PRODUCED WATER SOCIETY
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Intelligent Water Management in Unconventional Plays

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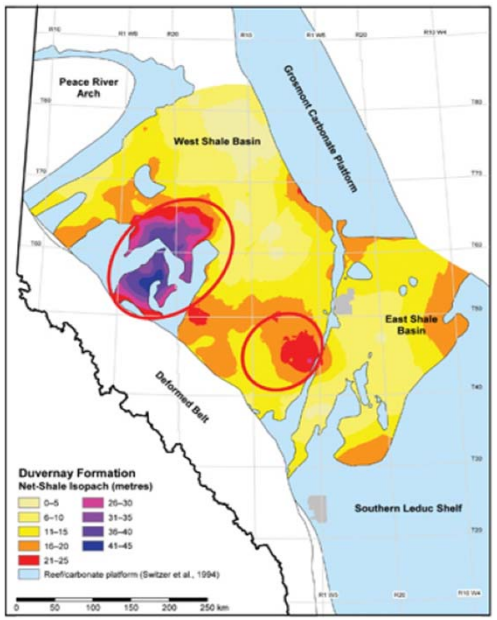
Problem / Opportunity

- Many of Alberta's best plays for future development are unconventional
  - E.g. Duvernay, Montney
  - **$34B** expected to be spent in Montney in next 5 yr on drilling and completions (FirstEnergy Capital)
  - **>$5B** in Kaybob-Duvernay in next 3 years

- Occur in sensitive areas requiring thoughtful and sustainable development:
  - Indigenous / First Nations
  - Caribou
  - Wetlands
  - Water

- **Water is the critical project resource/constraint, independent of the level of capital expenditure**



Source: http://www.pipelinenewsnorth.ca/news/industry-news/land-for-shale-1.1122801

Concerns in the Plays

- Economic Drivers:
  - Transportation, storage and disposal costs
- Regulatory Drivers
  - Regulatory Uncertainty - Area Based Regulations (ABR)
    - Minimize non-saline water use and reuse produced water
    - Minimize surface facilities and impacts
    - Engage in collaboration and water sharing (play-based)
    - Evaluate water management alternatives
    - Engage communities
- Social Drivers
  - Water Sourcing Concerns
    - Fear that there is not enough water for full scale development
  - Competitive uses (municipal and recreational)
    - Perception that water resources are declining
    - Impacts to fish bearing streams and lakes and loss of revenue
  - Widespread sentiment for reuse

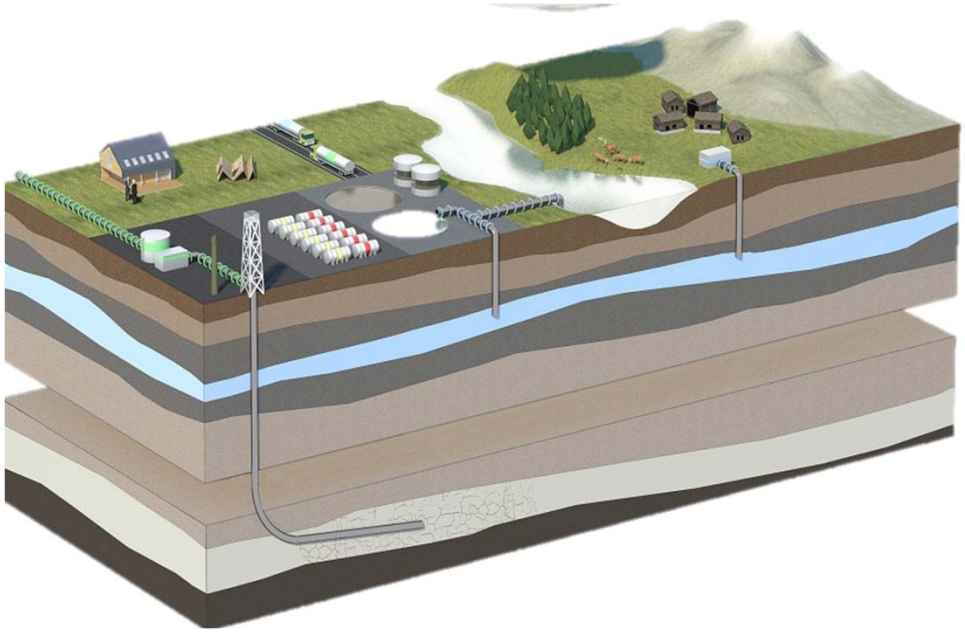
Need for Intelligent and Innovative solution

- To better understand what a sustainable based approach and solution for water management might look like in the Montney and Duvernay area.
- To determine how this could be supported from the perspective of the industry, regulators, stakeholders, and Indigenous Communities.

The Opportunity

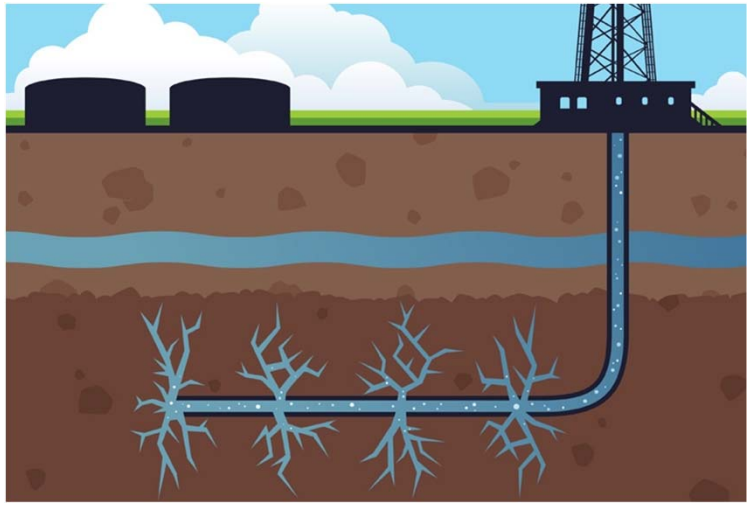
- **How do we optimize the interconnected system of surface assets?**
  - Includes pads, pipelines, facilities, roads, and **water** infrastructure
  - AND factor in social, environmental and economic considerations

Hydrocarbon=Water=$$$



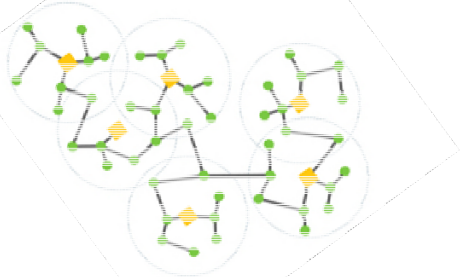
Water Management Implications / Risks

- Water **shortfalls** - insufficient storage, transportation, sourcing or availability
- Water **oversupply** – insufficient storage, transportation, disposal or recycling capacity
- **Delayed** fracking / activity schedules
- Higher **OPEX**
- **Underperforming** assets
- Regulatory **complexity** (Area Based Reg)



Planning Decision Support Framework

GoldSET



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Hydropti

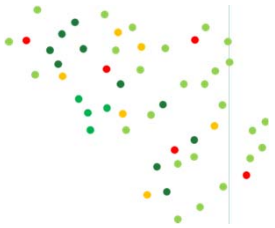
- **Footprint**
- Optimizes full-field development layout
- **Key outcomes:**
  - WP, GS, MGS locations
  - Water storage locations
  - Pipeline network

- **Water Use**
- Determine best water management plan(s)
- **Key outcomes:**
  - Long-term / Operational plans
  - Timing / Phasing
  - Economics

Optimization Method for Unconventional O&G

WELL PAD LOCATION

WHAT ARE THE BEST PAD LOCATIONS?



ASSET TYPES

- WELL PADS

PIPELINE OPTIMIZATION

WHAT PIPELINE METHOD IS BEST?

- WELL PADS
- PIPELINES

FACILITY OPTIMIZATION

HOW MANY FACILITIES?

- WELL PADS
- PIPELINES
- FACILITIES

WATER OPTIONS

WHAT ARE THE FEASIBLE OPTIONS?

- WELL PADS
- PIPELINES
- FACILITIES
- WATER MANAGEMENT

OPTIONS ANALYSIS

WHAT ARE THE BEST OPTIONS?

- WELL PADS
- PIPELINES
- FACILITIES
- WATER MANAGEMENT
- PHASING

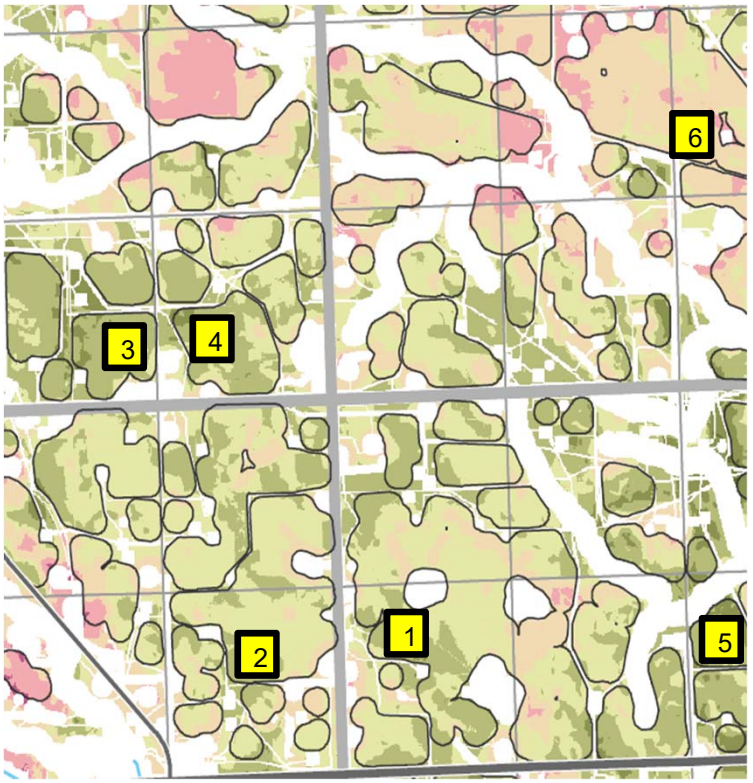
Case Study – Kaybob Duvernay (KD)

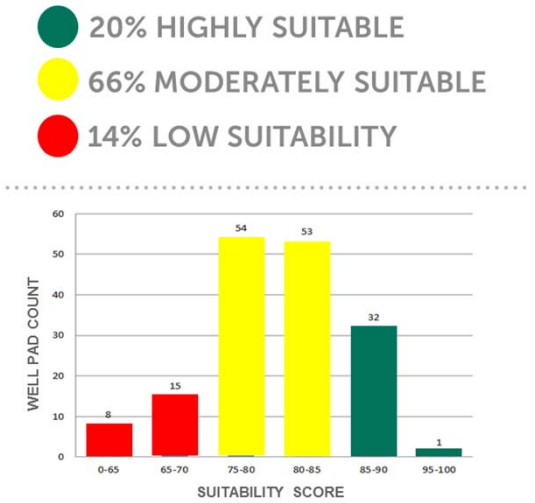
- Early asset planning phase (+/-30%)
- Optimization of full-field development at early asset development phase:
  - 210 Well Pads (WP) with up to 24 wells per pad
  - 34 Gathering Stations (GS)
  - 3, 4, 5, 6, 7, 12 Main Gathering Stations (MGS)
  - Pipelines (multiphase hydrocarbon, water)
  - 28 Water sources
    - Saline Groundwater, Non-Potable Groundwater, Potable Groundwater, Surface Water Stream, Surface Water Body, Industrial Reuse, Municipal Reuse, Other Third-Party Source
    - Included both inter-basin transfer and no transfer
  - Centralized water storage reservoirs (open pit storage)
  - Disposition including reuse, deep well injection, 3rd party processing

Objective - reduce cost through minimizing footprint and resource use

KD Case Study – WP Placement Results

- Sample WP Siting Tool Results

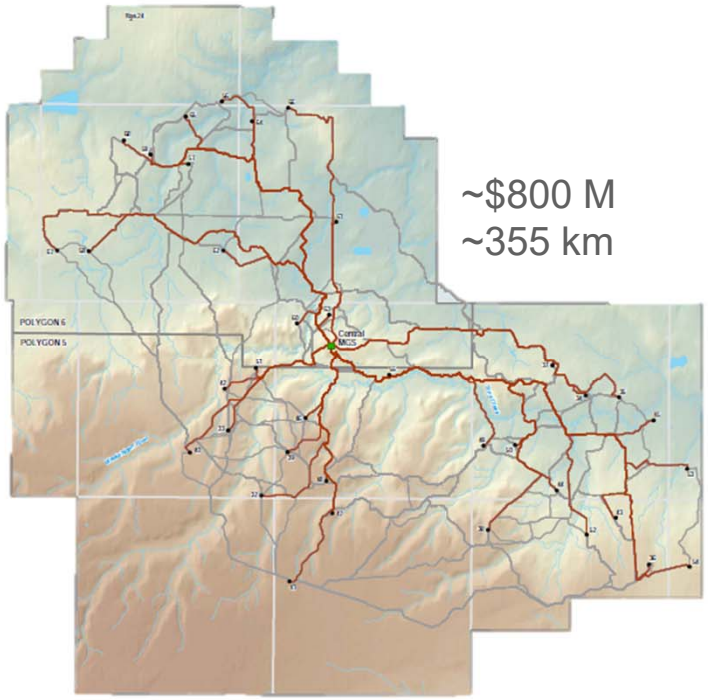




- Lower cost to construct and operate
- Reduced trucking distance
- Improved regulatory compliance

Pipeline Method, Spider vs. Daisy Chain

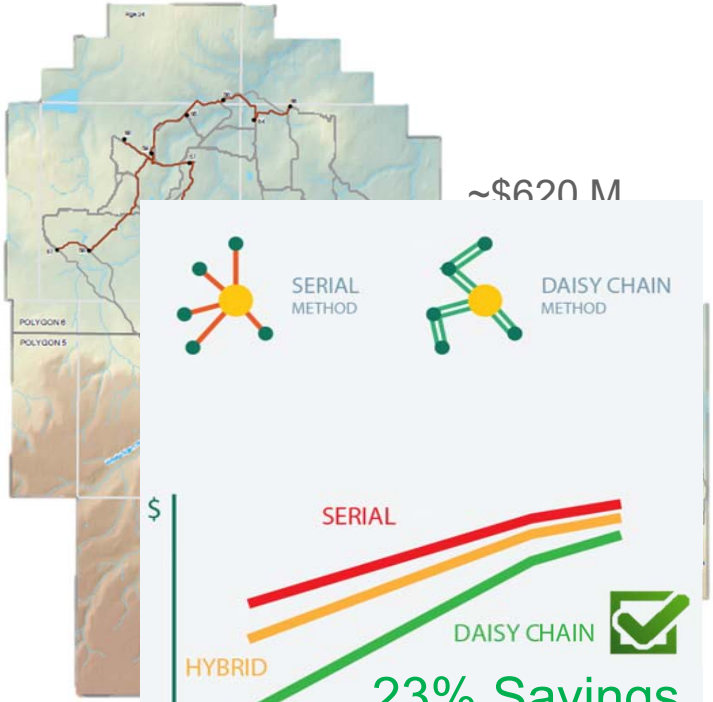
Spider Configuration



~$800 M
~355 km

- Every WP to WP connection modelled
- Each WP has a hydrocarbon pipeline (Multiphase)
- Temporary lay-flat hose for water on subsequent fracs

Daisy-Chain Configuration

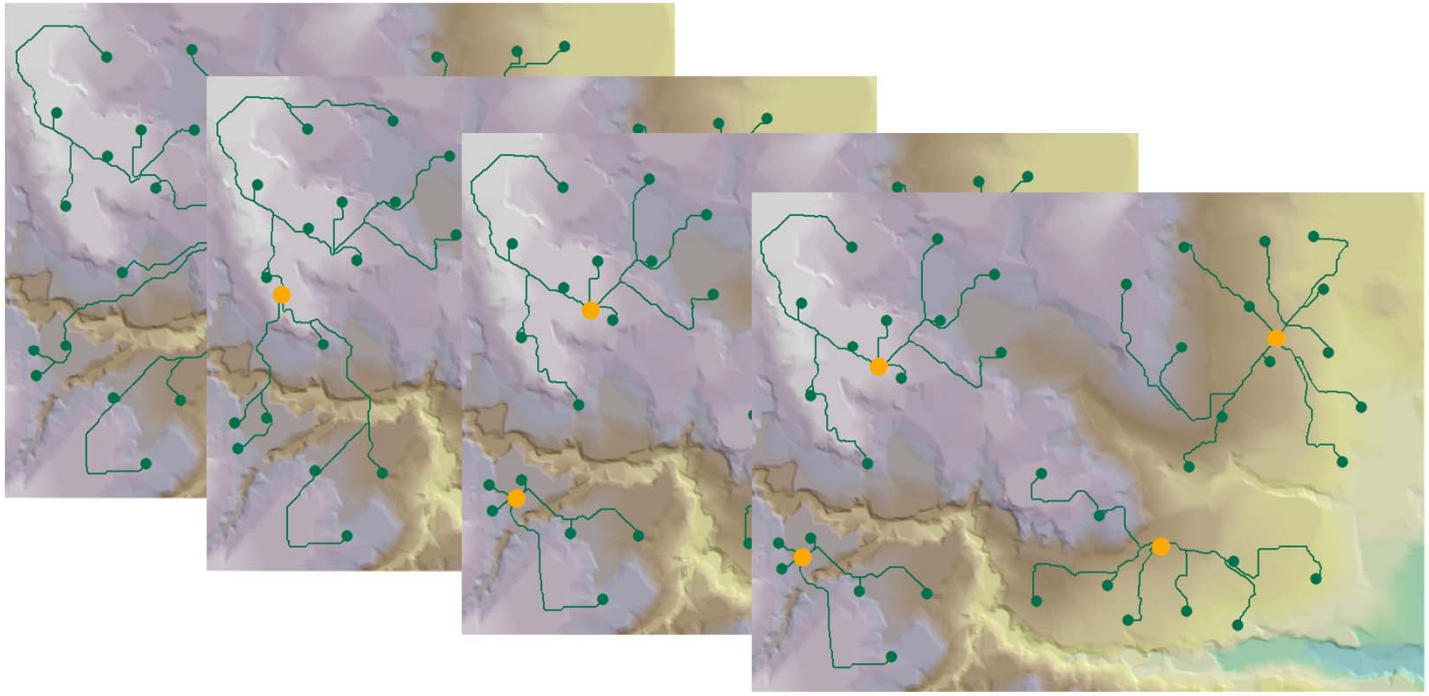


~$620 M

- Cluste
- Daisy-
- Dedica

Facility Optimization

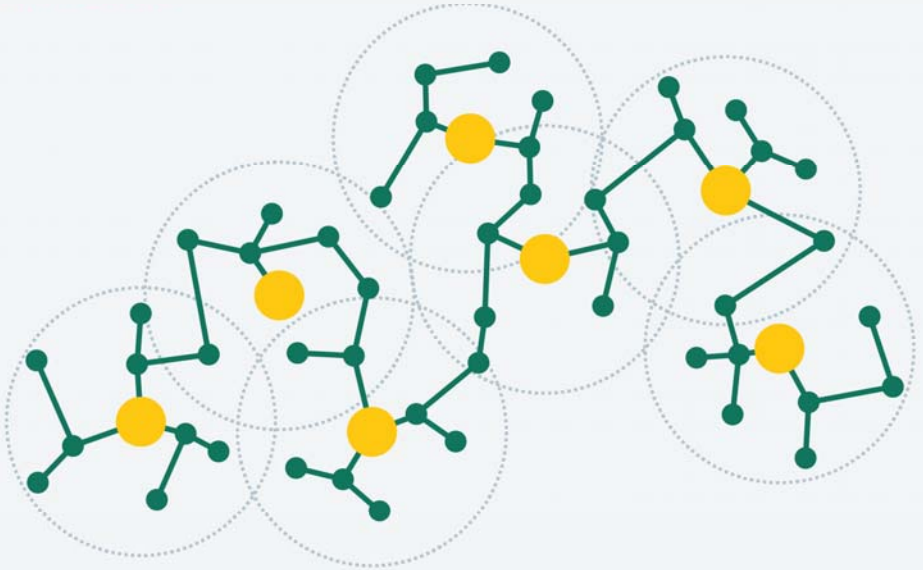
- How many GS and MGS are best?
- Routing solution automation



Facility Optimization

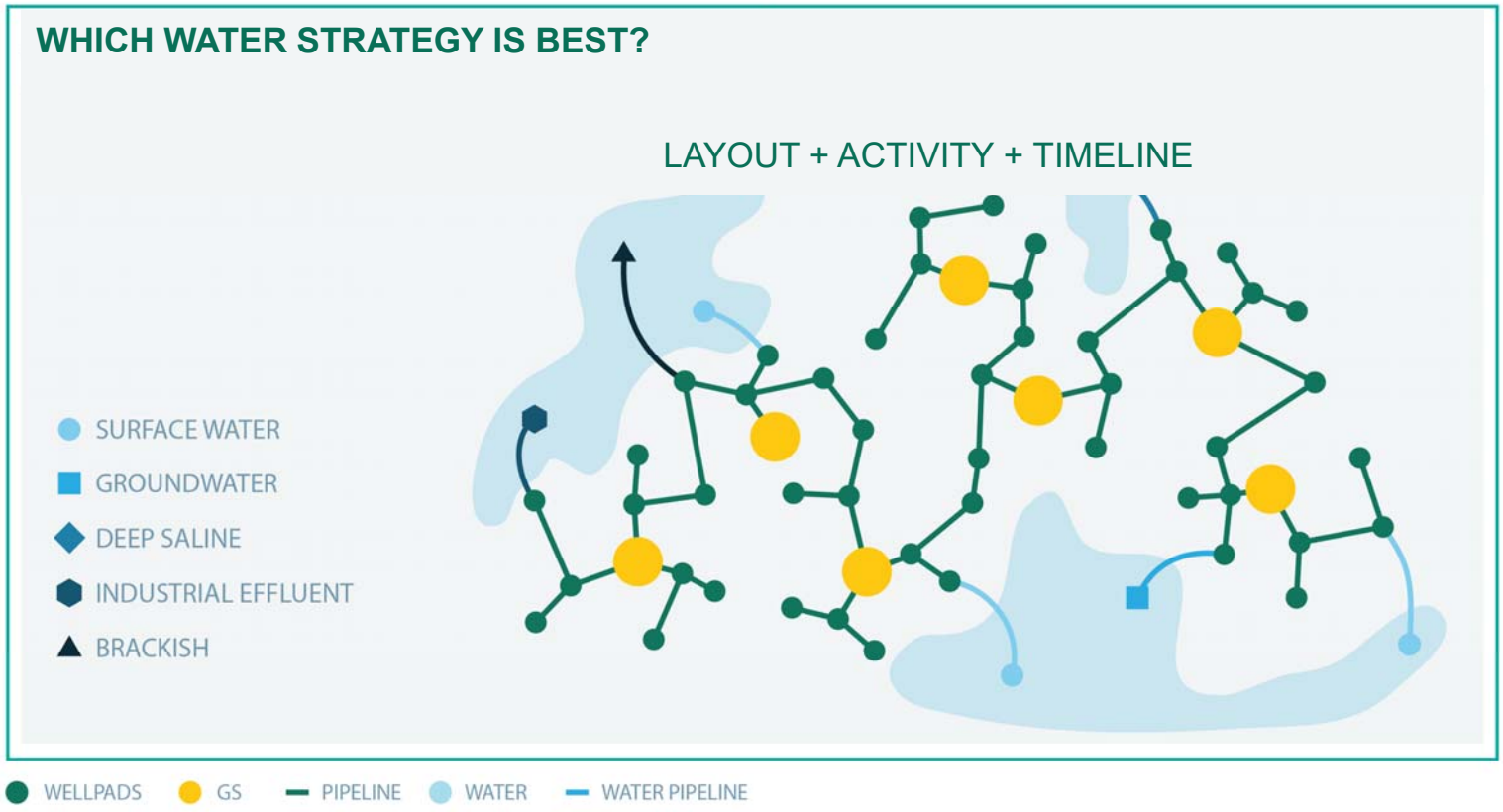
HOW MANY GS AND MGS ARE BEST AND WHERE SHOULD THEY BE LOCATED?

NUMBER OF GS	WELL PADS EXCLUDED
4	30-40%
5	12%
6	2%
7	0%
> 8	TOO COSTLY

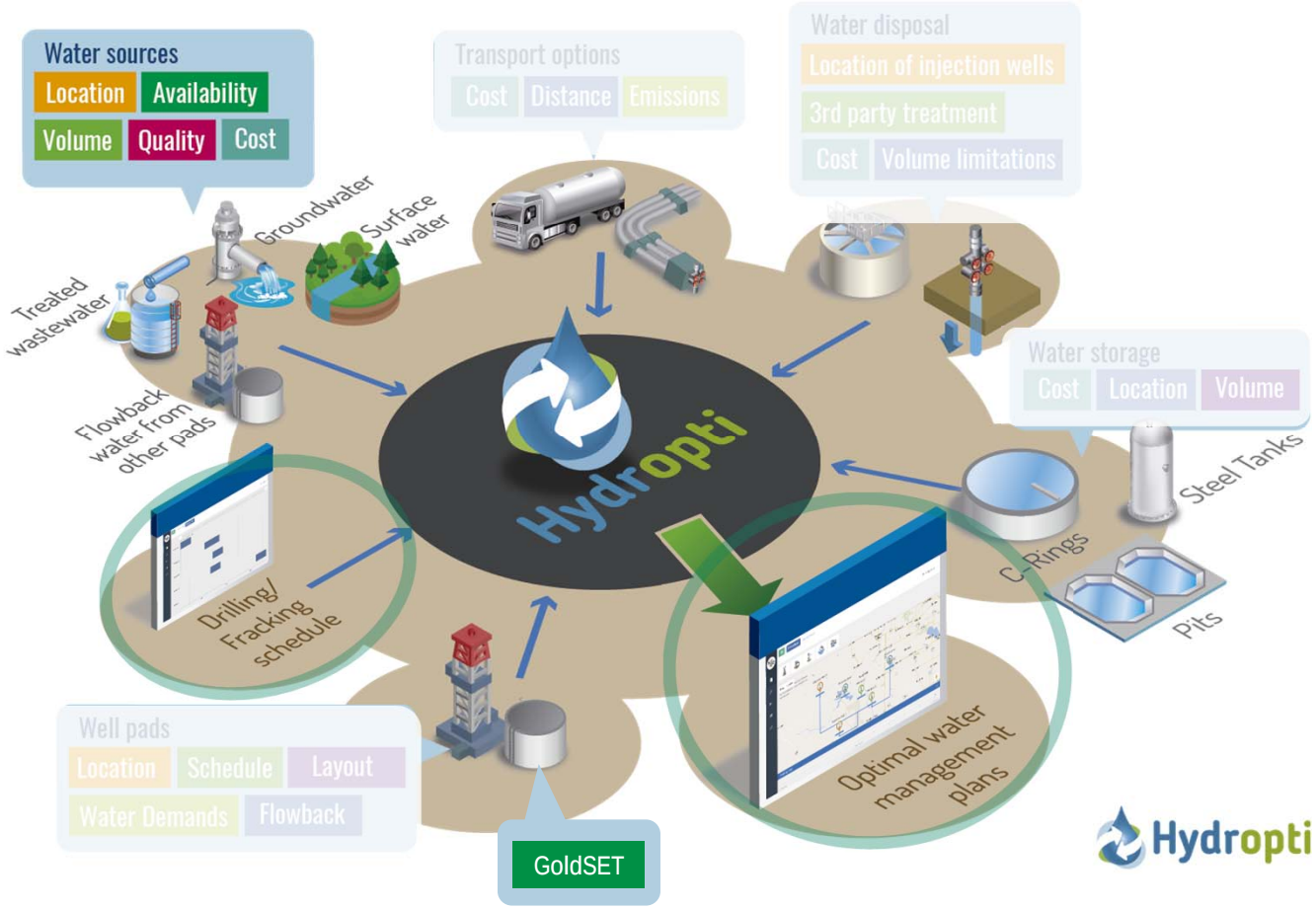


WELLPADS GS PIPELINE MAX PIPELINE LENGTH

Water Use Optimization



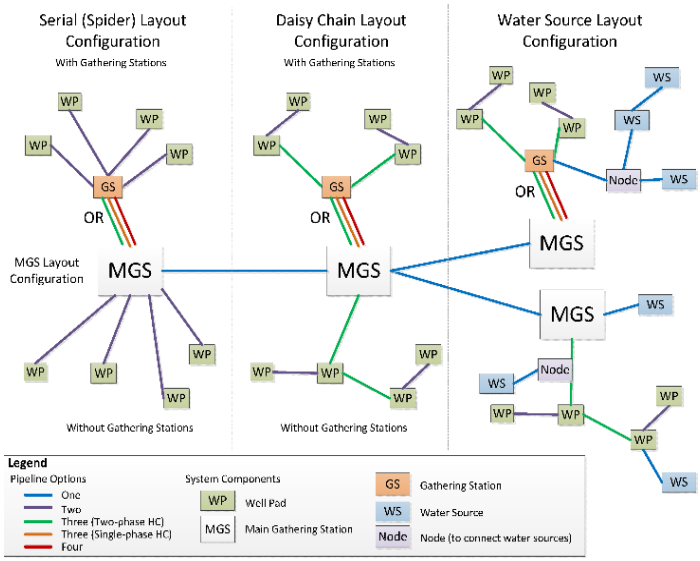
Water Management Simulator



Water Management Decisions

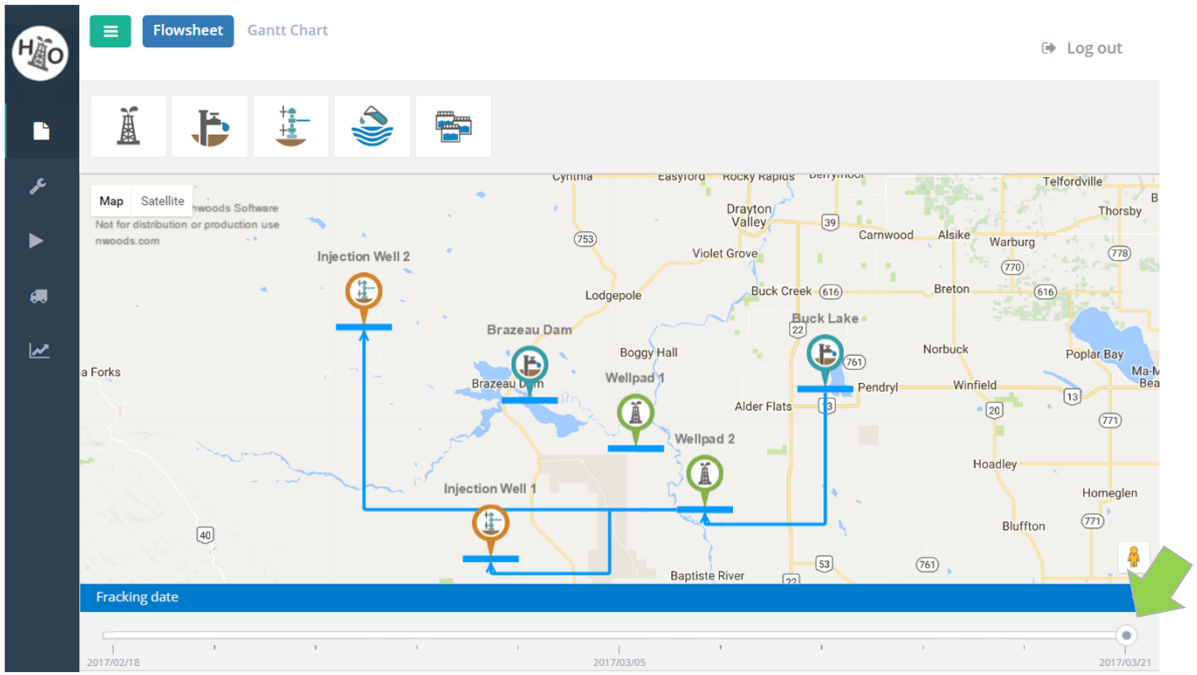
- Footprint and layout
- Sourcing/Disposition Options
  - Reuse
  - Capacity needs/availability
  - Regulatory constraints
  - Water treatment requirements/options
- Transportation
  - Truck
  - Permanent pipeline
  - Temporary pipeline
  - Rail/barge
- Storage
  - Centralized system
  - Decentralized system
  - Storage capacities

Footprint Layout



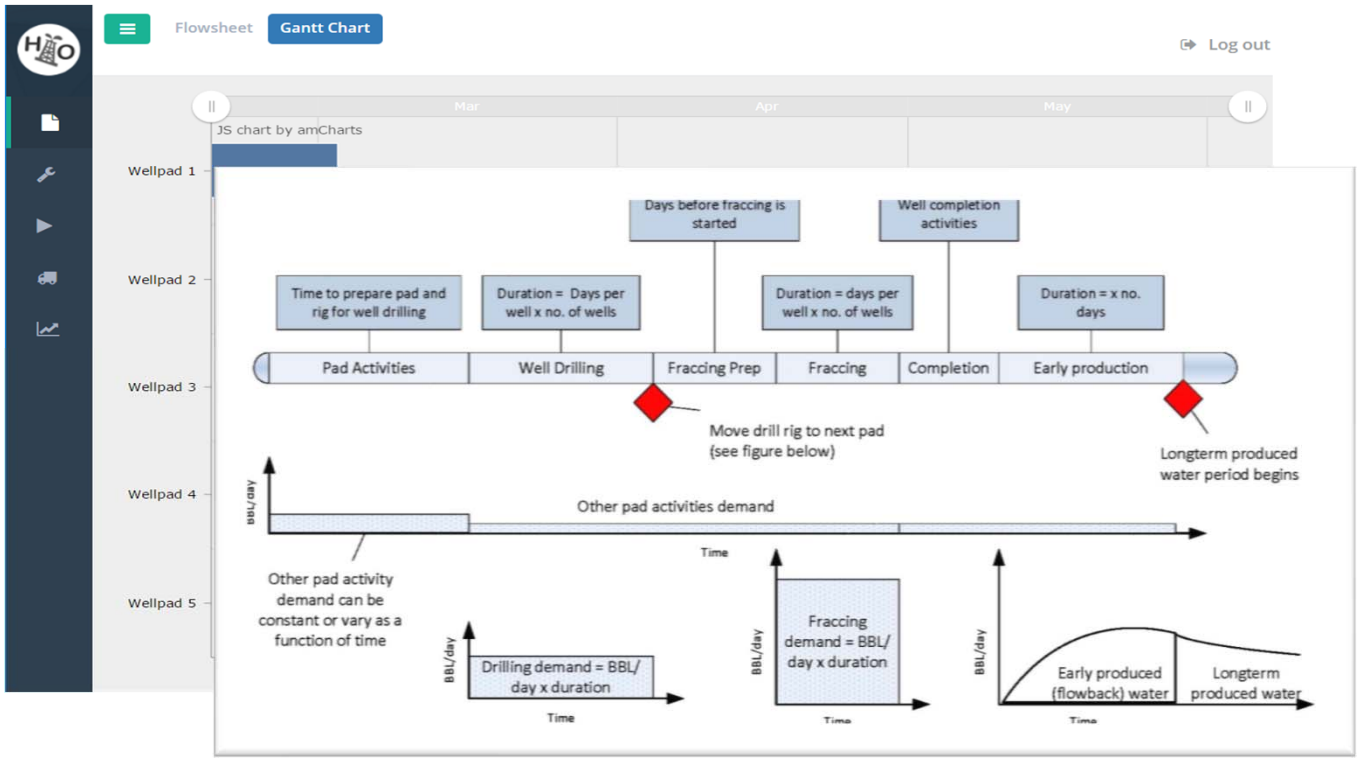
User Interface

- Graphical
- Cloud based



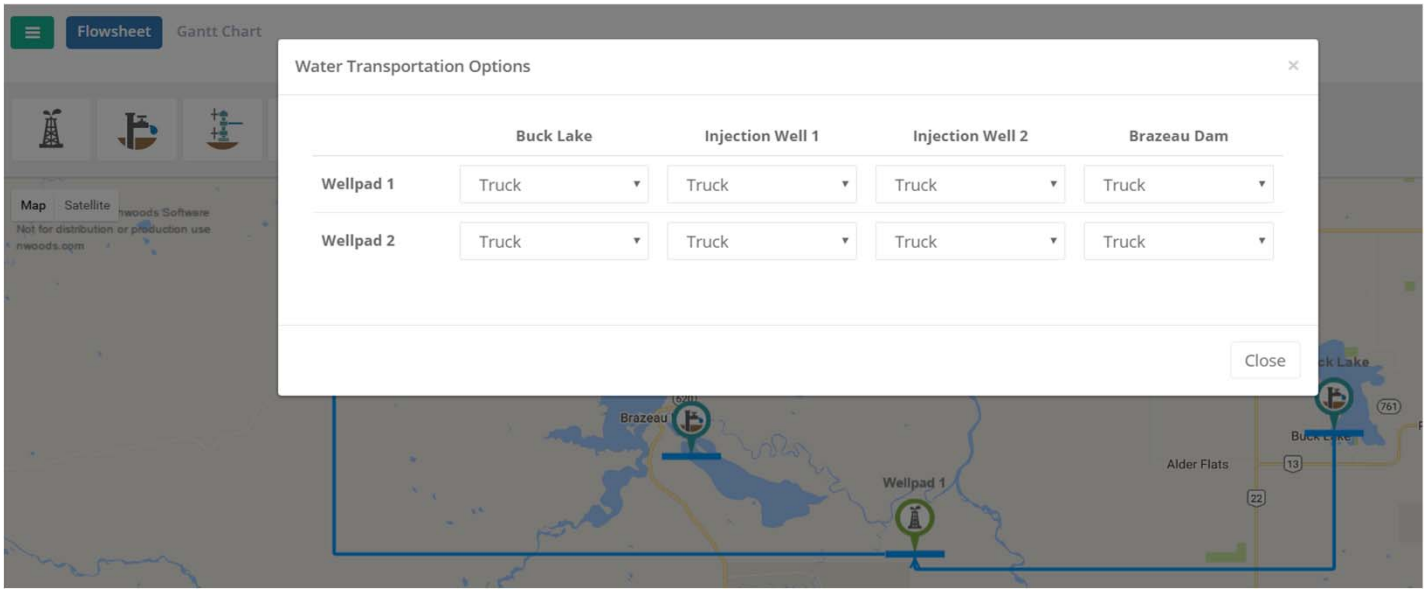
User Inputs – Activity Schedule

- User inputs the drilling and frac schedule as a Gantt Chart



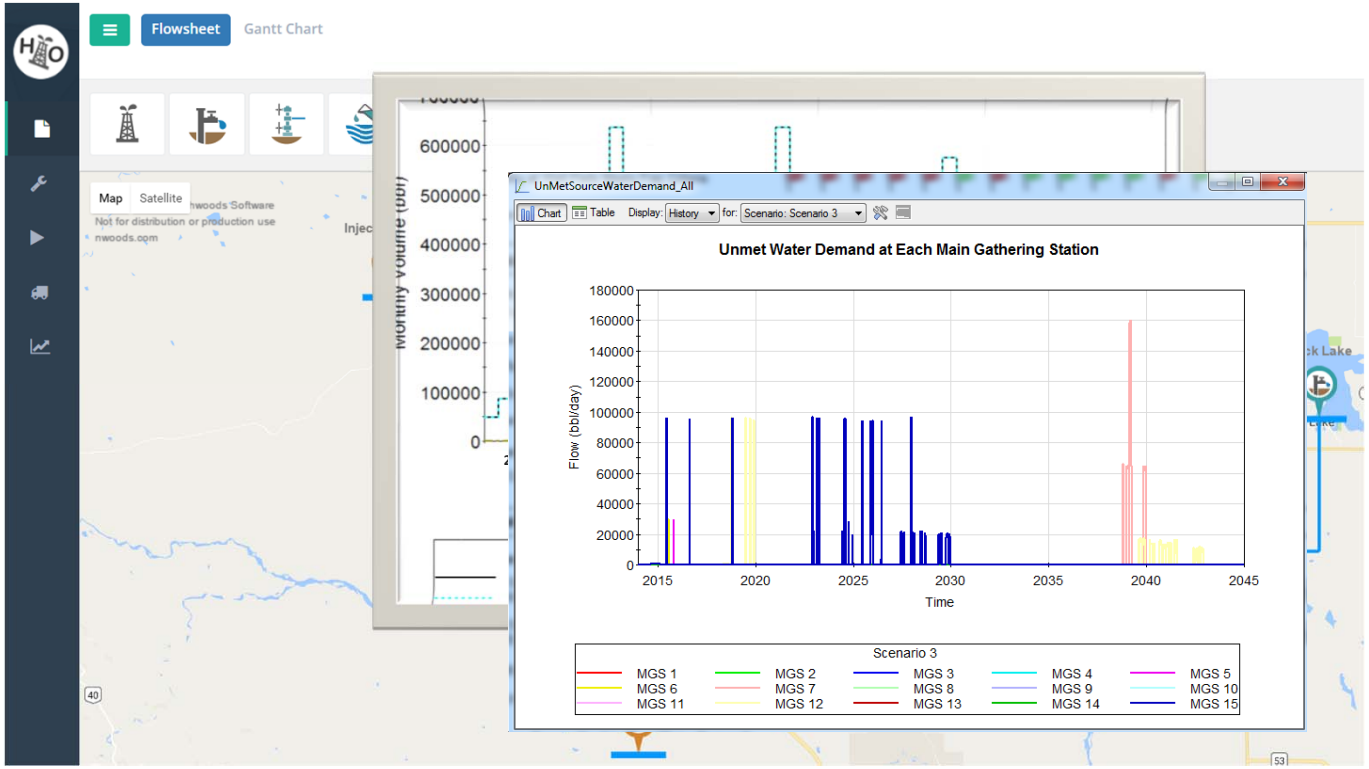
User Inputs - Transport Options

- User provides the transport option(s) between the nodes in the flowsheet.



Results

- Optimum strategy for handling the water in the system.



Sample Results

- Identifies minimum operating cost while providing the required volumes respecting the permits for sources and injection wells.

– Wellpad 1

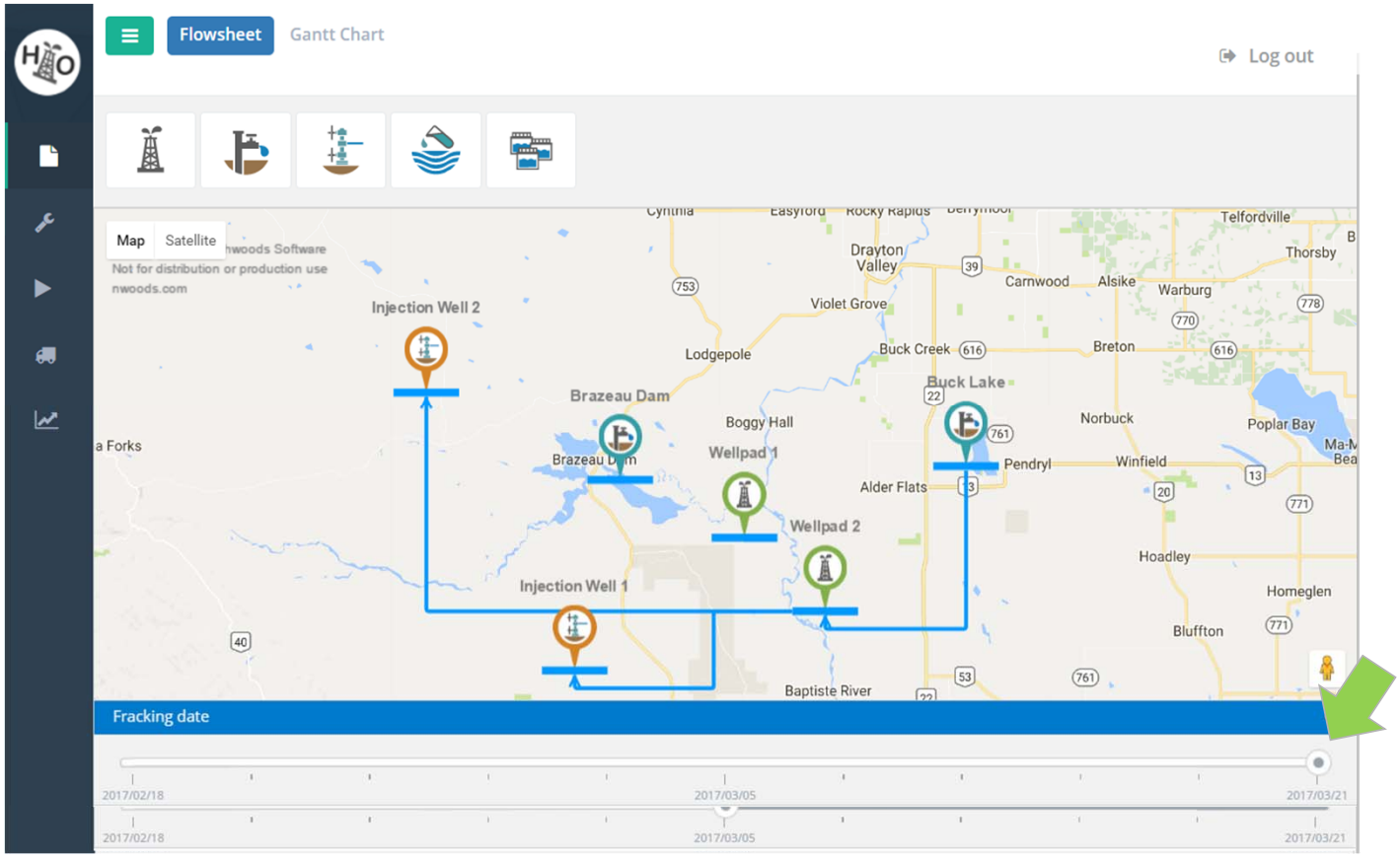
From	To	Volume		Transport cost		Transport option
Buck Lake	Wellpad 1	m3	5,000	CAD$	7,070.32	Truck
Brazeau Dam	Wellpad 1	m3	0	CAD$	0	Truck
Wellpad 1	Injection Well 1	m3	0	CAD$	0	Truck
Wellpad 1	Injection Well 2	m3	2,000	CAD$	4,100.46	Truck

– Wellpad 2

From	To	Volume		Transport cost		Transport option
Buck Lake	Wellpad 2	m3	10,000	CAD$	12,109.23	Truck
Brazeau Dam	Wellpad 2	m3	0	CAD$	0	Truck
Wellpad 2	Injection Well 1	m3	1,000	CAD$	1,527.04	Truck
Wellpad 2	Injection Well 2	m3	3,000	CAD$	7,977.29	Truck

Results – Time Dependency

- Using a time slider, user can quickly check the recommended solution at different times during the fracking operations .

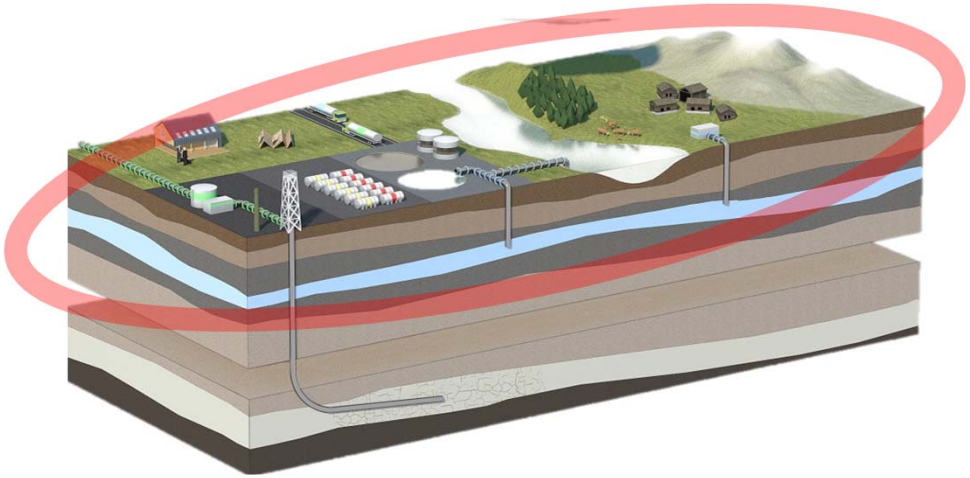


Delivered Outcomes

- **10 - 34% (+/- 30%) CAPEX reduction** based on initial design
- **10-15%** improvement on surface facility location suitability
- **1 – 4** months development time
- **Questions Answered:**
  - Is there sufficient source water, storage, disposition capacity when and where I need it?
  - What is my risk of having a water shortfall and what can I do to mitigate it?
  - What are the most viable single and multi-operator water plans?
  - What is net present cost?
  - Benchmarking evaluation of planned asset performance

The Opportunity

- Market shifting from scarcity to abundance
- Value shifting from exploration to timely and efficient development
- Optimize the interconnected network and system of surface assets focusing on Water
- Consider triple bottom line



Being Intelligent can

- Create an essential tool to better understand water resources and its use.
- Manage risks related to water quality and quantity
- Optimize water use, reuse and recycling to achieve operational efficiencies and decrease costs
- Strengthen regulatory compliance
- Improve corporate governance and transparency
- Unbiased, integrated, and holistic water management
- Minimize capital equipment costs
- Enhance company brand and image

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Acknowledgement

- Golder
- Process Ecology
- Multi Stakeholder Panel- Area based regulation
- University of Calgary
- Alberta Innovates
- Our Clients

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