LNAPL Modelling and Site Closure

Otter Creek Tank Farm Areas 1 & 2, Goose Bay, NL

October, 2021

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Site Location

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Objectives

- Client (DCC) wanted to update the LNAPL Conceptual Site Model
- Implement site management framework (for closure)
- Address Data Gaps identified previously
- Complete 4 more rounds of monitoring 120+ MWs (May, July, Sept, Nov)

How to do these is pretty standard

- Use existing data (and recently collected) to evaluate primary lines of evidence of LNAPL behaviour
  - LNAPL characterization, stability, mobility, recoverability
  - Dissolved phase stability, MNA, and NSZD

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Site background

- OCTF was built in the 1940s ASTs ranging from 1.6 to 2.4 million Litres
- Removed in the 1970s
- Nearly 50 years later
- LNAPL and lots of it
- PHCs in soil and GW

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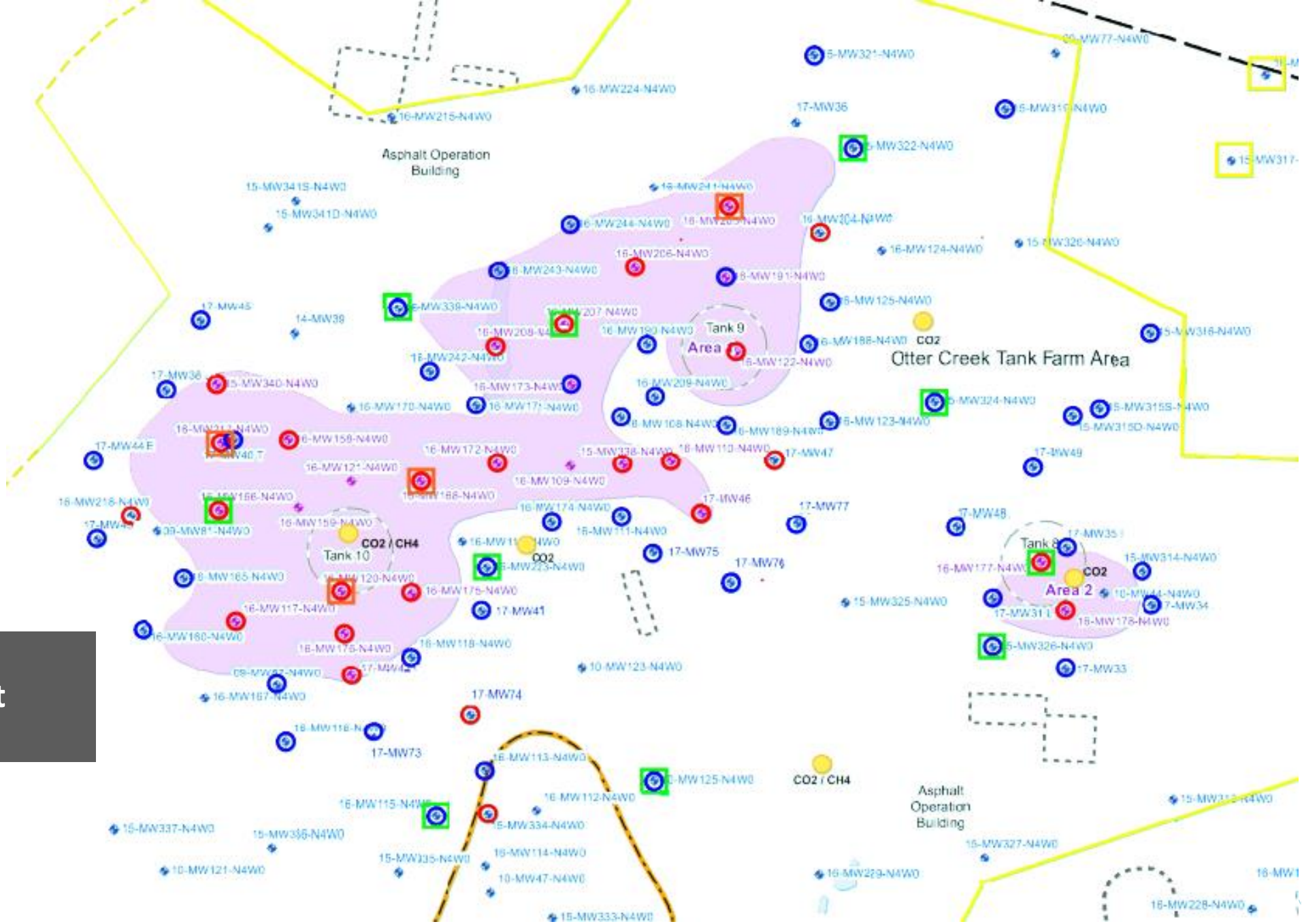
Site Layout


Asphalt Operation Building
Otter Creek Tank Farm Area
Tank 9 Area
Tank 10
Tank 8 Area 2
CO2
CO2 / CH4
Asphalt Operation Building

Questions arising from the Objectives

LNAPL

- Perception was: site had to be remediated
- Dillon was asked to apply the "*A Management Framework for LNAPL Sites at 5 Wing Goose Bay*"
- Monitoring Optimization
- Cost and Risk

What is the best thing to do here?

- Can LNAPL be managed in place?
- LNAPL Natural source zone depletion?
- Do we need all these wells?
- Do we need all these parameters?
- How many monitoring events do we need?

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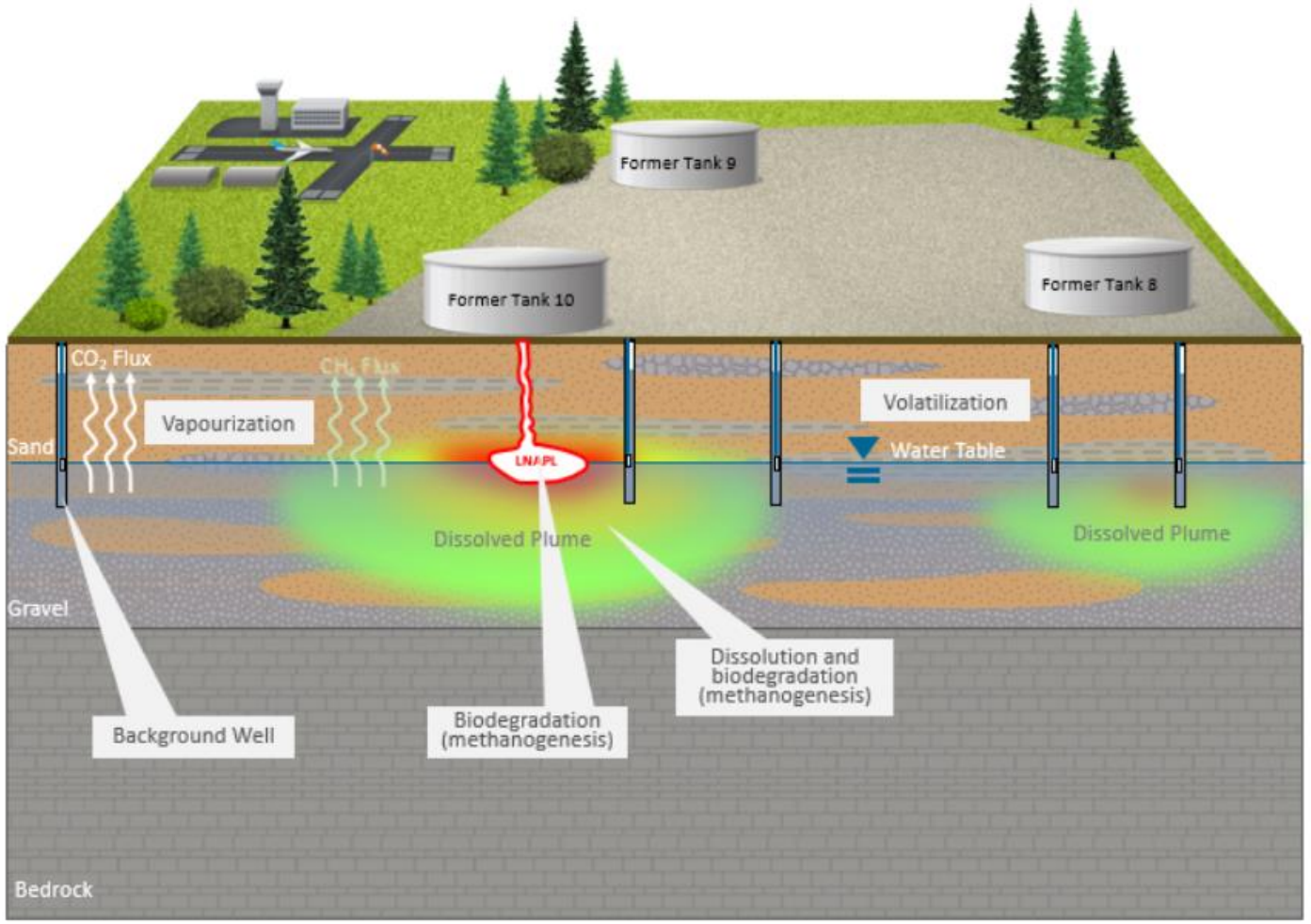
LNAPL CSM



- A former tank farm that was built in the 1940s and consisted of eight former aboveground storage tanks (ASTs) ranging in capacity from 1,613,800 to 2,441,200 Litres. The tank farm infrastructure was reportedly removed by the late 1970s. Petroleum hydrocarbon (PHC) impacts in soil and groundwater remain on-site
- Can the "*A Management Framework for LNAPL Sites at 5 Wing Goose Bay*" be used for the site?
- Framework is based on the assumption that LNAPL can be managed using a risk-based approach. Demonstrating plume stability is a key factor in identifying an appropriate site management strategy

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LNAPL Risks

Exposure Mechanisms

- LNAPL migration and time frame
- Dissolved phase migration and time frame
- Vapour migration

Receptors

- Humans current or future
- Ecological

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Primary Lines of Evidence

LNAPL Characterization

Sample ID	Date	Relative Density @ 15°C	API Gravity @ 15°C	Viscosity (cPs) @ 7°C
16-MW168	07/24/2018	0.8033	44.7	1.905
16-MW120	07/24/2018	0.8044	44.4	1.968
16-MW205	07/24/2018	0.8300	39.0	3.500
16-MW217	07/24/2018	0.8096	43.3	2.247

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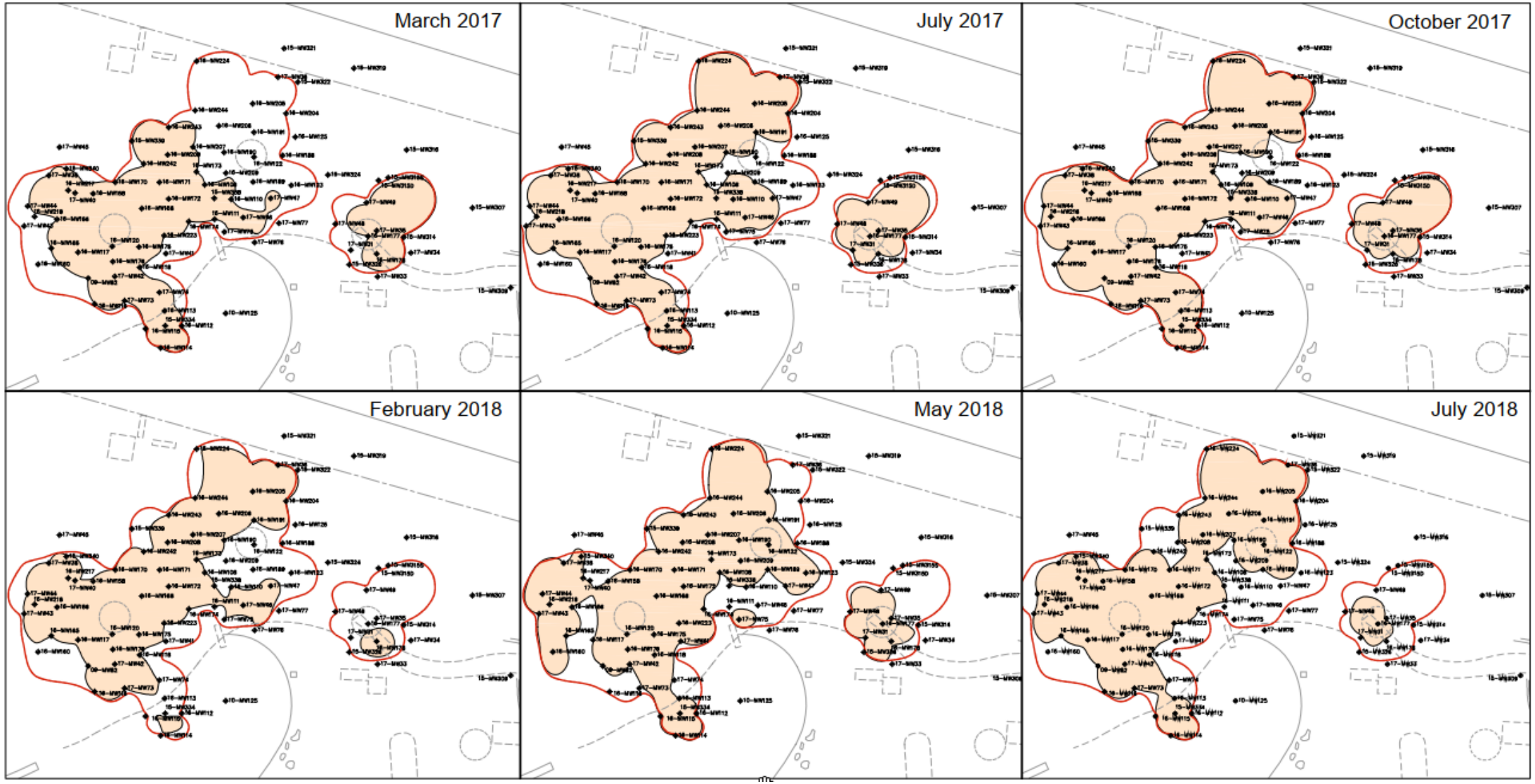
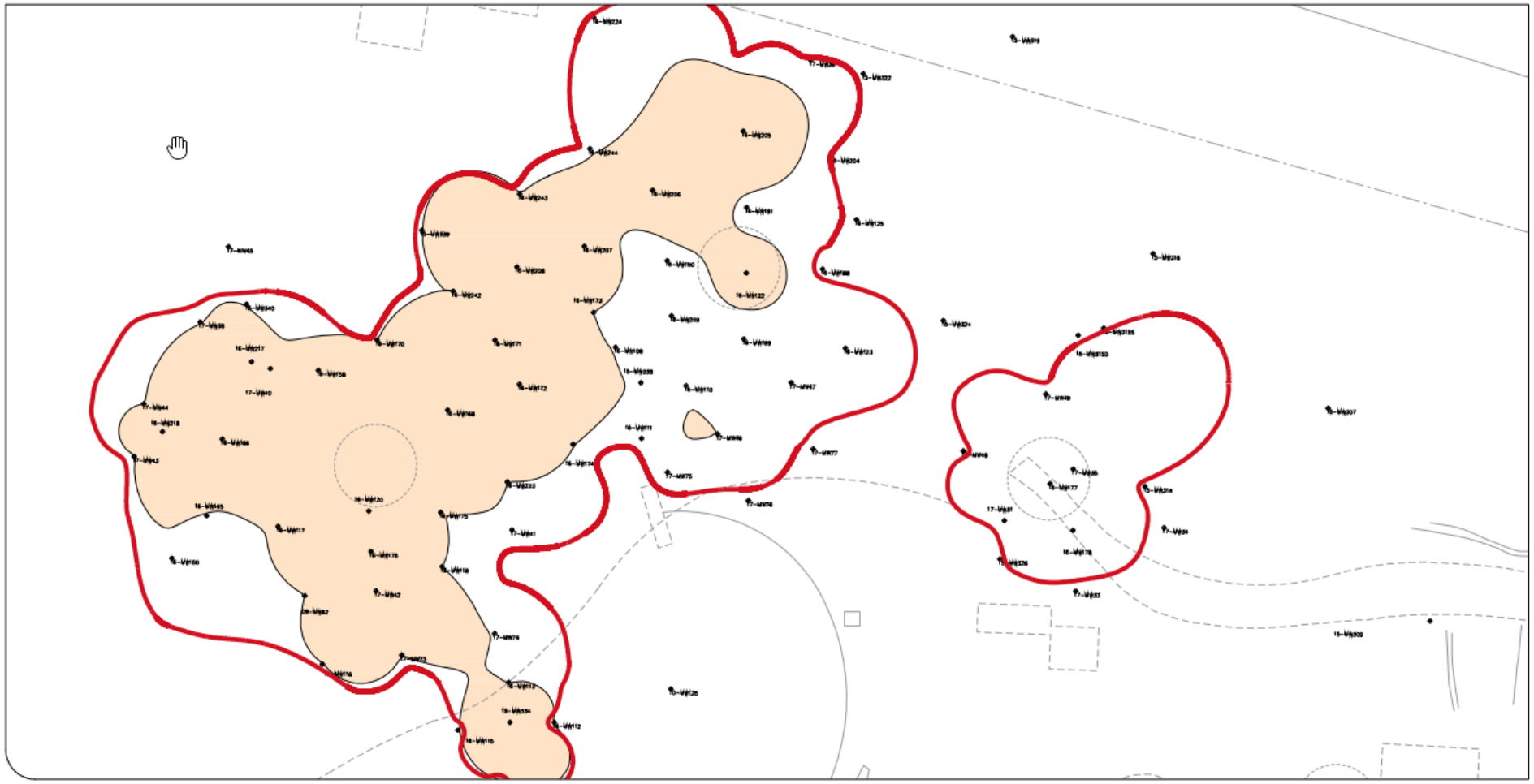
Primary Lines of Evidence

LNAPL Stability

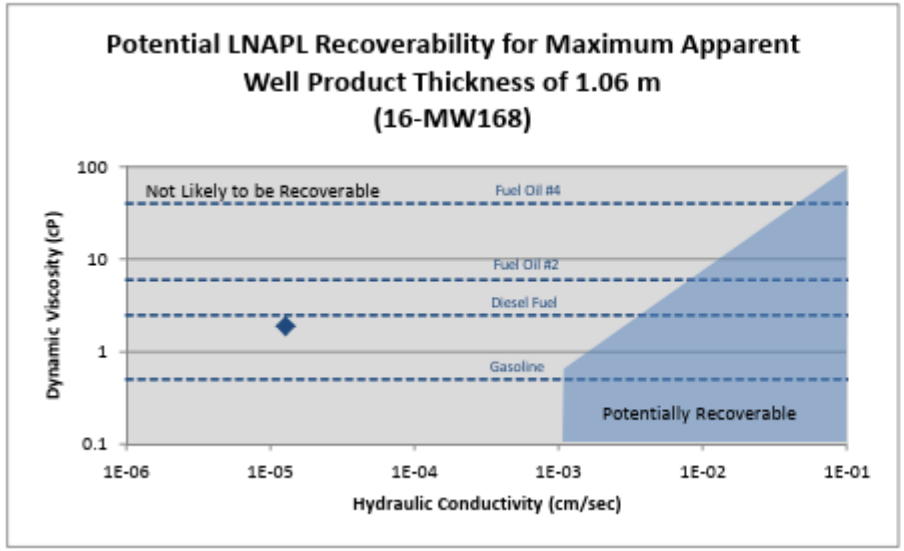


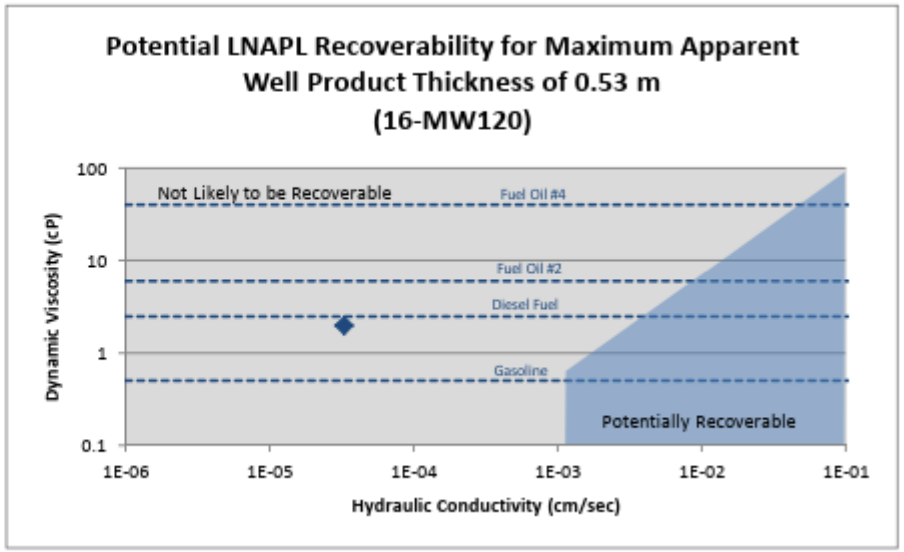
Primary Lines of Evidence

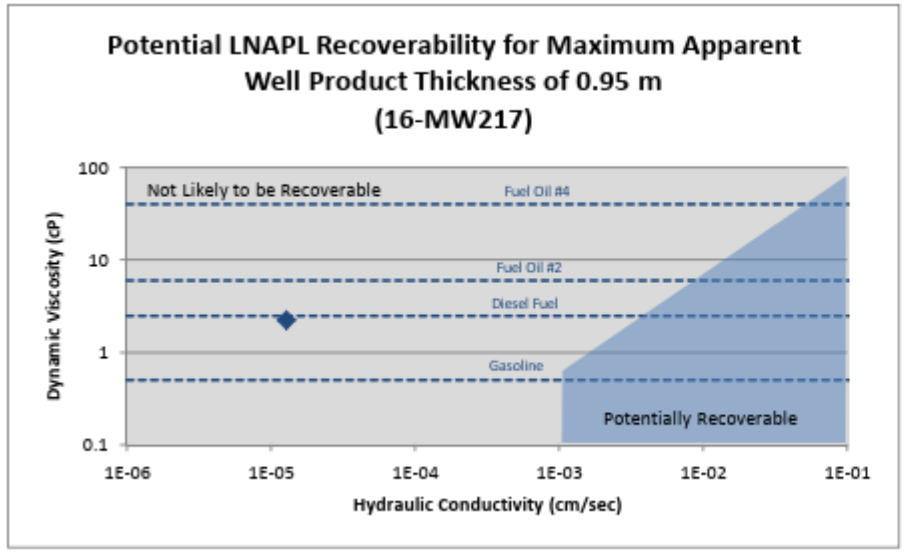
LNAPL Stability

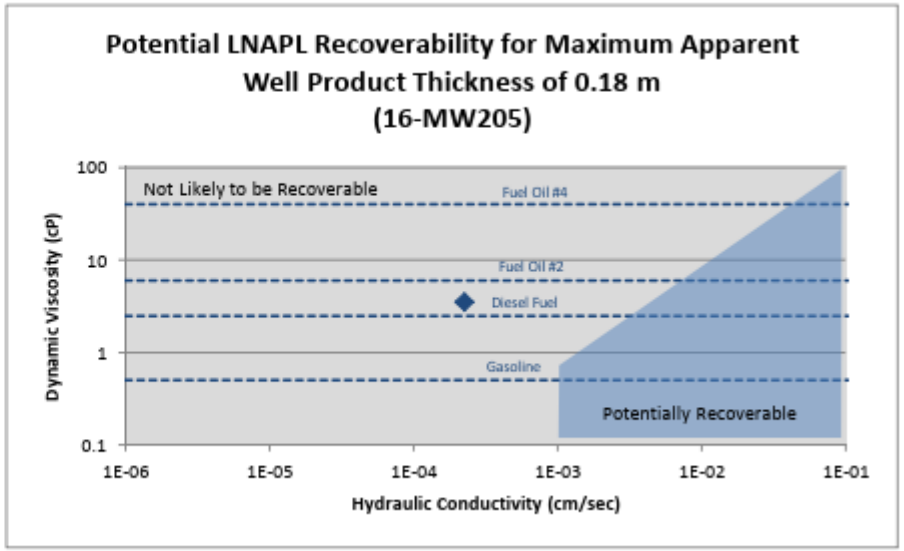


Primary Lines of Evidence - LNAPL Recoverability









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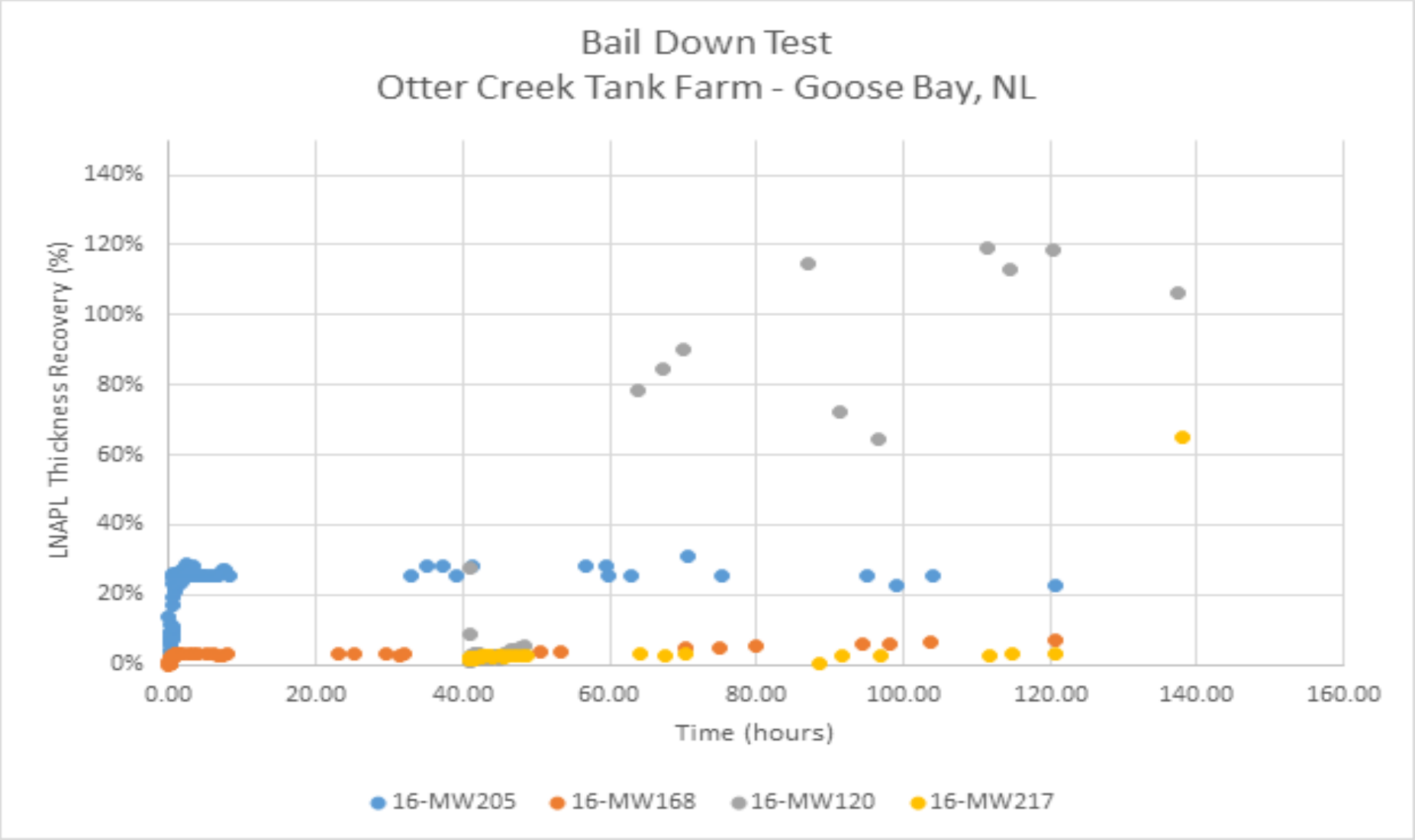
Primary Lines of Evidence

LNAPL Recoverability



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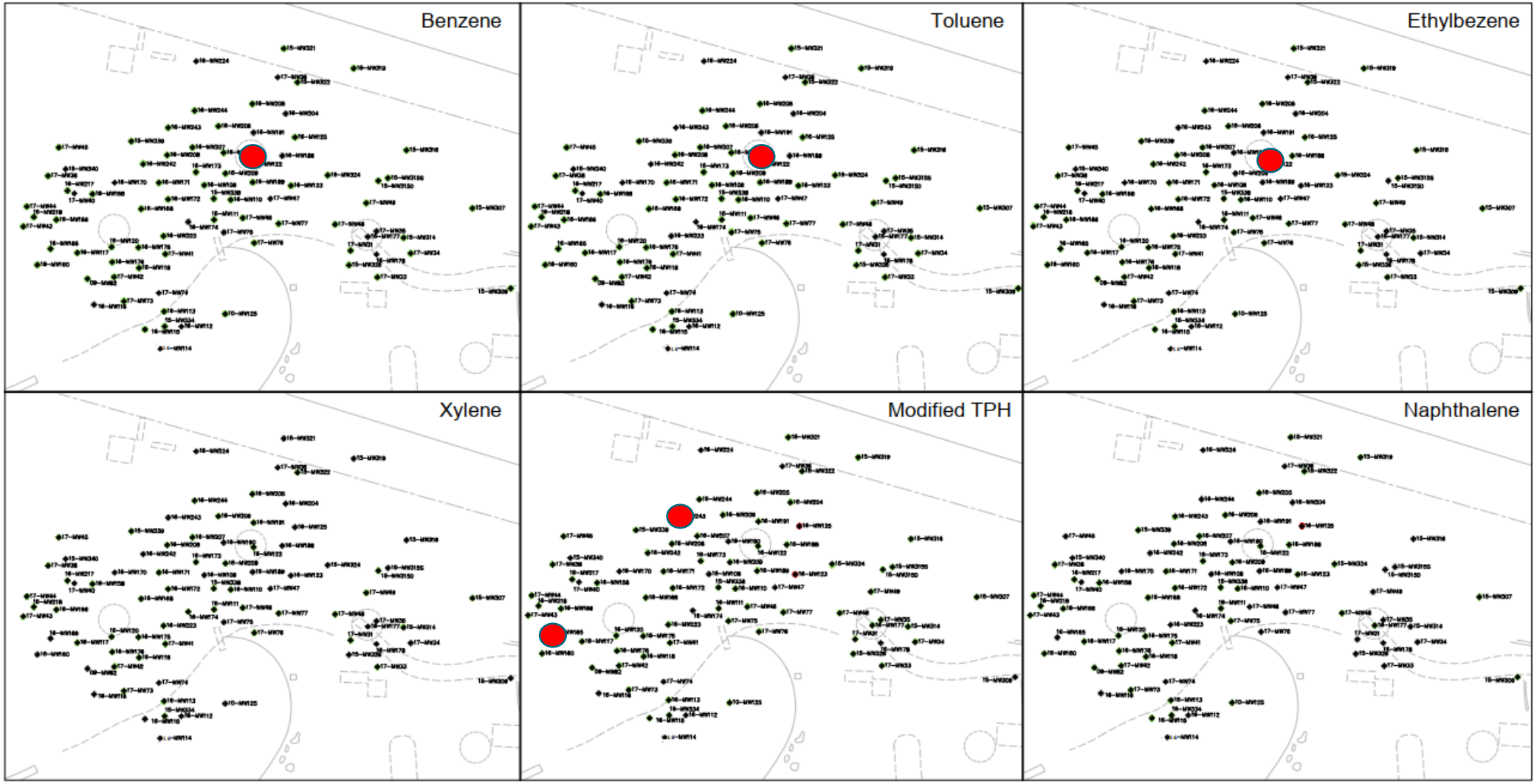
Primary Lines of Evidence – Dissolved Phase Stability

Mann-Kendall



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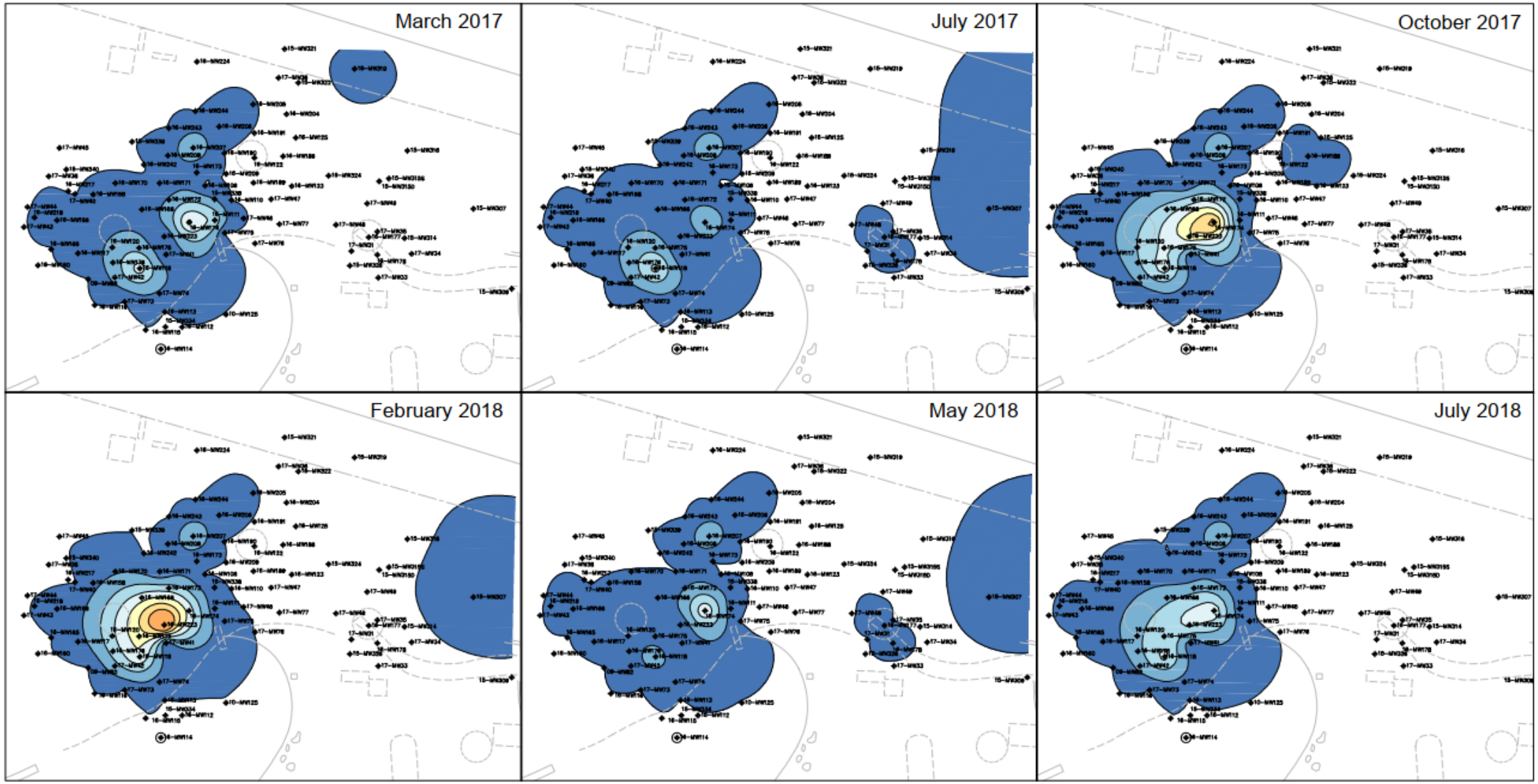
Primary Lines of Evidence - Dissolved Phase Stability

Ricker's



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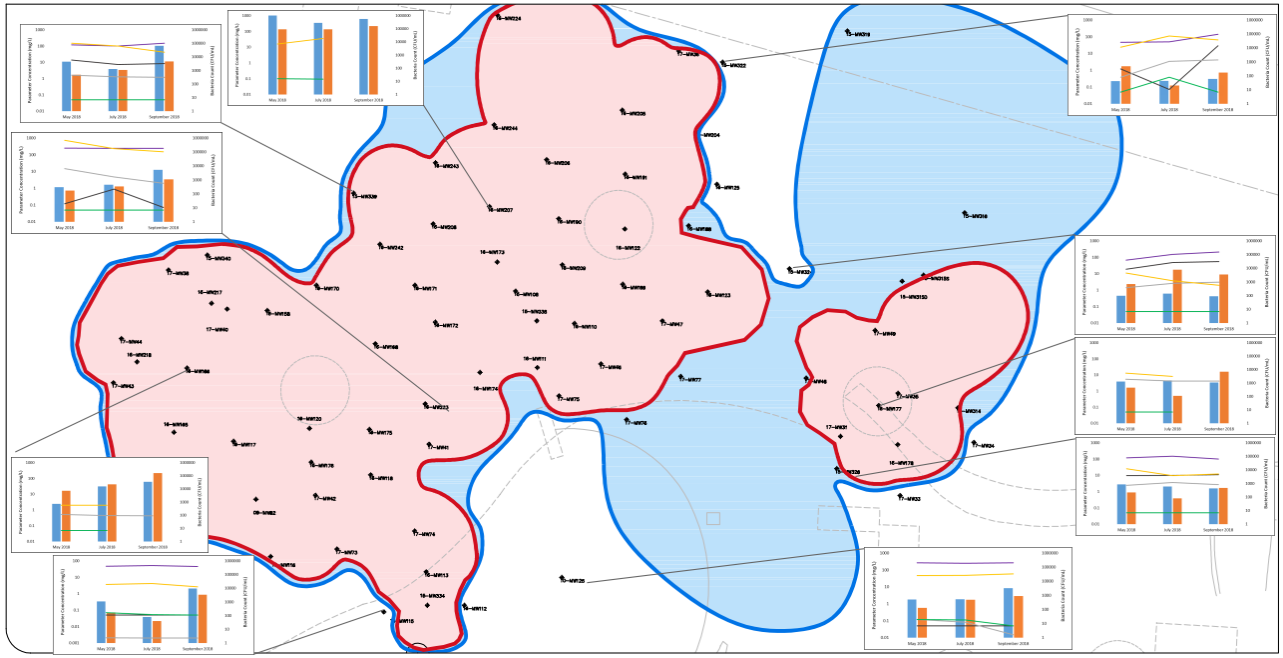
MNA

Area	Monitoring Well	Date Sampled	Biological Chemical Analysis	
			Heterotrophic PC @ 37°C	Hydrocarbon Utilising Bacteria
			CFU/mL	CFU/mL
RDL			1	20
Background	10-MW125-N4W0	2018-05-28	500	130
		2018-07-22	520	490
		2018-09-24	3200	900
A1-Plume	16-MW166-N4W0	2018-05-28	730	7200
		2018-07-23	15,500	22,000
		2018-09-24	35,000	>160,000
	16-MW207-N4W0	2018-05-28	1,000,000	92,000
		2018-07-23	280,000	92,000
		2018-09-24	560,000	160,000
A1-Dissolved Phase	16-MW223-N4W0	2018-05-28 (FD)	230	20
		2018-05-28	300	170
		2018-07-23	450	340
		2018-09-24	5300	1100
	15-MW324-N4W0	2018-05-28	96	700
		2018-07-23 (FD)	116	7900
		2018-07-23	142	7900
		2018-09-24	90	3500



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NSZD

Figure F-1 - Natural Source Zone Depletion: Carbon Dioxide (CO_2) Flux

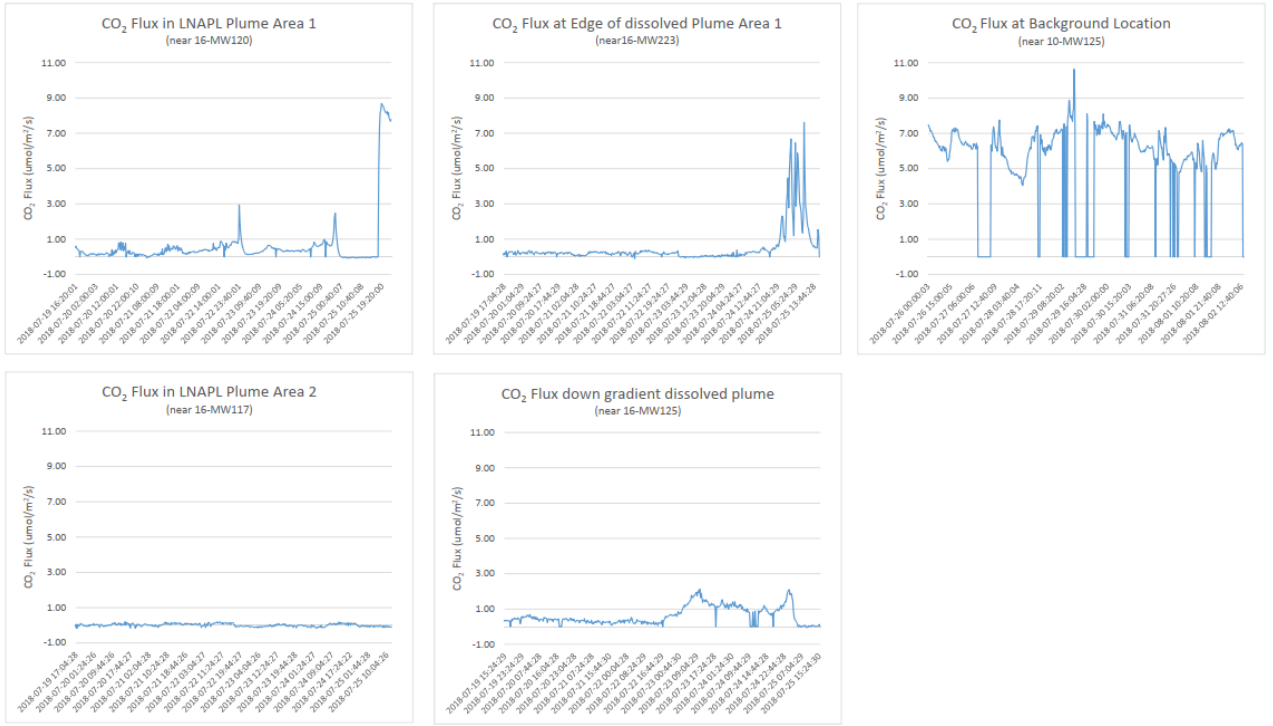
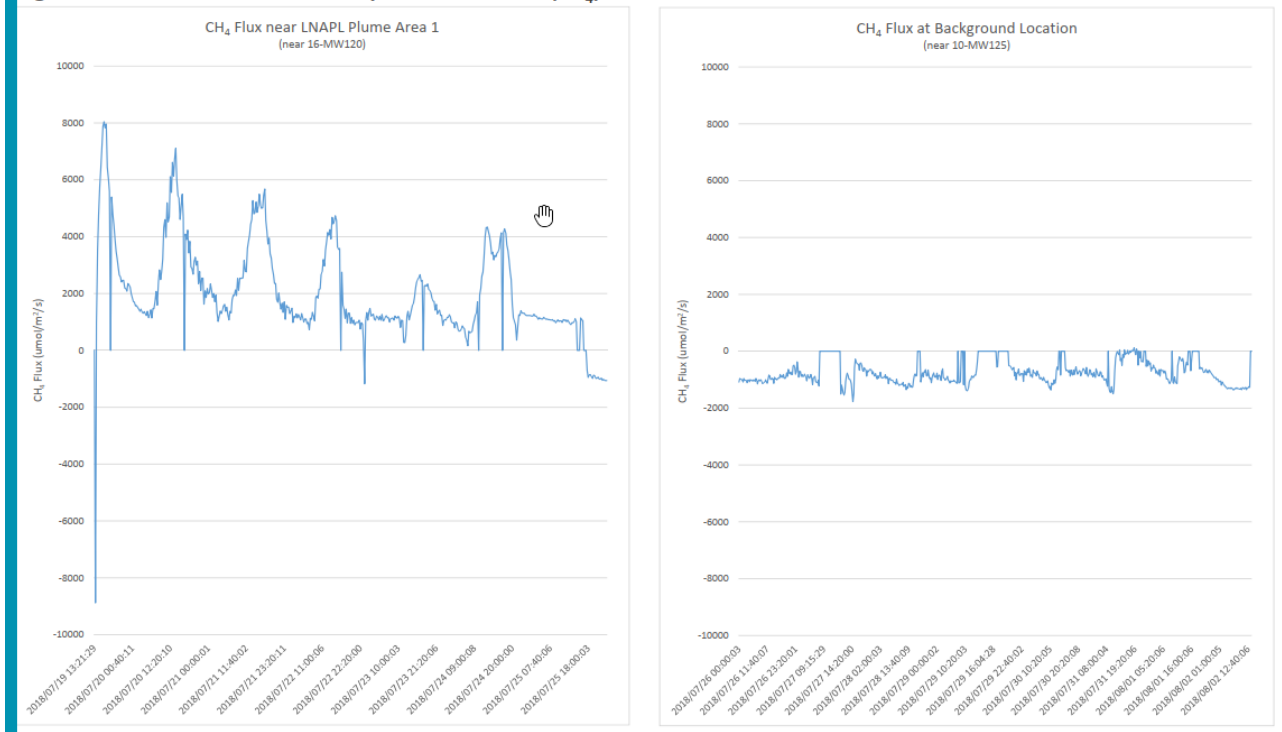


Figure F-2 - Natural Source Zone Depletion: Methane (CH_4) Flux



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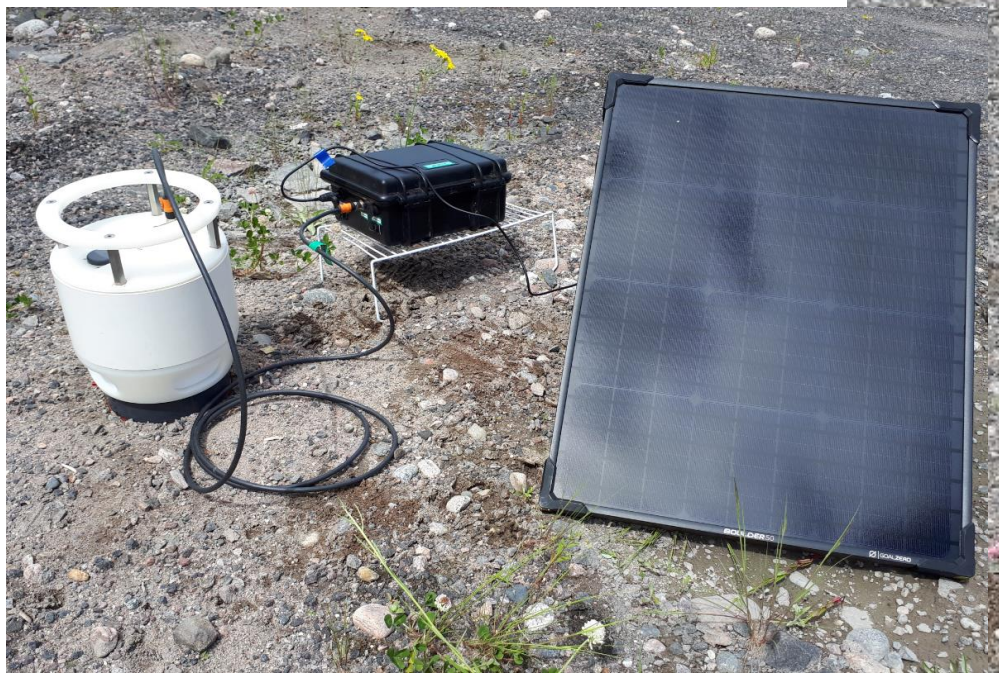
NSZD – is the LNAPL going anywhere or is anything eating it?

EOSense CO2 and methane flux

- Deployed in July of 2018



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Why only EOSense and NSZD in July

What are the risks?

LNAPL

- Always need more data
- Always need to do more remediation or to manage the risk
- Statistical power - is it enough? or should we put another bunch of wells in? or monitor until the end of time?

What is the best thing to do here?

- 50 years since tank removals and nothing is moving
- LNAPL is buried and no exposures
- 120+ MWs 50 years post tank removal, seven monitoring events. Lets save ourselves some expense and put this to rest.

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LNAPL Risks

Exposure Mechanisms

- LNAPL migration and time frame
  - Stable, hasn't moved much in 50 to 80 years
- Dissolved phase migration and time frame
  - Also Stable and elderly
- Vapour migration
  - No infrastructure
  - NSZD minor flux

Receptors

- Humans current or future
  - Currently vacant land
  - Future development will need to incorporate institutional controls
- Ecological
  - Limited potentials at depth in silty sands
  - No offsite migration
  - No surface expression

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Views of the site

How to Manage the Risks?

LCSM indicated

- **Old Weathered Diesel Plume**
- **LNAPL was stable**
- **LNAPL was not migrating**
- **LNAPL was not recoverable**
- **Dissolved Plume more of the same**
- **Limited potential risks via any pathways**

LNAPL management framework

- **No active remediation requirements**
- **Did not require compositional control**
- **Did not require saturation reduction**
- **Did not require contaminant containment**

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What next?

- LCSM identified a behaviour scenario that demonstrated that there was no unacceptable dissolved phase or LNAPL mobility (i.e., migration) risk or risk to any potential receptors
- LNAPL management in place?
- Wait its only ½ way thru scope (monitor 4 rounds this year) and we still have to do November and February
- Met with client to discuss strategic scope reduction and closure

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Strategic Approach

- Optimization of number of MW and analyses
- Used the LNAPL Risk management framework
- Strategically timed NSZD (only summer not winter)
- Timely and recurring data analysis
- Net savings >$100,000

How/Why?

- Reduced cost of monitoring events
- Assessed need for remediation vs management
- EOSense confirmed nature was reclaiming
- Obviated the need for a round of data collection
- Data demonstrated site ready for closure

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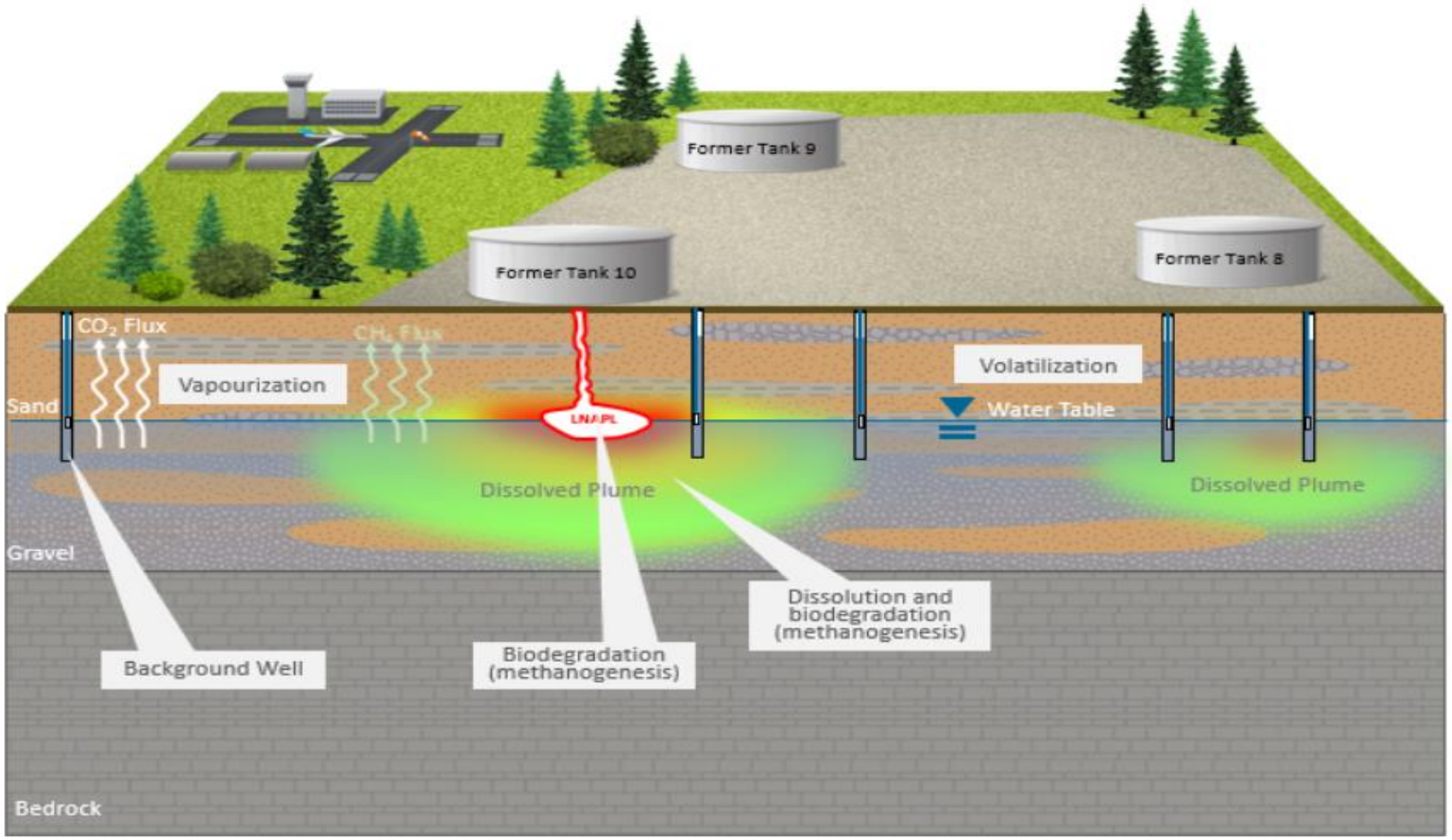

LNAPL Modelling and Site Closure – Useful tools to evaluate risk of LNAPL

Using these tools Dillon was able to achieve reduction and subsequent cessation of monitoring and ultimately acceptance of no further action ahead of schedule and under budget