

# A more complex Lakeshore example using all ArcNLET-Py modules

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# Contents

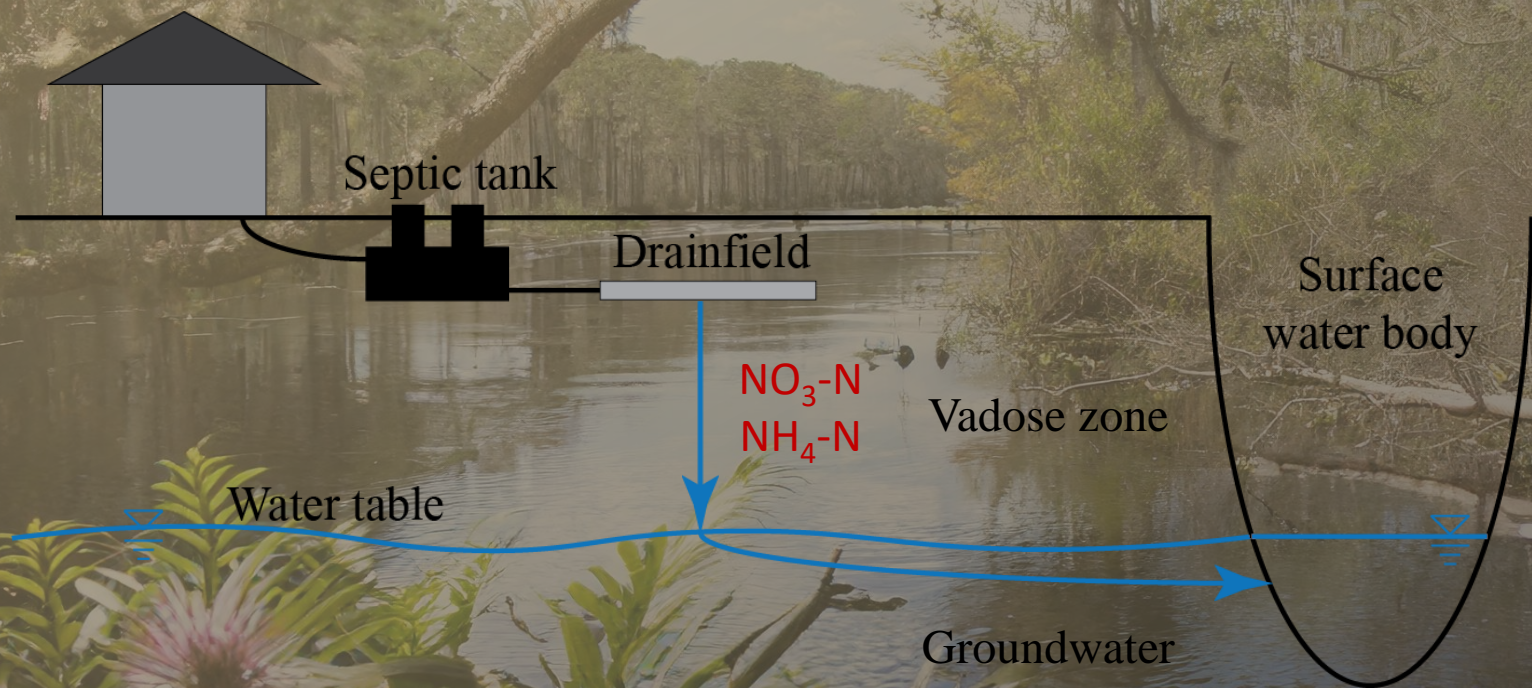
1. Introduction

2. Lakeshore example



# 1 Introduction

- A more complex Lakeshore example using all ArcNLET-Py modules



Model reactive transport of  $\text{NH}_4\text{-N}$  and  $\text{NO}_3\text{-N}$  in both vadose zone and groundwater



# 1 Introduction

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This is a complex example for advanced users

- Training videos on Youtube:

<https://www.youtube.com/@mingye9168/videos>

- Source code on GitHub and online User's manual:

<https://github.com/ArcNLET-Py/ArcNLET-Py>

- FSU Website:

<https://atmos.eoas.fsu.edu/~mye/ArcNLET/>



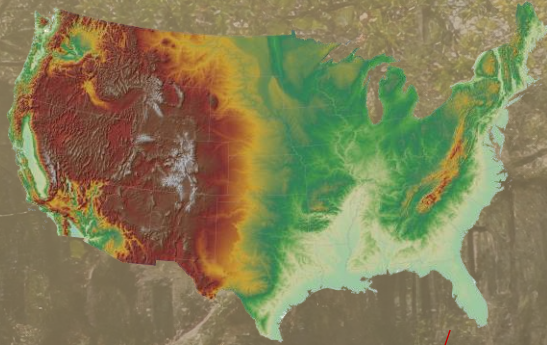


## 2. Lakeshore example

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# 2.1 Study area



265 septic tanks



## 2.2 Data prepare

- Study area — shapefile with one polygon
- DEM — raster
- Location of septic tanks — multi-point shapefile
- Waterbodies — shapefile

<https://github.com/ArcNLET-Py/ArcNLET-Py/tree/main/Examples>



All input files need to use the same projected coordinate



## 2.3 Structure of ArcNLET-Py

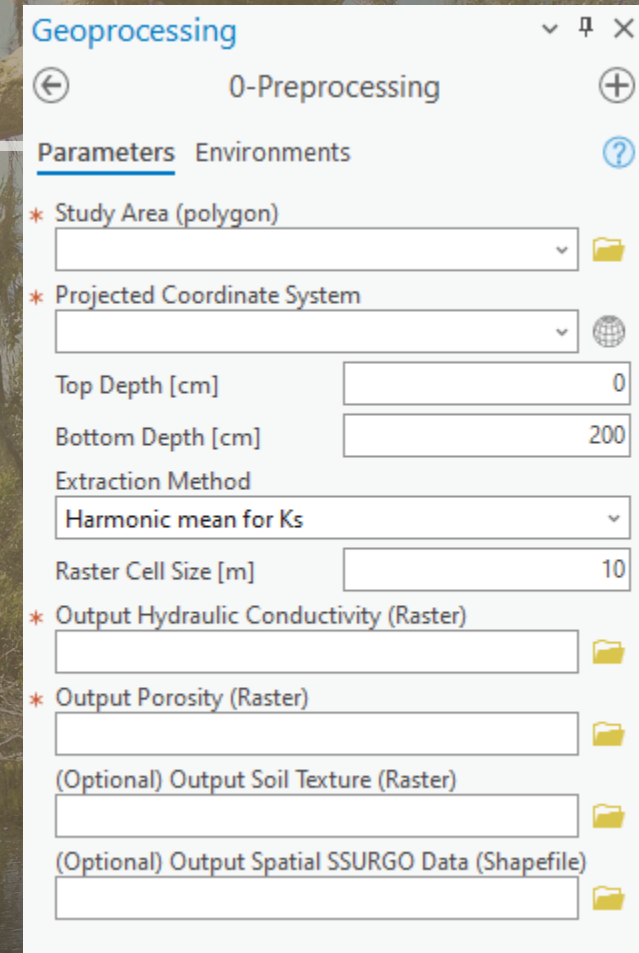
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- ArcNLET-Py modules
  - 0-Preprocessing
    - Extracts data (hydraulic conductivity, porosity, and soil types) from SSURGO database
  - 1-Groundwater Flow
    - Analyzes groundwater velocity and velocity direction based on DEM and soil data
  - 2-Particle Tracking
    - Simulates water particle movement from sources (septic tanks) to waterbodies
  - 3-VZMOD (Optional)
    - Models nitrate and ammonium concentrations in the Vadose Zone
  - 4-Transport
    - Models nitrate and ammonium plume transport in the groundwater
  - 5-Load Estimation
    - Estimates mass loading to surface waterbodies



## 2.4 Preprocessing module

- Inputs
  - Study area
- Outputs
  - Hydraulic conductivity
  - Porosity
  - Soil types



The screenshot shows the 'Geoprocessing' window with the '0-Preprocessing' tab selected. The 'Parameters' section is active, displaying a list of input and output fields. The 'Study Area (polygon)' and 'Projected Coordinate System' are marked with red asterisks, indicating required inputs. The 'Extraction Method' is set to 'Harmonic mean for Ks'. The 'Raster Cell Size [m]' is set to 10. The 'Output Hydraulic Conductivity (Raster)', 'Output Porosity (Raster)', and '(Optional) Output Soil Texture (Raster)' are marked with red asterisks. The '(Optional) Output Spatial SSURGO Data (Shapefile)' is also marked with a red asterisk. Each output field has a folder icon next to it, suggesting a file selection dialog.

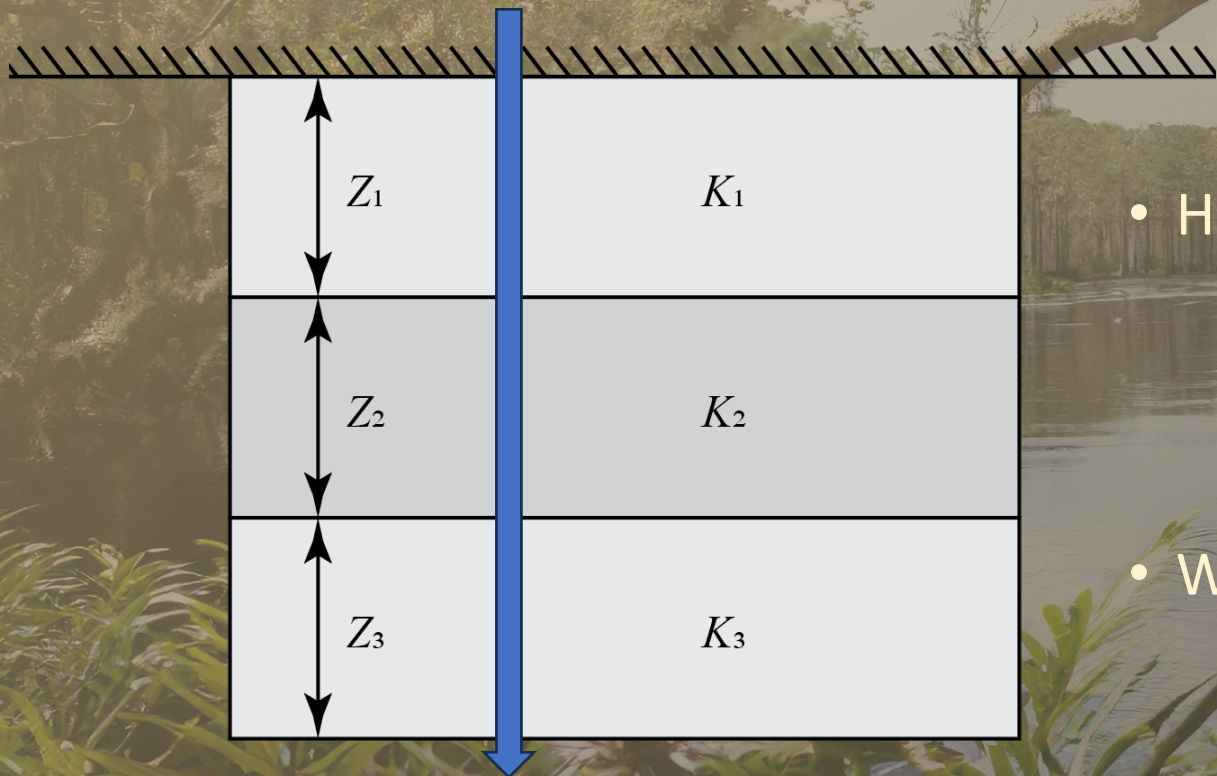
Parameter	Value
* Study Area (polygon)	[Empty field]
* Projected Coordinate System	[Empty field]
Top Depth [cm]	0
Bottom Depth [cm]	200
Extraction Method	Harmonic mean for Ks
Raster Cell Size [m]	10
* Output Hydraulic Conductivity (Raster)	[Empty field]
* Output Porosity (Raster)	[Empty field]
(Optional) Output Soil Texture (Raster)	[Empty field]
(Optional) Output Spatial SSURGO Data (Shapefile)	[Empty field]

Beaudette, D., Skovlin, J., Roecher, S., Brown, A. soilDB: soil database interface.  
<https://cran.r-project.org/web/packages/soilDB/index.html>



## 2.4 Preprocessing module

Water movement



- Harmonic mean

$$K = \frac{Z_1 + Z_2 + Z_3}{\frac{Z_1}{K_1} + \frac{Z_2}{K_2} + \frac{Z_3}{K_3}}$$

- Weighted average

$$K = \frac{Z_1 K_1 + Z_2 K_2 + Z_3 K_3}{Z_1 + Z_2 + Z_3}$$



# 2.5 Groundwater flow module

- Inputs
  - DEM,
  - Waterbodies
  - Hydraulic Conductivity
  - Porosity
- Parameters
  - Smoothing Factor
  - Z-Factor
- Outputs
  - Velocity Magnitude and Direction
  - Hydraulic Gradient
  - Smoothed DEM

Geoprocessing

1-Groundwater Flow

Parameters Environments

Input DEM [L] (raster)  
lakeshore.img

Input Water bodies (polygon)  
waterbodies

Input Hydraulic conductivity [L/T] (raster)  
hydr\_cond.img

Input Soil porosity (raster)  
porosity.img

Output Velocity Magnitude [L/T]  
demo\_vel\_mag

Output Velocity Direction [°wrt N]  
demo\_vel\_dir

(Optional) Output Smoothed DEM (VZMOD required)  
demo\_smthdem

(Optional) Output Hydraulic Gradient  
demo\_grad

Parameters

Smoothing Factor 50

Smoothing Cell 7

☐ Fill Sinks

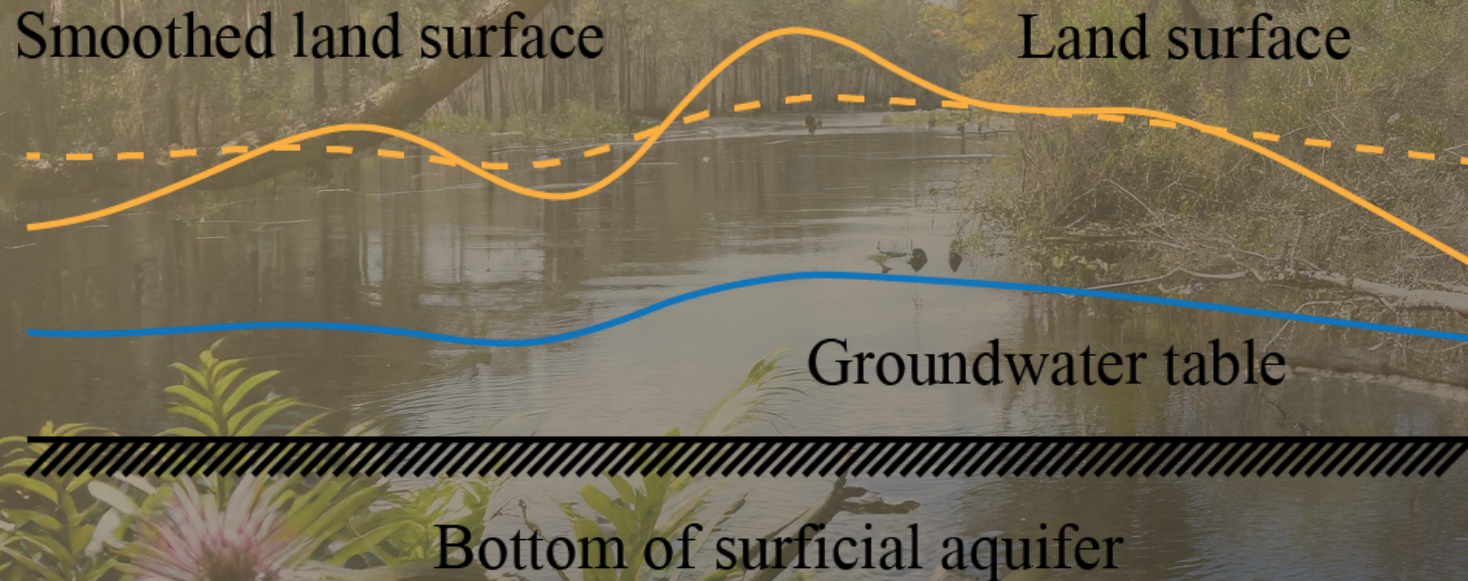
☐ Merge Waterbodies

Z-Factor 1



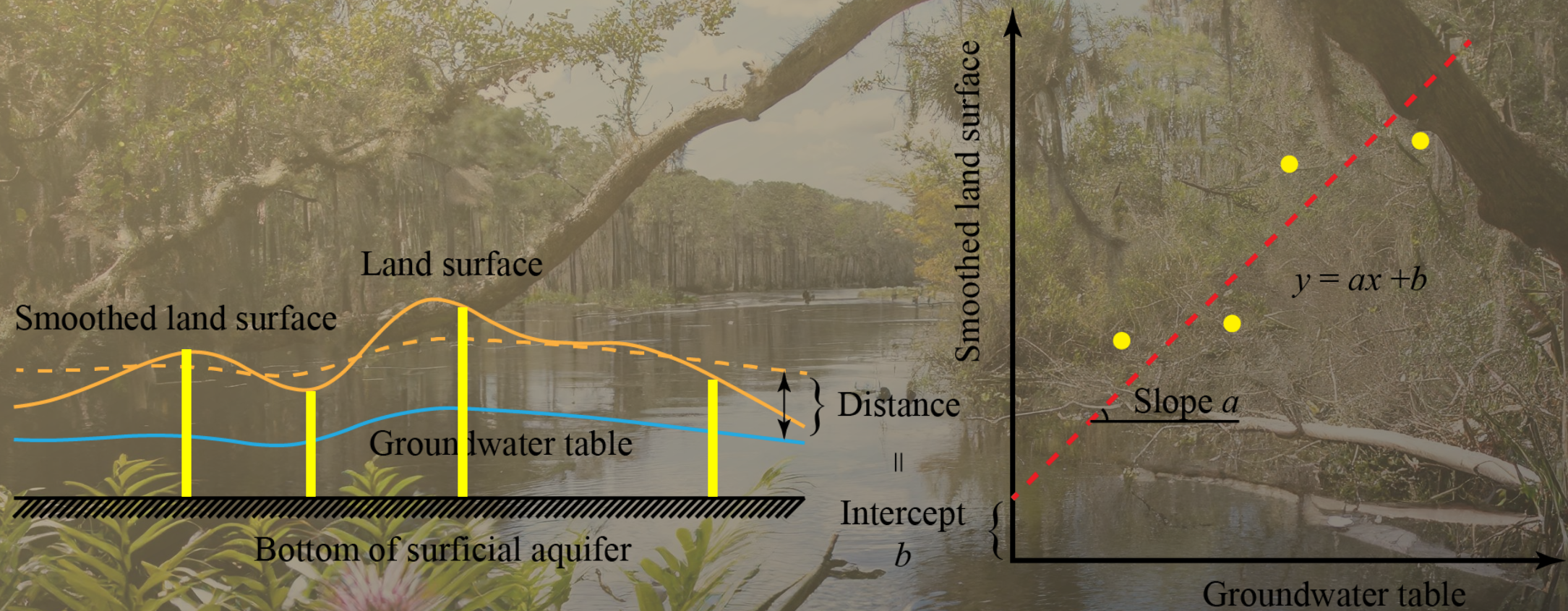
## 2.5 Groundwater flow module

How the Groundwater Flow Module Work?





## 2.5 Groundwater flow module





## 2.6 Particle Tracking module

- Inputs

- Velocity Magnitude and Direction
- Source locations
- Waterbodies
- Porosity

- Outputs

- Particle paths of potential contaminant travel routes

Geoprocessing

2 Particle Tracking

Parameters Environments

Input Source locations (point)  
PotentialSepticTankLocations

Input Water bodies (polygon)  
waterbodies

Input Velocity Magnitude [L/T] (raster)  
demo\_vel\_mag

Input Velocity Direction [°wrt N] (raster)  
demo\_vel\_dir

Input Soil porosity (raster)  
porosity.img

Output Particle Paths (Polyline)  
demo\_path

Parameters

☒ Precise truncation

WB Raster Resolution [L] 5

Step Size [L] 10

Max Steps 1000



# 2.6 Particle Tracking Module





## 2.7 VZMOD Module

- Ammonium and nitrate transport with sorption, nitrification, and denitrification in vadose zone

Geoprocessing

←

3-VZMOD (Optional)

+

Parameters

Environments

?

Single or multiple OSTDS

Single OSTDS

Soil types

Clay

Concentration of NH<sub>4</sub> (mg/L)

60

Concentration of NO<sub>3</sub> (mg/L)

1

Depth to water table (cm)

150

\* Output folder

> Hydraulic Params

> Nitrification Params

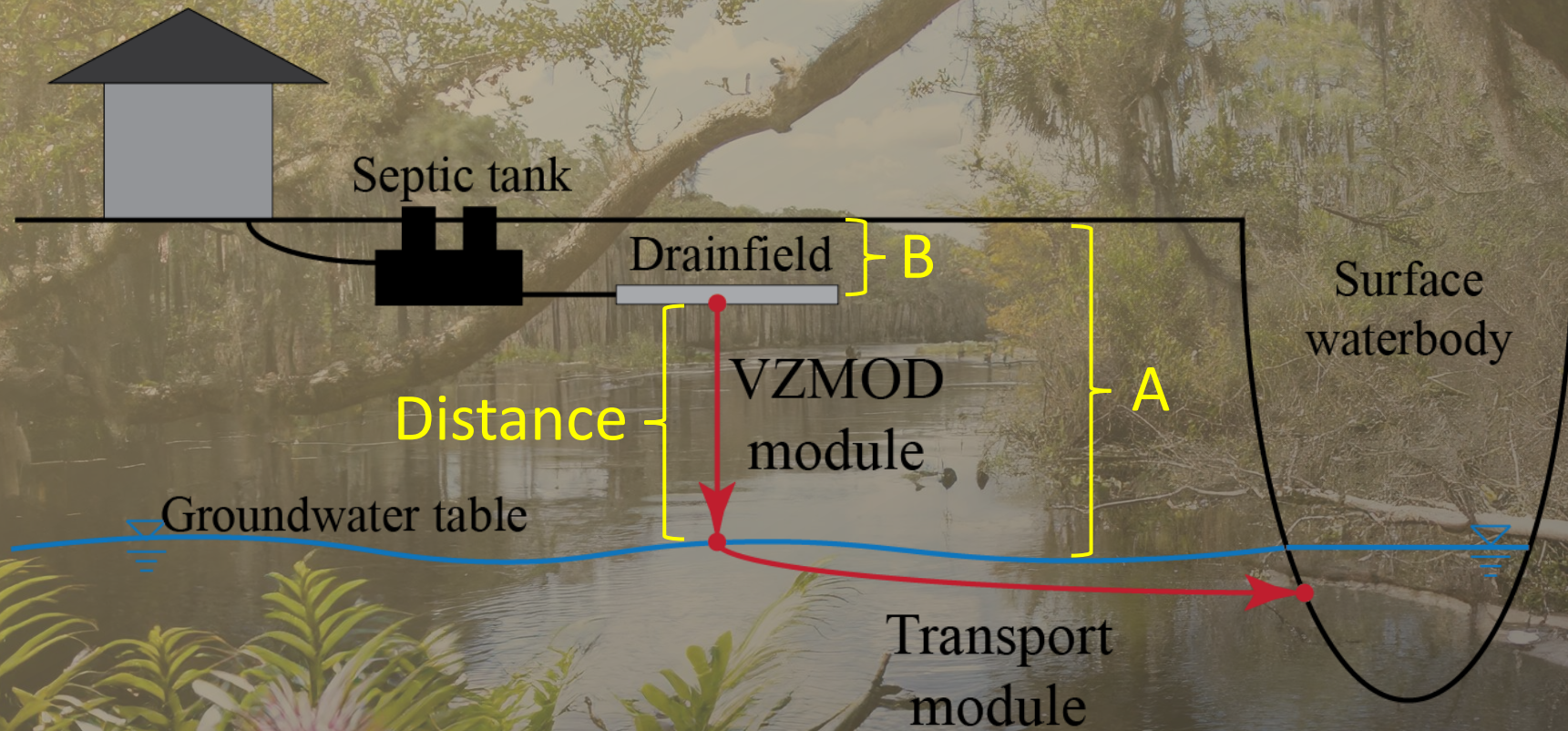
> Denitrification Params

> Adsorption Params

> Temperature and Transport Params



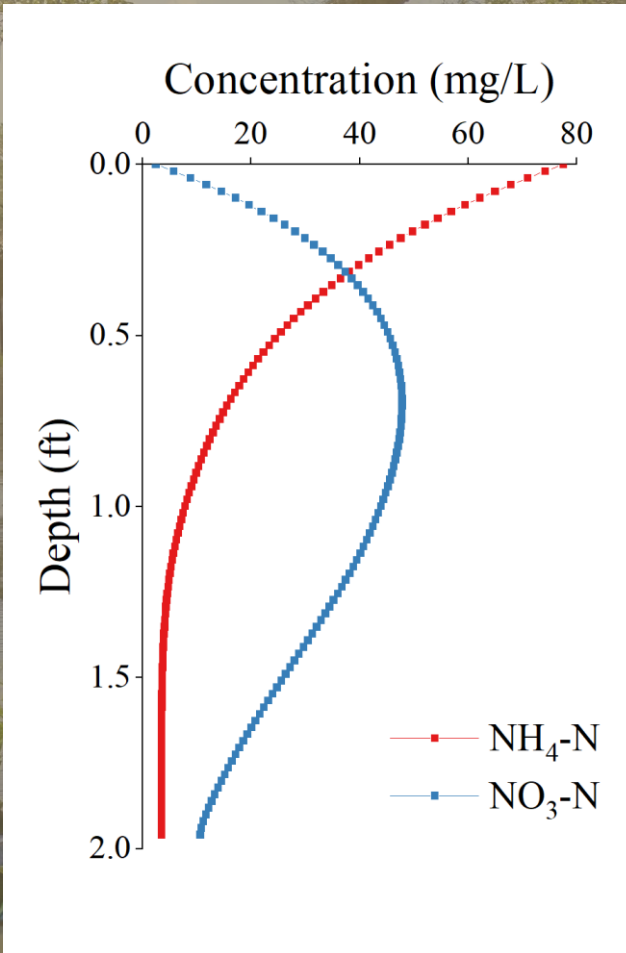
## 2.7 VZMOD Module



$$\text{Distance} = A - B$$



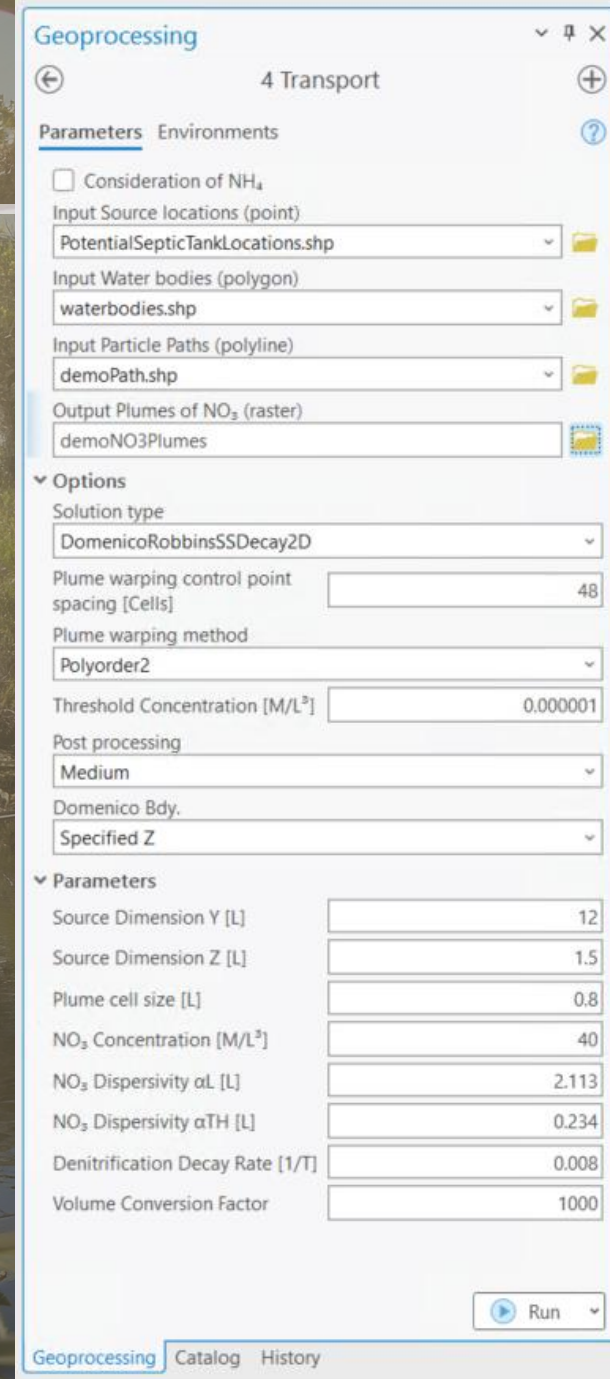
## 2.7 VZMOD Module





# 2.8 Transport Module

- Predicting nitrate and ammonium plumes in groundwater
- Inputs
  - Source locations
  - Waterbodies
  - Particle paths
- Outputs
  - Plume raster of concentration distribution
  - Plume info shapefile



**Geoprocessing** 4 Transport

Parameters Environments

☐ Consideration of NH<sub>4</sub>

Input Source locations (point)  
PotentialSepticTankLocations.shp

Input Water bodies (polygon)  
waterbodies.shp

Input Particle Paths (polyline)  
demoPath.shp

Output Plumes of NO<sub>3</sub> (raster)  
demoNO3Plumes

Options

Solution type  
DomenicoRobbinsSSDecay2D

Plume warping control point spacing [Cells]  
48

Plume warping method  
Polyorder2

Threshold Concentration [M/L<sup>3</sup>]  
0.000001

Post processing  
Medium

Domenico Bdy.  
Specified Z

Parameters

Source Dimension Y [L]	12
Source Dimension Z [L]	1.5
Plume cell size [L]	0.8
NO <sub>3</sub> Concentration [M/L <sup>3</sup> ]	40
NO <sub>3</sub> Dispersivity α <sub>L</sub> [L]	2.113
NO <sub>3</sub> Dispersivity α <sub>TH</sub> [L]	0.234
Denitrification Decay Rate [1/T]	0.008
Volume Conversion Factor	1000

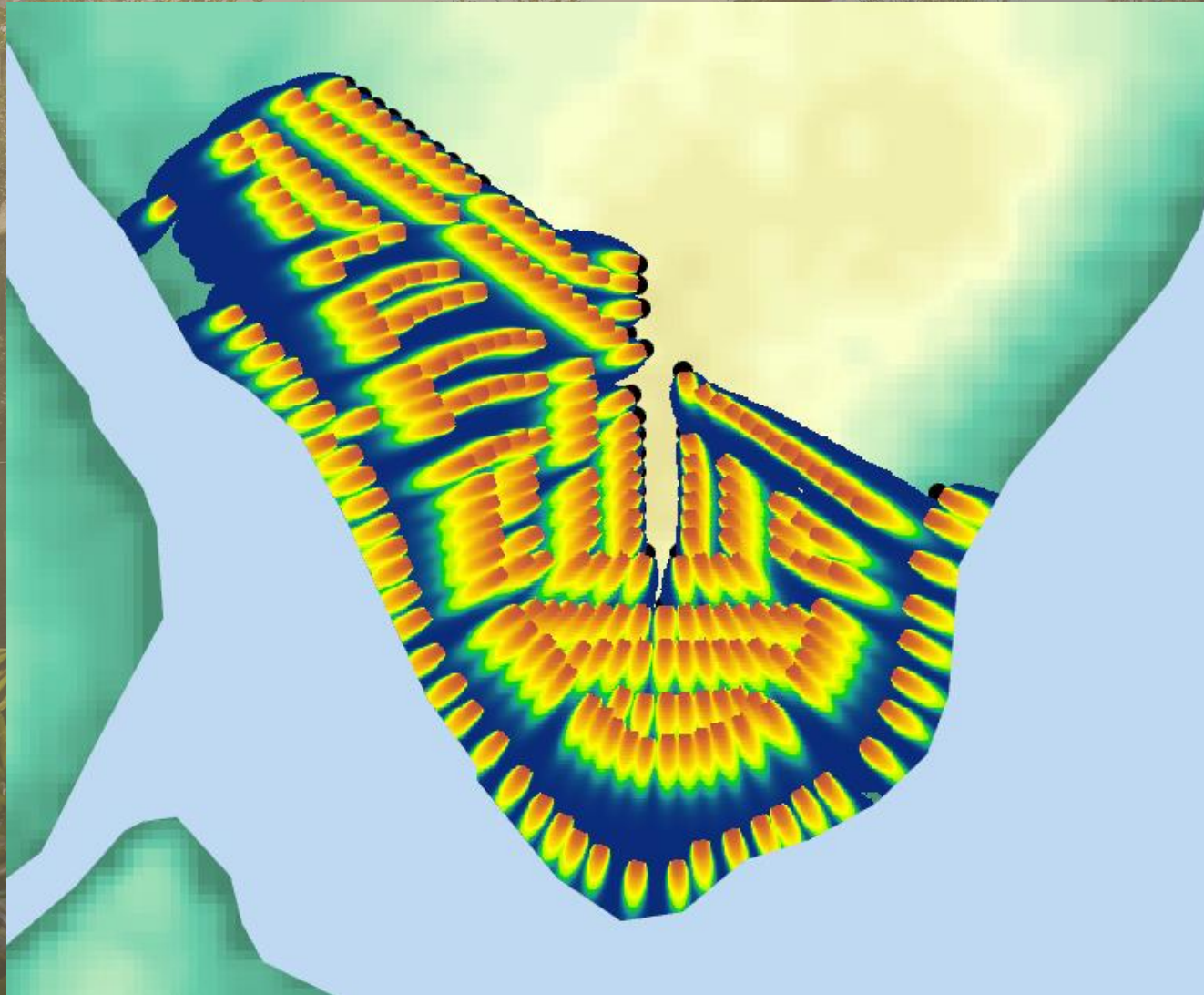
Run

Geoprocessing Catalog History



## 2.8 Transport Module

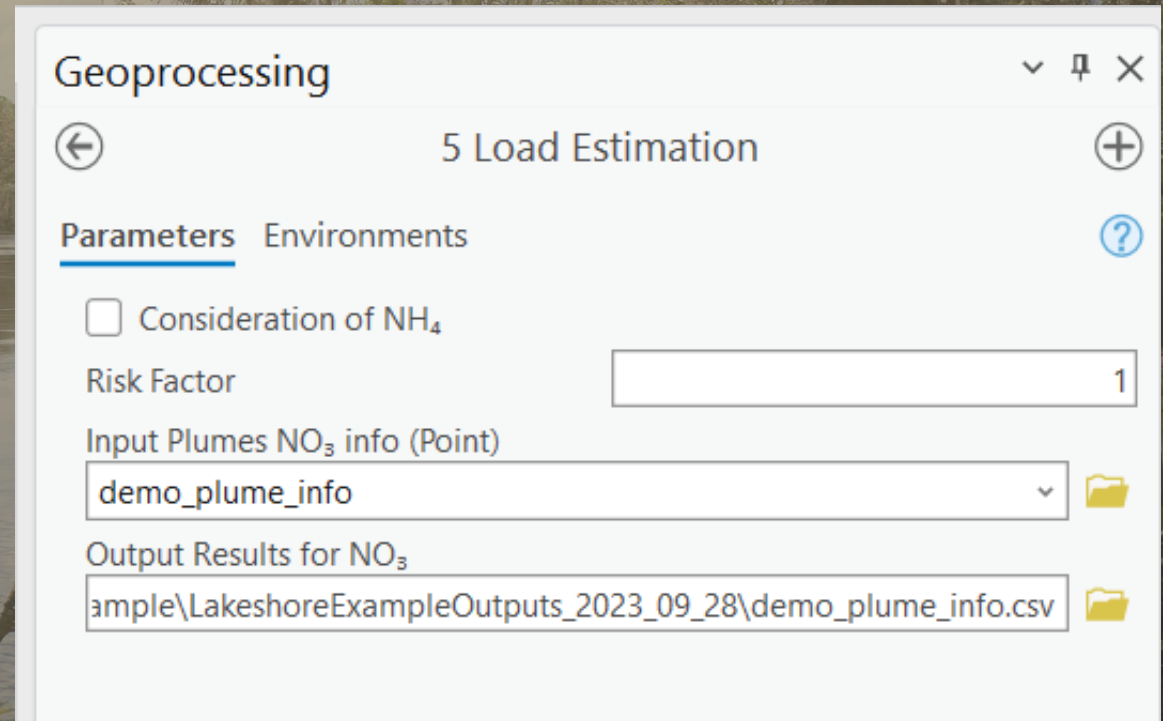
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## 2.9 Load Estimation Module

- Calculates the removal rate of nitrate and ammonium via denitrification
- Inputs
  - Plume info shapefile from the 4-Transport module
- Outputs
  - CSV
  - Mass output load
  - Mass removal rate
  - Mass input load



The screenshot shows the 'Geoprocessing' window with the tool '5 Load Estimation' selected. The 'Parameters' tab is active, showing the following settings:

- ☐ Consideration of NH<sub>4</sub>
- Risk Factor: 1
- Input Plumes NO<sub>3</sub> info (Point): demo\_plume\_info
- Output Results for NO<sub>3</sub>: sample\LakeshoreExampleOutputs\_2023\_09\_28\demo\_plume\_info.csv



A serene swampy landscape with a large tree branch arching over a body of water, surrounded by lush vegetation and Spanish moss. The scene is captured in a warm, slightly desaturated tone, giving it a vintage or artistic feel. The water is calm, reflecting the surrounding greenery and the sky. In the foreground, there are several large, green, spiky plants with purple flowers. The background shows a dense forest of trees, some with Spanish moss hanging from their branches. The overall atmosphere is peaceful and natural.

THANK YOU!