Task #6: Update the CF&T Model and Evaluate Whether to Perform Tracer Study

- Previous Contaminant Fate and Transport Modeling performed by Bob Whittier, using RT3D (TEC 2007)
- Modeling purpose: Conduct Tier 3 risk assessment
  - Establish site-specific risk-based level (SSRBL) for selected compounds
  - DOH EALs: Benzene: 0.005 mg/L; Total Petroleum Hydrocarbons (TPH): 0.100 mg/L
  - Must show compliance with MCL at drinking water source
- Modeling Question:
  - "How close can a hypothetical LNAPL plume get to the Red Hill Shaft without exceeding MCL or EAL?"
    - Note: NAPL has never been detected at the groundwater surface

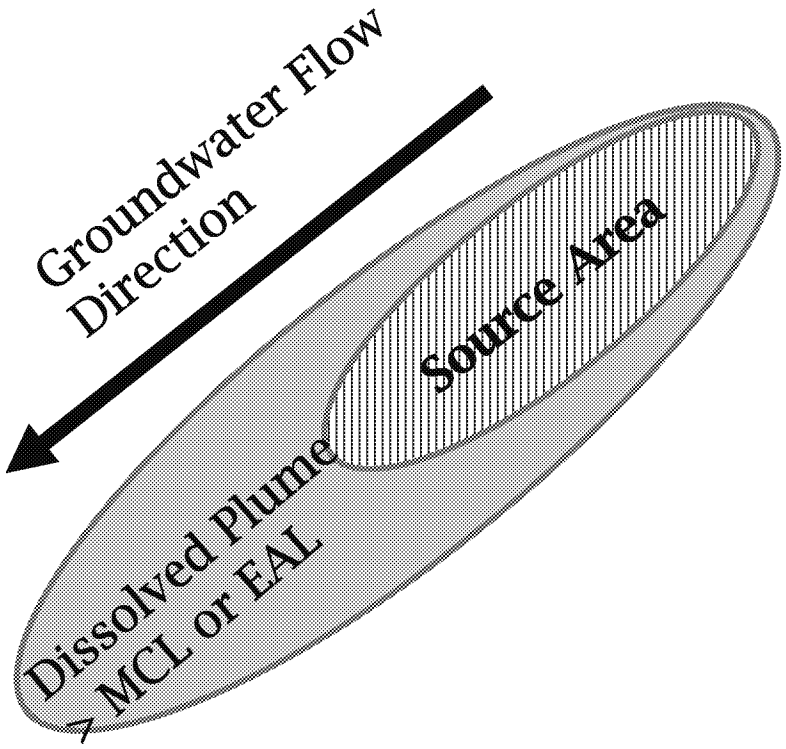
Task #6: Update the CF&T Model and Evaluate Whether to Perform Tracer Study

- **What this model DOESN'T do:**
  - **Simulate the LNAPL migration in the vadose zone**
    - Geologic CSM suggests NAPL is not migrating to the water table
  - **Simulate potential LNAPL migration along the water table**
    - NAPL has not been detected on the groundwater surface
- **What the model DOES do:**
  - **Estimate the degradation rate of dissolved contamination**
  - **Provide the foundation for Site Specific Risk Based Risk Based Level (SSRBL)**

Task #6: Update the CF&T Model and Evaluate Whether to Perform Tracer Study

- **Modeling Approach**
- **Select modeling code**
  - **Compatible with MODFLOW**
    - MODPATH, MT3D, RT3D
  - **MODPATH**
    - Particle tracking, good for delineating zones of contribution and estimating groundwater velocity
    - No dispersion
  - **MT3D**
    - Simultaneously simulate transport of multiple species
    - Include dispersion, sorption, first order decay
    - Some challenges in acquiring needed parameters
  - **RT3D**
    - Similar to MT3D, but can simulate biodegradation
    - Very challenging to get required parameters!

Task #6: Update the CF&T Model and Evaluate Whether to Perform Tracer Study



- Modeling Approach
  - Modeled source area as an immobile LNAPL Plume
  - Simulated microbial mediated degradation in the dissolved plume
  - Estimated distance dissolved plume travels prior to degrading to < MCL or EAL

Task #6: Update the CF&T Model and Evaluate Whether to Perform Tracer Study

- **RT3D required parameters**
  - **Dispersivity**
    - Estimated from rock core logs (50 ft) and USGS reports (250 ft)
    - Geometric mean 112 ft
    - Estimated Lahaina Tracer Test Value - 82 ft (for comparison)
  - **Sorption**
    - Assumed to be zero
    - Conservative assumption (probably not true)
  - **Natural Attenuation Parameters (NAPs)**
    - Concentrations
    - Consumptive rate
    - Reaction rates and coefficients

Task #6: Update the CF&T Model and Evaluate Whether to Perform Tracer Study

- **Model Simulations**
  - **Base – estimate proximity of LNAPL to RHS and still be compliant at the Red Hill Shaft**
    - TPH
    - Benzene
  - **Plume size**
    - Step-wise increase in width and length
  - **Infiltration only**
    - Simulate the impact on groundwater of recharge moving through contamination in the unsaturated zone
  - **Reaction rates**

Task #6: Update the CF&T Model and Evaluate Whether to Perform Tracer Study: Previous Model Results

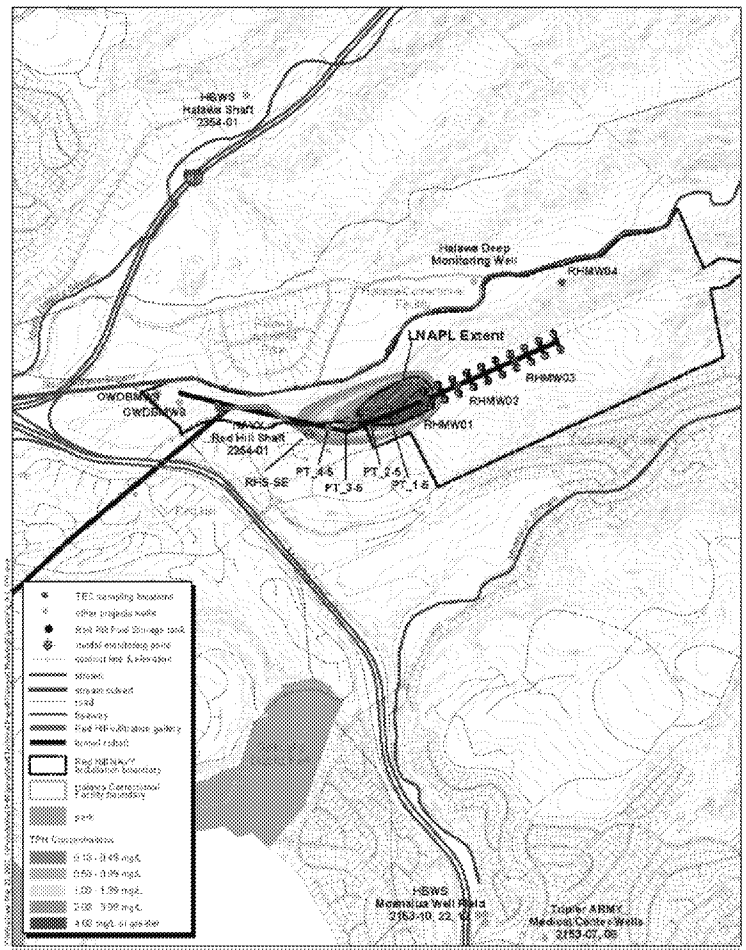


Figure 4-3
TPH Concentration Distribution When the TAL is Exceeded at the RHS

Total Petroleum Hydrocarbons

- Hypothetical LNAPL footprint: red hatched oval
- Results
  - LNAPL must extend to point mid-way between RHMW01 and RHMW05 for an exceedance to occur at the Red Hill Shaft
- TPH Dissolution Rate
  - 2.7 mg/d/ft^2
  - Compares favorably with analytical model
    - (Wiedeimerer et al 1995)

PRIVILEGED, Preliminary DRAFT pending full privilege review, Subject to Deliberative Process Privilege, 5 U.S.C. 552(b)(5): May contain Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5), critical infrastructure information, 5 USC 552(b)(3), well location information 5 USC 552(b)(9) or other information not subject to disclosure under Red Hill AOC para. 10.d. DRAFT to be destroyed and replaced when final marked for redaction version is provided.

Task #6: Update the CF&T Model and Evaluate Whether to Perform Tracer Study: Previous Model Results

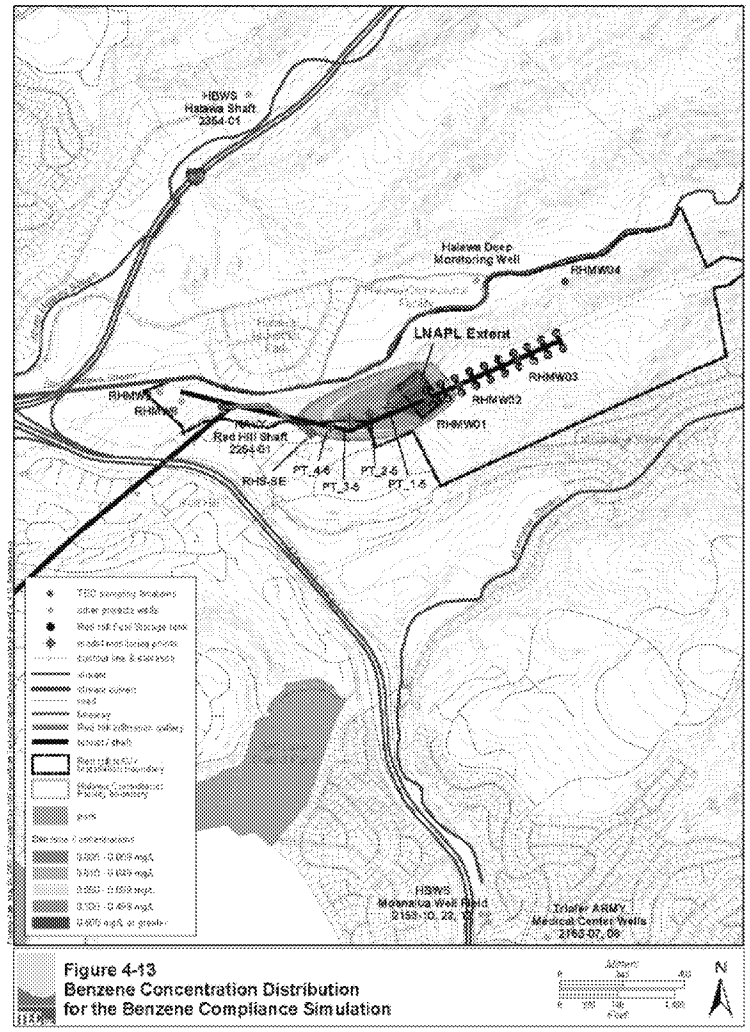


Figure 4-13
Benzene Concentration Distribution
for the Benzene Compliance Simulation

Benzene

- Results
  - A hypothetical LNAPL plume that reaches beyond RHMW01 could cause an exceedance at the RHS
- Concentration must be reduced by a factor of 150
  - TPH, only requires a 45 fold reduction
- But only infrequent, trace benzene detections, and benzene not a major constituent of JP-8
  - Benzene may not be the best COPC for modeling and planning purposes

Task #6: Update the CF&T Model and Evaluate Whether to Perform Tracer Study: Previous Modeling Conclusions

NAVFAC

Modeling Conclusions

- Jet fuels (JP-5) solubility is relatively low
  - TPH solubility of ~5 parts per million (mg/L)
  - Benzene content low, 0.7 mg/L maximum
    - May be much less
- Red Hill dissolved contamination is not extremely mobile
- Natural attenuation reduces TPH concentrations to < EAL over distances of 1000 – 2000 ft
- Properly characterizing NAP reaction rates is important for RT3D modeling

Task #6: Update the CF&T Model and Evaluate Whether to Perform Tracer Study: Previous Modeling Conclusions

- **Uncertainties**
  - **Actual solubility of JP-5 and JP-8**
    - One analysis lists JP-8 solubility as 12 mg/L
  - **Stoichiometry**
    - Bulk rates of natural attenuation parameter utilization
  - **Reaction rates and coefficients**
    - Data indicate that these are particularly important parameters
  - **Groundwater flow paths**

Task #6: Update the CF&T Model and Evaluate Whether to Perform Tracer Study: Previous Model Results

- Existing CF&T Model Strengths
  - RT3D is an industry standard model developed to model petroleum hydrocarbons
  - Leverage considerable previous effort by local experts
  - Models existing site data reasonably well (e.g., concentrations of dissolved oxygen and methane beneath UST facility)
  - Supports concept of modeling natural attenuation in the aquifer
- Recommendations for CF&T Model Improvement
  - Better define geometry, stratigraphy, and hydraulic properties
  - Evaluate effective porosity and dispersivity
  - Re-evaluate evaluate COPCs for JP-8
    - consider: presence, mobility, degradation, toxicity
  - Evaluate solubility of JP-8
  - Refine degradation rates for COPCs
  - Gather additional NAP data: dissolved oxygen, nitrate, ferrous iron, sulfate, and methane

Task #6: Update the CF&T Model and Evaluate Whether to Perform Tracer Study: Previous Model Results

- Recommendations for CF&T Model Improvement (cont'd)
- Gather and incorporate new data:
  - From USGS studies (e.g., pumping test of Halawa Shaft)
  - From new monitoring wells and sampling
  - From new well borehole stratigraphy and geochemical data
  - Gather additional NAP data
    - e.g., dissolved oxygen, nitrate, ferrous iron, sulfate, and methane

Task #6: Update the CF&T Model and Evaluate Whether to Perform Tracer Study

- Upon completion of all other tasks, and review of results, evaluate whether to perform a tracer study
- Purpose:
  - Study could refine site-specific estimates of field-scale:
    - groundwater velocity and flow direction,
    - hydraulic conductivity,
    - effective porosity, and
    - Dispersivity
  - Refine the SSRBLs
  - Inform Contingency Planning
- Considerations:
  - Does the new data suggest that contaminants are escaping the facility or otherwise pose an imminent and substantial endangerment?
  - Is groundwater flow regime amenable to a tracer study?
  - Are there suitable locations for tracer injection and monitoring?

Task #6: Update the CF&T Model and Evaluate Whether to Perform Tracer Study

- Tracer Study Design Parameters and Required Data:
  - Detailed hydrogeologic characterization
  - Tracer: non-toxic, easily measured, non-adsorptive, resistant to biodegradation; no undesirable color or odor
  - Injection points directly upgradient of monitoring points and close enough to define the complete break-though curve
  - Recommend pumping test to better define drawdown capture zone to select a tracer injection well location directly up-gradient from monitoring wells and close enough to define the complete tracer break-though curve
  - Use refined models and existing data to evaluate suitability of existing wells
  - Additional hydraulic head distribution data