EXHIBIT "C"

TECHNICAL MEMORANDUM

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TO:	Mr. Robert Miller, Wallace Group	DATE:	May 3, 2010
FROM:	Peter M. Pyle, P.G., CHG.	JOB NO:	2323

RE: Peer Review of the Los Osos Groundwater Model

Stetson Engineers Inc. was contracted by Brownstein Hyatt Farber Schreck, LLP, on behalf of the ISJ Parties to review and evaluate the groundwater model and related technical studies to determine the validity of the model and assumptions. We were also tasked with providing an opinion on the safe yield estimates determined using the model for the urban area and Los Osos Creek Valley portions of the groundwater basin with consideration of climate fluctuations. The contact for the ISJ Parties is Robert Miller of Wallace Group in San Luis Obispo who is managing the contract. Much assistance and additional data was provided by Mr. Spencer Harris of Cleath-Harris Geologists, Inc. (CHG).

Stetson Engineers, Inc. performed the following tasks for this peer review:

1) Reviewed key documents specified in the request for proposals (RFP) as well as additional information listed below.
2) Attended a kickoff meeting with the ISJ Technical Group in December 2009.
3) Conducted a one-day model work session with Spencer Harris of Cleath-Harris Geologists, Inc. of San Luis Obispo.
4) Reviewed the model electronic data and output.

Stetson Engineers, Inc. reviewed the following key reports for this study:

1) Seawater Intrusion Assessment and Lower Aquifer Source Investigation of the Los Osos Valley Groundwater Basin, Cleath and Associates, October 2005.
2) Flow Model Conversion and Urban Area Yield Update, Cleath-Harris Geologists, Technical Memorandum, July 2009a.
3) Los Osos Creek Valley Yield Evaluation, Cleath-Harris Geologists, Technical Memorandum, July 2009b.
4) Appendix D of the Draft Environmental Impact Report, Los Osos Waste Water Project, County of San Luis Obispo, November 2008.

In addition to those studies, the following reports and data were reviewed:

1) Simulated effects of a Proposed Sewer Project on Nitrate Concentrations in the Los Osos Valley Groundwater Basin, prepared for LOCSD and Cleath and Associates, Yates and Williams, November 2003.
2) Hydrogeology and Water Resources of the Los Osos Valley Groundwater Basin, USGS WRIR 88-4081, Yates and Wiese, 1988.
3) Conducted phone discussions with Spencer Harris of CHG on model input and output and basis for key model assumptions.
4) Sent via email requests for selected data and model sensitivity analyses, and reviewed and evaluated these additional data.
5) Los Osos Wastewater Management Plan Update, Technical Memorandum #3, Ripley Pacific Team, July 2006.
6) Comments regarding the Ripley Pacific Team's Technical Memorandum #3, Los Osos Wastewater Management Plan Update, Cleath and Associates, October 2006.
7) A Practical Guide to Groundwater and Solute Transport Modeling, Spitz and Moreno, 1996.
8) Applied Contaminant Transport Modeling, Zeng and Bennett, 1995.
9) A critical review of data on field-scale dispersion in aquifers, Gelhar and others, 1992.

Summary of Findings

While there is uncertainty in all models, the SEAWAT model developed by Cleath-Harris Geologists and recent model results (CHG, 2009a, b) appear reasonable. However, we have several recommendations; 1) The need for additional model documentation including definition of model limitations and uncertainty in the results and technical basis for input data, 2) Model refinement and additional scenarios including evaluation of climatic variability other than sea level rise and development of a monthly transient flow model using the model structure from the existing model with the addition of the STR package of Modflow. The recommendations are discussed in more detail in the various subsections and under Recommendations, below.

The scenario described in CHG (2009b) regarding redistribution of pumping in the basin with an increase in pumping the Los Osos Creek subbasin is reasonable and could be initiated without further modeling or analysis, provided the change is gradual, with continued water level and water quality monitoring and analysis. The model could be updated as the effects of that plan/strategy become more fully understood. The recommended approach is phased redistribution of pumping with contingency plans in place to make adjustments as needed and as ongoing monitoring data indicate.

Model Data and Assumptions

This section of the peer review focuses on important model structure and input data that can significantly affect model results.

Model Structure

Cleath and Associates (2005) report contains the information used as a basis for the current SEAWAT model of the Los Osos groundwater basin including the hydrogeology and structure of the basin, aquifer hydraulic parameters, sources of recharge, water quality (including isotope analysis) and the extent of seawater intrusion. Those data provide a strong foundation on which to build the groundwater flow and seawater intrusion model. The current (CHG, 2009a,b) SEAWAT model consists of four layers representing the three primary water bearing units in the basin and a thick aquitard that extends throughout much of the basin.

Based on the data and reports reviewed, the structure of the model is sound and can effectively simulate hydrologic processes in the groundwater basin, particularly as regards the different characteristics and extent of seawater intrusion in each of the main water bearing units (Zones C, D and E). The Los Osos creek subarea on the eastern side of the Los Osos basin has a slightly different structure which the current model (CHG, 2009 a,b) also suitably represents. The model grid is uniform at 250 x 250 feet which is reasonable for the Los Osos basin given its scale, density of data, and resolution required of model results.

Hydraulic Parameters

A key hydraulic parameter that controls groundwater and seawater flow in the model is horizontal hydraulic conductivity (Kh). Its distribution by layer were requested from CHG and reviewed. The distribution is shown for each model layer in the attached Figures 1 through 4. This distribution was discussed with Mr. Harris and compared to that of pumping test results presented in Cleath and Associates (2005), and supplemental data provided by Mr. Harris.

The K distribution by layer seems appropriate and honors the field test data, which need not be precisely replicated in the model due to field data limitations and scale. I had questions regarding the K distribution representing the Los Osos Creek alluvium which appeared different from that of typical stream alluvium. However, discussions with Mr. Harris confirmed that the K values used in that area honor the unique geology of this region.

This type of information (maps and discussion of aquifer hydraulic properties) should be included in a future report on the SEAWAT model used in the CHG (2009a,b) studies.

Recharge Preprocessor

The 2009 SEAWAT model does not include the upper two geologic units which occur in the western two thirds of the basin including the perched aquifer (Zone A) and the transitional aquifer (Zone B). The upper zones are not generally used for production and are effectively isolated hydraulically from the underlying aquifers (Zones C, D and E) by an extensive clay layer. An unsaturated zone exists between the clay layer and the underlying aquifers although there is some leakage that occurs through it. SEAWAT cannot simulate unsaturated flow while the more recently developed GSFLOW code developed by the USGS has that capability. This limitation of SEAWAT requires that recharge to the saturated flow portion of the model from precipitation, minor tributaries, return flow from irrigation and septic tank seepage be determined by other methods.

For the Los Osos basin this method has been a spreadsheet preprocessor developed by Yates and Williams (2003). That report briefly describes this recharge and nitrogen loading preprocessor program which calculates deep percolation. This model preprocessor was not evaluated in detail for this review. There are many parameters and sources of data which are used in that preprocessor, some of which were changed to develop input for the CHG 2009 SEAWAT model. An Excel worksheet containing the model and input data was provided by Mr. Harris for this review, but the input data could not be evaluated in detail in the time available.

It is suggested that the preprocessor documentation be updated such that the input data sources and methods of calculating deep percolation and evapotranspiration is transparent. Changes to the model for use in successive models should be sufficiently described, accessible and readily available for review. Flow diagrams showing how the spreadsheet preprocessor works and its most sensitive variables should be included. We do not have a suggestion at this time as to whether the preprocessor could be improved or replaced by a more conventional unsaturated flow model due to our limited knowledge of it. However, model code refinements may be available in the near future that will allow simulation of unsaturated flow and seawater intrusion using the same basic data sets as currently used in the current Los Osos model. It is suggested that the model be updated to include unsaturated flow when possible.

Representation of Los Osos Creek

The recharge pre-processor does not include calculation of the recharge from Los Osos Creek to the aquifer in the Los Osos Creek subarea. This is an important component of the model because it allows an increase in recharge as water levels decline in that area due to proposed increased pumping (CHG, 2009b). Recharge is controlled by the model using the RIV module which allows river/creek seepage based on the water level in the creek, the head in the aquifer beneath the creek, and a coefficient based on the width of the creek, creek bed thickness and vertical permeability. While use of the RIV module can produce usable results for this type of creek, the

STR module could have provided a better calibration. The STR module allows the stream flow to reduce or cease during dry periods or seasons, thus providing a limit to how much seepage/recharge can occur from the creek to the aquifer. A recent version of SEAWAT (late 2009 available in GW Vistas updates) is available and should be used in updated versions of the Los Osos model.

In order to evaluate whether the RIV module was properly used to represent Los Osos Creek seepage, two analyses were performed. For the first, Creek flow data and a precipitation graph with a cumulative departure curve was requested from CHG. The Creek flow data is shown in Figure 5. It shows that data is missing for 1983, a wet year, and 1985-93 most of which were dry years. The wet or dry year condition was determined using long term precipitation data with a cumulative departure curve requested from CHG (Figure 6). A comparison of Figures 5 and 6 indicate the creek flow data is skewed to wet years.

The average creek flow for all of the years shown is 3,940 afy with a median of 2,230 afy. If a balance period is selected (Figure 6) which is limited to 1979-81 creek flow data (Figure 5), the average is 2,326 afy with a median of 1,630 afy. This suggests that no more than about 1,600 afy should be allowed by the model to seep from the stream to the underlying aquifer. The results of the increased pumping in the Los Osos creek subarea by CHG (2009b) is well within this limit at 1,013 afy. In addition, the gage from which the flow data in Figure 5 was obtained is located somewhat downstream from the basin and model boundary such that some seepage to the aquifer can occur in the groundwater basin upstream of the gage. The STR package will allow more accurate representation of stream leakage in future revisions of the model.

The second analysis requested of CHG was a sensitivity analysis of the conductance coefficient used in the model RIV module representing Los Osos Creek. CHG went farther than that and performed a sensitivity analysis on all other RIV variables including head in the River. The results of that sensitivity analysis indicate that for a change in creek bed permeability of 100% the change in seepage is less than 1%. For a change in stream bed permeability of 100% and stream width increase of 100% the change in seepage is also less than 1%. The amount of seepage is more sensitive to stream stage with an increase in stream stage of 0.5 feet resulting in an increase in seepage of about 1.4% which is still not large. Mr. Harris has indicated he is aware of this sensitivity and has calibrated stream stage so as not to allow seepage in excess of available stream flow. Again, use of the more recent version of SEAWAT with the STR package and run in transient mode with monthly data, will improve model reliability with respect to the effects of increased pumping in the Los Osos Creek subarea.

Seawater Intrusion Coefficients

Seawater intrusion into the Los Osos groundwater basin is primarily effected by the relative elevations of the ocean and head in each aquifer, difference in fresh and seawater density and the aquifer coefficient of dispersion, particularly the longitudinal component (dL). This coefficient is an unknown that is dependent upon aquifer permeability and the scale of the intrusion problem. Three technical references were reviewed to evaluate the potential range of this variable for the Los Osos basin, as noted above. CHG was requested to perform a sensitivity analysis of the coefficient of longitudinal dispersivity. The results are shown below in Tables 1 and 2 for the 50 year calibration.

Table 1. Chloride 250 mg/l isochem - Distance from coastline 2005 (in feet)

Model Zone/Layer	Measured/Estimated	Calibration (dL/dT/dV)	Low range (dL/dT/dV)	High Range dL/dT/dV
		(100/20/2)	(10/2/0.2)	(200/40/4)
C/1	1,500	2,000	2,000	2,000
D/3	2,500 – 5,500	2,500 – 5,400	2,400 – 5,100	2,600 – 5,700
E/4	3,000 – 7,500	3,000 – 4,800	2,900 – 4,500	3,000 – 5,000

Note: dL = Longitudinal Dispersivity, dT =Transverse Dispersivity, dV = Vertical Dispersivity

Table 2. Change in distance of Chloride 250 mg/l isochem relative to calibration (in feet)

Model Zone/Layer	Calibration (dL/dT/dV)	Low range (dL/dT/dV)	High Range (dL/dT/dV)
	(100/20/2)	(10/2/0.2)	(200/40/4)
C/1	0 ft	0	0
D/3	0	-300	+300
E/4	0	-250	+250

The longitudinal, transverse and vertical dispersivities are related and are generally express as a ratio. Table 1 indicates the model simulated accuracy relative to the dL of 100 used in the model and to a wide range of values. Table 2 indicates the relative sensitivity of the model to the same range. The results indicate the model is surprisingly insensitive to longitudinal dispersivity and that the differences in simulated intrusion under the wide range of coefficients simulated is only 300 feet or about one model cell width after 50 years.

In addition to the analyses discussed above, Stetson Engineers requested that CHG provide a composite map of the simulated and measured extent of seawater intrusion as of 2005, the end of the 50 year calibration period to determine visually how well the model matches the data base on the 250 mg/l Chloride isochem. Figure 7 shows the results provided by CHG where the green area represents the 250 mg/l Chloride isochem as a wedge in Zone D due to density differences and the blue line (0.03 isochem) represent the model simulated extent of the 250 mg/l Chloride isochem in the middle of the aquifer. The model appears to match the data relatively well. A comparison of columns 2 and 3 in Table 1 provides a more precise measure of this difference.

SEAWAT Model Limitations

The current transient calibration for the SEAWAT model only represents three multi-year period and the predictions are run with steady-state (average hydrologic) inputs. This increases the uncertainty in the model for calibration and prediction of monthly water levels, recharge, stream seepage and storage change during critical dry periods. While the model structure is in place for developing a monthly transient calibration, it may take significant time and effort to calibrate the SEAWAT model. This is primarily due to known problems with numerical instability in SEAWAT when running in transient mode. This effort may be warranted in the long term but, in the short term the suggested redistribution of pumping to the Los Osos Creek area need not be delayed. In future model updates it is suggested that the model be calibrated with monthly stress and the STR package to better represent Los Osos Creek seepage to the underlying aquifer.

While careful use of the RIV module can result in reasonable results as discussed above, this is still a model limitation that, when combined with the absence of a transient SEAWAT calibration is of concern with respect to more precise evaluation of management alternatives. Note that what is suggested is more accurate predictions, and not that the current SEAWAT model does not provide useful results.

Model Results and Uncertainty

Although it was not a part of the scope of work for this review, it was hoped that an estimate of the uncertainty of the extent of predicted sweater intrusion and subbasin safe yield under future management scenarios could be provide in this review. However, as with most models, this is best defined by the developer of the model who is most familiar with the model, its input data and limitations. As suggested below, some estimate should be placed on these model results (current and future) for the purpose of assisting decision makers in allowing consideration of alternate plans should the model not prove100% accurate.

All models have an inherent degree of uncertainty. That does not invalidate their results, but knowing the uncertainty in key results is important for the planning process. In this case, such planning could include a gradual shift in municipal pumping to the Los Osos Creek subarea with appropriate monitoring to evaluate the effects of such a change, which will likely be slow to occur. Planning could therefore include various steps that could be taken should underpredicted, but not surprising results occur. For example large storage declines during dry periods in the Los Osos Creek subarea when pumping there is increased, or seawater intrusion does not slow at the rate expected, or the reduction in septic tank seepage does not slow at the rate expected, etc.

Seawater Intrusion

The model calibration provides reasonable results as noted above. However, there is likely some uncertainty regarding the exact extent of the landward movement of seawater intrusion under predictive scenarios. It is important to note that when making a comparison between predictive model simulations that the relative difference between the extent of seawater intrusion that is important for evaluating basin management alternatives rather than the absolute value of the extent of seawater intrusion or specific Chloride concentrations at any one location due to model limitations discussed above.

Given the limitations of SEAWAT, the Recommendations discussed below include suggestions for evaluating dry period, seasonal and intermittent stream conditions by updating the current model using monthly transient stress periods.

Safe Yield Estimates

The safe yield estimate for the Urban Area of 3,200 afy (CHG, 2009a) is a reasonable long term average estimate, but with limitations discussed above regarding the uncertain response of the aquifers during extended dry periods. It is suggested that a +/- value be added to that estimate based on model uncertainty.

The SEAWAT limitations regarding the RIV module to simulate leakage to the aquifer have been address above, and the additional recharge under the scenario of expanded pumping in this area is reasonable due to consideration of this limitation by CHG. An uncertainty range could also be added to the Los Osos Creek subarea safe yield estimate of 3,150 afy (CHG, 2009b) for the same reasons. Additional recharge from Los Osos Creek is an important component of this estimate. Improvements in model accuracy could be made through a monthly transient calibration of the existing SEAWAT model using the updated code with STR package capability. Reporting on an improved version of the model should still include a section on uncertainty.

Conclusions

The current SEAWAT model and results regarding seawater intrusion and safe yield provides usable results on which to base near-term changes in pumping distribution to mitigate seawater intrusion (CHG, 2009a, b). However, it is suggested that uncertainty values should be assigned by CHG to the model results given the model limitations to assist decision makers in their choice of action and any additional measures that should also be considered. Our involvement with the USGS in other basins indicates they include, and recommends others include, a limitations and uncertainty section in model documentation (W. Danskin, USGS Research Hydrologist, 2009). SEAWAT is an appropriate model code for the Los Osos basin for evaluation of the average groundwater basin budget (including basin and subarea yields), the extent of seawater intrusion, and for use in evaluating the relative effects of development and changes in basin management or climate variability.

Recommendations

Although recommendations were not requested as part of this review, they are included in the text above and summarized below.

1) Add uncertainty values to seawater inflow extent and rate, and safe yield estimates in CHG (2009 a,b) and future model documentation, memos, etc.
2) Calibrate SEAWAT in monthly transient mode and use the STR package to represent Los Osos Creek. Use a long period of record that includes the critical dry period for the region. Repeat the same hydrologic period for predictive simulations.
3) Continue to review climate change literature and determine if a comprehensive scenario regarding climate change should be run using an updated version of the model.
4) Write up the Yates preprocessor used to estimate deep percolation to the saturated flow model (SEAWAT, MODFLOW, etc) including diagrams, screen capture or other method to show how model the works, include the source of model input data, what variables are usually changed for predictive runs and which variables are most sensitive. This preprocessor provides significant input to the flow models and more complete information is needed.
5) Additional model documentation is needed on the SEAWAT model for the Los Osos Creek Basin including assumptions, maps of hydraulic property distributions by layer, stream input data, reference to the unsaturated flow preprocessor and changes to input for model simulation, and other details sufficient for a complete understanding of the model.
6) For the benefit of users of model results, future reviewers or model users it is suggested that a summary of Los Osos models and related documents be prepared. This documentation should include, at a minimum, a table with; a) the model code used, b) whether transient or steady state, c) period simulated (calibration and prediction) and stress period length, d) if Yates preprocessor or other method used to estimated deep

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percolation, f) if transport, which species were simulated, and g) date and title of key documentation. This would have saved the reviewer a lot of time in trying to determine relevance and differences between these models listed below.

- Yates and Weise,1988
- Yates and Williams, 2003
- URS, 2000
- CHG 2005
- CHG 2009a, b

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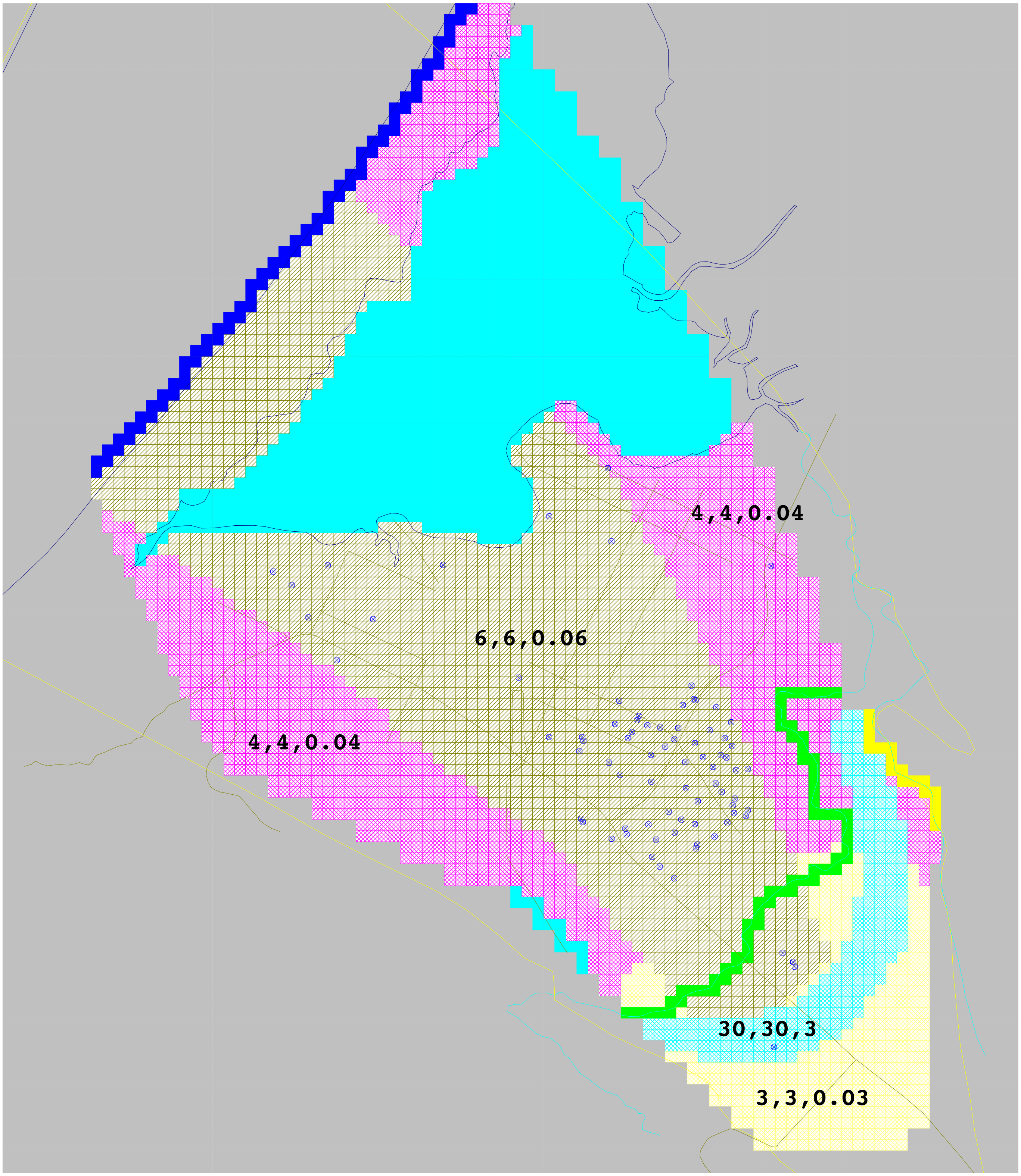

Figure 1. Horizontal Hydraulic Conductivity - Layer 1

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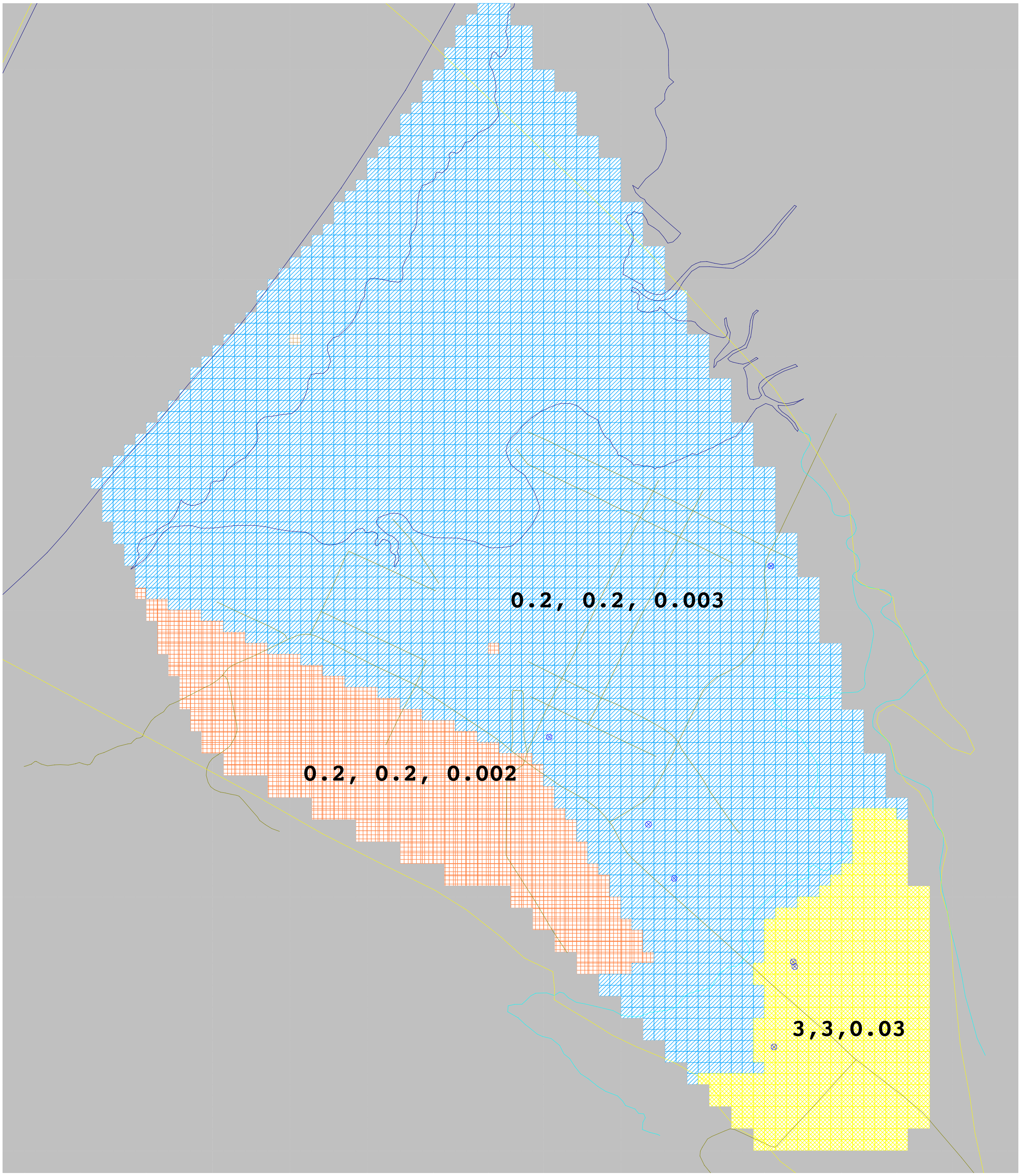

Figure 2. Horizontal Hydraulic Conductivity - Layer 2

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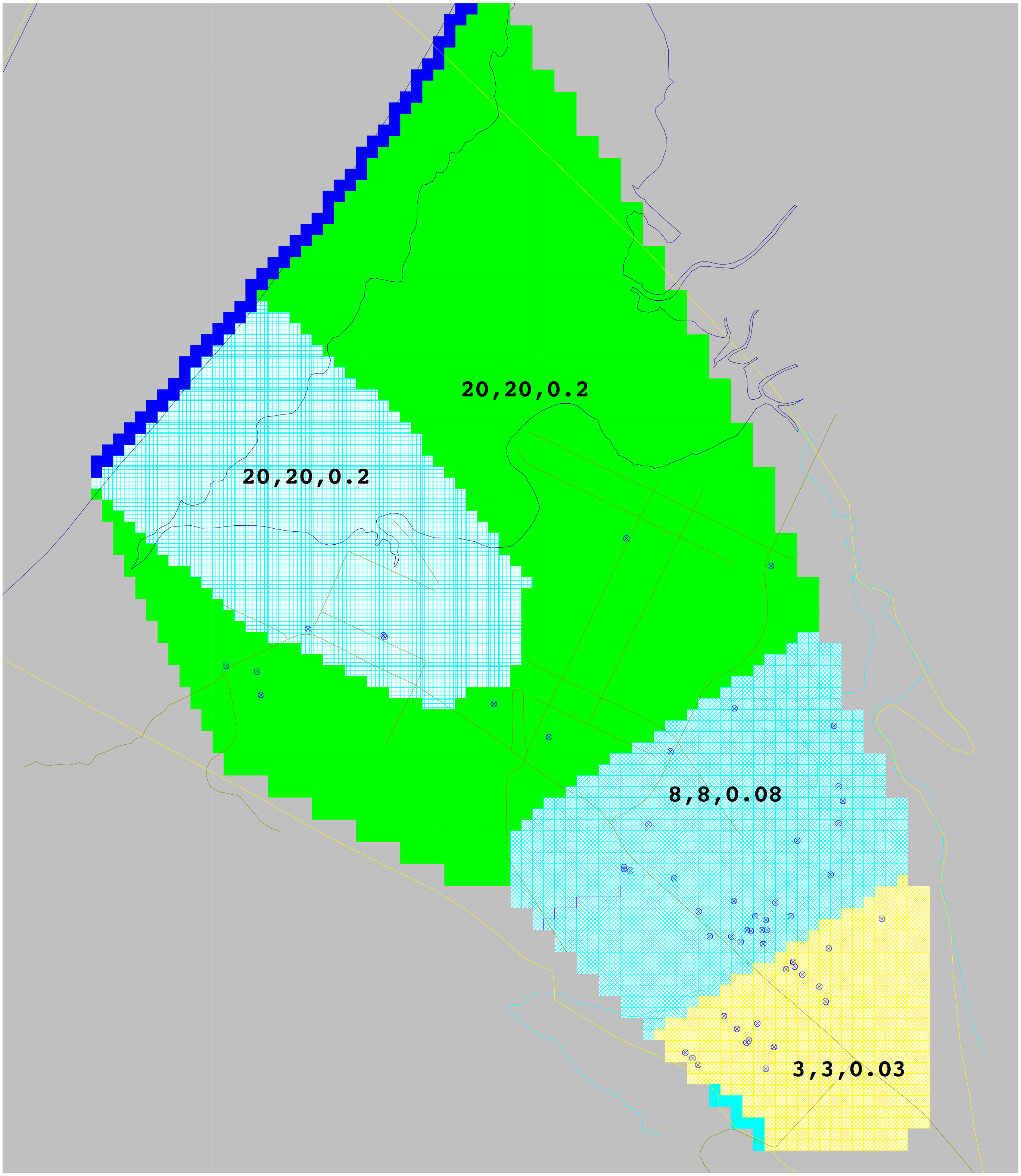

Figure 3. Horizontal Hydraulic Conductivity - Layer 3

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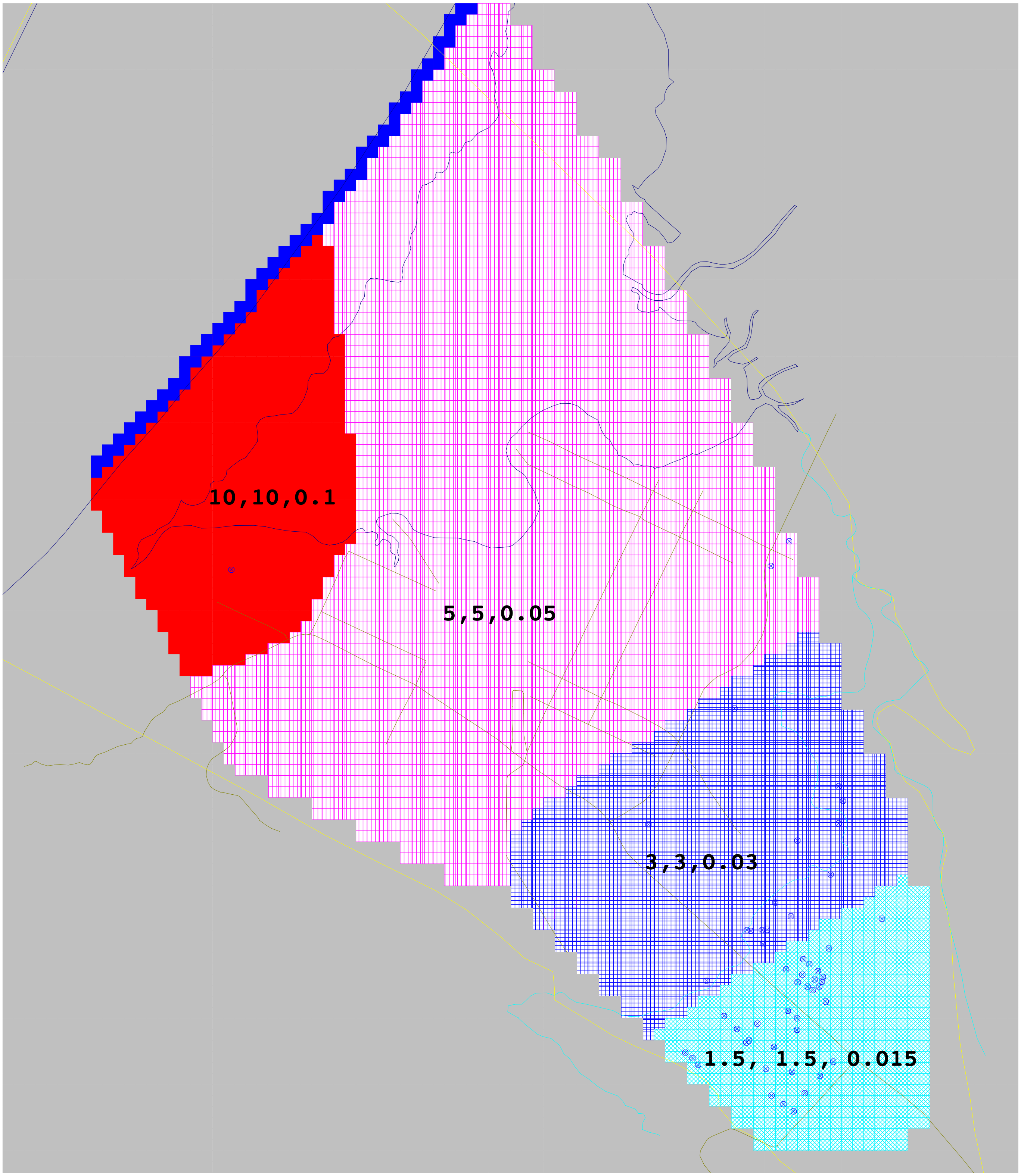

Figure 4. Horizontal Hydraulic Conductivity - Layer 4

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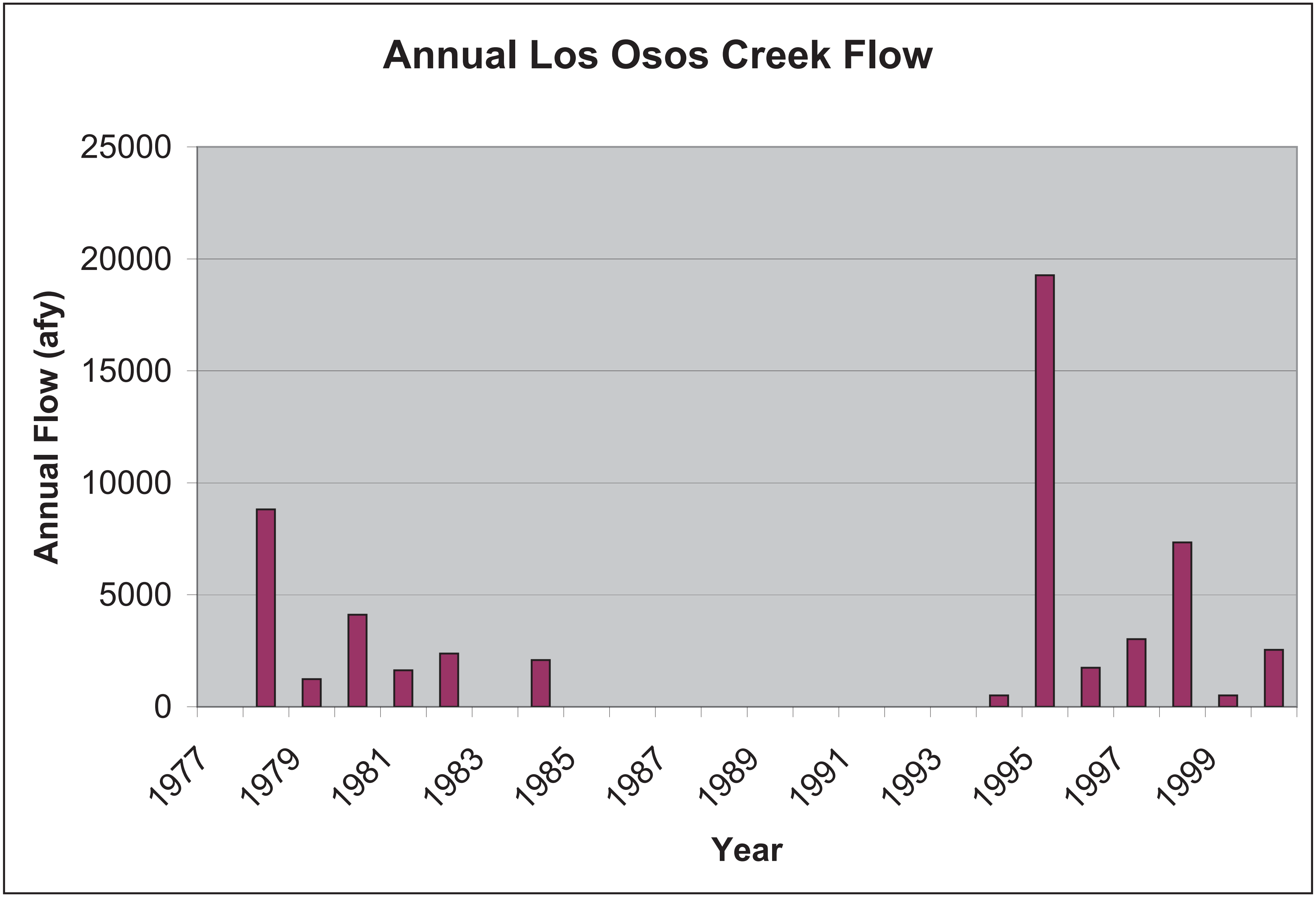

Figure 5. Annual Los Osos Creek Flow (1978-2002)

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Figure 6
Cumulative Departure Curve
Los Osos Station 197 (South Bay Fire Dept.)

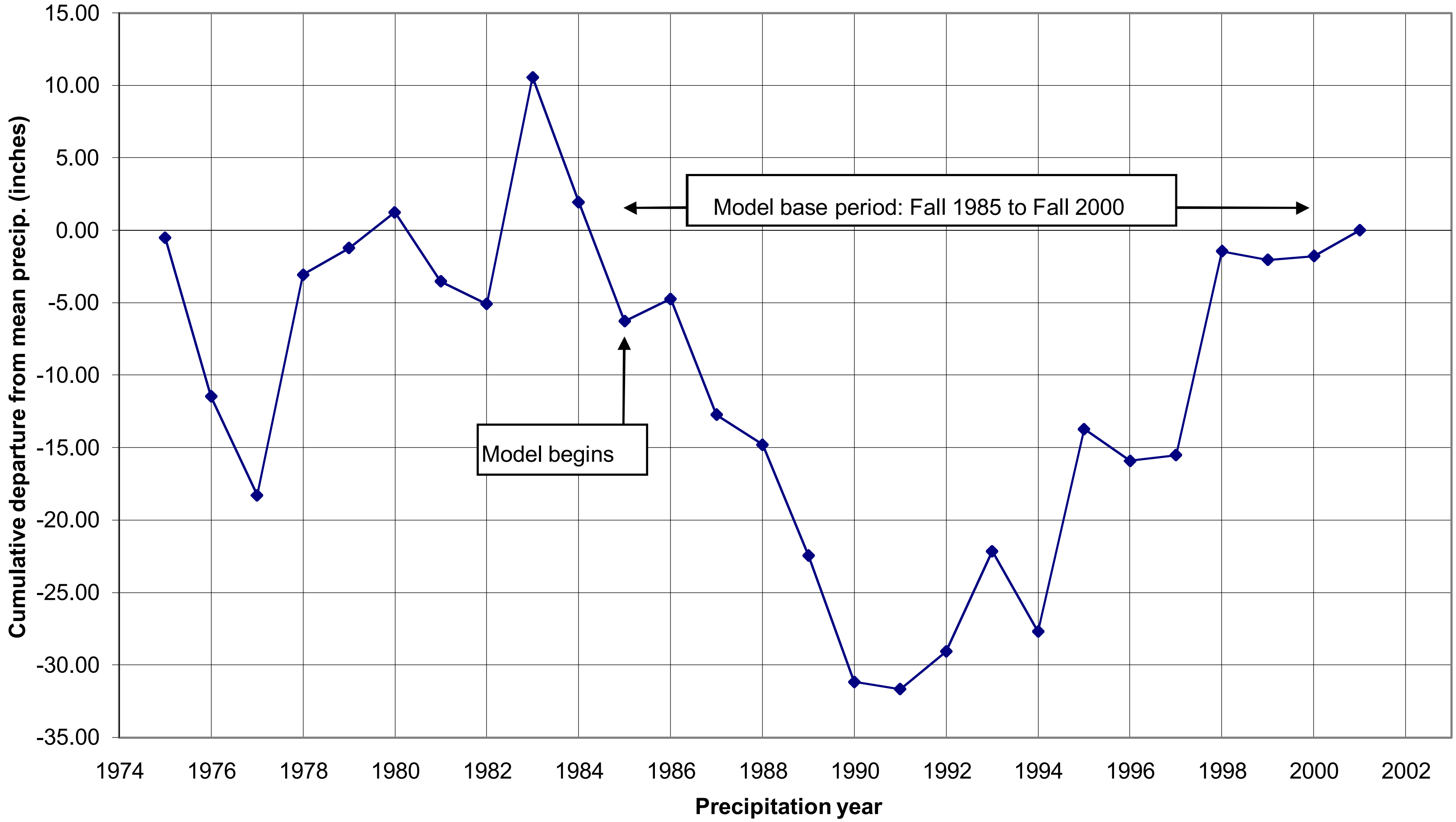

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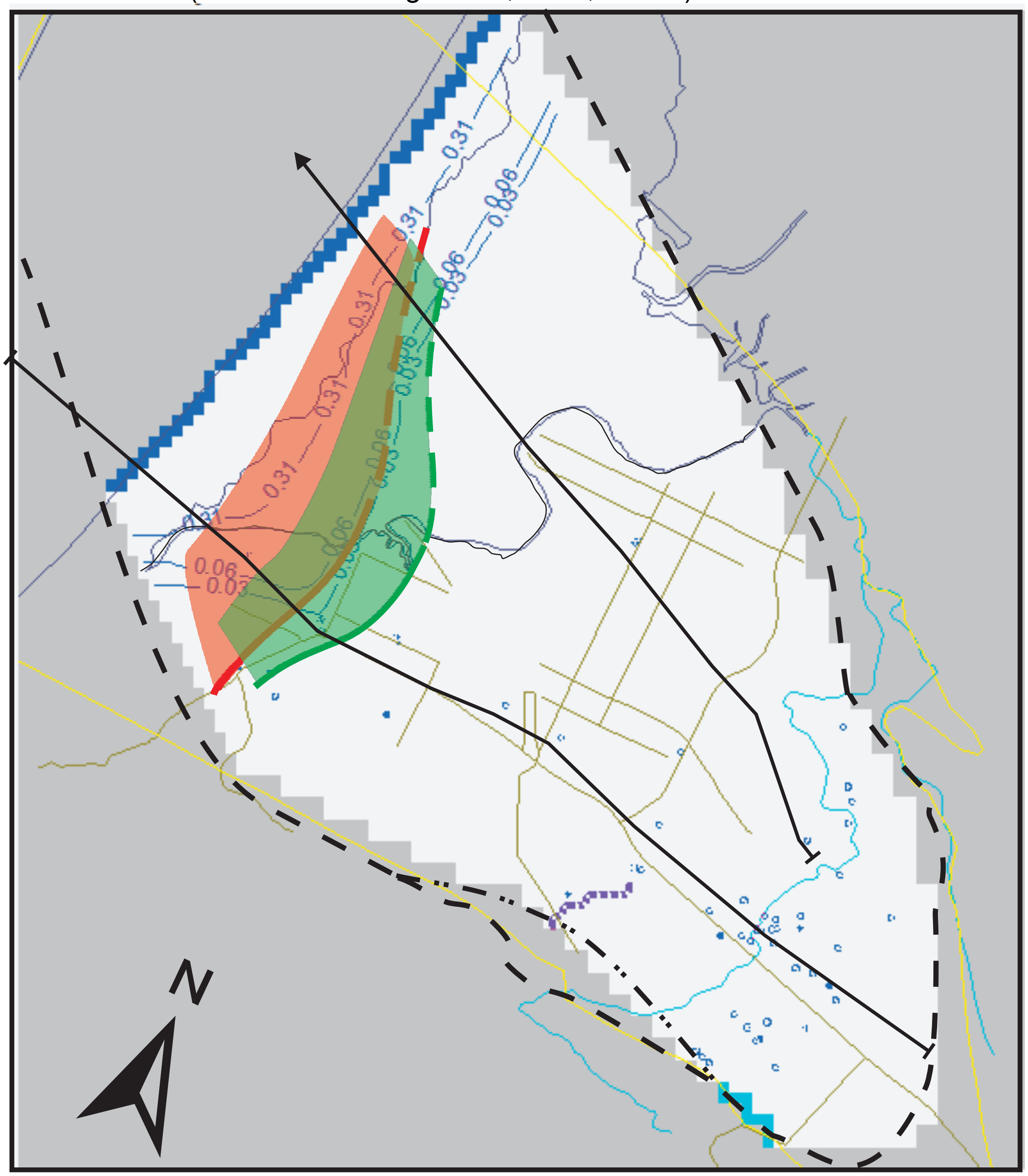
Figure 7. Zone D, measured and simulated extent of seawater intrusion, 2005.
(modified from Figure A3, CHG, 2009b)



Scale 1" = 4000 feet

Simulated TDS isoconcentrations in lb/ft3

0.03 lb/ft3 = 500 mg/l TDS ≈ 250 mg/l Chloride
0.06 lb/ft3 = 1,000 mg/l TDS≈ 500 mg/l Chloride
0.31 lb/ft3 = 5,000 mg/l TDS≈ 2,500 mg/l Chloride

2005 Transition Zone:

Estimated extent of 2500 mg/l Zone D isochlor (shading shows change with depth)

Estimated extent of 250 mg/l Zone D isochlor (shading shows change with depth)

~~Figure A3~~

TDS Isoconcentrations
Calibration Run-2005 Zone D
May 2009 SEAWAT Model
Los Osos ISJ Group

Cleath-Harris Geologists, Inc.