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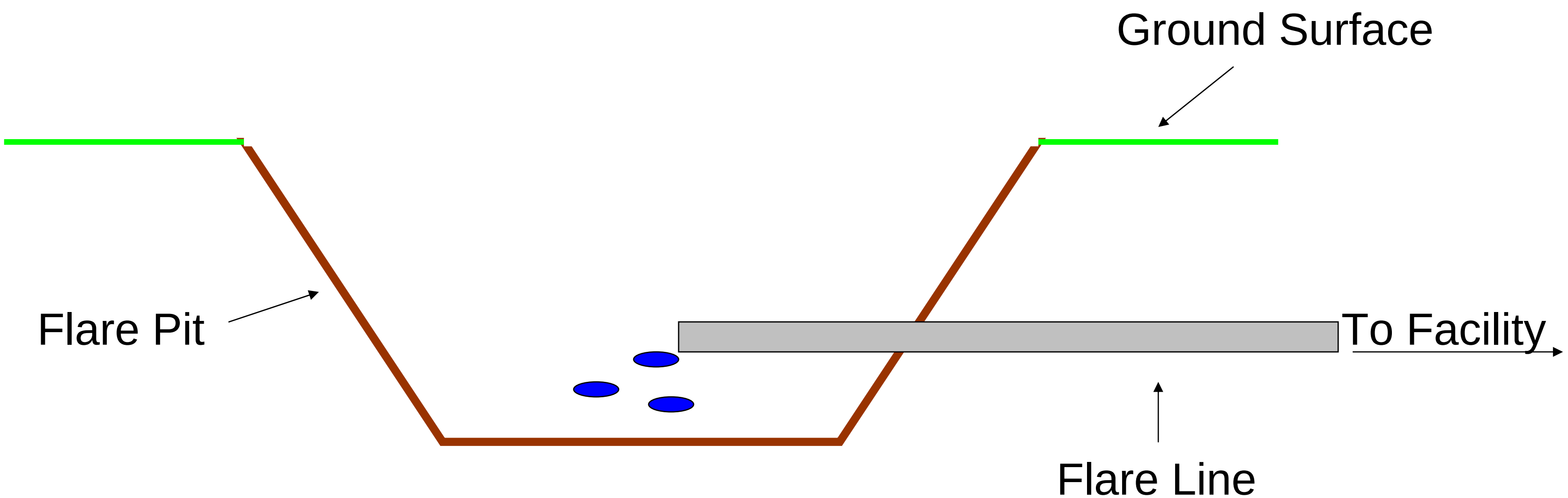
Interaction of Collected Water and Soil Within Remediation Excavations at Several Locations in Central Alberta

Introduction

- Earthen pits, also known as flare pits are a legacy of historical operations at oil and gas sites in Alberta



Introduction

- In the mid-1990's the ERCB (formerly the EUB) amended regulations and prohibited the use of earthen pits

- Rough estimates put the number at well over 150,000 pits in Alberta

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Flare Pits

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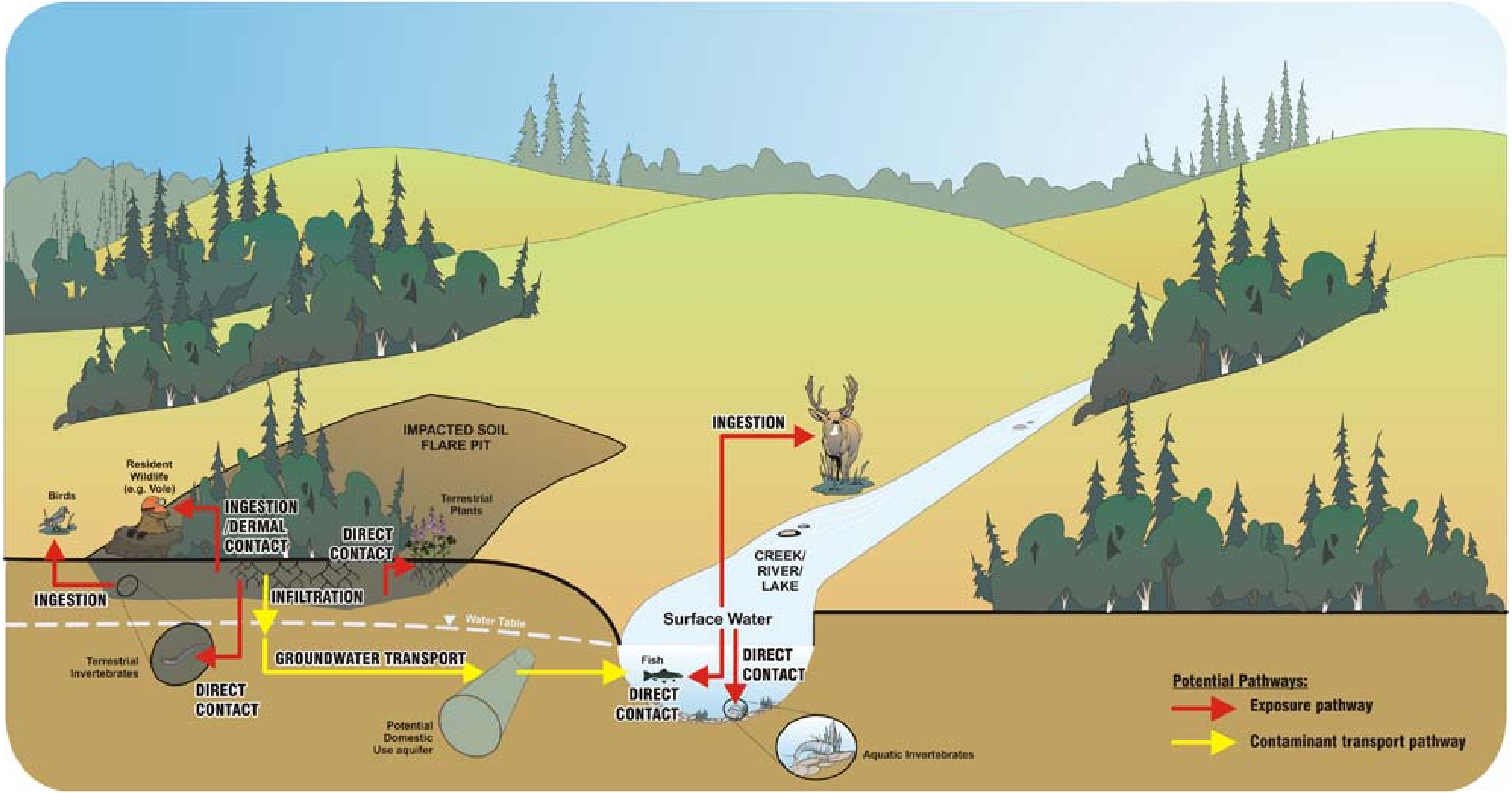
Receptors



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Flare Pit Excavations

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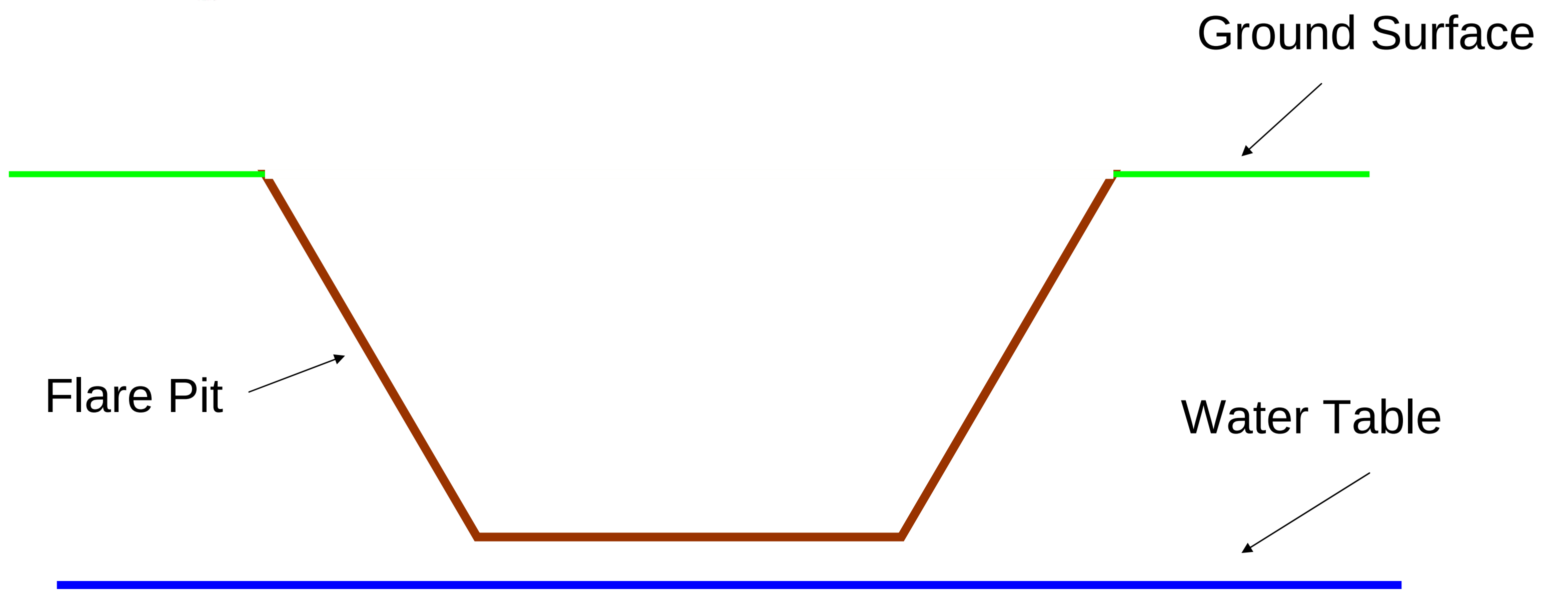
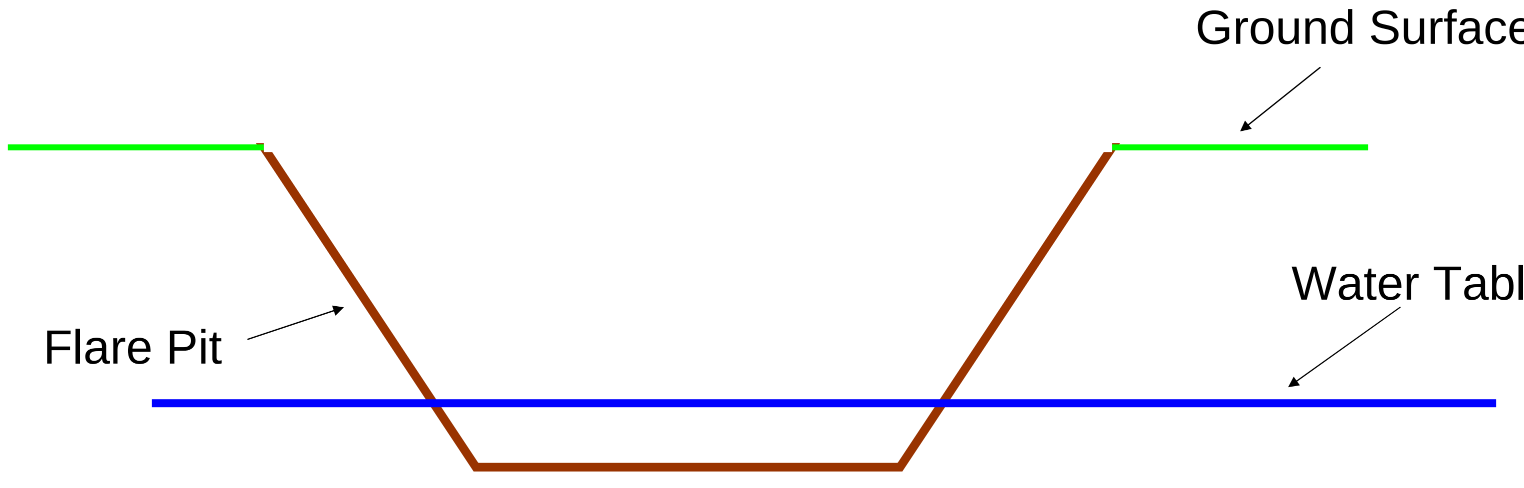
Contaminants


790E LC

Remediation

Water Table


Ground Surface
Flare Pit
Water Table

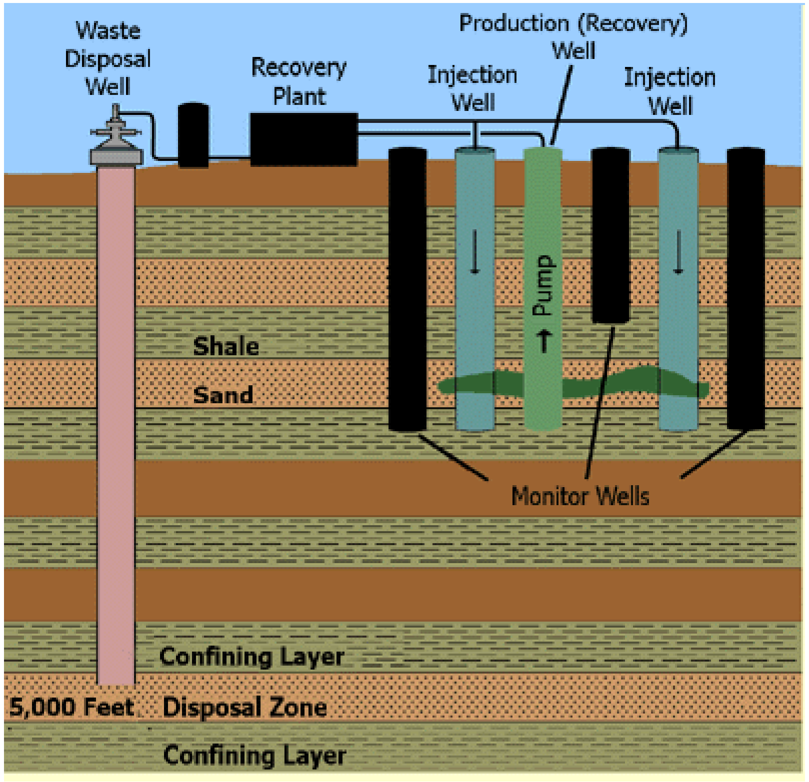

Ground Surface
Water Table
Flare Pit

Collected Water

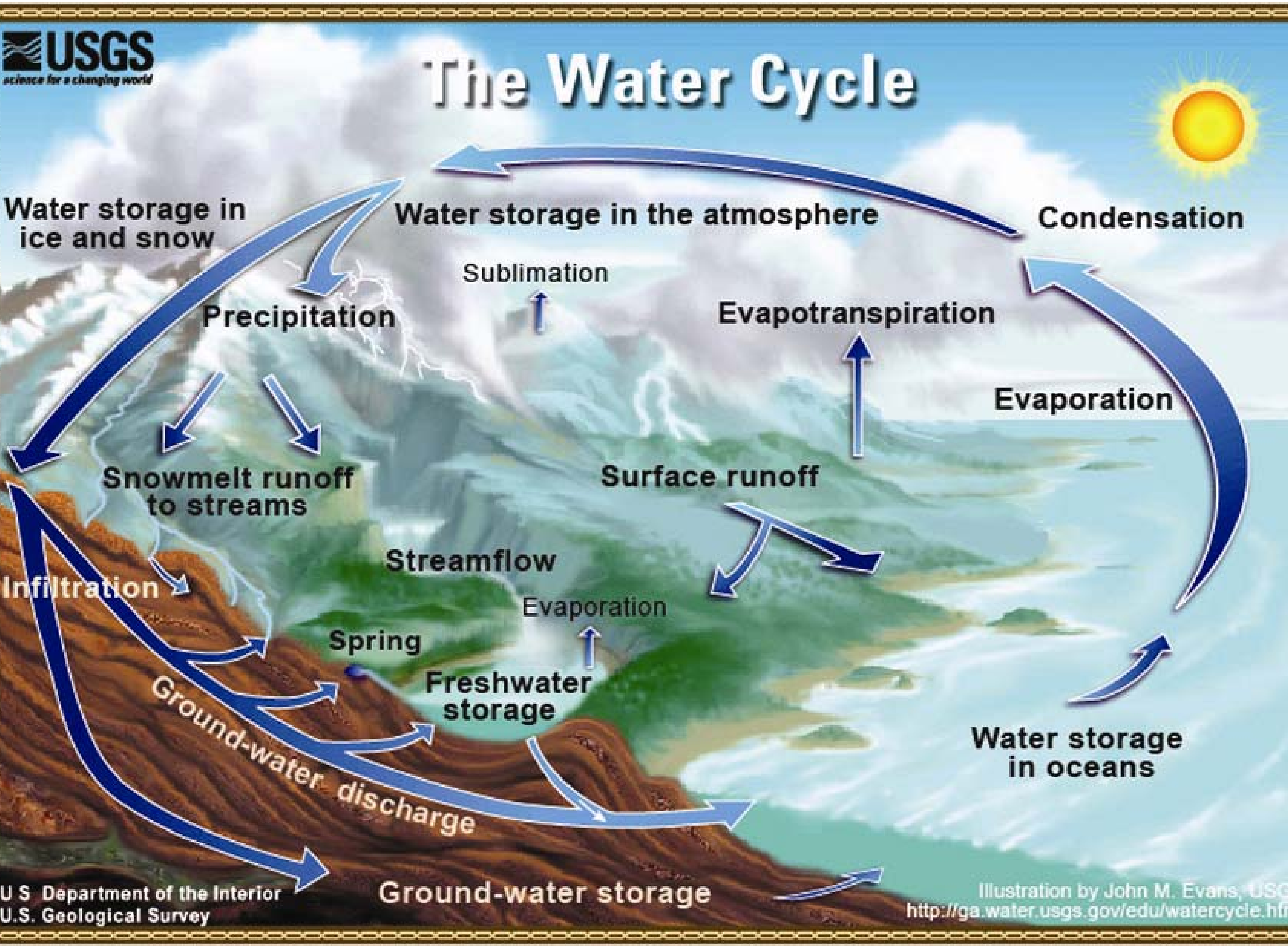
- Water also collects as a result of rain and snow fall event

Flare Pits


LEACHATE



Leachate = Deep Well Injection



USGS
science for a changing world
The Water Cycle
Water storage in ice and snow
Water storage in the atmosphere
Condensation
Sublimation
Precipitation
Evapotranspiration
Evaporation
Snowmelt runoff to streams
Surface runoff
Streamflow
Infiltration
Evaporation
Spring
Freshwater storage
Ground-water discharge
Water storage in oceans
Ground-water storage
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Illustration by John M. Evans, USGS
http://ga.water.usgs.gov/edu/watercycle.htm

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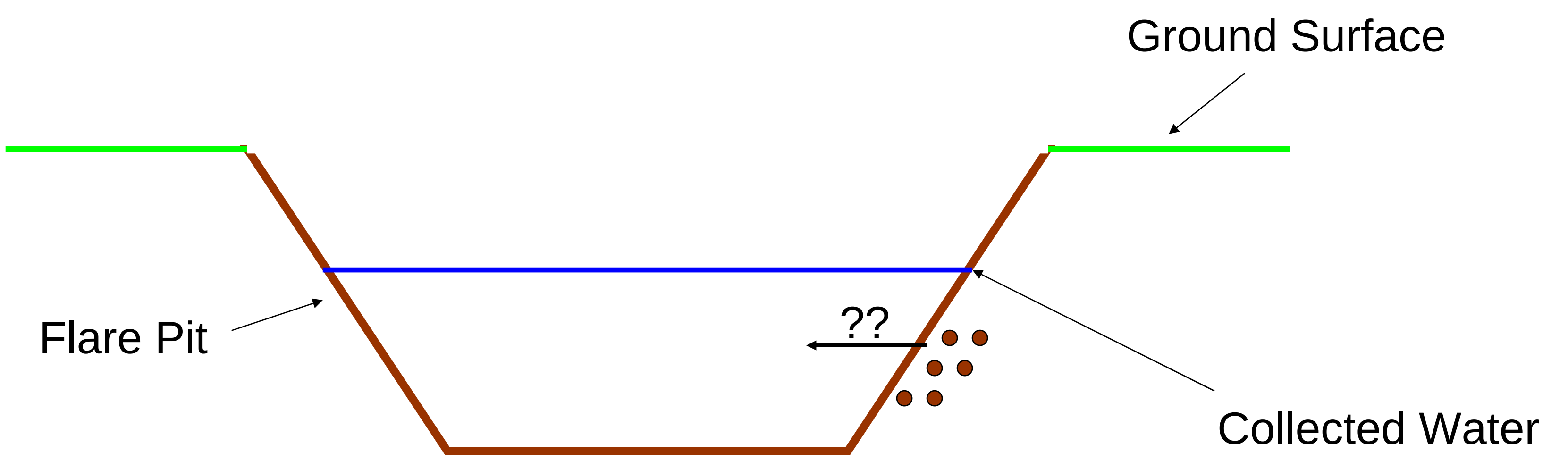
The Problem

- Is there a better way to handle this type of water?
- In 2000, began sampling the collected water and found that despite soil impact, water was relatively clean

The Problem

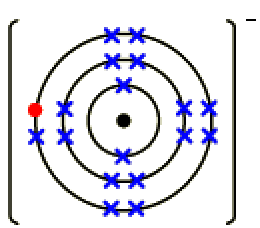
- Is there a way to predict the amount of contaminants that would transfer from the soil to the collected water?



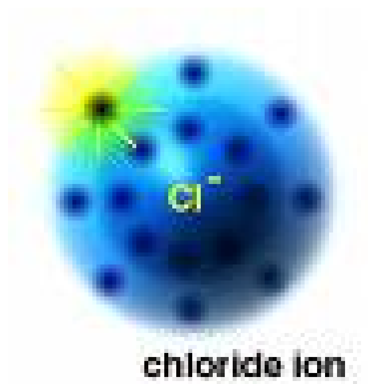
Methods

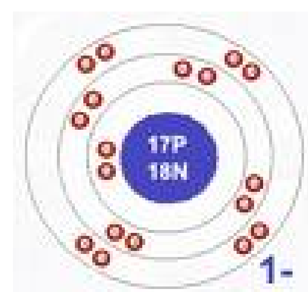
- Used a combination of three methods:
  - Case study data
  - Numerical model
  - Fick's Law Calculations

- Used chloride due to its conservative nature



chloride ion,
Cl^{-} [2,8,8]$^{-}$





Results

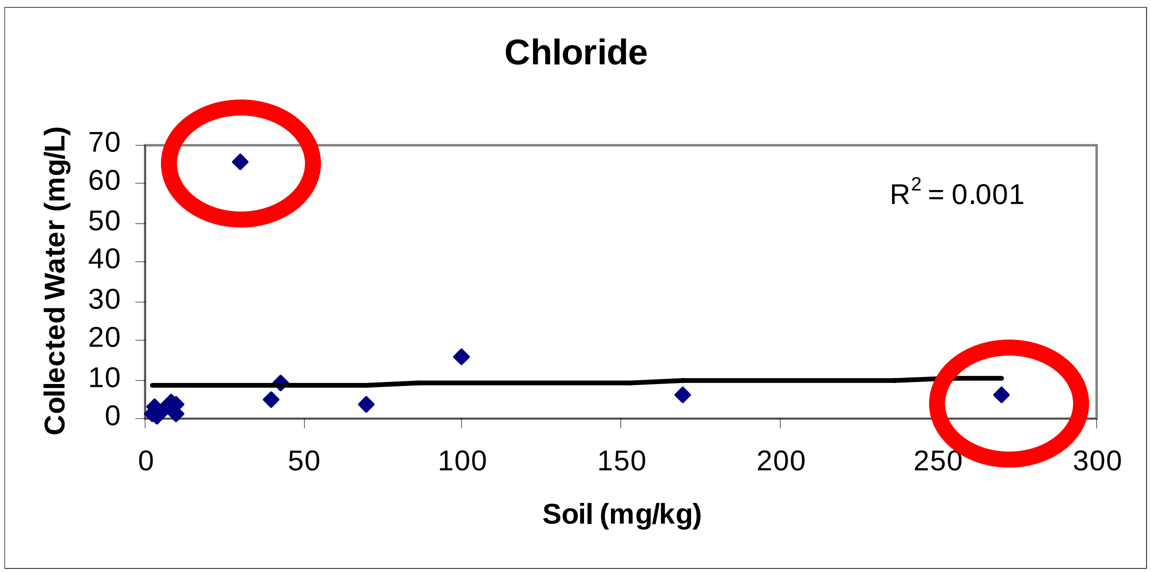
- Case Study Sites
  - 17 sites were used
  - information regarding flare pit surface area, volume of collected water in excavation and soil and water chemistry

Results

- Case Study Sites
  - Average chloride concentration found in soil was 51.5 mg/kg
  - Average chloride concentration found in collected water was 8.6 mg/L

- Case Study Sites

  - There was no correlation between concentrations of chloride found in the soil and the concentration found in the collected water

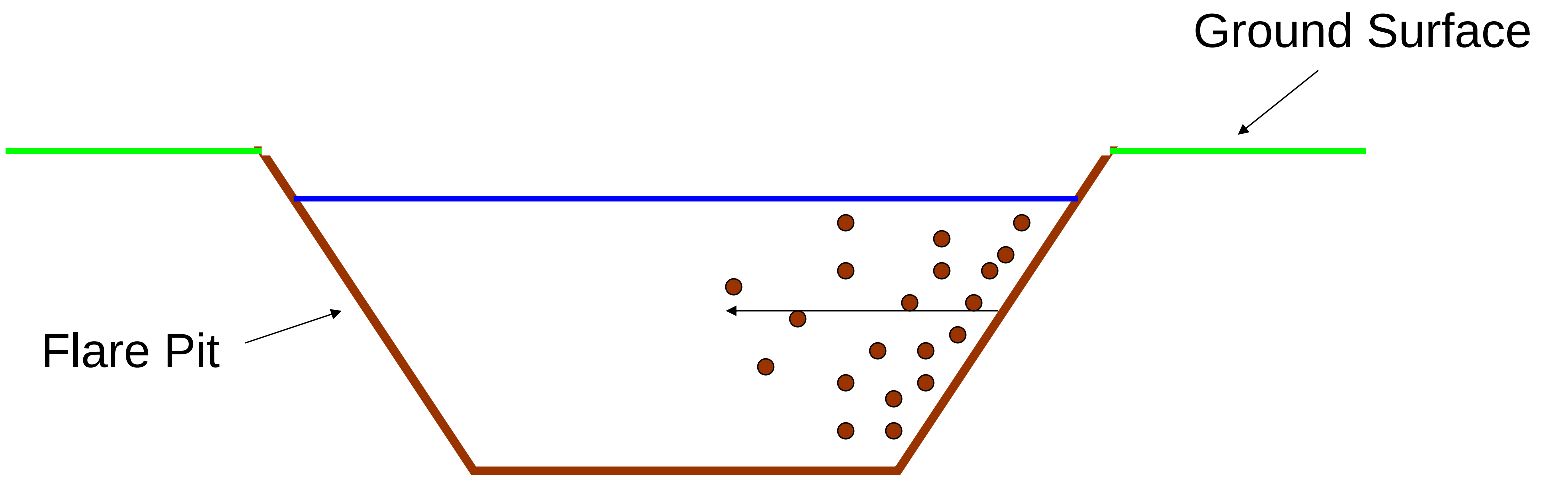


Results

- Numerical Model
  - Used ModFlow
  - Used case study site data and published values to populate the model
  - Started with 1000 mg/kg of chloride in the soil and ran the model for 1 year

Results

- Numerical Model
  - After 1 year the predicted concentration of chloride in the simulated excavation was <10 mg/L



Results

- Calculations
  - Used Fick's First and Second Laws to calculate flux ranges
  - Concentration of a diffusing substance over an area and time

Results

$$F = -D_d\left(\frac{\delta C}{\delta x}\right)$$

Where,

$F =$ mass flux of solute per unit area per unit time (M/L^2T)

$D_d =$ diffusion coefficient (L^2/T)

$C =$ solute concentration (M/L^3)

$\left(\frac{\delta C}{\delta x}\right) =$ concentration gradient ($M/L^3/L$)

$$D^* = \omega D_d$$

Where,

$D^* =$ effective diffusion co-efficient (L^2/T)

$\omega =$ coefficient related to porosity and tortuosity (unitless)

$$\frac{\delta C}{\delta t} = D^* \frac{\delta^2 C}{\delta x^2}$$

Where,

$\frac{\delta C}{\delta t} =$ concentration over time (M/L^2T)

$D^* =$ effective diffusion co-efficient (L^2/T)

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$$\frac{\delta^2 C}{\delta x^2} = \text{concentration gradient (M/L}^3\text{/L)}$$

Significance

- Using three methods all results were below:

  500 mg/L (Health Canada, 2006)

  230 mg/L (AENV, 2009 – Natural Area)

  100 mg/L (AENV, 2009 – Agriculture, Irrigation)


LEACHATE?

Alternatives

- An application was made to the ERCB for the "surface discharge of collected water to adjacent lands".
- A rigorous sampling protocol and analytical schedule for collected water was developed and approved by the ERCB.
  - water can not have a visible sheen
  - each sample analyzed for hydrocarbons, routine potability and contaminants identified in the excavation
  - landowner acceptance of analytical data and discharge area

Alternatives

- The application of the protocol is cumbersome
  - precipitation events are unpredictable
  - lab turn around time on samples
  - landowner availability for approval prior to discharge

- Best available practice for the time being

Alternatives

- In the future, collected water should fall under a generic guideline and a discharge protocol set up similar to retention ponds at oil and gas facilities.

Alternatives

- This would ensure that the water is not removed from the hydrological cycle and the most is being made of this scarce resource.

Thank You

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- Dr. L. Bentley, University of Calgary
- M. Morden, Petro-Canada
- M. Bowles, Golder and Associates Ltd.

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