Project PARETO – DOE's Produced Water Optimization Initiative

PARETO
The Produced Water Optimization Initiative

NETL Resource Sustainability Project Review Meeting

Pittsburgh, PA

NATIONAL ENERGY TECHNOLOGY LABORATORY
BERKELEY LAB
Carnegie Mellon University
Georgia Tech
NM STATE
GROUNDWATER PROTECTION COUNCIL
U.S. DEPARTMENT OF ENERGY

Introduction & Motivation: Oil & Gas Produced Water

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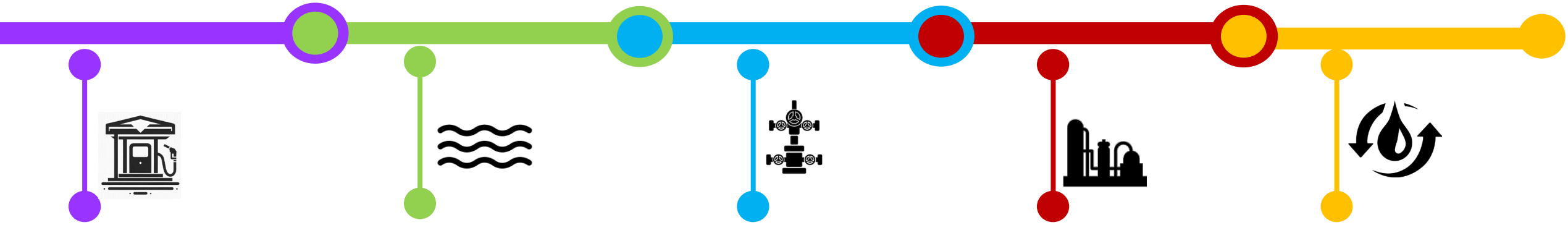

Rise in unconventional oil and gas production-hydraulic fracturing	Increasing stress on fresh water resources	Rise in Produced water volume	Seismic Response Area (SRA) & Disposal constraints	Timing-volume discrepancies for frac demand versus produced water (Limited recycling)

The U.S. oil & gas industry faces many challenges related to produced water management, necessitating the development of optimized strategies to ensure the sustainable and responsible production of hydrocarbons.

Project Premise & Goals

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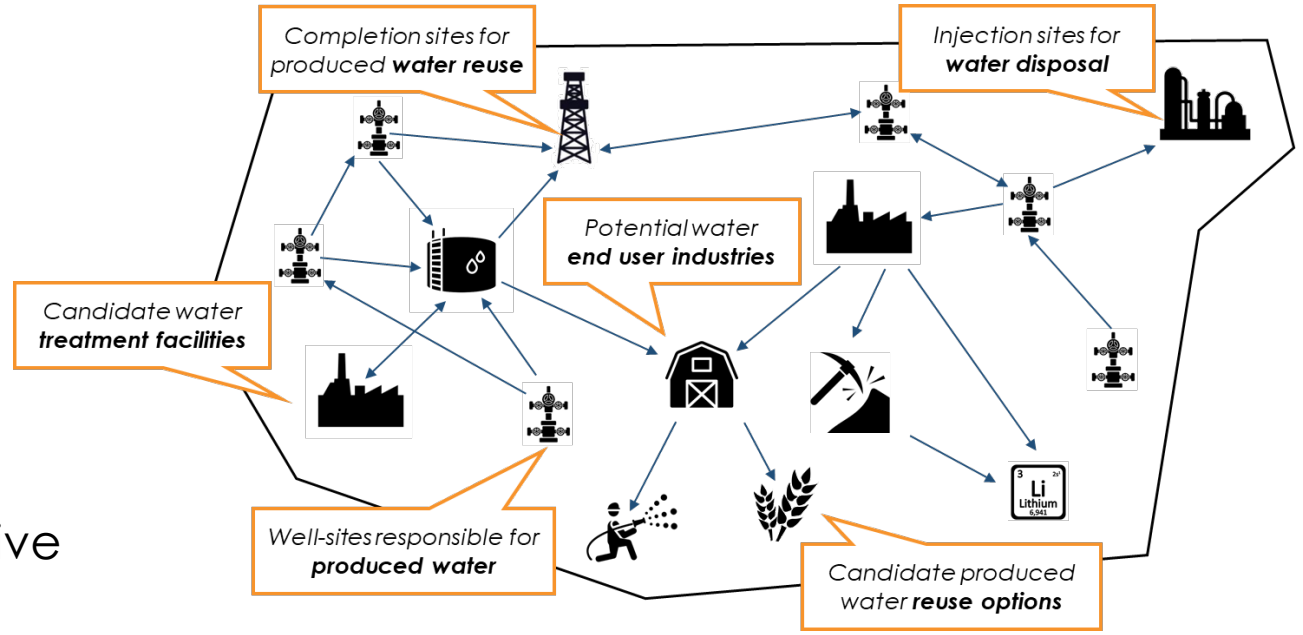
Premise: Develop a free and trusted software program ("PARETO") to help organizations transport, treat, store, inject and/or reuse produced water from onshore oil & gas operations.

PARETO helps with:

1) produced water **management** (2021 focus)
   → infrastructure buildout, fluid flow optimization
2) produced water **treatment** (2022 focus)
   → systems integration of treatment solutions
3) produced water **beneficial reuse** (2023 focus)
   → evaluation of beneficial water reuse options

- Views produced water from "systems" perspective
- Addresses "macro" vs. "micro" challenges



PARETO is meant to become a trusted **decision-support tool for the extended produced water community (i.e., upstream operators, midstream/service companies, regulators, …).**

PARETO's Core Capabilities

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Model Library

IDAES Institute for the Design of Advanced Energy Systems

Strategic Model

PYOMO

Operational Model

Production forecasts	Trucking & Trucking logistics	Water quality
Water demand	Water reuse	Water Treatment
Freshwater sources	Disposal	Economics

Pipeline network design	New treatment facilities	ASTs expansion
New disposal sites	New storage sites	

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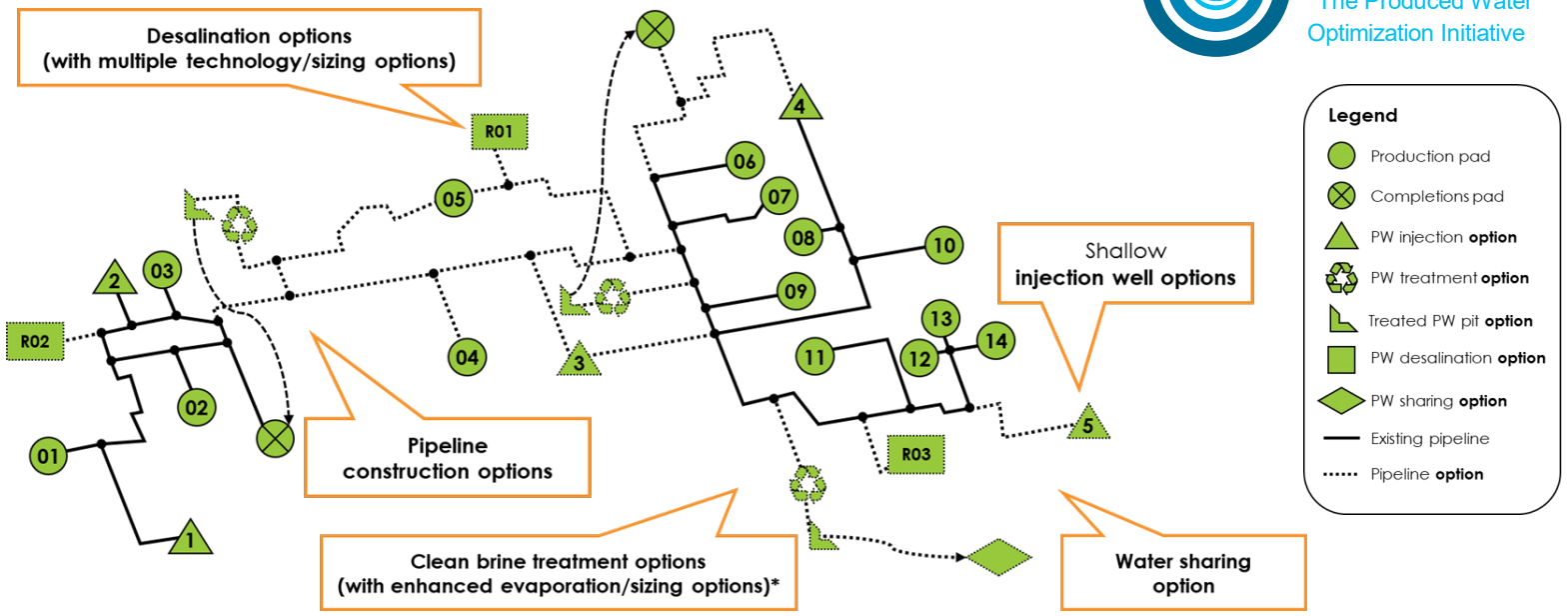

The PARETO model suite approaches:

The Operational Model, enhancing daily operations with existing infrastructure insights

The Strategic Model, projecting infrastructure buildouts for long-term strategic development.

PARETO 101: How does it work?

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PARETO builds a digital twin of YOUR system to use for optimization and determines the best possible solution for YOU

Use pre-built spreadsheet templates or connect to database

1. Plug in Data

- Existing infrastructure
- Expansion opportunities
- Produced water forecasts
- Cost assumptions
- …

2. Select your …

a) Preferred Objective(s)

- Minimize LOE (upstream)
- Maximize profits (midstream)
- Facilitate reuse (regulator)
- …

b) Applicable Constraints

- Logistics (e.g., flow balances)
- Engineering (e.g., equipment sizing)
- Business (e.g., cash flow)
- …

PARETO immediately visualizes the solution and stores results

3. Get Recommendations

- Suggested fluid flow
- Proposed infrastructure buildout
- Environmental performance
- Anticipated economics or KPIs
- …

PARETO does not just calculate, predict or simulate possible scenarios; the program makes specific recommendations on how to improve water management strategies.

What Else? University Collaborations!

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The team has established close **collaborations** with several universities:

	Carnegie Mellon University	Georgia Tech	Carnegie Mellon University	NM State University
Research PI	Larry Biegler & Sakshi Naik	Nick Sahinidis & Yijiang Li	Carl Laird & Arsh Bhatia	Pei Xu & Laura Capper
Research Focus	Incorporation of rigorous **desalination** models into PARETO (e.g., MVC, OARO)	Consideration of **hydraulic** effects across PW pipeline networks (e.g., MAOP)	**REE/CM recovery** from produced water systems (e.g., Lithium)	Develop a PARETO utility on **induced seismicity** and SRA actions

"Project PARETO" works closely with academic partners across the nation.

What Else? Industrial Collaborations!

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The team continues to **collaborate** with several industrial partners:

	OLYMPUS ENERGY	ConocoPhillips	ARIS WATER	equitrans Midstream
Basin	Appalachian	Permian	Permian	Appalachian
Segment	Upstream	Upstream	Midstream	Midstream
Case Study Focus	Truck routing, storage placement/sizing, treatment/disposal cost sensitivities	Capacity expansion (injection, pipelines, storage), third party constraints	Water management, desalination integration, beneficial reuse	Water "hubs", produced water sharing, storage management
PARETO Model	PARETO^{Ops}	PARETO^{Strategy}	PARETO^{Strategy}	PARETO^{Exchange}

PARETO has been developed with and tested by several industrial partners.

PARETO features and extensions

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1. Beneficial reuse
2. Resource recovery
3. Treatment and desalination modeling
4. Hydraulic analysis
5. Seismic risk analysis
6. Environmental KPI measures
7. Water sharing

PARETO and Beneficial Reuse

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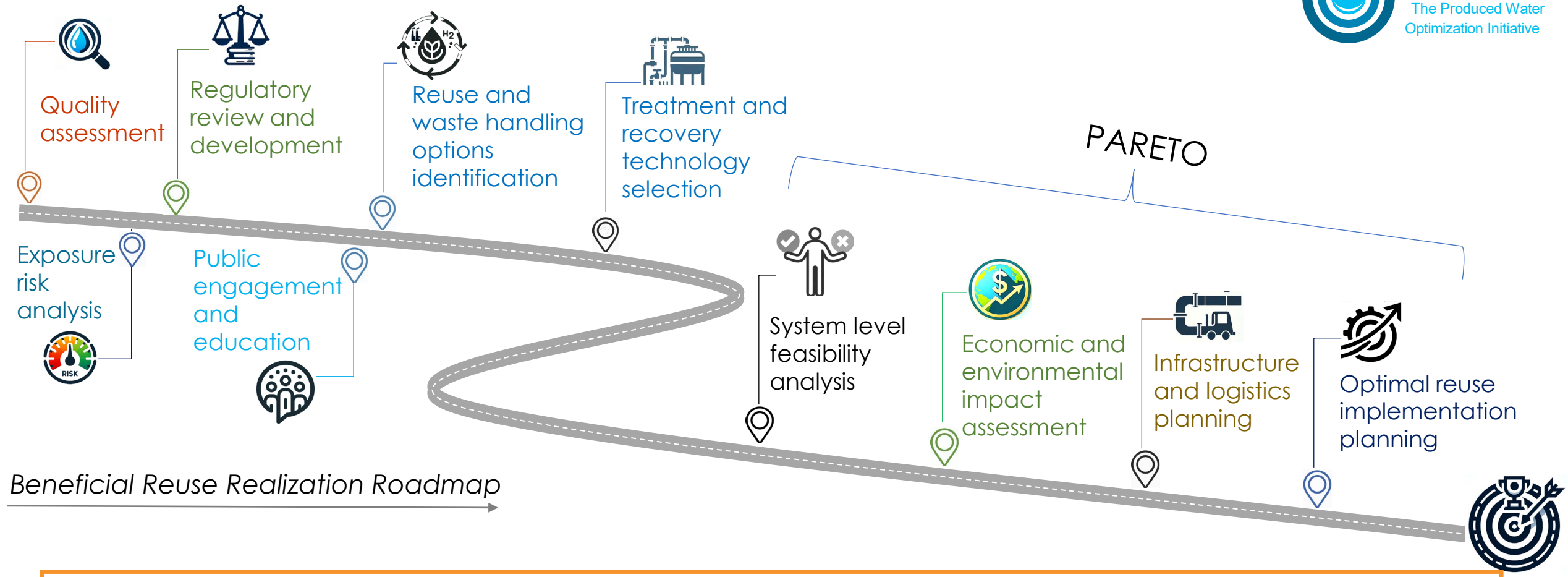

PARETO delivers cross-project adaptability, offering optimal reuse solutions and feasibility analysis that eliminates the necessity of initiating analysis from scratch for each project—saving substantial time and financial resources across various sectors

PARETO Beneficial Reuse

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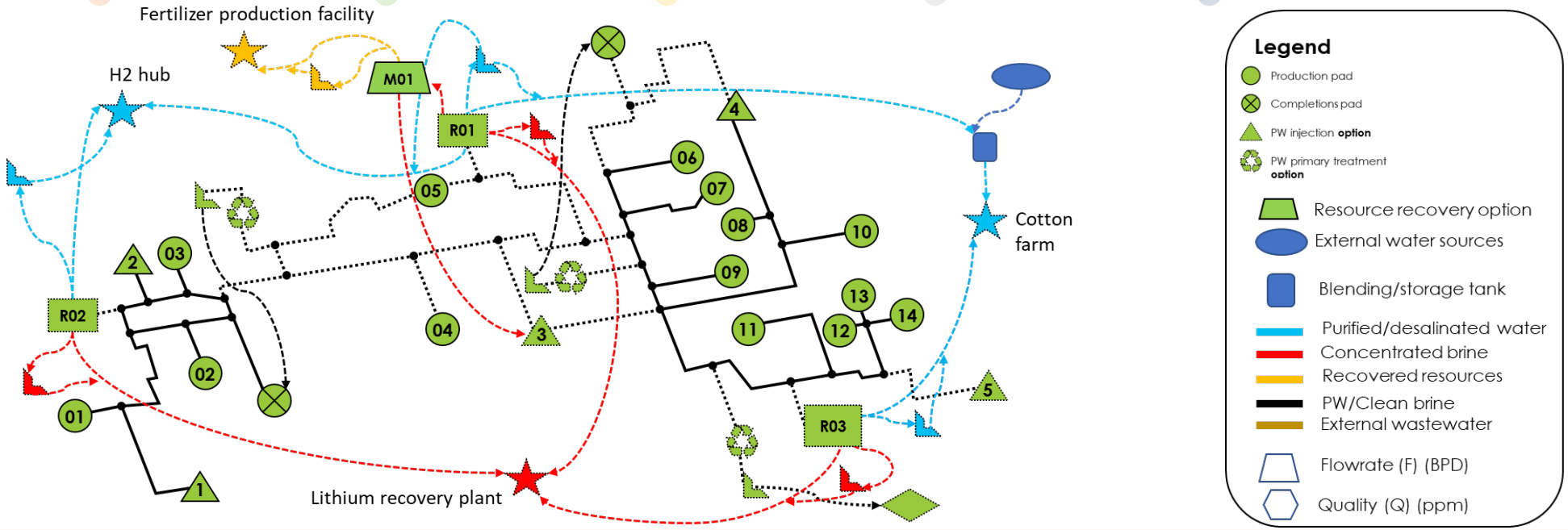
Seasonal needs | flow Commit-ments | Reuse Selection | Resource Allocation | Quality Tailoring | Waste handling



PARETO adapts to varied reuse challenges and enhances beneficial reuse realization through what-if scenario analysis and integrated strategies, effectively illustrating what "realistic success" could look like.

Adapted from M.M. Hightower, "2022 Technology Demonstration, Testing, and Evaluation," New Mexico Produced Water Research Consortium, Las Cruces, NM, December 2022.

PARETO Resource Recovery

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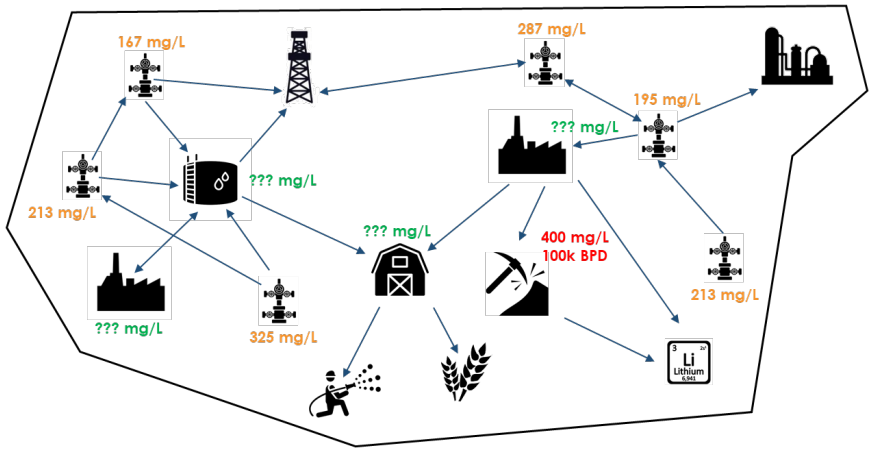
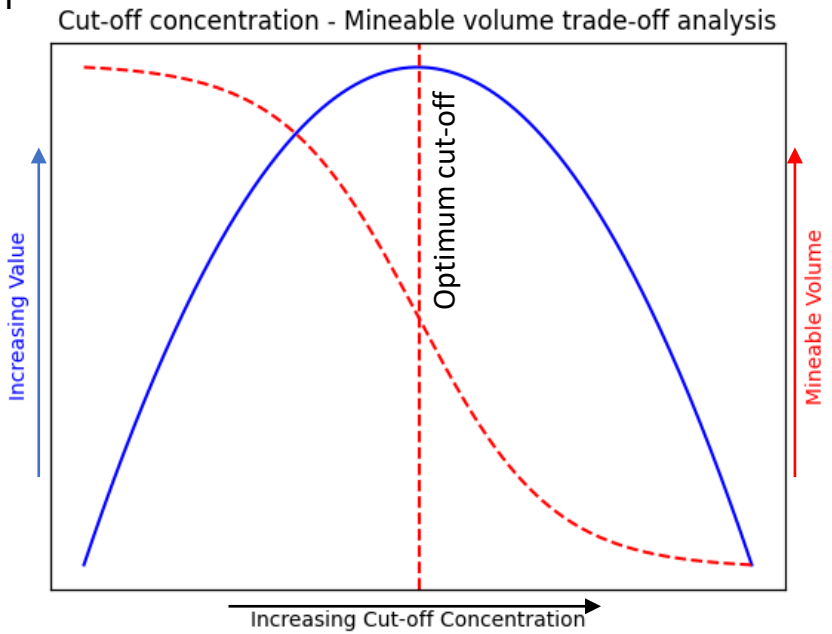
PARETO resource recovery solution:

- Tracks concentration across the networks
- Sets concentration thresholds
- Analyses cutoff-concentration vs. mineable volume trade-off
- Determines break-even concentration point





PARETO empowers resource recovery within the produced water network through a meticulous analysis of key factors including cut-off concentration, extraction efficiency, logistics optimization, and precise, material-specific cost management

Adapted from M.M. Hightower, "2022 Technology Demonstration, Testing, and Evaluation", New Mexico Produced Water Research Consortium, Las Cruces, NM, December 2022.

PARETO Water Treatment and Desalination

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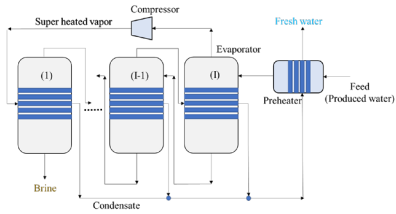
Data-Driven Cost Analysis

Uses vendor and literature data for cost evaluation and technology performance

Rigorous Optimization

WaterTAP

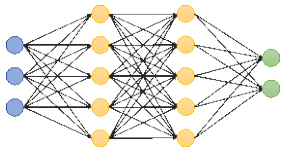
Leverages the WaterTap library for optimization of desalination processes



Rigorous MVR model

Surrogate Models

Implements machine learning methods to streamline the complexities of rigorous models.



Neural Networks

PARETO treatment models are adeptly designed to address water quality demands for diverse applications, offering user-specific detail levels to balance treatment intensity and cost.

PARETO Hydraulics Module

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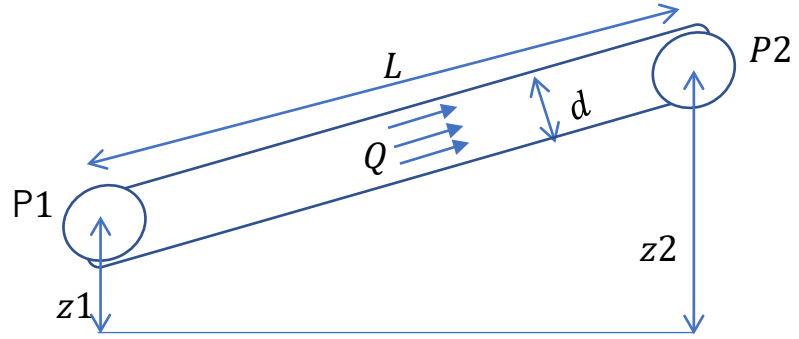
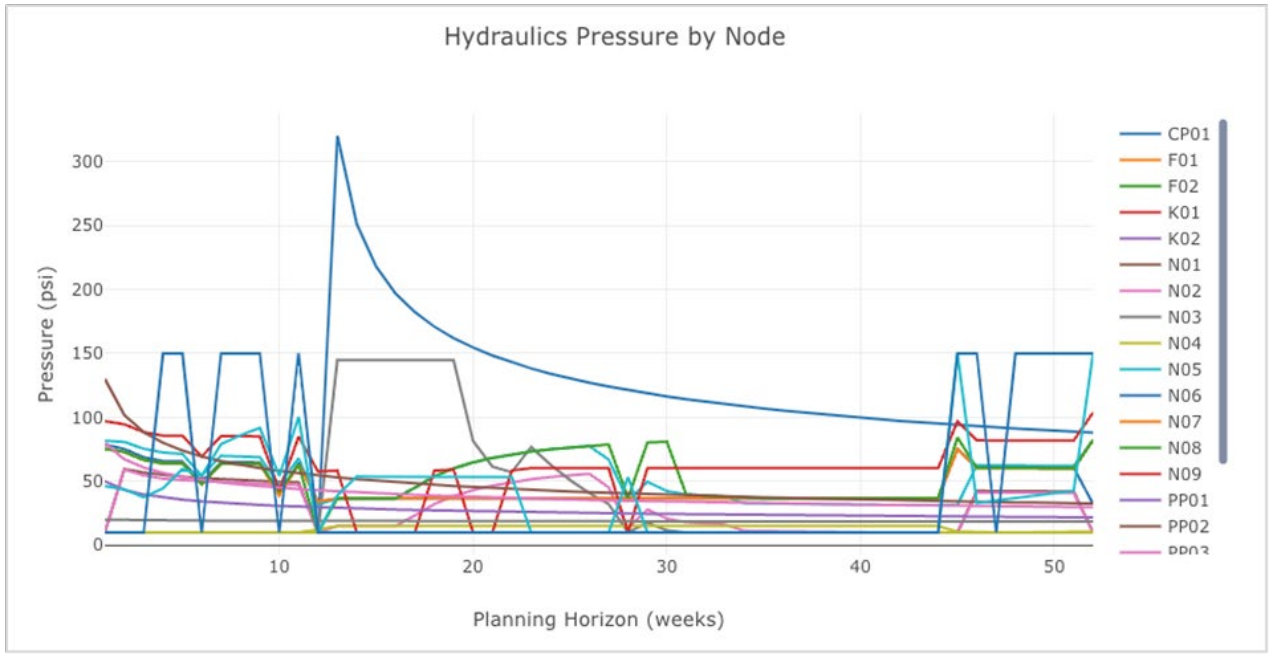
PARETO hydraulic module:

- Consider elevation changes and frictional losses
- Track pressure across the network nodes
- Identify pumping needs
- Sets maximum allowable operation pressure



Q = volumetric flow (m^3/s), P = pressure (Pa), z = elevation (m),
L = Length of pipeline (m), d = pipeline diameter (m)



PARETO hydraulic modules ensures hydraulic feasibility for network solutions while co-optimizing water management and pressure regulation costs.

PARETO Seismic Risk Reduction

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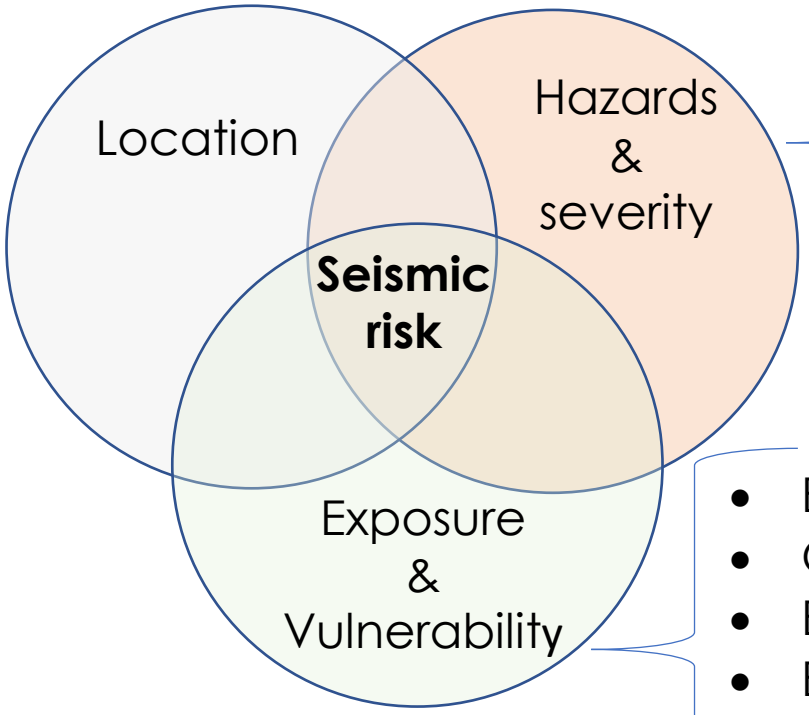
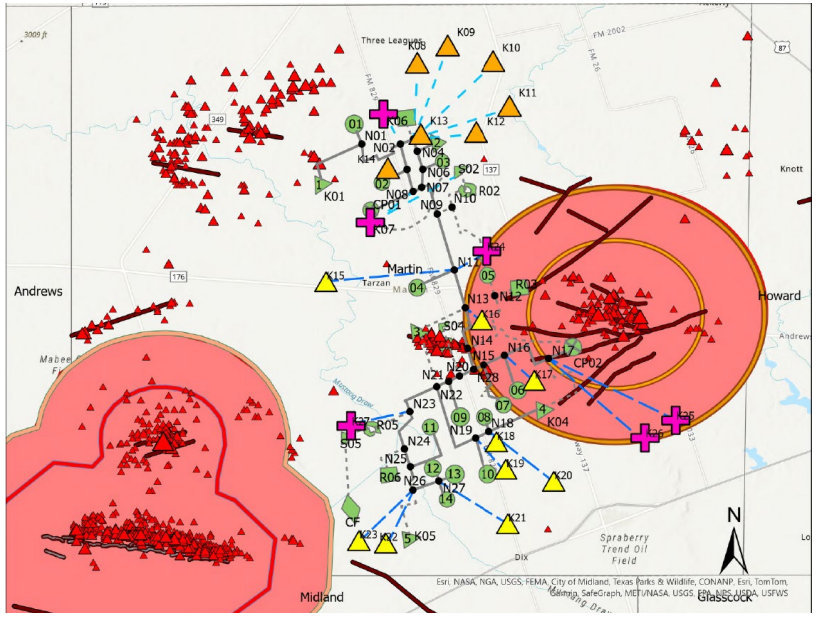


- nearby earthquake location
- faults
- High-Pressure injection zones
- Low-Pressure injection zones
- Injection rate

- Orphan wells
- Old Plugged & Abandoned wells
- Old Long-duration Temporarily Abandoned wells



- Exposed population
- Quality of construction
- Earthquake preparedness
- Exposed critical infrastructure
- Value of exposed property
- Secondary hazard

PARETO's seismic risk module informs injection strategies, providing trade-off analysis between cost optimum and distributed injection, integrating SRA and enhanced risk avoidance policies.

PARETO Environmental and Env. Justice Measures

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PARETO Environmental and Environmental Justice KPIs Categories:

Air pollutant metrics
Greenhouse gas emissions

(CO2 equivalents), NH3, NOx, SO2, and PM2.5

Trucking activity

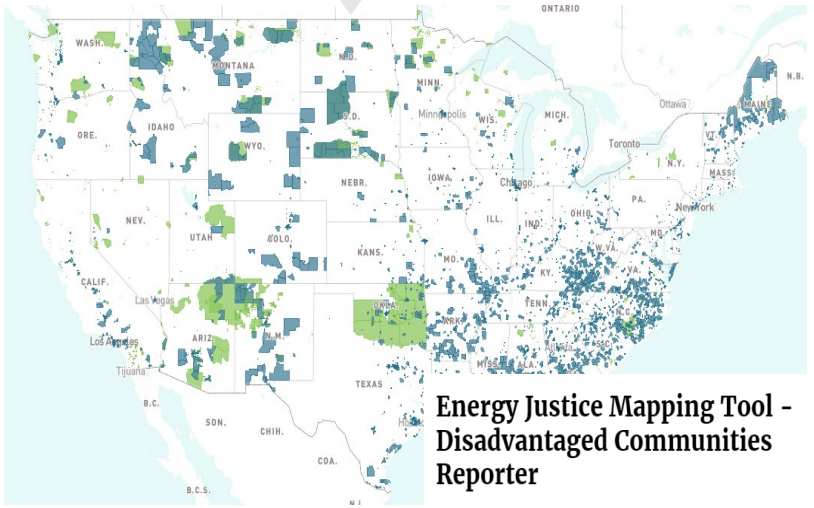
-Total volume of water trucked

-Total hours of trucking

Environmental Exposure in Disadvantaged Communities (DAC).

-Air pollutants exposed to DAC

-Infrastructure built across DAC



Energy Justice Mapping Tool - Disadvantaged Communities Reporter

PARETO now allows for reporting on environmental and environmental justice measures, which could inform ESG impact.

PARETO UI Snapshots

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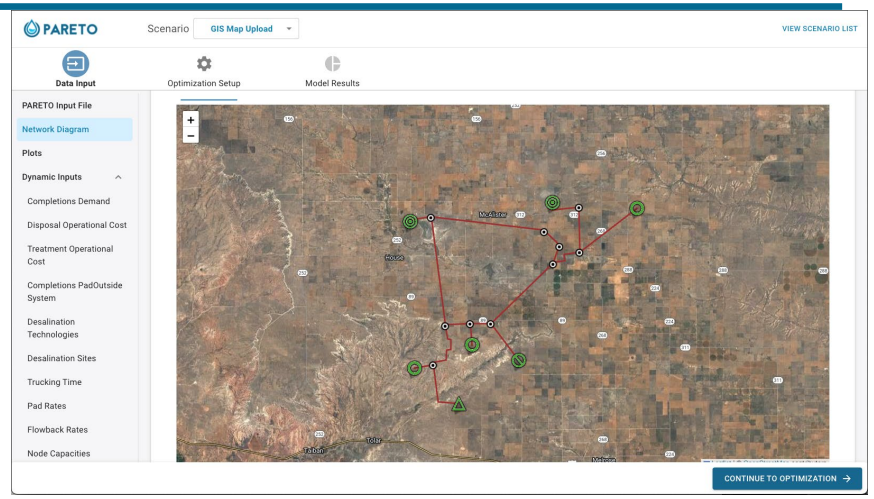
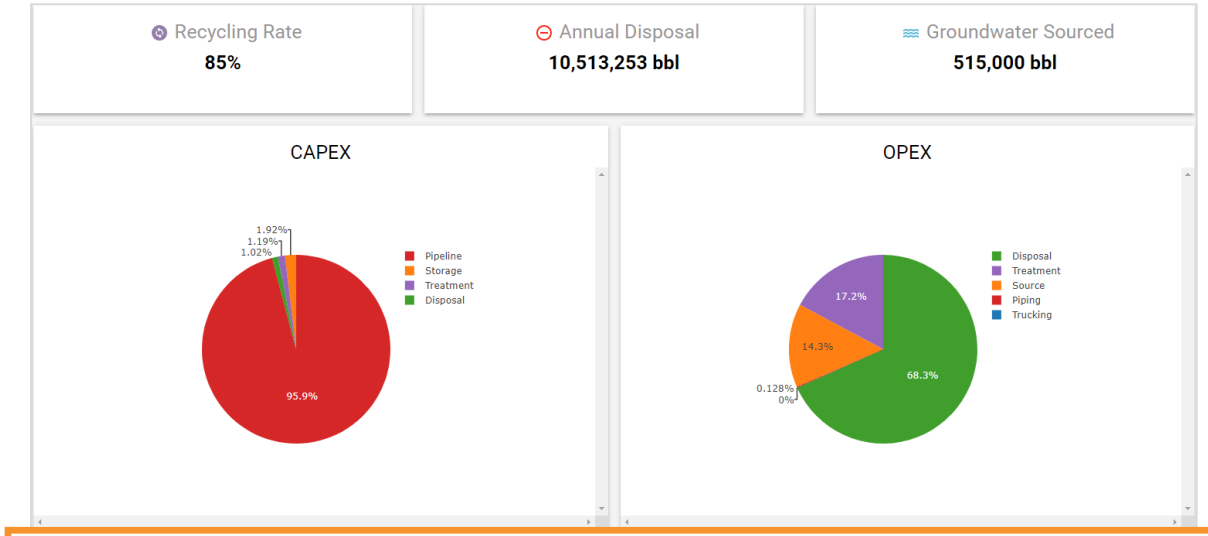
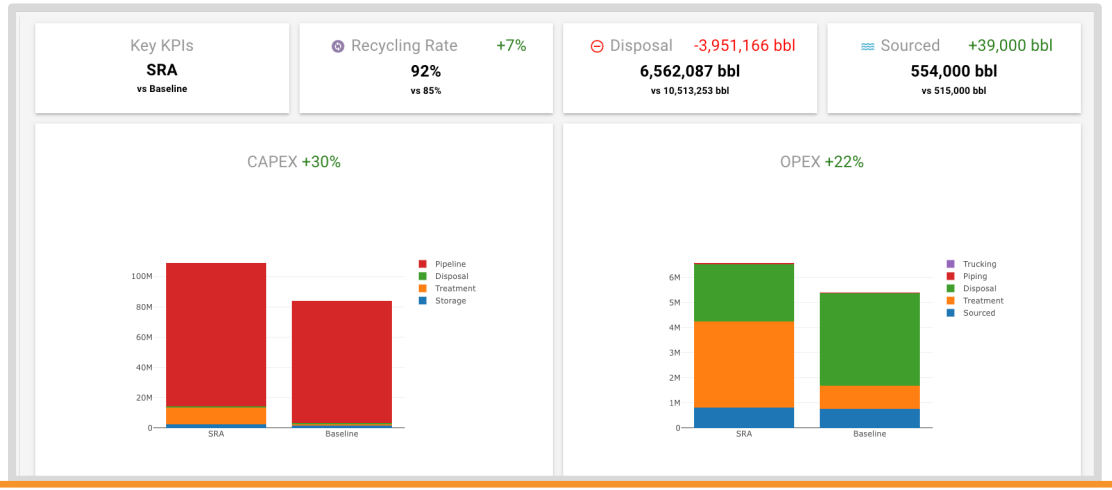


GIS integration





PARETO's UI offers a code-free gateway to its prowess, presenting results in vibrant and impactful visuals

What Else can PARETO do? Water Sharing!

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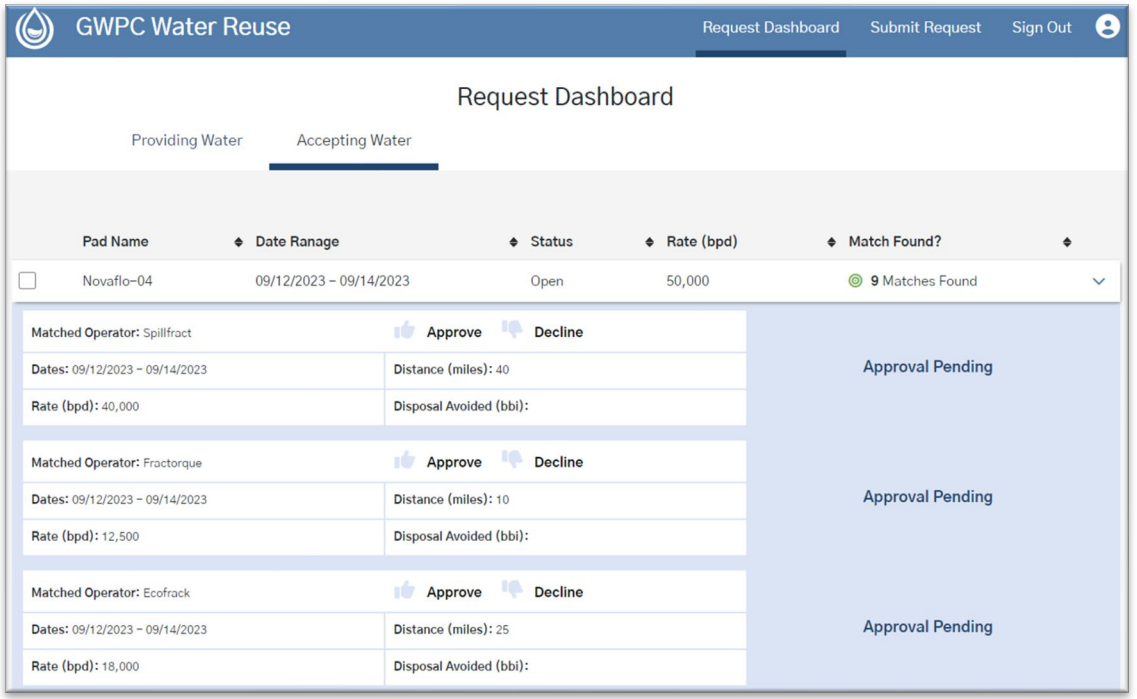
A custom-built online portal for produced water sharing

- Collaboration between **DOE-NETL & GWPC**
- A web portal that functions like a **matchmaker**
- Simple and user-friendly **submission forms**
  - "I have water"
  - "I need water"
- Organizes PW "matches" in a **dashboard**
  - Users can accept or decline matches
- Emphasis on **minimal data inputs**



2024 Outlook

PARETO - Water Optimization Initiative

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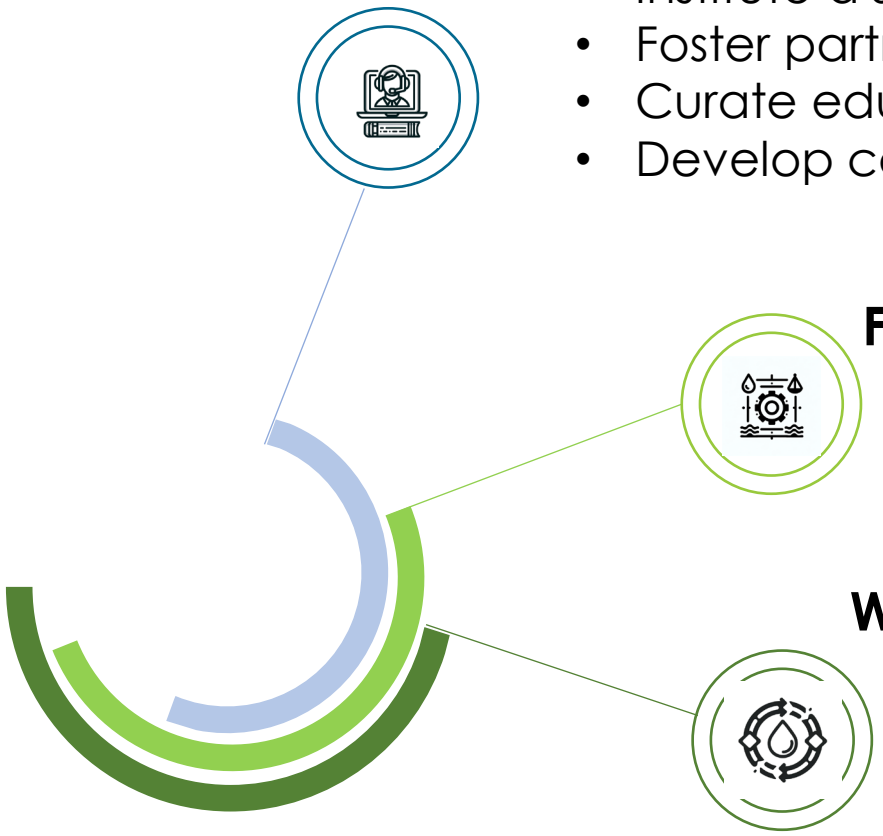
User Support and Education

- Institute a support workflow
- Foster partner communication
- Curate educational resources
- Develop case studies



Framework Support and maintenance

- Refine and maintain PARETO framework

Water Exchange

- Deploy Water Exchange platform
- Expand Water Exchange platform capabilities
- Develop demonstration cases (via industrial collaborations)

PARETO Training Workshop

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- The team has developed a PARETO **Training Workshop:** Learn how to
  - **Install** PARETO software.
  - **Input data** into PARETO.
  - **Run** PARETO optimization.
  - **Develop** a variety of complex network scenarios.
  - **Analyze, interpret, and compare** results.
- Additional sessions are planned for the future (possibly virtually).
- Video tutorials have also been developed and should be publicly available soon.

PARETO workshop at NMPWRC meeting, Albuquerque, December 2023

The PARETO Team

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Acknowledgements and Disclaimer

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Thank You!

To request a follow-up meeting or demo, please contact pareto-support@lbl.gov

For questions and comments, please contact

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