# Headquarters U.S. Air Force

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# OT071 Hydrus Model Proposed Setup and Calibration

**Former George Air Force Base**
**September 2017**
**Sacramento, CA**



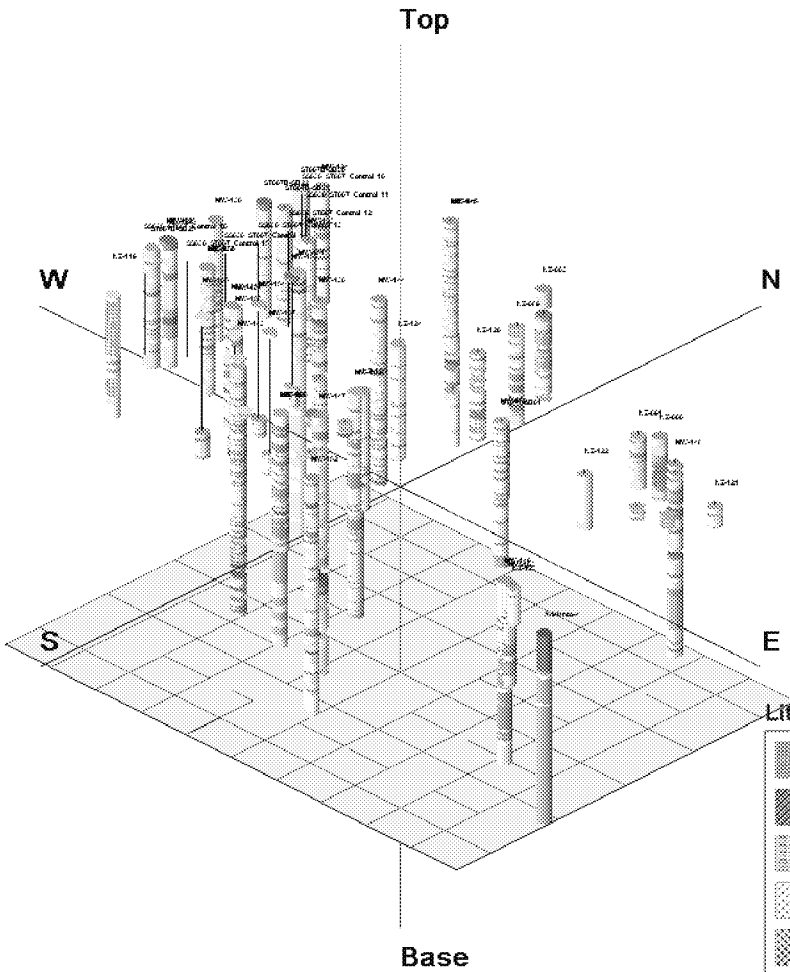
ED_003054_00003343-00001

# Overview

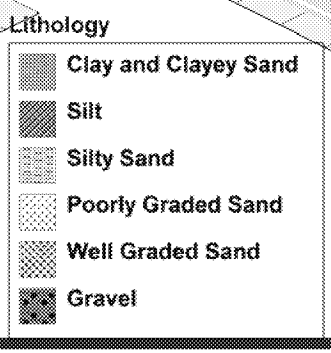
- Purpose of the modeling—Develop concept of how dieldrin migrates and develop tool for remediation analysis
- Key input parameters
  - Lithology
  - Precipitation, evapotranspiration, and artificial recharge
  - Soil geotechnical parameters (previously discussed)
  - Hydraulic conductivity—laboratory and field testing (previously discussed)
- Flow and transport modeling process
  - Stage 1 simple model
    - Define key Dieldrin colloidal transport parameters
    - Recharge from historical irrigation areas—housing, golf course, water tower pond
  - Stage 2 complex model
    - 2D larger area model
    - Incorporate detailed lithology along section line
    - Recharge and colloidal transport parameters from Stage 1 model
    - Calibration goal is to replicate observed Dieldrin plume

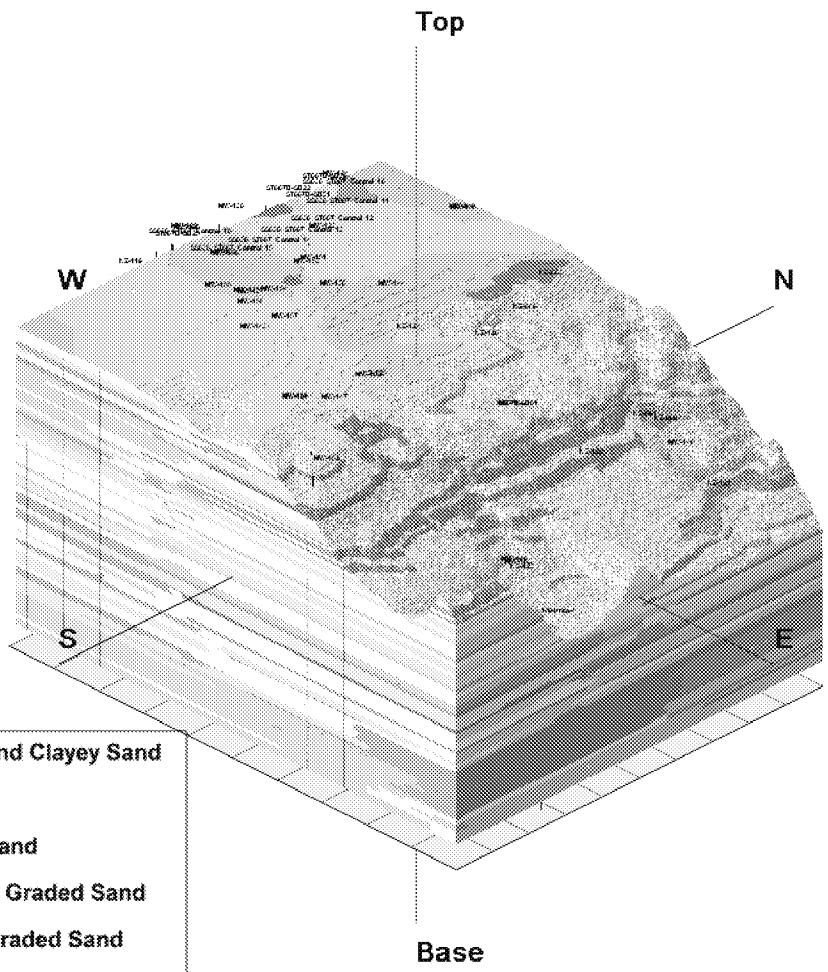
# Lithology

# OT071 Lithology Model




Input Boring Logs




Resulting Block Model

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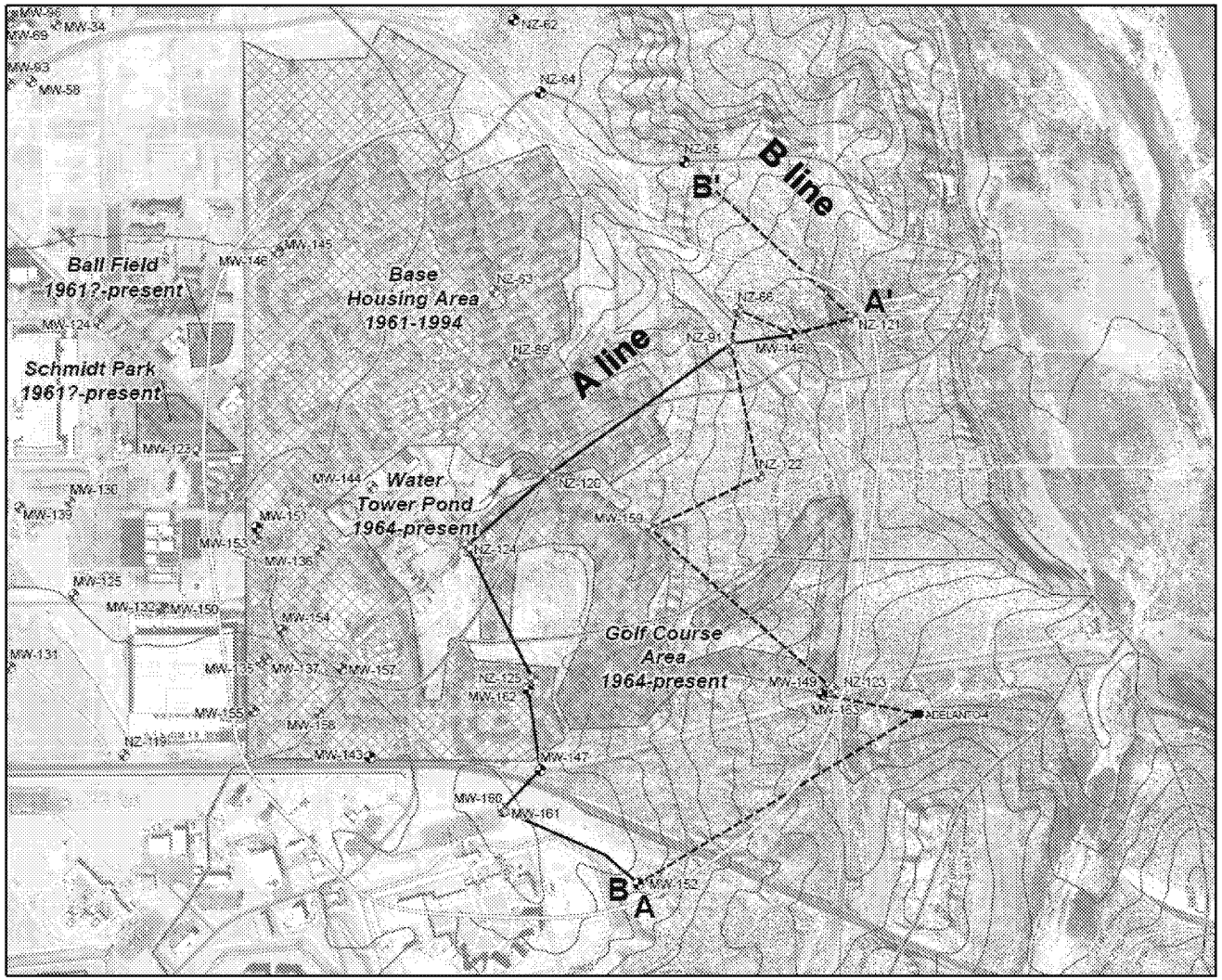
# OT071 Cross-section Lines and Artificial Recharge Areas

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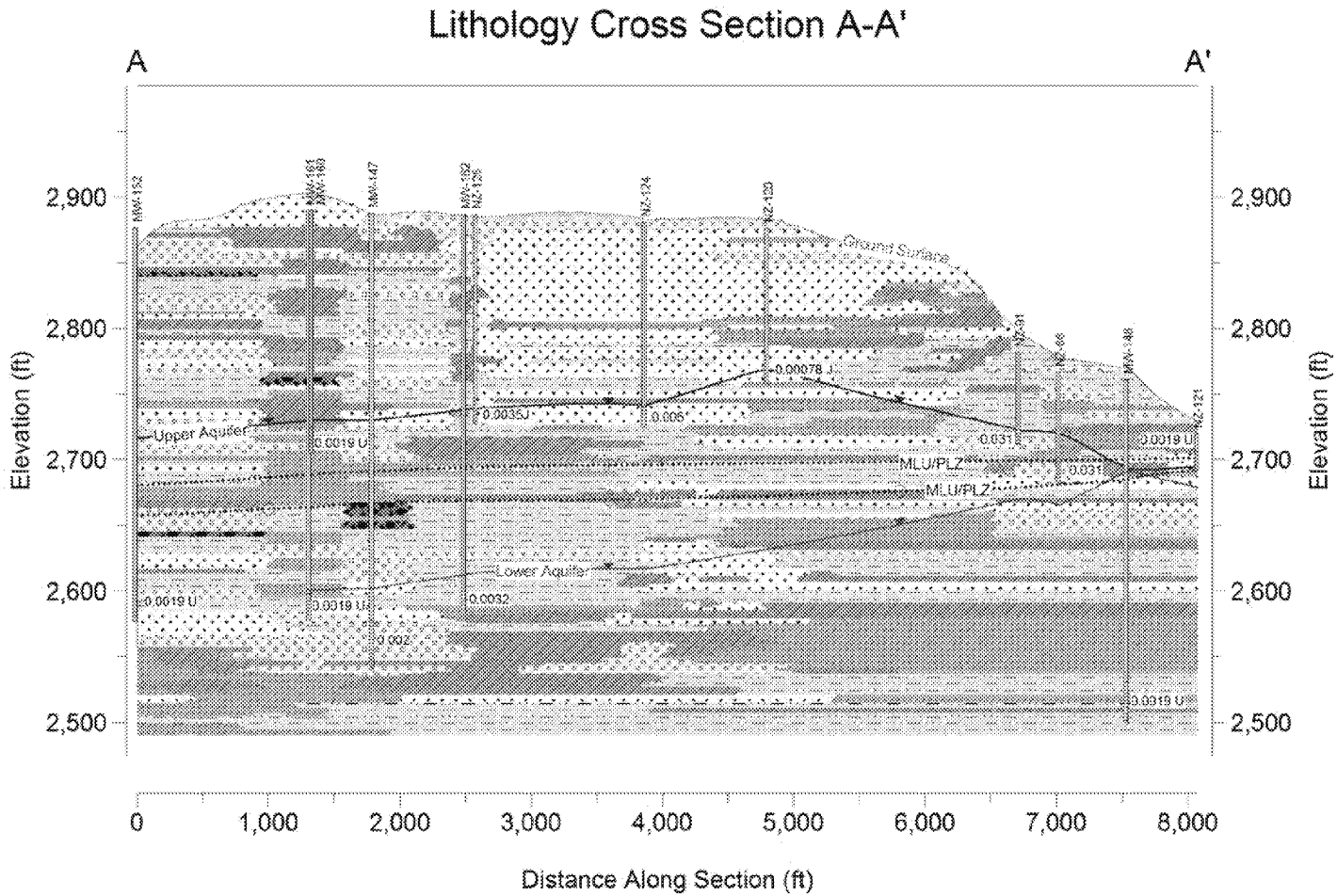
# Cross-Section A-A'

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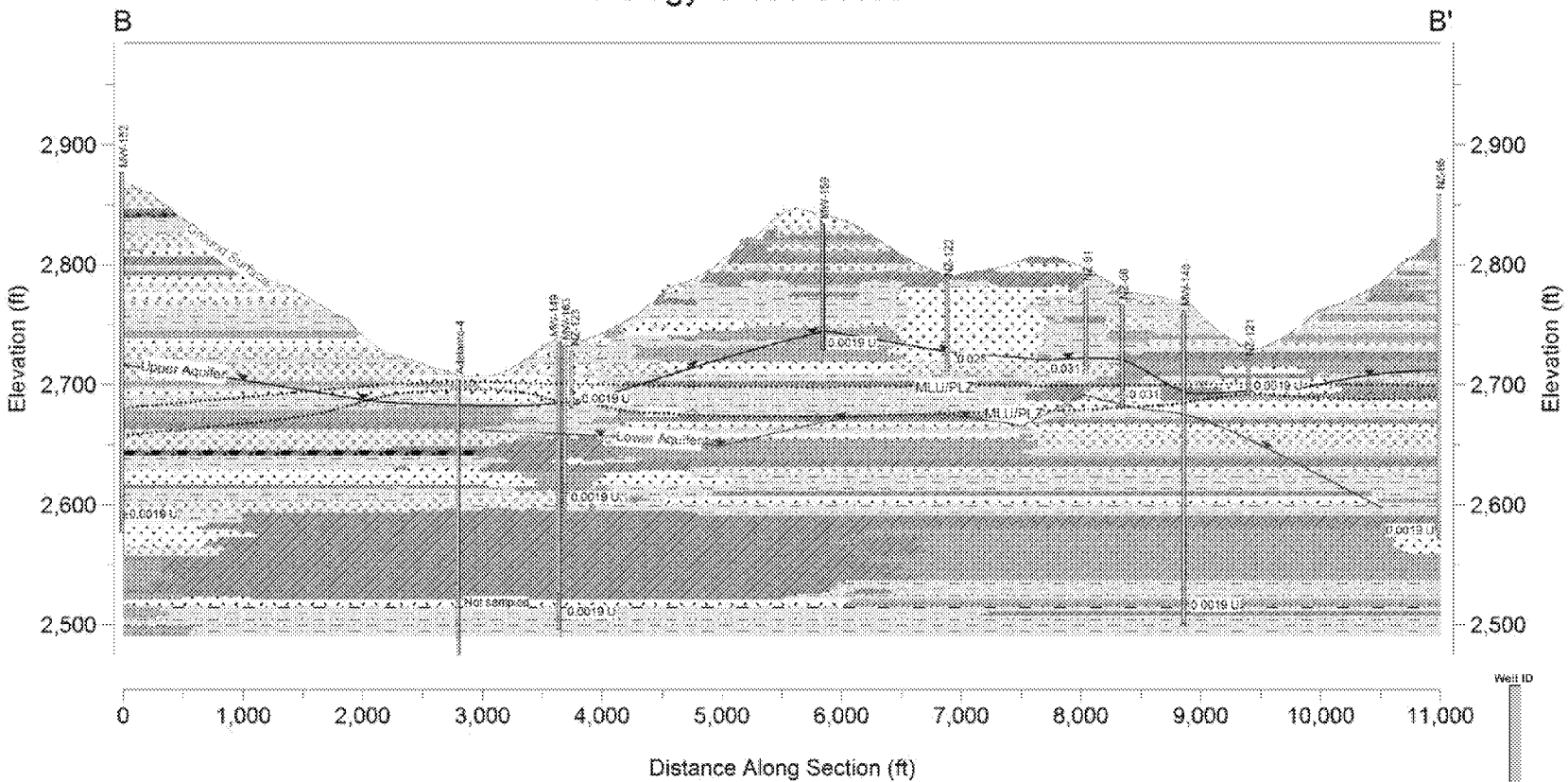
# Cross-Section B-B'




**Lithology**

- Clay and Clayey Sand
- Silt
- Silty Sand
- Poorly Graded Sand
- Well Graded Sand
- Gravel

Well ID
Casing
Screen-GW

Dieldrin Conc. (ug/L)
0.0019 U

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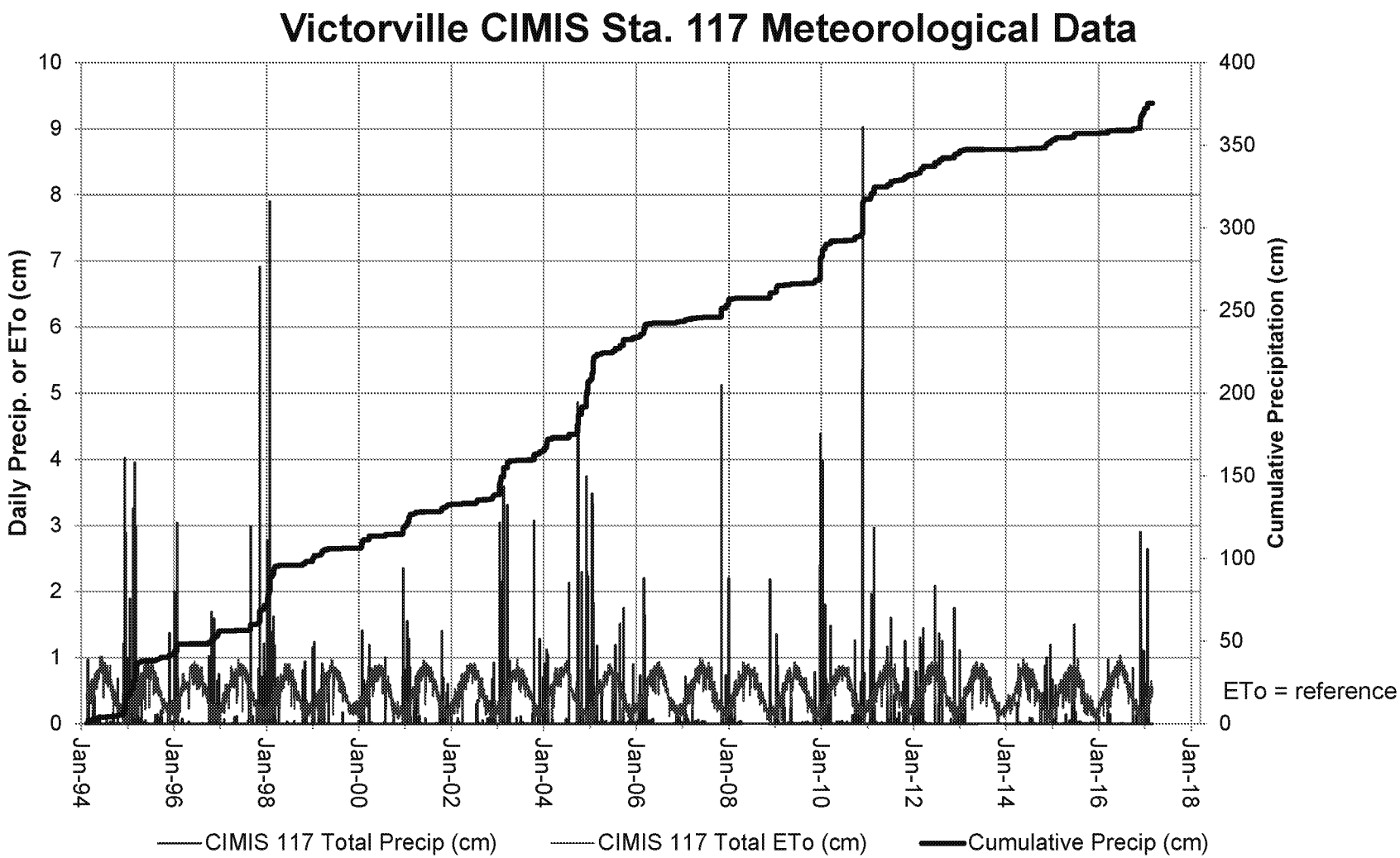
# Recharge

# Precipitation/Evapotranspiration Model Input)

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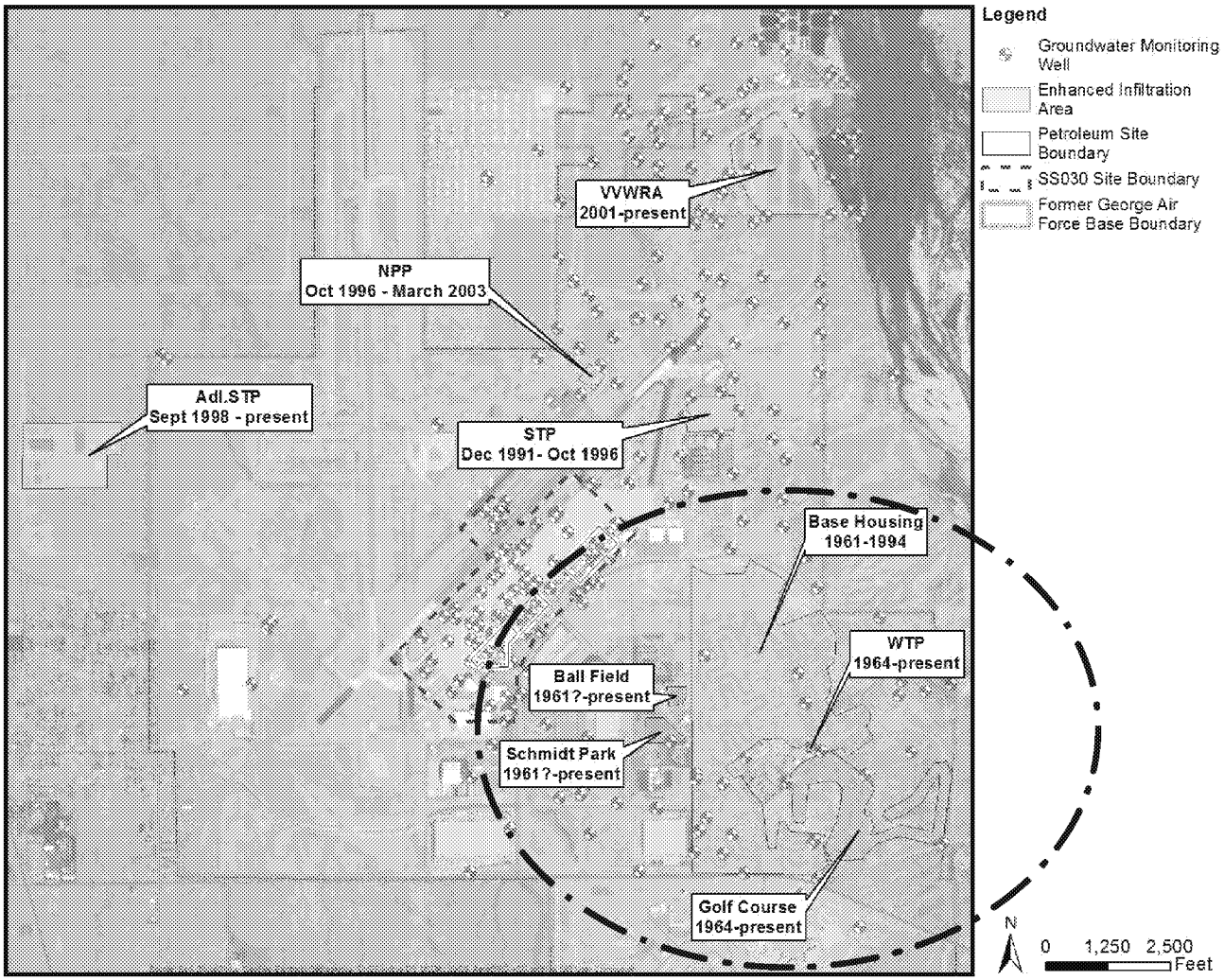
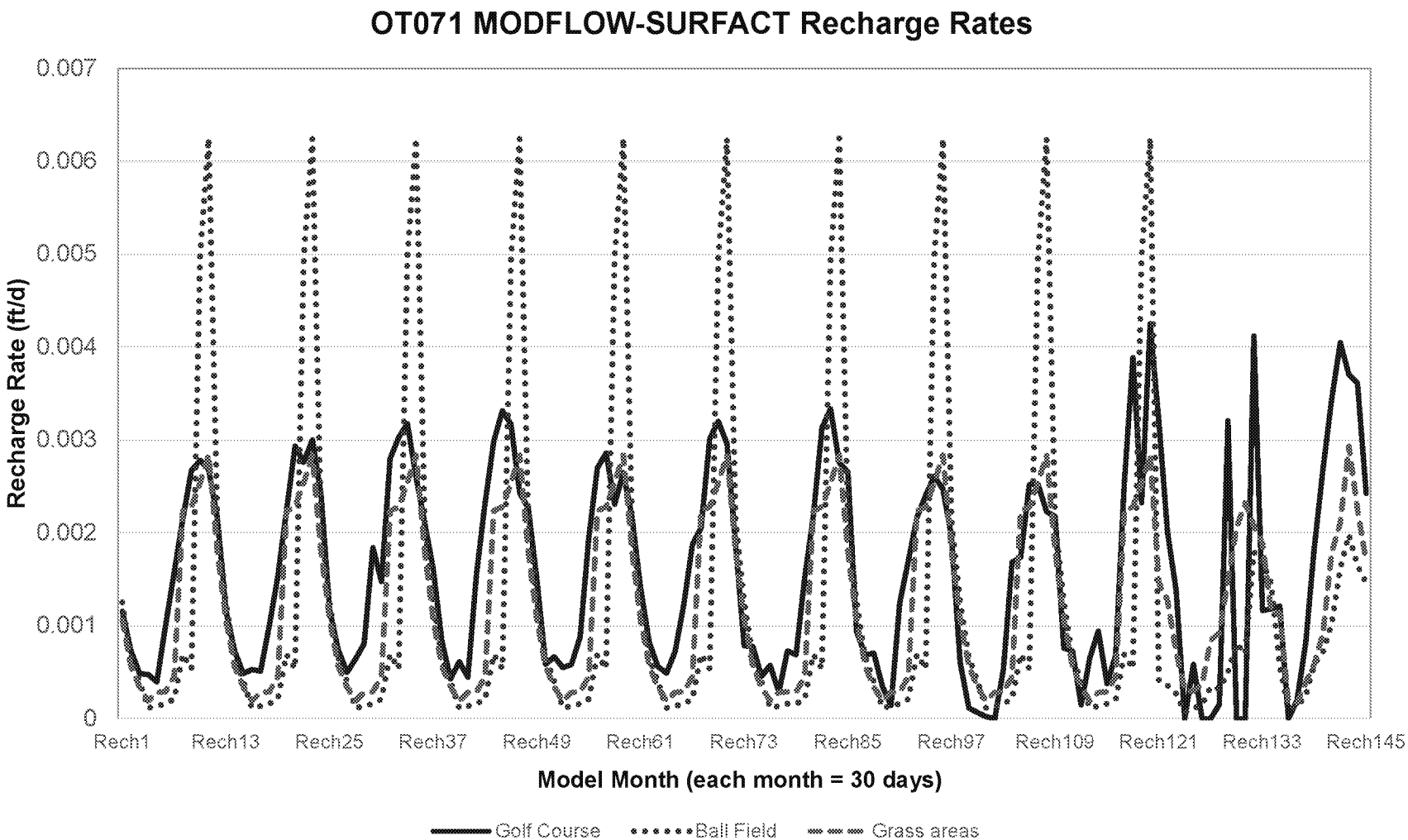
# Enhanced Infiltration Areas



# OT071 Recharge Rates from 2009 MODFLOW Model

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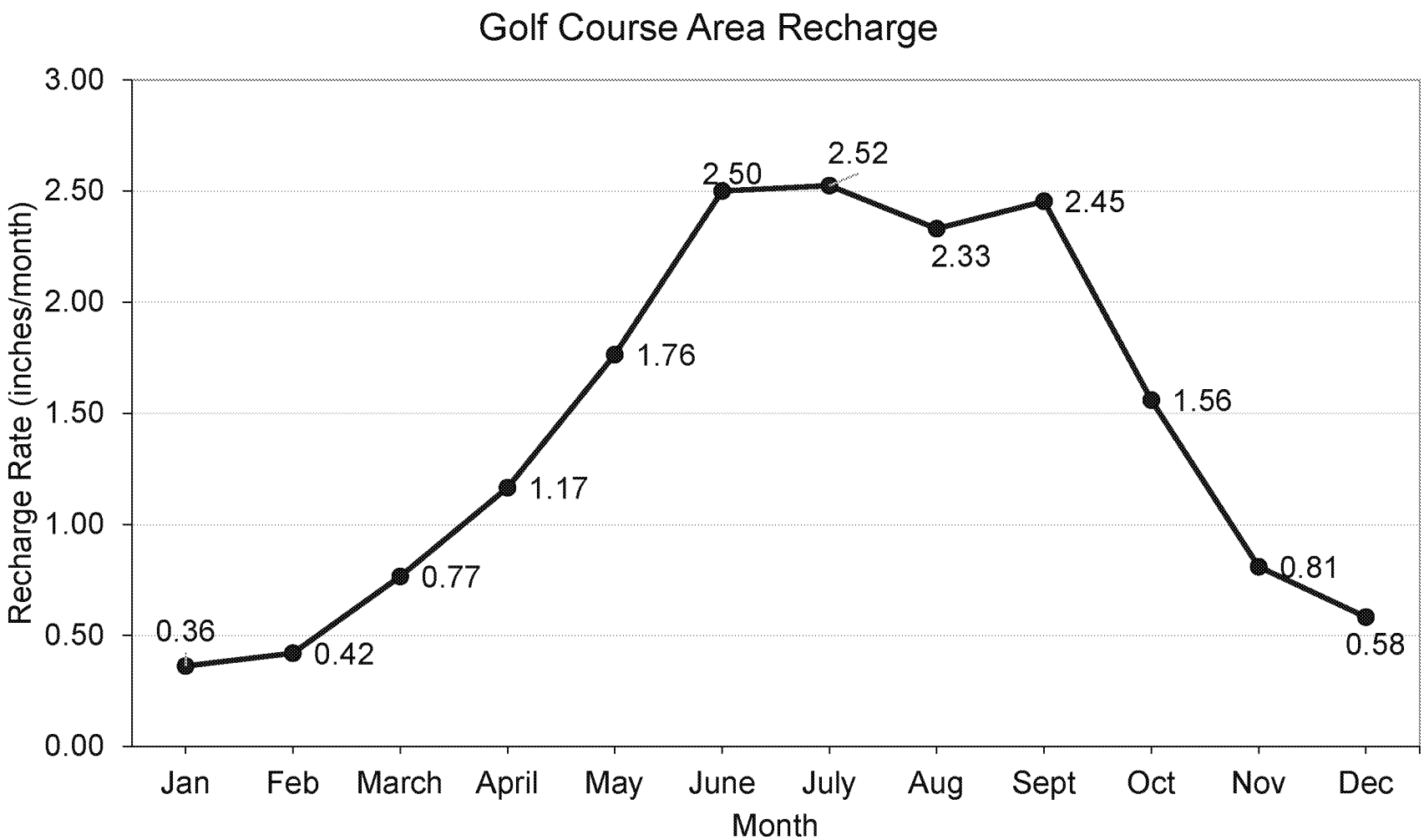
# OT071 Model Golf Course Area Average Recharge Rates

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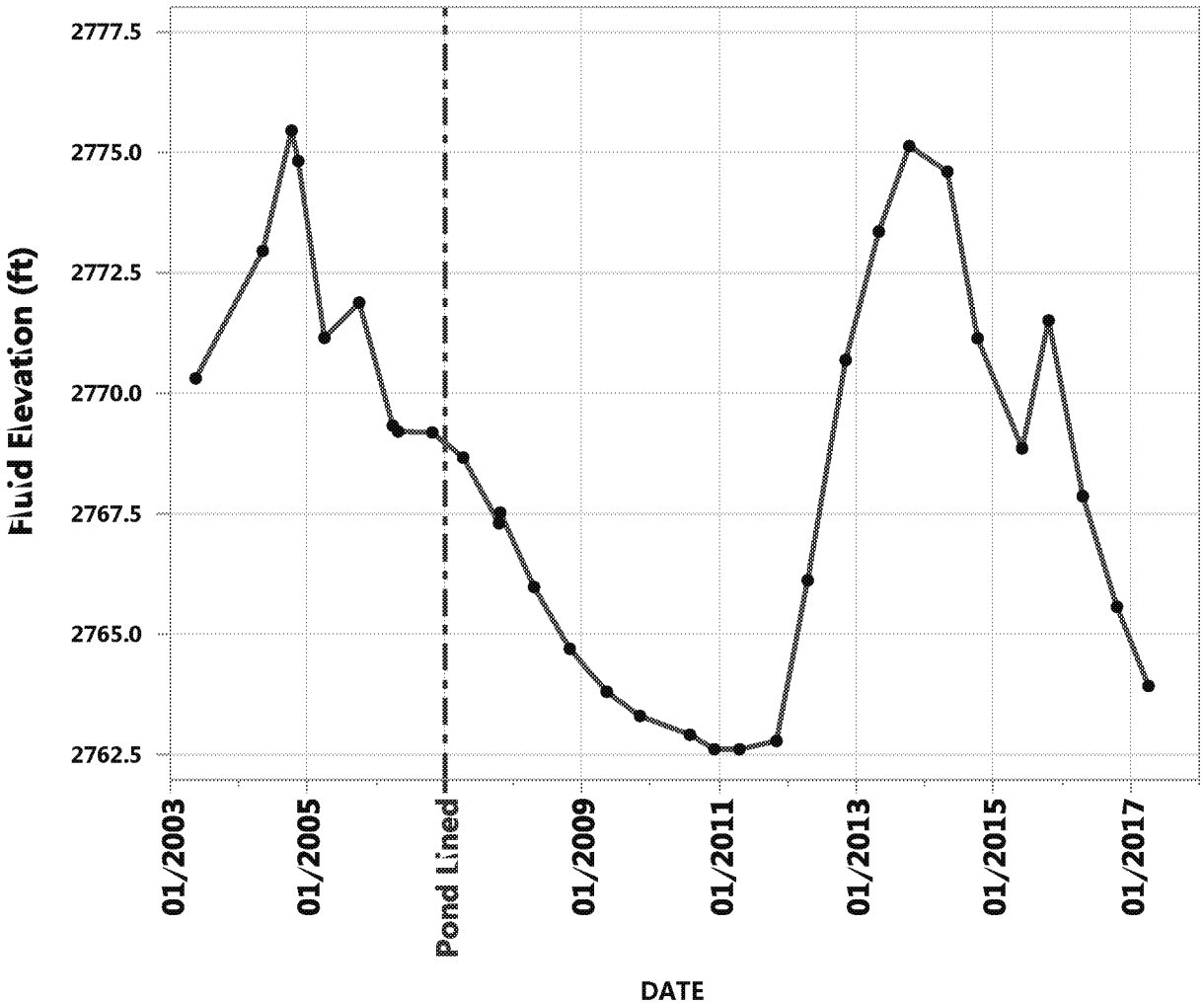
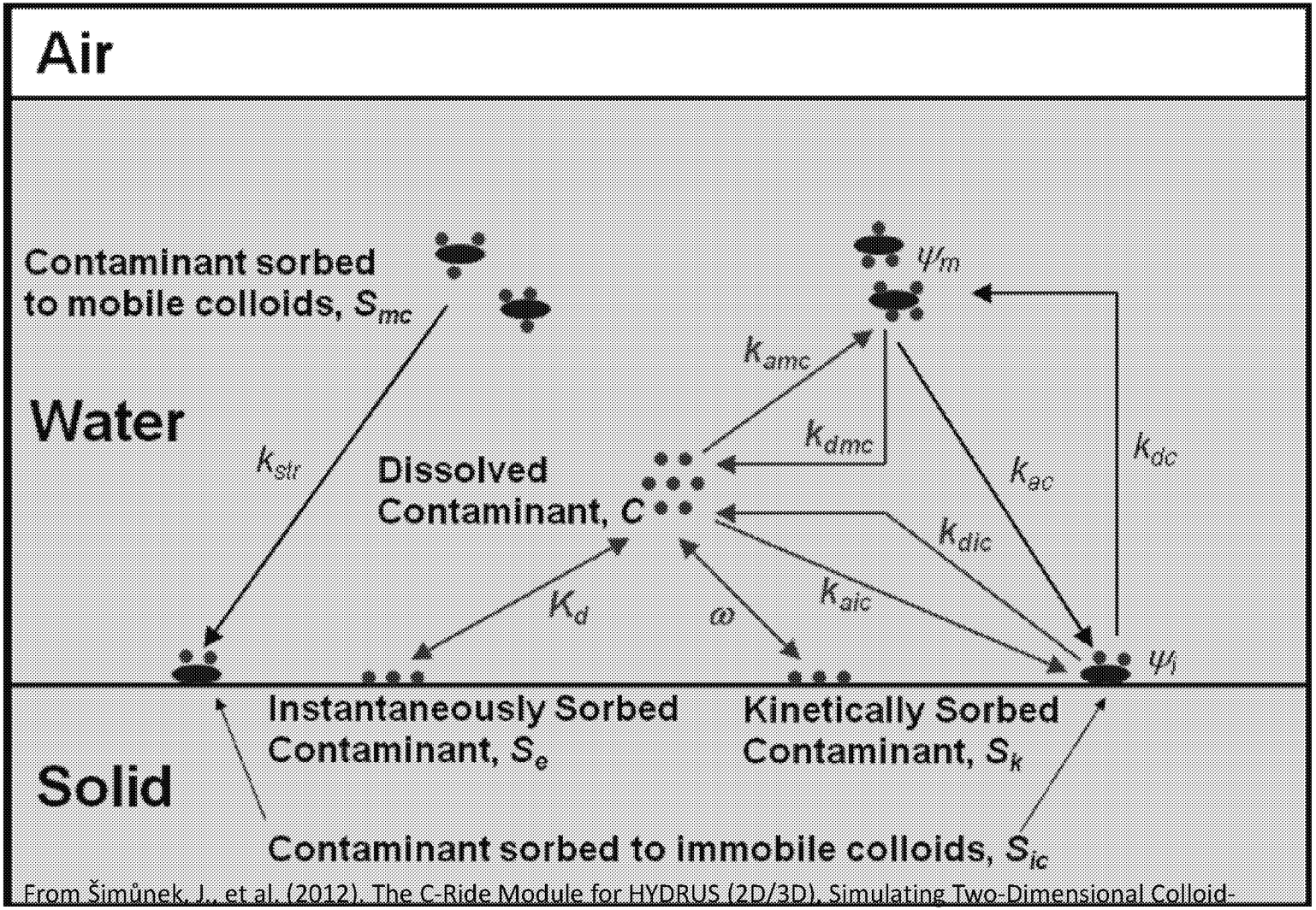
# Water Tower (Golf Course) Pond Infiltration: NZ-120 Hydrograph



# C-Ride Colloidal Transport Variables




From Šimůnek, J., et al. (2012). The C-Ride Module for HYDRUS (2D/3D), Simulating Two-Dimensional Colloid-Facilitated Solute Transport in Variably-Saturated Porous Media. Prague, Czech Republic, PC-Progress. 45 p., Figure 2.

# Colloidal Transport Variables

| Species description | Variable | Units |
|---|---|---|
| Colloid species | | |
| Mobile colloids | $C_c$ | $nL^{-3}$ |
| Colloids attached to the solid phase | $S_c^{att}$, $S_{c1}$ | $nM^{-1}$ |
| Strained colloids | $S_c^{str}$, $S_{c2}$ | $nM^{-1}$ |
| Solute (contaminant) species | | |
| Dissolved contaminant | C | $ML^{-3}$ |
| Contaminant instantaneously sorbed to the solid phase | $S_e$ | $MM^{-1}$ |
| Contaminant kinetically sorbed to the solid phase | $S_k$ | $MM^{-1}$ |
| Contaminant sorbed to mobile colloids | $S_{mc}$ | $Mn^{-1}$ |
| Contaminant sorbed to immobile colloids (attached) | $S_{ic1}$ | $Mn^{-1}$ |
| Contaminant sorbed to immobile colloids (strained) | $S_{ic2}$ | $Mn^{-1}$ |

L is the length unit, M is the mass unit, and n is the number of colloids

Initial values will be from literature values from column tests

# Reaction Parameters for First Component (Colloids)

| No. | Parameter | Symbol | Description | Example Value |
|---|---|---|---|---|
| 1 | Kd | $K_d$ | Should be equal to 0, not used with colloid transport [L3/M] | 0 |
| 2 | Nu | $\eta$ | Should be equal to 0 (used for Langmuir η [L3/M]). | 0 |
| 3 | Beta | $\beta$ | Should be equal to 1 (used for Freundlich exponent β). | 1 |
| 4 | Henry | $K_H$ | Should be equal to 0 (used for the Henry's law constant $K_H$, which is not used with colloid transport). | 0 |
| 5 | SinkL1 | $\mu_{cw}$ | Should be equal to 0 (used for colloid immobilization in the liquid phase $\mu_{cw}$). Parameter not be used when the colloid-facilitated solute transport is considered. | 0 |
| 6 | SinkS1 | $\mu_{cs}$ | Should be equal to 0 (used for colloid immobilization in the solid phase $\mu_{cs}$). | 0 |
| 7 | iPsi2 | – | Type of blocking on the second sorption sites (=0; no blocking; =1: Langmuirian dynamics; =3: random sequential adsorption model; =4: depth dependent blocking coefficient). | 0 |
| 8 | iPsi1 | – | The same for the first sorption sites. | 0 |
| 9 | SMax2 | $S_{max}$ | Parameter in the blocking function for the second sorption sites. | 0 |
| 10 | AttachS2 | $k_{ac}$ | First-order deposition (attachment) coefficient, $k_{ac}$ (or $k_{str}$) [T-1], for second sorption sites. | 0 |
| 11 | DetachS2 | $k_{dc}$ | First-order entrainment (detachment) coefficient, $k_{dc}$ [T-1], for second sorption sites. | 0 |
| 12 | SMax1 | $S_{max}$ | Parameter in the blocking (straining) function for first sorption sites. | 0.01 |
| 13 | AttachS1 | $k_{ac}$ | First-order deposition (attachment) coefficient, $k_{ac}$ (or $k_{str}$) [T-1], for first sorption sites. | 0.01/min |
| 14 | DetachS1 | $k_{dc}$ | First-order entrainment (detachment) coefficient, $k_{dc}$ [T-1], for first sorption sites. | 0.005/min |

# Reaction Parameters for Second Component (Dieldrin on Colloids)

| No . | Parameter | Symbol | Description | Example Value |
|---|---|---|---|---|
| 1 | Kd | $K_d$ | Should be equal to 0. This parameter is usually reserved for the sorption parameter Kd, which is not used with colloid transport [L3/M]. | 0 |
| 2 | Nu | $\eta$ | Should be equal to 0 (used for Langmuir η [L3/M]). | 0 |
| 3 | Beta | $\beta$ | Should be equal to 1 (used for Freundlich exponent β). | 1 |
| 4 | Henry | $K_H$ | Should be equal to 0 (used for the Henry's law constant KH, which is not used with colloid transport). | 0 |
| 5 | SinkL1 | $\mu_{cw}$ | Should be equal to 0 (used for colloid immobilization in the liquid phase μcw). This parameter should not be used when the colloid-facilitated solute transport is considered. | 0 |
| 6 | SinkS1 | $\mu_{cs}$ | Should be equal to 0 (commonly used for colloid immobilization in the solid phase μcs). | 0 |
| 7 | Not used | | | |
| 8 | Not used | | | |
| 9 | RefImCol | $\psi_i$ | Parameter adjusting the sorption rate to the number of immobile colloids present | 0 |
| 10 | AttImCol | $k_{aic}$ | Solute adsorption rate to immobile colloids [T-1] | 0.05/min |
| 11 | DetImCol | $k_{dic}$ | Solute desorption rate from immobile colloids [T-1] | 0.02/min |
| 12 | RefMobCol | $\psi_m$ | Parameter adjusting the sorption rate to the number of colloids present | 1 |
| 13 | AttMobCol | $k_{amc}$ | Solute adsorption rate to mobile colloids [T-1] | 0.05/min |
| 14 | DetMobCol | $k_{dmc}$ | Solute desorption rate from mobile colloids [T-1] | 0.02/min |

# Reaction Parameters for Third Component (Dieldrin in Water)

| No . | Parameter | Symbol | Description | Example Value |
|---|---|---|---|---|
| 1 | Kd | $K_d$ | Should be equal to 0. This parameter is usually reserved for the sorption parameter Kd, which is not used with colloid transport [L3/M] | 0 |
| 2 | Nu | $\eta$ | Should be equal to 0 (commonly used for Langmuir η [L3/M]) | 0 |
| 3 | Beta | $\beta$ | Should be equal to 1 (commonly used for Freundlich exponent β) | 1 |
| 4 | Henry | $K_H$ | Should be equal to 0 (commonly used for the Henry's law constant KH, which is not used with colloid transport). | 0 |
| 5 | SinkL1 | $\mu_w$ | Degradation rate for contaminant dissolved in the liquid phase [T-1] | |
| 6 | SinkS1 | $\mu_s$ | Degradation rate for contaminant sorbed to the solid phase [T-1] | |
| 7 | Not used | | | |
| 8 | Not used | | | |
| 9 | Not used | | | |
| 10 | Not used | | | |
| 11 | Not used | | | |
| 12 | Not used | | | |
| 13 | Not used | | | |
| 14 | Alpha | ω | First-order rate coefficient for one-site or two-site nonequilibrium adsorption [T-1] | 0/min |

# OT071 Calibration

- Flow calibration
  - Include natural and artificial recharge over time
  - Match observed water level fluctuations
  - Gradients in Upper and Lower Aquifers and changes over time
- Transport calibration
  - Simulate dieldrin migration from 1961 to 2016
  - Compare results to observed dieldrin concentrations over time
  - Because this is a 2D profile model and dieldrin concentrations are dispersed, observed results may come from wells across the plume

# Questions / Comments