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Groundwater Assessment to Set Site – Specific Remedial Objectives for Herbicides (Tebuthiuron)

Presented by:
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Water Tech 2009 – Banff Alberta

Outline

- Project Objectives
- Team Members
- Background (Land Use, Environmental Setting, Tebuthiuron Properties and Pathways)
- Groundwater Assessment (on- lease and off lease)
- Site-Specific Remedial Objective (Groundwater) – Methods and Results

Overall Project Goal

To remediate and reclaim a former oilfield battery in order to obtain a reclamation certificate and remove the site from the company's environmental liability list

Unique Aspects of Project

- Conduct a Groundwater Assessment and Model to Prove that Leaching of Tebuthiuron in the Future Would Not Affect Receptors
- Use a Tier 2 Soil Ecotoxicity Study to Set Soil Eco-Contact Guideline
- Conduct Soil Remediation
- Dewatering for Soil Remediation

Groundwater Assessment & Modeling - Objectives

- To Determine the Potential Risk of Adverse Effects of the Tebuthiuron Leaching from the Soil on Water Resources in the Area and
- To Set Site Specific Clean-up Criteria Protective of the Water Resources.

Team Members

- **Alfred Burk***, EnCana

- **Thomas Dance***, Kathryn Bessie, Natasha Harckham, Felix Lin, Bonnie Derksen and Aaron Sentes, EBA

* *Co-Authors of Presentation*

Background – Land Use

- Battery Site (Abandoned) - Operational in 1968
- Southern Alberta
- Crown Land – Managed by ASRD
- Agricultural Land Use

Background – Environmental Setting

Background - Summary of Environmental Work

- 2002 - Phase 1 completed
- 2003 - Phase 2 completed
- 2005 - PHC contaminated soils excavated and landfilled except in former culvert well area. Dewatering is proposed prior to excavation in culvert well area. Tebuthiuron identified as a possible issue.
- 2006 – Tebuthiuron guidelines proposed in AENV Tier 1 and Tier 2 guidelines “draft-for public comment” issuance
- 2007 – Sterilant literature review, ecotoxicity testing to establish Soil Eco Contact Guideline, **Further on-lease and off-lease soil and groundwater investigations to set site specific remediation objectives for the protection of water resources**, permits for dewatering from AENV, pilot test and full scale soil remediation using thermal desorption.

Tebuthiuron – Properties

- ⇨ broad-spectrum herbicide (sterilant)
- ⇨ trade name is Spike
- ⇨ water soluble (2,500 mg/L @ 25^{o}C) and leachable
- ⇨ sorption to soils increases with clay and organic matter content

Tebuthiuron - Tier 1 Guidelines in Groundwater

AENV Tier 1 Guidelines for coarse textured soil

Pathway	Tier 1 (mg/L)
Human – Drinking Water	0.66
Human – Inhalation	--
Eco – Soil Contact	--
Eco – Aquatic Life	0.0016
Eco – Irrigation Water	0.00027
Eco – Livestock Water	0.13
Eco – Wildlife Water	--

Tebuthiuron – Applicable Pathway

Pathways Excluded:

- Drinking Water - Thin silty sand sediments, proximity of the lake combined with the physical setting (within the high water level of the lake and thus prone to flooding).

- Irrigation Water and Livestock watering - The proximity of the lake, it was unlikely that the underlying water bearing sediments would ever be used as a source of irrigation water or for livestock watering.

Applicable Pathway:

- Freshwater Aquatic Life - The points of exposure occur at the shoreline of a Lake some 550 m from lease. This criteria was used to establish clean-up criteria for remedial action on the site.

Groundwater Assessment - Approach

Steps Followed:

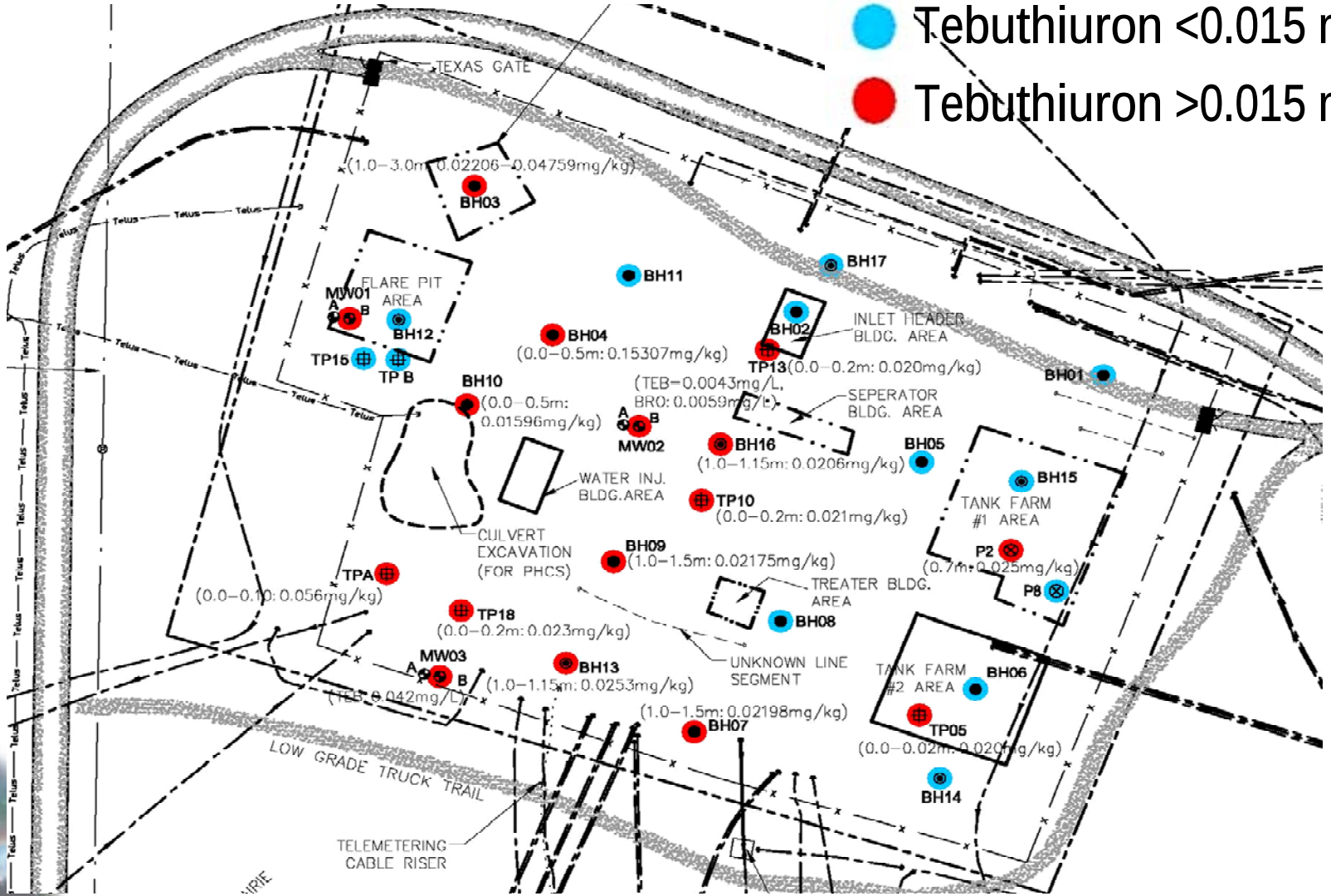
- On Lease Assessment
- Off Lease Assessment

On- lease Assessment

On-Lease

- Three nested pairs of wells – screened 1.25 - 4.3 mbgs (shallow) and 6.8-7.6 mbgs (deep).
- Tebuthiuron concentration was 0.0043 mg/L and 0.042 mg/L in two shallow wells compared to Tier 1 freshwater aquatic life guideline of 0.0016 mg/L on-lease, all other wells were less than detection limit

On- lease - *Tebuthiuron in Soil*

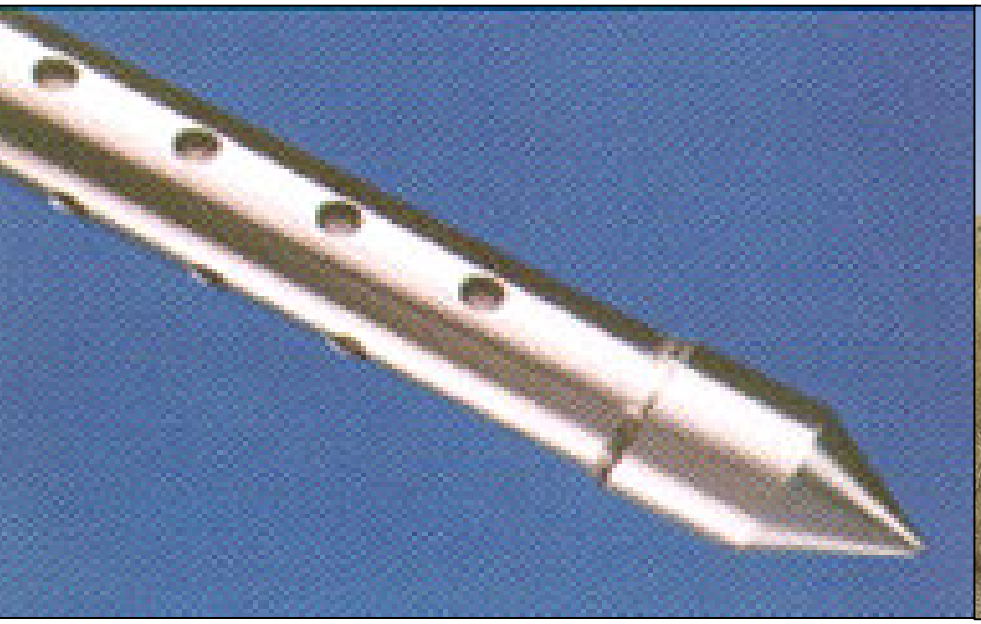


On lease - *Tebuthiuron in Soil* (Cont.)

On-lease

- The highest concentration was 0.1530 mg/kg in surface soil sample (0 -1.0 m) in the east side of the lease.
- the west side of lease concentrations were around 0.015 mg/kg or 0.020 mg/kg (1.0 -1.15 m)
- there were traces of Tebuthiuron in soils down to about 4 m

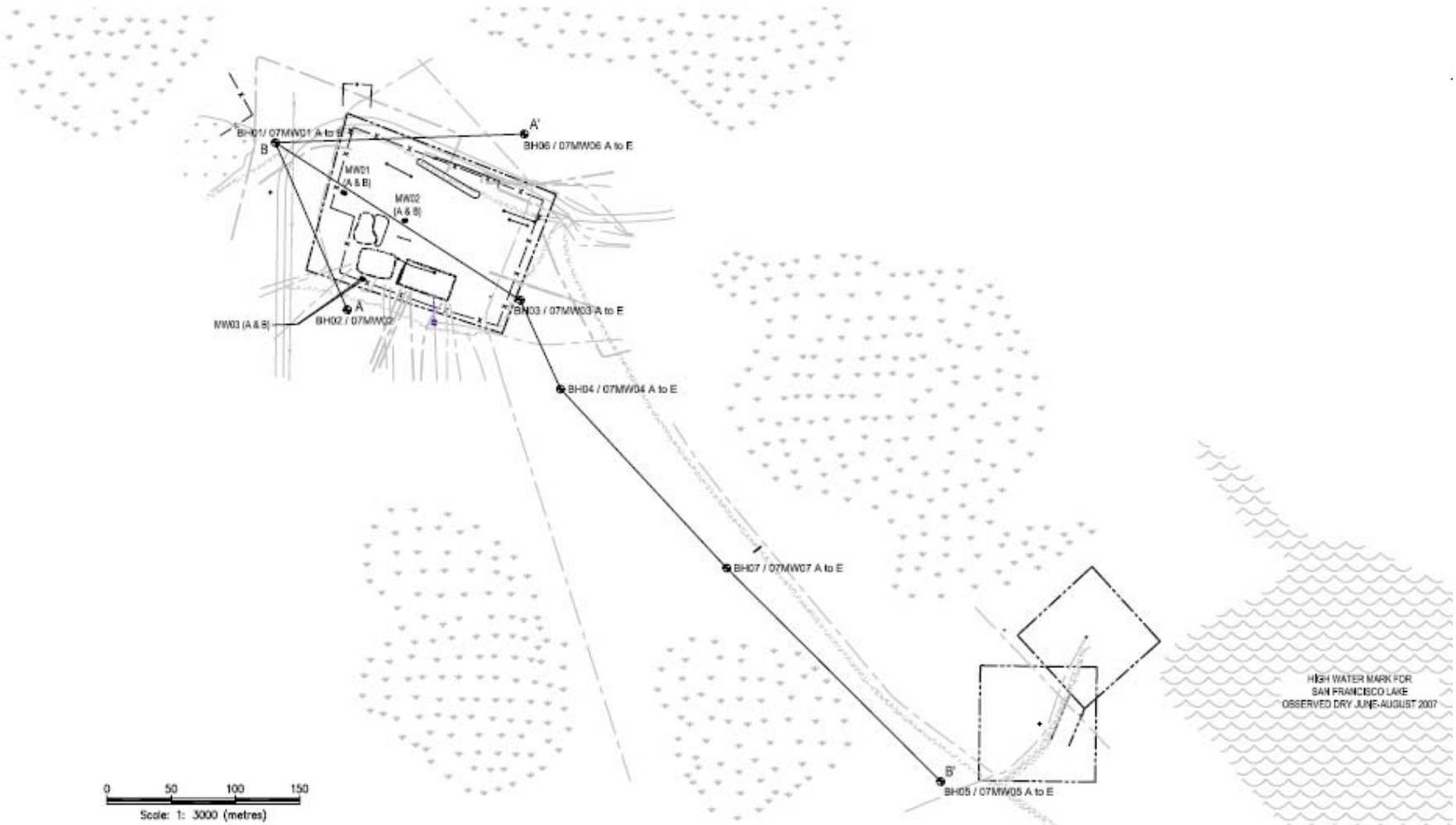
Off lease Assessment



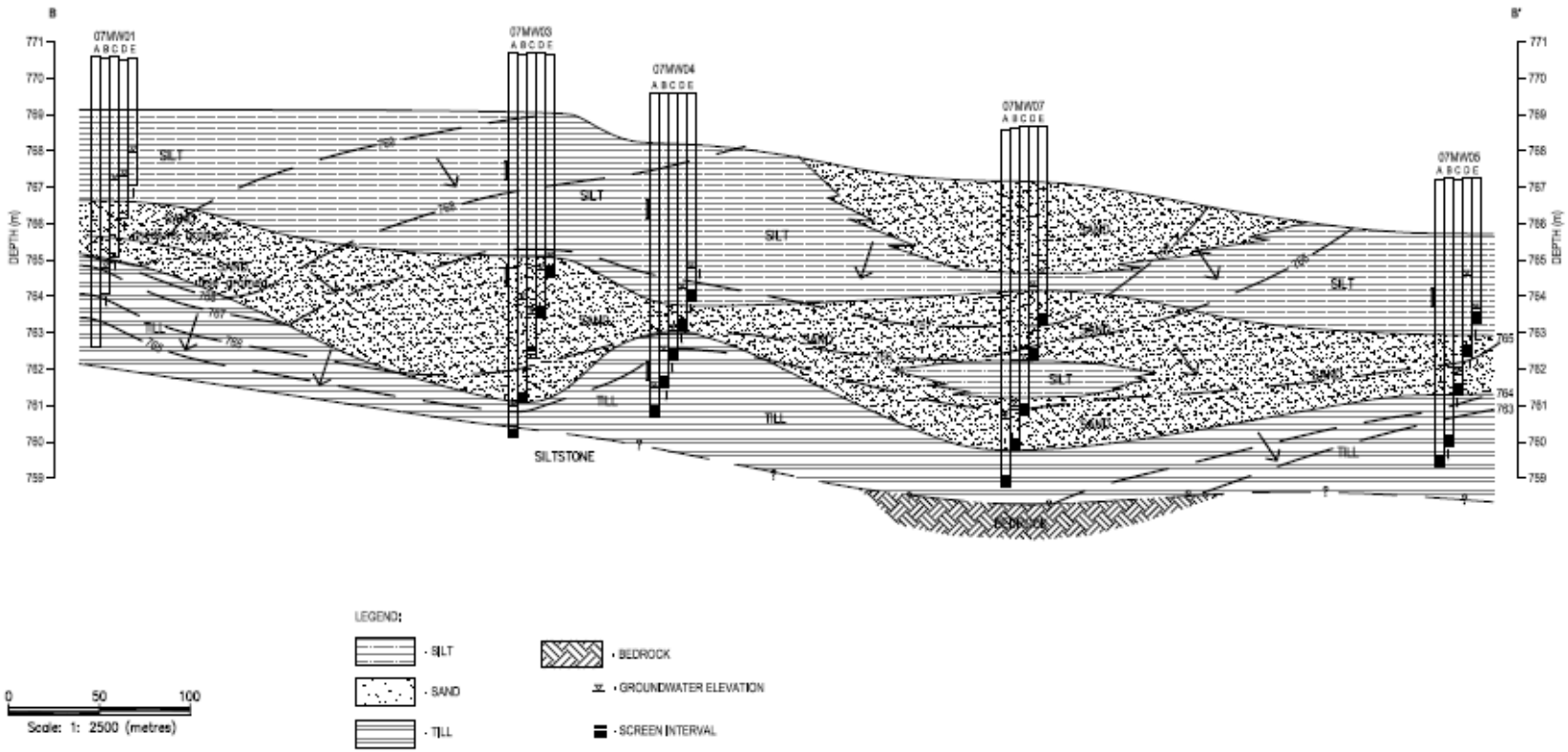
Special Point Measurement for Nested Groundwater Monitoring Wells in Layered Sediments – using Stainless Steel Points (0.3 m long)

Five nested monitoring wells at each location

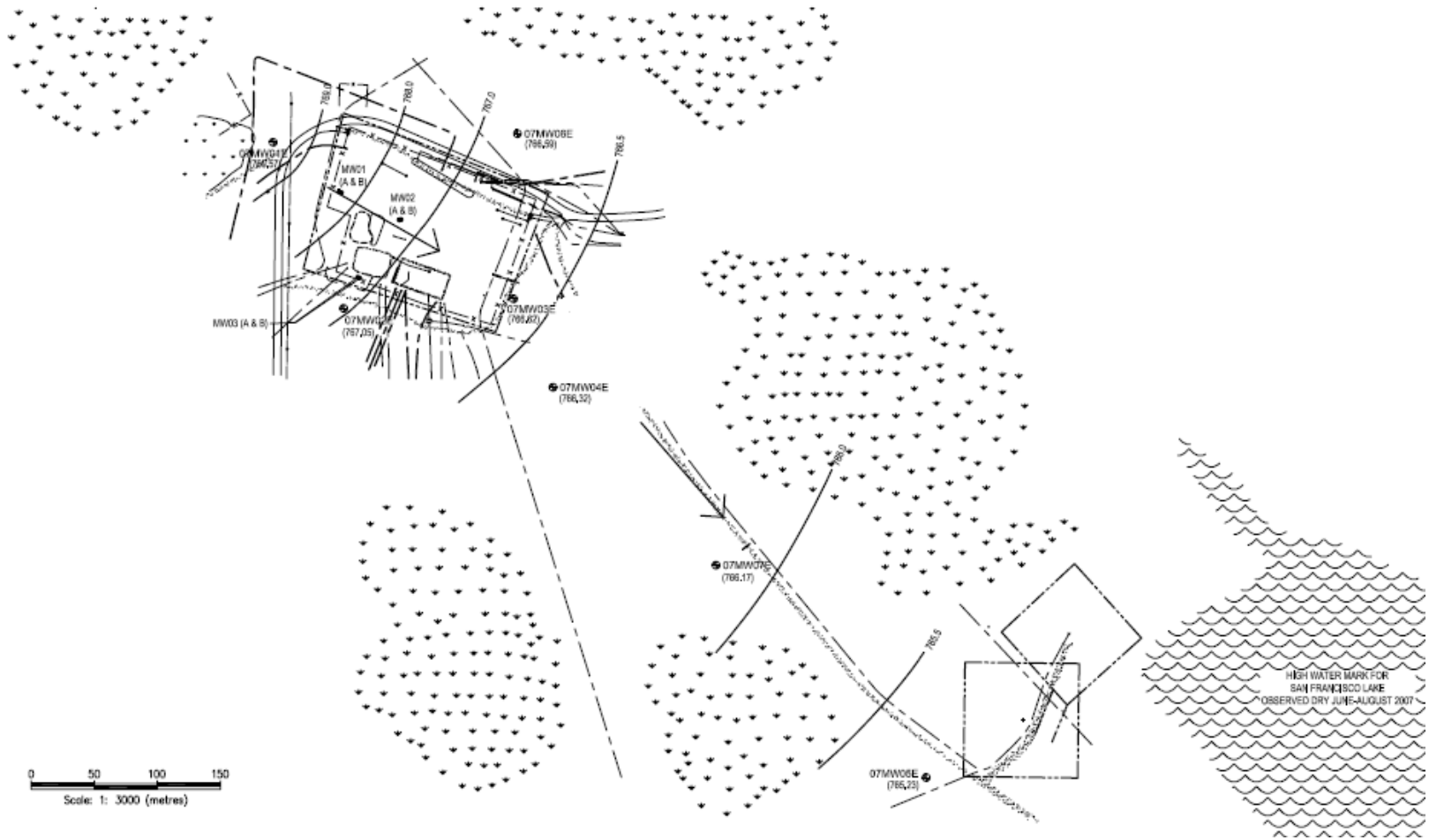
Off lease Assessment – Nested Well Locations



Off lease Assessment – Lithology and Flow Net



Off lease Assessment – Flow Direction



Off-lease Assessment - *Tebuthiuron Concentrations*

Off-lease (Soil)

- Less than the detection limit of 0.00016 mg/kg except one soil sample: 4.5-5.0 m with 0.0036 mg/kg

Off-Lease (Groundwater)

- All samples analyzed were less than the detection limit

Site Specific Clean – Up Criteria

ISSUES AND CONCERNS

- Off-lease - No off-lease issues with Regards to Tebuthiuron

- On-lease – Tebuthiuron in Soil and Groundwater

Therefore, a Site Specific Clean-up Criteria Protective of the Water Resources Needed to be Developed.

Site Specific Clean – Up Criteria (Cont.)

Two Considerations:

- Is it likely that Tebuthiuron leached from the site could reach the lake at concentrations greater than the analytical detection limit? And if so,
- What are the criteria needed to ensure the quality of groundwater reaching the lake are protective of the freshwater aquatic life?

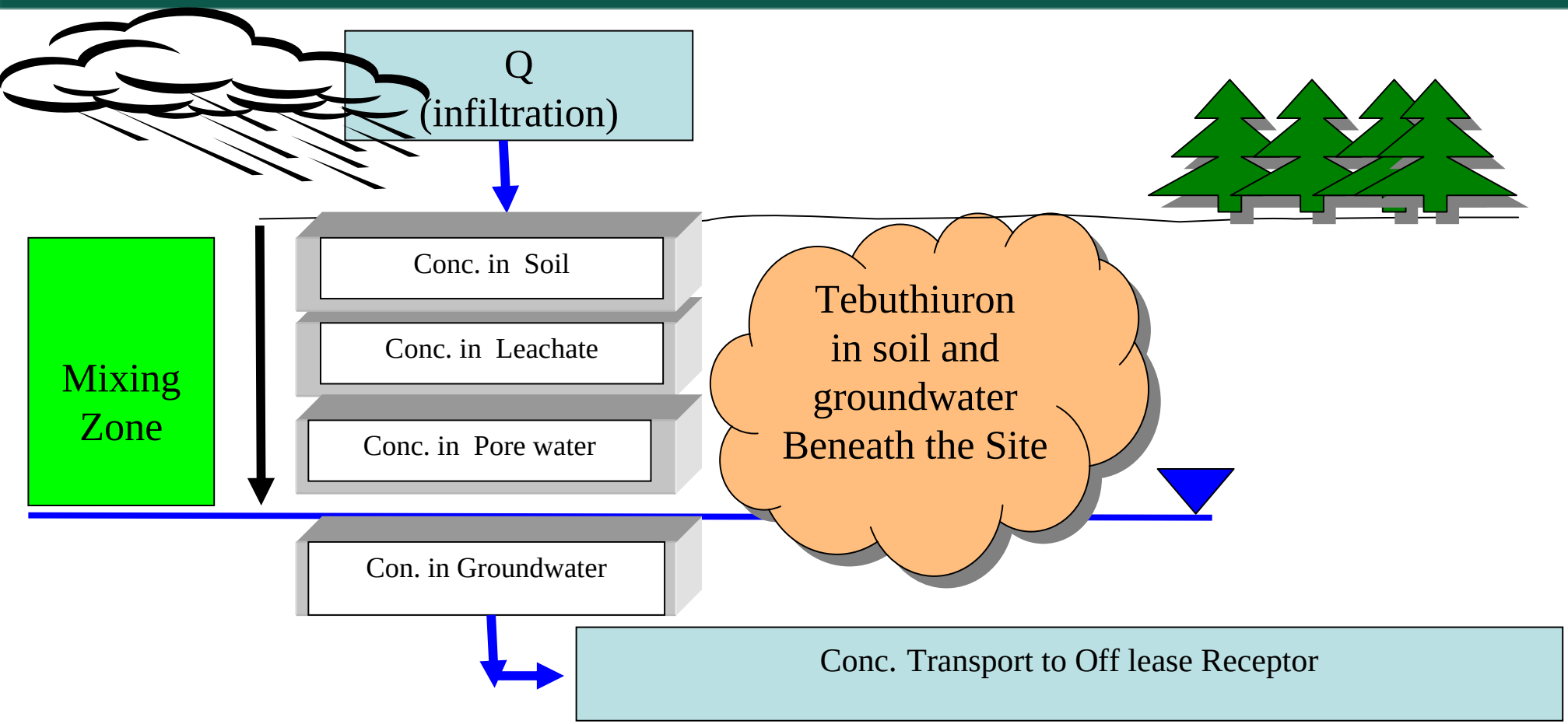
Site Specific Clean – Up Criteria (Cont.)

The numerical modelling approach used by the AENV Tier 2 Guideline (AENV 2007) was applied.

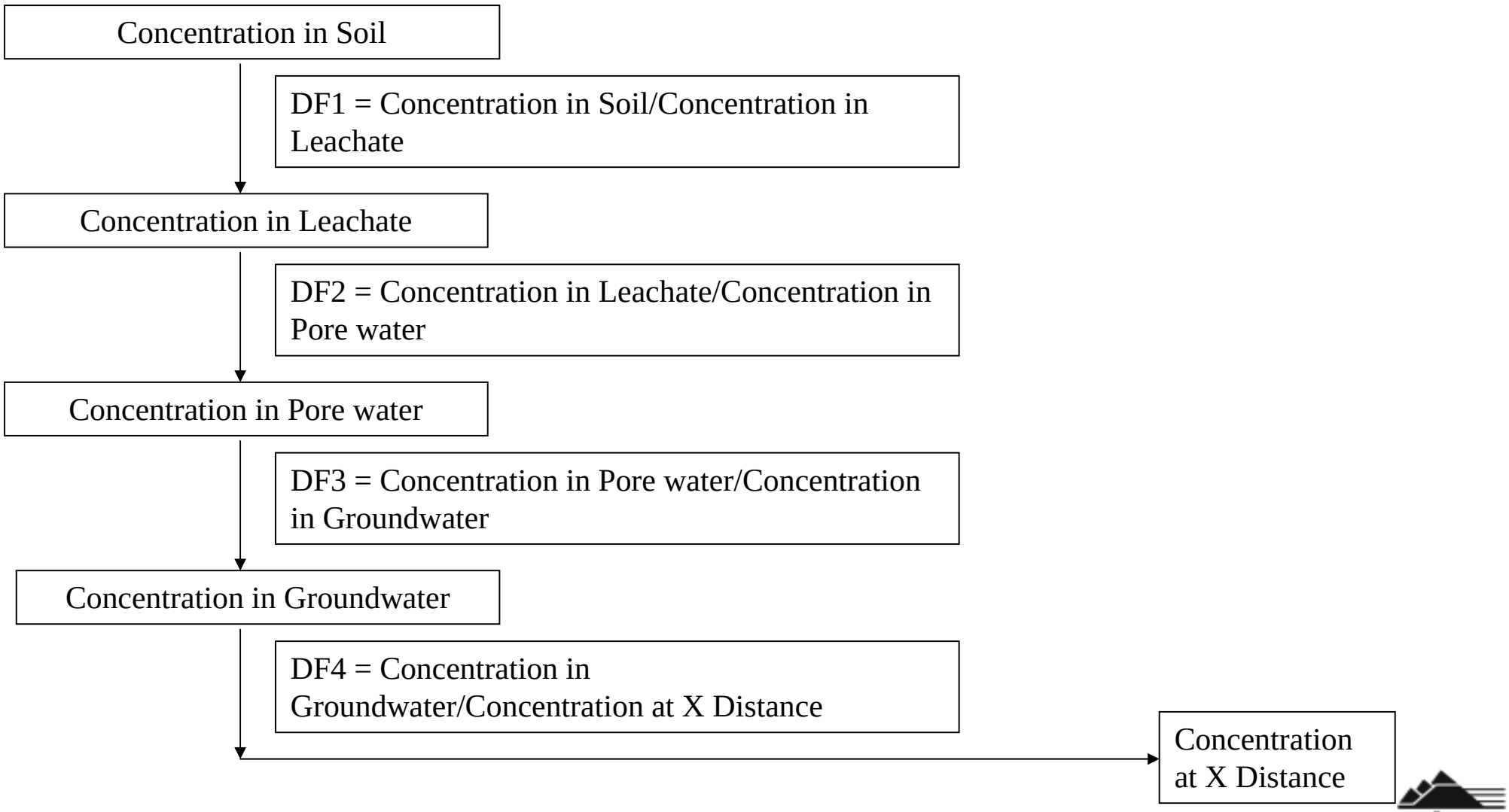
Four contaminant transport processes involving a dilution factor in each transportation process (e.g., DF1 through DF4) to determine the overall dilution factor DF.

Each dilution factor represents a different compartment in the transport and process from the soil and through the groundwater to the receptor location.

Conceptual Leaching Model



Conceptual Leaching Model (Cont.)



Site Specific Clean – Up Criteria (Cont.)

- DF1 f K_{oc}, f_{oc}, H', water filled and air filled porosity and dry bulk density of contaminated soil
- DF2 f thickness of unsaturated zone below the source zone, dispersivity and decay constant of contaminant in unsaturated zone
- DF3 f thickness of mixing zone, Darcy's velocity, infiltration rate, unconfined aquifer thickness, aquifer hydraulic conductivity and lateral hydraulic gradient
- DF4 f K_{oc}, $f_{oc,}$ lateral distance between source and receptor, decay constant, Darcy's velocity, retardation factors

Site Specific Clean – Up Criteria (Results)

- DF1 = 15 (L/Kg);
- DF2 = 1 (L/L);
- DF3 = 2.4 (L/L); and
- DF4 = 1E+34 (L/L) - Significantly High Dilution Factor

Site Specific Clean – Up Criteria (Cont.)

$$SRG = SWQG \times DF$$

Where,

SRG = Soil Remediation Guideline

SWG = Surface Water Quality Guideline

DF = Overall Dilution Factor

= (DF1 x DF2 x DF3 x DF4)

Site Specific Clean – Up Criteria (Cont.)

$$GWRG = SWQG \times DF_4$$

Where,

GWRG = Groundwater Remediation Guideline

SWQG = Surface Water Quality Guideline

DF4 = Con. in GW/Con. at X distance

Tebuthiuron – Applicable Pathway

Pathways Excluded:

- Drinking Water - Thin silty sand sediments, proximity of the lake combined with the physical setting (within the high water level of the lake and thus prone to flooding).

- Irrigation Water and Livestock watering - The proximity of the lake, it was unlikely that the underlying water bearing sediments would ever be used as a source of irrigation water or for livestock watering.

Applicable Pathway:

- Freshwater Aquatic Life - The points of exposure occur at the shoreline of Lake some 550 m from lease. This criteria was used to establish clean-up criteria for remedial action on the site.

Site Specific Clean – Up Criteria Results (Cont.)

- Soil Remediation Guideline = 6.3E+32
- Groundwater Remediation Guideline = 1.7E+31
- Extremely High Guideline Values Due to High Dilution Factor 4 (DF4).

Site Specific Clean – Up Criteria Results (Cont.)

- DF4 = 1E+34 (conc. in gw beneath the source/concentration close to the Lake)
- Highest detected conc. in GW = 0.042 mg/L
- Therefore calculated concentration close to the lake is much less (i.e., less than the laboratory detection limits) – verified with field results.

Conclusions

- No off lease groundwater issues with Tebuthiuron. Tebuthiuron detected in on-lease soil and groundwater is not present in the perimeter monitoring wells and off lease monitoring wells.

- The calculated Tebuthiuron concentration in the groundwater close to the Lake is less than the analytical detection limit.

Conclusions (Cont.)

- Concentrations on lease do not pose a threat of adverse impact to water resources and more stringent clean-up criteria are not required.

- The groundwater immediately below the lease was determined not to be suitable for potable use and irrigation use.

Next Steps – Soil Remediation & Dewatering

- Soil Remediation to Eco-Contact Guideline Using Thermal Desorption

- Dewatering for Soil Remediation

Questions ?

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