Project PARETO – DOE's Produced Water Optimization Initiative

Resource Sustainability Meeting

PARETO
The Produced Water Optimization Initiative

October 2022

NATIONAL ENERGY TECHNOLOGY LABORATORY

BERKELEY LAB

U.S. DEPARTMENT OF ENERGY

Introduction: Oil & Gas Produced Water

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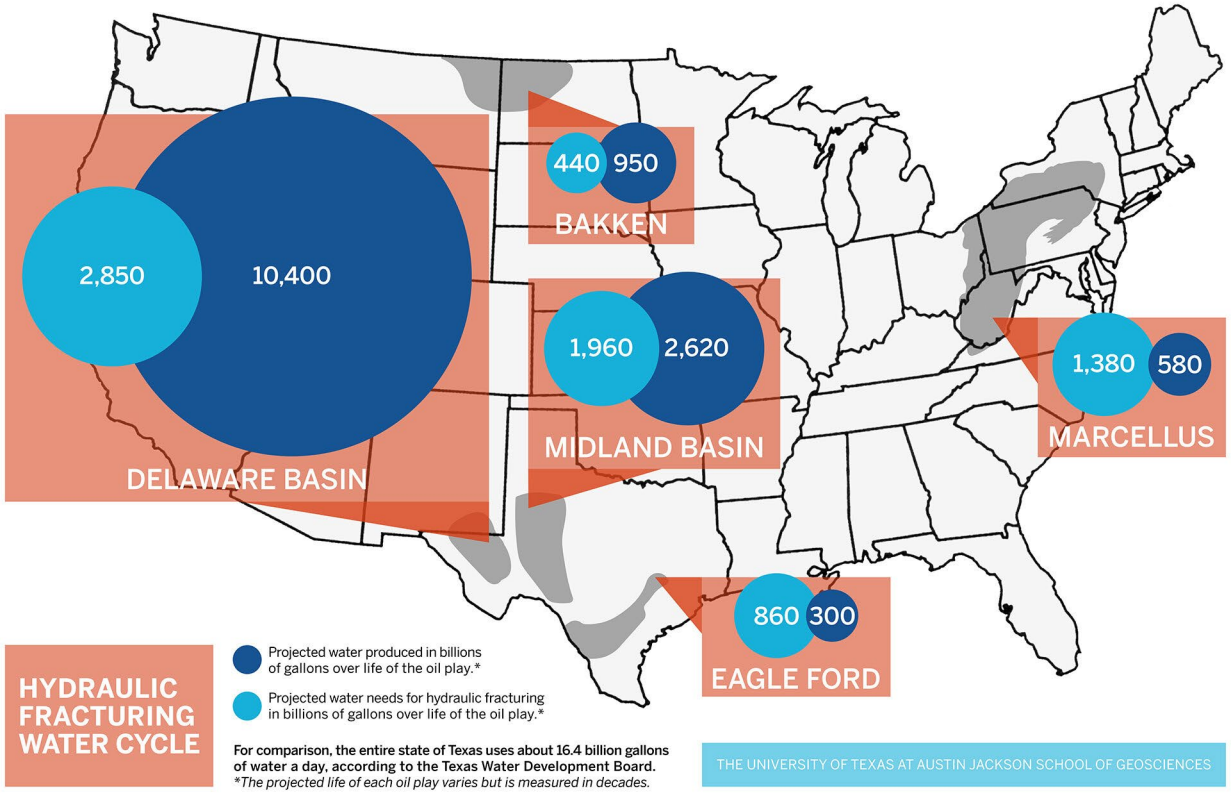
- **Well-known**: oil & gas development requires water (e.g., >1 MM bbl per well)
- Water is used to drill wells and to fracture oil-/gas-bearing formations
- **Less-known**: water is co-produced as oil & gas is recovered from the reservoir
- So-called **"produced water"** is a waste byproduct to upstream operators
- The amount of co-produced water varies significantly basin-by-basin



The U.S. oil & gas industry produces more water than it consumes.

Source: University of Texas at Austin, Jackson School of Geosciences, *Hydraulic Fracturing Water Cycle*, February 2020: https://news.utexas.edu/2020/02/20/water-reuse-could-be-key-for-future-of-hydraulic-fracturing/

Motivation: Produced Water Management Options

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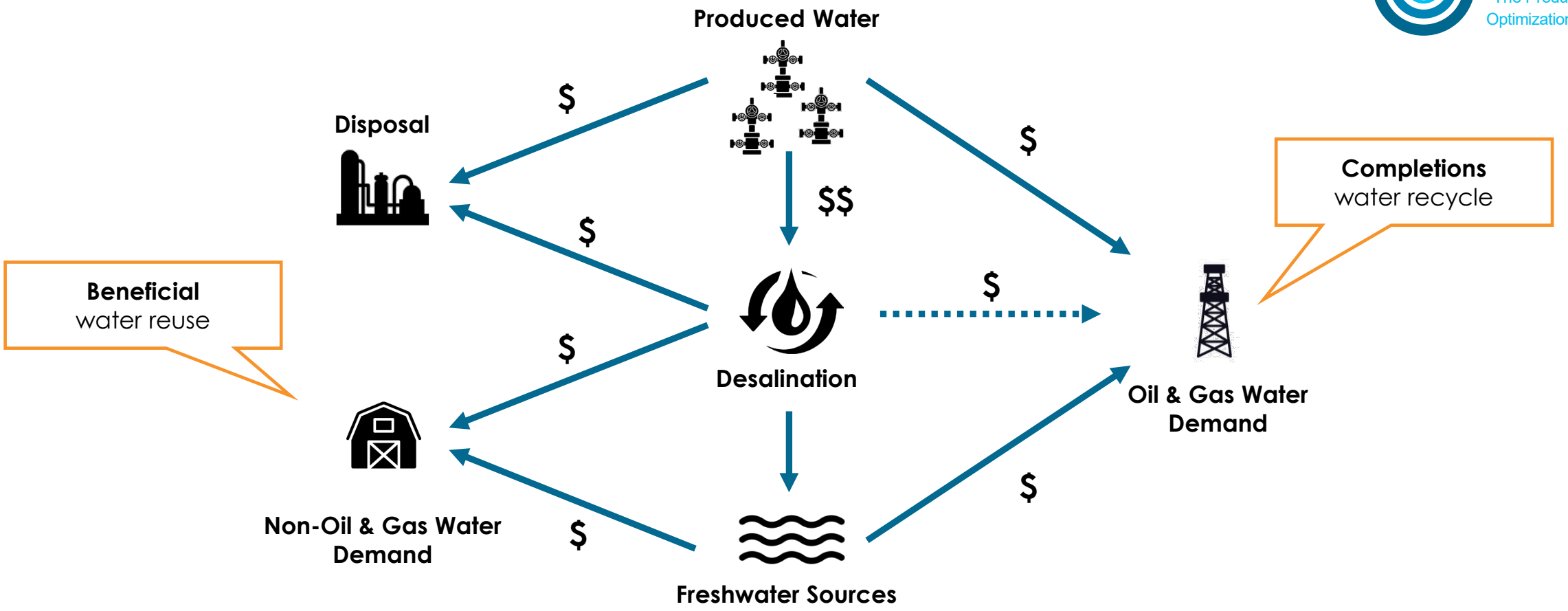

Produced water management is a complex supply chain optimization problem.

Perspective: Foreseeable Challenges

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1) Produced water **volumes are increasing** at rapid pace due to recent O&G activity

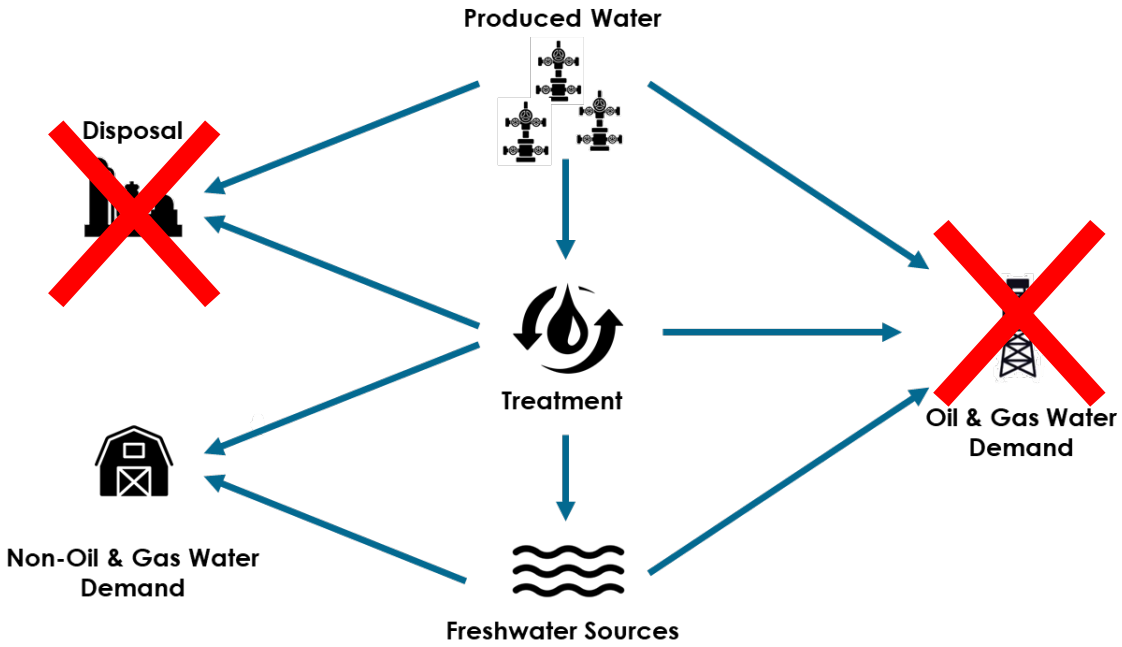
2) Disposal capacity is **swiftly decreasing** (rising well pressures, induced seismicity)

3) Oil & gas development activity by itself **cannot "absorb" all produced water**

→ even if O&G uses no freshwater at all:

produced water supply >> O&G water demand

→ produced water recycling in oil & gas not enough



It is clear that the oil & gas industry needs to find new ways of dealing with produced water – and it seems that treatment (i.e., desalination) may become a necessity.

Source: "Challenges for Produced Water in the Permian: An Analysis of SWD Supply and Demand", Digital H2O, January 2017
https://www.lbcg.com/media/downloads/events/615/pp17-piers-wells.11331.pdf

Introduction: Project PARETO

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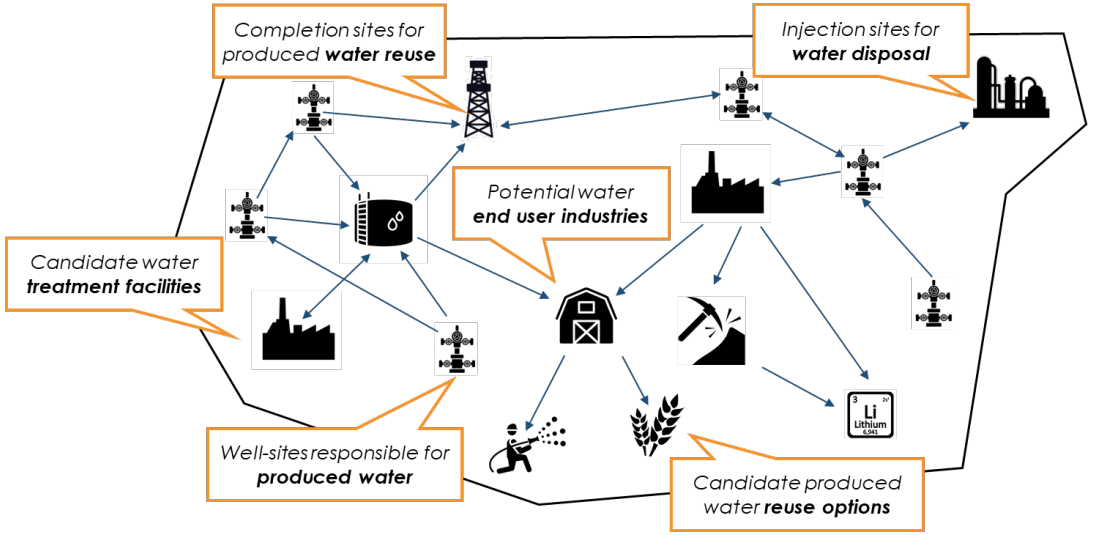
Goal: Develop free and open-source software ("PARETO") to help organizations transport, treat, store, inject and/or reuse produced water from onshore oil & gas operations.

PARETO helps with:

a) **buildout** of the produced water infrastructure
b) **management** of produced water volumes
c) **selection** of effective treatment technologies
d) **placement & sizing** of treatment facilities
e) **identification** of beneficial water reuse options
f) **distribution** of treated produced water for reuse

- Views produced water from "systems" perspective
- Aims to serve as a resource to the community



2021	2022	2023	Total Value
$850k	$2,100k	$3,160k	$4,750k+

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

How does PARETO work at a high level?

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Use pre-built spreadsheet templates or connect to database

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

PARETO immediately visualizes the solution and stores results

1. Plug in Data

- Produced water forecast
- Existing infrastructure
- Expansion opportunities
- 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)
- …

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 your PW management strategy.

Deeper Dive: How can PARETO help the produced water community?

Setup: A Typical Permian Basin Produced Water System

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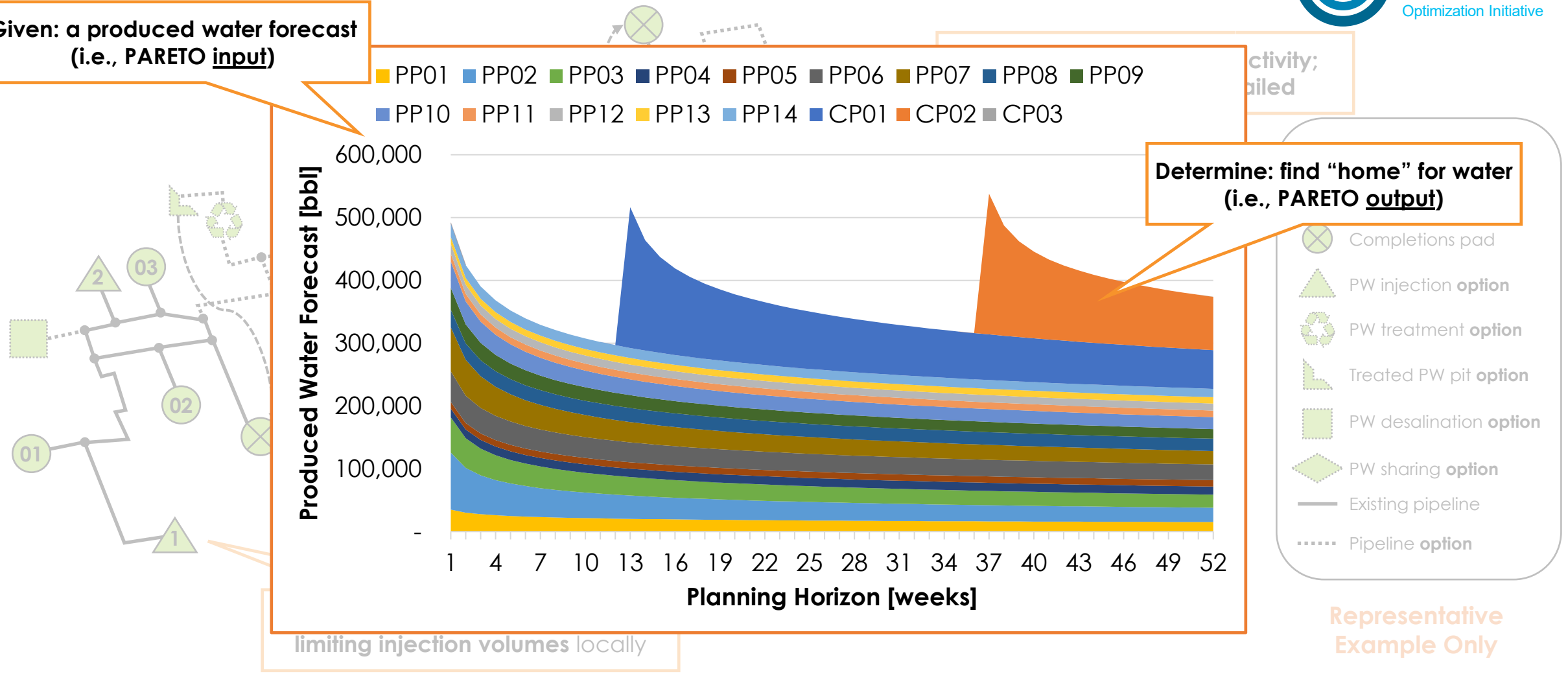
Given: a produced water forecast (i.e., PARETO input)



Determine: find "home" for water (i.e., PARETO output)

- Completions pad
- PW injection **option**
- PW treatment **option**
- Treated PW pit **option**
- PW desalination **option**
- PW sharing **option**
- Existing pipeline
- Pipeline **option**

Representative Example Only

limiting injection volumes locally

Outcome: PARETO-Proposed Infrastructure Buildout

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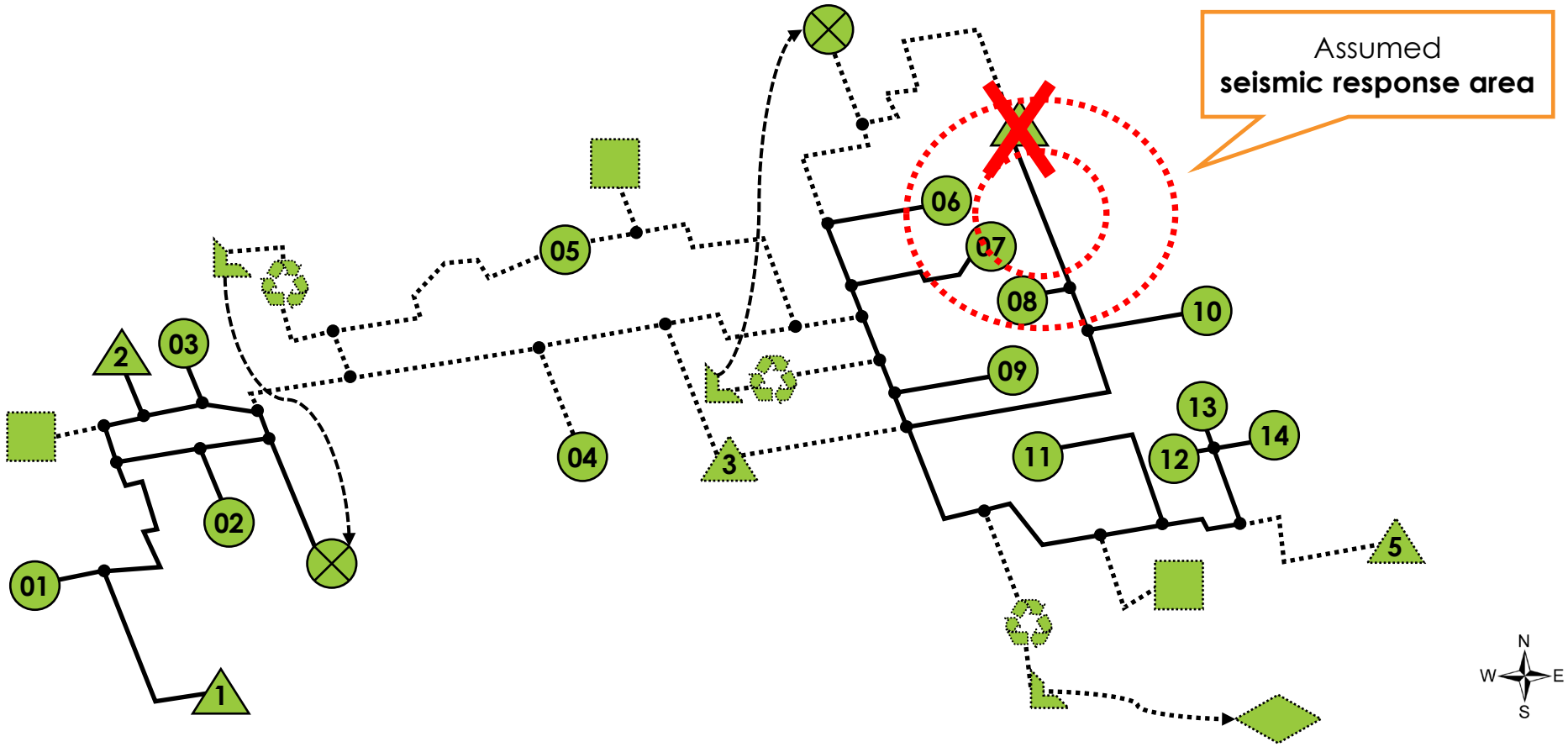

Legend

- Production pad
- Completions pad
- PW injection **option**
- PW treatment **option**
- Treated PW pit **option**
- PW desalination **option**
- PW sharing **option**
- Existing pipeline
- Pipeline **option**

Representative Example Only

[1] *Model size:* ***7,022 binary variables****; 69,450 continuous variables; 37,126 constraints*
Machine specs: Intel Xeon 2.80GHz, 32 GB RAM, Python Pyomo 6.0.1, Gurobi Optimizer 9.1.2
Solution time: 75 seconds (0.0% optimality gap)

Outcome: PARETO-Proposed Infrastructure Buildout

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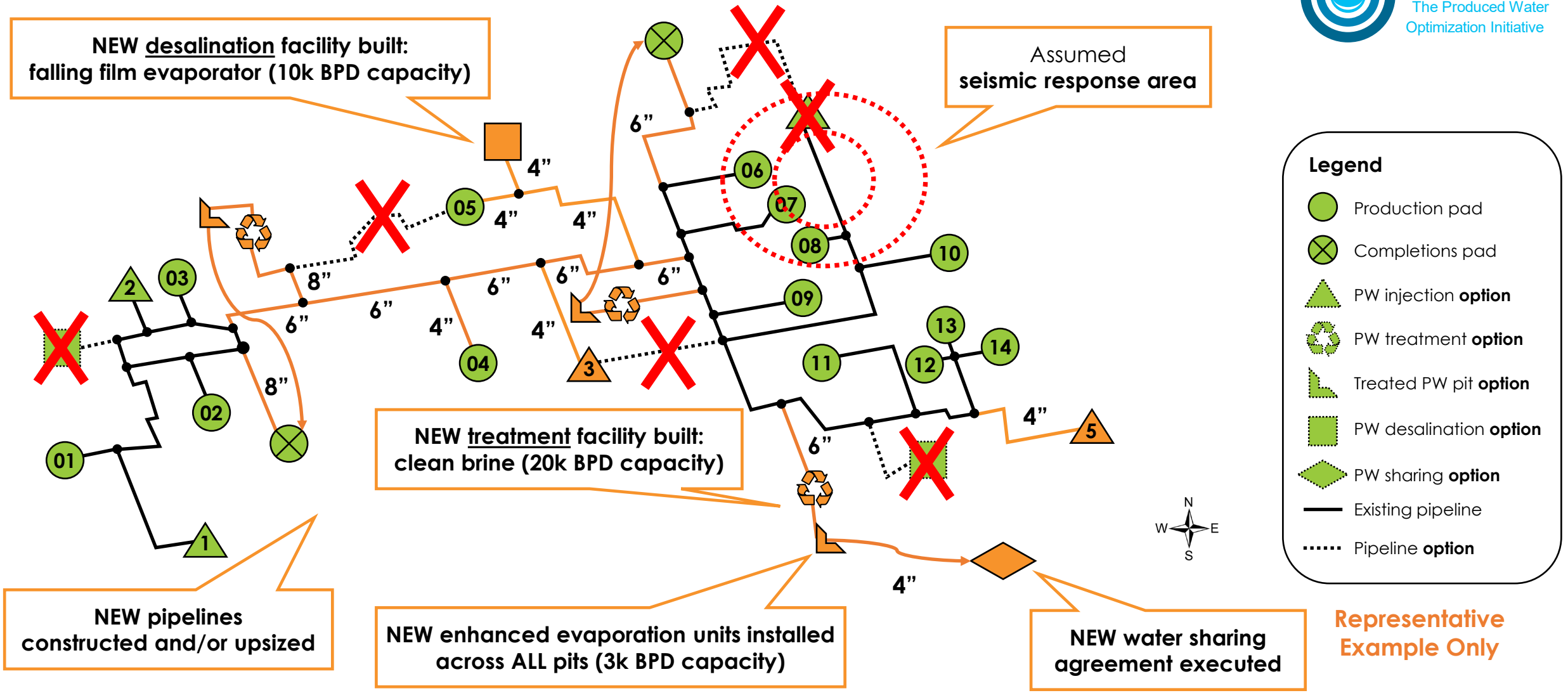

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Outcome: PARETO-Proposed Water Deliveries

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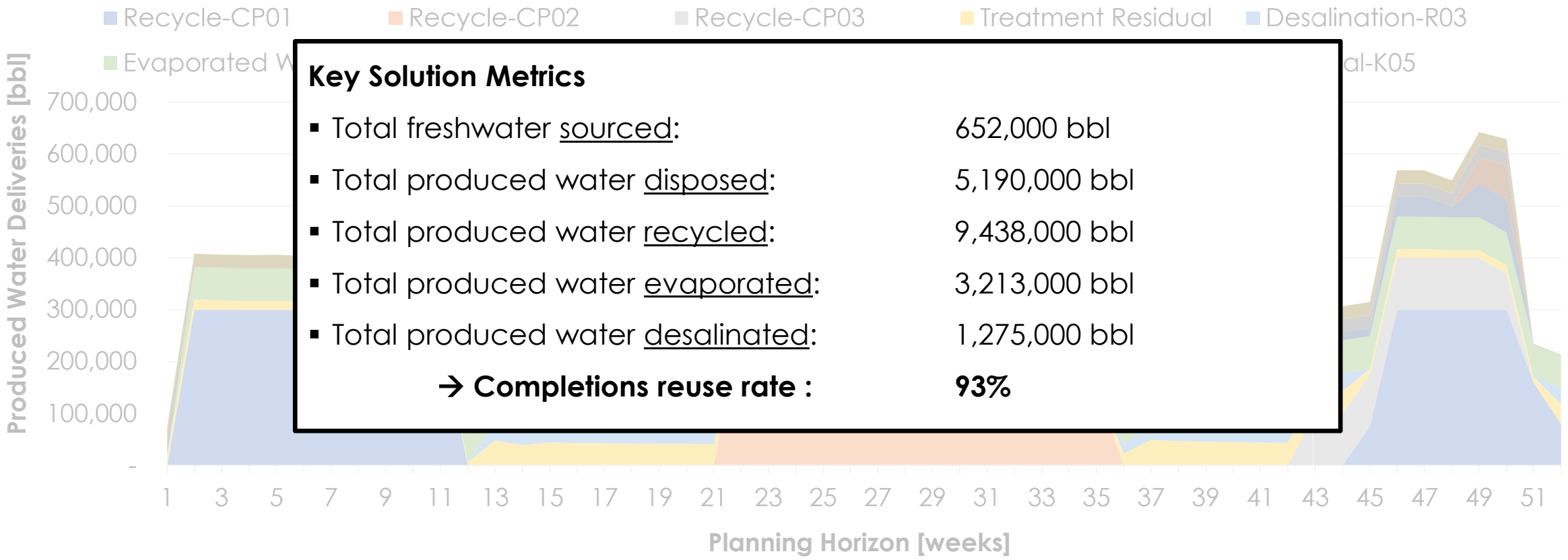

Key Solution Metrics

▪ Total freshwater sourced:	652,000 bbl
▪ Total produced water disposed:	5,190,000 bbl
▪ Total produced water recycled:	9,438,000 bbl
▪ Total produced water evaporated:	3,213,000 bbl
▪ Total produced water desalinated:	1,275,000 bbl
→ Completions reuse rate :	**93%**

PARETO prescribes where – over time – produced water volumes are ultimately delivered to by destinations (including completions pads, disposal sites, desalination facilities).

Pillars of Produced Water Optimization

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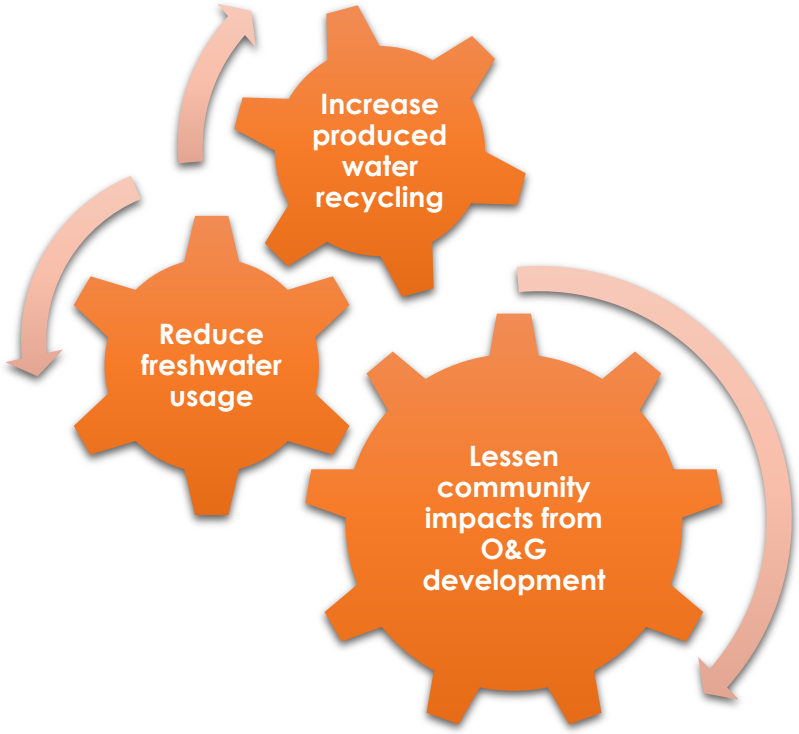
PARETO will **advance DOE's goals** in the produced water space:



Example of ***optimization impact***

	Without Optimization		With Optimization
Truck Routing	Water trucks are routed primarily based on **hauler experience**		Water trucks are routed exclusively by the optimization based on **drive time data**
Recycling Campaign	Flowback & production water mostly sent to **disposal facilities**	**25% Cost Reduction**	Flowback & production water **recycled** as much as possible to meet frac water demand
Storage Management	**Reactive** production tank management: wait for tanks to fill, then empty		**Proactive** production tank management: empty tanks as soon as outlet nearby available
Freshwater Trucking	**Significant volumes** even when production water is available nearby		**Last resort**, only when no pipeline available and impaired water recycling maxed out
Truck Count	Longer drives due to poor routing translates into **more trucks** on the road	**25% Truck Reduction**	Efficient routing and coordinated storage management **decrease trucking activity**
Environmental Impact	Limited production water recycling requires **substantial freshwater**	**35% Freshwater Reduction**	Increased produced water recycling **reduces freshwater consumption** & disposal volumes
Safety Record	More trucks on the road **increases risk** of accidents, injuries & spills	**30% Incident Reduction**	Less trucks on the road implies **less potential** for accidents, driver fatigue, injuries

PARETO will help the community (1) reduce freshwater consumption, (2) maximize produce water recycling, and (3) lessen community impacts.

Source: Prescriptive Analytics for Produced Water Management, M. Drouven, Exenity, Produced Water Society Seminar 2020, February 2020, https://www.producedwatersociety.com/resources/library

Community Engagement

Project PARETO Stakeholder Board

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Context

- In 2021, DOE established an open **produced water optimization stakeholder board**
- The Board involves **over 30 organizations** representing the produced water community*
- Its main purpose is to ensure DOE is addressing **timely and important challenges**
- The project team regularly consults the stakeholder board to **better serve the community**

Regular Board Meetings

- Generally, very well-attended (virtual & in-person)
- Organizations include *Range Resources, ConocoPhillips, Chevron, Olympus Energy, Aris, XRI Water, Exterran, Redox Systems, B3 Insight, …*

The PARETO stakeholder board in action at its most recent in-person meeting in Midland, TX, in August 2022

Engagement with the produced water optimization stakeholder board is a cornerstone of "Project PARETO".

* Organizations represent upstream operators, midstream companies, technology providers, universities, national laboratories, consultants, water analytics companies, non-profits, …

Ongoing Industrial Collaborations

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The team is **actively collaborating** with several industrial partners:

	OLYMPUS ENERGY	ConocoPhillips	ARIS WATER
Basin	Appalachian	Permian	Permian
Segment	Upstream	Upstream	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
PARETO Model	Operational	Strategic	Strategic

Details of the collaboration between DOE and Olympus Energy were recently published in a joint article.

Related Efforts

PARETO for Produced Water Sharing

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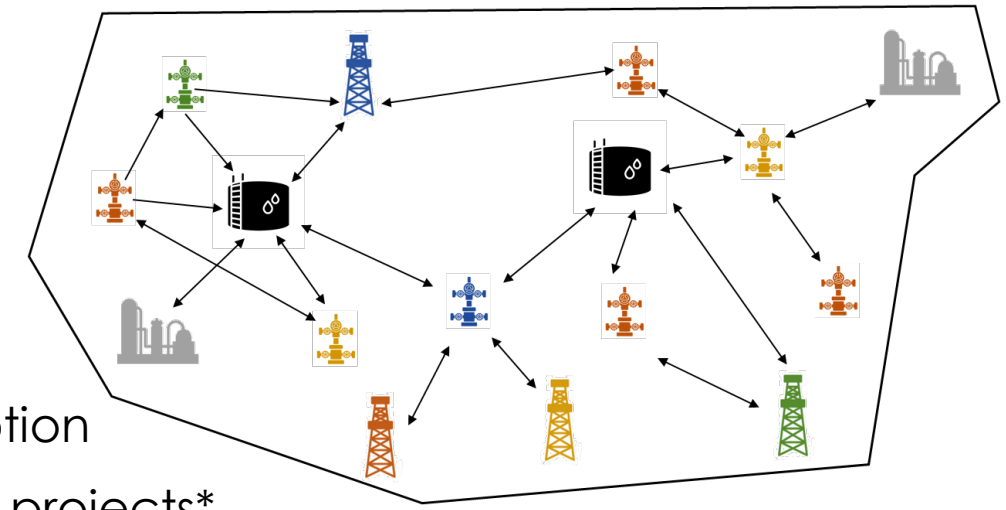
Goal: This project extends the PARETO framework to develop an optimization-based <u>produced water exchange platform</u> to facilitate the sharing of water within basins.

GROUNDWATER PROTECTION COUNCIL

The extension would be expected to optimize:

a) **which** parties could benefit from water sharing
b) **how** much water each party delivers or receives
c) **where** water needs to be delivered to
d) **whether** and how to leverage storage facilities
e) **how** credits/debits should be distributed fairly
f) **which** benefits the community can realize



- Quantify the benefits of water sharing to facilitate adoption
- Draw on DOE and GWPC successes with states on data projects*

This work will allow DOE to support the produced water community in maximizing produced water reuse, reducing freshwater consumption, and restricting injection volumes.

* FracFocus, WellFinder, etc.

PARETO for REE/CM Recovery

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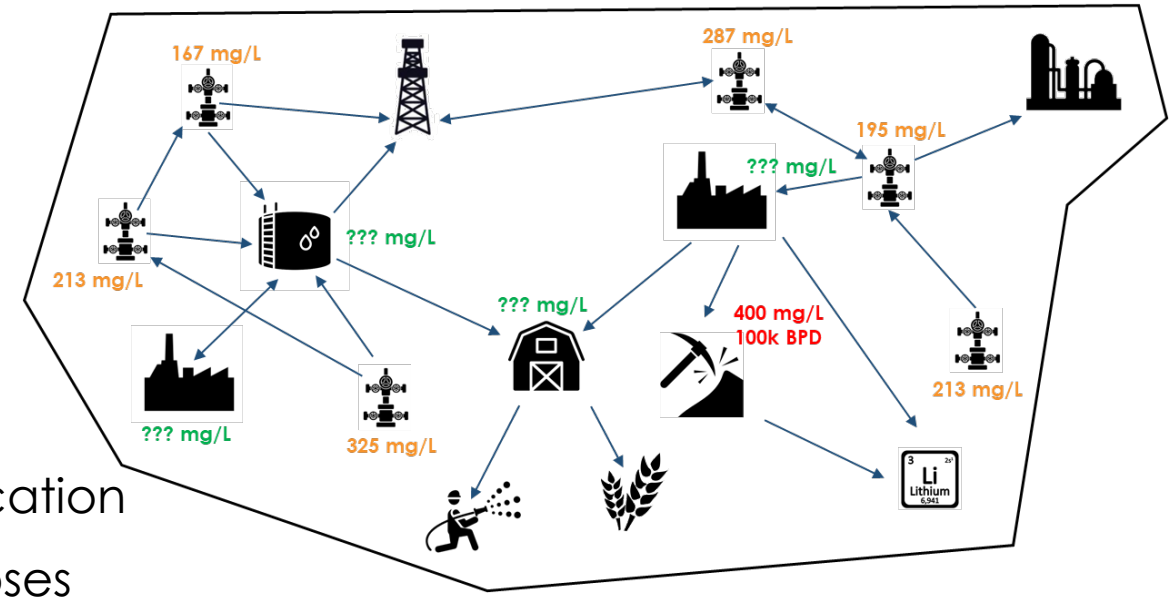
Goal: This project extends the PARETO framework to design and operate <u>multi-enterprise networks</u> for <u>REE/CM recovery</u> from produced water and other waters/fluids*.

Carnegie Mellon University

The extended framework is expected to identify:

a) **which** wells/sources contribute to the mine feed
b) **how** much brine should be delivered over time
c) **where** pipelines need to be constructed
d) **whether** and how to leverage storage facilities
e) **how** much brine intensification will be required
f) **which** type of brine intensification is suitable



- Develop models/algorithms specifically for this application
- Leverage machine learning models for various purposes

The work will allow DOE and the produced water community better explore opportunities for REE/CM recovery from domestic resources.

* Coal waste fluids, acid mine drainage, recycling discharges

Project Timeline & Deliverables

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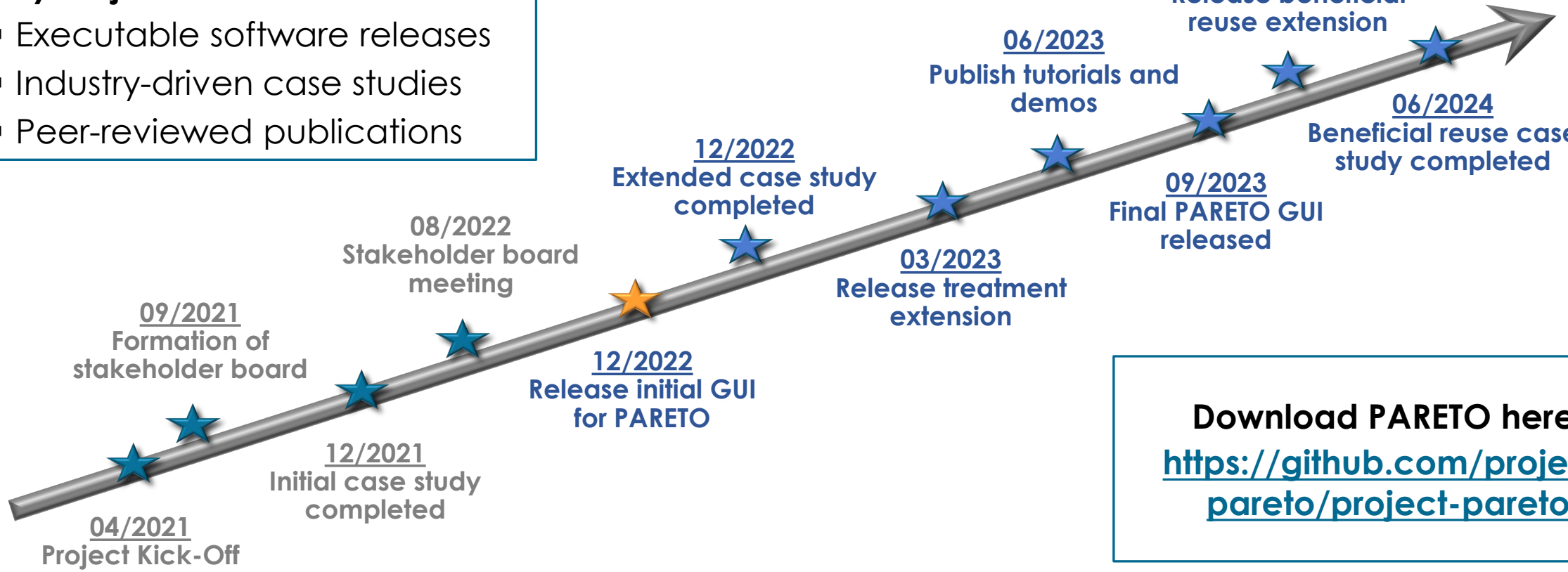
Key Project Deliverables

- Executable software releases
- Industry-driven case studies
- Peer-reviewed publications



Download PARETO here:
https://github.com/project-pareto/project-pareto

DOE's goal is to make this technology as accessible and useful as possible.

The PARETO Team

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We gratefully acknowledge support from the U.S. Department of Energy, Office of Fossil Energy and Carbon Management, through the Environmentally Prudent Stewardship Program.

Thank You!

For questions and comments, please contact our Case Study Advisor, Karen Work (kkwork2008@lbl.gov) or the Stakeholder Coordinator, Lisa Henthorne (lhenthorne@lbl.gov), or the Technical Director, Markus Drouven (markus.drouven@netl.doe.gov).

Visit **PARETO website**:
https://www.project-pareto.org/

Download **PARETO Library**:
https://github.com/project-pareto/project-pareto

Read **PARETO documentation**:
https://pareto.readthedocs.io/en/latest/

Project Details

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Project Information

FWP Number:	**1022477**
FWP Title:	**An Optimization Framework for Produced Water Management and Beneficial Reuse**
Program Office:	**Natural Gas & Oil**
Recipient Organization:	**National Energy Technology Laboratory (NETL)**
Planned Project Start Date:	**04/01/2021**
Planned Project End Date:	**03/31/2024**

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