

An aerial photograph of Calgary, Alberta, showing the city skyline, the Bow River, and surrounding urban areas. The image is partially obscured by a dark blue geometric overlay on the left side.

Site Characterization & Conceptual Site Model - Proposed West Village Development Area, Calgary, Alberta

Calgary Municipal Land Corporation

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Remtech 12-Oct-2016.

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Presentation Outline

- **Current & Historical Infrastructure**
- **Previous Investigations**
- **Hydrogeological Setting**
- **Data Gaps and Site Assessment Priorities**
- **Phase 2 ESA Program**
 - **Soil, Groundwater, Soil Vapour, NAPL**
- **Conceptual Site Model**
- **Questions**

Recent Photo – Proposed West Village Site



Former Canada
Creosote Site

Auto Dealerships

Pumphouse Theatre

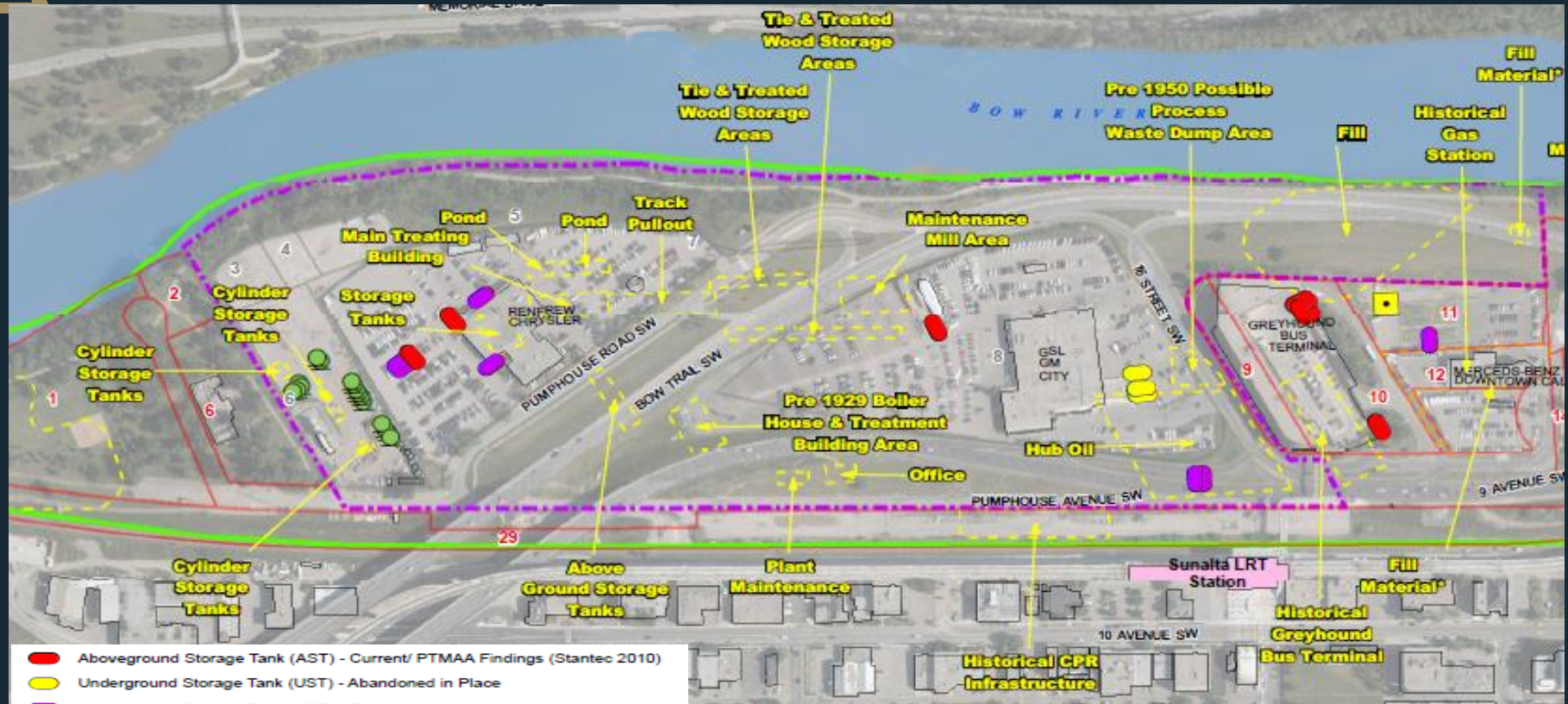
Bow & Crowchild Trails



Historical Infrastructure

Time Period	Key Operations
1924-1962	<ul style="list-style-type: none">• Canada Creosote Site (CCS) wood treatment operations – coal tar & creosote were used to treat lumber, rail ties & utility poles.• Treatment with zinc chloride during WWII• Treatment with pentachlorophenol (PCP) in a diesel-like carrier oil was added in 1950's• Treatment & maintenance buildings, AST's, waste sumps & ponds, drying & storage areas
	<ul style="list-style-type: none">• Surrounding properties to west had petroleum depot & bulk storage AST facilities
1960's	<ul style="list-style-type: none">• After wood treatment was demolished in early 1960's, extensive fill was redistributed or imported to level the site for redevelopment. Poor fill quality in some areas
1970's to present day	<ul style="list-style-type: none">• Car dealerships, related maintenance facilities• UST's and AST's for fuelling & waste oil storage• Major roads & snow dump area

Historical Infrastructure



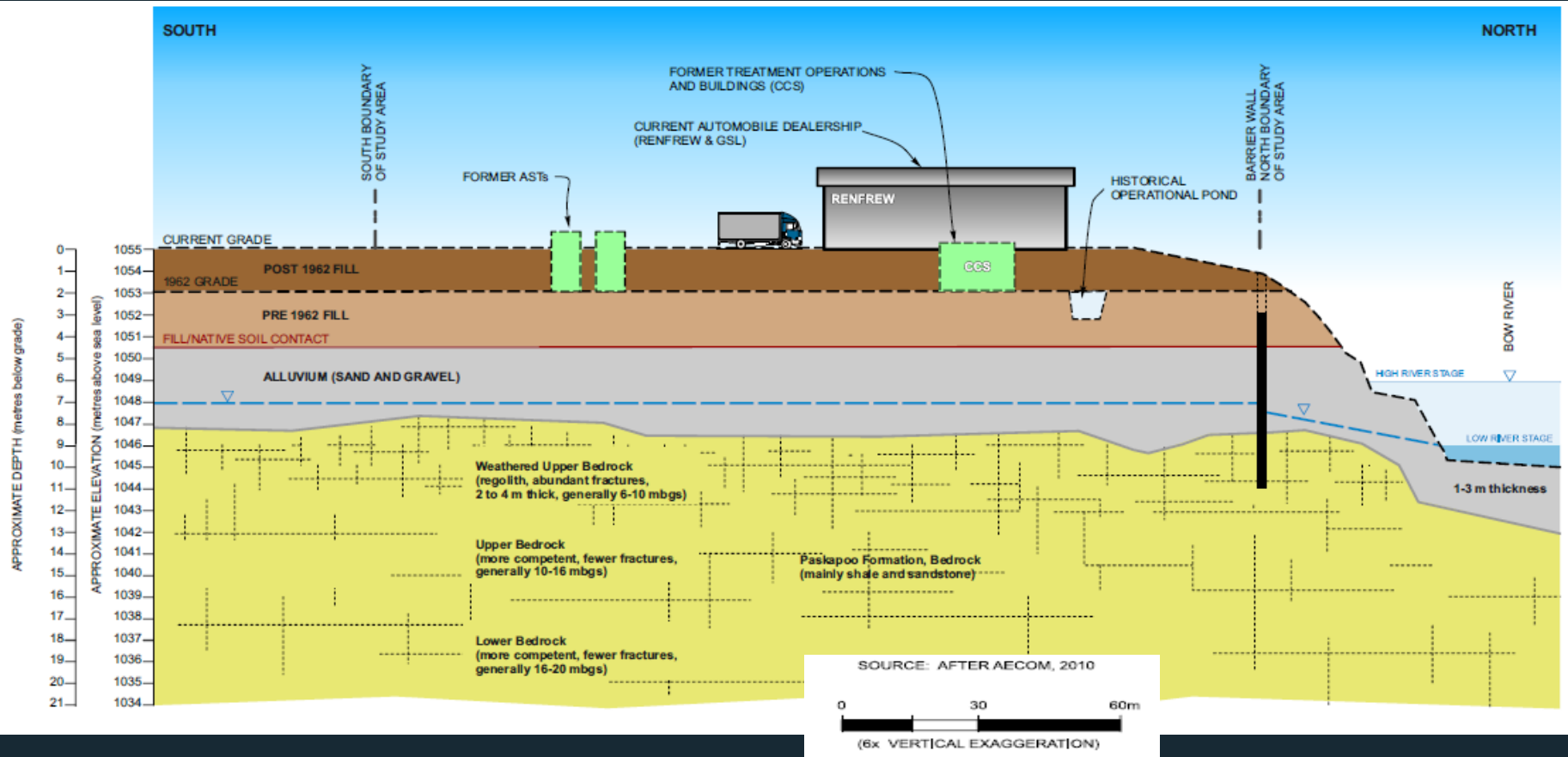
Site Investigation Milestones (1)

Timeframe	Key Activities and Findings
1988-90	<ul style="list-style-type: none">• Preliminary Phase II ESA's under CCS & Bow River• Evaluate creosote DNAPL migration controls & dissolution• Identification of chemicals of potential concern (COC's)• Recognized bedrock topography as controlling factor• Alberta Environment (AE), Alberta Research Council (ARC)• Golder Associates, O'Connor Associates, etc.
1991-92	<ul style="list-style-type: none">• Characterize creosote north of Bow River, DNAPL evidence in bedrock fractures (Golder)• Groundwater flow model for remedial containment design on CCS (ARC)
1993-96	<ul style="list-style-type: none">• Groundwater containment system, bentonite slurry wall & secant pile wall was designed and installed• Physical & hydraulic containment at north perimeter of CCS. "Clean" wells prevent in-flow at southern perimeter, while "Dirty" wells capture dissolved plume & some NAPL• ARC, CH2M Hill, Thurber, Acres

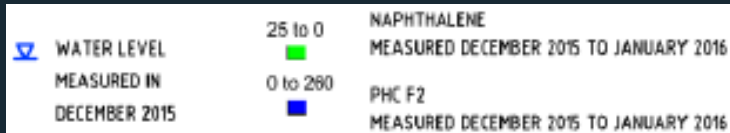
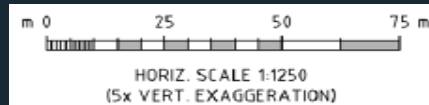
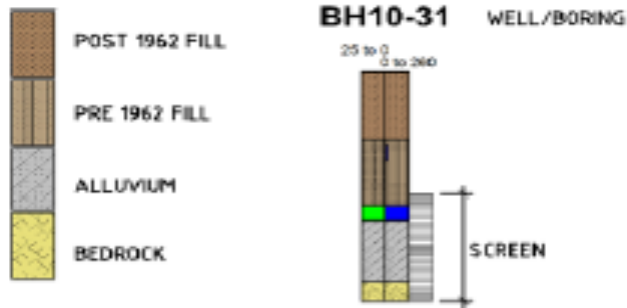
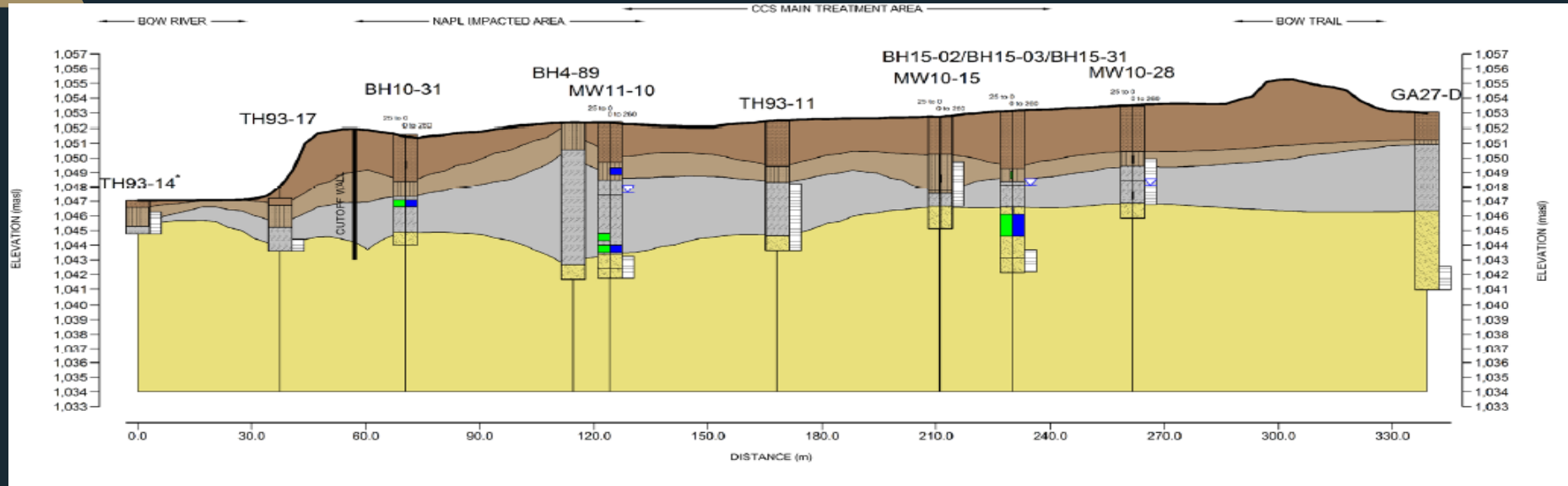
Site Investigation Milestones (2)

Timeframe	Key Activities and Findings
1995-present	<ul style="list-style-type: none">Remediation system is owned by Province of Alberta, but has been operated by City of Calgary wastewater services
1996-2008	<ul style="list-style-type: none">Various Phase II ESA's, mainly related to car dealerships and City of Calgary snow storage siteEBA Engineering, Great White North
2005, 2010	<ul style="list-style-type: none">Phase I ESA's, former CCS & proposed West Village areasJacques Whitford, Stantec Consulting
2010-2015	<ul style="list-style-type: none">Additional Phase II ESA's at CCS, Remedial Options (AECOM)Preliminary CCS soil vapour investigations (Golder)
2015-2016	<ul style="list-style-type: none">Calgary Municipal Land Corporation (CMLC), requests data gap analysis, site investigation, risk assessment, remedial management options (Advisian, Millenium & AECOM)

Hydrogeological Schematic (south-north)



Cross-Section NE to SW (G-G')



Data Gaps Identified & COC's

Category	Details
General & Regulatory	<ul style="list-style-type: none">• Visualization of historical & new data in GIS format• Work toward regulatory acceptance of risk managed scenarios
Soil & Groundwater	<ul style="list-style-type: none">• Build statistically defensible data density for key areas & layers• Expand on analytical data to ensure all COC's identified• Refine soil volume calculations for remedial scenarios
Soil Vapour	<ul style="list-style-type: none">• Supplement sparse historical data• Support human health risk assessment & remedial options
NAPL	<ul style="list-style-type: none">• Refine delineation of "mobile" NAPL pools & residual DNAPL fringe based on multiple lines of evidence
Bedrock	<ul style="list-style-type: none">• Add data density for bedrock topography, weathered upper bedrock vs. more competent lower bedrock• Fracture orientations, apertures, potential pathways
COC's	<ul style="list-style-type: none">• Polycyclic aromatic hydrocarbons (PAH's), petroleum hydrocarbons (PHC's), salts, metals, PCP & dioxin/furan

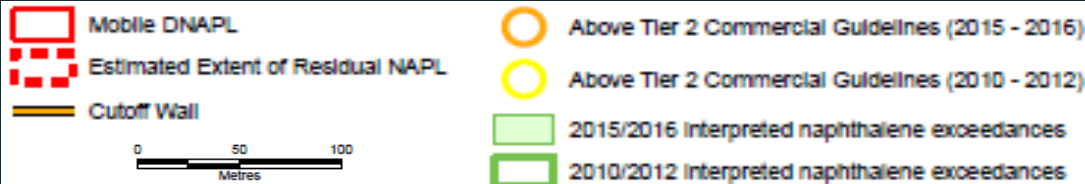
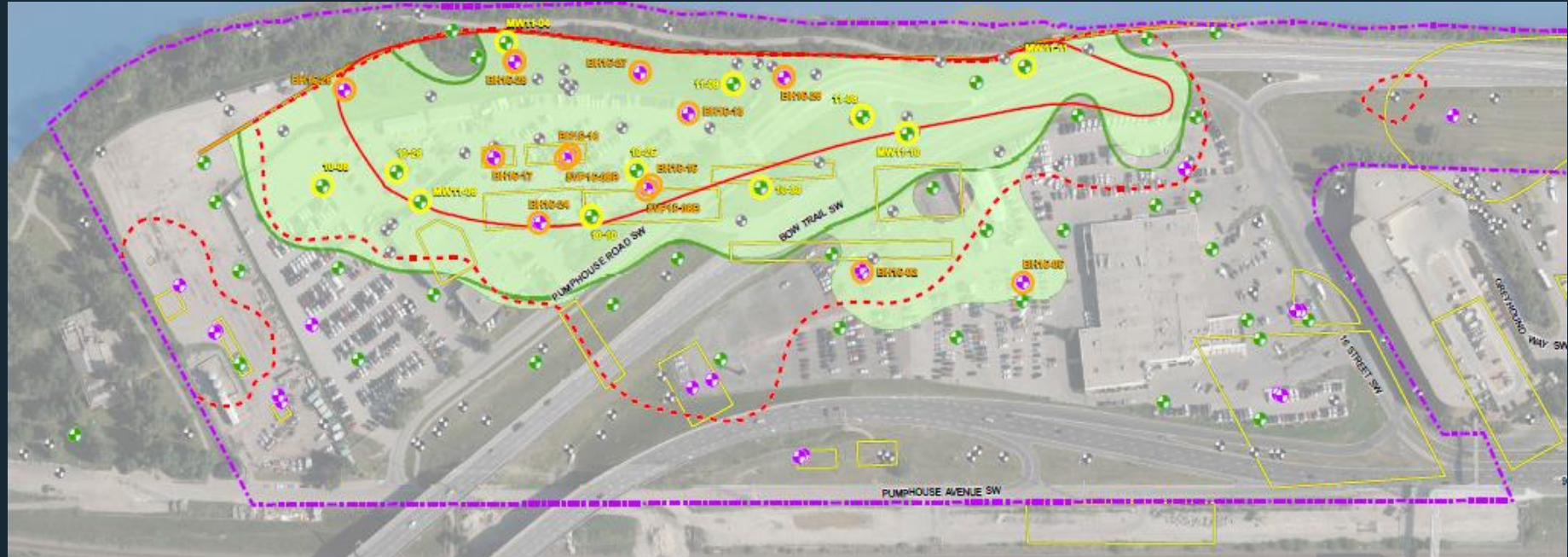
Phase 2 ESA – 21 intrusive locations

Task	Numbers	Details
Soil vapour sampling	20 direct push boreholes	<ul style="list-style-type: none"> Vapour probe installations in shallow and deeper fill (total depths 1.5 to 3.5 mbgs) Samples in thermal desorption tubes (VPH) & Summa canisters (VOC's, methane)
Soil sampling	34 mini sonic boreholes	<ul style="list-style-type: none"> Depths ranging 7.5 to 19.5 mbgs Lab samples from fill, alluvium, upper bedrock Abt. 110 discrete intervals sampled + 10% QA
GW Sampling	46 wells	<ul style="list-style-type: none"> 24 GW monit. wells installed & sampled 22 pre-existing wells also sampled
Bedrock Coring	14 coreholes	<ul style="list-style-type: none"> 10 core locations in upper bedrock (regolith) 4 cores in lower bedrock (2 angled, 2 vertical)
Geophysics Surveys		<ul style="list-style-type: none"> Downhole tools in bedrock coreholes – acoustic televiewer, formation & fluid EC, fluid temp 3 ERT lines, 6 seismic lines, 14 GPR lines
Geotech		<ul style="list-style-type: none"> Baseline study at 11 holes – SPT and lab geotech work



Soil Quality Results

Inferred Naphthalene in Soil Exceeding Tier 2 Management Guidelines (commercial)

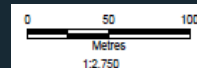


Note inferred residual DNAPL "fringe"

Dioxin and Furan Monitoring Locations



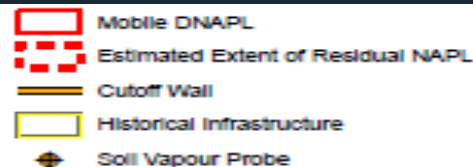
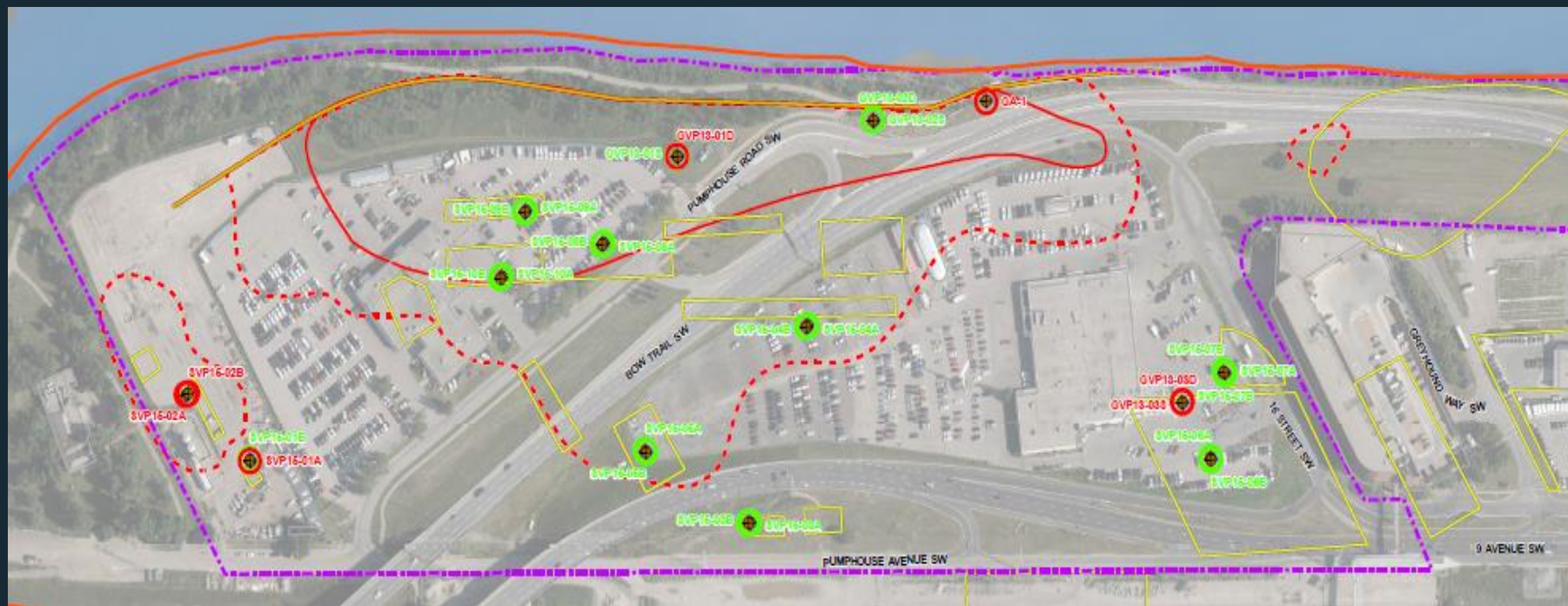
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|--|---|---|--|
|  | Historical Dioxin & Furan Sampling Location (Water Sample) |  | Above Applied TEQ Guideline in Soil or NAPL Samples (see text for details) |
|  | Historical Dioxin & Furan Sampling Location (Soil or NAPL Sample) |  | Below Guideline |
|  | Recent Dioxin & Furan Sampling Location (Soil Sample) | | |



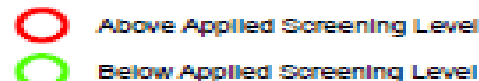


Soil Vapour Quality Results

Hydrocarbon Exceedances in Soil Vapour, Relative to Screening Levels (probes in shallow & deep fill units)

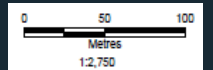
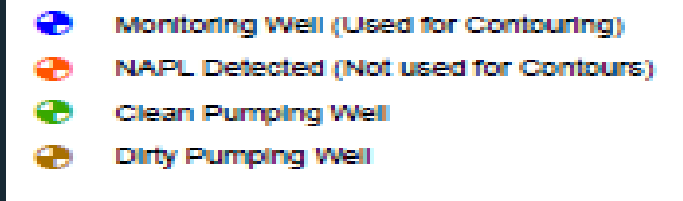
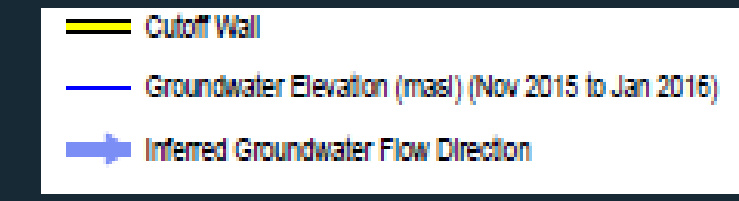


Soil Vapour PHC Concentrations





Groundwater Quality Results

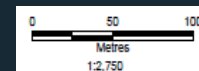
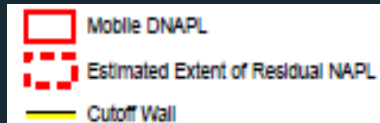
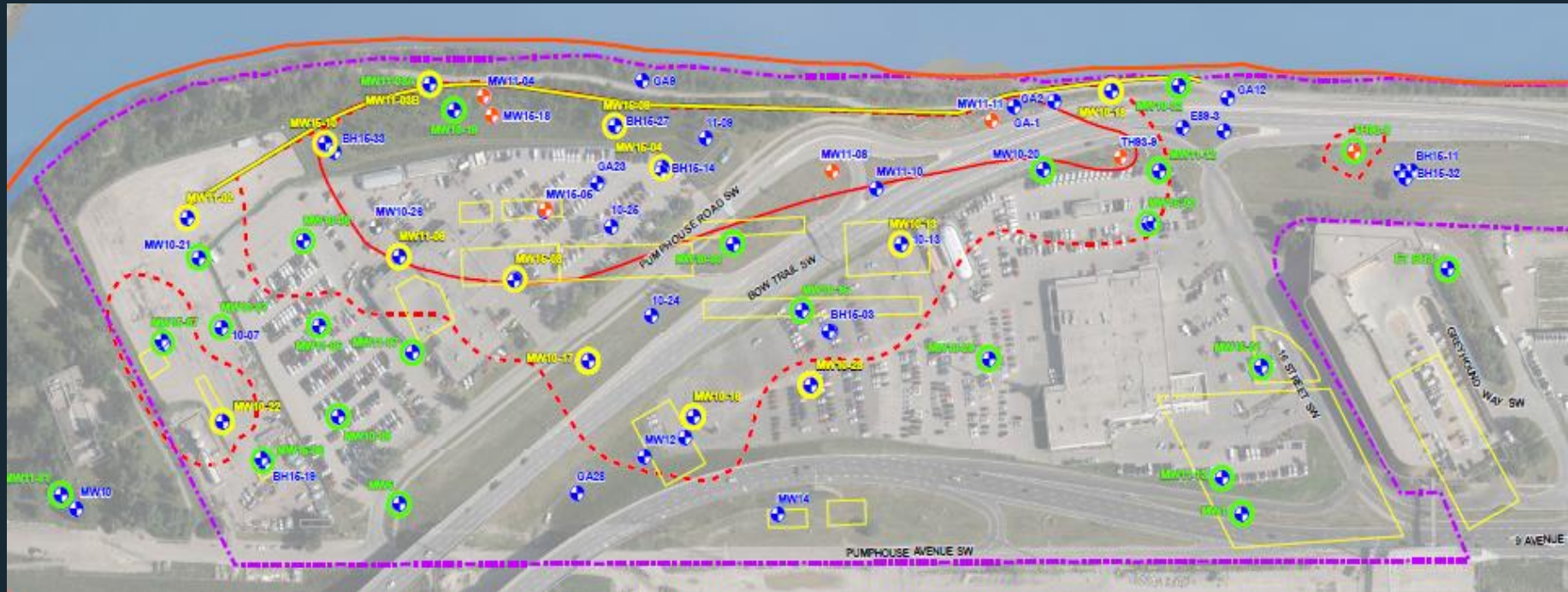


Groundwater Parameters, Exceedances Relative to Applied Guidelines

Hydrogeologic Unit	# Wells with Exceedances			
	BTEX or PHC-F1	PHC-F2	PCP	Naphthalene
Alluvium & Upper Bedrock Regolith	2 / 29	13 / 37	1 / 25	2 / 15
Competent Upper & Lower Bedrock	0 / 13	0 / 13	0 / 12	0 / 12

Note: Applied guidelines are AEP Alberta Tier 2, commercial land use, coarse-grained criteria for groundwater remediation, with pathway exclusions for FWAL and DUA

Groundwater PHC-F2, Alluvium and Upper Bedrock Regolith Wells



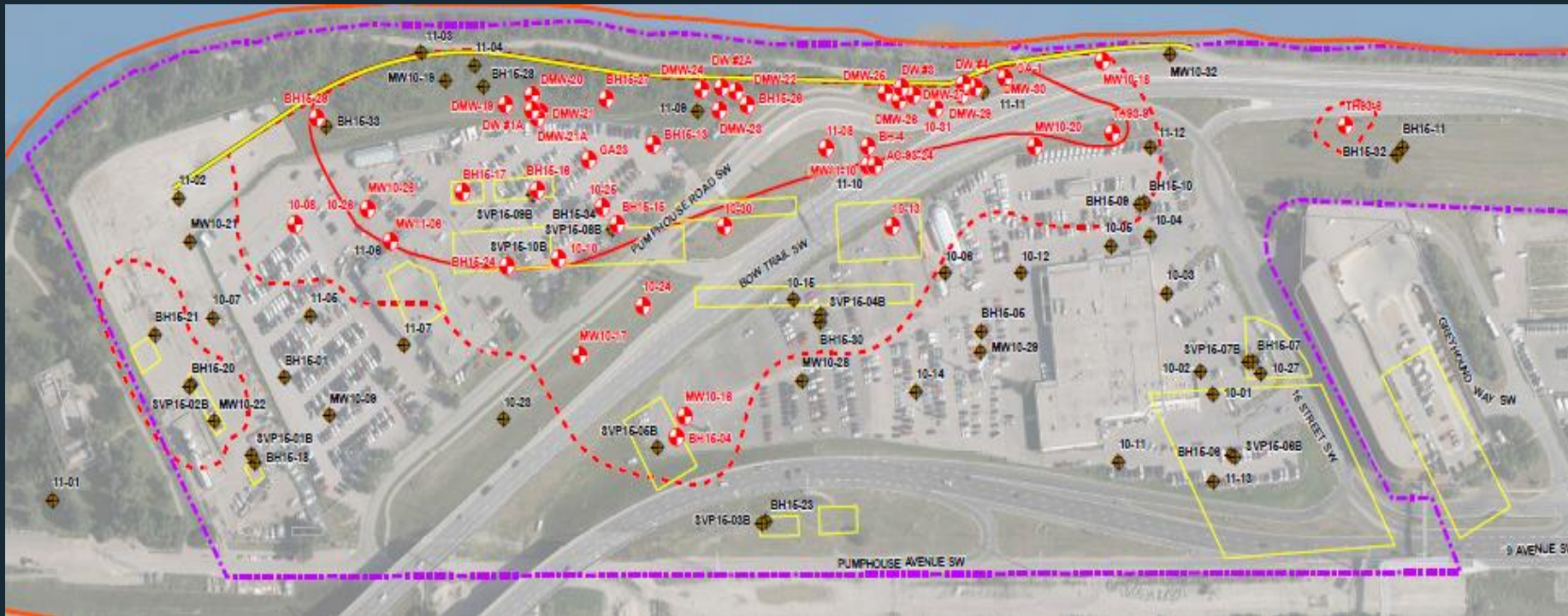





DNAPL and LNAPL Delineation



NAPL – Lines of Evidence

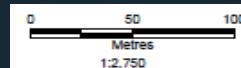
	Matrix	Details
Strong Quantitative Evidence of NAPL	NAPL in wells & drill cuttings	<ul style="list-style-type: none">• Measurable thickness in well, NAPL noted during development/sampling• Visible sheen or oily phase in cuttings
	Oil-in-Soil™ tests	<ul style="list-style-type: none">• Red dye activates if NAPL present in jar
Moderate Evidence of potential NAPL	Lab Chemistry	<ul style="list-style-type: none">• Soil & water quality guideline exceedences for PHC-F2, naphthalene, benzene, PCP
Qualitative Field Evidence of potential NAPL	Visual & Olfactory Indicators	<ul style="list-style-type: none">• Strong odours & staining in soil cuttings• Field PID values greater than 10 ppm

Inferred NAPL Distribution in Alluvium

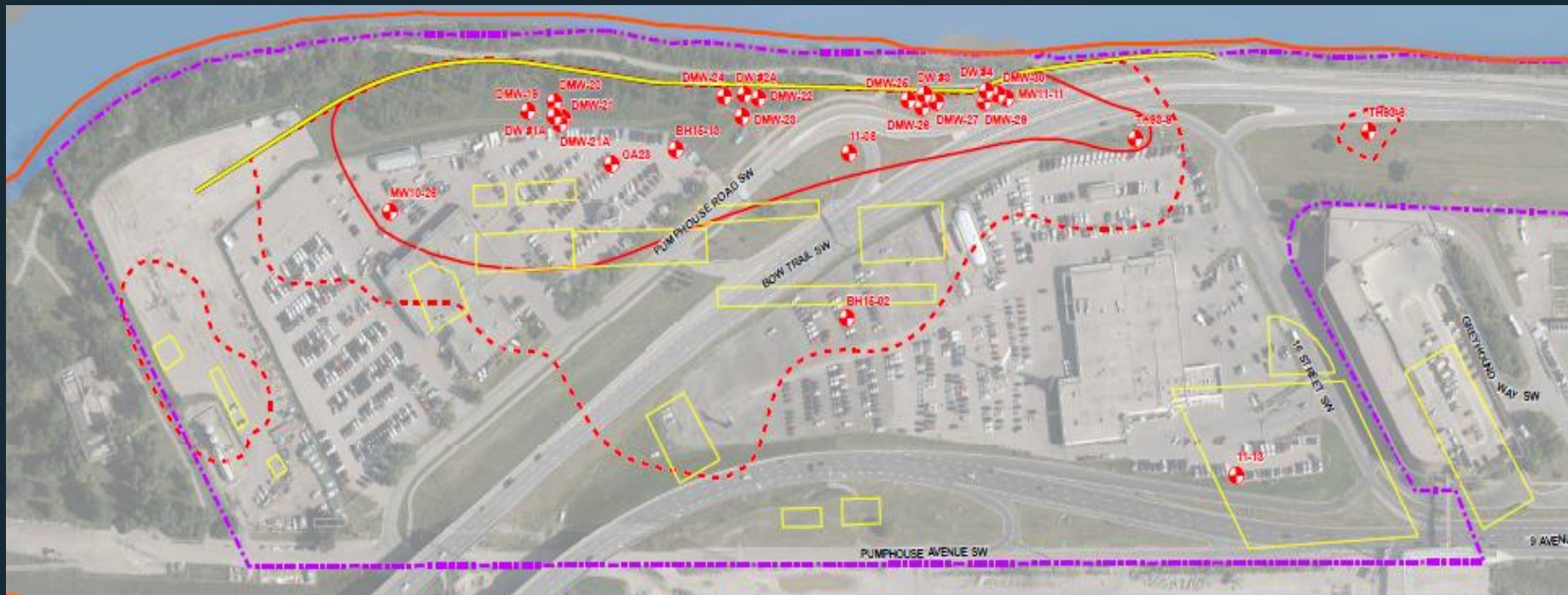


-  Mobile DNAPL
-  Estimated Extent of Residual NAPL
-  Cutoff Wall

-  NAPL Inferred in Alluvium
-  Historical Monitoring Location



Inferred NAPL Distribution in Upper Bedrock Regolith (heavily weathered and fractured)



Inferred NAPL Distribution in Competent Upper and Lower Bedrock (discretely fractured)



- Mobile DNAPL
- Estimated Extent of Residual NAPL
- Cutoff Wall

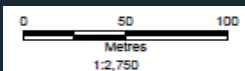
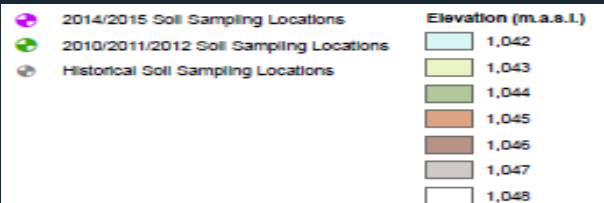
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- NAPL Inferred Within Upper Bedrock at this Location
- Lower Bedrock, no NAPL Inferred at this Location
- Historical Monitoring Location (Upper and Lower Bedrock)



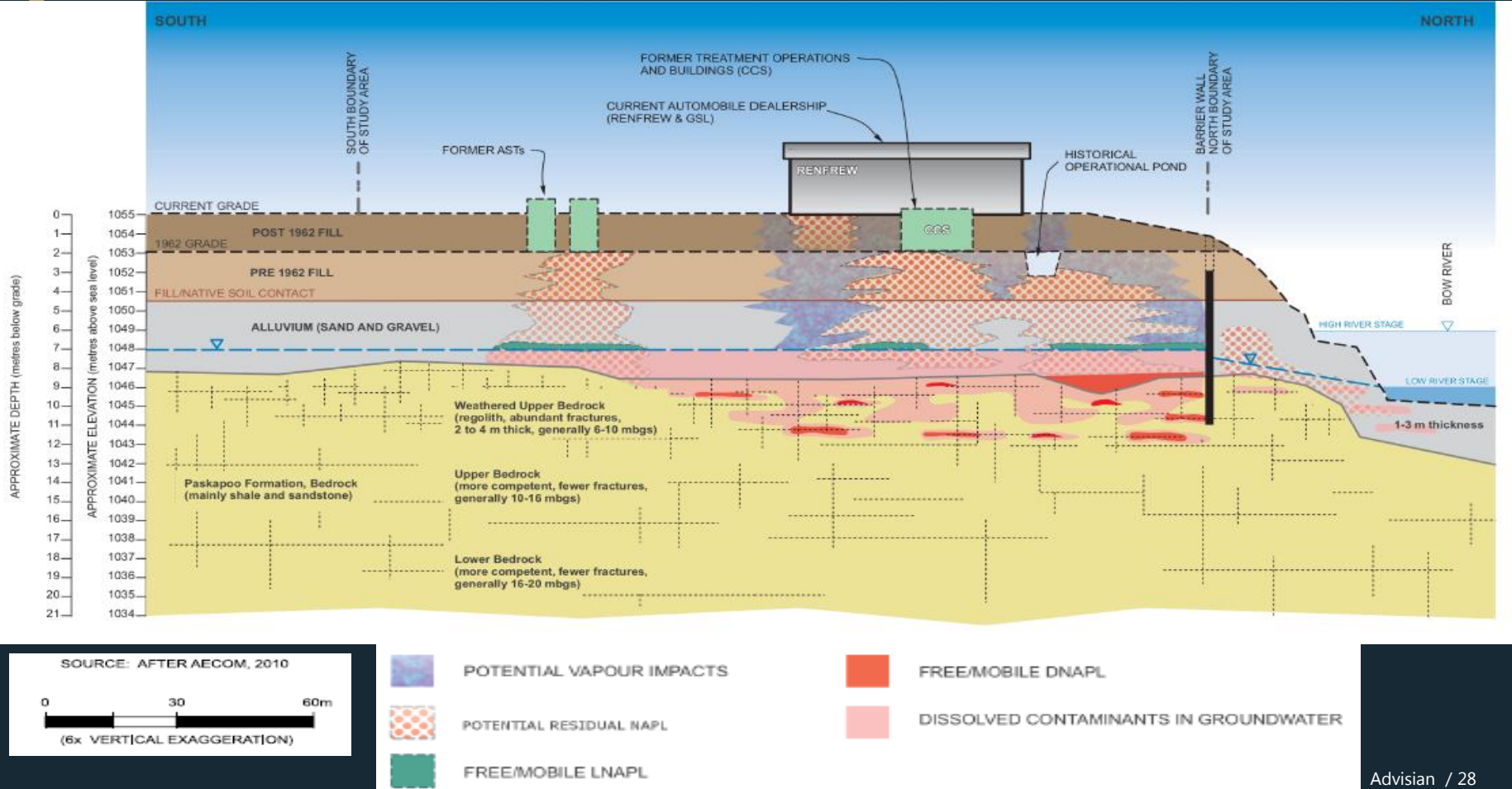
Key Findings and Conceptual Site Model

Inferred Competent Upper Bedrock Topography



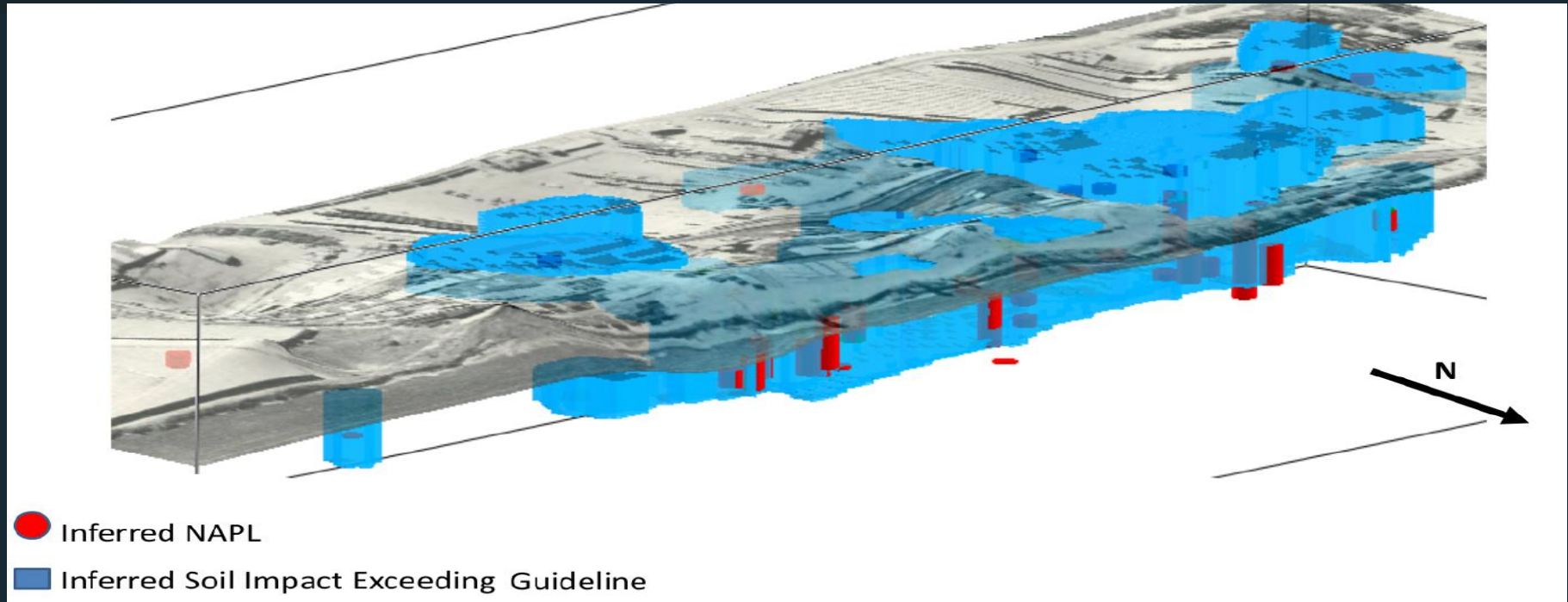
Bedrock topography controls DNAPL pooling

Conceptual Site Model (south-north)





Key Deliverable – Rockworks™ Model



- Interpolated volume of impacted soils in 3-D Rockworks model, grid size 5 x 5 x 0.2 m thick
- 1962 image is draped over inferred 1962 working surface
- Powerful tool for visualization and sensitivity analysis for remedial options



Collaborators & Contributors

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MMM Group

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Envirocore



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