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From: Deni Chambers, C.E.M., C.E.G., C.Hg. **Date:** June 7, 2010
Pascual Benito, Ph.D.
Mary Stallard, C.E.G., C.Hg.
Farrukh Mohsen, Ph.D., P.E.

To: Shannon Harbour
Nevada Division of Environmental Protection (NDEP)

RE: Responses to NDEP May 25, 2010 Comments on
Hydrogeologic Modeling Work Plan, Tronox LLC, Henderson, Nevada, dated:
April 29, 2010

Tronox (TRX) has prepared this memorandum to respond to the above-referenced NDEP comments on the *Hydrogeologic Modeling Work Plan, Tronox LLC, Henderson, Nevada*, dated April 29, 2010. Tronox's responses are given below. A complete copy of the revised Work Plan incorporating these changes and comments is also included for your convenience, with changes shown in redline strikeout (RLSO).

1. *Section 1.1, p 1, given the very specific goal in the 2nd bullet of evaluating capture at the Interceptor Well Field, Athens Road Well Field, and the Seep Well Field, TRX should consider the development of only the proposed sub-models for each of these areas using heads from nearby wells for model input boundary conditions for simplification of the model process for time and efficiency purposes.*

   Response: As described in the Work Plan, the large extent of the model domain is necessary to avoid having the lateral boundaries of the active domain intersect active sources and sinks, in order to accurately reflect the hydraulic stresses which may impact the evaluation of groundwater capture zones and future plume evolution.

   Additionally, one of the aims of the modeling is to better understand the daylighting of perchlorate from the Upper Muddy Creek formation (UMCf) into the Quaternary alluvium (Qal). Given the regional extent of the perchlorate plumes, as well as the three-dimensional nature of the flow system, this aspect could not be adequately evaluated or characterized using only the smaller and isolated sub-domain models, as capture will need to be evaluated using the full set of streamlines that daylight from the UMCf.

   Another potential benefit of using the large regional model and focused sub-models is that in the event a transient model is warranted, the telescopic mesh refinement (TMR) will provide the transient boundary conditions for the smaller domains. This

avoids time-consuming and difficult manual unsteady boundary condition determinations for disjoint smaller models.

It should also be re-emphasized that Figure 2 of the Work Plan is intended to show the maximum possible model domain extent. In practice, TRX intends to tighten (i.e., narrow) the lateral extent of the model to the west and east of the site as much as possible based on an evaluation of more complete potentiometric and flow line maps and the locations of known active or proposed hydraulic stresses.

2. *Section 1.1, page 1, 3rd bullet, TRX should discuss how the perchlorate travel time will be calculated including specifying the start and end points given heterogeneities along potential flowpaths.*

   Response: Since perchlorate undergoes very little or no retardation (Sellers et al. 2006) its travel times from the Upper Muddy Creek formation (UMCf) into the Quaternary alluvium (Qal) will be calculated based on the time for advective transport along a streamline from the location of the center of mass of the perchlorate in the UMCf to the surface defining the UMCf/Qal contact. If needed additional margins will be added around the center of mass.

   Section 6.1 of the Work Plan was expanded to include this discussion.

   Note: the following reference has been added to the Reference section of the Work Plan:

   Seller, K., W. Aslop, S. Clough, M. Hoyt, B. Pugh, J. Robb and K Weeks 2006, Perchlorate: Environmental Problems and Solutions, Taylor & Francis

3. *Section 2.1, page 3, 2nd paragraph, please specify whether the term "line recharge" means "mountain block recharge".*

   Response: Agreed. The use of the term "line recharge" is intended to refer to the term "mountain block recharge". The text has been changed to use "mountain block recharge" instead.

4. *Section 2.1.2, page 4, given the conceptual model presented, TRX should consider and discuss the possibility that fluid recharges the UMCf from the surface and/or the Qal in upgradient areas (south), and from below (UMCf) in downgradient areas (north).*

   Response: Agreed. It is possible that there is recharge to the UMCf from surface infiltration or from the Qal in upgradient areas or in areas with active recharge

activities. TRX will consider this during model development. Section 2.1.2 has been revised to include this.

5. *Section 2.2, page 5, TRX should discuss whether time dependent capture zones will be calculated and if so, how will other chemicals be evaluated as a part of this capture zone analysis.*

   Response: TRX is not planning on calculating time-dependent capture zones. Rather, steady state capture zones will be developed for periods of time during which hydraulic stresses can be considered generally constant.

   The USEPA's guidance on capture zone evaluation (USEPA, 2008) states that "if a variety of contaminants of concern are present, the Target Capture Zone should consider each contaminant." Accordingly, TRX will consider the plume locations and plume extents for other chemicals when defining the Target Capture Zone for each containment and extraction system.

   In the future, if a transient contaminant transport model is developed, then chemical specific retardation factors will be used when evaluating transport of other chemicals.

   Section 6.1 of the Work Plan was expanded to include this discussion.

6. *Section 4.0, page 8, 1st paragraph, please provide the full reference for Holzbecher, 1998.*

   Response: The following reference has been added to the reference section of the work plan:

   Holzbecher, E.O., 1998. Modeling density-driven flow in porous media: principles, numerics, software, Spring-Verlag, Heidelberg, 253p, 1998.

7. *Section 5.2.1, page 10, TRX should specify what type(s) of boundary conditions will be used for the sub-models (e.g. specified head, specified flow, head-dependent) and criteria used to make the selection.*

   Response: For steady state models, the telescopic mesh refinement (TMR) of the Groundwater Vista software allows both specified head, specified flux or head dependent boundary conditions. At this stage Tronox plans to use specified head boundary conditions unless conditions are faced in actual development that warrant other forms of boundary conditions. TMR method supports only the use of specified head boundary conditions when used with transient models.

8. *Section 5.2.2, page 10 NDEP has noted that given a combined thickness as small as 10 ft for three layers, the proposed model may be numerically unstable if simulated using unconfined (convertible) conditions. Please revise as necessary.*

   Response: TRX is cognizant of the potential instability. Rather than using arbitrary starting head values, TRX will input starting heads based on an interpolation of a set of actual measurements. If instability persists, attempts will be made to temporarily convert the layers from unconfined to confined and use the resulting potentiometric heads as initial heads for an unconfined run. Section 5.2.2 has been revised to include this.

9. *Section 5.2.3, page 11, TRX should note that if density issues are deemed important (i.e. SEAWAT), then a transient flow model will be required even if sources and sinks are constant. Please revise as necessary.*

   Response: The text has been expanded to clarify that should variable density modeling with SEAWAT be necessary to reflect the possible impacts of the high TDS plumes, then a transient flow model will be required, even if modeling a period during sources and sinks are constant. In this case, suitable time step discretization will be chosen for numerical stability and accuracy.

10. *Section 5.3, page 11, 2nd paragraph, as the conceptualization and numerical implementation of the spatial variability of hydraulic conductivity is important for this modeling exercise, TRX should provide the following information:*

    a. *Clarify whether a single or variable hydraulic conductivity value(s) will be assigned for a given hydro-lithologic zone.*

    b. *Discuss how the aquifer testing data will be incorporated into the simulated hydraulic conductivity field.*

    c. *Discuss how the hydro-lithologic zones will be mapped to the model grid (e.g. subjective mapping, indicator interpolation schemes, or stochastic approaches).*

    Response: A single hydraulic conductivity value will represent a hydro-lithologic zone. Examples of a hydro-lithologic zone would include buried coarser grained paleo-channels. If core and pump-test estimates of hydraulic properties or other geologic data are sufficient to define sub-regions within the hydro-lithologic zones with different properties, then these zones will be sub-divided, with different properties assigned to each sub-division. The hydro-lithologic zones will first be

defined as polygons on the model base map, and then the zonal properties will be mapped to grid cells. Section 5.3 was revised to include this explanation.

11. *Section 5.4.1, page 12, it is NDEP's understanding that the BRC recharge estimates are "net" values, which already take into account any evaporation/evapotranspiration so including ET in MODFLOW would be double counting. Likewise, TRX should note that the MODFLOW Lake package would be more appropriate if MODFLOW will be used to calculate the water balance in the pond areas, but net infiltration estimates have already been calculated.*

    Response: TRX agrees that applying both the final "net" infiltration values from BRC's model while still applying the ET package would be double counting. TRX's intent however, is to use BRC's calibrated input values to the Modflow Recharge package, which do not include the effects of ET, rather than the "net" infiltration values. This same approach is also planned to be used for the ponds area, consistent with the approach used in the BRC model whereby infiltration from the ponds was simulated using the Recharge package.

12. *Section 5.4.2, page 12, TRX should consider that using the well package would be more appropriate if flux estimates from the lower boundary will be calculated. Please revise as necessary.*

    Response: The model investigation by BRC (DBS&A, 2008b) indicates that the hydraulic gradient between the deep and shallow zone of the UMCf is generally upward in the southern and central portions of their model domain and generally downward in the regions north of the spray wheel and south-southeast of the northern rapid infiltration basins (RIBs). BRC used a GHB package to capture this behavior and TRX feels that this would be better suited to their model. Using the MODFLOW Well package to specify vertical fluxes will not allow for automatic adjustment of the vertical gradient when modeling time periods during which hydraulic stresses such as increased pumping or infiltration may produce localized regions of downward gradients (reversals in gradients). The Well package, however, may be appropriate for simulation of periods when the vertical fluxes are well understood and the model is not being used to determine the nature of the localized vertical gradients. Section 5.4.2 was expanded to include a discussion of this point.

13. *Section 5.4.3.2, page 13, TRX should use the well package for mountain block recharge rather than GHB if recharge estimates are known. Please revise as necessary.*

Response: The Work Plan has been revised to explain that if mountain block recharge estimates are known, then the Well package will be used to simulate mountain block recharge, rather the General Head Boundary (GHB) package. Alternatively, if adequate upgradient hydraulic head data are available, then MODFLOW's GHB package could be used to represent the flux across the southern boundary. Section 5.4.3.2 was revised to include this discussion.

14. *Section 5.7.1, page 14, TRX should include discussion on what calibration procedure will be performed and what types of calibration metrics will be employed (e.g. RMSE, one-to-one plots).*

    Response: Calibration metrics will include the average error, average absolute error, root mean square error (RMSE), as well as one-to-one plots of predicted versus observed hydraulic heads. Section 5.7 was revised to include this.

15. *Section 5.8, page 14, TRX should conduct a sensitivity analysis both predicted hydraulic heads and particle tracking analysis. Please revise as necessary.*

    Response: The text has been expanded to clarify that the sensitivity analysis will examine the effects of varying parameters on both the hydraulic head distribution and on the particle tracking analysis (i.e., via changes to streamlines resulting from parameter variation). Section 5.8 was revised to include this.

16. *Section 6.1, page 15, NDEP has the following comments:*

    a. *TRX should include discussion on how PMPATH was selected.*

       Response: The text should have read "MODPATH" rather than "PMPATH", and has been corrected.

    b. *TRX should clarify whether (and if so, how) heterogeneity will be included in the model and if heterogeneity is not included in the model, then please clarify how dispersion will be managed.*

       Response: Heterogeneity will be included in the flow model through the definition of "hydro-lihtologic zones" with distinct hydraulic flow properties. Examples of this include buried coarser grained paleo-channels. If core and pump-test estimates of hydraulic properties are sufficient to define sub-regions within the hydro-lihtologic zones with different properties, then these zones will be sub-divided. Dispersion will be addressed indirectly during the Target Capture

Zone definitions by evaluation of width of the lateral plume dispersion away from the plume center of mass as estimated from existing plume contour maps.

17. *Appendix A, step 2, TRX should consider that if target capture will be based on a percentage of perchlorate mass flux, then the simulated capture zones may calculate the same. Since mass flux is a calculation that depends on fluid flux and perchlorate concentration, a transport model would have to be used. Please revise as necessary.*

Response: (See also response to Comment 16b). TRX is not proposing a transport model at this time; instead, the particle tracking analysis will be used in conjunction with estimates of chemical specific lateral plume dispersion widths to define Target Capture Zones which will provide a basis for estimates of percentage of mass flux. Step 2 of Appendix A was revised to include this discussion.