The Science and Engineering Behind EPA's Water Modeling – Celebrating 50 Years of Progress and Charting a Path for the Future

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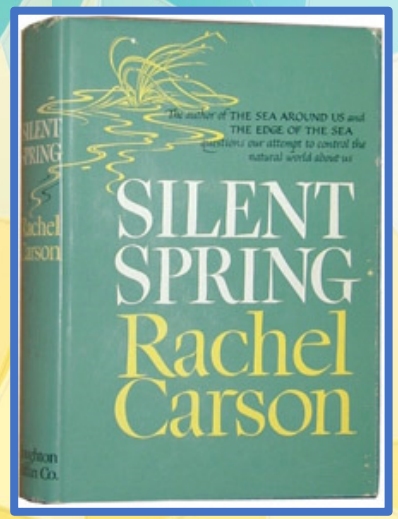
Center for Environmental Solutions and Emergency Response

Presentation Overview

- A Brief History of the EPA
- EPA's Water Research Highlights
- Current Water Research Priorities
- Water Modeling Today at EPA
- Looking to the Future

The Origins of the US Environmental Protection Agency



EPA Established December 2, 1970

First Earth Day

NEPA

Administrati

COUNCIL ON ENVIRONMENTAL QUALITY

EPA Early Actions to Address Critical Issues

Clean Air Act

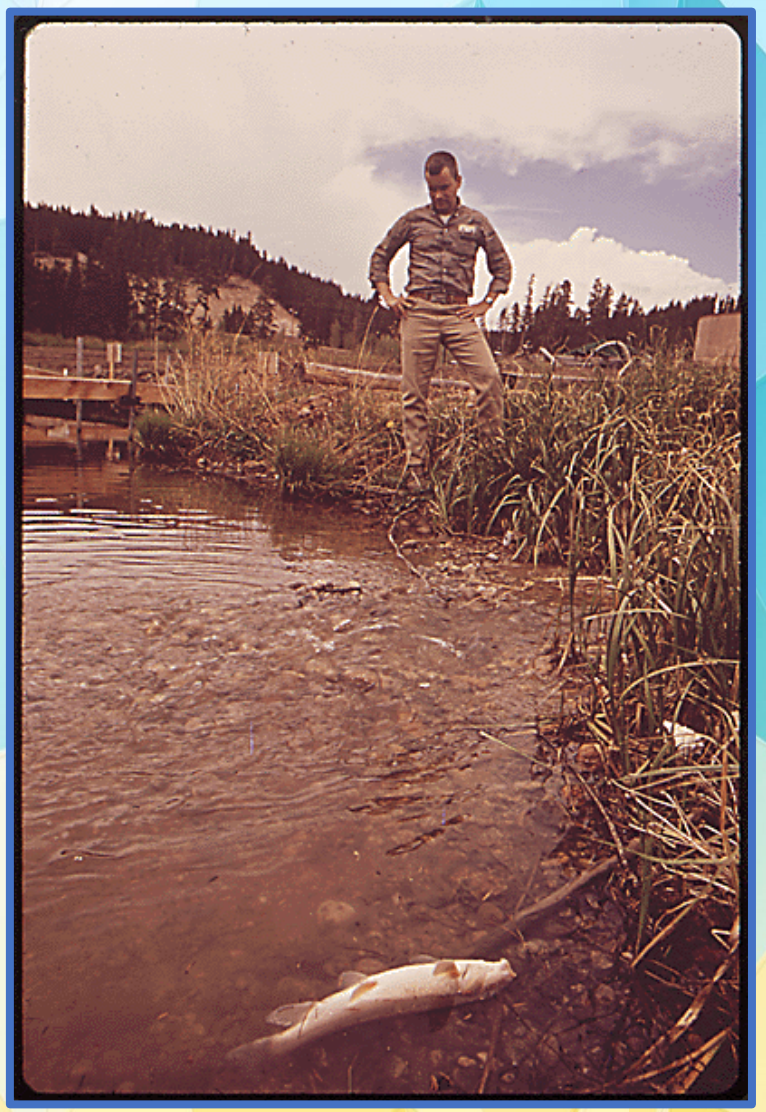
Air Quality Standards

Car Fuel Economy

Lead Based Paint Restrictions and Gasoline Phaseout

DDT Ban

EPA Early Actions to Address Water Issues



Clean Water Act

Great Lakes Water Quality Agreement

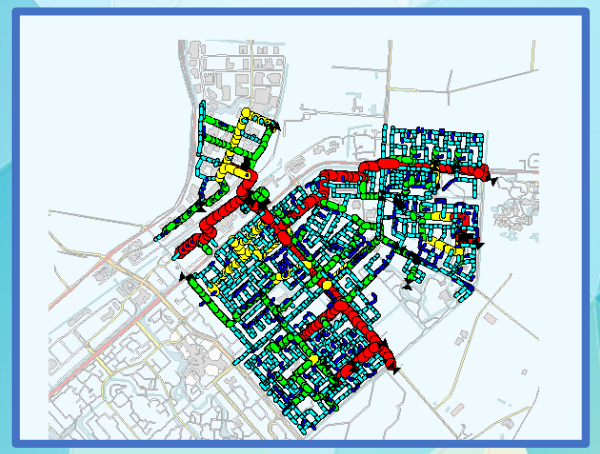
Ocean Dumping Act

Safe Drinking Water Act

EPA Opens Water Research Facility in Cincinnati

EPA Water Research Highlights

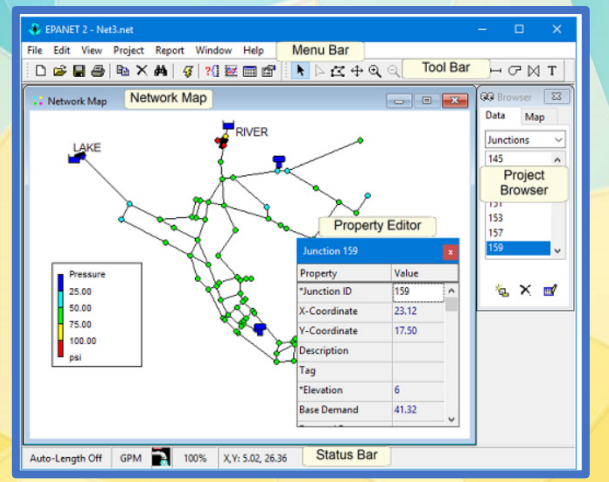
Analytical Methods



SWMM

Security & Resilience

Treatment Technologies



EPANET

Green Infrastructure

Current EPA Water Research Priorities

Clean Water Act

Safe Drinking Water Act

Watersheds

Nutrients and Harmful Algal Blooms

Water Treatment and Infrastructure

SAFE AND SUSTAINABLE WATER RESOURCES RESEARCH PROGRAM

Watersheds Research Areas

Research Area 1

Assessment, Monitoring, and Management of Aquatic Resources

Nationally consistent and scientifically defensible assessments of U.S. waters to implement the National Aquatic Resource Surveys (NARS).

Research Area 2

Improved Aquatic Resource Mapping

Methodologies, tools, and datasets for aquatic resource mapping of waters of the United States.

Research Area 3

Human Health and Aquatic Life Criteria

Science to support EPA's Office of Water (OW) to assist regions, states, and tribes with new or revised water quality criteria and their implementation, including support to protect human health and aquatic life from pollutants in surface water.

Nutrients and Harmful Algal Blooms

Research Area 1

Assessment and Management of HABs

Provide stakeholders and decision-makers at the national, regional, state, and local levels with scientific information and tools to more effectively assess and manage HABs and associated toxicity events.

Research Area 2

Science to Support Nutrient-Related Water Quality Goals

Advance the science to inform decisions related to nutrient and co-pollutant water quality goals of program offices, regions, states, and tribes.

Research Area 3

Assessment and Management of Nutrients

Support to plan, implement, and track the effectiveness of nutrient reduction strategies at multiple scales, including watersheds draining to receiving waters potentially affected by HABs or other nutrient-related water quality issues.

Water Treatment and Infrastructure Research

Research Area 7 Drinking Water/Distribution Systems

Provide essential results and tools for managing existing and future drinking water needs. Specifically, it focuses on areas of recent concern that require novel solutions.

Research Area 8 Per- and Polyfluoroalkyl Substances (PFAS)

Robust analytical methods for analyzing PFAS in water, solids, and tissues, and a website for treatment and pretreatment recommendations for wastewater and reuse.

Research Area 9 Wastewater/Water Reuse

Guidance on new and existing treatment technologies and analytical methods for emerging contaminants and contaminant risks.

Research Area 10 Integrated Stormwater Management

Integrated aspects of green/gray infrastructure and stormwater flow control to help states, municipalities, and utilities reduce the number of combined sewer overflows.

Research Area 11 Technical Support

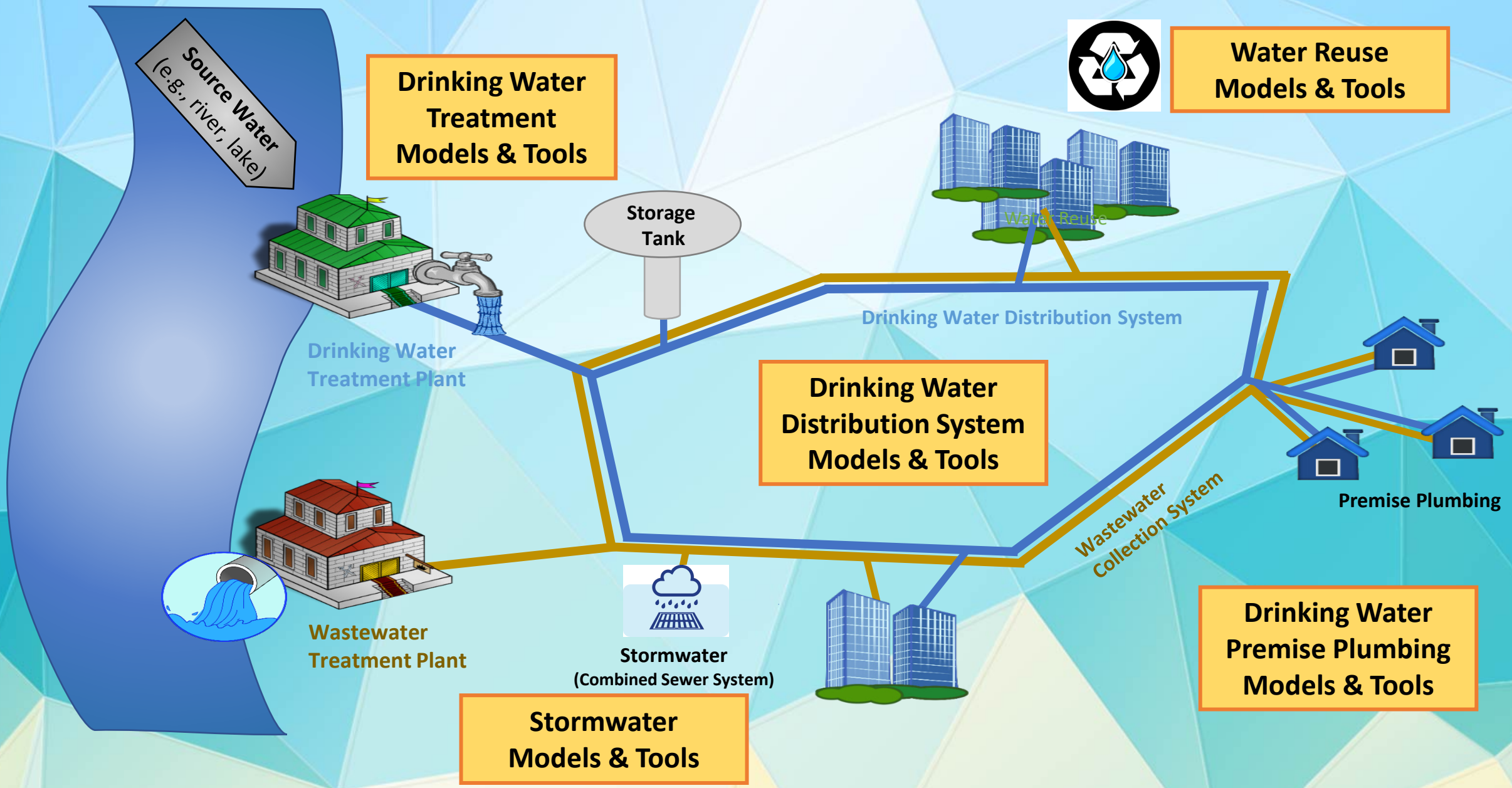
Provide a means for rapid response to specific, unplanned program office, state, tribe, and community research needs concerning high-priority issues.

Water Modeling at EPA

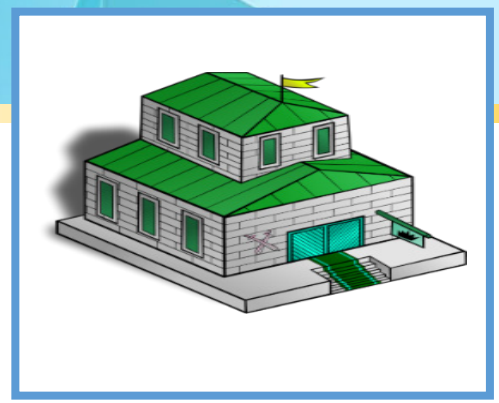
Guiding Principles

- Customer driven - EPA's Office of Water, Regional offices, states, communities
- Meeting national priorities
- Solving problems
- Freely available, open, transparent, reproducible

Water Infrastructure Models and Tools

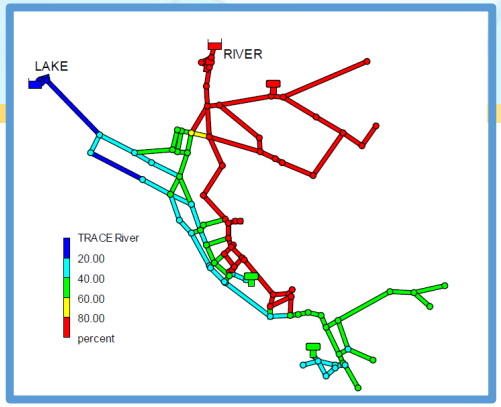


Drinking Water Models and Tools



Drinking Water Treatment Models & Tools

- Disinfection
- Treatment
- Treatability DB



Drinking Water Distribution System Models & Tools

- EPANET
- EPANET-MSX
- Real-time
- Resilience

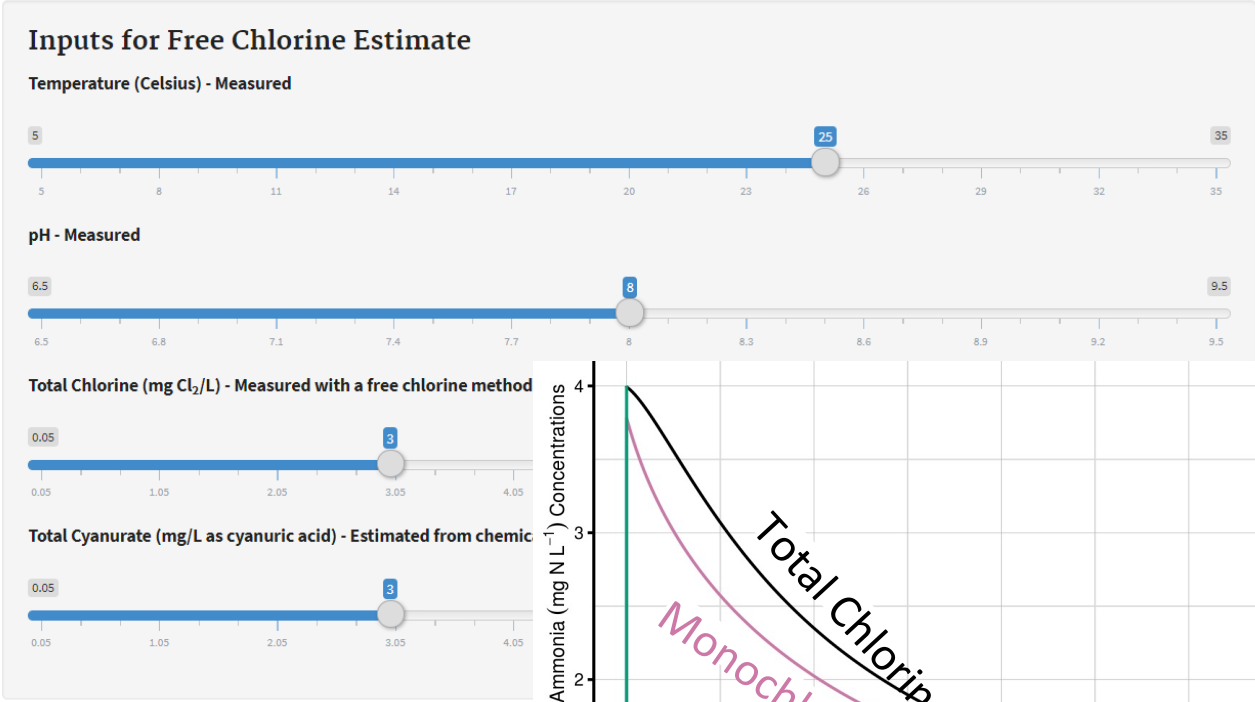
Drinking Water Premise Plumbing Models & Tools

- PPM Tools

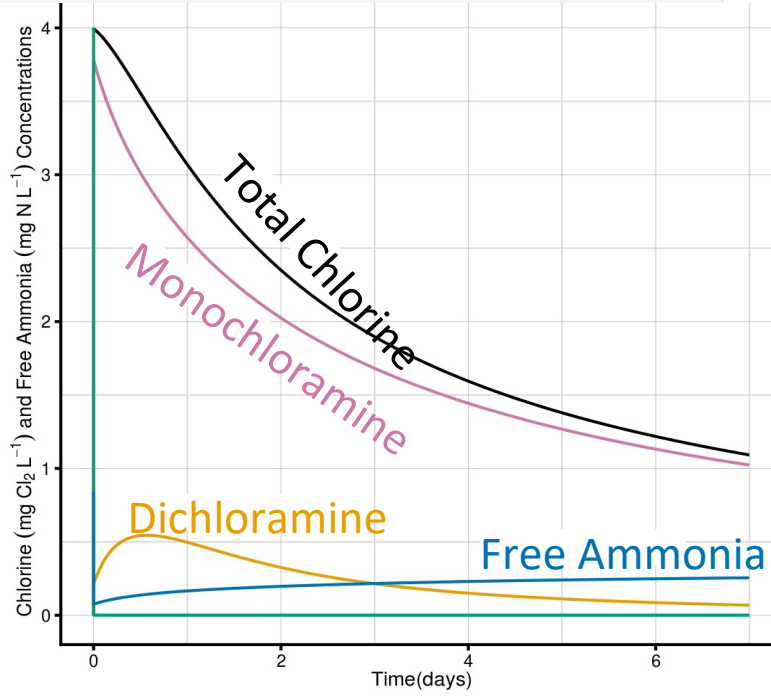
Access these models and tools through EPA's Science Models and Research Tools (SMaRT) Search

Drinking Water Disinfection Models

- **Web-based calculators**
  - Chloramine formation and decay
    https://shiny.epa.gov/cfd/
  - Chlorine breakpoint curve
    https://shiny.epa.gov/cbcs/
  - Chlorine and cyanuric acid chemistry
    https://shiny.epa.gov/fccas/
  - Free chlorine estimator for dichlor/trichlor disinfection
    https://shiny.epa.gov/fcedts



Estimated free chlorine concentration =



Drinking Water Treatment Models

Environmental Technologies Design Option Tool (ETDOT)

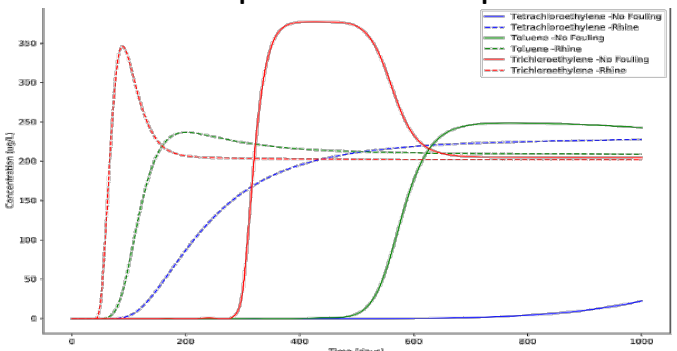
- Suite of software for modeling a variety of treatment technologies.
- Originally developed by Michigan Technological University (MTU).
- Includes models for adsorption, advanced oxidation, aeration, biofilters, PAC adsorption, ion exchange.

  http://www.epa.gov/water-research/environmental-technologies-design-option-tool-etdot

- **Granular Activated Carbon Model**
  - Pore and Surface Diffusion Model (PSDM)
  - Includes parameter estimation
- **Ion Exchange Media**
  - Supports gel-type, macroporous ion exchange resins & competition from divalent ions, such as sulfate

https://github.com/USEPA/Water_Treatment_Models

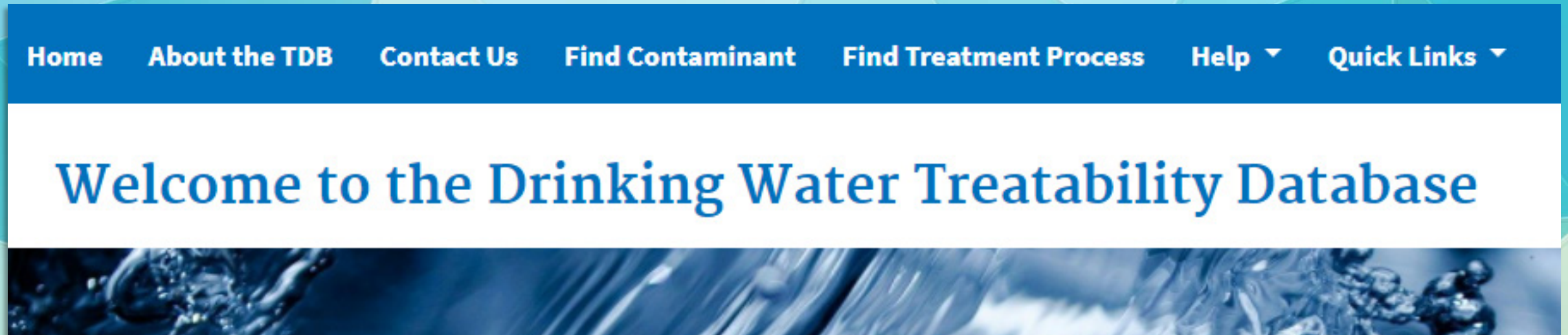
Competitive Adsorption



Treatment Tools: Treatability Database

- Interactive searchable database.
- 123 regulated and unregulated contaminants.
- 35 treatment processes commonly employed or known to be effective.
- Referenced information gathered from thousands of literature sources.

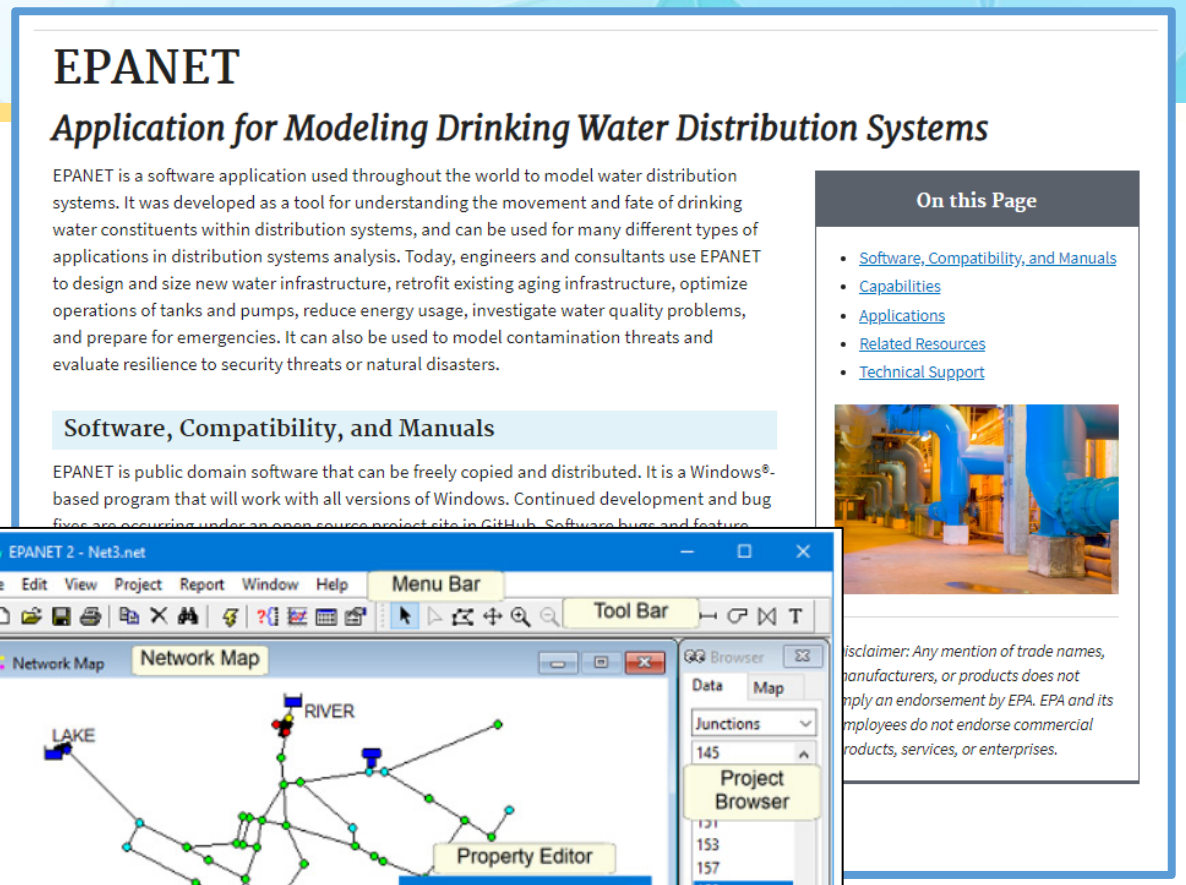
epa.gov/water-research/drinking-water-treatability-database-tdb

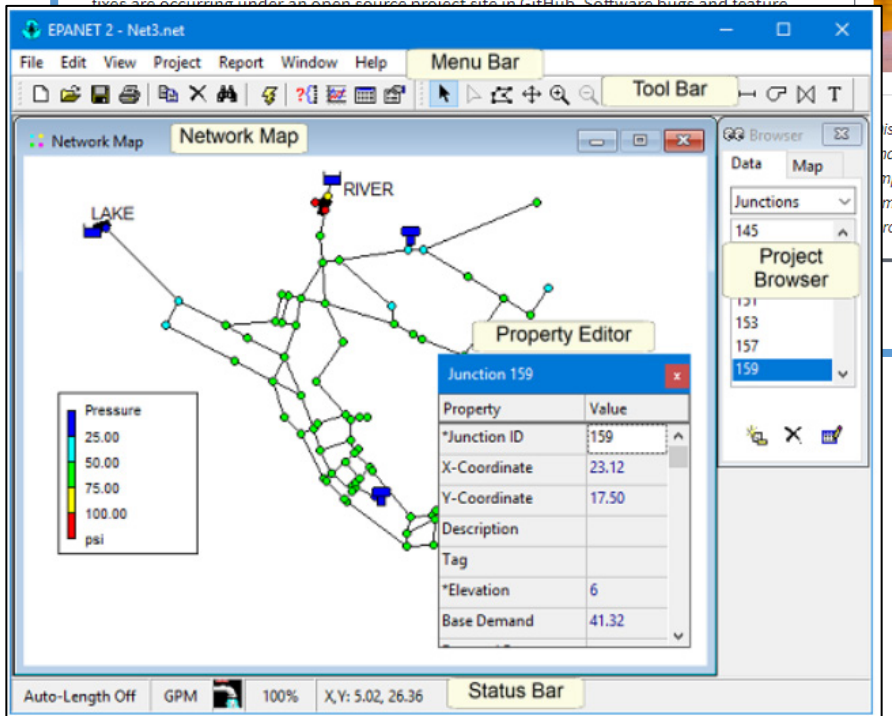


Distribution System Model: EPANET

- Simulates hydraulics within a water distribution network.
- Models decay/growth of a single substance.
- More than 50,000 downloads per year.
- Components utilized for multiple commercial software packages.
- Latest official release: version 2.2 in July 2020.

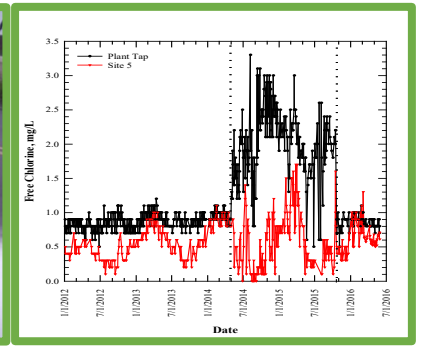
epa.gov/water-research/epanet





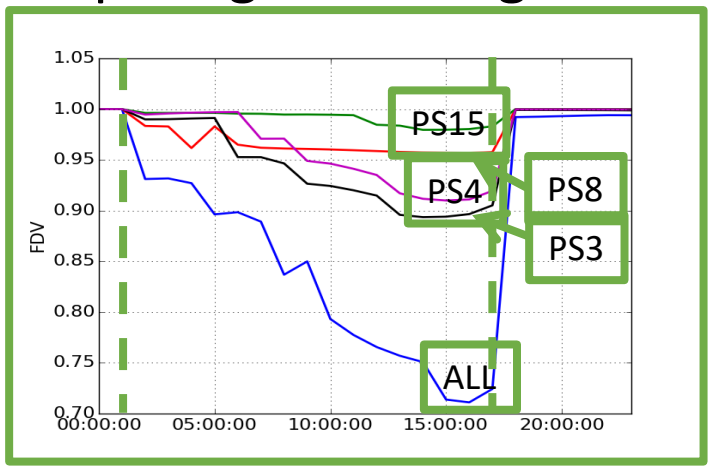
EPANET Typical Uses and Applications

Solving Regulatory Problems

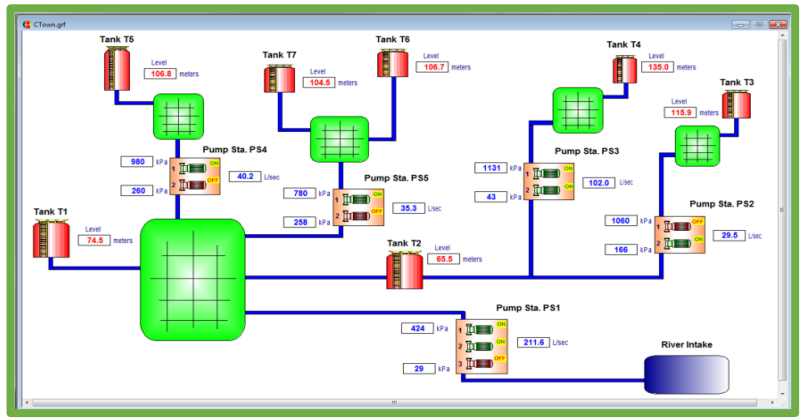


Designing and Replacing Aging Infrastructure

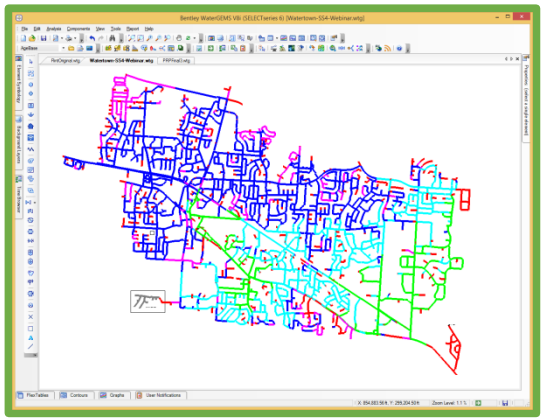
Preparing for Emergencies



Optimizing Operations to Improve Water Quality

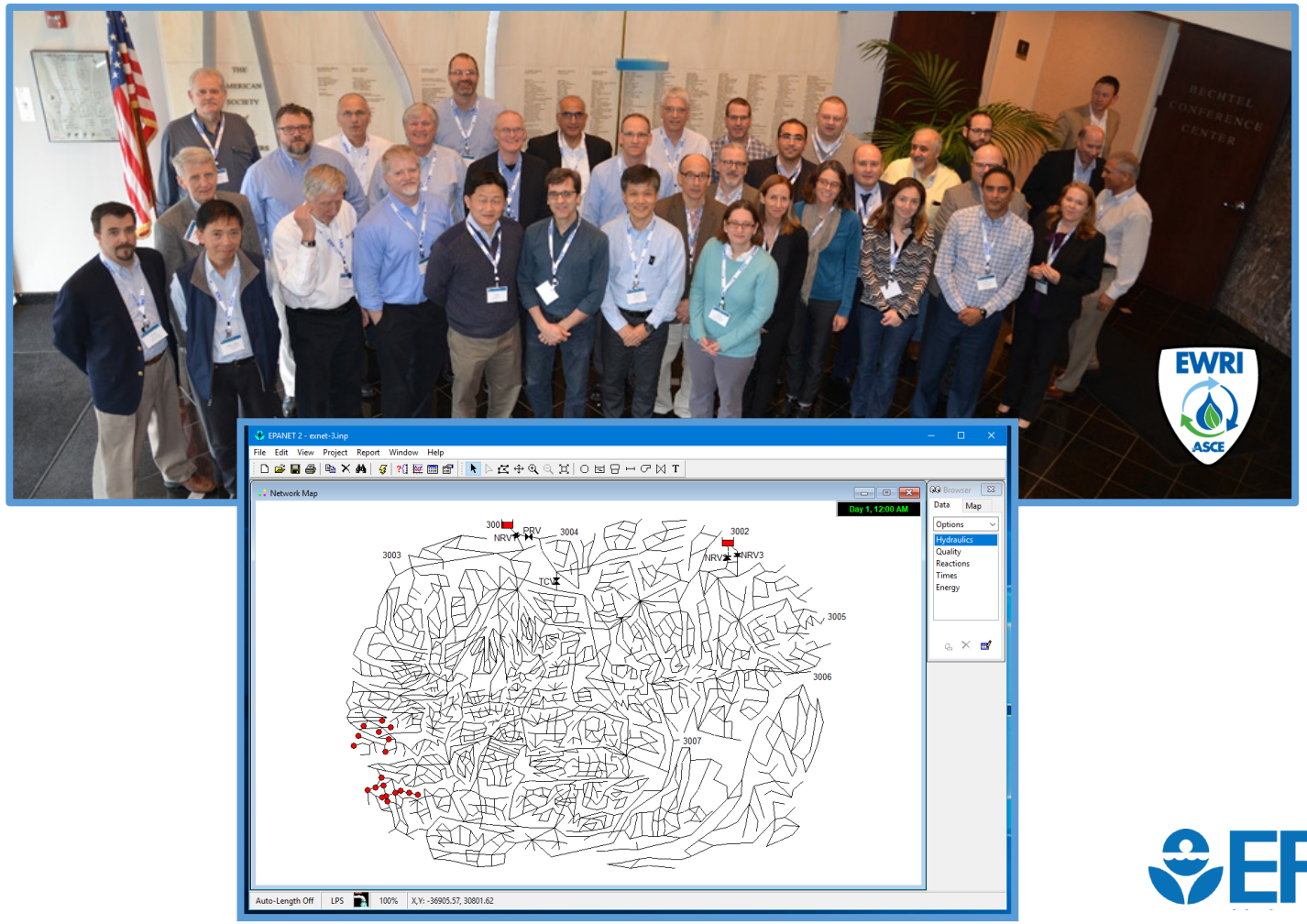


Real-time Operations and Decision Making



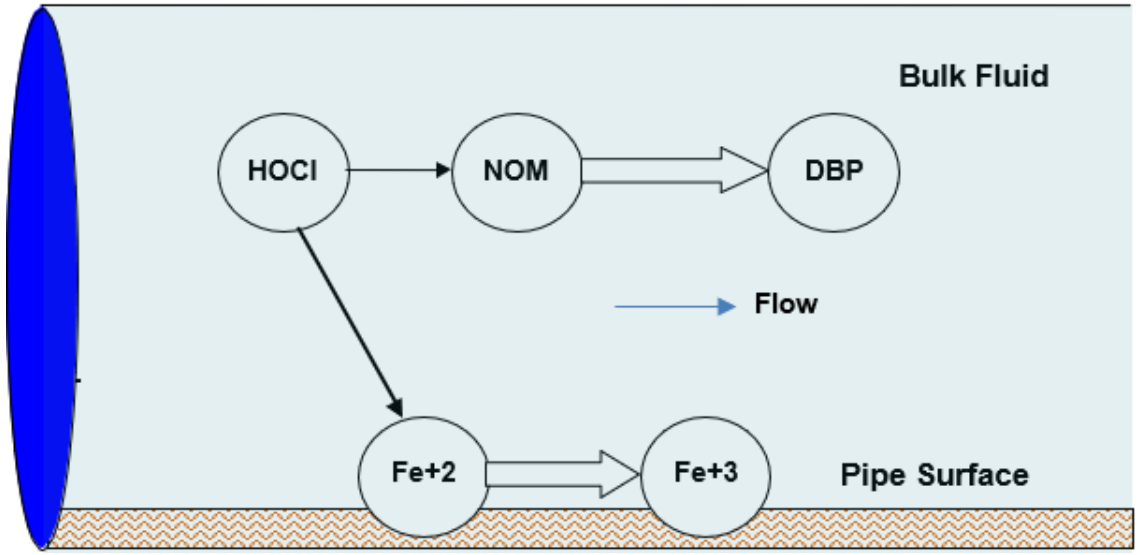
EPANET Recent Updates *(version 2.2)*

- Online User Manual
- Testing and QA
- User interface
- Improved solution performance and accuracy
  - Pressure dependent demand analysis
  - Water quality mass balance
  - Handling of low flows
  - Convergence criteria
- External contributors



EPANET Extensions: EPANET-MSX

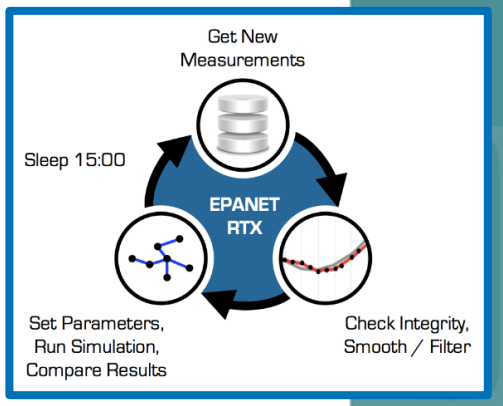
- EPANET-MSX can model the following:
  - Adsorption/desorption on pipe walls
  - Attachment to biofilms
  - Chemical reactions
  - Biological growth and decay
- Planned features:
  - Update to EPANET 2.2
  - 1D ADR dispersion modeling
  - Built in contaminant fate and transport models (temperature, DBPs, chloramines)
  - Results viewer

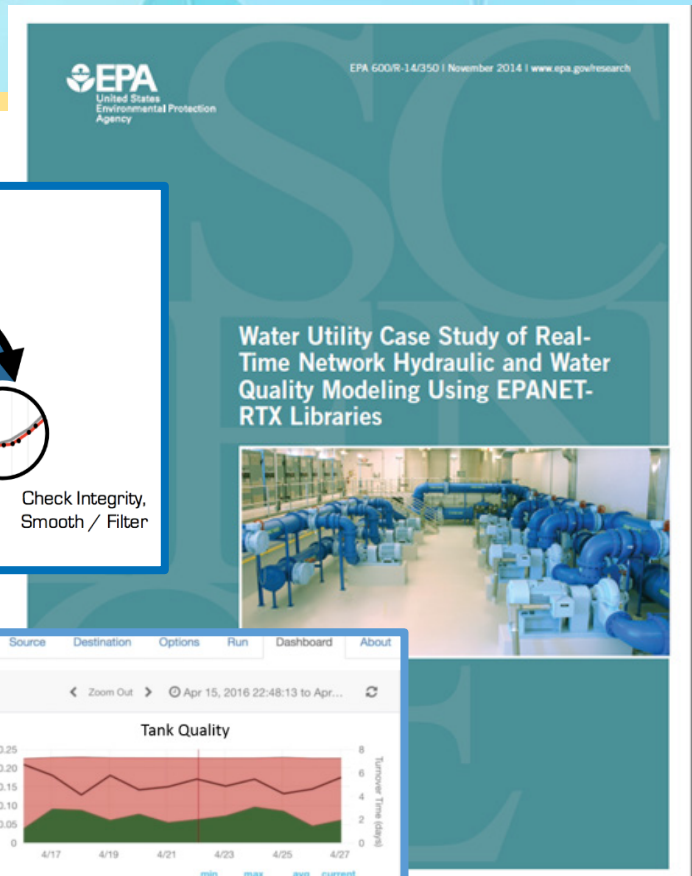


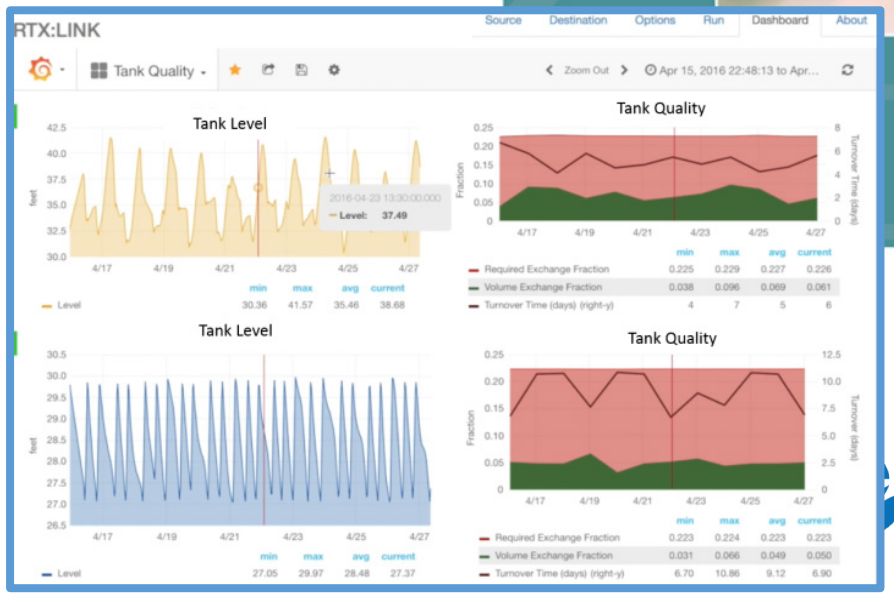
epa.gov/water-research/epanet

EPANET Extensions: Real-time Tools

- EPANET-RTX is a suite of software libraries to integrate EPANET with SCADA operational data.
- Real-time analytics for automated:
  - Forward and hind cast
  - Model calibration
  - Simulate and compare operational decisions
- Continuous comparison and analysis between model and SCADA outputs allowing for more accurate predictions.
- RTX:LINK accesses water system data remotely, calculates simple analytics, and provides view on smart phones and mobile devices.

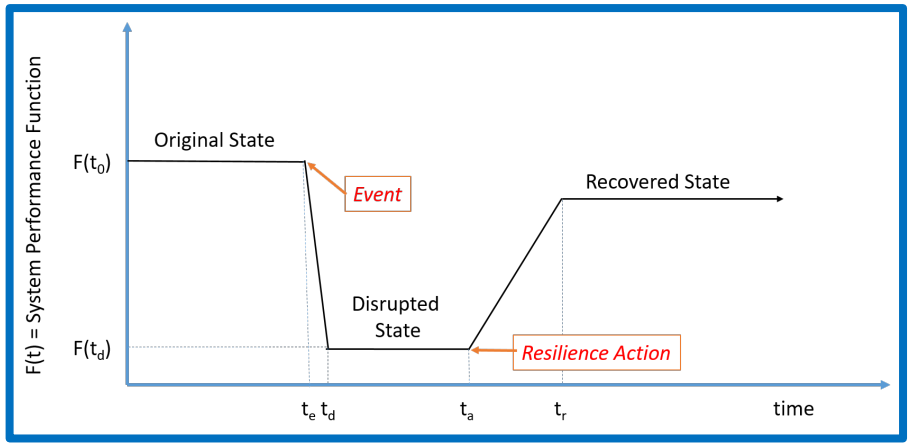


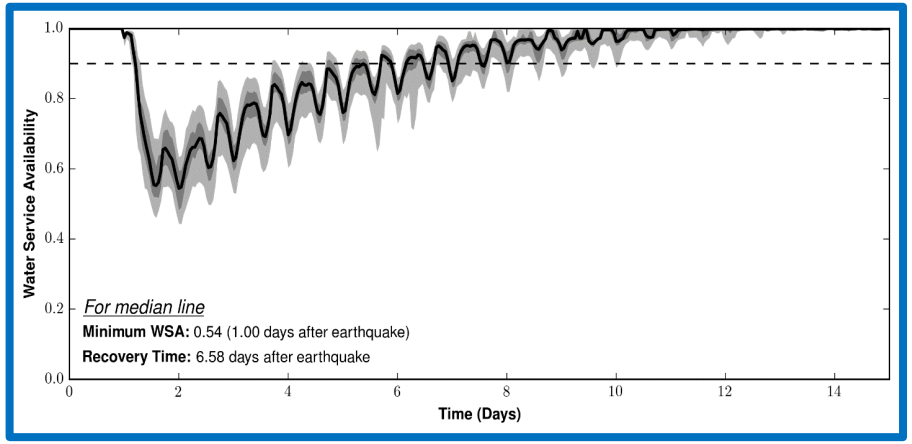




EPANET Extensions: Resilience Analysis

- Simulates disaster scenarios such as earthquakes, power outages, floods, and contamination incidents.
- Predicts damage to infrastructure.
- Calculates resilience metrics.
- Evaluates response and mitigation strategies to improve resilience.

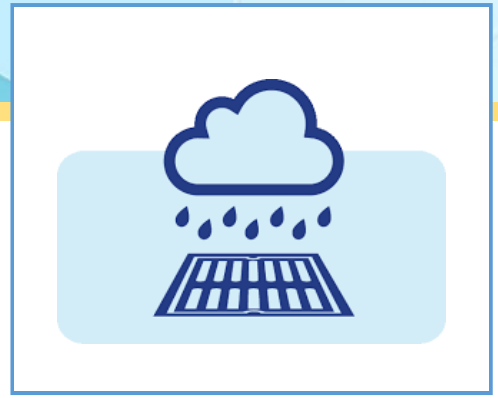




WNTR
Water Network Tool for Resilience

https://github.com/USEPA/WNTR

Stormwater and Water Reuse Models and Tools



Stormwater Models & Tools

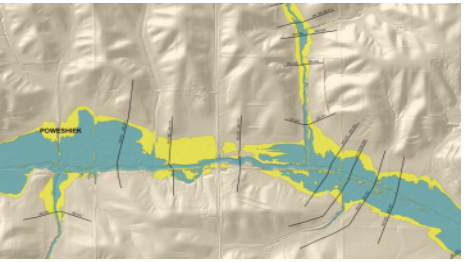
- SWMM
- Stormwater Calculator
- GI Toolkit

Water Reuse Models & Tools

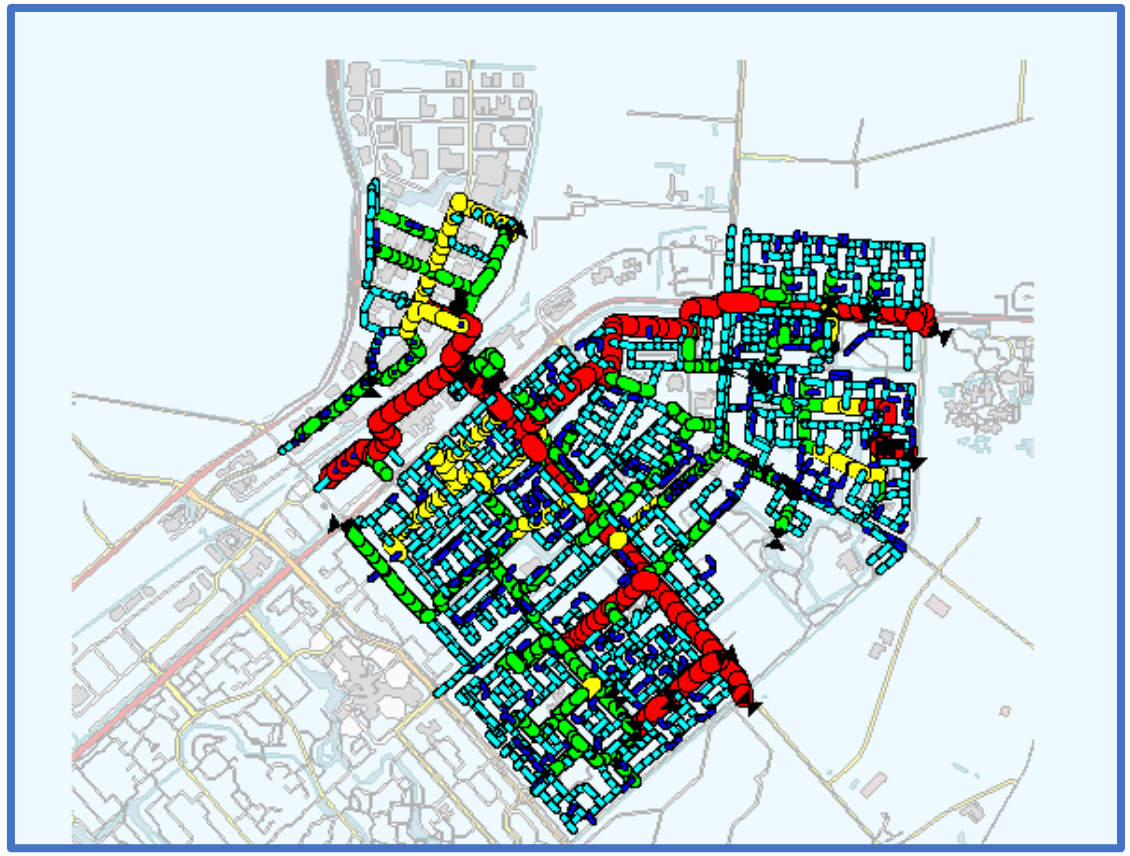
- NEWR
- Microbial Risk Assessment

Access these models and tools through EPA's [Science Models and Research Tools (SMaRT) Search]

EPA SWMM



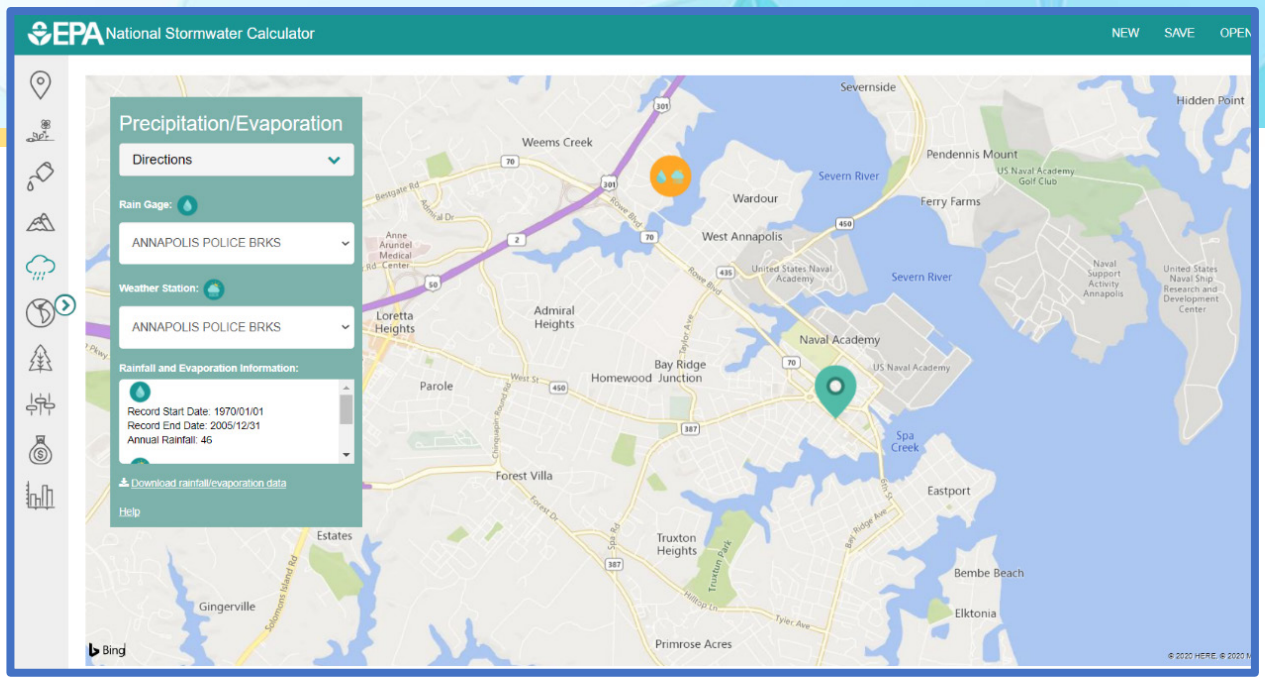
- Distributed, dynamic hydrologic - hydraulic - water quality model
- Continuous simulation of runoff quantity and quality from primarily urban areas
- Used to evaluate green/gray infrastructure stormwater control strategies



https://www.epa.gov/water-research/storm-water-management-model-swmm

Stormwater Calculator

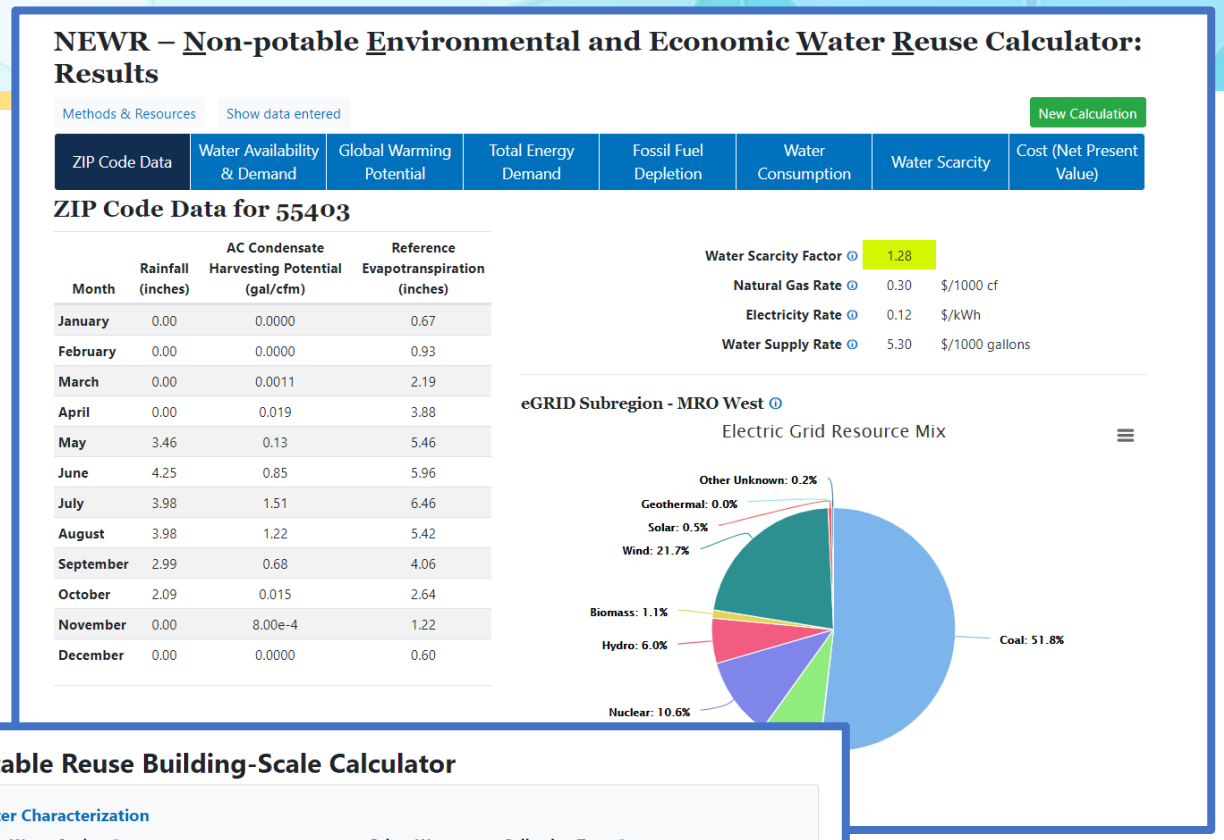
- Distributed, Estimates annual rainwater and frequency of runoff
- Site specific
- Low impact development controls



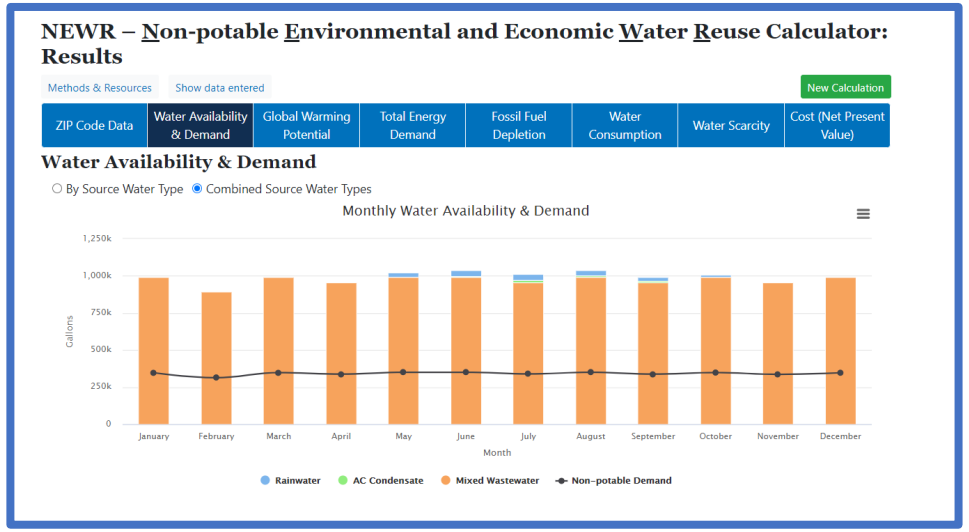
https://www.epa.gov/water-research/national-stormwater-calculator

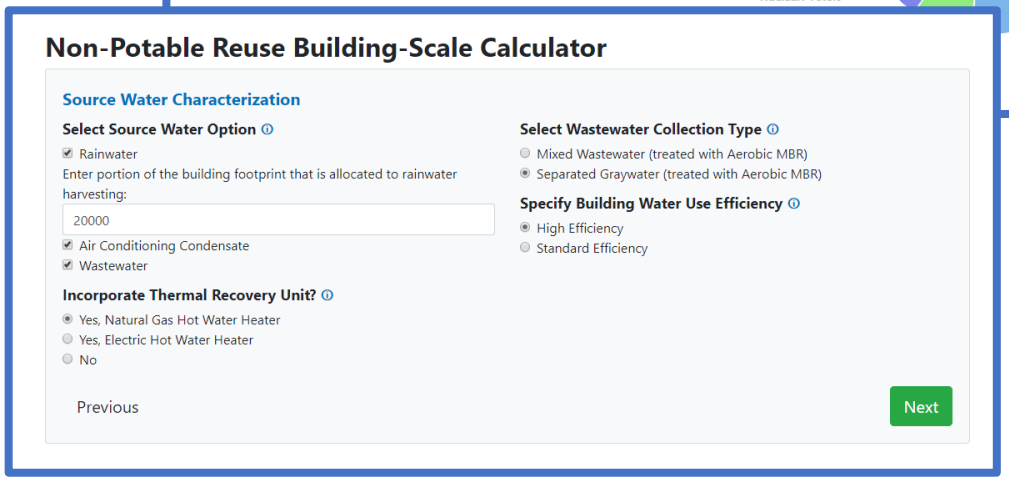
Building Water Reuse Calculator

- NEWR compares water reuse options within a single building
- Based on geography, end use, building specifications, and source water type
- Calculates costs as well as environmental benefits



Month	Rainfall (inches)	AC Condensate Harvesting Potential (gal/cfm)	Reference Evapotranspiration (inches)
January	0.00	0.0000	0.67
February	0.00	0.0000	0.93
March	0.00	0.0011	2.19
April	0.00	0.019	3.88
May	3.46	0.13	5.46
June	4.25	0.85	5.96
July	3.98	1.51	6.46
August	3.98	1.22	5.42
September	2.99	0.68	4.06
October	2.09	0.015	2.64
November	0.00	8.00e-4	1.22
December	0.00	0.0000	0.60





EPA Water Modeling Workgroup

UPDATES & HIGHLIGHTS FROM THE WATER MODELING WORKGROUP

Issue 1

Who is WMW?

EPA's Water Modeling Workgroup (WMW) was formed by EPA Office of Water (OW), Office of Research and Development (ORD), and Regional Water Programs to address Agency-wide water quality modeling challenges.

Goals:

- Promote collaboration and communication between water quality modelers.
- Enable EPA to access modeling expertise for critical water quality projects and targeted consultations.
- Maintain and improve water quality models and resources.
- Provide training resources on water quality modeling and address emerging water quality modeling and research needs.

Final Peer Review for Nutrient-Related Modeling Expected This Year

The 1985 Second Edition of Rates, Constants, and Kinetics Formulations in Surface Water Quality Modeling is recognized as a trusted source for water quality modelers on kinetic formulations and associated rate constants and coefficients used in surface water quality modeling.

EPA Training Workshop

Exploring and Applying Surface Water Modeling Tools to Achieve Program Goals

For EPA, States, Tribes and Territories
October 29, 2019 - November 1, 2019
EPA Region 6 HQ - Dallas, TX

This four-day workshop is for program staff from EPA, states, tribes, and territories who want to learn more about surface water quality modeling and how these tools can be used to support their program activities. The workshop will provide an opportunity to learn about a variety of surface water quality modeling tools, and updates on anticipated advances and changes to models. Attendees will assist in identifying information technology enhancements for user interfaces, architecture, and maintenance for key models.

See page 2 and visit the workshop webpage for the workshop agenda.

- Coordination of modeling efforts within EPA Office of Research and Development, Office of Water, and Regions
- Hosting modeling training and workshops: https://www.epa.gov/waterdata/surface-water-quality-modeling-training
- Peer reviewing models and data: https://cfpub.epa.gov/si/si_public_record_report.cfm?Lab=NHEERL&dirEntryId=342391

https://www.epa.gov/waterdata/surface-water-quality-modeling

Looking to the Future: EPA Water Modeling

- Stakeholder engagement
- Collaboration with external organizations
- Integrated water resources modeling
- Climate change and resilience
- Support for infrastructure improvements

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Science Models and Research Tools (SMaRT) Search