The N-EWN Knowledge Series

A Continuing Education Series about Engineering with Nature

Anthony Aufdenkampe, PhD
Senior Environmental Scientist
LimnoTech

Modern, reproducible modeling workflows for water feature design

Nature-based solutions (NBS) seek to improve water quality by leveraging natural ecological and biogeochemical processes, but the interplay between these processes, especially in moving water, is challenging to anticipate. When high confidence in outcomes is needed, stakeholders often turn to numerical modeling. However, most existing water simulation tools are outdated and based on empirical relationships rather than modern, process-based simulations.

Recognizing this gap, federal agencies are promoting a vision for reproducible, process-based modeling workflows. This webinar will present this federal vision and describe LimnoTech's related work, including the development of the new ClearWater (Corps Library for Environmental Analysis and Restoration of Watersheds) modeling system. It will also cover the application of the MF6RTM package, which couples groundwater transport with geochemical reaction models for contaminant mobility in Aquifer Storage and Recovery (ASR) planning, and the use of GLM-AED libraries to assess design scenarios for the biofiltration of constructed lakes.

Save the date!
Upcoming webinars will take place the 3rd Thursday of the month.

Apr. 16
12:30pm ET

Dr. Anthony Aufdenkampe, LimnoTech
Modern, reproducible modeling workflows for water feature design

May 21
12:30pm ET

Sarah Copertino, US Army Corps of Engineers
EWN Compass: Implementation Toolbox for Natural and Nature-Based Features

Jun. 18
12:30pm ET

Dr. Mike Beck and Dr. Borja Reguero, UC Santa Cruz
Topic: TBA

Register here: https://bit.ly/3gR9ADL or scan:

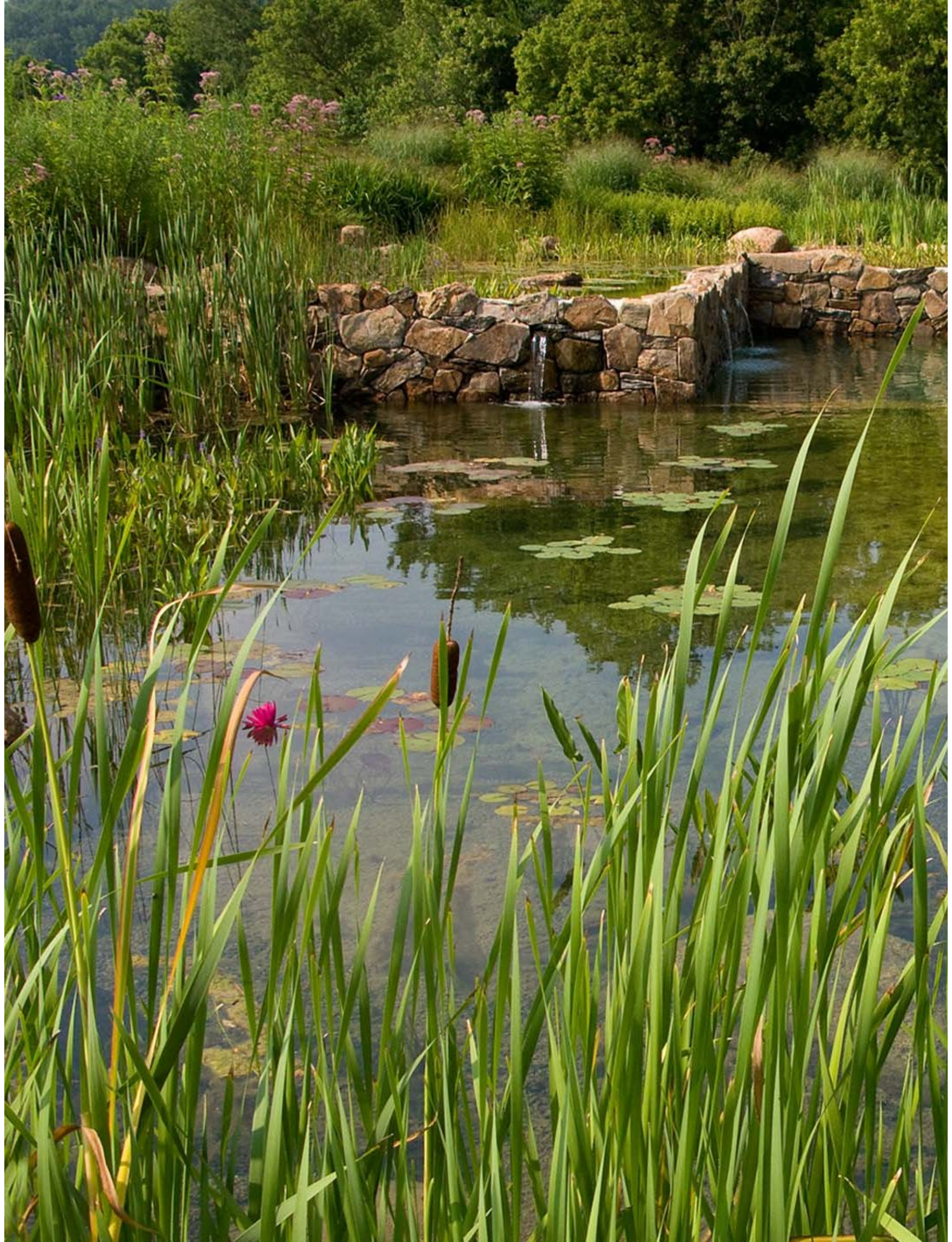
1 Continuing Education Credit (CEC) is available to attendees

Recorded webinars will be posted online at: https://n-ewn.org/resources/n-ewn-knowledge-seminars/

Presented by:

NETWORK FOR ENGINEERING WITH NATURE · LimnoTech (Water | Environment | Scientists | Engineers) · UNIVERSITY OF GEORGIA · ERDC

Questions? Please contact:
Alex Curwin, LimnoTech
acurwin@limno.com



MODERN, REPRODUCIBLE MODELING WORKFLOWS FOR WATER FEATURE DESIGN

The N-EWN Knowledge Series, April 16, 2026

Anthony Aufdenkampe, Ph.D.

LimnoTech

OUR LONG-USED MODELS FALL SHORT

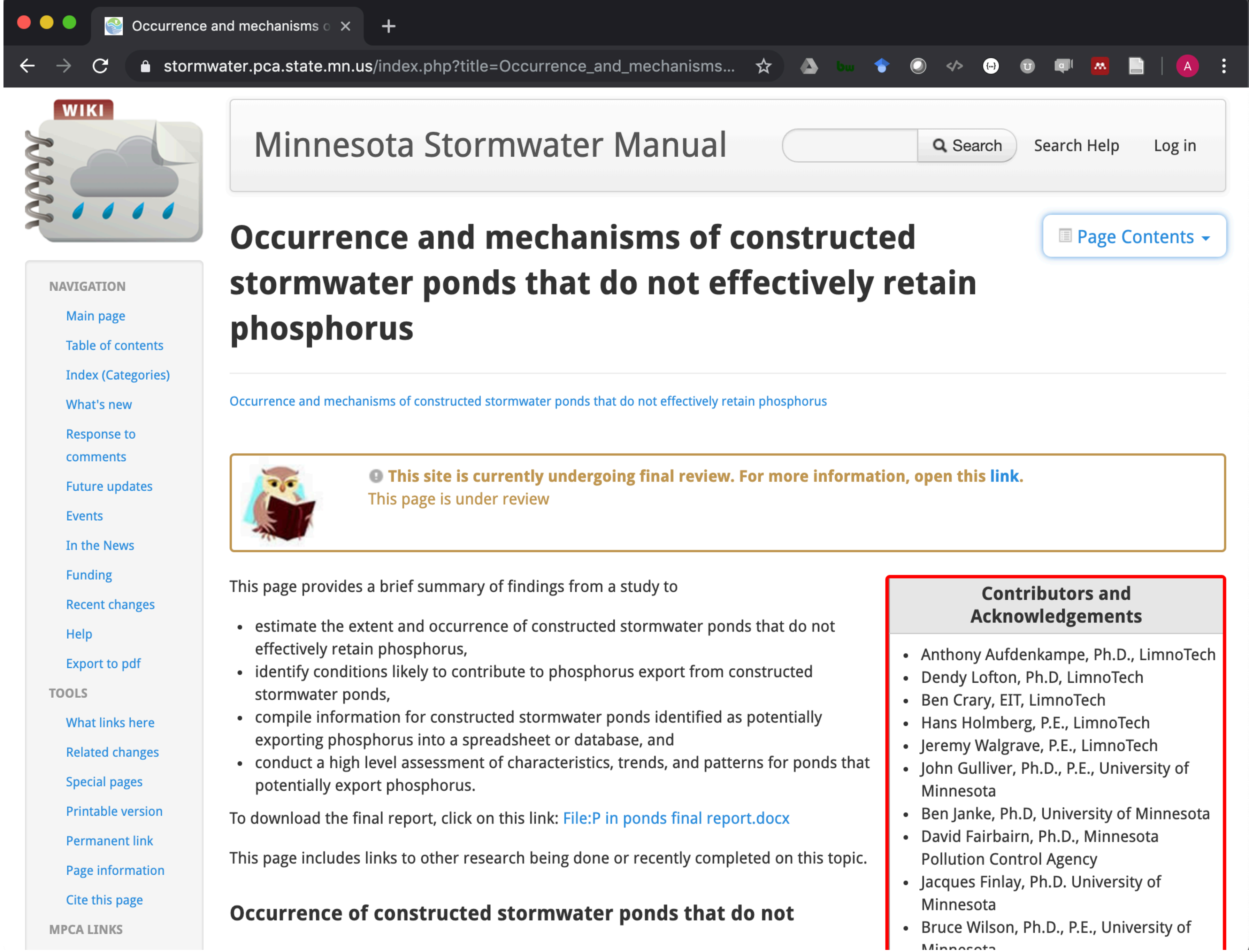
Models need to simulate:

- all relevant processes
- at relevant scales
- at sufficient spatial and temporal resolultion

…to provide results that are meaningful for adaptive water management

DO PONDS EXPORT PHOSPHORUS?

- **Literature and Data Review for Minnesota Pollution Control Agency (MPCA)**



Occurrence and mechanisms o ×

stormwater.pca.state.mn.us/index.php?title=Occurrence_and_mechanisms...

WIKI

Minnesota Stormwater Manual

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NAVIGATION

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TOOLS

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MPCA LINKS

Page Contents

Occurrence and mechanisms of constructed stormwater ponds that do not effectively retain phosphorus

Occurrence and mechanisms of constructed stormwater ponds that do not effectively retain phosphorus

This site is currently undergoing final review. For more information, open this link.
This page is under review

This page provides a brief summary of findings from a study to

- estimate the extent and occurrence of constructed stormwater ponds that do not effectively retain phosphorus,
- identify conditions likely to contribute to phosphorus export from constructed stormwater ponds,
- compile information for constructed stormwater ponds identified as potentially exporting phosphorus into a spreadsheet or database, and
- conduct a high level assessment of characteristics, trends, and patterns for ponds that potentially export phosphorus.

To download the final report, click on this link: File:P in ponds final report.docx

This page includes links to other research being done or recently completed on this topic.

Contributors and Acknowledgements

- Anthony Aufdenkampe, Ph.D., LimnoTech
- Dendy Lofton, Ph.D, LimnoTech
- Ben Crary, EIT, LimnoTech
- Hans Holmberg, P.E., LimnoTech
- Jeremy Walgrave, P.E., LimnoTech
- John Gulliver, Ph.D., P.E., University of Minnesota
- Ben Janke, Ph.D, University of Minnesota
- David Fairbairn, Ph.D., Minnesota Pollution Control Agency
- Jacques Finlay, Ph.D. University of Minnesota
- Bruce Wilson, Ph.D., P.E., University of

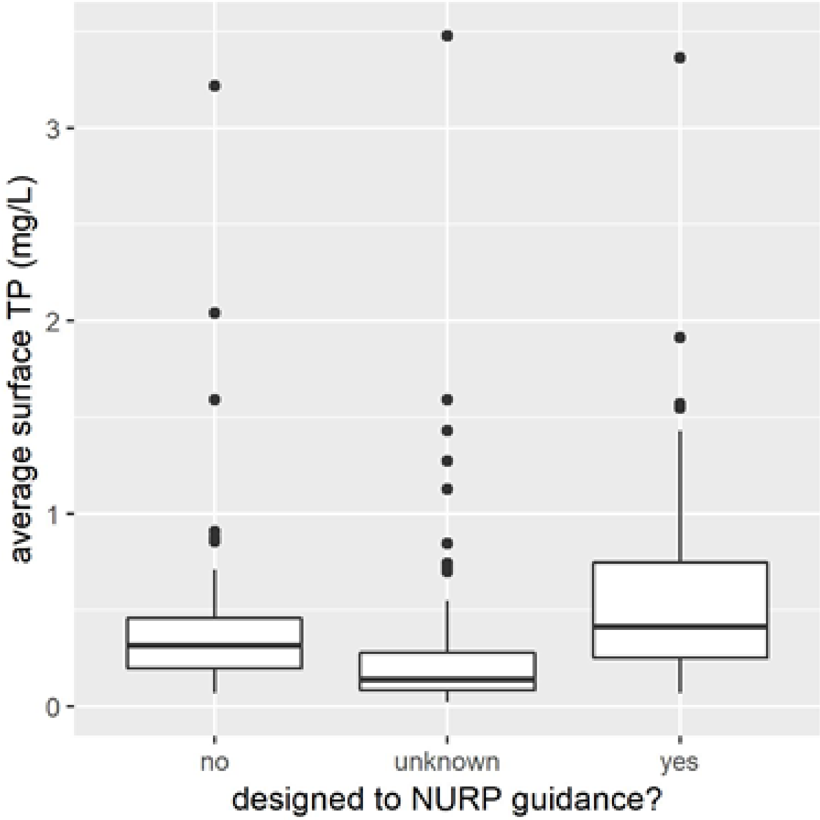
Occurrence of constructed stormwater ponds that do not

DO PONDS EXPORT PHOSPHORUS?

- **Literature and Data Review for Minnesota Pollution Control Agency (MPCA)**

- Many ponds do have high Total Phosphorus (TP) in surface waters.
- 13% of ponds have higher effluent than influent concentrations
- Most studies do not have sufficient data to answer the question.
- TP is often higher in ponds designed to "NURP standards"
  – EPA's Nationwide Urban Runoff Program (NURP), 1983

Number of Ponds	66
Median Number of Samples	8
Median % paired [Effluent TP] > [Influent TP]	13% (0% - 100%)
Ponds with at least one paired [Effluent TP] > [Influent TP]	46



POND DESIGN

Constructed stormwater pond design, retrofit, and maintenance criteria need to be updated.

Current criteria:

- Are based on performance curves developed 36 years ago by modeling single-storm data
- Consider only physical mechanisms for Phosphorus removal

Minnesota Stormwater Manual | Search | Search Help | Log in

MIDS Calculator stormwater pond design level criteria related to pond volume

Main Page > Special:Search > MIDS Calculator stormwater pond design level criteria related to pond volume

MIDS Calculator stormwater pond design level criteria related to pond volume

Link to this table

MIDS Stormwater Pond Design Level[1]	Permanent Pool Volume (V_{pp}), ft^3	Water Quality Volume (V_{wq}), ft^3	Pollutant reduction (%)[2]			
			TSS	TP	PP	DP
Design Level 1	≥ 1,800 ft^3 per acre of tributary area	<= 1 inch from impervious area	60	34	62	0
Design Level 2		<= 1 inch from impervious area	84	50	84	8
Design Level 3		<= 1.5 inch from impervious area	90	60	90	23

Under the MPCA Permit, it is REQUIRED that:

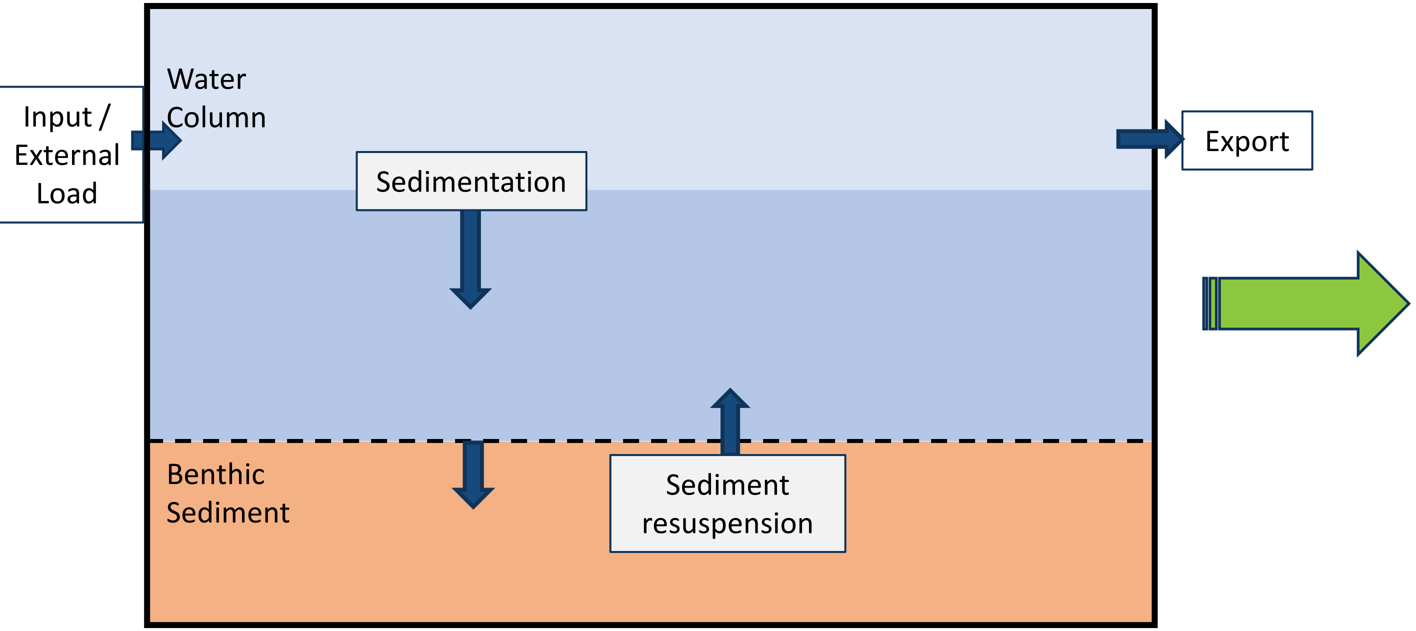
- stormwater ponds have permanent pool volume (dead storage) equal to at least 1800 cubic feet per acre of drainage to the pond.
- permanent pool depths be a minimum of 3 feet and maximum of 10 feet at the deepest points.

BASIS FOR POND DESIGN SINCE 1987

From Walker 1987 based on EPA NURP datasets

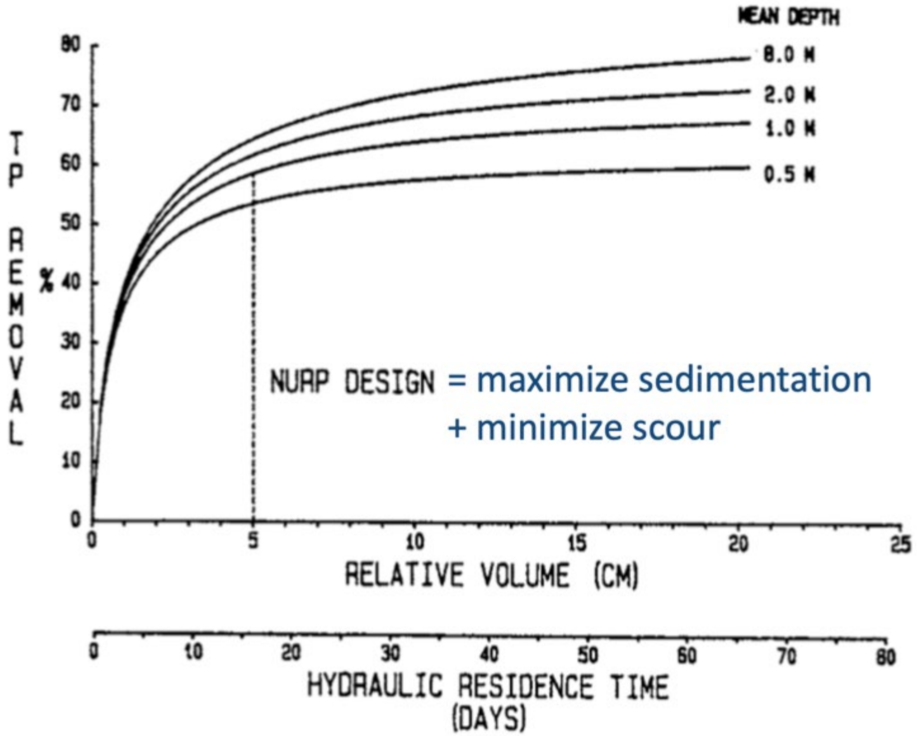
Synthesize knowledge

- Model known mechanisms.
- Calibrate & validate with real-world data.



Apply understanding (wisdom)

- Relate results of interest to controllable design parameters

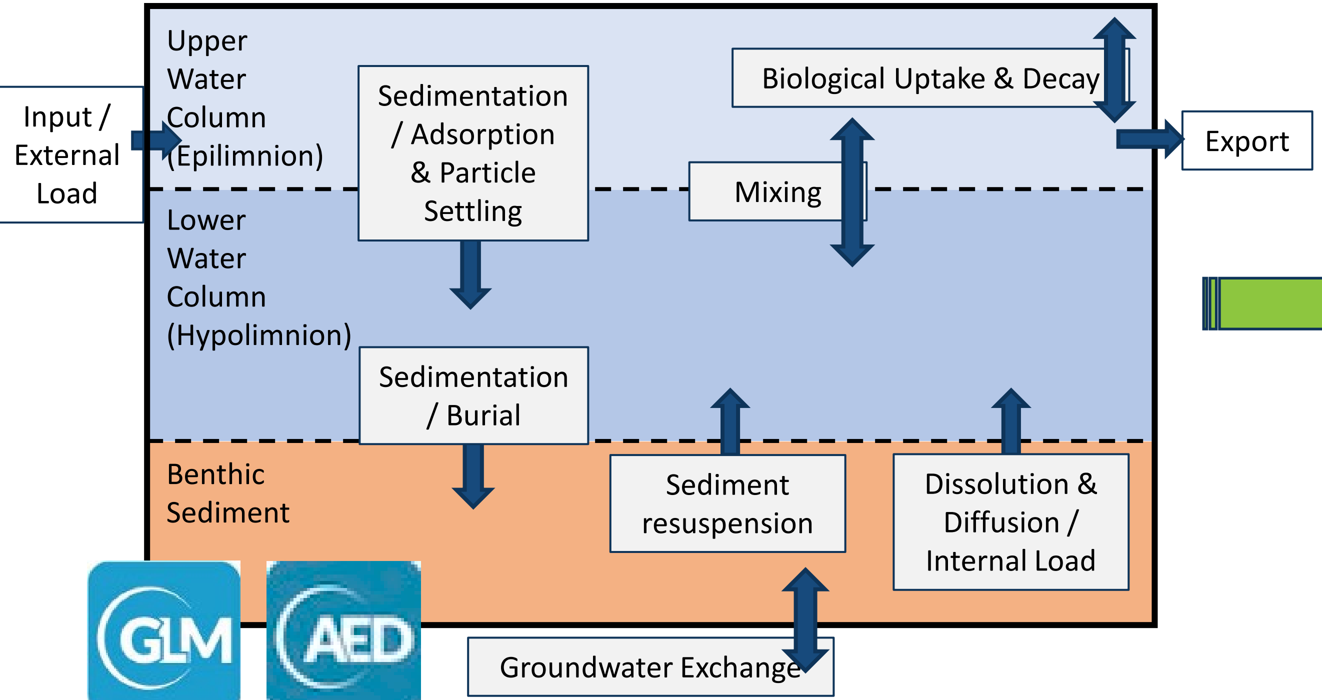


BASIS FOR POND DESIGN OF THE FUTURE

Proposed by our team

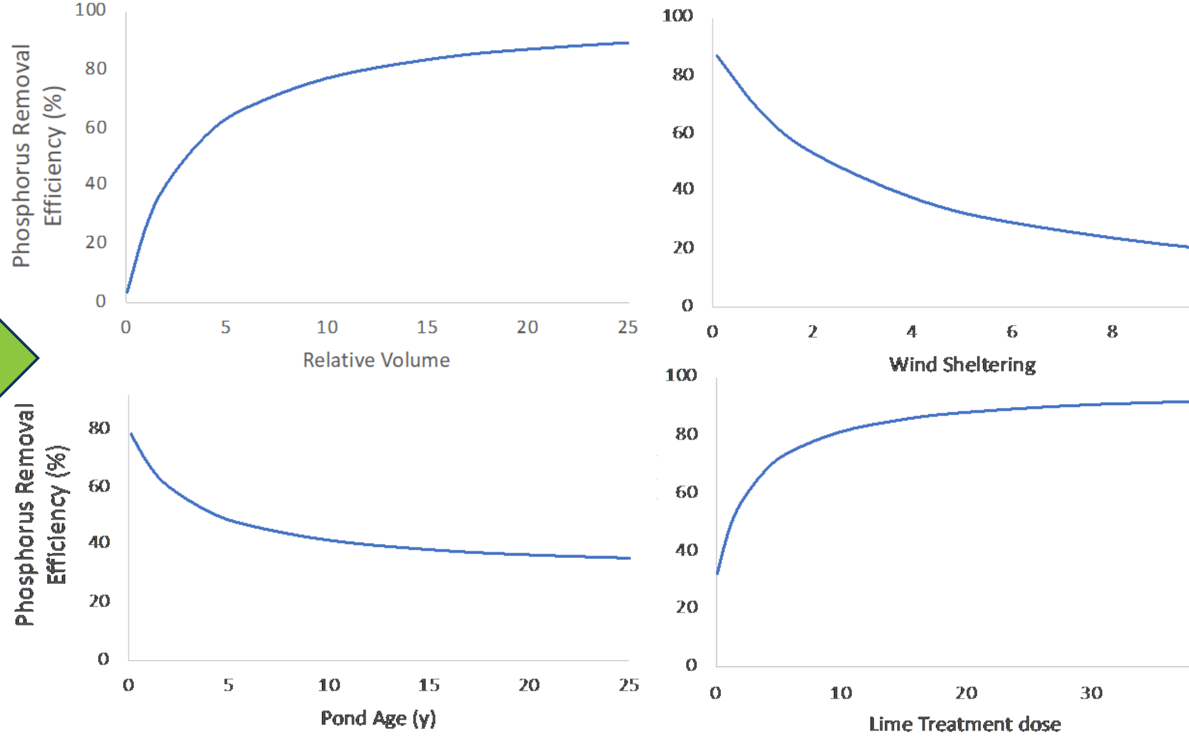
Synthesize knowledge

- Model known mechanisms: physical + biological + chemical
- Calibrate & validate with real-world data, collected for years



Apply understanding (wisdom)

- Relate results of interest to controllable design parameters and maintenance practices, which might include…



+ Other Objectives: rate control, flood protection, removal of other contaminants

FEDERAL WATER MODELING VISION

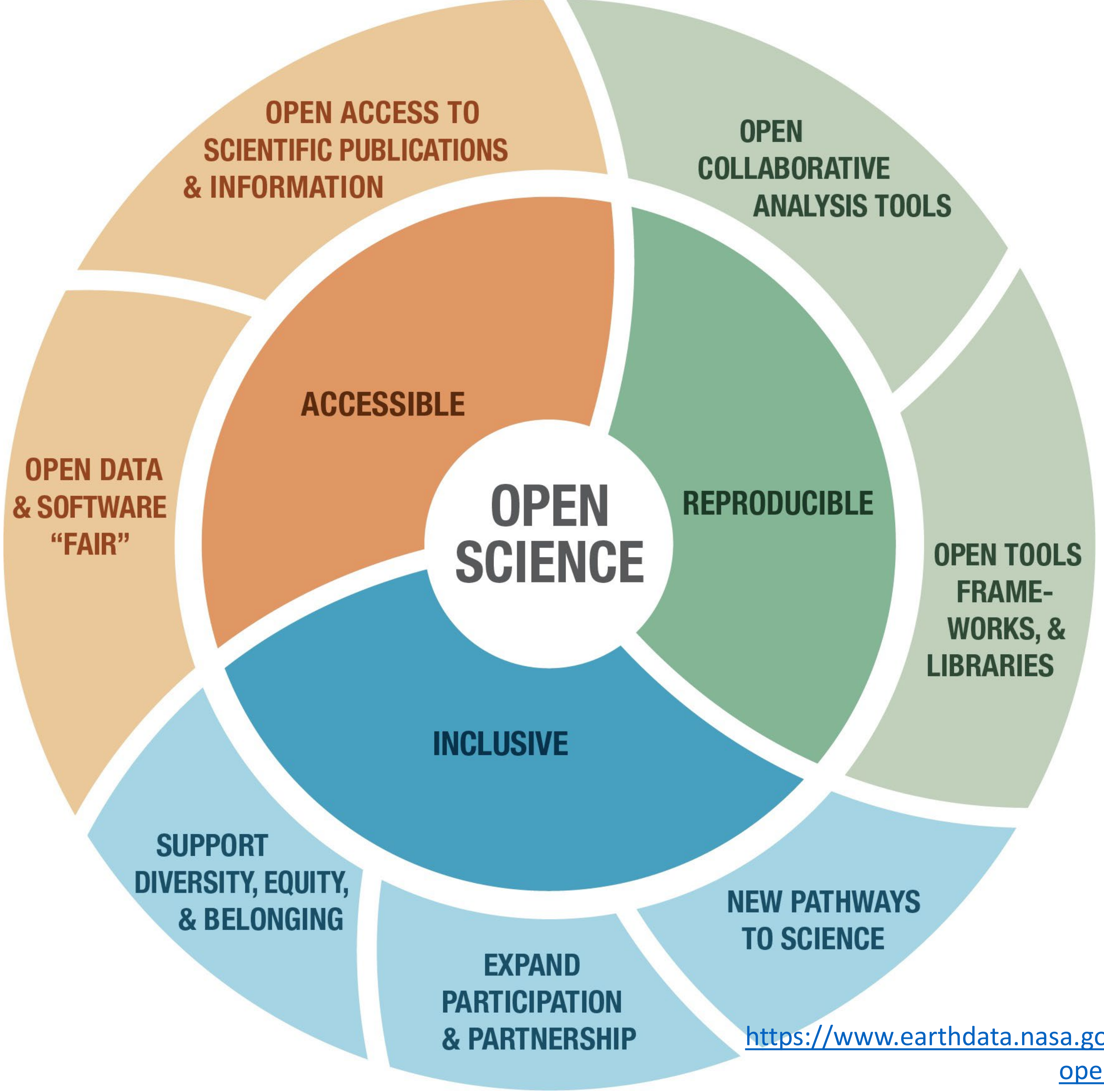
To improve earth system simulation forecast accuracy (”skill), uncertainty estimation, and credibility to meet societal needs

REPRODUCIBLE SCIENCE

The ability to obtain consistent results using the same input data, computational steps, and methods as an original study

“Reproducibility Crisis” identified in early 2010s led to the **Credibility Revolution**

- Documentation
- Data availability
- Automation
- Open-source tools



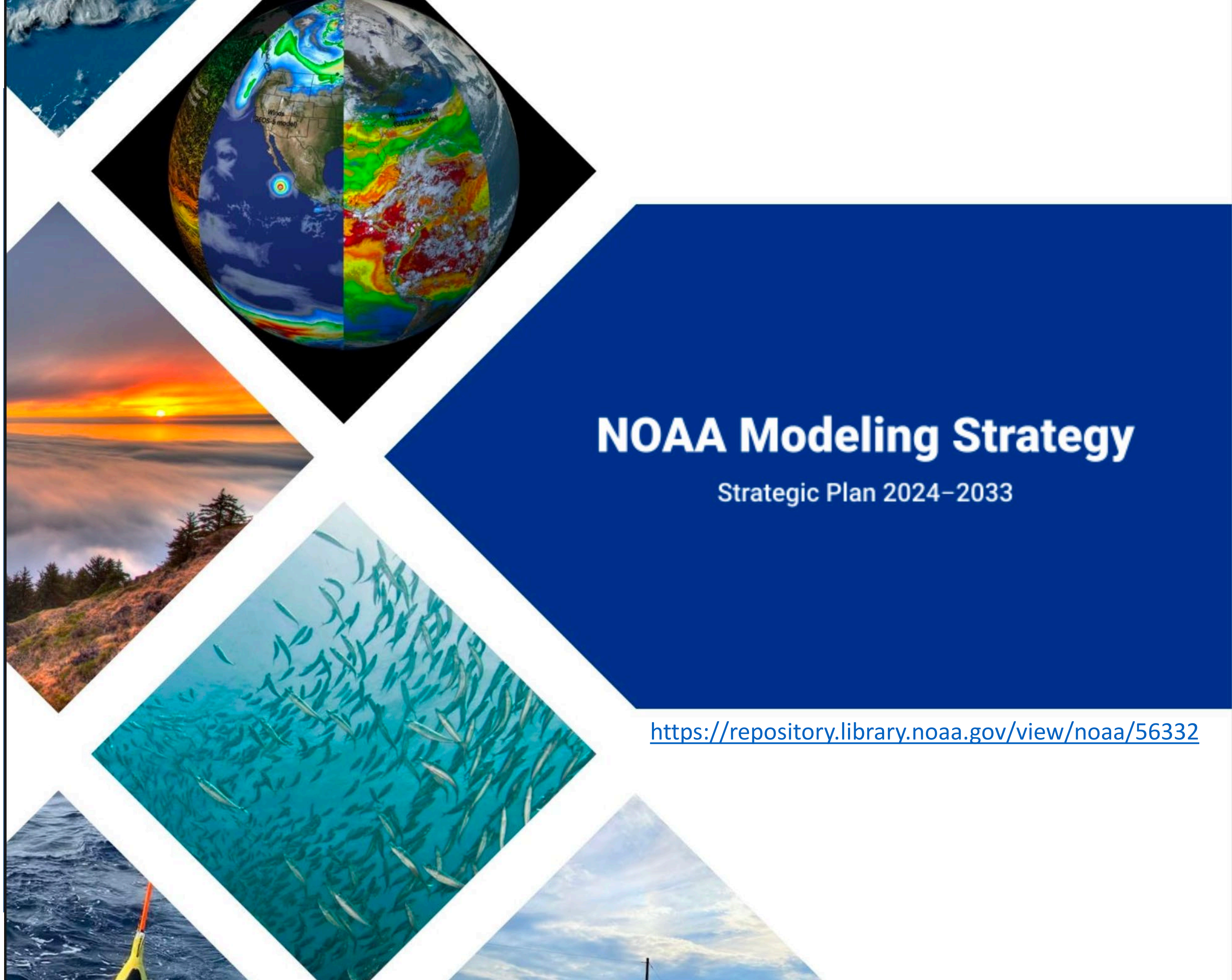
https://www.earthdata.nasa.gov/about/open-science

NOAA MODELING STRATEGY

Strategic Plan for 2024-2033

Adopted a Unified Approach to NOAA's full Earth System Modeling (ESM) portfolio

- Motivation: Provide better predictions through:
    - Open-science,
    - Model-driven observations,
    - Community development and governance,
    - Software modernization
    - Coupled process models



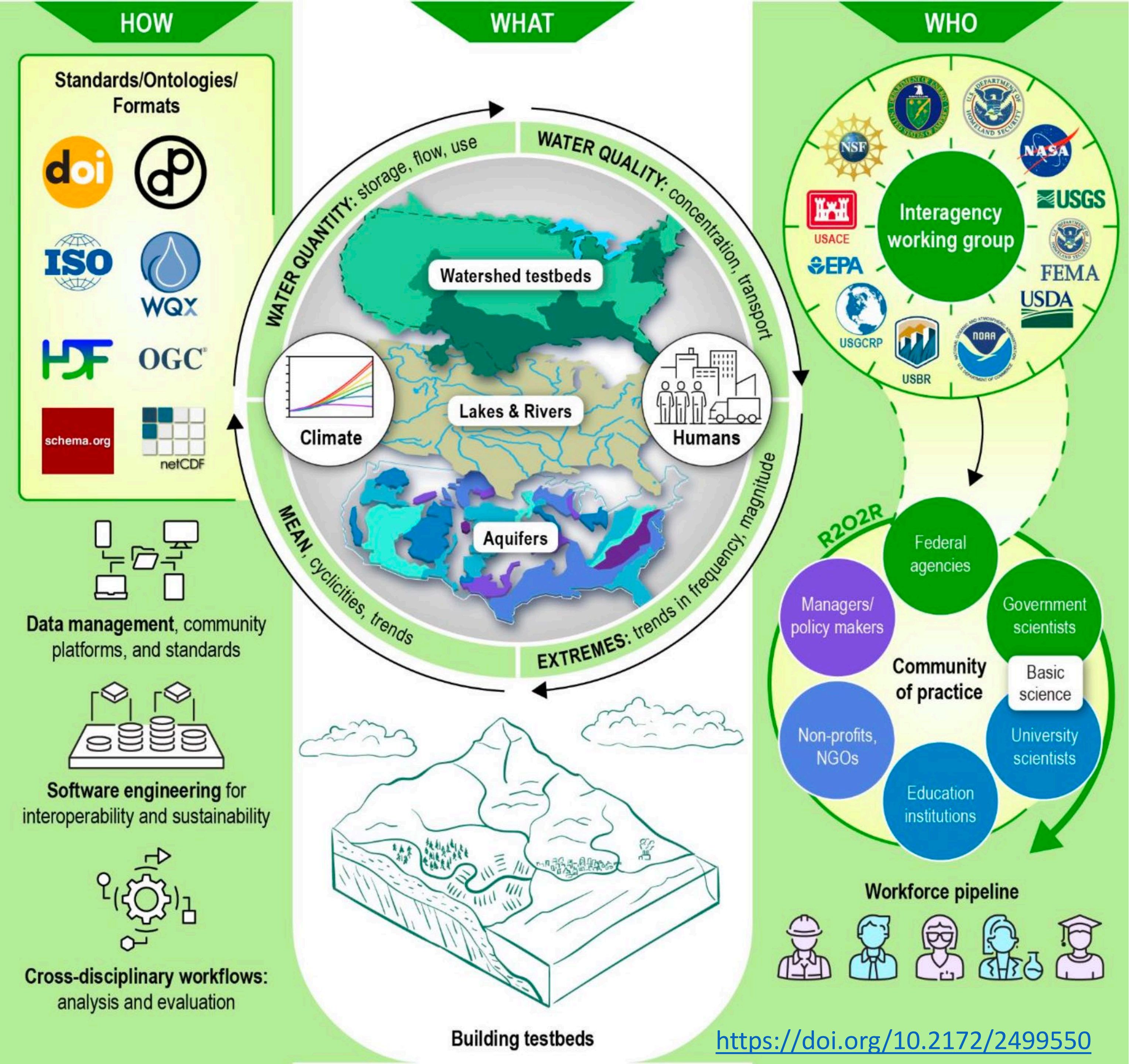
https://repository.library.noaa.gov/view/noaa/56332

FEDERAL WATER MODELING VISION

Integrated Hydro-Terrestrial Modeling 2.0 (2025)

Progress and Path Forward on Building a National Capability

- Motivation:
  Provide better prediction of likely outcomes of water management strategies
- Audience:
  Water-Resources Management Community in all sectors



https://doi.org/10.2172/2499550

FEDERAL WATER MODELING VISION

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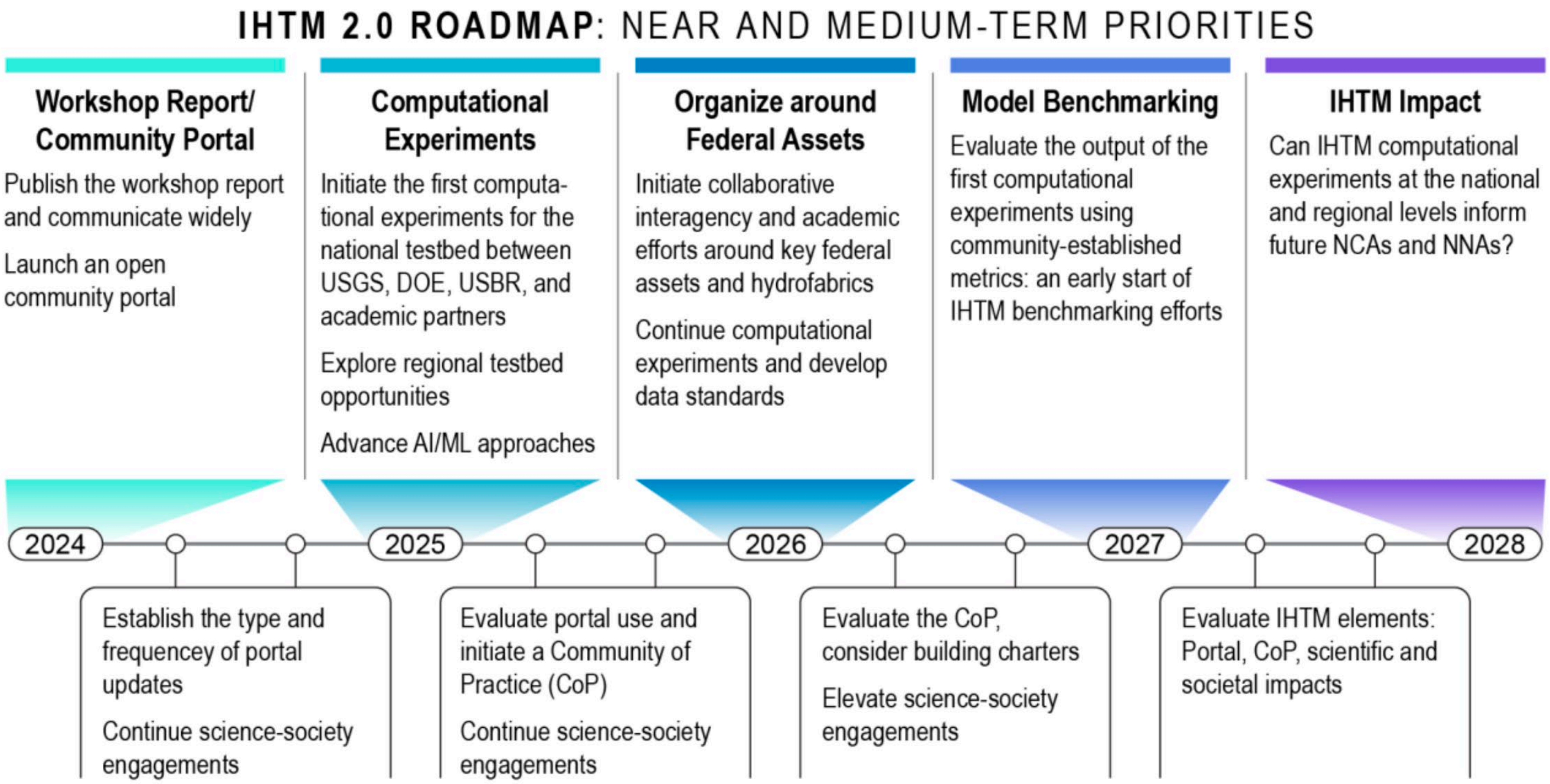
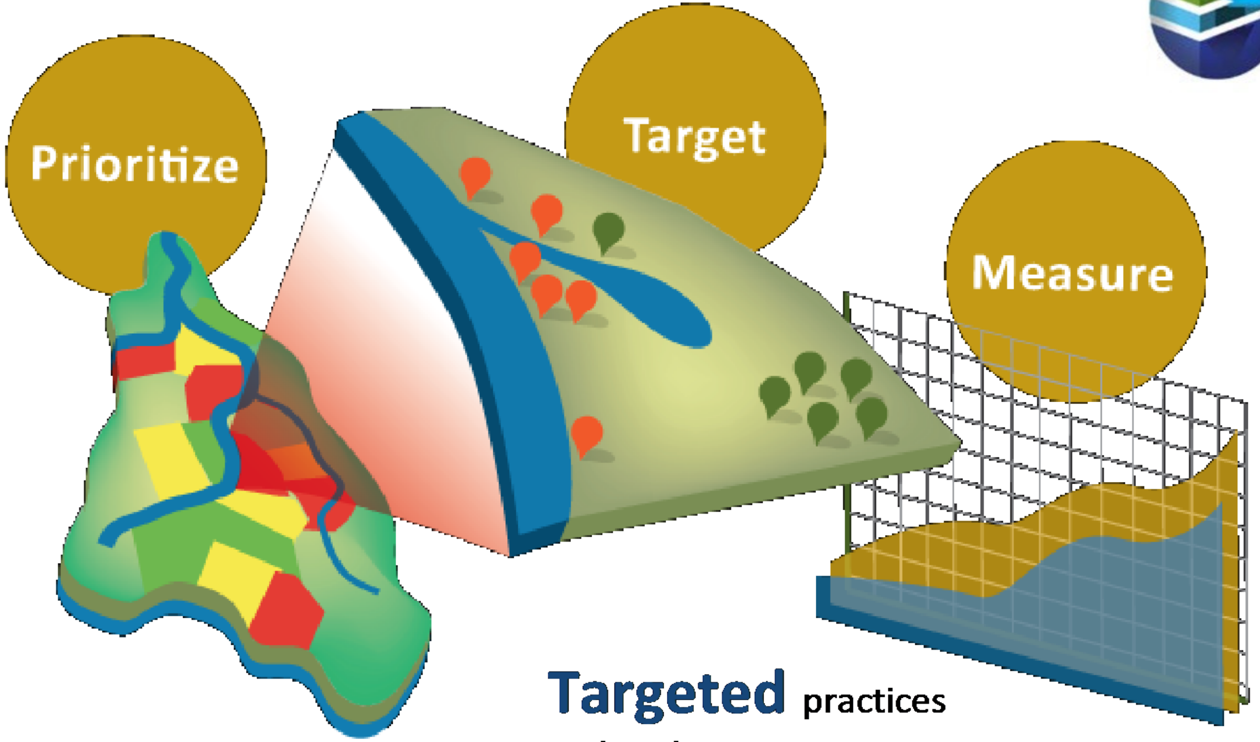


https://doi.org/10.2172/2499550

MODELING FOR MANAGEMENT

- **Watershed-scale hydrologic, hydraulic, and water quality modeling systems:**
  - Best done by local experts and stakeholders
  - Used for critical decision making
  - Undergoing transformative software modernization for scalable high-performance computing



Prioritized areas to focus where implementation matters most.

Targeted practices within the priority areas provide direction for on-the-ground action based on sound science.

One Watershed One Plan

Minnesota Board of Water & Soil Resources

Measurable results that can show the pace of progress towards the identified goals.

USGS INTEGRATED WATER PREDICTION

- Water Data for the Nation
- Modernizing Modeling Software

FAIR DATA PRINCIPLES

- **FAIR Data are foundational for Open Science**
- **Open Geospatial Consortium (OGC) provides international governance of standards for search and access**
- **Analysis-Ready, Cloud-Optimized (ARCO) datasets are the gold standard for Interoperable**

Data and metadata must be easy to find. They should be assigned a globally unique and persistent identifier (e.g., DOI), described with rich metadata, and registered in a searchable repository.

Once found, users need to know how to access the data. This involves using authorized, standard communication protocols (e.g., HTTP) and keeping metadata accessible even if the data itself is unavailable.

Data should be able to work with other systems, applications, or workflows. This requires using a formal, accessible, and shared language (e.g., controlled vocabularies) for knowledge representation.

The ultimate goal, data should be well-documented (provenance) with clear, accessible, and licensed usage rights to allow for replication or new research.

https://www.go-fair.org/fair-principles/

api.waterdata.usgs.gov

An official website of the United States government Here's how you know

USGS science for a changing world

Water Data APIs | Documentation | Water Data Home | Connect | Get an API Key

USGS Water Data APIs

This site is the home for modernized access to USGS water data in machine-readable formats via REST APIs, a common type of web service programs use to search and download data. These services provide USGS water data, ranging from continuous measurements of streamflow to information about individual USGS sites and more. The links below lead to documentation for how to use each service, and web forms to build queries for each endpoint.

Continuous Values

This API provides the most recent real-time measurements of streamflow, gage height, and hundreds of other parameters for USGS monitoring locations.

Daily Values

Interested in historical summarized daily data about our nation's streams, lakes and wells? This API provides a wealth of historical water data. Daily data is available for USGS water monitoring locations include mean, median, maximum, minimum, and/or other derived values.

Monitoring Locations

Location information is basic information about the monitoring location including the name, identifier, agency responsible for data collection, and the date the location was established. It also includes information about the type of location, such as stream, lake, or groundwater, and geographic information about the location, such

Time Series Metadata

Daily data and continuous measurements are grouped into time series, which represent a collection of observations of a single parameter, potentially aggregated using a standard statistic, at a single monitoring location. This endpoint provides metadata about those time series, including their operational thresholds, units of measurement,

USGS Water APIs

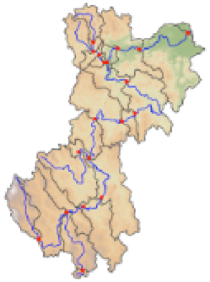
Modernized API access to the USGS Water Resources Mission Area's hydro-network linked navigation services, processing functionality, and spatio-temporal data.

Questions? Contact us: mdmf@usgs.gov

The Hydro-Network Linked Data Index

Network Navigation and Linked Data Discovery

The Hydro Network Linked Data Index (NLDI) puts a restful application programming interface (API) in front of the National Hydrography dataset. Now, instead of needing to be a GIS



pygeoapi

National Hydrologic Geospatial Fabric spatial layers

This instance of pygeoapi hosts data from the NHDPlusV2 and Watershed Boundary Dataset. pygeoapi is a Python server implementation of the OGC API suite of standards which provides the capability to

GDP USGS Geo Data Portal

pygeoapi

Geo Data Portal SpatioTemporal Asset Catalog and Processing.

This instance of pygeoapi supports a spatio temporal asset catalog and related geoprocessing services. pygeoapi is a Python server

CONUS404: Four-kilometer long-term regional hydroclimate reanalysis over the conterminous United States (ver. 2.0, December 2023)

February 21, 2023

View Data Release

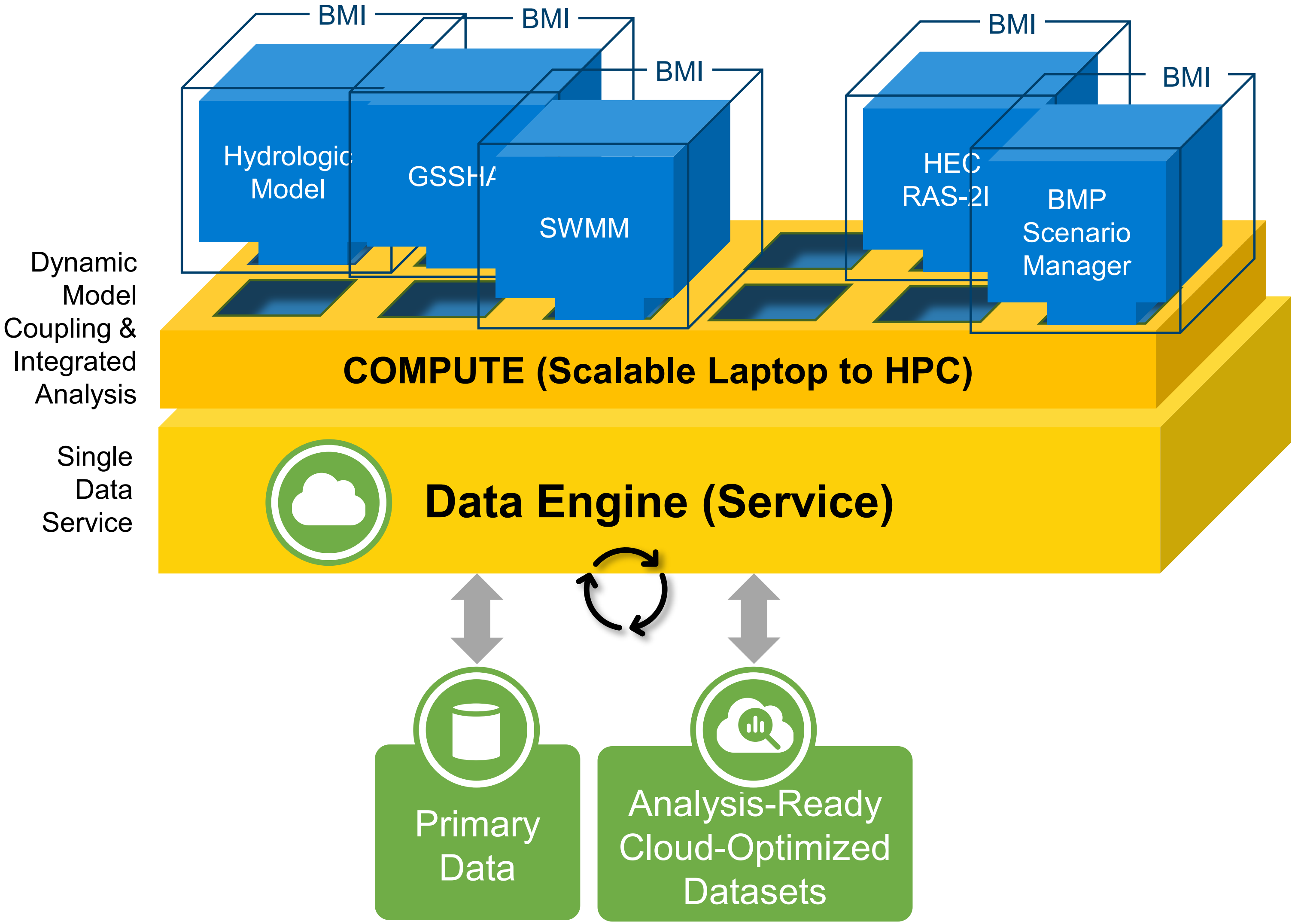
CONUS404 is a unique, high-resolution hydro-climate dataset appropriate for forcing hydrological models and conducting meteorological analysis over the contiguous United States. CONUS404, so named because it covers the CONtiguous United States for 40 years at 4-km resolution, was produced by the Weather Research and Forecasting (WRF) Model simulations run by National Center for Atmospheric Research (NCAR) as part of a collaboration with the U.S. Geological Survey (USGS) Water Mission Area. In fact, CONUS404 includes 41 years of data (water years 1980-2020) and the spatial domain extends beyond the CONUS into Canada and Mexico, thereby capturing transboundary river basins and covering all contributing areas for the CONUS surface waters.

The CONUS404 dataset, produced using WRF version 3.9.1.1, is the successor to the CONUS1 dataset (Liu and others, 2017) with improved representation of weather and climate conditions in the central United States due to the addition of a shallow groundwater module and several other improvements in the Noah-Multiparameterization (Noah-MP) Land Surface Model land surface model. It also uses a more up-to-date and higher-resolution reanalysis dataset (ERA5; Hersbach and others,

Study Area

WATER MODEL COUPLING

- **Built with open-source, cloud-native libraries designed to scale**
- **Basic Model Interface (BMI) API built into every model, for flexible coupling**
    - **Python "wrappers" coordinate coupling**
- **Shared, Scalable Compute Frameworks**
- **Shared Data Engine, as a Service**



MODEL COUPLING

Modeling community moving toward systems of coupled models from modular model components.

BMI 2.0 has become the standard for model coupling

- Basic Model Interface (BMI)
  - Provides a common set of functions
    - To run models and exchange information and data on grids, variables, timesteps, etc.
  - Shares data among models using a zero-copy approach
    - Each model reads and writes to the same in-memory object using pointers
  - Supports models written in C, C++, Fortran, Java, Python, Javascript, Julia
    - NOTE: BMI must be implemented in the source code of a model before it can be used to couple that model to other BMI-compliant models
  - Learn more: https://bmi.readthedocs.io

Files

main

Go to file T

- .github
- data_dependencies
- doc
- domain_data
- nhgf_v2_fabric_modifica...
- nhm_helpers
- notebook_scripts
- pestpp_ies_calibration
- .gitignore
- .pre-commit-config.yaml
- DISCLAIMER.md
- LICENSE.md
- README.md

nhm-assist / README.md

barkermi updated README.md w directions for generating notebooks from py 32452c8 · 8 months ago History

Preview Code Blame Raw

nhm-assist

nhm-assist is a collection of python workflows presented in Jupyter notebooks for evaluating, running and interpreting National Hydrologic Model (NHM) subdomain models using `pywatershed`, a python package for simulating hydrologic processes motivated by the need to modernize important, legacy hydrologic models at the USGS, particularly the Precipitation-Runoff Modeling System (PRMS, Markstrom et al., 2015). nhm-assist allows users to:

- evaluate hydrofabric element connections such as hydrologic response unit connections to streamflow segments, segment routing order, and gage placement accuracy;
- display NHM subdomain parameter values on interactive maps and plots;
- run the NHM subdomain using `pywatershed` and create output for chosen variables;
- display NHM subdomain output values, such as recharge or actual evapotranspiration, on interactive maps and plots; and

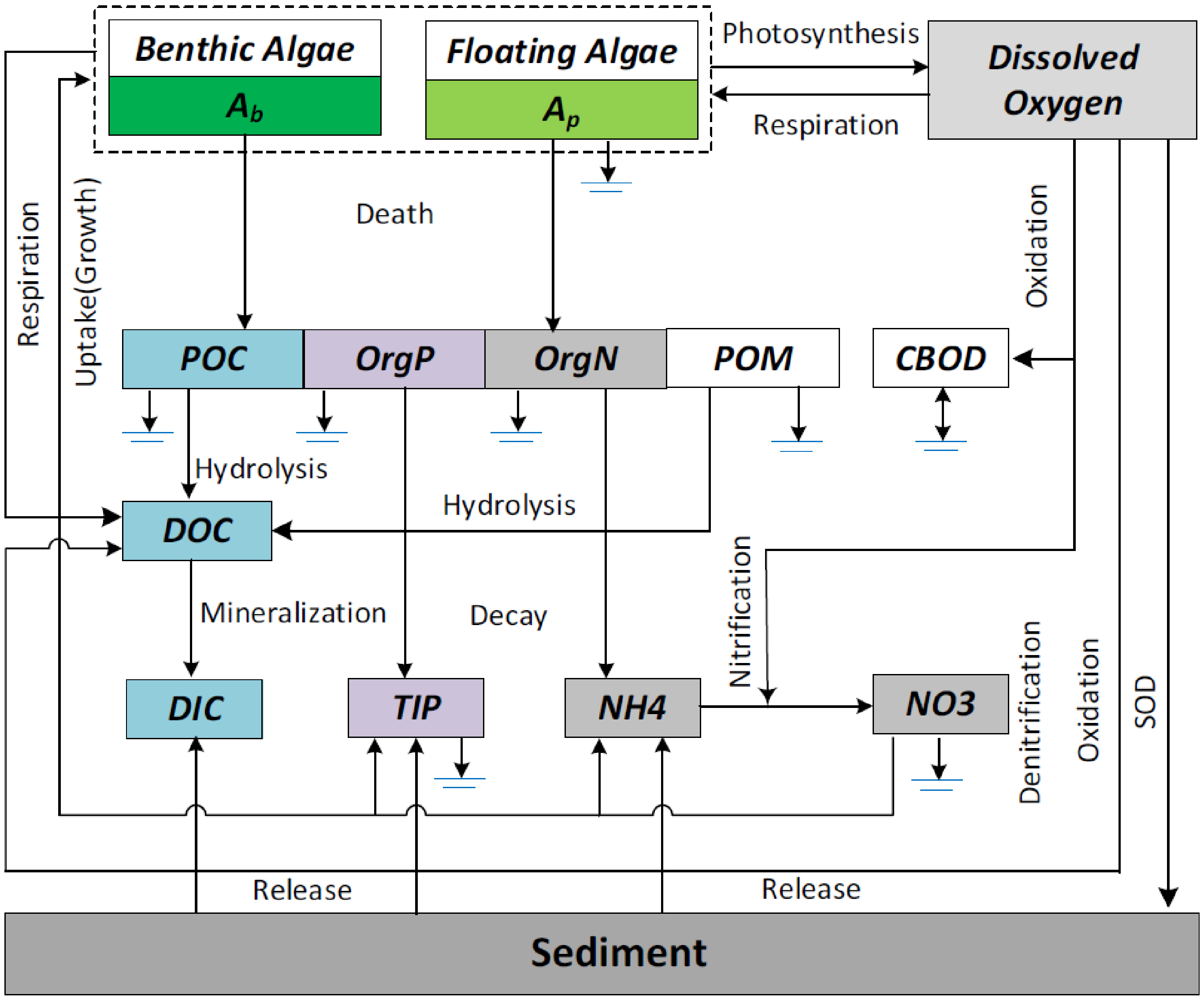
USACE ERDC WATER MODEL COUPLING

- Modernizing

CLEARWATER MODELING

- **Corps Library for Environmental Analysis and Restoration of Watersheds (ClearWater)**
- **Goal:**
    - Port water quality modules from Fortran to modern Python
    - Couple to 2D flow models
    - Leverage cloud-native frameworks

Nutrient Simulation Module (NSM) Processes



https://github.com/EcohydrologyTeam/ClearWater-modules

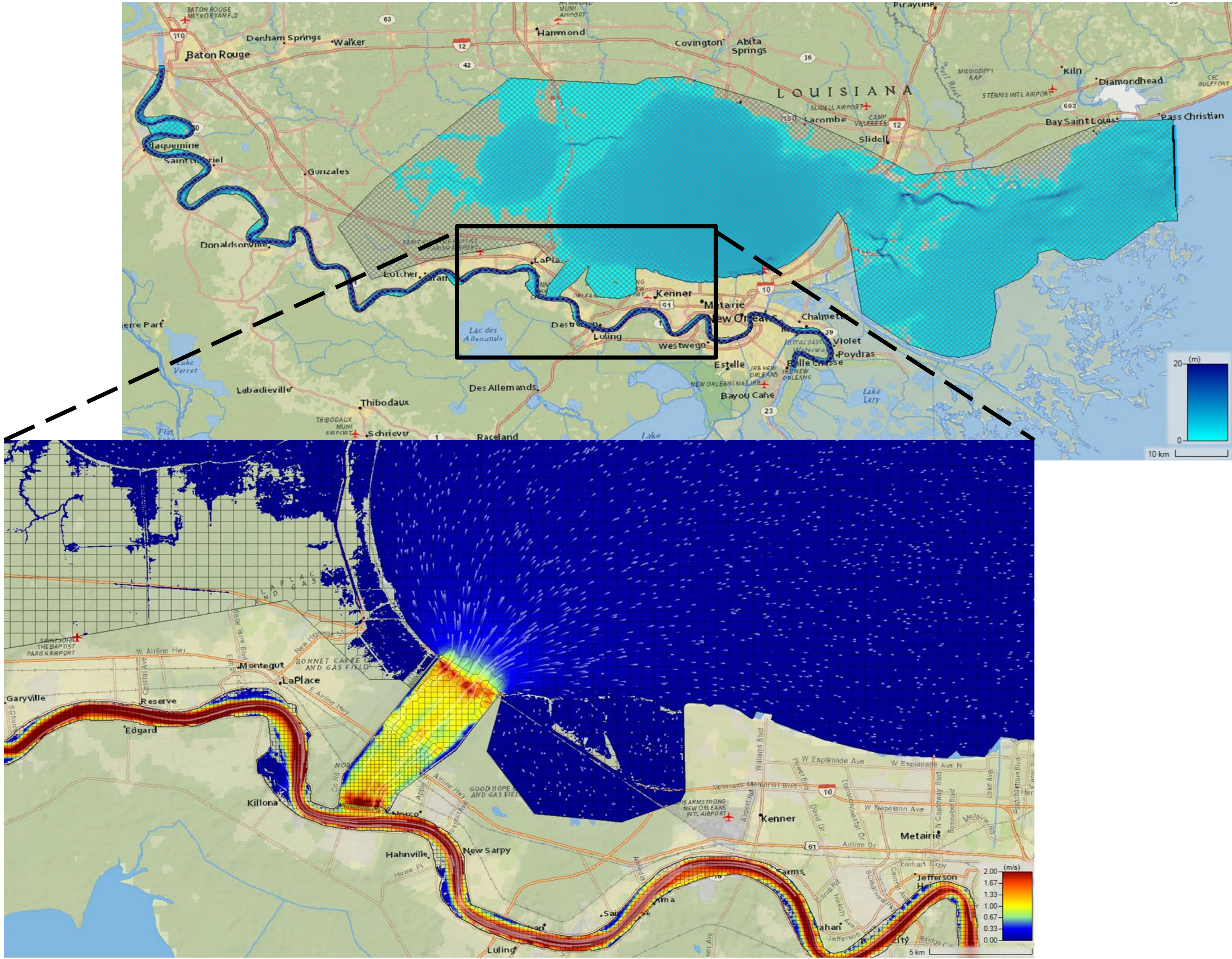
MOTIVATION: SCALING

Scaling to real-world scenarios

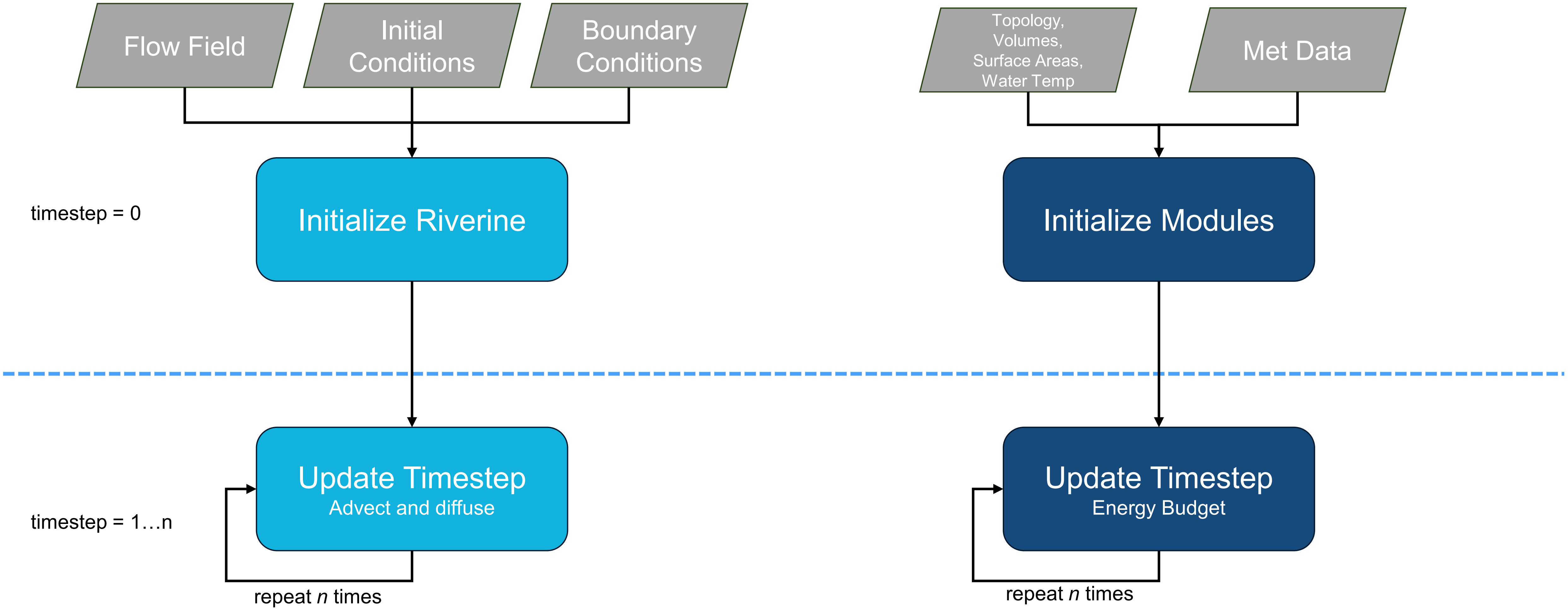
The **Lake Pontchrtrain** use case.

- 26,000 grid cells
- 5 to 60 second time steps
- 18 GB RAS-2D binary output file (HDF5) is input

Conventional coupling methods exceed the memory of typical desktop modeling computers.



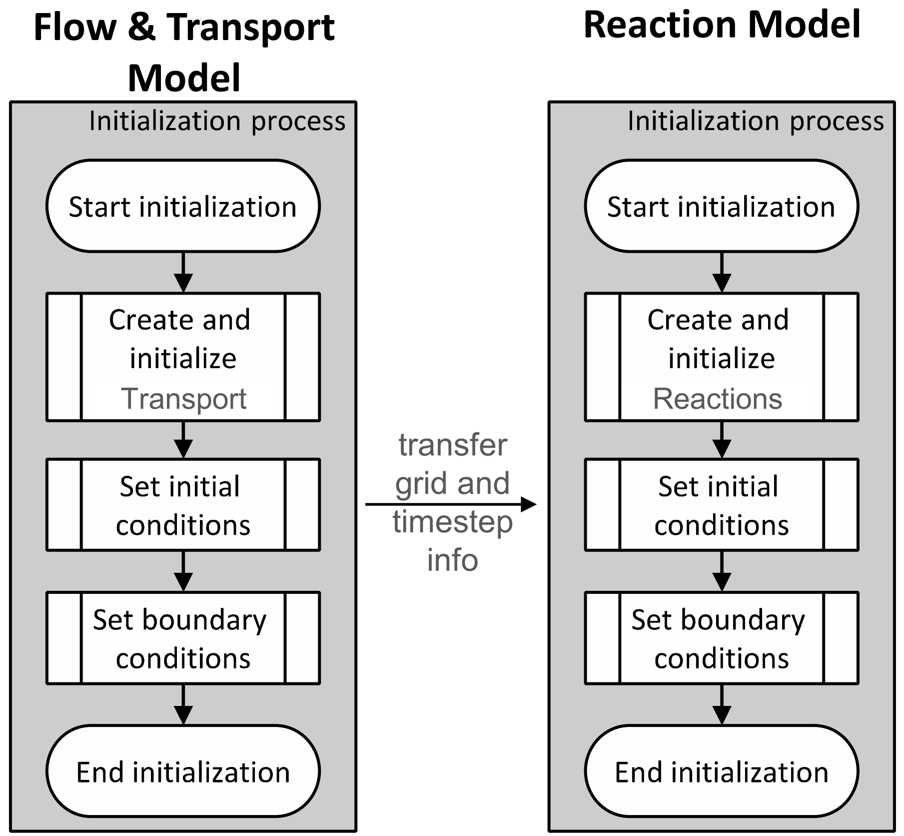
Running Clearwater-Riverine and Clearwater-Modules Individually



Reactive Transport Coupling Workflow

All processes and flows represented are controlled by Python

Initialize Model Detail



Initialize Models

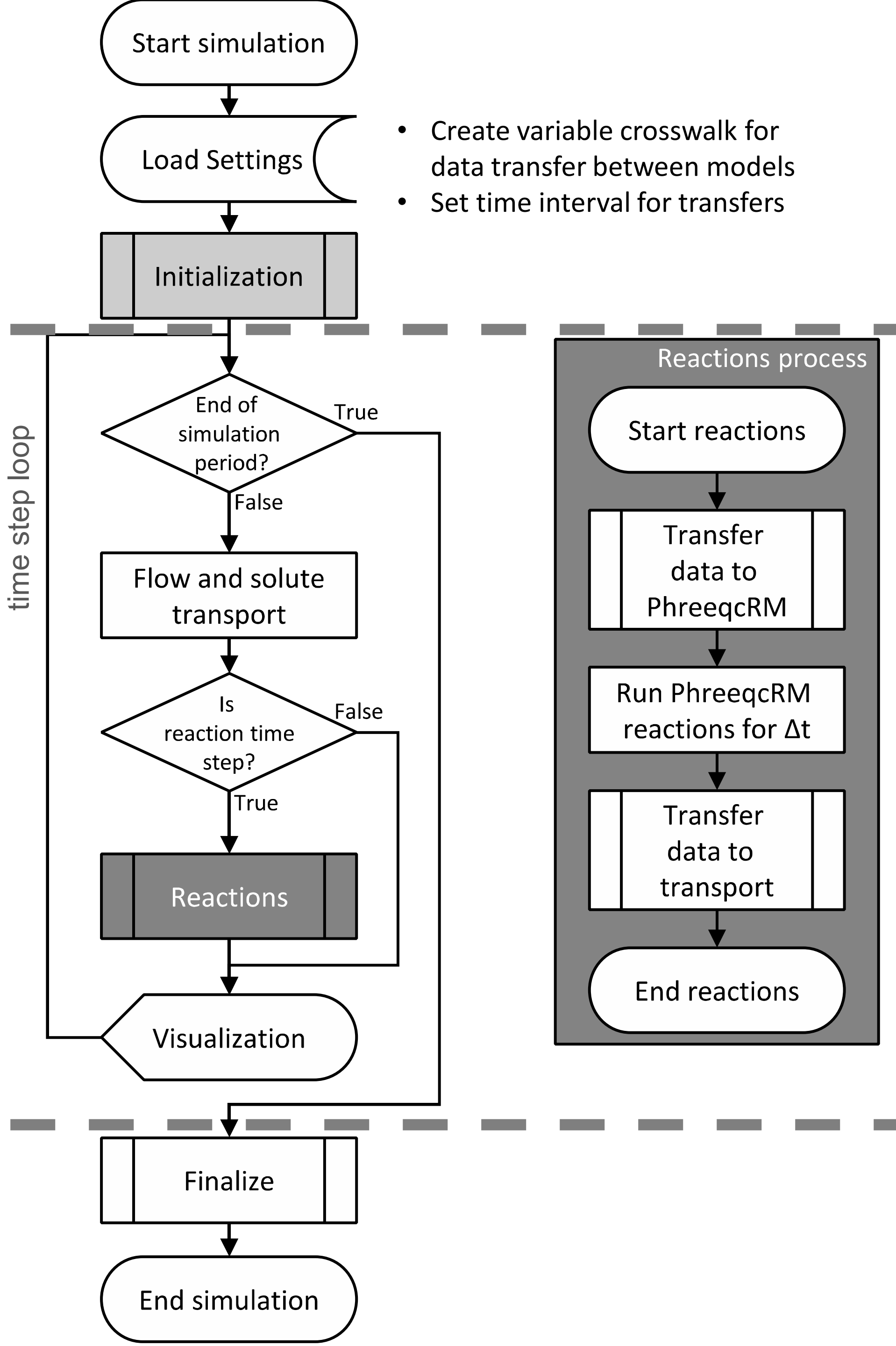
- Read inputs
- Setup transfer

Update Models by timestep(s)

- In-memory data transfers between models
- Optional copy to in-memory netCDF dataset container

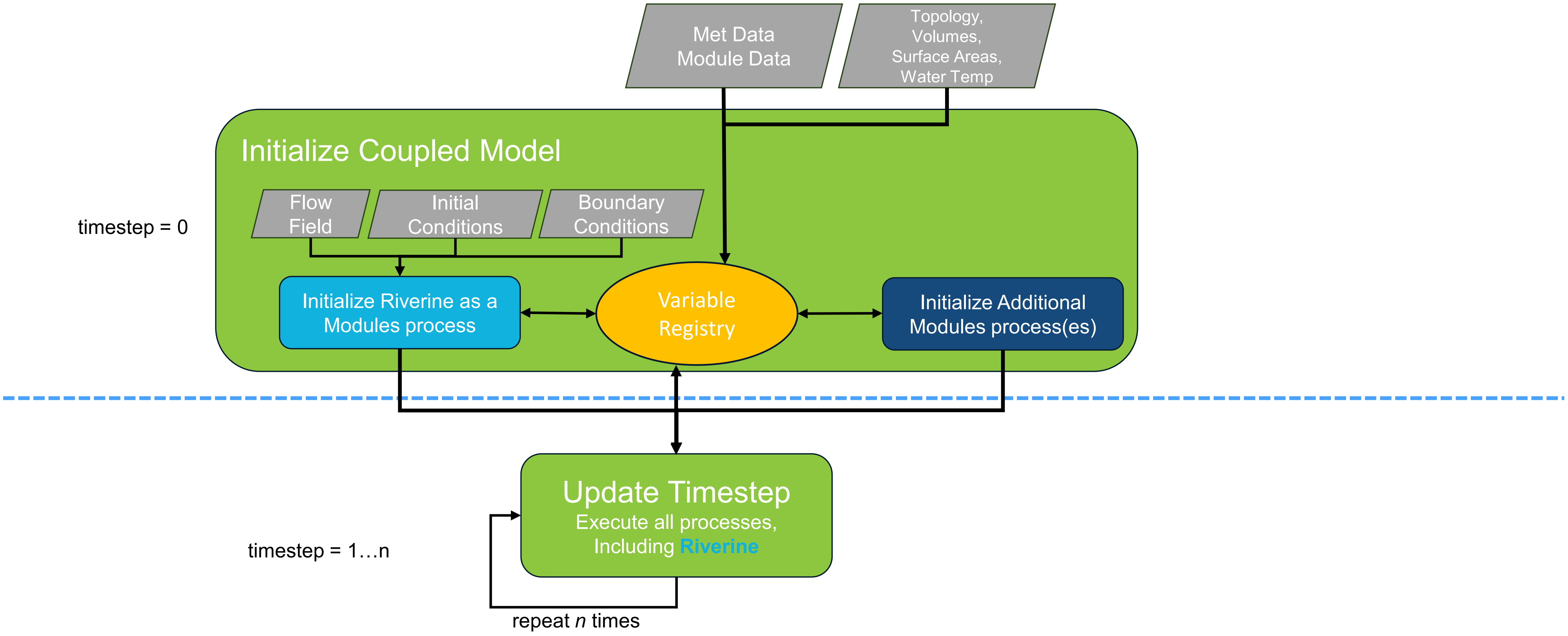
Finalize Models

- Save outputs
- Deallocate memory



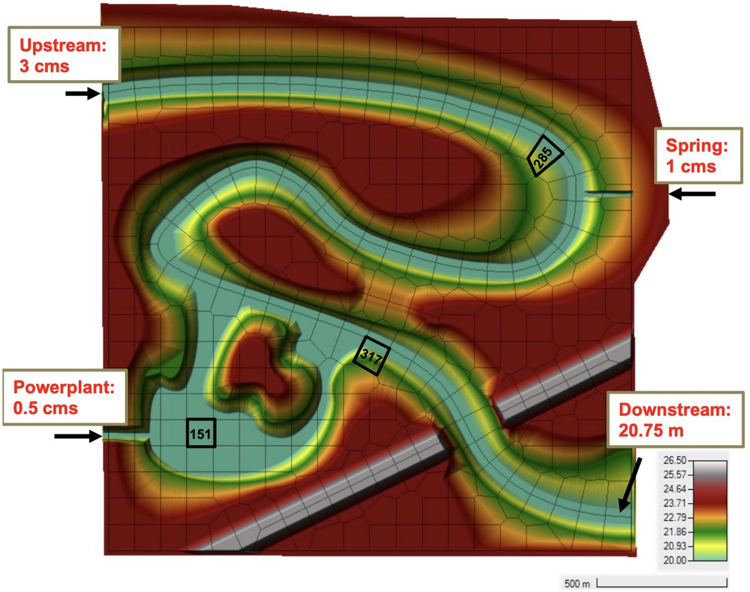
Adapted from Parkhurst & Wissmeier 2015.
Symbology: https://www.zenflowchart.com/flowchart-symbols

Running Clearwater-Riverine and Clearwater-Modules as Linked Models

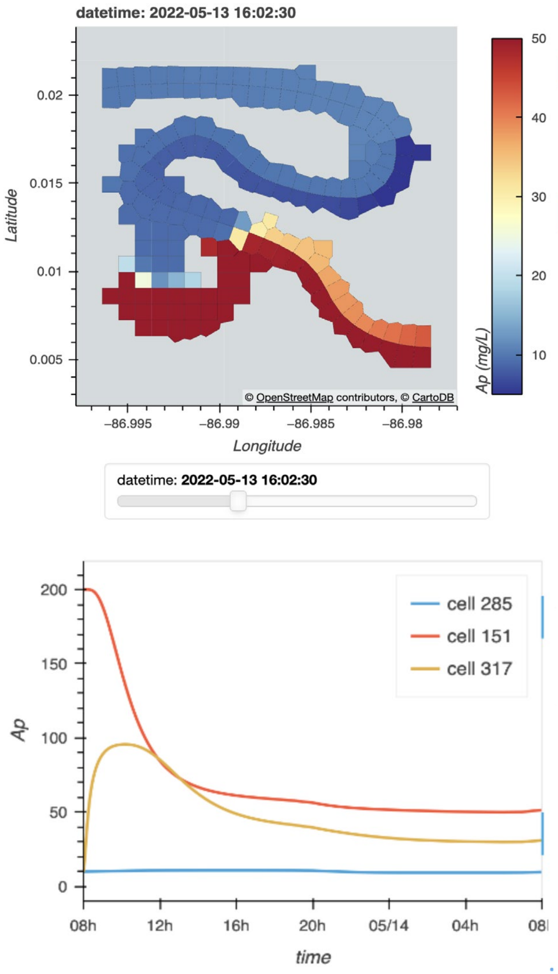


CLEARWATER RESULTS

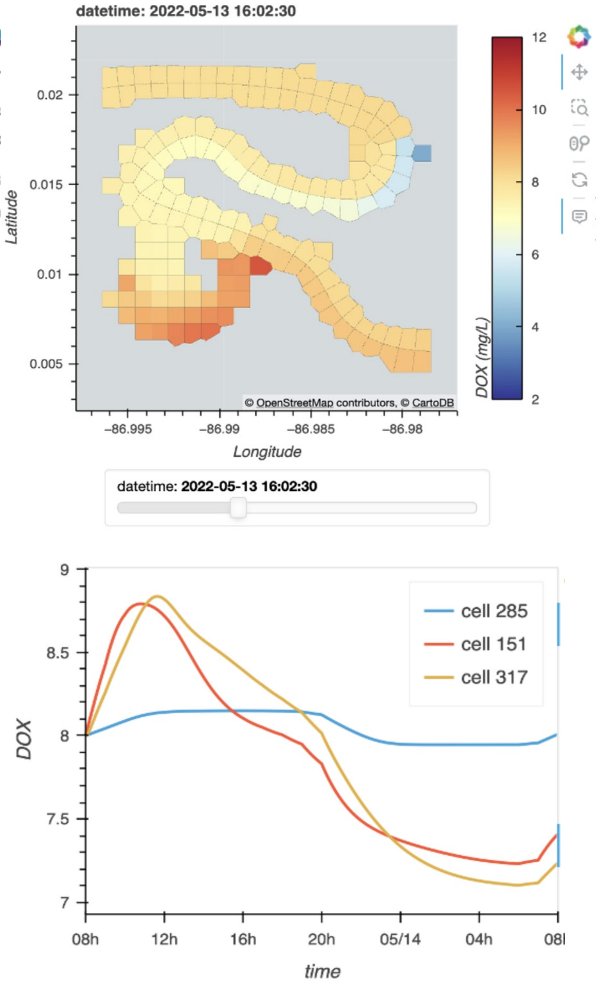
- **Passes all tests for predictions**



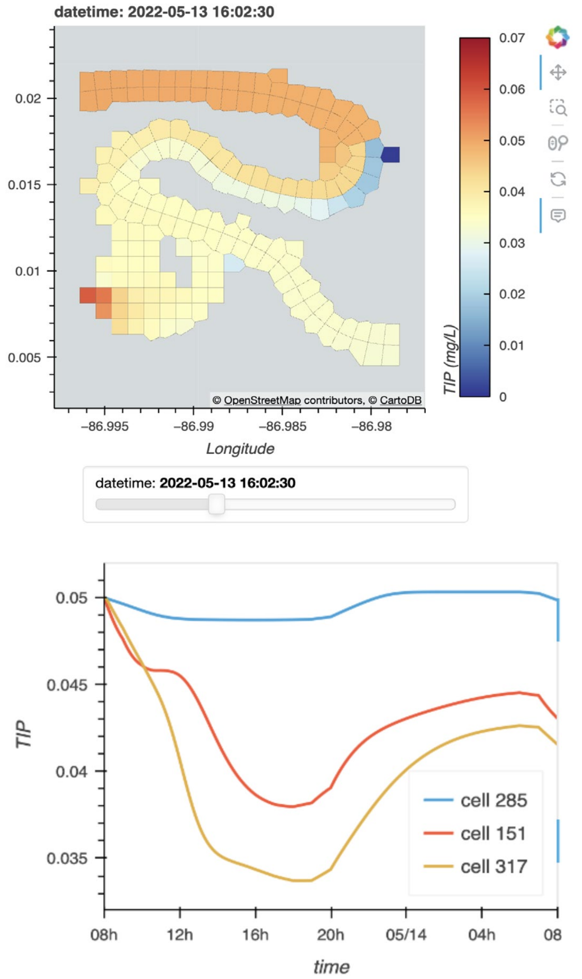
Algal Plankton



Dissolved Oxygen

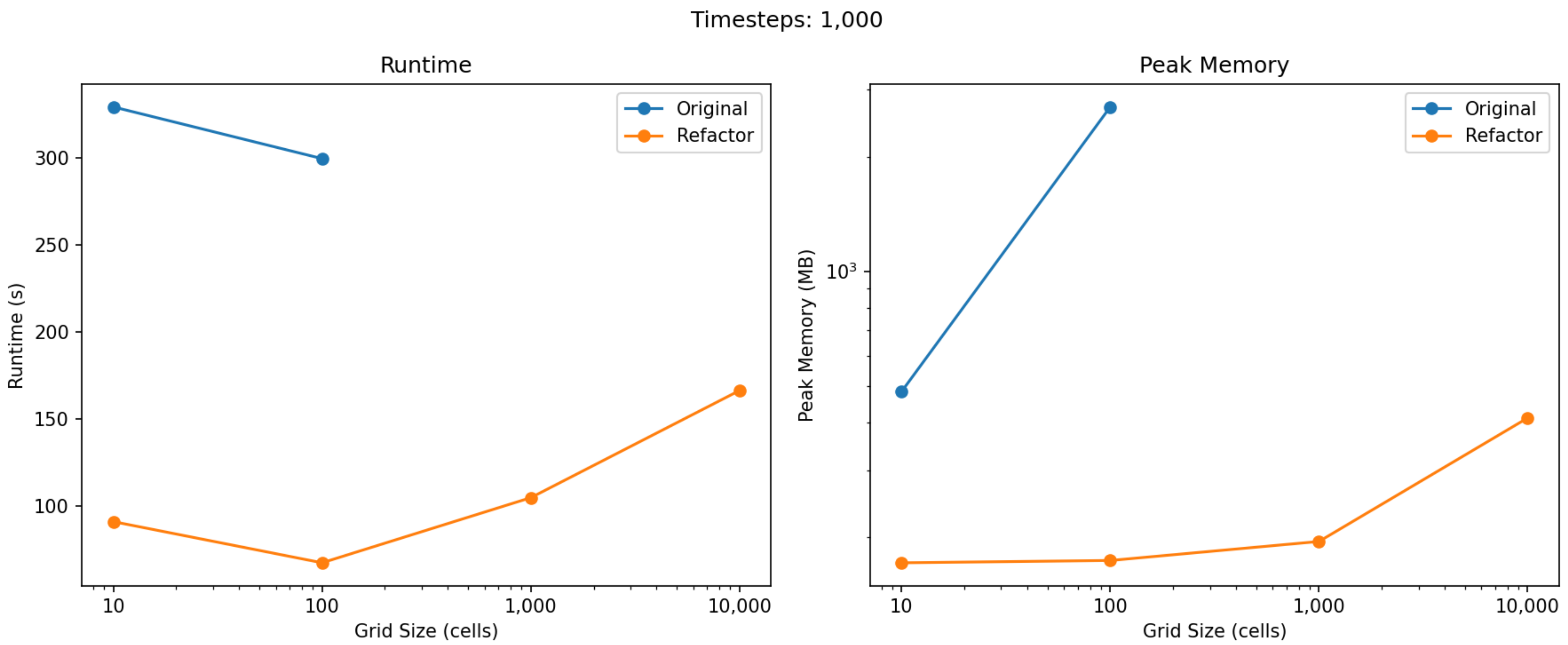


Phosphorus



CLEARWATER RESULTS

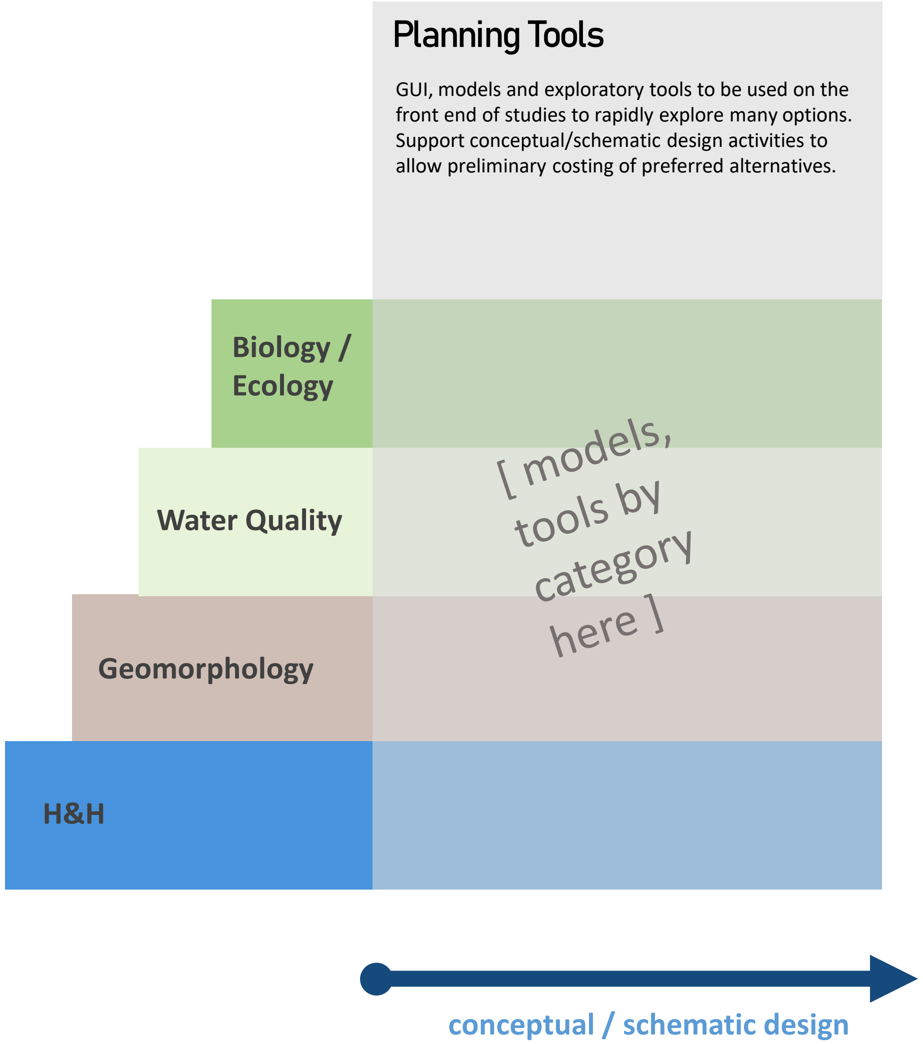
- Passes all tests for scalability



LAKE DESIGN MODELING

- Models need to simulate all relevant processes at relevant scales to provide results meaningful for management

LimnoTech Decision Support for a Repeatable Design Process



LimnoTech Decision Support for a Repeatable Design Process

Planning Tools

GUI, models and exploratory tools to be used on the front end of studies to rapidly explore many options. Support conceptual/schematic design activities to allow preliminary costing of preferred alternatives.

Biology / Ecology

Water Quality

Geomorphology

H&H

[models, tools by category here]

Planning tool supports development and transfer of:

Conceptual design alternatives, associated costs, preliminary assessment of benefits, prioritization and ranking scheme.

Engineering Design Toolset

GUI and more advanced models and other analytical tools designed to further evaluate highly ranked options, select preferred alternative, and support design development, detailed design, CD/CA, and cost estimation.

[models, tools by category here]

Design tool supports development and transfer of:

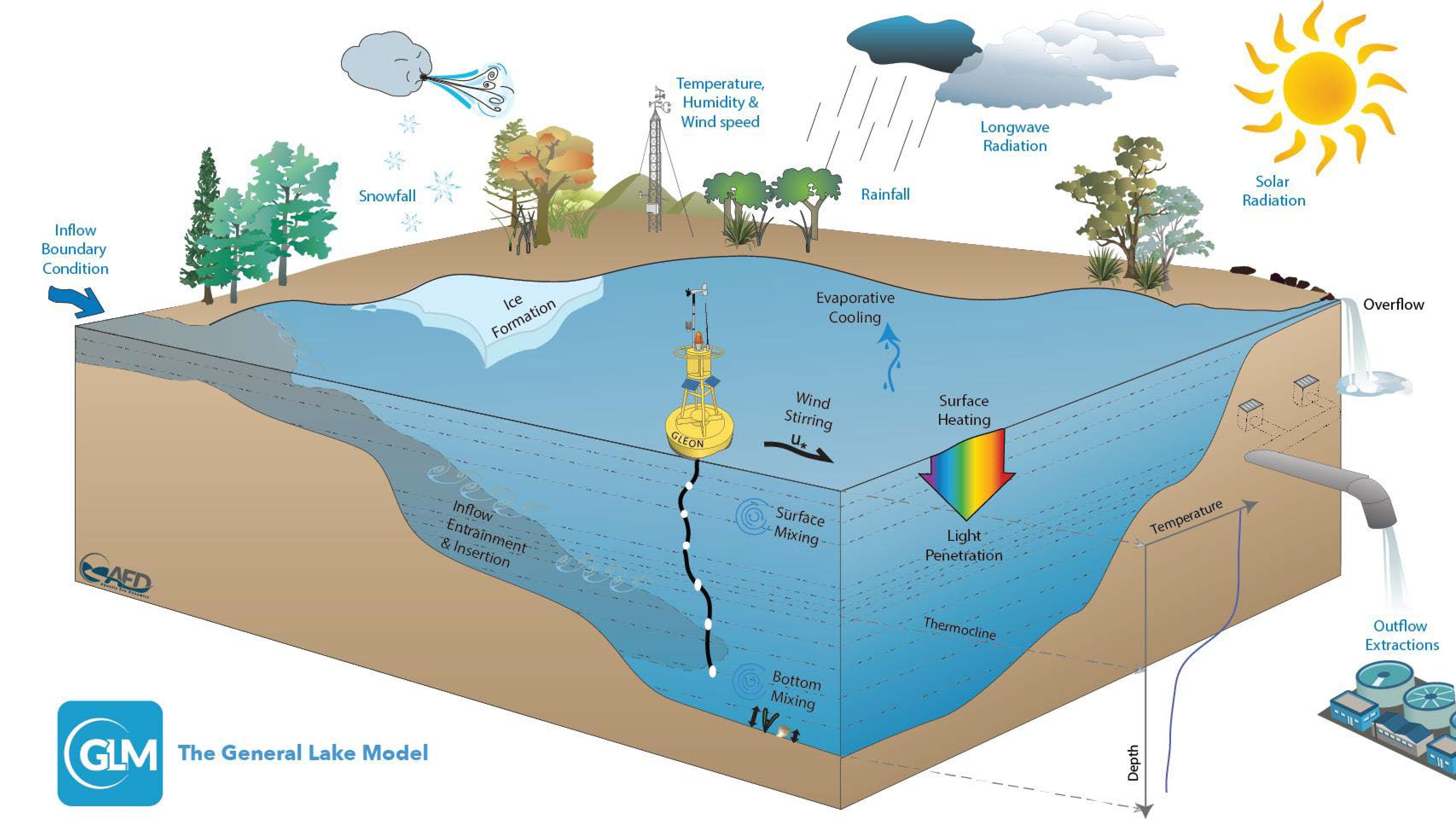
Detailed design of preferred alternative, refined costs, life cycle costs and benefit analysis, dataset and analytical toolset that can be converted to operationalized tool.

Operations Toolset

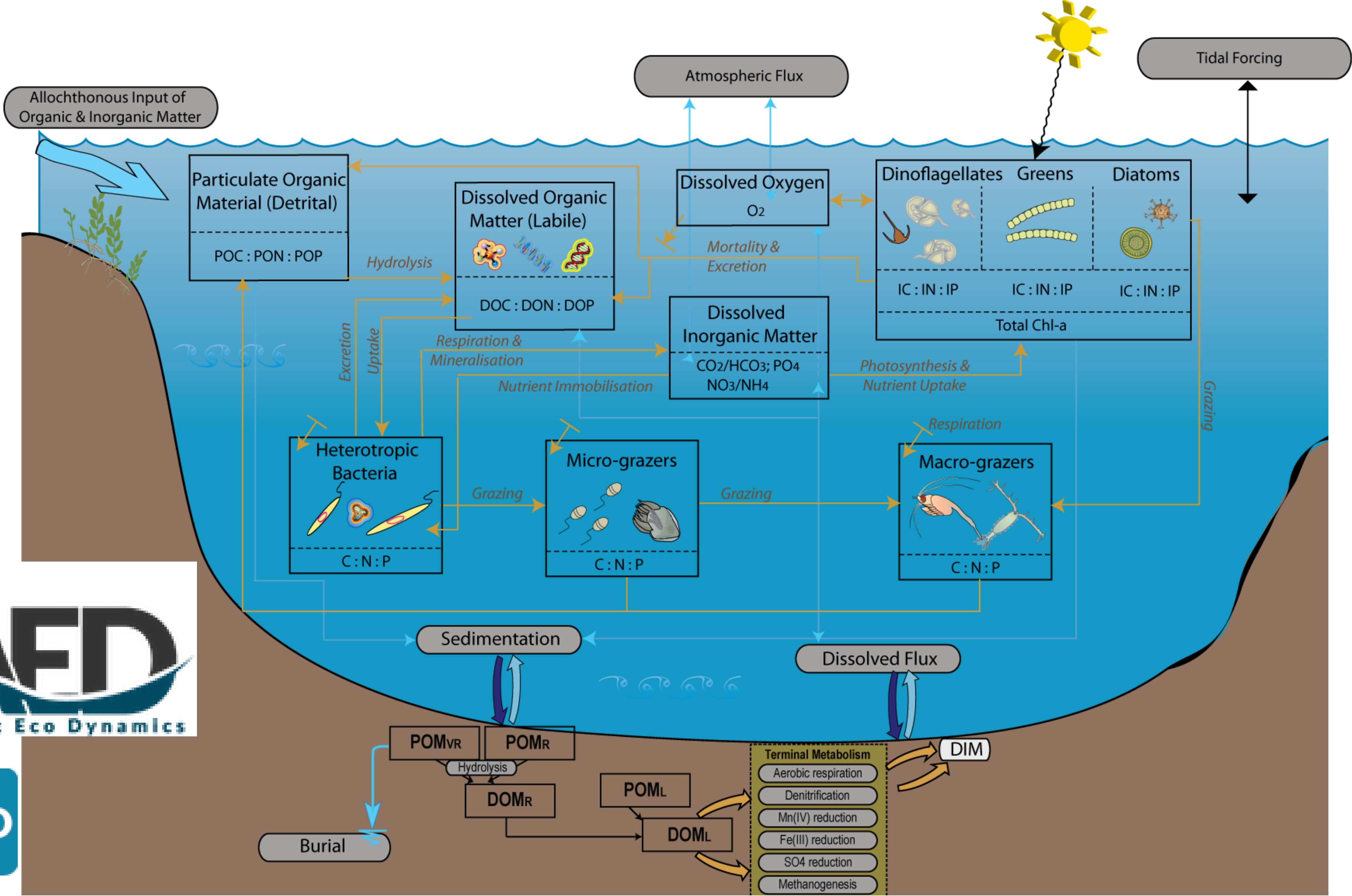
Combination of operationalized models and monitoring network tools that support long-term maintenance and adaptive management of the system.

[models, tools by category here]

conceptual / schematic design → design development / detailed design / construction → post-construction / O&M / adaptive mgmt



Snowfall
Temperature, Humidity & Wind speed
Longwave Radiation
Rainfall
Solar Radiation
Inflow Boundary Condition
Ice Formation
Evaporative Cooling
Overflow
Wind Stirring
u_*
GLEON
Surface Heating
Surface Mixing
Light Penetration
Temperature
Inflow Entrainment & Insertion
Thermocline
Bottom Mixing
Depth
Outflow Extractions
AED
GLM
The General Lake Model



Aquatic Eco Dynamics

WATER QUALITY MODEL RESULTS

Phase 2 Model Simulations

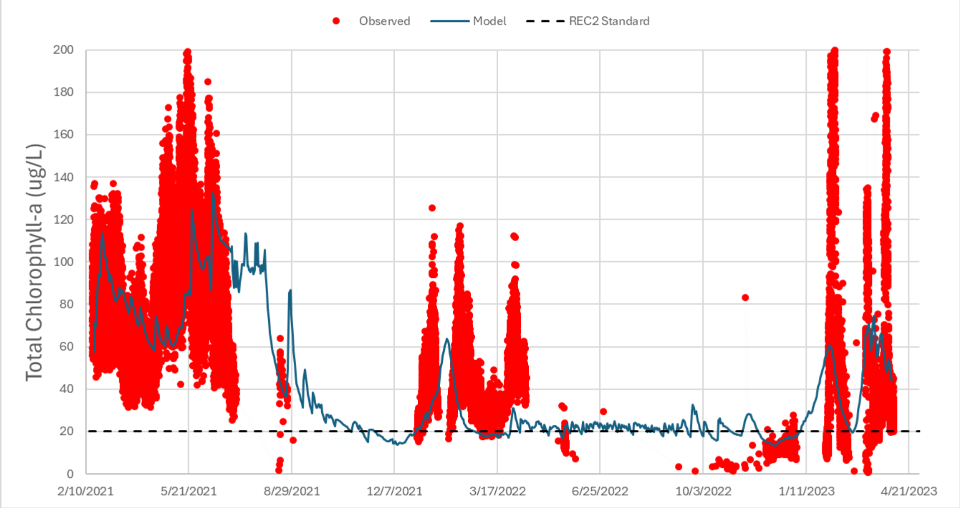
Scenario	Description	Recirculation	Pathogen?	Notes
A	Baseline w/ Pathogen	NA	Conservative tracer	Revised calibration, added small pathogen tracer load
B	Pathogen load + flushing	1000 GPM	Conservative tracer	Assumed influent nutrient concentrations equal to REC2 Water Quality Standards
C	Pathogen load + lake recirculation	1000 GPM	Conservative tracer	Influent nutrient concentrations taken from iteration of model simulation, recirculated through the lake
D	Pathogen load + lake recirculation	1000 GPM	1.0 day^{-1} loss rate on pathogens	Influent nutrient concentrations taken from iteration of model simulation, recirculated through the lake

Lack of pathogen data (in-lake or for loading) prevents a true quantitative analysis. Model was set up to demonstrate relative impacts between scenarios, and to show sensitivity in pathogen decay rates.

Pathogen load set to be roughly stable over calibration simulation (initial C = 100, average of simulation = 92)

A-REVISED CALIBRATION INCLUDING PATHOGEN TRACER

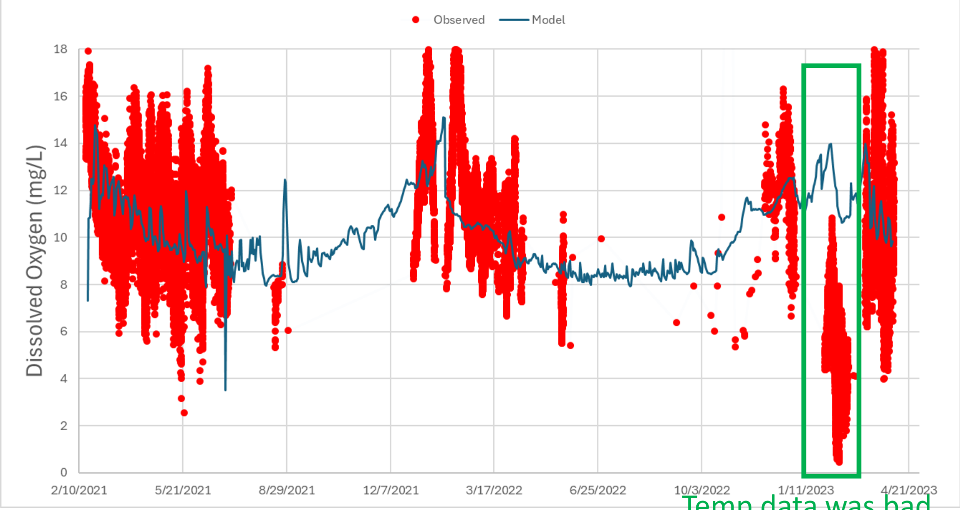
Low-end of chlorophyll-a concentrations in the revised calibration might be high, but therefore acts as conservative estimate in reduction scenarios



	Summer TP (mg/L)	Summer TN (mg/L)	Summer Chl (ug/L)	Annual Chl (ug/L)	Peak Chl (ug/L)	HRT (days)	Pathogen (Relative %)
2021	0.15	0.52	77.3	60.8	132.5	129	92.2
2022	0.04	0.57	22.0	23.2	32.5	311	89.8

Dissolved Oxygen follows seasonal patterns, model output is daily, and misses diurnal fluctuations

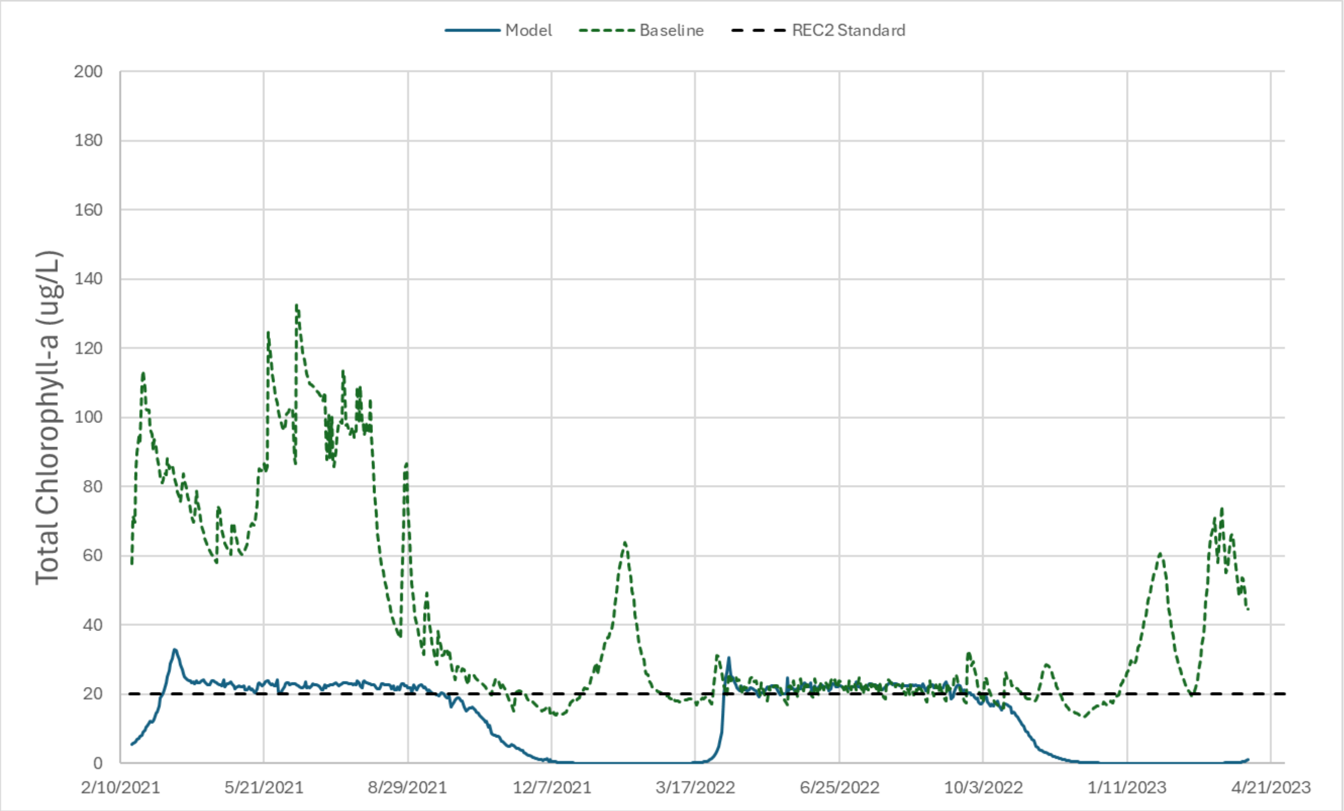
Model very rarely falls below 5 mg/L



Temp data was bad in this period

B-1000 GPM FLUSHING, ASSUMING REC2 WATER QUALITY STANDARDS

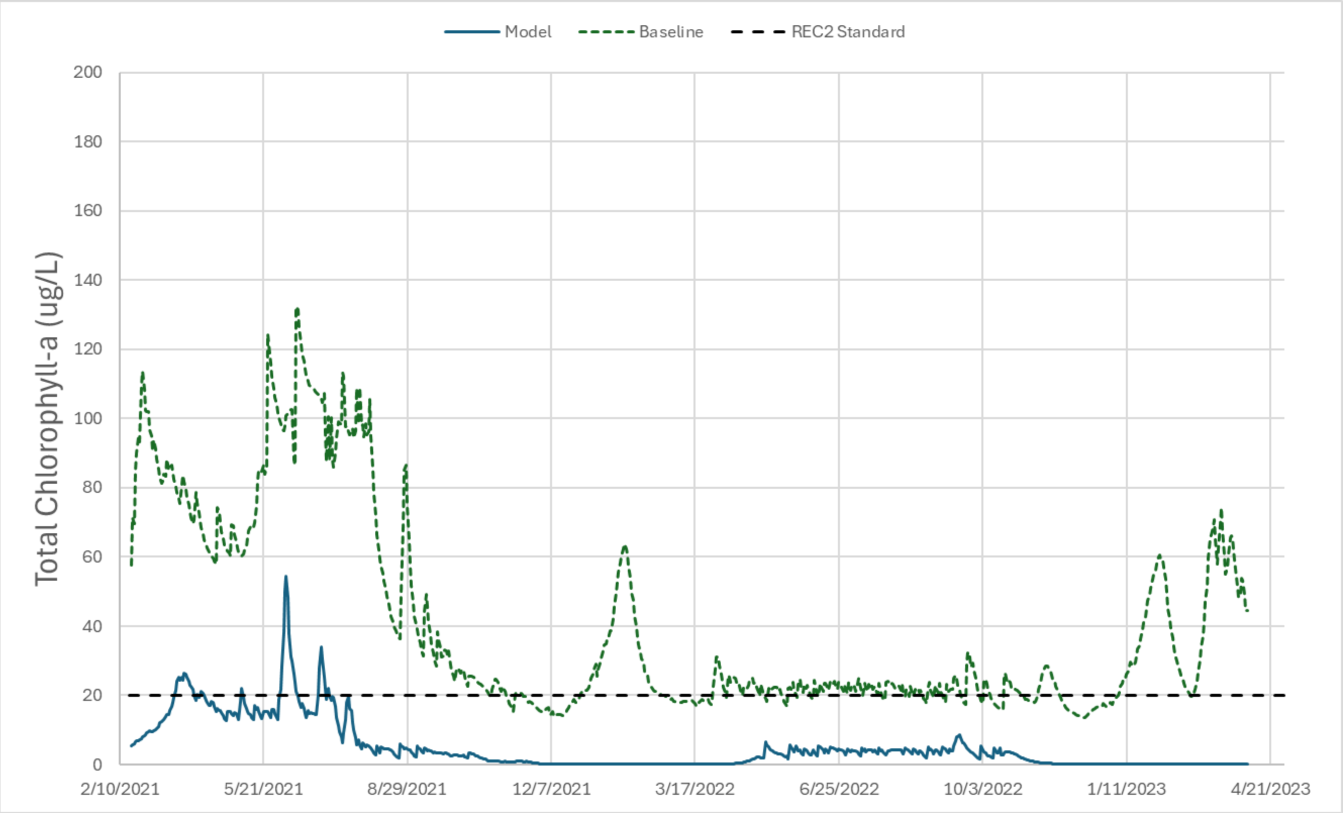
- Flushing inflow, even at lower nutrient levels, can produce algal blooms
- Reminder that calibration tended to be slightly elevated in low production periods (conservative estimate)
- Residence time reduced to ~4 days
- *CONSTANT nutrient load, even though at low concentrations
- 1000 gpm inflow does not include pathogen load in this scenario
- No decay rate applied to pathogen tracer



	Summer TP (mg/L)	Summer TN (mg/L)	Summer Chl (ug/L)	Annual Chl (ug/L)	Peak Chl (ug/L)	HRT (days)	Pathogen (Relative %)
2021	0.01	0.63	22.1	17.0	24.1	4	2.9
2022	0.01	0.62	21.8	12.5	24.7	4	0.9

C-1000 GPM FLUSHING, RECIRCULATED WATER FROM LAKE (MODEL VALUES)

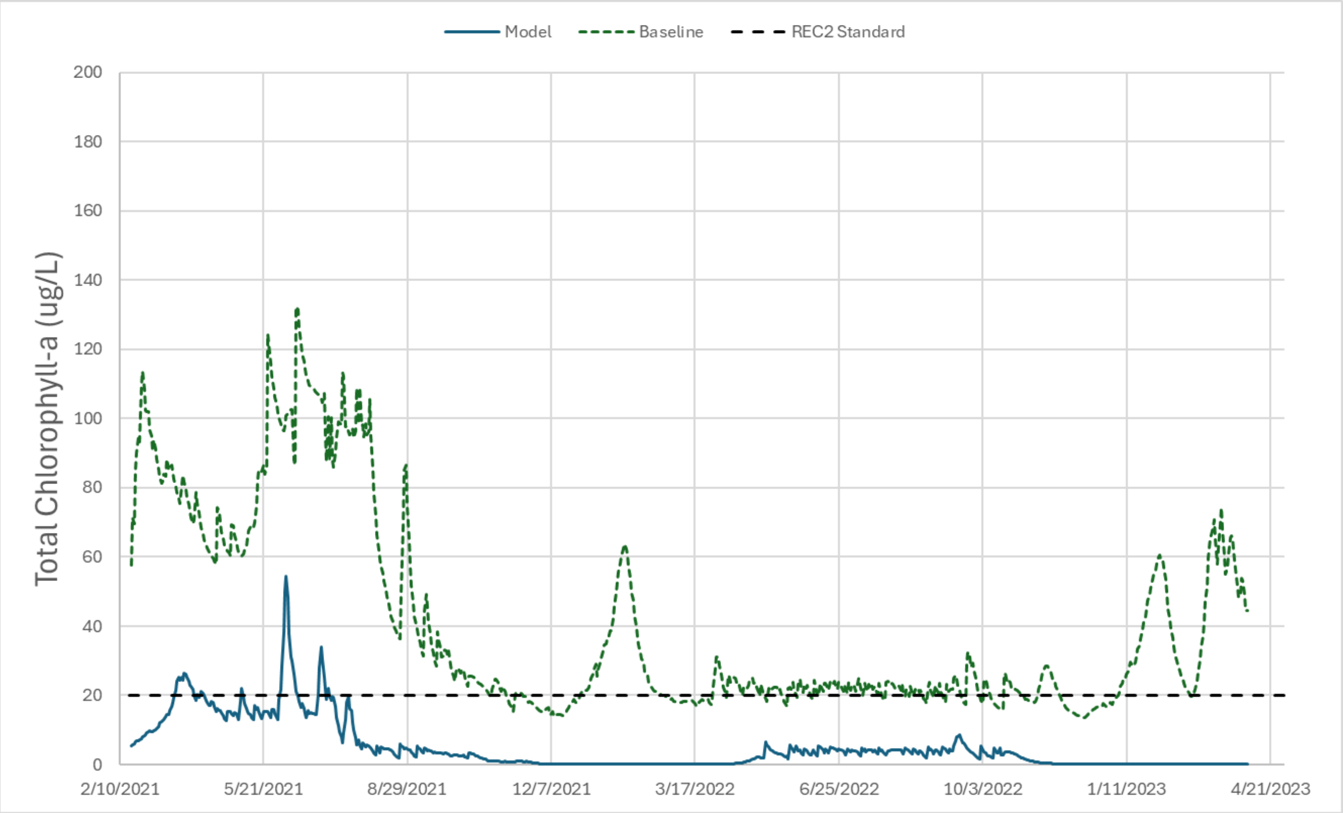
- Flushing inflow has nutrients, pathogen tracer and other state variables directly from model (1 iteration)
- Residence time reduced to ~4 days
- No decay rate applied to pathogen tracer
- *VARIABLE nutrient load
- Some algal biomass exceeds REC2 standard in short-term, but summer and annual averages are low



	Summer TP (mg/L)	Summer TN (mg/L)	Summer Chl (ug/L)	Annual Chl (ug/L)	Peak Chl (ug/L)	HRT (days)	Pathogen (Relative %)
2021	0.04	0.28	12.2	9.7	54.6	4	101.1
2022	0.01	0.52	4.0	2.1	8.6	4	105.7

D-1000 GPM FLUSHING, RECIRCULATED WATER FROM LAKE, PATHOGEN DECAY

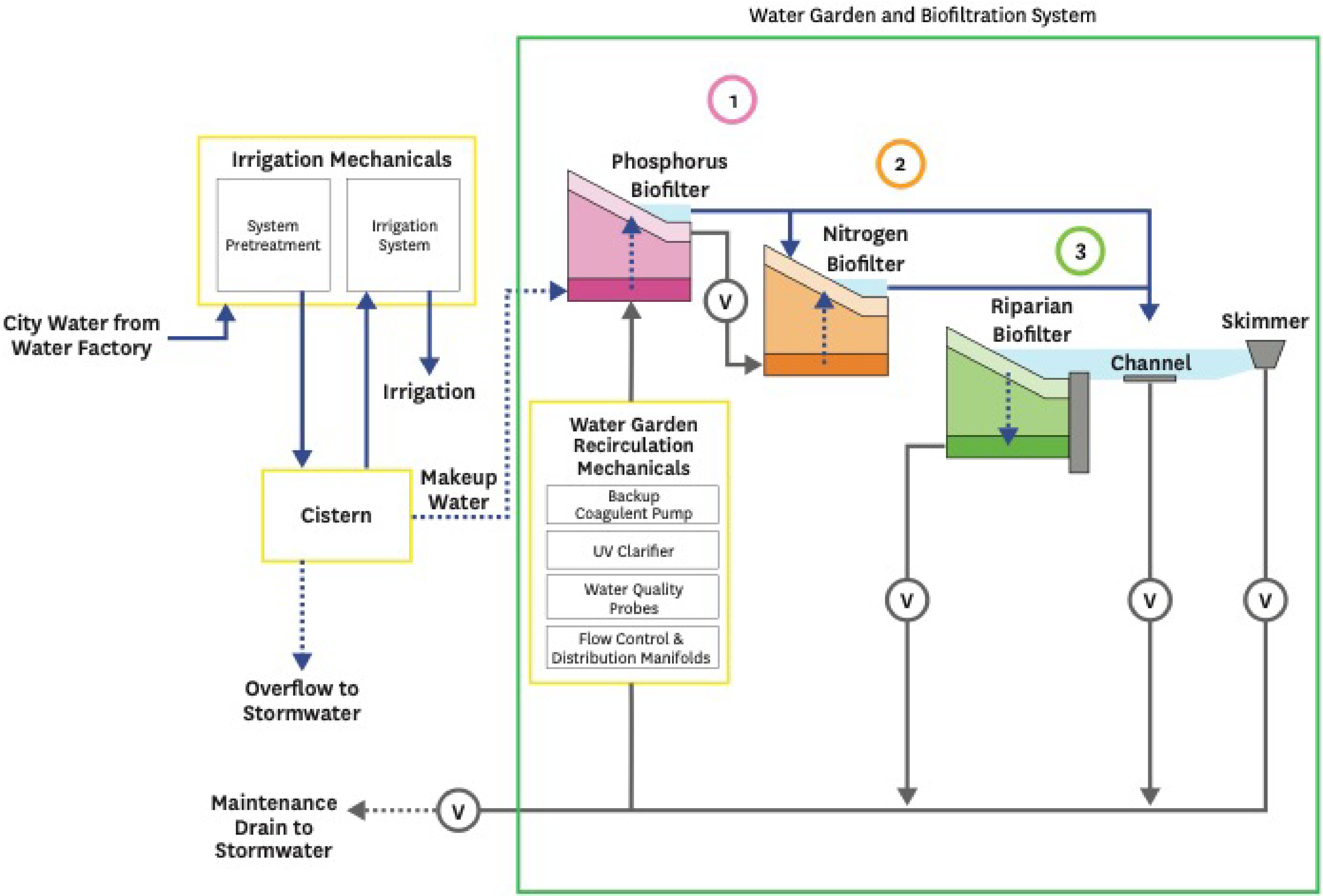
- Flushing inflow has nutrients, pathogen tracer and other state variables directly from model (1 iteration)
- Residence time reduced to ~4 days
- 1.0 day^{-1} decay rate applied to pathogen tracer (**high decay rate**)
- Some algal biomass exceeds REC2 standard in short-term, but summer and annual averages are low



	Summer TP (mg/L)	Summer TN (mg/L)	Summer Chl (ug/L)	Annual Chl (ug/L)	Peak Chl (ug/L)	HRT (days)	Pathogen (Relative %)
2021	0.04	0.28	12.2	9.7	54.6	4	23.2
2022	0.01	0.52	4.0	2.1	8.6	4	20.0

BIOFILTRATION

BIOFILTRATION



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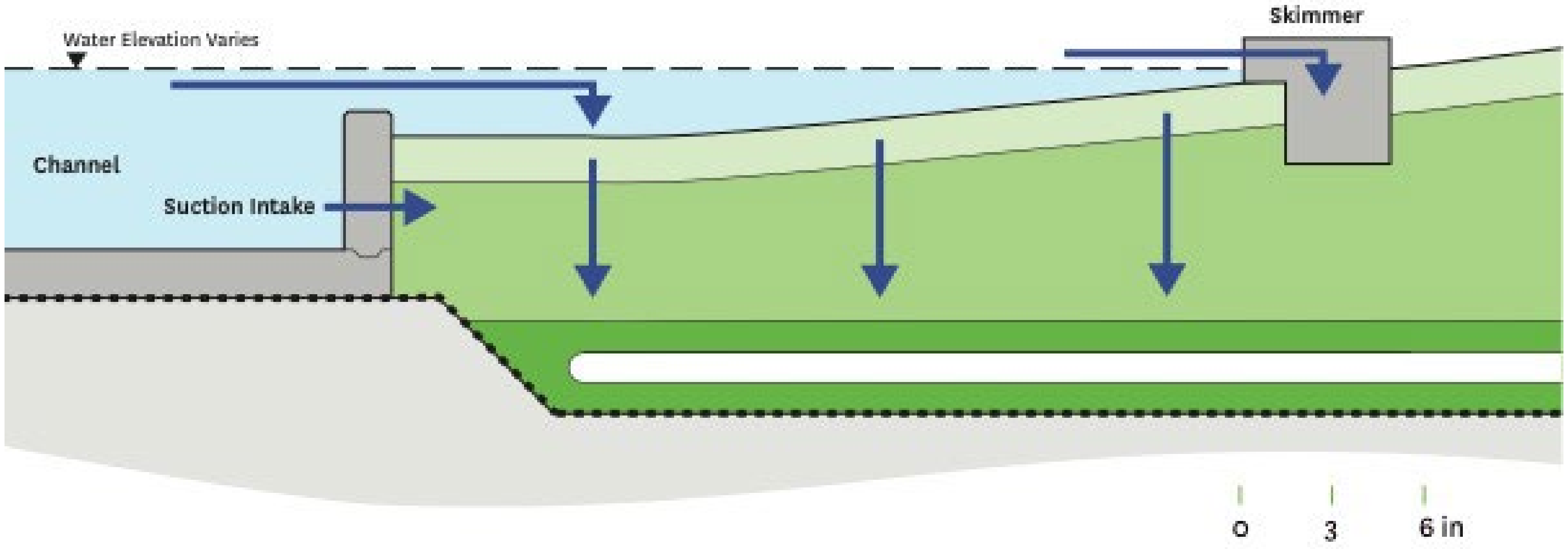

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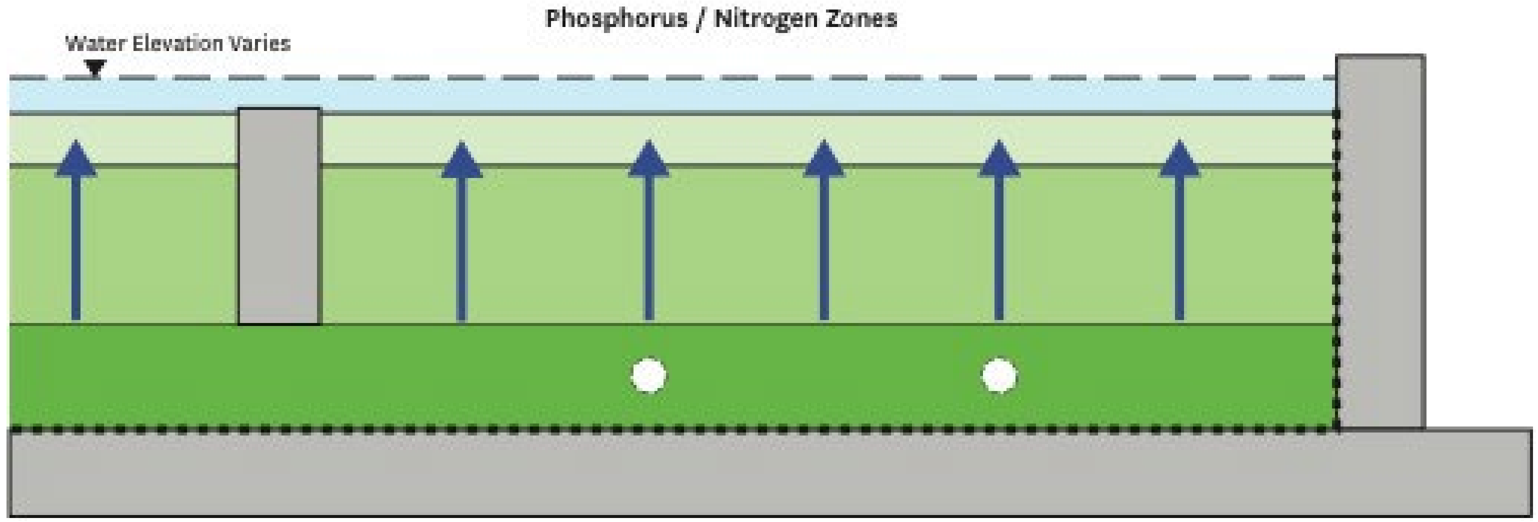

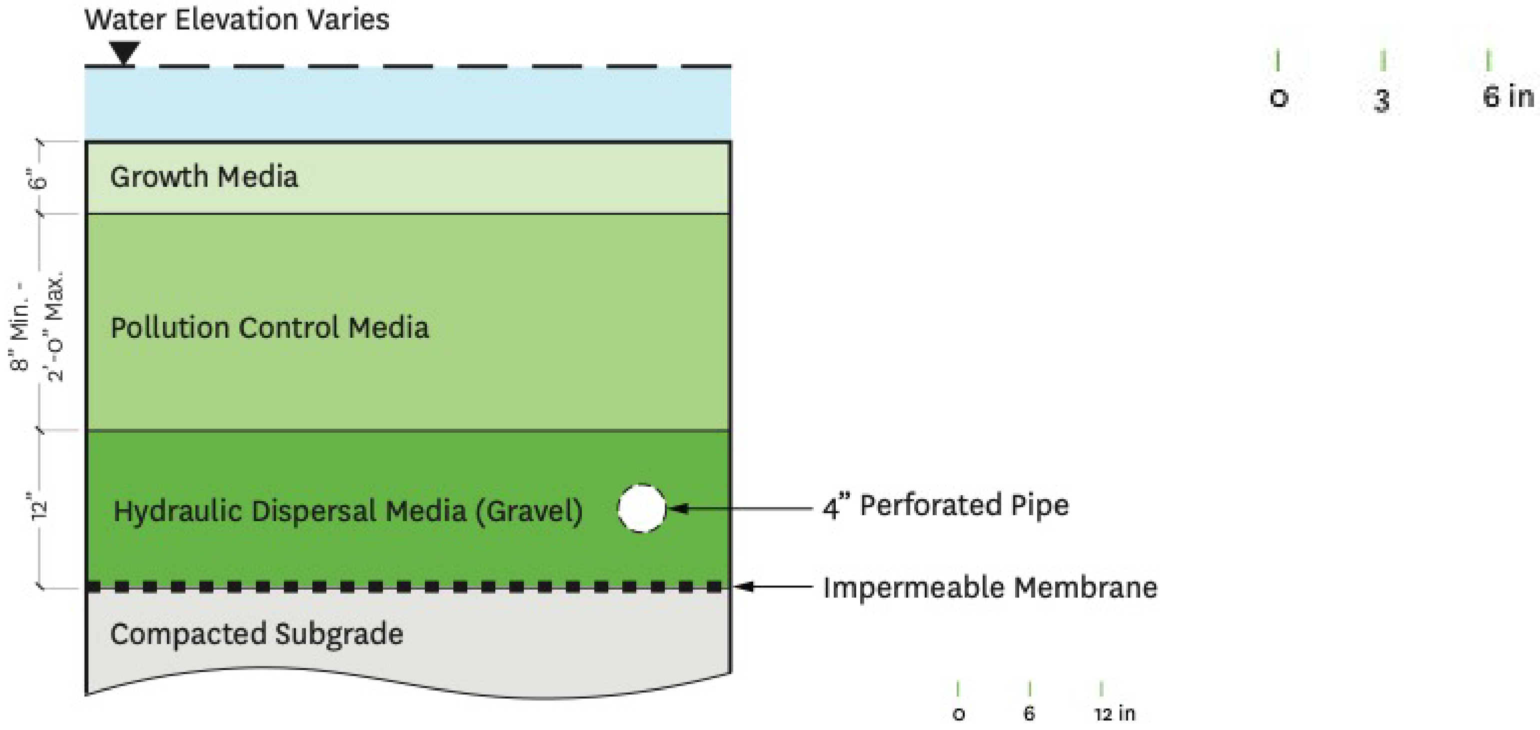

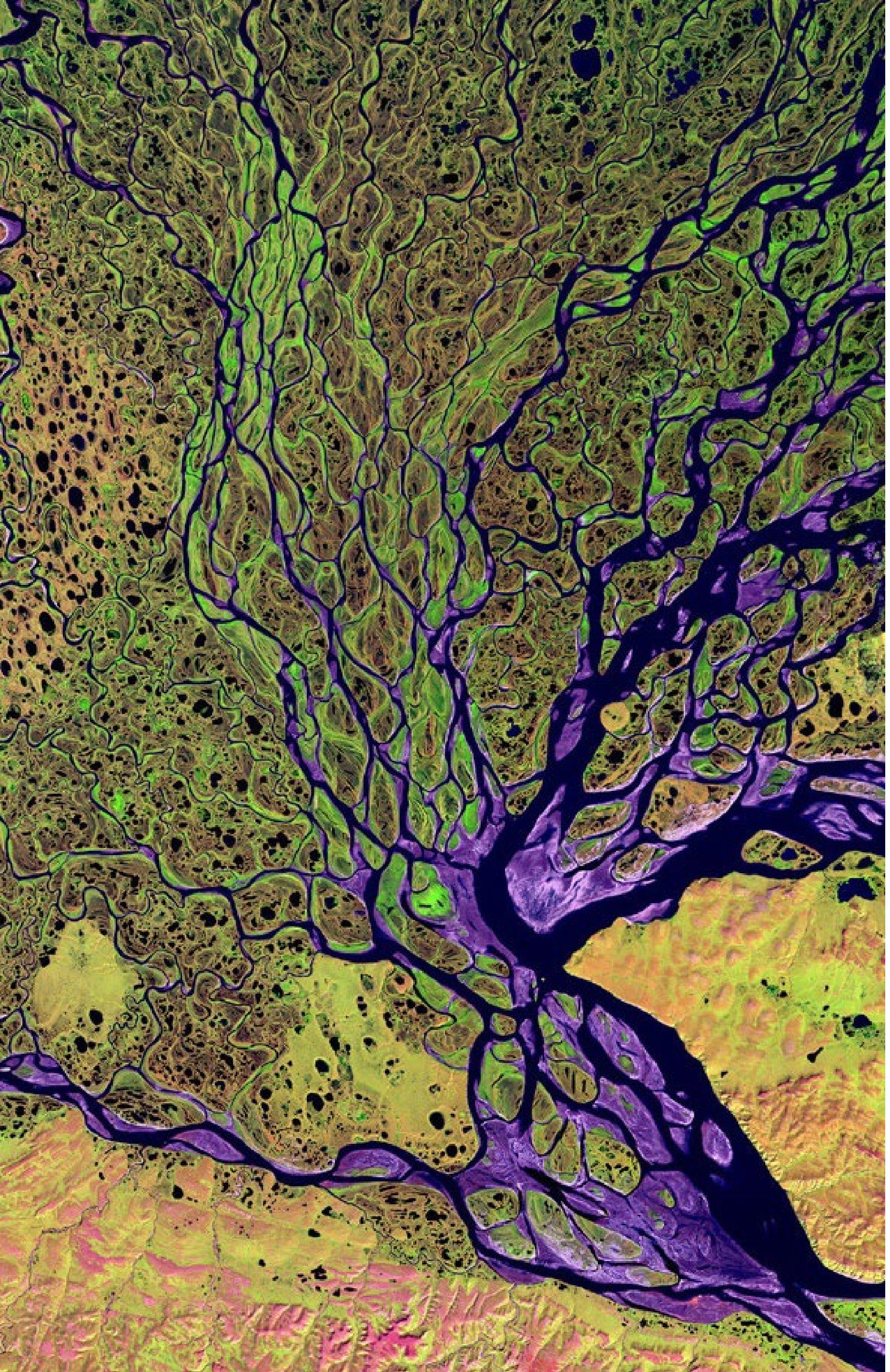

THANK YOU

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LimnoTech

The N-EWN Knowledge Series
A Continuing Education Series about Engineering with Nature

Anthony Aufdenkampe, PhD
Senior Environmental Scientist
LimnoTech

Modern, reproducible modeling workflows for water feature design

Nature-based solutions (NBS) seek to improve water quality by leveraging natural ecological and biogeochemical processes, but the interplay between these processes, especially in moving water, is challenging to anticipate. When high confidence in outcomes is needed, stakeholders often turn to numerical modeling. However, most existing water simulation tools are outdated and based on empirical relationships rather than modern, process-based simulations.

Recognizing this gap, federal agencies are promoting a vision for reproducible, process-based modeling workflows. This webinar will present this federal vision and describe LimnoTech's related work, including the development of the new ClearWater (Corps Library for Environmental Analysis and Restoration of Watersheds) modeling system. It will also cover the application of the MF6RTM package, which couples groundwater transport with geochemical reaction models for contaminant mobility in Aquifer Storage and Recovery (ASR) planning, and the use of GLM-AED libraries to assess design scenarios for the biofiltration of constructed lakes.

Save the date!
Upcoming webinars will take place the 3rd Thursday of the month.

Apr. 16
12:30pm ET
Dr. Anthony Aufdenkampe, LimnoTech
Modern, reproducible modeling workflows for water feature design

May 21
12:30pm ET
Sarah Copertino, US Army Corps of Engineers
EWN Compass: Implementation Toolbox for Natural and Nature-Based Features

Jun. 18
12:30pm ET
Dr. Mike Beck and Dr. Borja Reguero, UC Santa Cruz
Topic: TBA

Register here: https://bit.ly/3gR9ADL or scan:

1 Continuing Education Credit (CEC) is available to attendees

Recorded webinars will be posted online at: https://n-ewn.org/resources/n-ewn-knowledge-seminars/

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