A Model for Phosphorus from Shoreland Development

Paul McGinley

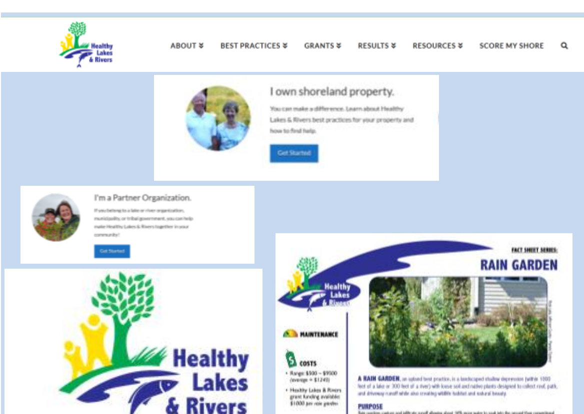
Stormwater Workshop
Waukesha Co & WI Land & Water
April, 2025

Lakes & Phosphorus

- Add a little P, and you can make a lot of algae:

1 lb P → **500 lbs Algae***

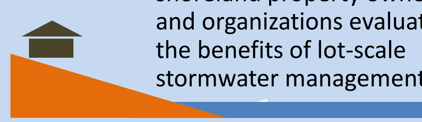
*p 275 in ***Limnology,*** Robert Wetzel, Academic Press, 2001



https://healthylakeswi.com

Objective

Develop a tool to help shoreland property owners and organizations evaluate the benefits of lot-scale stormwater management

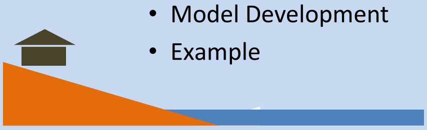


Collaborators

- Dave Ferris, Burnett Co
- Cheryl Clemens, Harmony Environmental
- Carolyn Scholl, Vilas Co
- Emily Moore and Shawn O'Connell, Burnett Co
- We appreciate John Panuska's comments about this project, and the discussions about lakes, development and related modeling with <u>many</u> DNR and Extension Colleagues.

Outline

- Shorelands & Phosphorus
- Model Development
- Example



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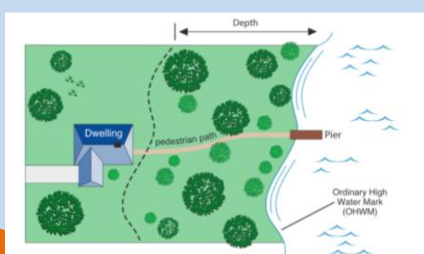
Shorelands & Phosphorus

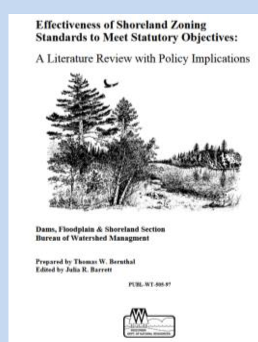
Shorelands & Phosphorus



How well a shoreland works depends on slope, soil, natural vegetation and other factors.

Lakes Partnership Shoreland Stewardship Series Cooperative Extension Publications 877-947-7827, Carmen Wagner, John Haack, and Robert Korth

Shorelands & Phosphorus



Effectiveness of Shoreland Zoning Standards to Meet Statutory Objectives:

A Literature Review with Policy Implications

Dams, Floodplain & Shoreland Section
Bureau of Watershed Managment

Prepared by Thomas W. Berthal
Edited by Julia R. Barrett

PUBL-WT-505-97

The modeling results and empirical studies ….demonstrate that phosphorus levels can increase with even small levels of residential development around lakes.

WDNR, 1997

Shorelands & Phosphorus

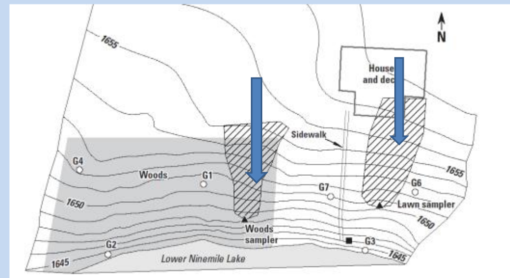
USGS
science for a changing world

In cooperation with the Wisconsin Department of Natural Resources

Hydrology, Nutrient Concentrations, and Nutrient Yields in Nearshore Areas of Four Lakes in Northern Wisconsin, 1999–2001

By David J. Graczyk[1], Randall J. Hunt[1], Steven R. Greb[2], Cheryl A. Buchwald[1], and James T. Krohelski[1]

Water-Resources Investigations Report 03-4144



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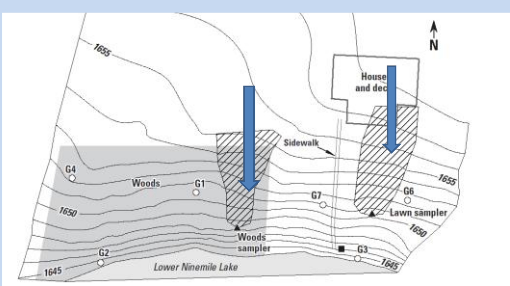

Quantity of phosphorus transported was related to the volume of runoff

USGS
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Model Development

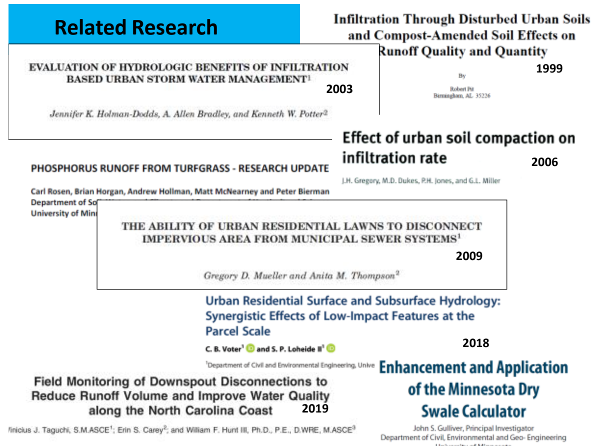
Directly Connected Impervious

Model Development

Disconnection

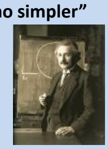
Foster, K.M. 2008. The role of the residential shoreland lawn as a hydrologic connection between the downspout and lake. M.S. Thesis, College of Natural Resource, University of Wisconsin-Stevens Point. (available on 9/13/2023 at https://minds.wisconsin.edu/bitstream/handle/1793/81198/Foster.pdf)

Related Research

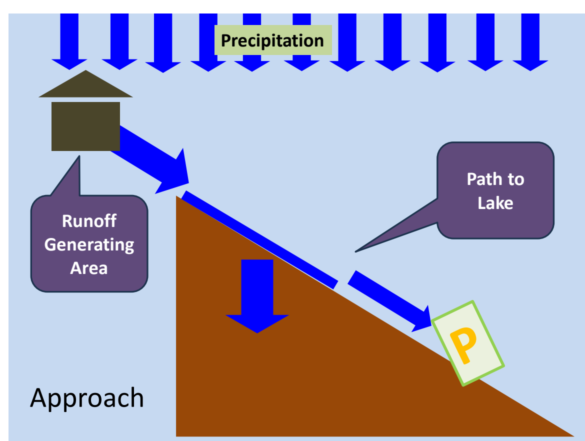


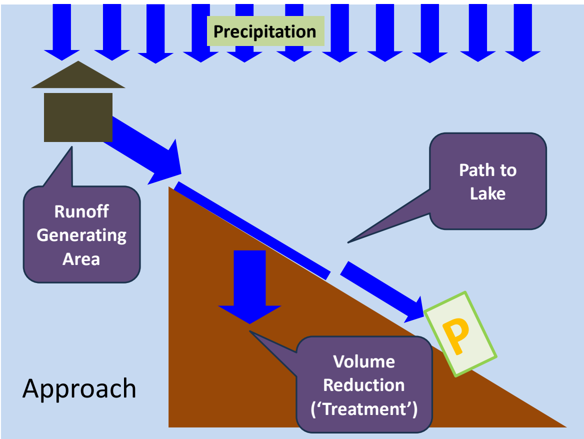
Model Development

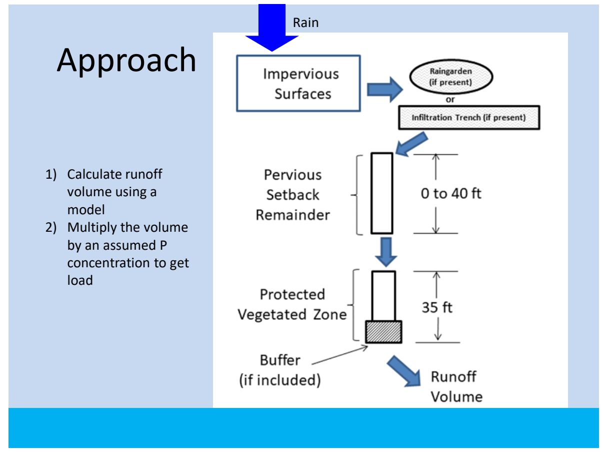
"Everything should be made as simple as possible, but no simpler"
A. Einstein

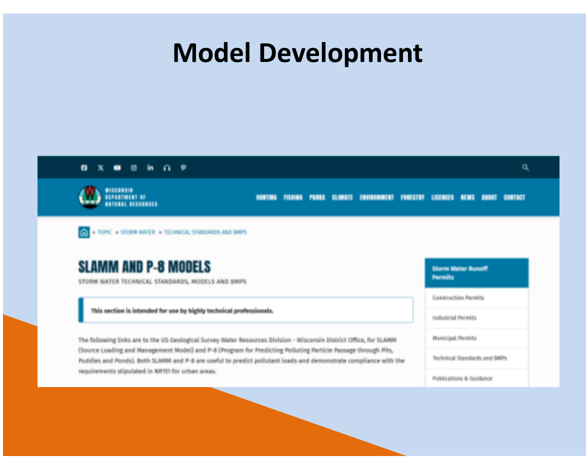


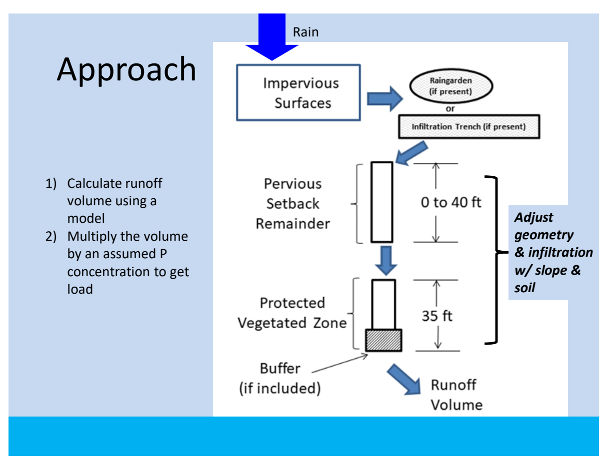
"All models are wrong but some are useful"
G. Box



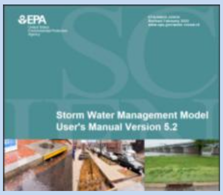

Precipitation
Runoff Generating Area
Path to Lake
Volume Reduction ('Treatment')
P
Approach

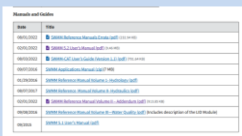

Approach
1) Calculate runoff volume using a model
2) Multiply the volume by an assumed P concentration to get load
Rain
Impervious Surfaces
Raingarden (if present)
or
Infiltration Trench (if present)
Pervious Setback Remainder
0 to 40 ft
Protected Vegetated Zone
35 ft
Buffer (if included)
Runoff Volume


Model Development
SLAMM AND P-8 MODELS

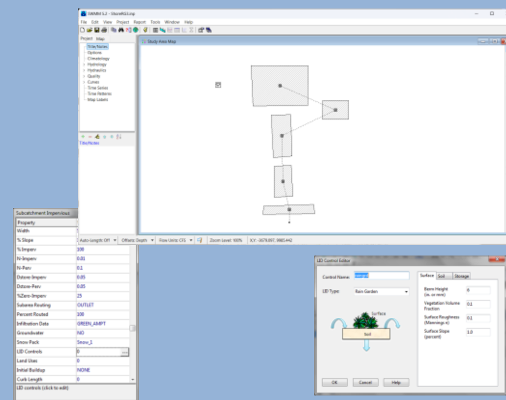

Approach
1) Calculate runoff volume using a model
2) Multiply the volume by an assumed P concentration to get load
Rain
Impervious Surfaces
Raingarden (if present)
or
Infiltration Trench (if present)
Pervious Setback Remainder
0 to 40 ft
Protected Vegetated Zone
35 ft
Adjust geometry & infiltration w/ slope & soil
Buffer (if included)
Runoff Volume

US EPA Storm Water Management Model (SWMM)



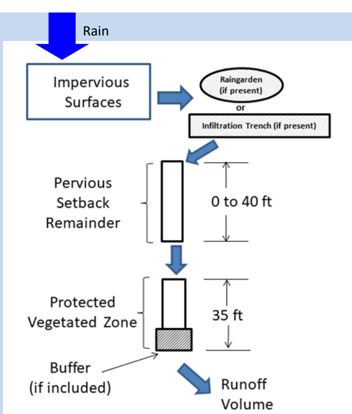


- Continuous simulation model
- Flexible, open-source model
- Adapted Wisconsin's hourly rainfall files
- Can be automated with python packages



Approach

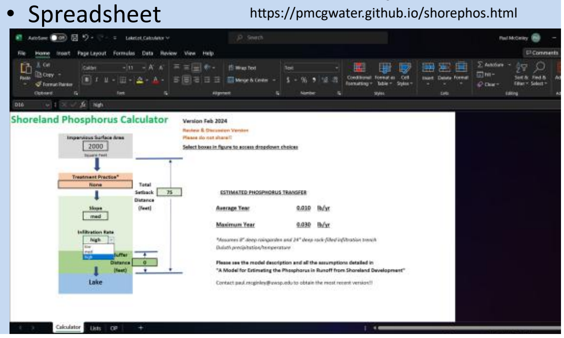
1) Calculate runoff volume using a model
2) Multiply the volume by an assumed P concentration to get load
3) **Run base-case models 1000s of the times and summarize the results**



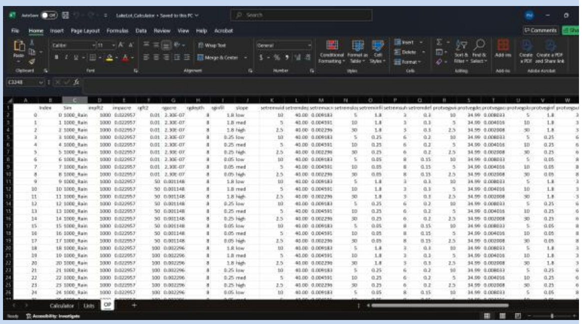
Model Application

email me at paul.mcginley at uwsp.edu
or
https://pmcgwater.github.io/shorephos.html

- Spreadsheet

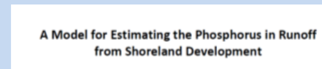


The Spreadsheet: *Behind the scenes*

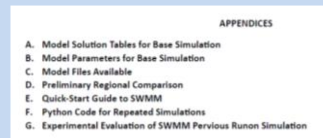


Related Resources

- Report
  - 12 page overview
- Appendices



A Model for Estimating the Phosphorus in Runoff from Shoreland Development



APPENDICES

A. Model Solution Tables for Base Simulation
B. Model Parameters for Base Simulation
C. Model Files Available
D. Preliminary Regional Comparison
E. Quick-Start Guide to SWMM
F. Python Code for Repeated Simulations
G. Experimental Evaluation of SWMM Pervious Runon Simulation

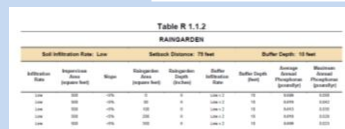


Table R 1.1.2

RAINGARDEN

Related Resources

- SWMM Input Files

APPENDIX C. MODEL FILES AVAILABLE

Shoreland Development Runoff Phosphorus Model Files

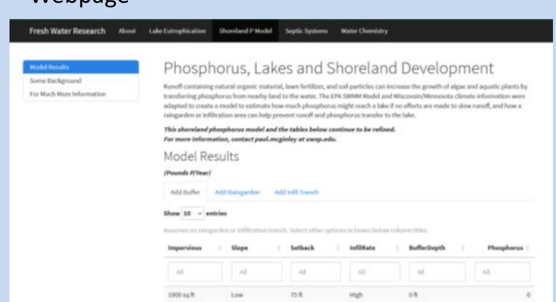
Appendix C Continued.

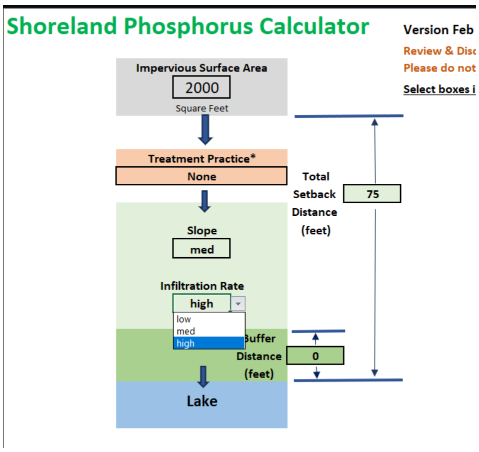
SWMM File used for Base Simulation

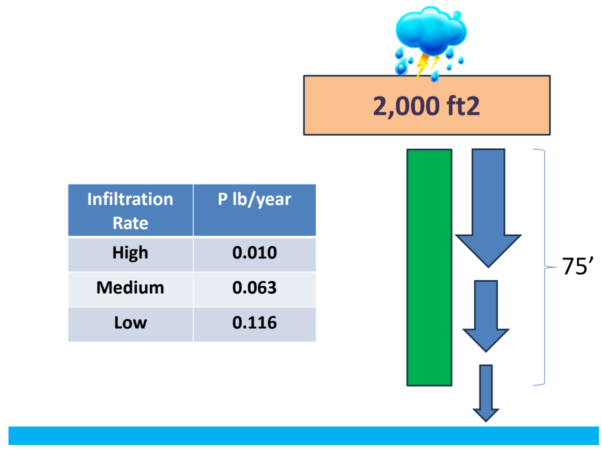
Related Resources

https://pmcgwater.github.io/shorephos.html

- Webpage

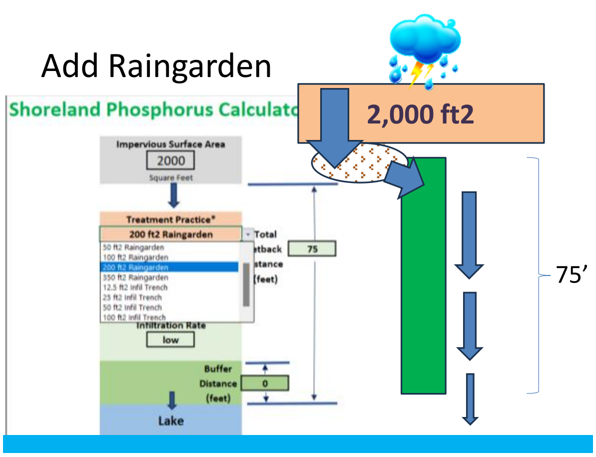




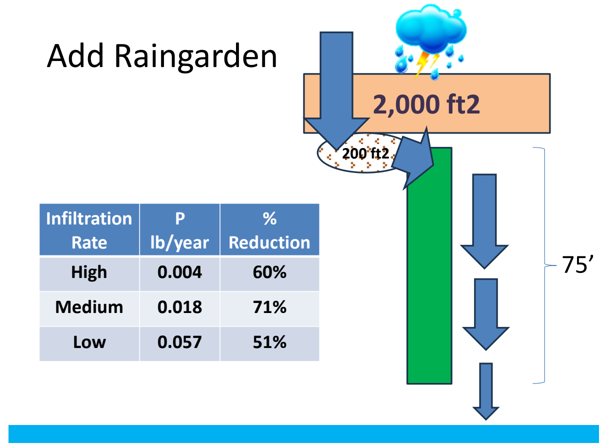


Infiltration Rate	P lb/year
High	0.010
Medium	0.063
Low	0.116

Add Raingarden



Add Raingarden



Infiltration Rate	P lb/year	% Reduction
High	0.004	60%
Medium	0.018	71%
Low	0.057	51%

Close /Summary /Discussion Ideas

- Focusing on runoff generating areas
  - Impervious surfaces
  - Other areas?
- Not a 'worst case' model
  - Assuming little sediment movement
  - Using an average annual (not highest year)
- Goal should be zero

Close /Summary /Discussion Ideas

- What's next?
  - Continuing to seek comments
  - Could revise with new information and better user guidance
  - Research ideas
    - Runoff from disturbed pervious areas
    - Saturation excess runoff
    - Site monitoring methods

Close /Summary /Discussion Ideas

- What's next?
  - Continuing to seek comments
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    - Runoff from disturbed pervious areas
    - Satur
    - Site m

Thank you!

comments & questions:
paul.mcginley @ uwsp.edu