



**Remediation Strategy for a LNAPL Impacted
Sediment:
A Case Study**
Bjorn Bjorkman

International Petroleum Environmental Conference
Denver, Colorado
October 31, 2018



Overview

- Site Background and Regulatory Issues
- Development of Sediment Remedial Strategy
- Components of Strategy
- Expected Outcomes and Next Steps



A Sediment Challenge

1. The “default” approach often dredging – high disturbance and \$\$\$\$
2. Remedy constraints from regulatory requirements
3. Consideration of alternative approach:
 - Contaminant migration potential
 - Human and ecological exposures (“risk”)
 - Regulatory drivers



This case study: this approach achieves a cost-effective solution that is protective of the environment



Site and Regulatory Context

Site

- Former petroleum facility - multiple operators over time
- Previous investigations and remediation – mostly upland areas
- River-side ‘lagoons’ - formerly received wastewater– limited investigation

Regulatory

- We developed strategic plan to address environmental concerns – including sediment
- Strategic plan breaks logjam – now with approved path forward from Agency
- This presentation: focus on the strategic aspect



Scope of Sediment Issue

Sediment remedial action is needed

Dredging not a reasonable option

Need protective yet reasonable solution

Acceptable to State

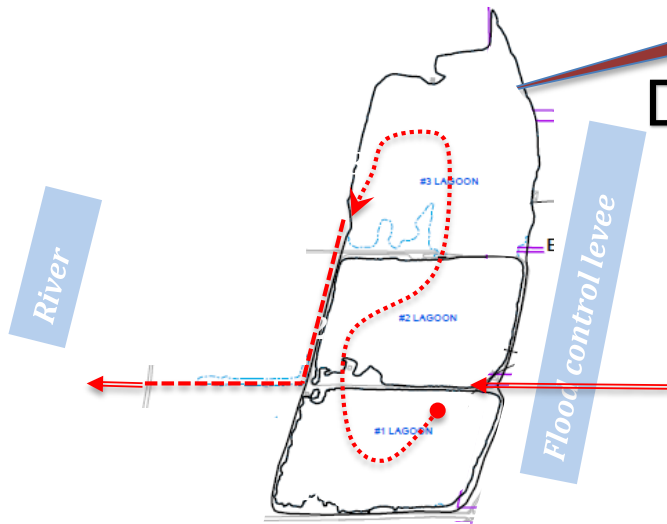
Achieving forward movement where:

- Impacted sediment will be addressed
 - Agency is on board
- Costs and scope are reasonable



Site – former petroleum facility

Three “lagoons” – formerly received refinery waste water



Discharge occurred during 50's, 60's and 70's

Lagoons' – originally borrow pits from levee construction

More recently NPDES permitted outfall bypasses lagoons

No hydrologic connectivity to river (except during flooding)

Lagoons now have a sediment 'cap' deposited by river flooding and deposition



Current conditions

Visually

A functioning ecosystem

No current sheening or releases to surface

No hydrologic connectivity

No public access – but not inaccessible

Prior sediment investigation

LNAPL present in 'lagoon' sediment - 'free product'* and sheens

Impacted sediment overlain by natural 'cap' of river sediment deposits

Elevated PAHs, BTEX, other SVOC, metals present in lagoon location

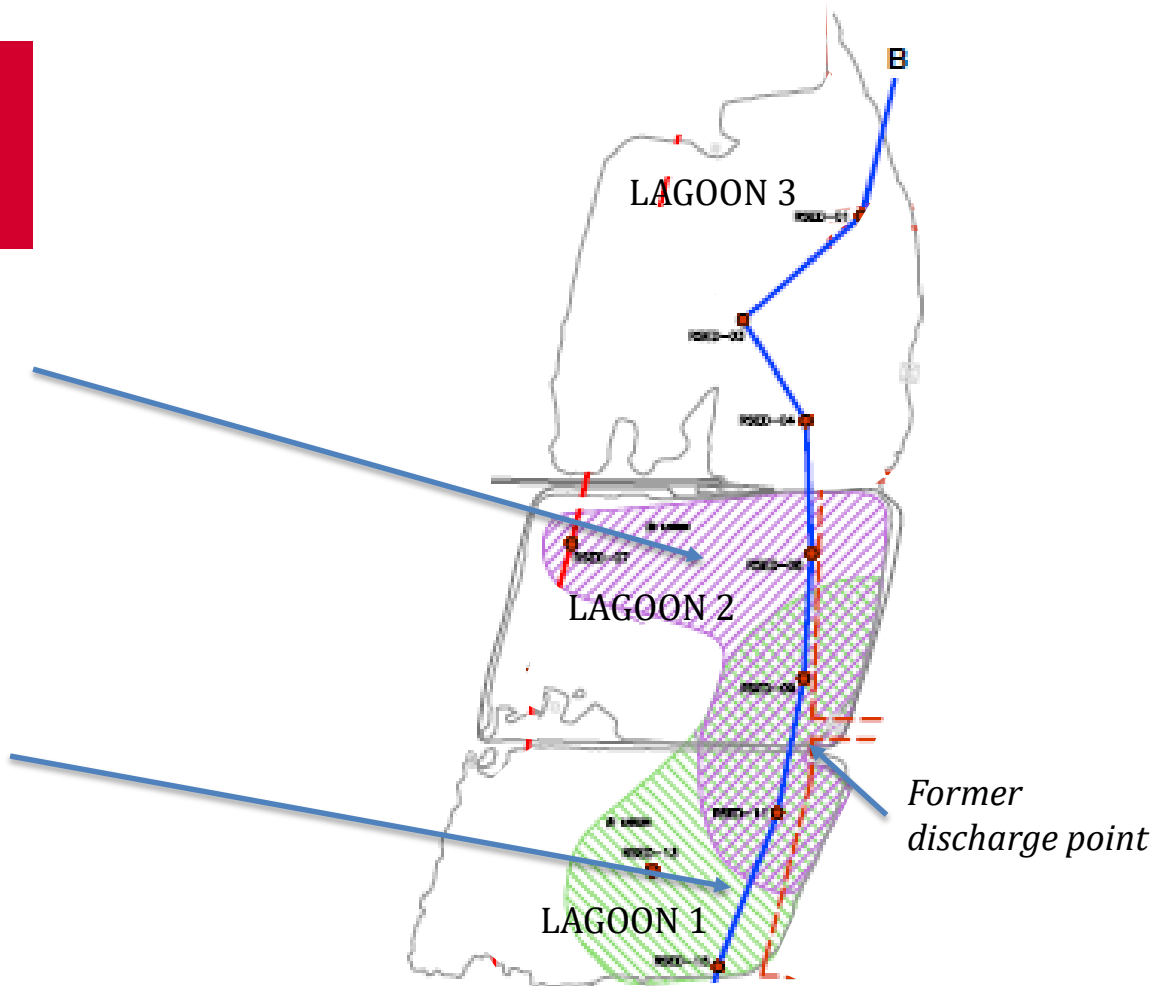
* 'Free product' - the term in State regulations for visible NAPL



Plan View

LNAPL (sheens and/or free product) – in discontinuous lenses in deeper sediment

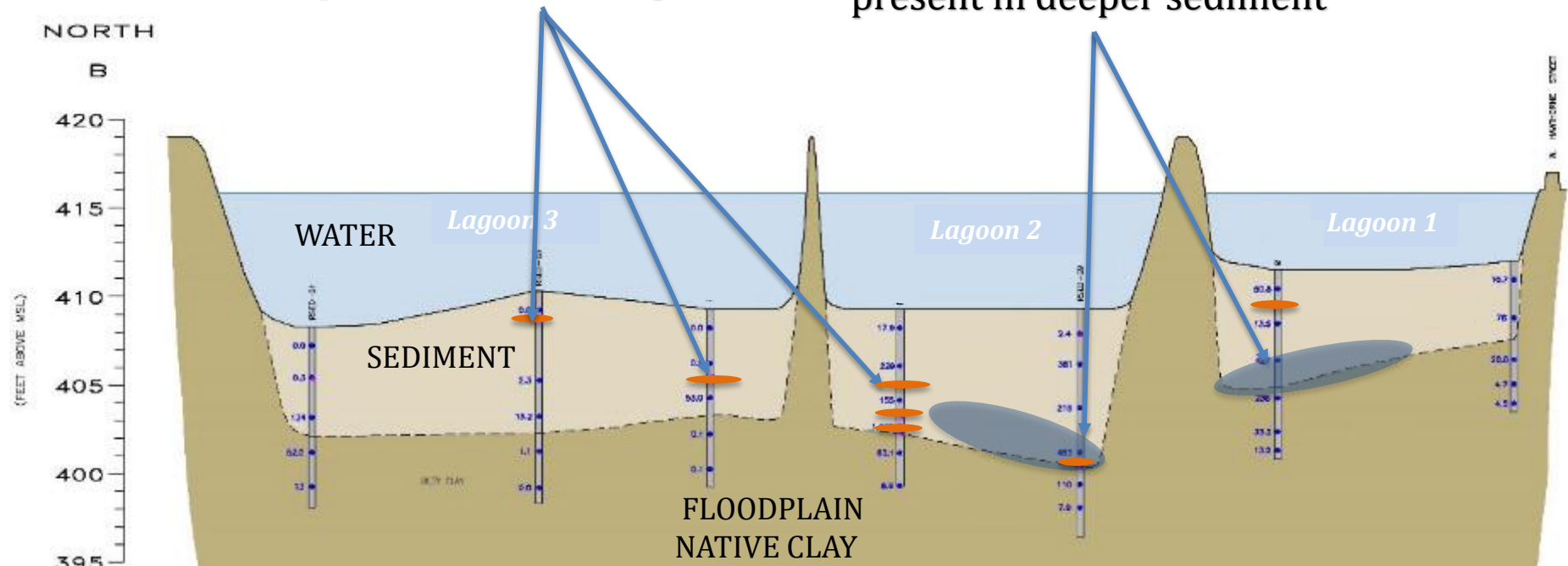
Elevated PAHs, BTEX and/or lead – mostly in deeper sediment



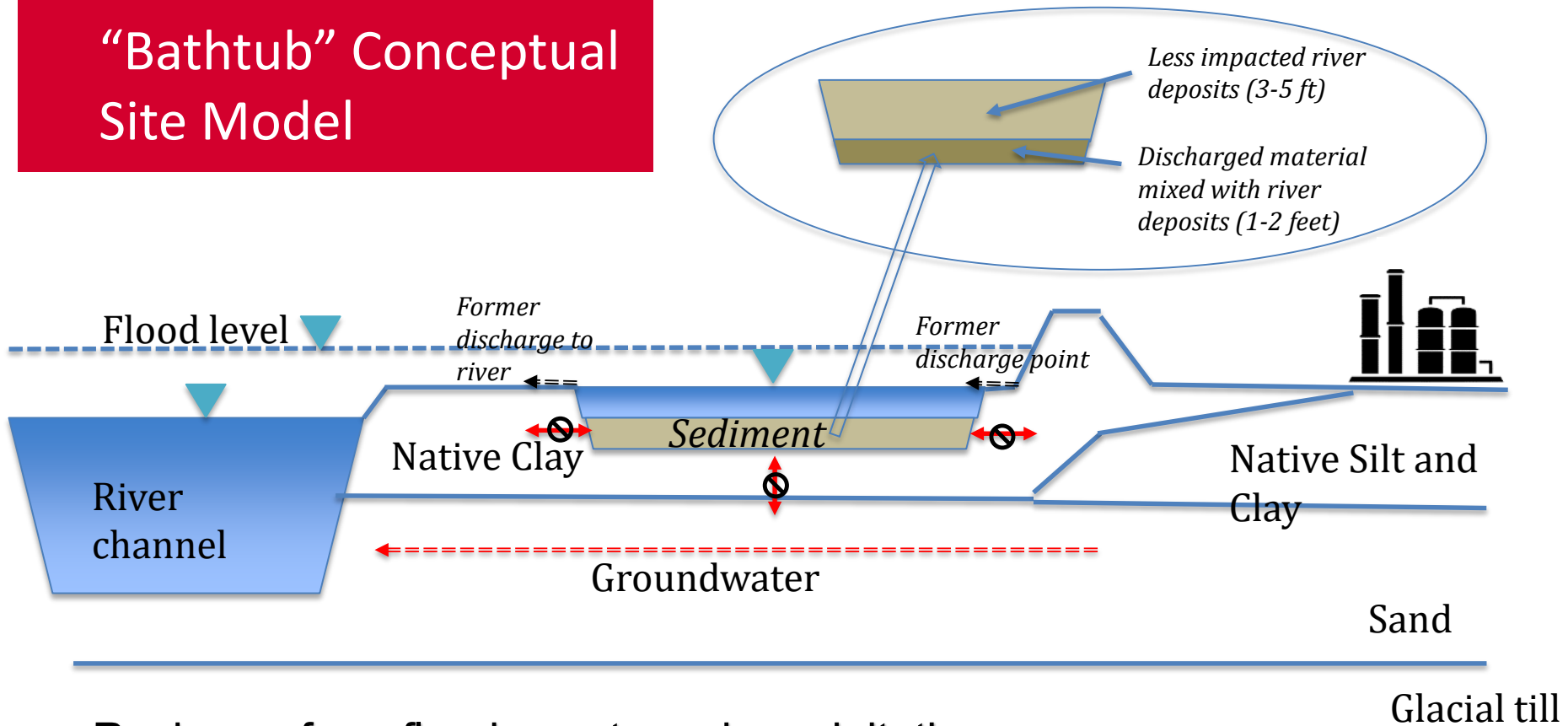
Profile View

LNAPL occurs as discontinuous lenses of free product or sheening

Other contaminants (PAHs and BTEX but also some metals and other SVOCs) present in deeper sediment



“Bathtub” Conceptual Site Model



- Recharge from flood events and precipitation
- No surface discharge channel to river
- Intermittent flooding deposits river sediment above impacted material
- Limited or no lateral or vertical hydraulic connectivity in the native clay



- Has relatively **little to say** about sediments in regulations
- Does have a **risk-based approach** to sediments affected by hydrocarbons



Regulatory Constraints

Risk based closure

- When sediment toxicity and/or benthic community integrity risk acceptable
 - When engineering and institutional can control human access
- Conditions for risk based closure likely present in most but not all the system

But...

Regulations constrain risk based approach

- 'Free product' precludes risk-based approach
- Material exceeding TCLP criteria precludes risk-based approach



Initial Positions

- Agency initially favored removal remedy
- Cost for dredging - prohibitive
- Sampling costs to delineate discontinuously distributed impacts - very high

Remedial
Strategy

- To define remedy without extensive additional sampling
- To define remedy protective under current and future conditions
- To meet regulatory requirements



Path Forward: Presumptive Remedy

Discussions held with State on preliminary data evaluation and path forward strategy.

- Presumptively suitable to **subaqueous capping** (amended and/or simple)
- **Cap throughout with GAC amended materials** to address uncertainty about nature and extent
- Consider **additional remedy** (including spot removal) for areas with “migrating” LNAPL and material exceeding TCLP limits

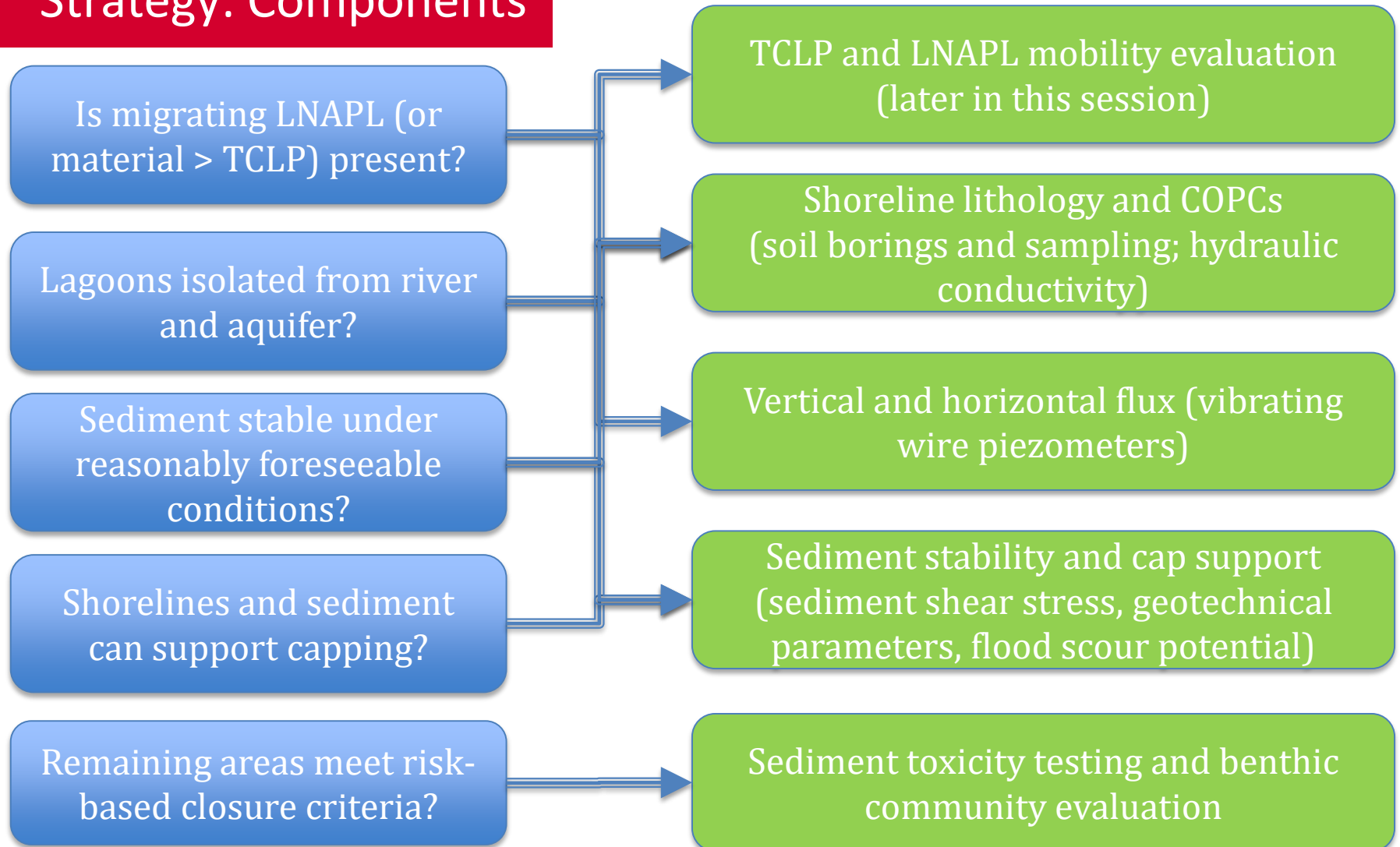
REMEDIATION STRATEGY APPROACH

Has been accepted

Next steps – implement Work Plan to evaluate remedy feasibility



Implementing the Strategy: Components



LNAPL Mobility (and TCLP)

- Details for **migrating LNAPL** evaluation to be presented in next session
- TCLP – elevated **lead and benzene** co-located with LNAPL – evaluate if exceeding TCLP limits



*Flex wall
permeameter*



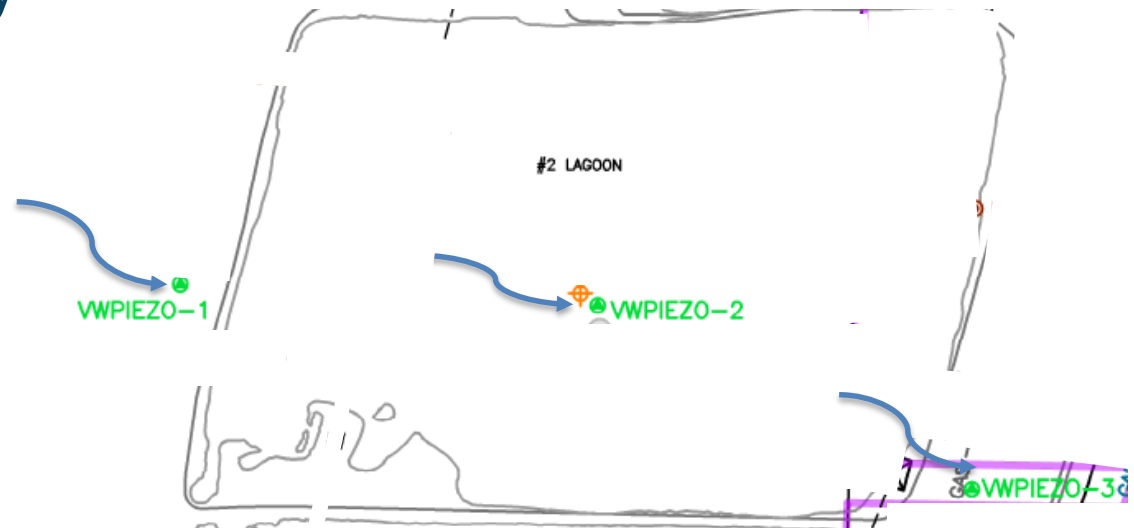
Shoreline stability and lithology

- Soil lithology around perimeter of lagoons
- Hydraulic conductivity testing
- Geotechnical parameters



Vertical and horizontal flux

- Vibrating wire piezometers – shoreline and in lagoons
- Monitoring program encompassing seasonal variability



Sediment Stability and Cap Support



- In-situ and lab vane shear testing
- USGS and Corps of Engineers flooding data review
- Sediment consolidation testing – field and lab under simulated cap load
- Porewater extrusion and analysis – top 3 feet



Risk based closure

- Sediment toxicity testing
 - Sediment community integrity
- ... compared to reference sediment



Expected Outcomes and Next Steps

- Lagoon sediment is stable and suitable for capping
- GAC amended cap will address most impacts
- Area of migrating NAPL and/or exceeding TCLP small or absent – and can be addressed via additional amendment or spot removal

Next steps – fine tune and implement Work Plan to confirm feasibility





Questions?

Bjorn Bjorkman (bbjorkman@geiconsultants.com), Thomas Daigle (tdaigle@geiconsultants.com), Mike Hawthorne (mhawthorne@geiconsultants.com), Camille Carter (ccarter@geiconsultants.com) (GEI Consultants, Denver, CO, USA), and Mike Ruetten (mruetten@geiconsultants.com) (GEI Consultants, Green Bay, WI, USA)