APPENDIX N

SCREENING LEVEL GROUNDWATER MODELING

As discussed in Sections 7.1.and 7.2 of the accompanying RI Report, groundwater discharges into surface water were characterized using temporary wellpoint stations established in the nearshore Marine Area. A primary focus of this effort was the characterization of groundwater-to-surface water transport pathways. The wellpoints were installed along offshore transects oriented to coincide with existing shoreline monitoring wells. The RI data revealed that groundwater concentrations of sulfide (a bacterially derived wood breakdown product) at a single nearshore well location at the Former Scott Mill Site exceeded the benthic infauna protection screening level. However, sediment porewater (0 to 10 cm) sulfide concentrations in the adjacent beach area were undetected. The reduced porewater concentration was consistent with tidal mixing and associated oxidation of sediment porewater that occurs near the sediment/water interface.

Screening-level 2-D Visual MODFLOW groundwater modeling was performed for this RI to characterize advection and dispersion processes occurring at the shoreline, to further describe fate and transport pathways for groundwater discharges into Fidalgo Bay, focusing on the groundwater-to-porewater transects included in the RI sampling (i.e., MW-106 to WP-2; and MW-2 to WP-1.) A numerical transport analysis was performed to evaluate the influence of tidal fluctuations, molecular diffusion, and hydrodynamic dispersion on migration of a non-sorbing tracer. The sections below describe model development and calibration.

Model Development

For this analysis a 2-D Visual MODFLOW model grid was developed to reflect the contact between the shallow aquifer in fill materials (predominantly gravel, sand, and wood debris), and the underlying confining unit of native marine silts and clays. The inland boundary of the model was set 300 feet inland of the shoreline. Groundwater flow into the model grid from the west (upgradient) was represented by specifying a groundwater gradient of 0.006 ft/ft, based on the average hydraulic gradient measured at the Site for well pairs with a groundwater flow to Fidalgo Bay (versus to Cap Sante Waterway). The gradient calculated for different water level monitoring periods (August 2004, July 2005, and January 2006) were all consistent with a gradient of 0.006 ft/ft.

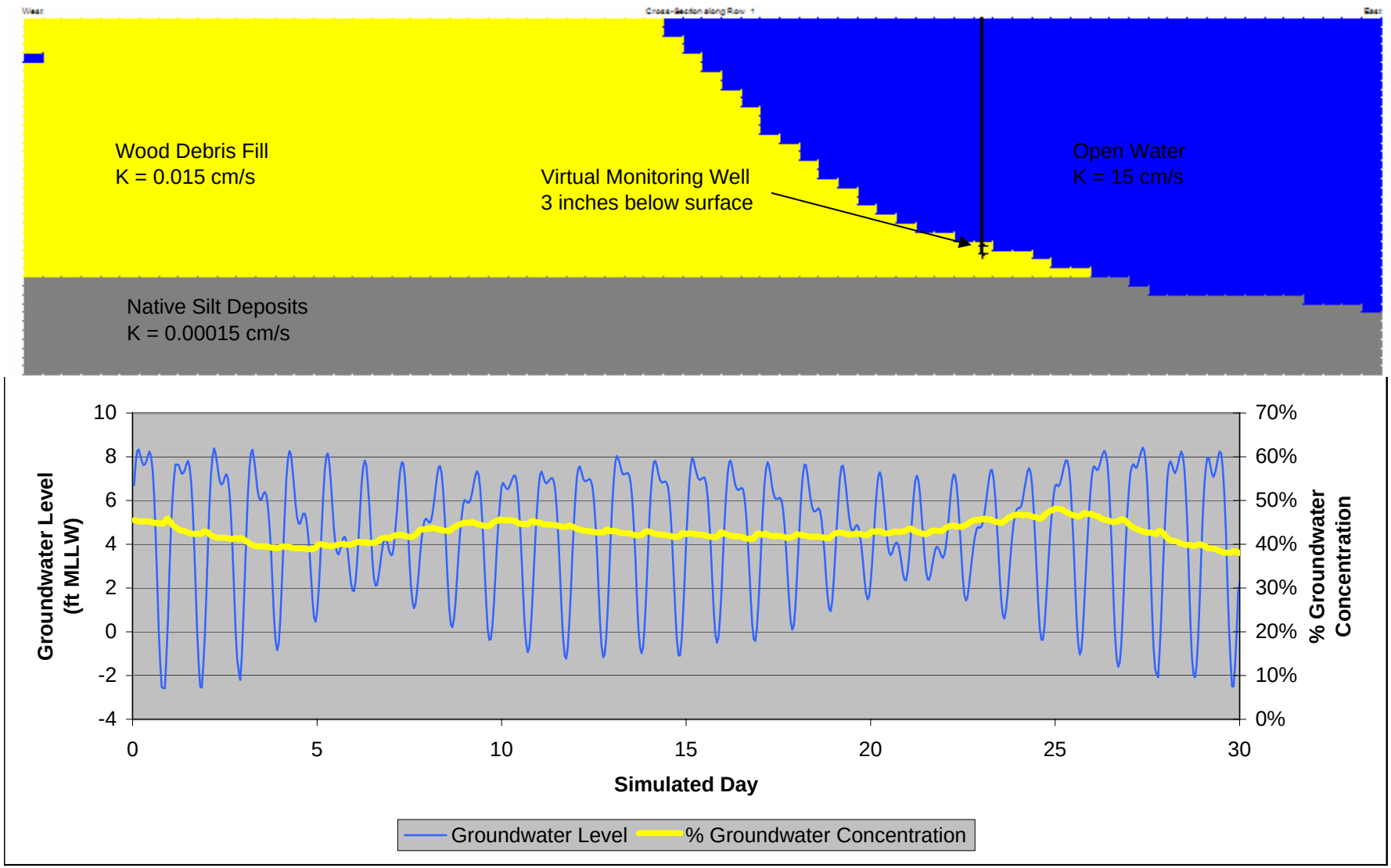
The average horizontal hydraulic conductivity of the fill unit was characterized based on tidal monitoring. Appendix F of the ThermoRetec (1999a) RI/FS summarizes tidal monitoring data for 4 wells (MW-5, MW-7, MW-8, and MW-9), with an average calculated horizontal hydraulic conductivity of 1.5×10^{-2} cm/sec. This average value was used in the model. The reported average horizontal hydraulic conductivity of the underlying confining unit of native marine silts and clays unit was 1.5×10^{-4} cm/sec.

The shoreface boundary of the model was a variable head boundary that simulated the tidal fluctuation in Fidalgo Bay. The input tidal data used in the model was obtained from the local NOAA tide gage, for the time period corresponding with the RI sampling events. The remaining model boundaries were no-flow boundaries, thus the model approximated a two dimensional model..

Within the model grid, the uppermost active layer was treated as an unconfined layer while lower layers were treated as confined/unconfined. This was accomplished through the "LAYCON" variable in MODFLOW. The storage parameter in the lower layers and in cells adjacent to Fidalgo Bay were automatically adjusted in the model to use a storage coefficient (Ss) when the cells were fully saturated or a specific yield value (Sy) when the water table dropped below the top of cells. The REWET option was specified to simulate model cells adjacent to Fidalgo Bay.

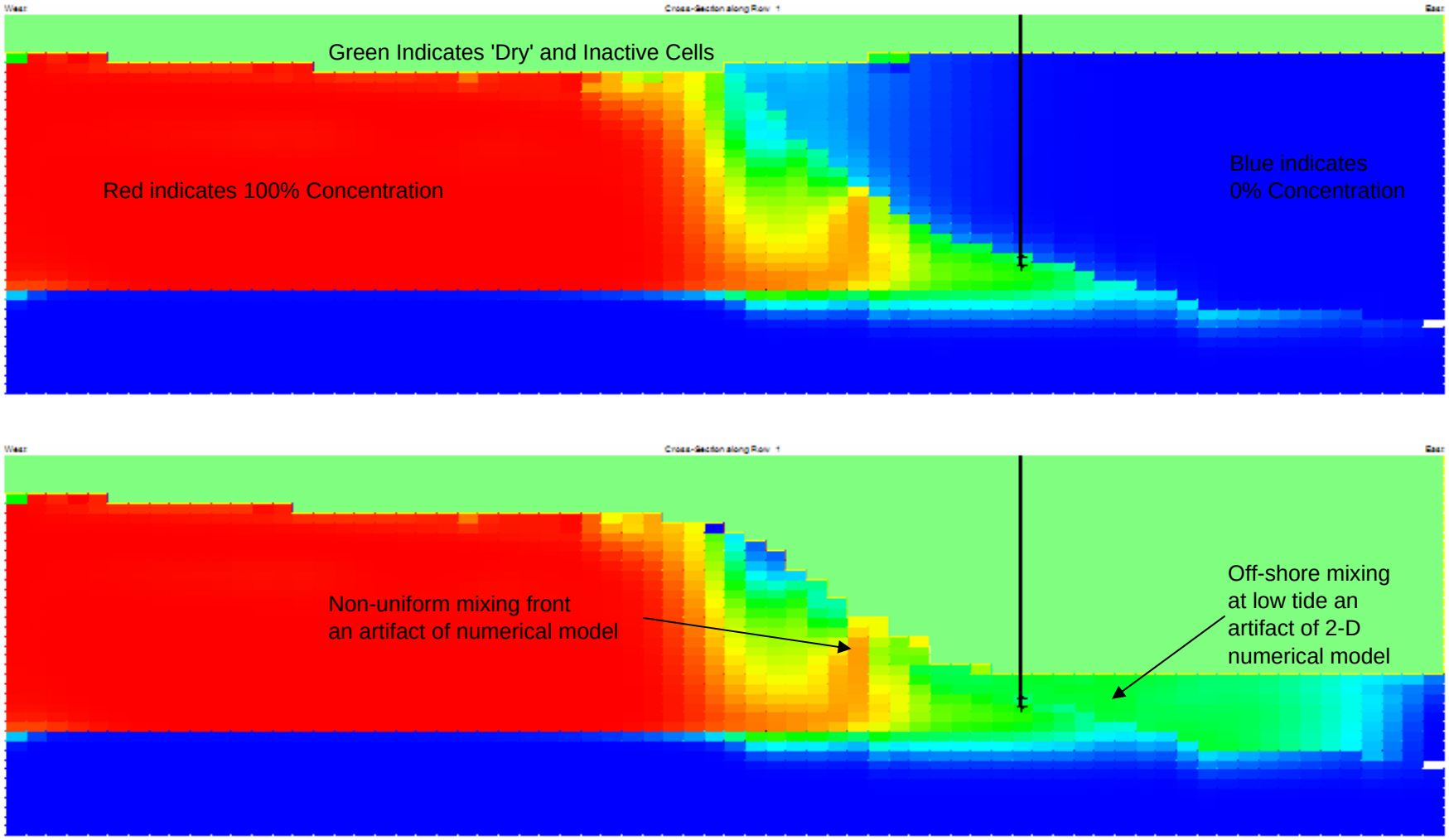
Model Results

Model results are presented graphically in Figures 1 and 2, and are discussed in the main body of the accompanying RI Report.



Model Setup and Simulated Groundwater Response
Former Scott Paper Site
Anacortes, Washington

Figure 1



High-tide and Low-tide Mixing Zones
Former Scott Paper Site
Anacortes, Washington

Figure 2