Wastewater & Watershed Management

Assessment, Protection, and Restoration

From Pollution Control to Resource Recovery: A Holistic Approach.

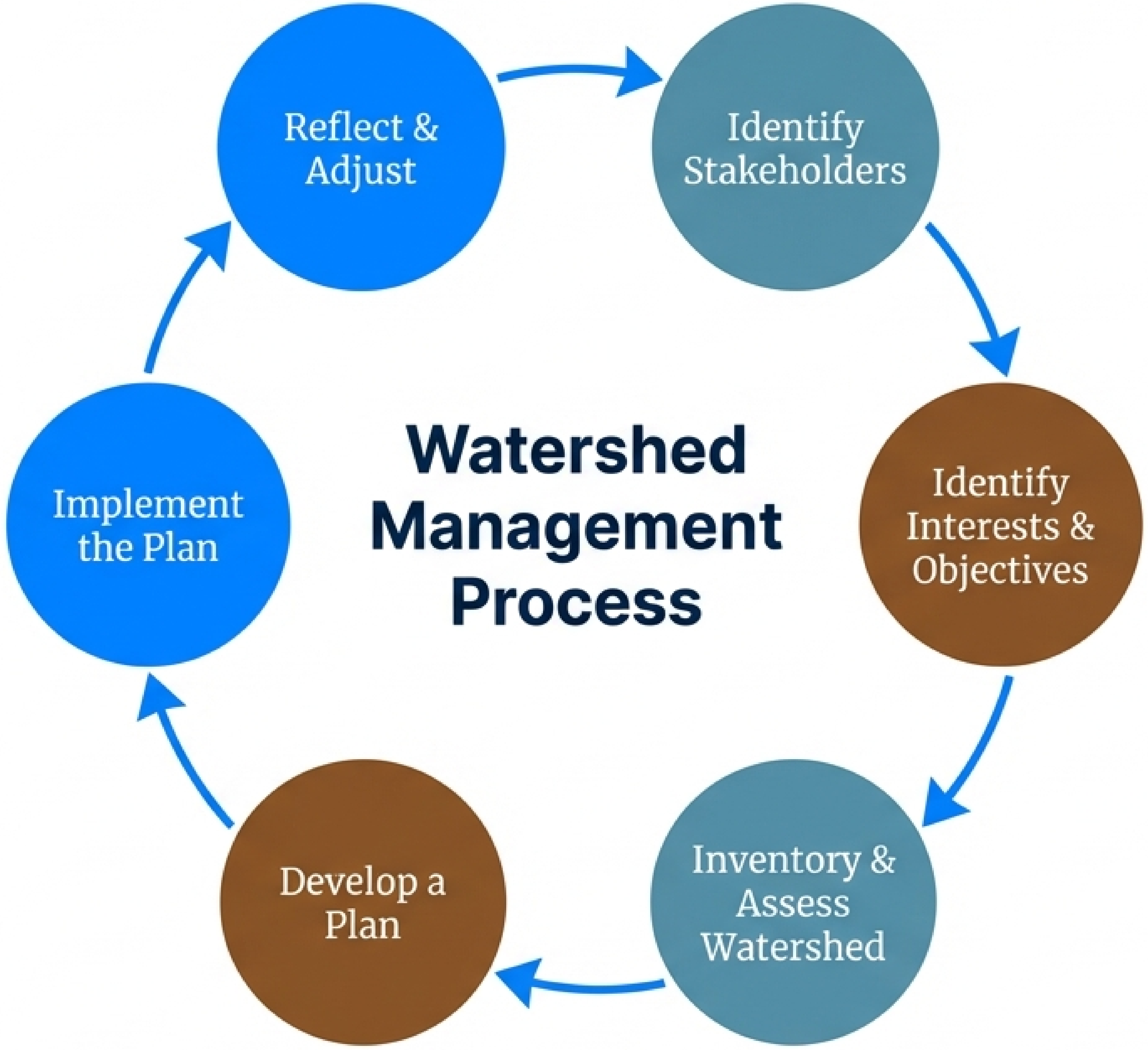
This presentation covers the complete cycle of water management: identifying the watershed, modeling water quality, engineering interventions (point and non-point), and the sustainable reuse of grey water and biosolids.

The Management Unit: Understanding the Watershed

Watershed management is the study of relevant characteristics aimed at the sustainable distribution of resources. It involves creating plans to enhance functions affecting plant, animal, and human communities.

The Scope

Management extends beyond just water quality to include water supply, drainage, stormwater runoff, and water rights. It requires coordination between landowners, land use agencies, and environmental specialists.



Technical Editorial

Defining Success: New Jersey Water Quality Standards

Surface Water Classifications

Outstanding National Resource Waters

High quality, parks, wildlife refuges.

Category One Waters

Protected from “measurable changes” due to exceptional ecological significance.

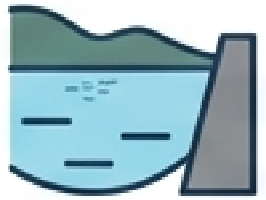
Category Two Waters

Standard designation.

The Hard Targets: Nutrient Policies

Streams

Total Phosphorus (TP) ≤ 0.1 mg/l (Unless TP is not limiting)



Lakes & Reservoirs

Total Phosphorus (TP) ≤ 0.05 mg/l

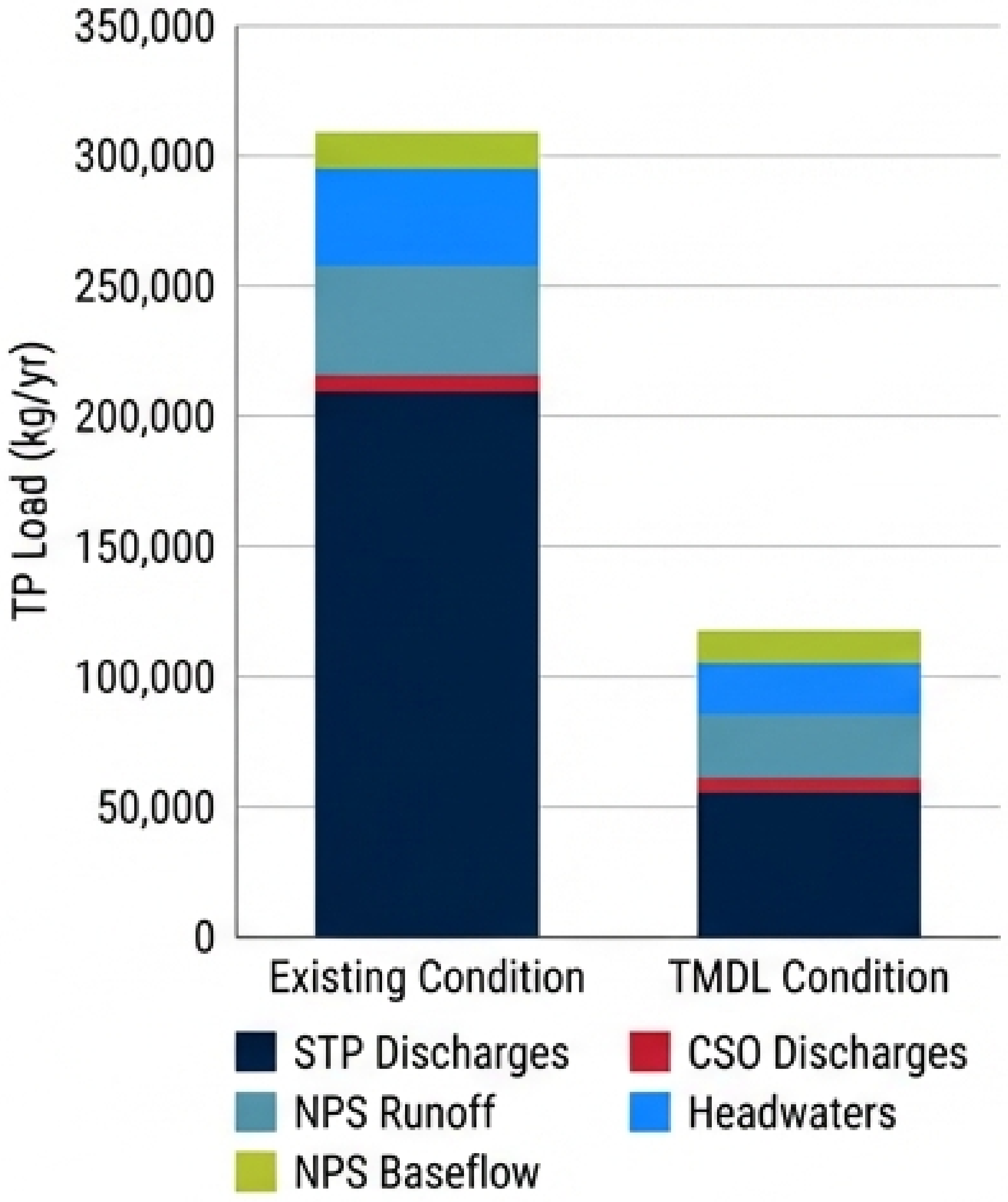
Effluent Limits: Discharge limits are set to ensure these ambient criteria are met, often requiring reductions far below the standard 1.0 mg/l b

The Pollution Budget: Total Maximum Daily Load (TMDL)

Case Study: The Non-Tidal Passaic River

Goal: Reduce chlorophyll-*a* levels to 10-20 µg/L.

Annual Average Phosphorus Loads: Existing vs. TMDL

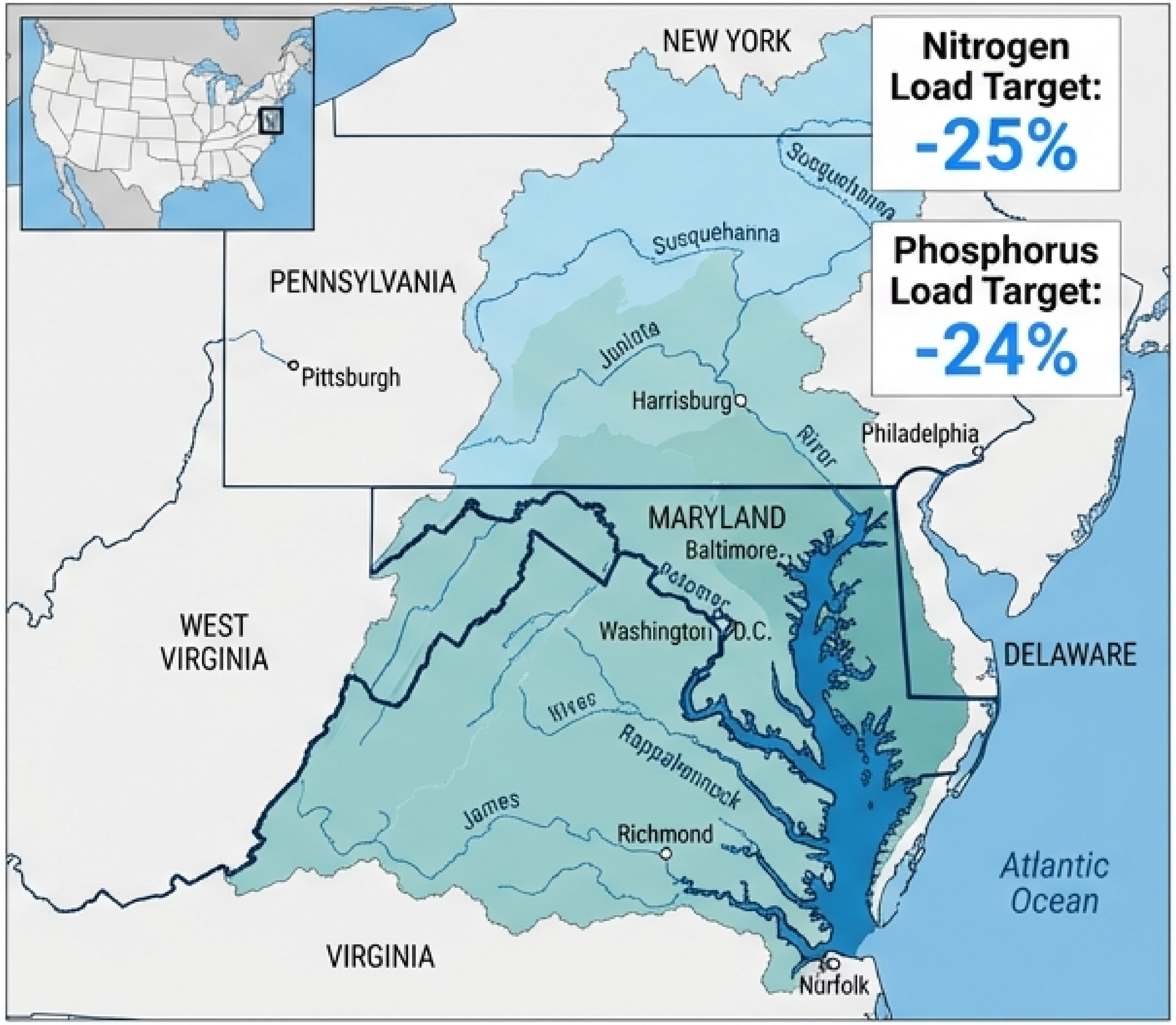


38% Reduction in Wastewater Effluent

60% Reduction in Stormwater Runoff

Case Study: The Chesapeake Bay

The largest and most complex TMDL in the U.S.

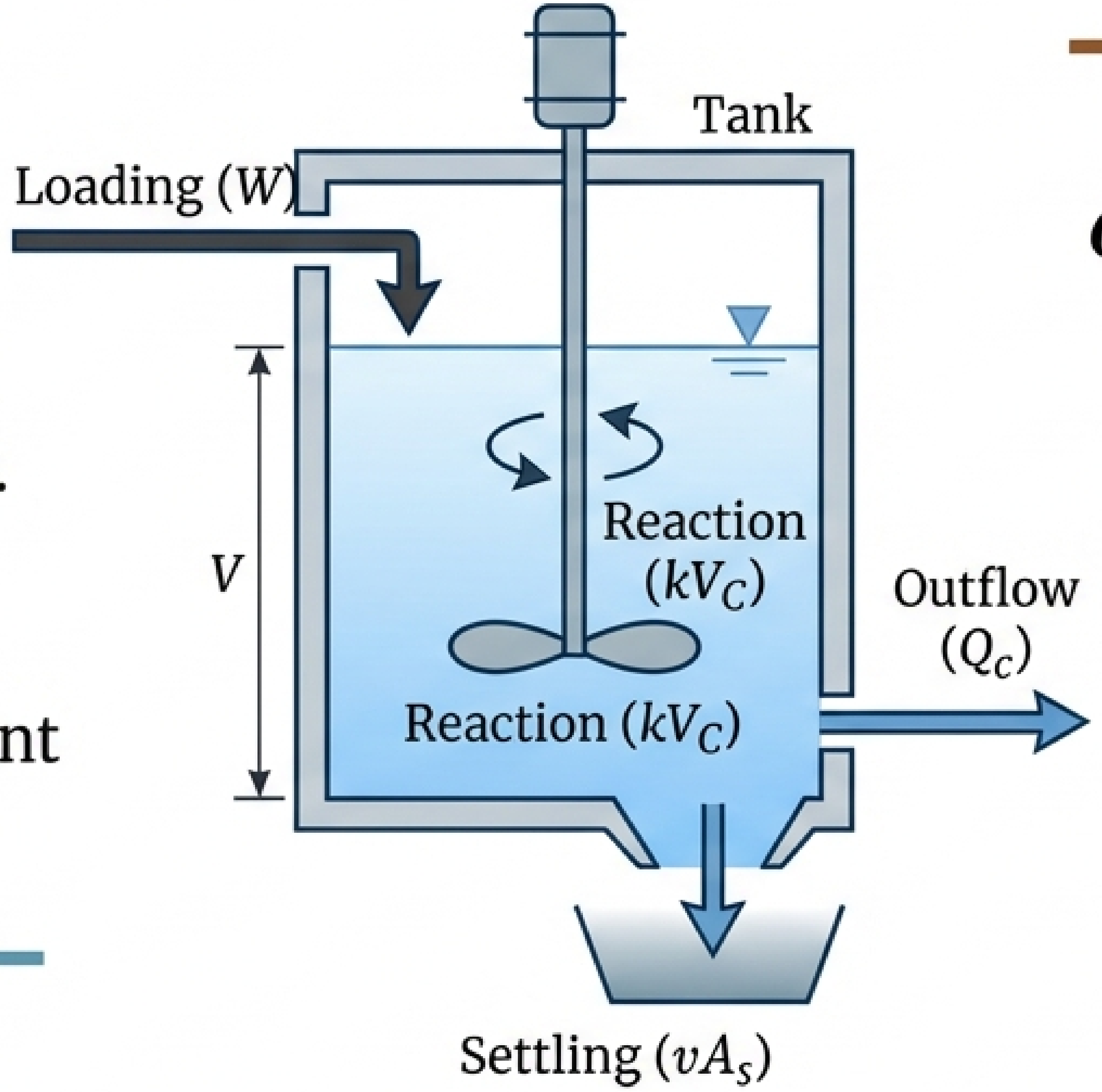


The Science of Prediction: Water Quality Modeling

The Continuously Stirred Tank Reactor (CSTR) Model

Inputs (Loading):

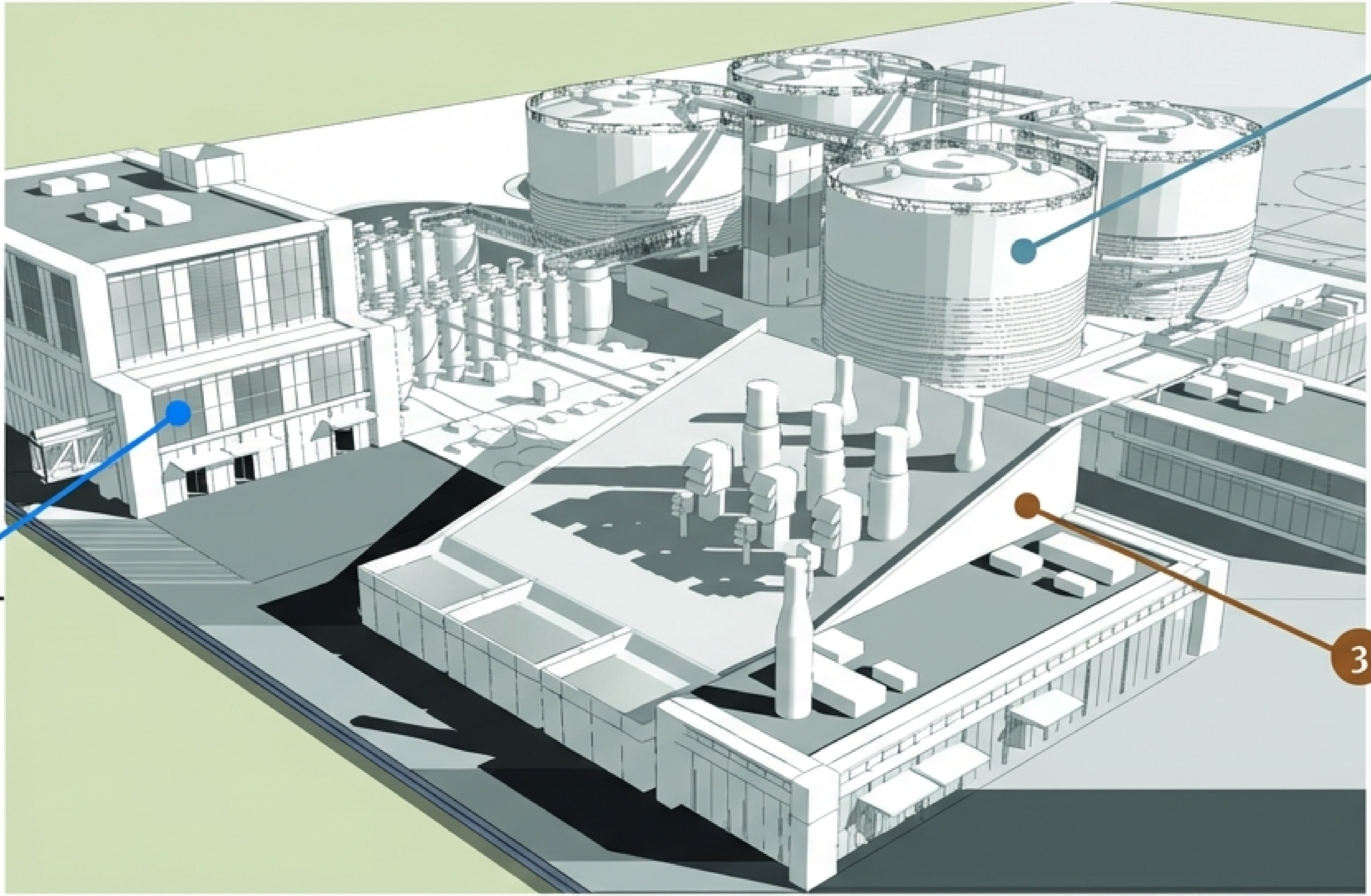
- Point Sources: Well-defined, constant (Municipal/Industrial).
- Non-point Sources: Diffuse, transient, precipitation-dependent (Runoff/Ag).



$$c = \frac{W}{Q + kV + vA_s}$$

c = Concentration
W = External Loading
Q = Flow Rate
kV = Reaction Loss
vA_s = Settling Loss

Point Source Control: Advanced Treatment & Energy Harvest



1 **Advanced Technol-ogies:** Biological Membranes, Ultrasonic Waves, Microwaves.

2 **Aerobic/Anaerobic Processes:** Microbes identified via metagenomic analysis.

3 **Resource Recovery:** Anaerobic biodigesters harvest energy from bottom sludge.

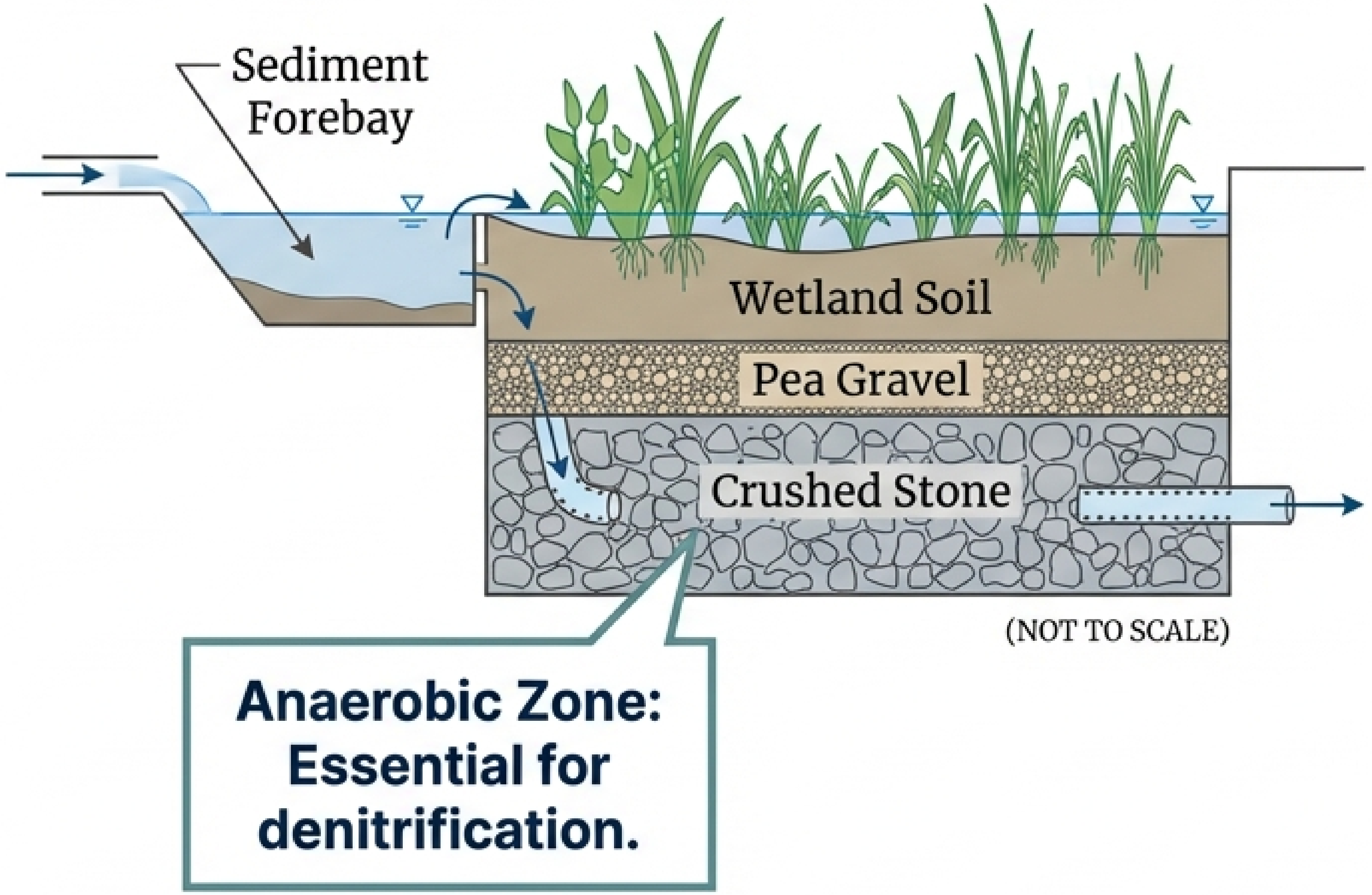
Future Frontier: Microbial Fuel Cells for direct electrical power generation from wastewater.

Non-Point Source Control: The Barnegat Bay Rules

The Regulatory Checklist (2011)

- ✔ **Fertilizer:** 20% slow-release nitrogen minimum.
- ✔ **Soil Testing:** Phosphorus prohibited unless deficit proven.
- ✔ **Buffers:** No application near river banks.
- ✔ **Soil Health:** Mandatory decompression of compacted soil.
- ✔ **Infrastructure:** Conversion of detention basins to Subsurface Gravel Wetlands.

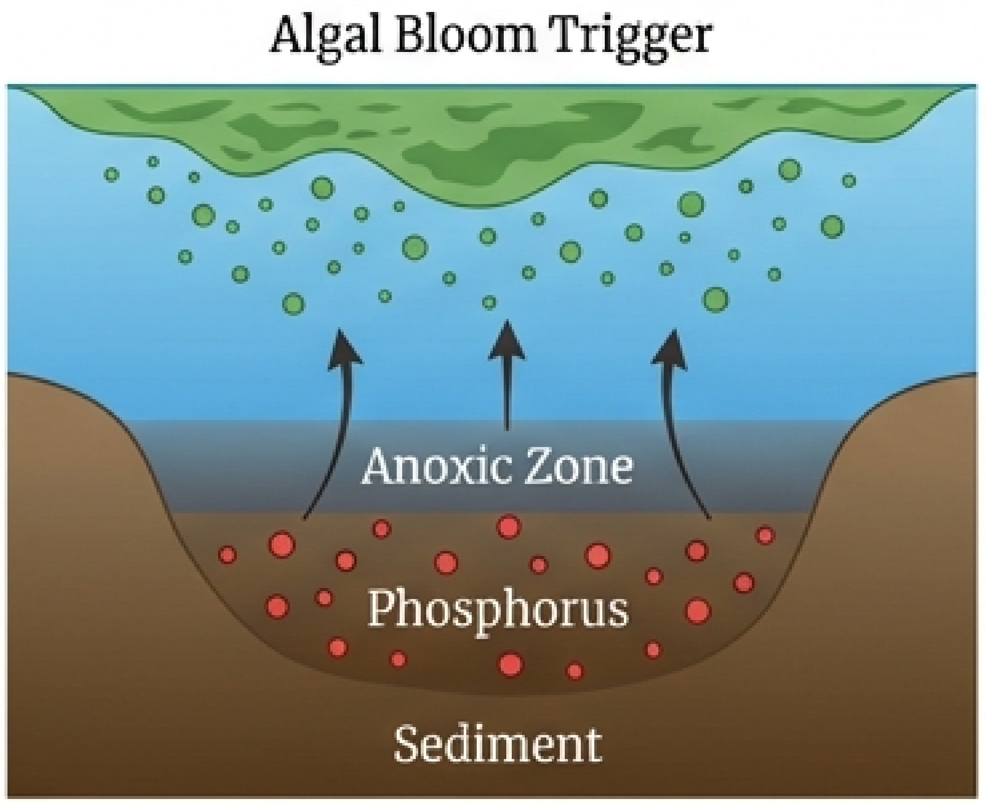
Technical Solution: Subsurface Gravel Wetland



Internal Source Control & In-Situ Treatment

Addressing pollution stored in bottom sediment.

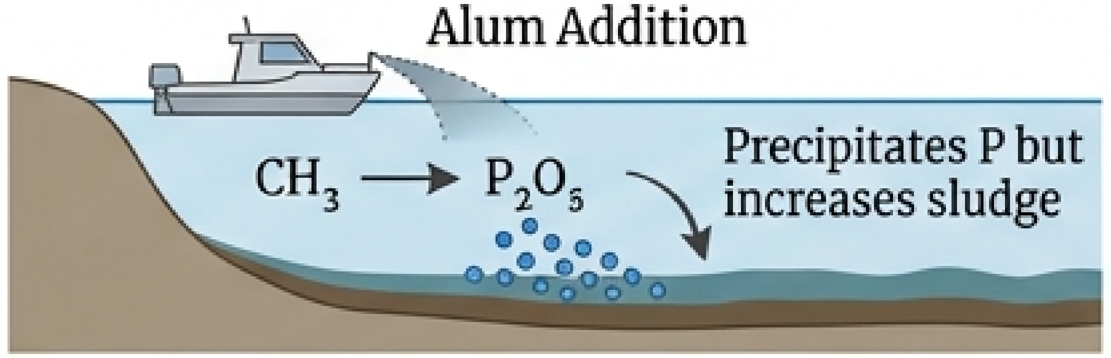
The Problem



Phosphorus release from sediment during anoxic conditions triggers algal blooms.

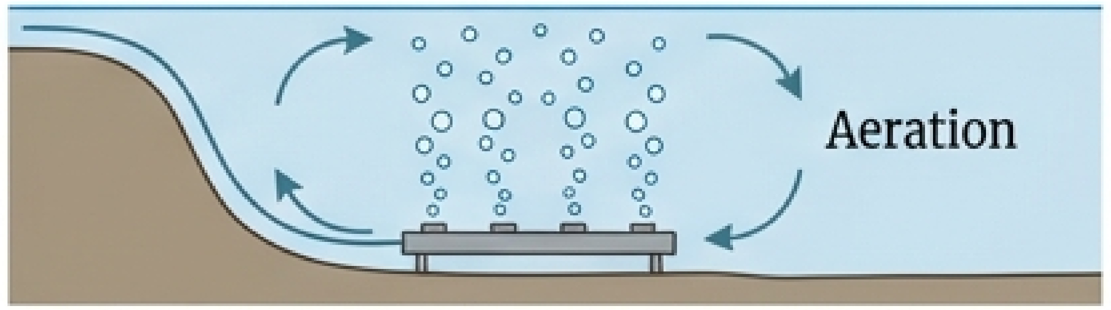
Alien Interventions (Less Desirable)

Chemicals:



Alum addition (precipitates P but increases sludge).

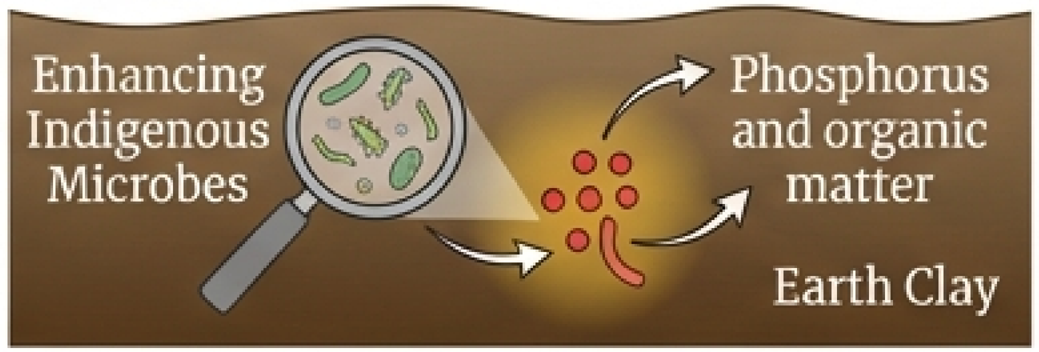
Physical:



Aeration.

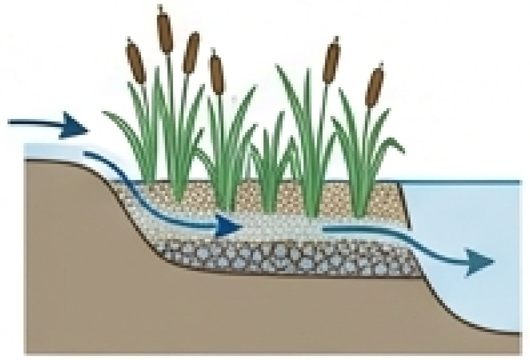
Self-Purification (The Goal)

Bio-stimulation:

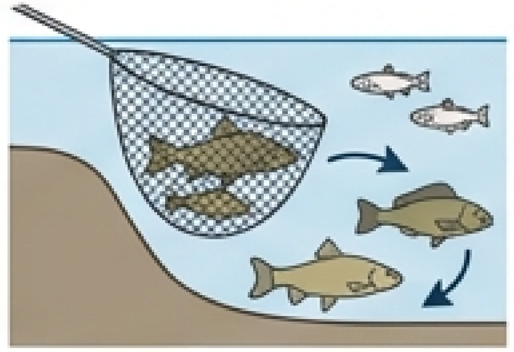


Enhancing indigenous microbes.

Case Study: Lake Apopka, FL:



Marsh Flow-Way Restoration (filtering).



Rough Fish Harvesting (food web manipulation).

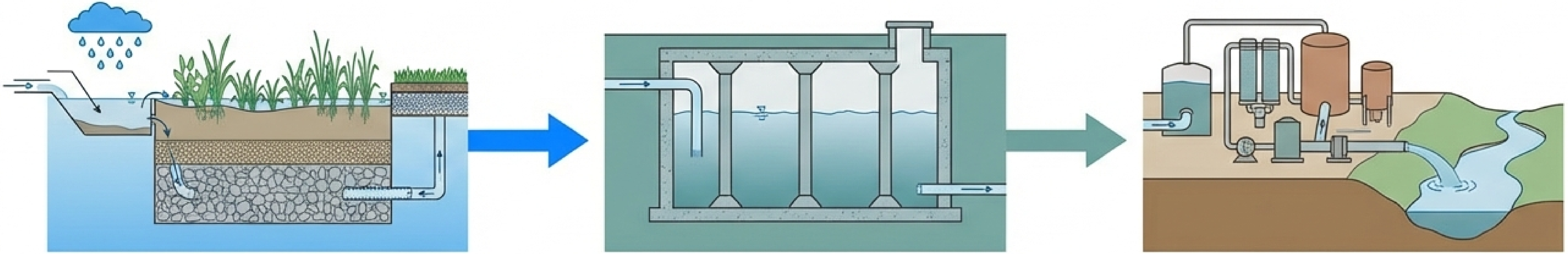
A water body has self-purification capability. Engineering should enhance, not replace, this natural function.

The Infrastructure Challenge: Combined Sewer Overflows (CSOs)

The Scope

850 Billion gallons of raw sewage and stormwater discharged annually in the U.S.

Three Methods of CSO Control



1. **Reduction:** Reduce Runoff Volume (Green Infrastructure).
2. **Storage:** Store for later treatment.
3. **High-Rate Treatment:** Treat overflow at the outfall.

CSO Control Strategies: Integrated Approach

Closing the Loop: Grey Water Reuse

Non-potable applications for treated water in an era of scarcity.

Applications

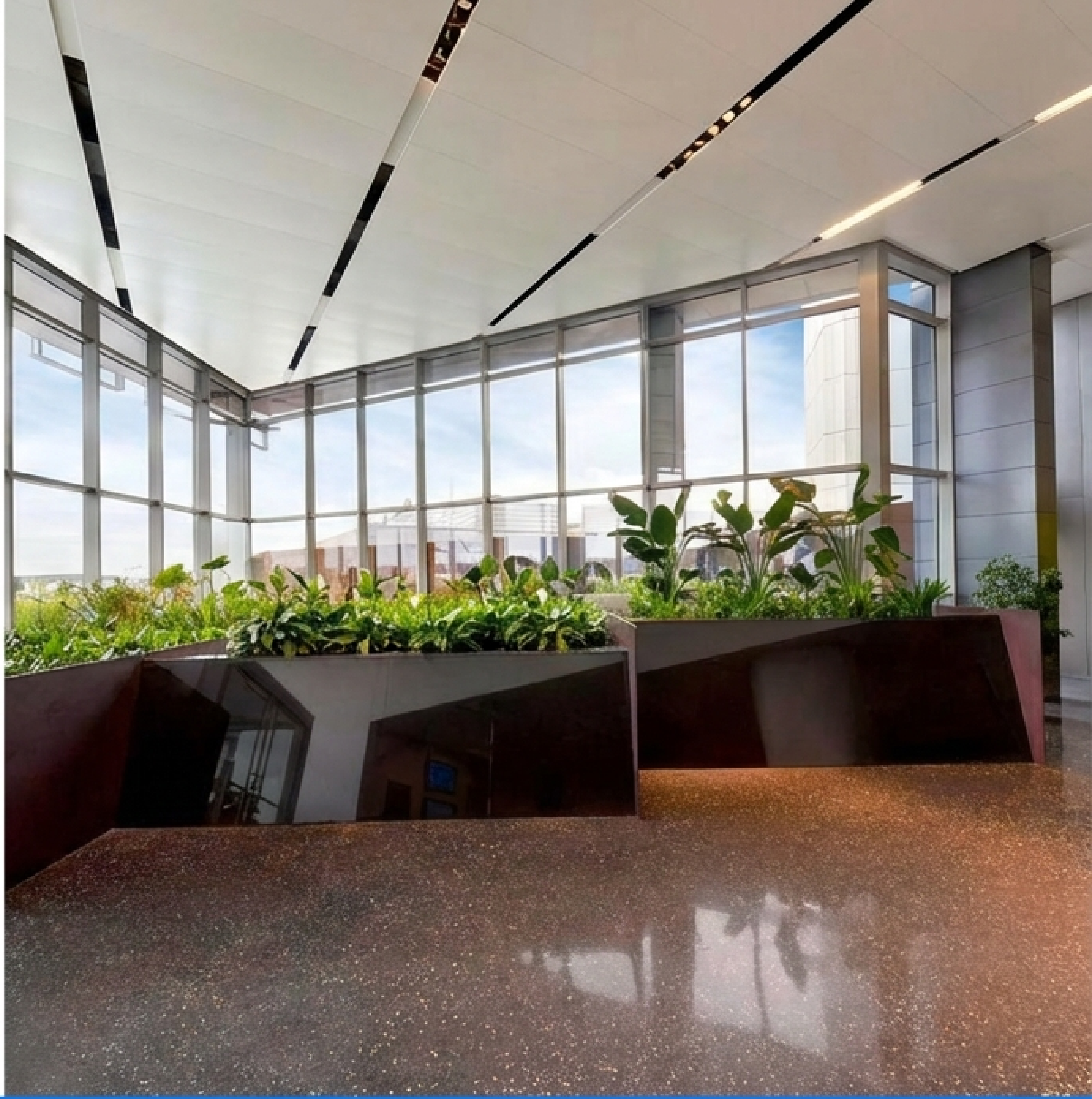
- Landscape & Agricultural Irrigation
- Toilet Flushing
- Industrial Cooling
- Saltwater Intrusion Barrier

Global Case Studies

St. Petersburg, FL (1977): Extensive irrigation network.

Tokyo, Japan (1984): Shinjuku District high-rise recycling.

The Solaire, NYC (2000): In-building reuse for cooling and green roofs.



Grey water reuse is a critical component of sustainable water management.

The Risks of Reuse: Pathogens & Contaminants

Reuse requires strict regulation due to cross-contamination risks and emerging contaminants (EDCs).

Pathogen Survival Rates on Crops.

Pathogen/Target	Crop/Condition	Conditions/Month	Survival (days)/Required Time
Salmonella	Radish/Lettuce	Sunny	**10 days**
Salmonella	Radish/Lettuce	Shady	**31 days**
Poliovirus	Grass	30-42°C	**0.33 days**
Poliovirus	Grass	4-16°C	**2 days**
Romaine Lettuce (Target: 99% Reduction)	(Required Time)	July	**5.9 days**

Data Source Note: <IMAGE 2> and <IMAGE_3>.

From Sludge to Biosolids: Regulatory Framework

‘Biosolids’ are nutrient-rich organic materials resulting from the treatment of sewage sludge. (EPA 40 CFR Part 503).

Class B Biosolids

- Pathogens reduced but not eliminated.
- Restricted Use: Crop harvesting waiting periods (30 days - 1 year).
- Public access restricted.

Further Treatment / Time →

Class A Biosolids

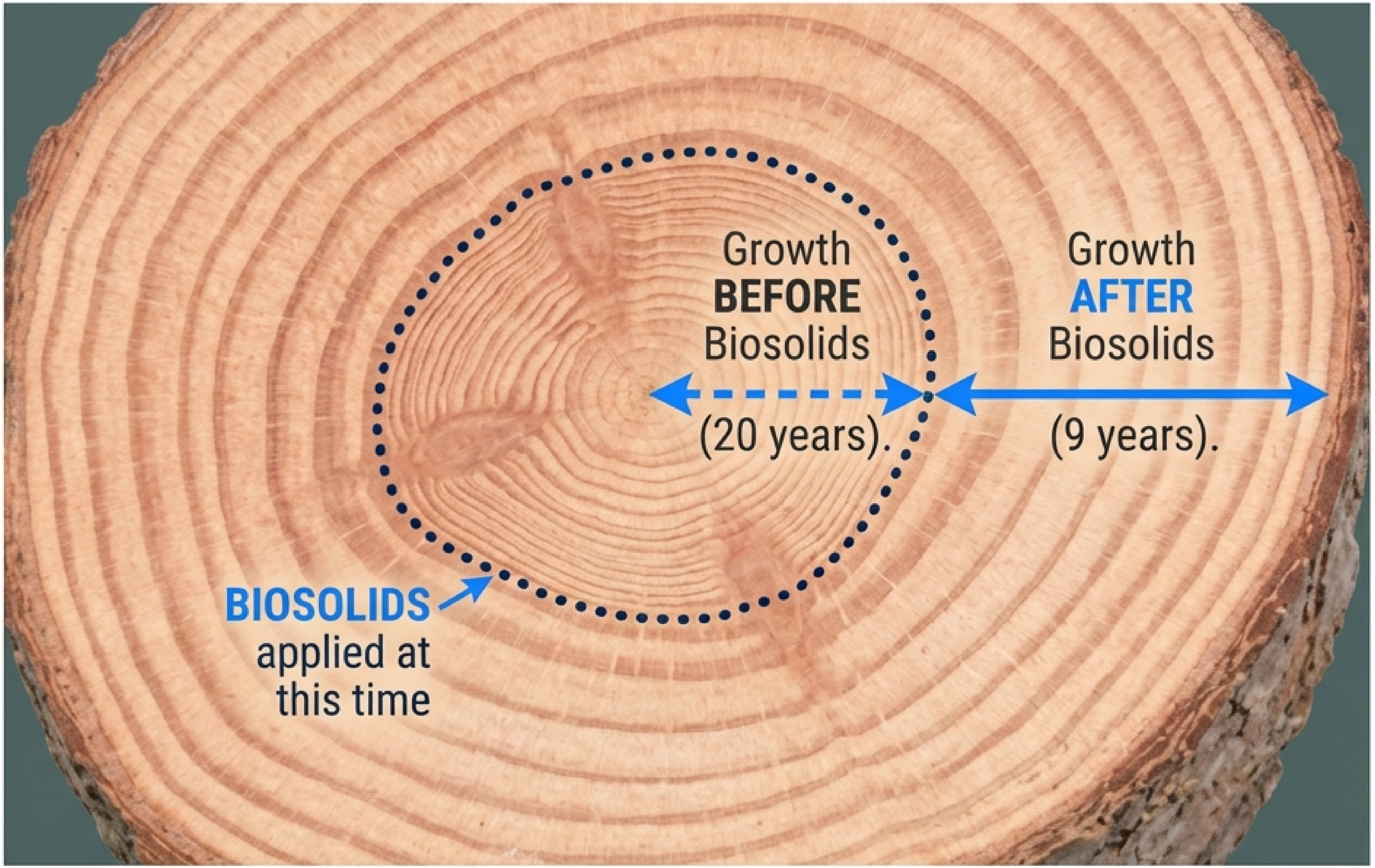
- Pathogens virtually eliminated.
- Vector attraction reduced.
- No site restrictions.

Exceptional Quality (EQ)

- Meets most stringent metal/pollutant limits.
- Can be sold as standard fertilizer.

Regulatory frameworks ensure the safe and beneficial reuse of biosolids.

Beneficial Use: Restoring the Earth



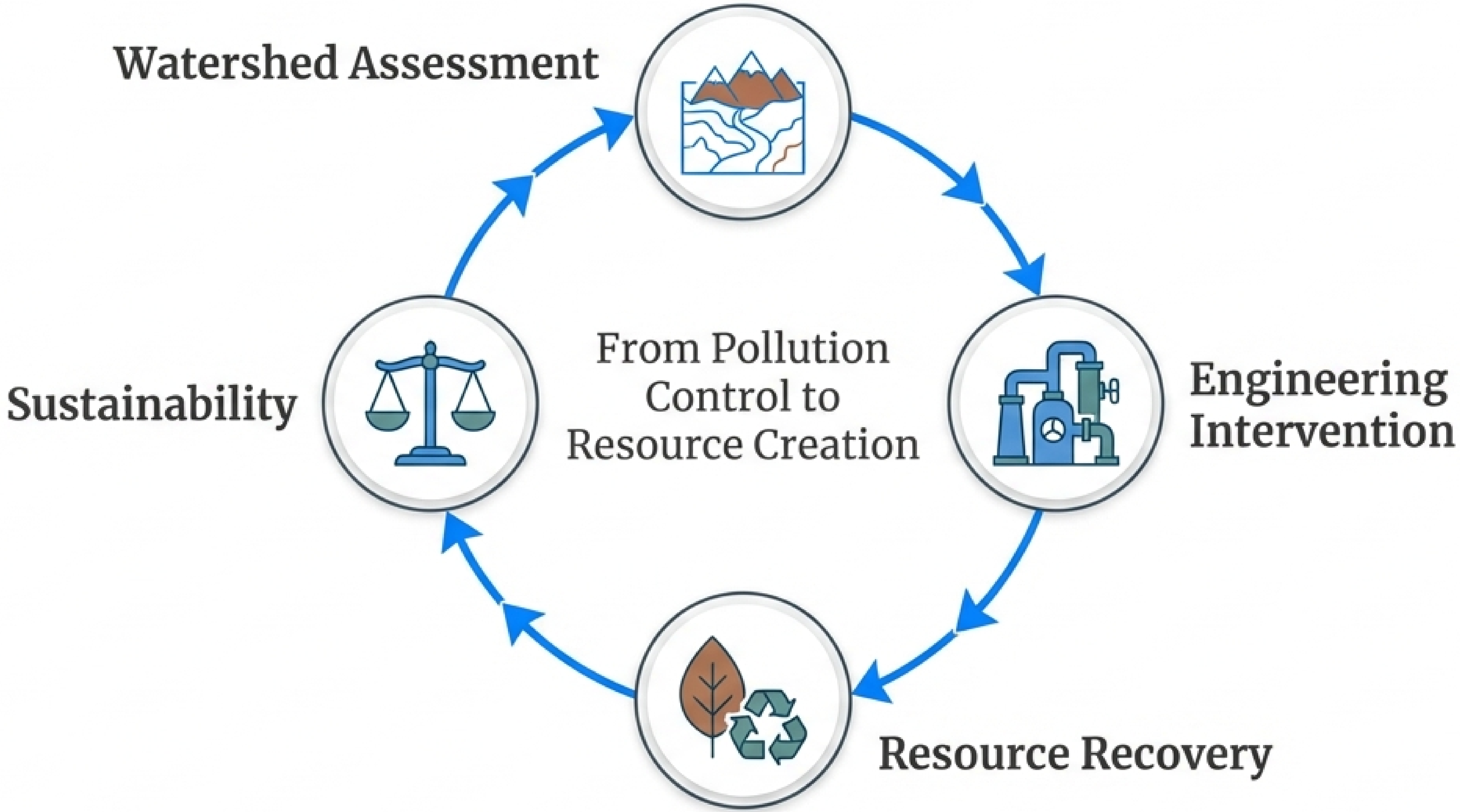
Visual evidence of forestry growth rate acceleration using biosolids (King County, WA).

Applications:

- **Land Reclamation:** Restoring strip mines, gravel pits, and landfills.
- **Forestry:** Soil amendment for carbon-depleted lands.
- **Key Factor:** Balancing Nitrogen/Phosphorus content vs. heavy metals.

NotebookLM

Integrated Water Resources Management



Through the TMDL process and advanced engineering, we do not just protect the environment; we recover valuable resources, quantitatively reducing costs and ensuring sustainability for future generations.