anchor presses FDA chief on baby formula shortage. See his response," "Sheriff gives details of what churchgoers did to shooting suspect," and "It took CNN over 3 min all the US have ha shootings it's on".

Florida's war on weeds is killing fish and supercharging red tide, opponents say

by Rose, CNN
February 7, 2020

The fight to reform Florida's dependence on chemical herbicides

March 8, 2021



Mr. YUK MEANS NO! STAY AWAY!



Florida Manatees Face A New Threat: Weed Killer

By Jessica Meszanos
Feb 11, 2021 at 3:25 AM EDT



HEALTH

Anglers, environmentalists laud FWC for suspending herbicide spraying, including Roundup

Tyler Treadway
Treasure Coast Newspapers

Published 4:55 p.m. ET Jan. 24, 2019 | Updated 11:07 a.m. ET Jan. 25, 2019

only used to kill weeds he blood of Florida's entration of glyphosate increased from 2009 to

st shows the state's manatees are ke Roundup. The research concluded

Industrial Solutions

- Concrete – expensive – not natural
- Limited Treatment - Not Environmentally Responsible



Natural Solutions

- What would mother nature want?
- What do grant agencies want?

Green/Grey Infrastructure



Public works structures consisting of man-made materials with an element of green habitat.

Bioengineering



Approach that uses natural materials and systems to mimic natural processes with the goal of reducing hazards.

Engineering with Nature



Water resources projects using natural and engineering processes to create multifunctional infrastructure.

Natural Solutions

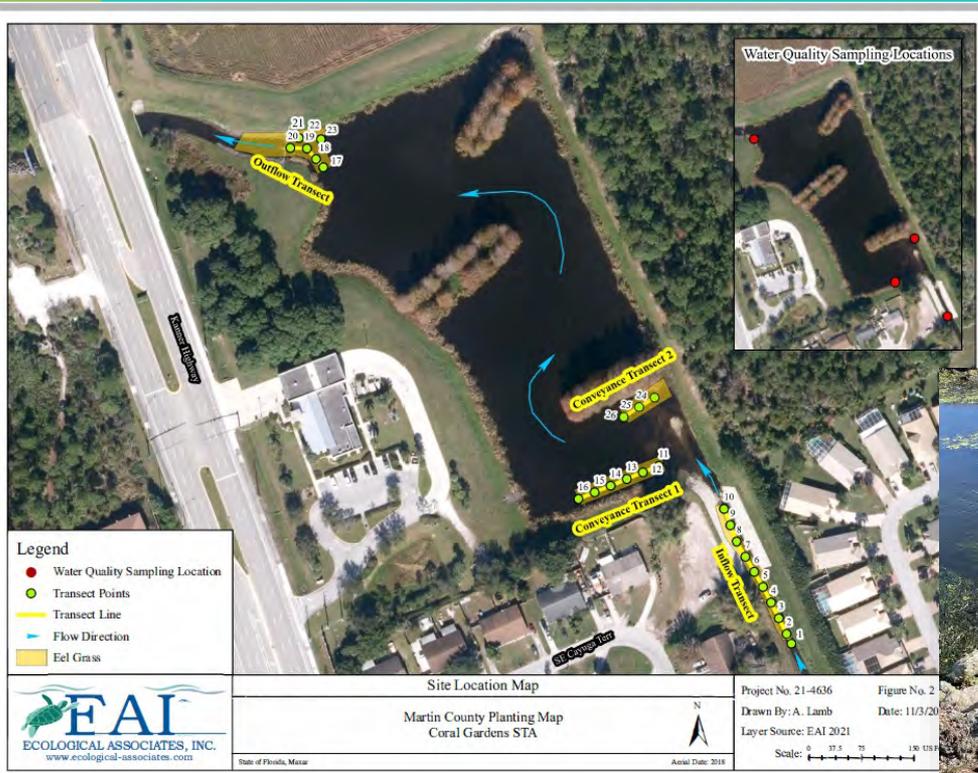
- What if Nature already solved the problem?



- Beneficial Submerged Aquatic Vegetation (SAV)?

Beneficial SAV Pilot Project

CORAL GARDENS STORMWATER TREATMENT AREA PLANTED IN 2020



- ▶ Why
- ▶ How
- ▶ Partners
- ▶ What we learned
- ▶ Next Steps

Beneficial SAV Pilot Project

- Reduce Sediment Transport by stabilizing channel bottom
- Beneficial use for water quality and Environmental habitat restoration
- Ability to out-compete nuisance SAV (such as Hydrilla)

▶ Why

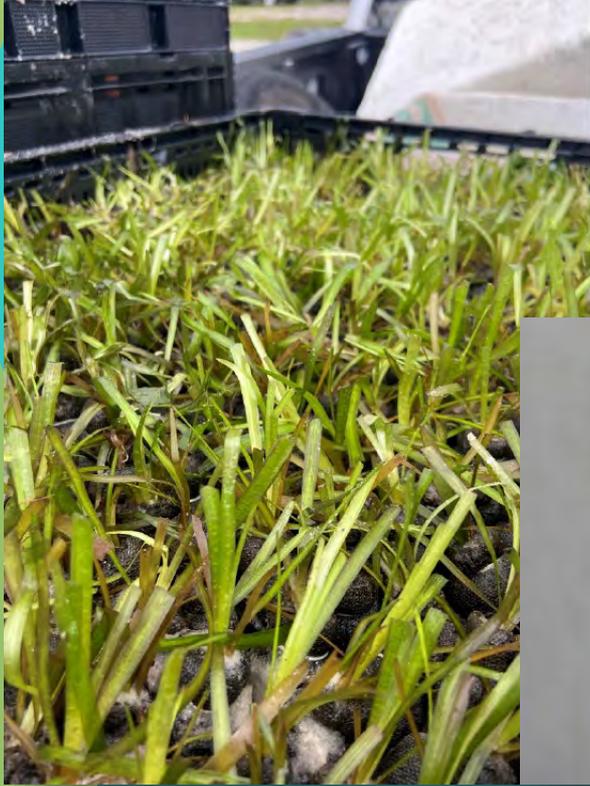
▶ How

▶ Partners

▶ What we learned

▶ Next Steps

Beneficial SAV Pilot Project



- ▶ Why
- ▶ How
- ▶ Partners
- ▶ What we learned
- ▶ Next Step

Beneficial SAV Pilot Project



- ▶ Why
- ▶ How
- ▶ Partners
- ▶ What we learned
- ▶ Next Steps

Beneficial SAV Pilot Project

- Eelgrass loves moving water
- Predation is MAJOR factor in success
- Ability to compete with nuisance SAV



▶ Why

▶ How

▶ Partners

▶ What we learned

▶ Next Steps

Beneficial SAV Pilot Project

- Expect 1-2 years for establishment
- Requires limited maintenance for establishment (~ 80 hrs annually)
- Enhances water quality



- ▶ Why
- ▶ How
- ▶ Partners
- ▶ What we learned
- ▶ Next Steps

Beneficial SAV Pilot Project



- ▶ Why
- ▶ How
- ▶ Partners
- ▶ What we learned
- ▶ Next Steps

Beneficial SAV Pilot Project



2 samples each location

Only 200' of Eelgrass bed

No other inputs/outlets

- Preliminary Water Quality Testing Plan

- ▶ Why
- ▶ How
- ▶ Partners
- ▶ What we learned
- ▶ Next Steps

Beneficial SAV Pilot Project

Pollutant Reductions

	<i>T. Coliform</i>	<i>E. Coli</i>	<i>TSS</i>	<i>TN</i>	<i>TKN</i>	<i>TP</i>	<i>OrthoP</i>
<i>March Reductions</i>	-55%	-71%	-38%	-44%	-50%	-47%	-55%
<i>April Reductions</i>	+69%	-76%	-72%	-20%	-27%	-41%	-30%

► Why

► How

► Partners

► What we learned

► Next Steps

- Preliminary Results
- Only 200' of Eelgrass bed
- Typical water speed
0.25 to 0.5 fps

- Project Cost
\$ 15,000
- Annual Maintenance
\$ 1,500

Into the Weeds – Technical Details

- Vegetation still impacts flood control.
- It's obvious: YES, Manning's coefficient increases for vegetated channels and flood plains.
- Could beneficial SAV (eelgrass) be the exception to the rule ?
- How can it be acceptable ?

Into the Weeds – Technical Details

The Manning's Equation

- Open Channel Flow
- Modelling Parameter
- Manning's Roughness Coef.
- Determines Flow Rate

Manning's Equation:

$$Q = VA = \left(\frac{1.49}{n} \right) AR^{\frac{2}{3}} \sqrt{S} \quad [\text{U.S.}]$$

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Where:

Q = Flow Rate, (ft³/s)

v = Velocity, (ft/s)

A = Flow Area, (ft²)

n = Manning's Roughness Coefficient

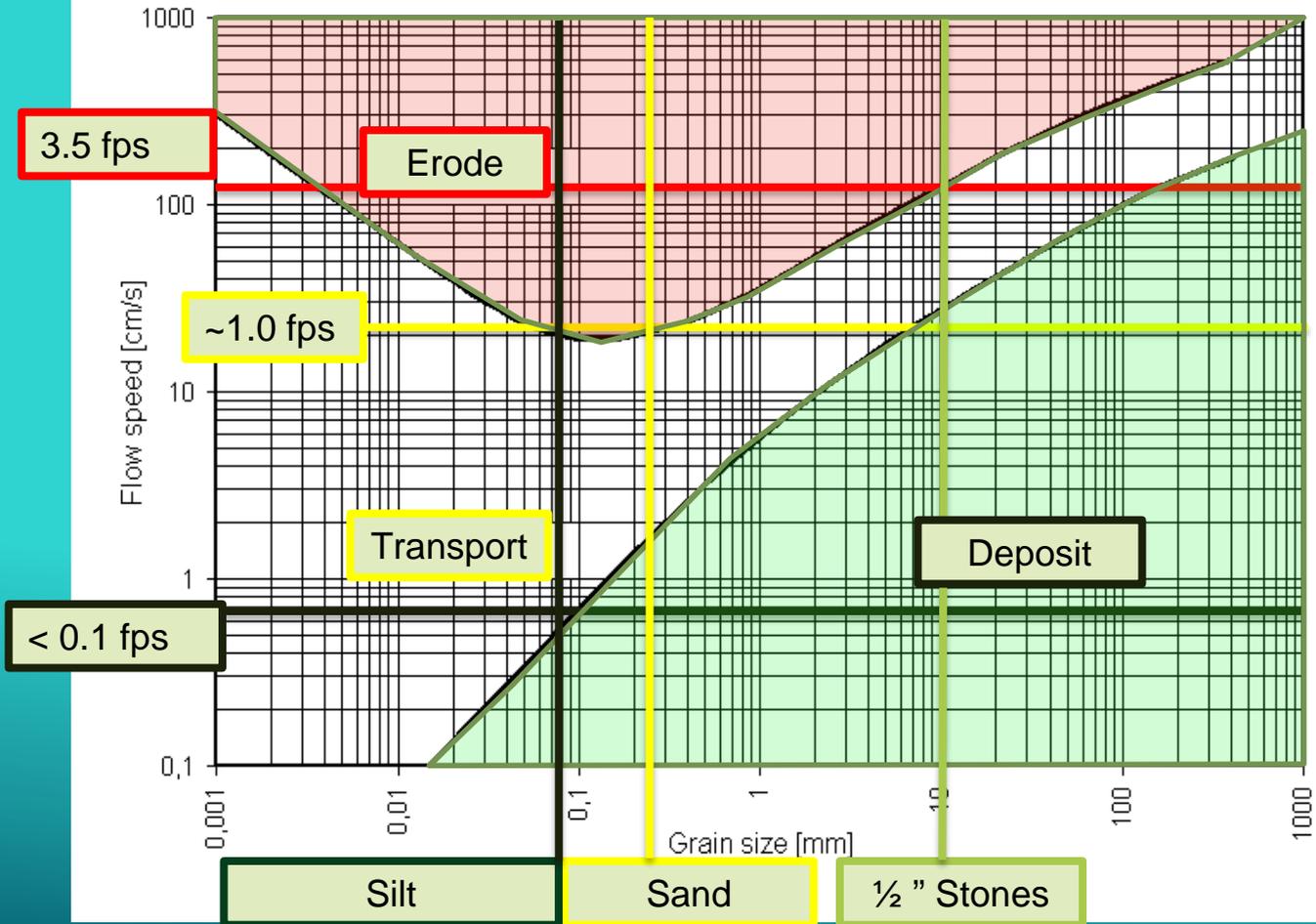
R = Hydraulic Radius, (ft)

S = Channel Slope, (ft/ft)

Into the Weeds – Technical Details

Sediment Transport

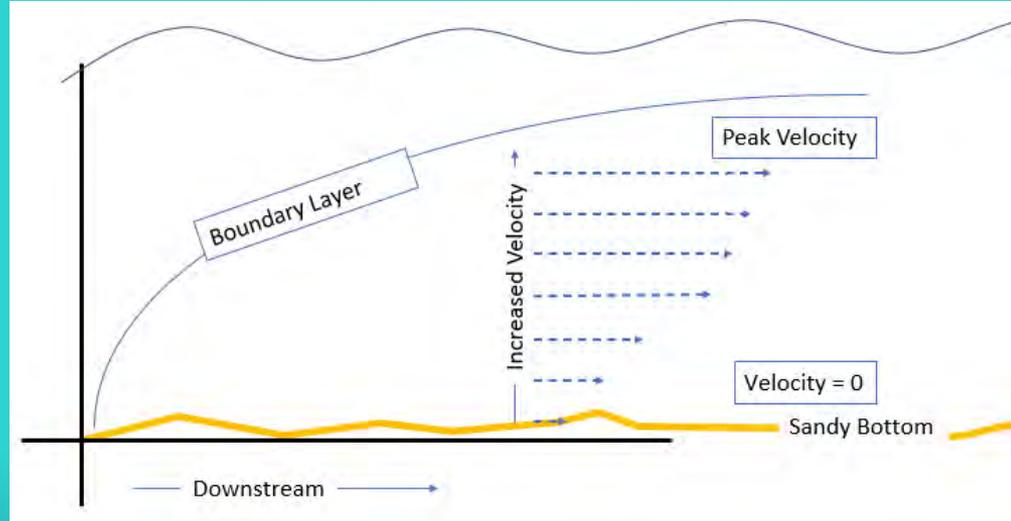
- Size of Sediment vs. Velocity
- Erode, Transport, or Deposit
- Hjulström Curve / Shields Diagram
- Sediment impacts water quality



Into the Weeds – Technical Details

Boundary Layer Theory

- Thin layer of fluid
- Affected by surface roughness and fluid velocity (speed)
- Where speed changes from zero on the surface to the speed of moving water.



Into the Weeds – Technical Details

Selecting a Good Location

- Right Tool – Right Job
- Downstream of critical controls
- Consider hydraulics
- Avoid public opinion conflicts
(false perception of issues)

Into the Weeds – Why it's a Great Idea!

Into the Weeds – Why it’s a Great Idea!

Increased Residence Time

- Significantly increases residence time during base flow condition
- Improves water quality
- Most important factor for water quality performance (Harper, 2007)

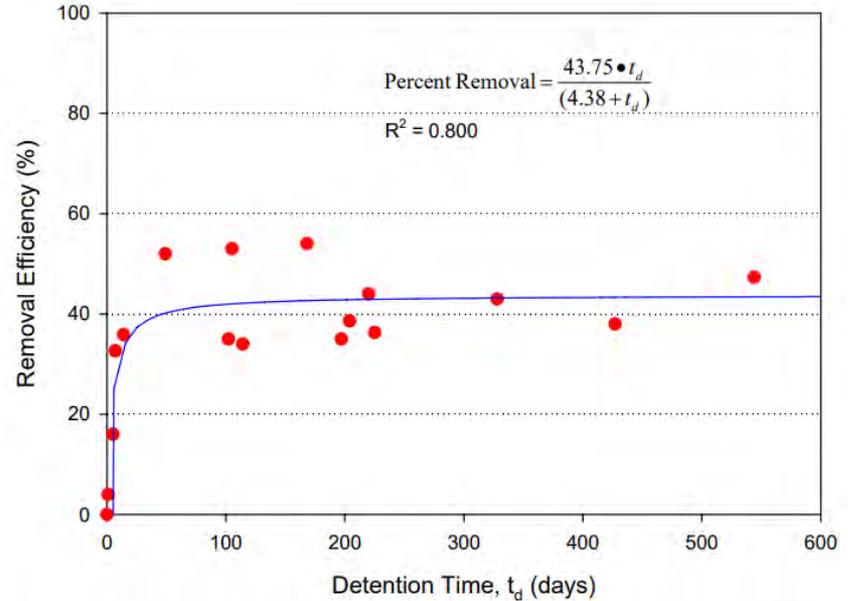
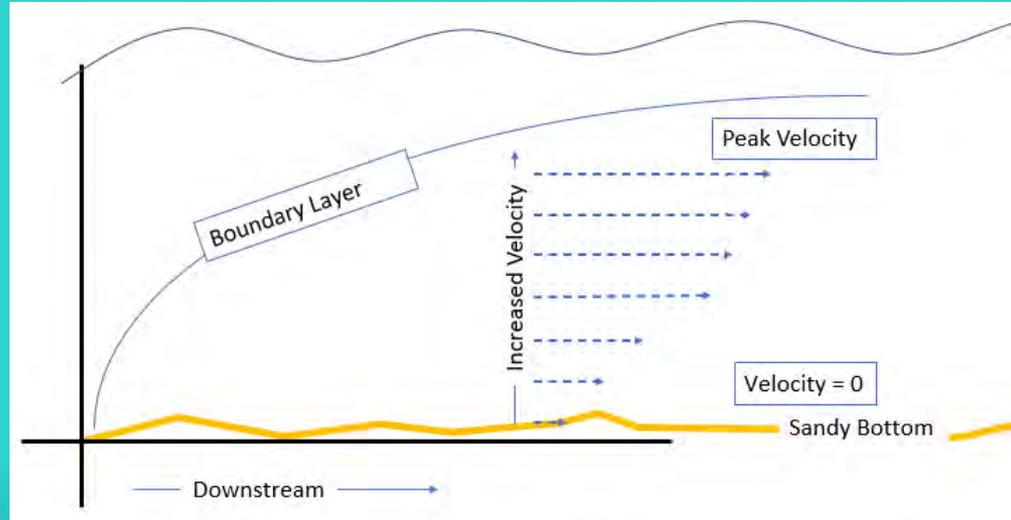


Figure 5-10. Removal Efficiency of Total Nitrogen in Wet Detention Ponds as a Function of Residence Time.

Into the Weeds – Why it's a Great Idea!

Stabilizing the Boundary Layer

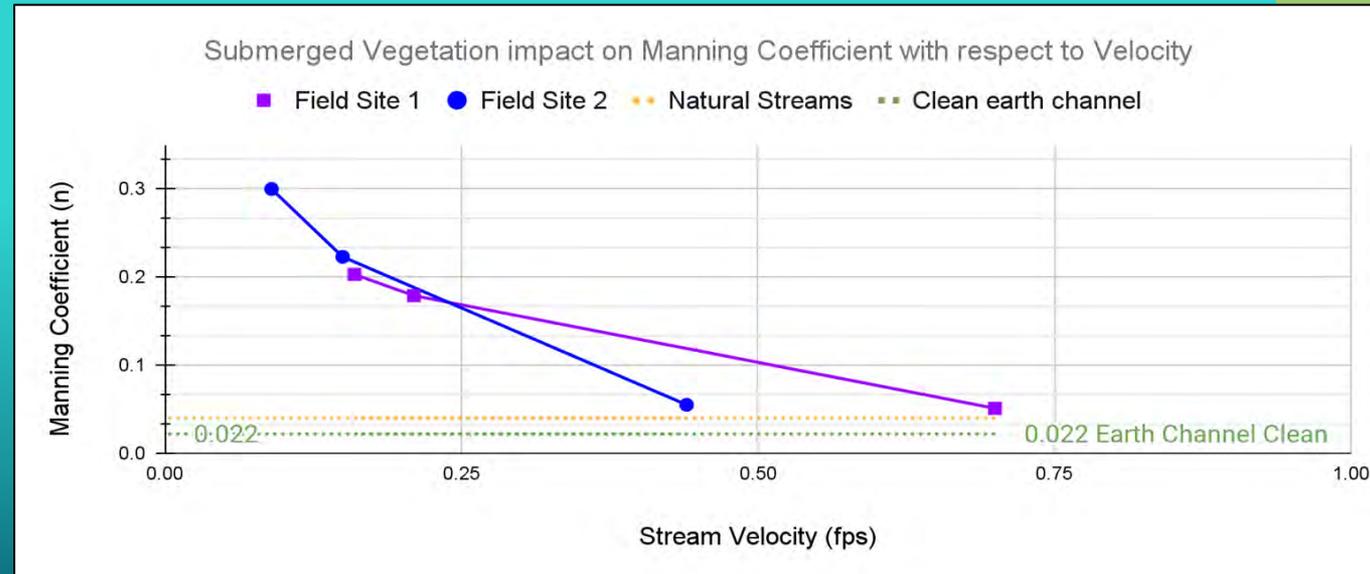
- Reduces sediment transport
- Reduces erosion
- Improves water quality
- limits nuisance SAV (e.g., hydrilla)



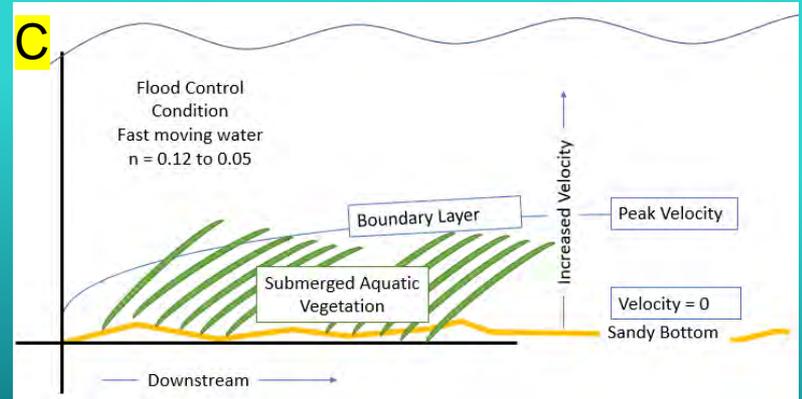
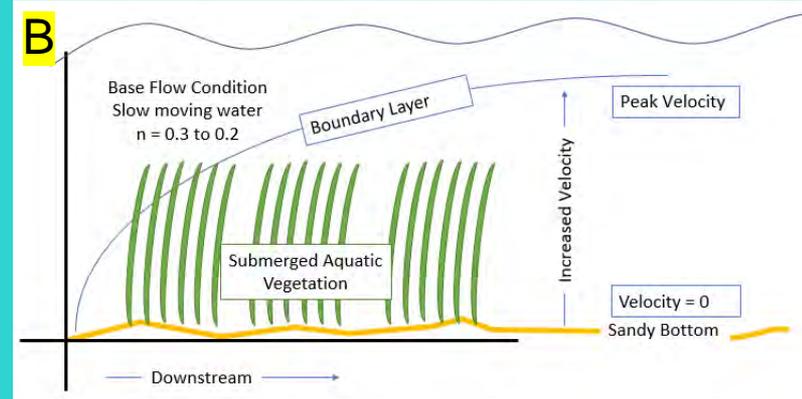
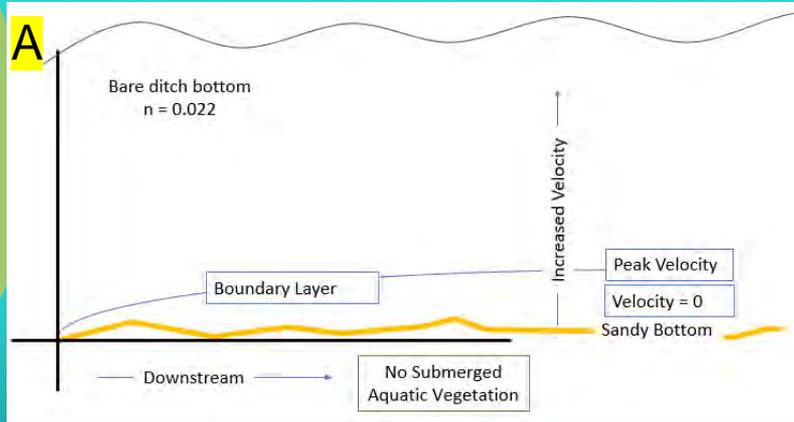
Into the Weeds – Why it's a Great Idea!

Effect on Manning's Roughness Coefficient

- For flexible vegetation, vegetation height decreases with increased flow velocity, and hence the flow resistance decreases with flow velocity
- Lower impact to flood control



Into the Weeds – Why it’s a Great Idea!



Schügerl, R. et al.: Effect of aquatic vegetation on Manning's roughness coefficient value – Acta Hydrologica Slovaca, Volume 21, No. 1, 2020, 123–129

Into the Weeds – Why it's a Great Idea!

Creates an Improved Ecosystem

- Bryozoon
- Blue Crabs
- Shrimp
Macrobrachium Spp.
- Much More



- Submerged Aquatic Vegetation (SAV) is a great idea for your stormwater system.

Questions ?

- Adaptable & inexpensive
- Select the right location
- Select the right plants
- Evaluate for Flood Control
- Change Maintenance Practice
- Improve Habitat & Water Quality
- Looks better than the alternatives!

