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Peer Review of Groundwater Modeling for the

Monterey Peninsula Water Supply Project (MPWSP) April 2015 Draft EIR

Christine Doughty, Preston D. Jordan, and Curtis M. Oldenburg*

*Corresponding author

cmoldenburg@lbl.gov

510-486-7419

Energy Geosciences Division 74-316C

Lawrence Berkeley National Laboratory

Berkeley, CA 94720

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Abstract

The proposed Monterey Peninsula Water Supply Project (MPWSP) involves desalinating water produced from slant wells completed in sand aquifers along the coast of Monterey Bay in Marina, California. Aquifers in the adjacent Salinas Valley are used heavily for groundwater for agricultural irrigation, and seawater intrusion has been a longstanding problem in the area. As part of the CEQA process, a team led by the CPUC carried out groundwater modeling to determine the impacts of the MPWSP on groundwater in the surrounding aquifers.

Following a change in leadership of the groundwater modeling effort, the CPUC requested LBNL hydrogeologists to carry out an independent and objective peer review of the original groundwater modeling that was used to support the Draft EIR published in April 2015.

In our review, we re-created the workflow used by the original modeling team, reviewed conceptual models of the shallow subsurface in the Marina area, re-ran models using data files and executable codes provided by the CPUC, and compared the outputs of our modeling results against those presented in Appendix E2 of the Draft EIR.

We found that the computer simulations carried out by the modeling team can be replicated using the input and executable codes provided to us. Agreement between the original output and our re-run results was mostly excellent (agreed exactly or differences were very small). Differences in simulation results can probably be attributed to machine round-off and cancellation errors.

We also found that the groundwater model results may not represent the detailed response of the actual system because the conceptual model used for groundwater modeling of the shallow sands at Marina neglected to include an aquitard present in the subsurface (the Fort Ord Salinas Valley Aquitard, or FO-SVA). We recommend that future groundwater modeling include the FO-SVA. Finally, we found the initial and calibrated hydraulic conductivities in the simulation were higher by one to two orders of magnitude and the Dune Sand aquifer storativity* was low compared to values derived from nearby field data. This may be because the lack of FO-SVA in the model resulted in higher horizontal to vertical conductivity ratios in the aquifers than is typical and indicated by the field data. We recommend using results from surrounding field data to initialize the model in those areas.

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*Storativity is a measure of the amount of water released by an aquifer for a given drop in hydraulic head.

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1. Introduction

The proposed Monterey Peninsula Water Supply Project (MPWSP) entails construction and operation of a desalination plant to produce potable water from saline groundwater extracted from beneath the sea floor near the shoreline. The resulting supply will compensate for reduced diversions from the Carmel River and reduced extraction from the Seaside Groundwater Basin, both of which are legally required. The proposed desalination plant would also produce potable water in excess of that needed to replace the aforementioned reductions. This additional water would provide a stable supply for existing customers, fire suppression, future development, and tourism.

The Project was determined to require full environmental analysis in accord with the California Environmental Quality Act. An analysis was prepared under the auspices of the California Public Utilities Commission (CPUC) and issued as a Draft Environmental Impact Report (DEIR) in April 2015. Among the potential environmental impacts considered, reduction of groundwater supplies, declines in groundwater levels resulting from extraction of saline groundwater from beneath the sea floor near the shoreline, and degradation of groundwater quality were assessed.

The approach to assessing these impacts involved development of conceptual models of the surface and groundwater hydrology in the area that could potentially be affected by the groundwater withdrawals associated with the project. This was followed by development of the quantitative inputs necessary to simulate the subsurface hydrology using groundwater models, such as description of the hydrostratigraphy and selection of hydraulic parameter values. Using these as inputs, groundwater modeling of subsurface hydrology without and with the proposed groundwater extraction was performed to assess the magnitudes of water level drawdown and the changes in water quality throughout the study area.

Following a change in the leadership of the groundwater modeling effort, the CPUC commissioned Lawrence Berkeley National Laboratory (LBNL) to review the numerical simulations of the proposed saline groundwater extraction at the CEMEX and Potrero Road sites. The scope did not include reviewing any of the other results in the DEIR, such as the effect of the project on groundwater in the Seaside Groundwater Basin.

This report conveys the results of LBNL's review of the proposed saline groundwater extraction modeling and its effects in a series of Appendices. We present in Appendix A the scope of work we carried out as defined by the CPUC. As shown, the primary focus of our review was the groundwater modeling with an emphasis on replicating the groundwater modeling results presented in Appendix E2 of the DEIR. In Appendix B we summarize the modeling workflow, and do consistency checks on model input files. In Appendix C we present the results of re-running the groundwater models and comparing input parameters with values in tables and figures in the DEIR. In Appendix D, we summarize our review of the conceptual model of the local hydrostratigraphy, groundwater budget, and hydrologic parameters. In total, LBNL reviewed the following aspects of the overall groundwater modeling effort:

- Numerical simulations
- Hydrostratigraphy
- Groundwater budget
- Hydrologic parameters, such as hydraulic conductivity
- The impact assessments based upon all of the above

The DEIR discusses these analyses in Section 4.4 and Appendices E1 and E2. LBNL reviewed those parts of these sections that regarded the saline groundwater extraction and its impacts. Below we present first the results of our summary of the groundwater modeling work flow reported in Appendix E2, and the comparisons and analysis of the groundwater modeling that we carried out to confirm the results presented in the DEIR Appendices E1 and E2. The approach we took was to re-run all of the groundwater models using identical input and executable code (groundwater modeling software) and compare output files in various ways. This review of groundwater modeling is followed by our review of the hydrostratigraphy, groundwater budget, hydrologic parameters, and related impact assessment.

2. Conclusions

Based on this review, LBNL found its simulation results match those in Appendix E2 of the DEIR. Some of the groundwater modeling outputs are reproduced exactly, while others show small differences that can be attributed to computer round-off and cancellation errors.

As for our review of the foundation of the groundwater modeling, we find that there are shortcomings in the hydrostratigraphic model and simulation inputs that could potentially change the impact assessments. Chief among these was the absence of the Fort Ord-Salinas Valley Aquitard (FO-SVA), which hydraulically separates the Dune Sand and 180-foot equivalent (180-FTE) aquifers from greater than about 2 km east of the proposed extraction site.

The extent of the FO-SVA relative to the proposed slant extraction wells should be characterized. The numerical simulation of the proposed groundwater extraction should be performed including this unit. The accuracy with which the simulation results predict the capture zones, the drawdown distribution, and the percentage of the extracted water that flows from beneath onshore is particularly sensitive to the position of the western edge of the FO-SVA and initial water levels in the 180-FTE at this edge.

If there are insufficient data to constrain the position of water levels and the position of the FO-SVA, multiple simulations should be conducted to provide a suite of results that in sum bracket the likely changes resulting from the proposed extraction. This suite of results can be used to determine the maximum capture area, drawdowns, and extraction from beneath onshore, or to provide a probability distribution for those values if probability distributions for the inputs can be established. If the maximum output value approach is utilized, these will not all result from one simulation out of the suite, but rather from a combination of simulations.

The new simulation should be initialized with hydraulic conductivities measured from field data collected in the nearby former Fort Ord. In general these hydraulic conductivities are lower than

than those previously used to initialize the model and resulting from calibration by the model. The model should also be initialized with larger storativities in the Dune Sand aquifer based upon analysis of field data from the nearby former Fort Ord.

3. Acknowledgments

This work was funded by the California Public Utilities Commission through Earth Science Associates (ESA), San Francisco, CA, and by Lawrence Berkeley National Laboratory, University of California, under Department of Energy Contract No. DE-AC02-05CH11231.

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Appendix A. Task list and schedule

Task 1. Workflow review Review the North Marina Groundwater Model (NMGWM)/CEMEX model files received from ESA. Develop a detailed simulation pathway schematic (i.e., workflow) which includes all pre- and post-processing steps and the specific software required to complete each step. Resolve questions and outstanding information needs and finalize the workflow schematic.	**Weeks 1-2**
Task 2. Consistency check Confirm the NMGWM/CEMEX model input files are consistent with the description in the documentation provided by the CPUC CEQA Team. For example, confirm grid extent, model cell dimensions, types, and location of boundary conditions, aquifer parameters, prescribed stresses (recharge, pumpage, and stream percolation), and water quality (for solute transport simulations).	**Weeks 2-4**
Task 3. Groundwater modeling Run NMGWM/CEMEX models and confirm output is consistent with results reported by the CPUC CEQA Team. Ensure the models run as described and that they produce reasonable results.	**Weeks 2-8**
Task 4. Reporting Prepare a Draft report documenting the peer-review process and its results to CPUC CEQA Team. Revise and issue a Final report, incorporating comments, as appropriate.	**Weeks 2-10**

Appendix B. Workflow and Consistency Check

Task 1: Review the North Marina Groundwater Model (NMGWM)/CEMEX model files received from ESA. Develop a detailed simulation pathway schematic (i.e., workflow) which includes all pre- and post-processing steps and the specific software required to complete each step. Resolve questions and outstanding information needs and finalize the workflow schematic.

Workflow review

We were provided with a CD containing the DEIR and all of its appendices, along with a portable external hard disk containing 1,151 Gb of datafiles and executables of groundwater modeling files. We reviewed all of the files.

A workflow is presented below. The only specific software noted are the main simulation programs: IGSM, MODFLOW, MT3DMS, SEAWAT; and the pre/post-processing package Groundwater Vista, which is used to develop the NMGWM and Cemex models and to import initial conditions (IC) from the regional SVIGSM to the NMGWM model. Information on programs used to present simulation results graphically was not found.

Workflow

1. Review historical data.
2. Collect new borehole data (DEIR, Appendix C).
3. Run SVIGSM using finite element model IGSM (we do not have source or executable; there is a critical review of model correctness (LaBolle et al., 2003) but we did not examine that issue.
    a. Update and calibrate SVIGSM (Described in DEIR App. E2, App. A; we do not have files); old calibration period 1949-1994; new calibration period 1949-2011.
        i. Recharge and discharge data applied: precipitation, evapotranspiration, surface water in/out, groundwater pumping
        ii. Observations: groundwater levels
        iii. Parameters varied: horizontal and vertical permeability, effective porosity
    b. Run SVIGSM for all calibration and predictive scenarios to be simulated with NMGWM to determine boundary conditions (BC) for NMGWM: head at boundaries, pumping, deep percolation, stream inflow/outflow.
4. Run NMGWM using MODFLOW and MT3DMS (DEIR App. E2).
    a. Take parameters, IC, and BC from SVIGSM; assign to NMGWM.
    b. Calibrate NMGWM (1980-2011; we have files).
        i. Observations : groundwater levels and TDS
        ii. Parameters varied: horizontal and vertical permeability, effective porosity, dispersivity

    c. Run 17 predictive scenarios (15 cases cover MPWSP operation for years 2012-2074; 2 cases cover rebound after MPWSP ceases for years 2075-02137; we have files)
5. Run CEMEX Model (CM) using SEAWAT
    a. Take parameters, IC, and BC from NMGWM; assign to CEMEX model.
    b. Calibrate CM against long-term pump test from test slant well (DEIR App. E1)
    c. Run two CEMEX predictive scenarios (2012-2074; we have files)
6. Plot and present all results.

Consistency check

Task 2: Confirm the NMGWM/CEMEX model input files are consistent with the description in the documentation provided by the CPUC CEQA Team. For example, confirm grid extent, model cell dimensions, types, and location of boundary conditions, aquifer parameters, prescribed stresses (recharge, pumpage, and stream percolation), and water quality (for solute transport simulations).

In the notes below "Consistent with App. E2" means that every entry was checked – this was only possible for uniform parameter distributions or for control parameters. "Consistent with Figure * in App. E2" means that the values in the files were plotted and the plots compared visually with those in Appendix E2. "Taken from SVIGSM; not checked in detail" means that the SVIGSM results shown graphically in Figures 12-24 in Appendix A of Appendix E2 were found reasonable, but were not correlated to individual entries in the input files. Similarly, "Taken from NMGWM; not checked in detail" means that the NMGWM results shown graphically in Figures 12-24 in Appendix E2 were found reasonable, but were not correlated to individual entries in the input files. To verify all individual entries of these input files would require far more time than was allotted for this review.

MODFLOW input files

NAM – name file with file names of all other input files

BAS – basic input. For each of 8 model layers, identifies each cell in the 300 by 345 array as being variable head, no flow, or constant head. Provides initial head values for all cells. Cell identifiers are consistent with Figure 18 of App. E2. Initial head distributions were plotted and appear reasonable.

DIS – discretization information. Provides number of cells as 300 by 345, uniform lateral discretization: 200 ft by 200 ft; depth distributions of 8 model layers. Bottom elevation of each layer is consistent with Figure 19 of App. E2.

LPF – layer properties. Provides distributions of hydraulic conductivity, vertical hydraulic conductivity, and primary storage for 8 model layers. Horizontal hydraulic conductivity values are consistent with Figure 31 of App. E2. Vertical hydraulic conductivity values are consistent with Figure 32 of App. E2, except for one small region in the upper left corner of Layer 1 where Figure 32 claims vertical conductivity is between 0.21 and 0.40, but the file indicates it is 4. Storativity values are not consistent with Figure 33 of App. E2, but tend to be much lower, as shown in **Figure B1** in this report.

WEL – well package. Roughly 90,000 entries for each of 252 stress periods (number of entries varies by stress period); taken from SVIGSM; not checked in detail.

GHB – general head boundary package. 711 entries around the non-ocean perimeter of NMGWM for each of layers 2-8, for each of 252 stress periods; taken from SVIGSM. First stress period should match end of calibration (2011). See App. E2, App. A, Figure 6a: SVIGSM Layer 1 maps to NMGWM layer 4 – compares okay; Figure 6b: SVIGSM Layer 2 maps to NMGWM layer 6 – compares okay. Note that boundary for NMGWM layer 2 has a section in the NE with heads >200 ft, but this corresponds to a location where no-flow cells exist in layers 2 and 3 (See App. E2, Figure 31), so these high head values should have no effect. The time variation for boundary conditions appears reasonable: seasonal variations, plus long-term decrease for first 20-year period (prolonged dry), then long-term recovery for second 20-year period (prolonged wet).

RCH – recharge package. 103,500=300*345 entries (one for each cell in top layer of model) for each of 252 stress periods; taken from SVIGSM; not checked in detail.

OC – output specifications. Specify 252 one-month-long stress periods for each 20-year simulation. Consistent with App. E2.

PCG– preconditioned conjugate-gradient package – not mentioned in App. E2.

LMT – link to MT3DMS – not mentioned in App. E2.

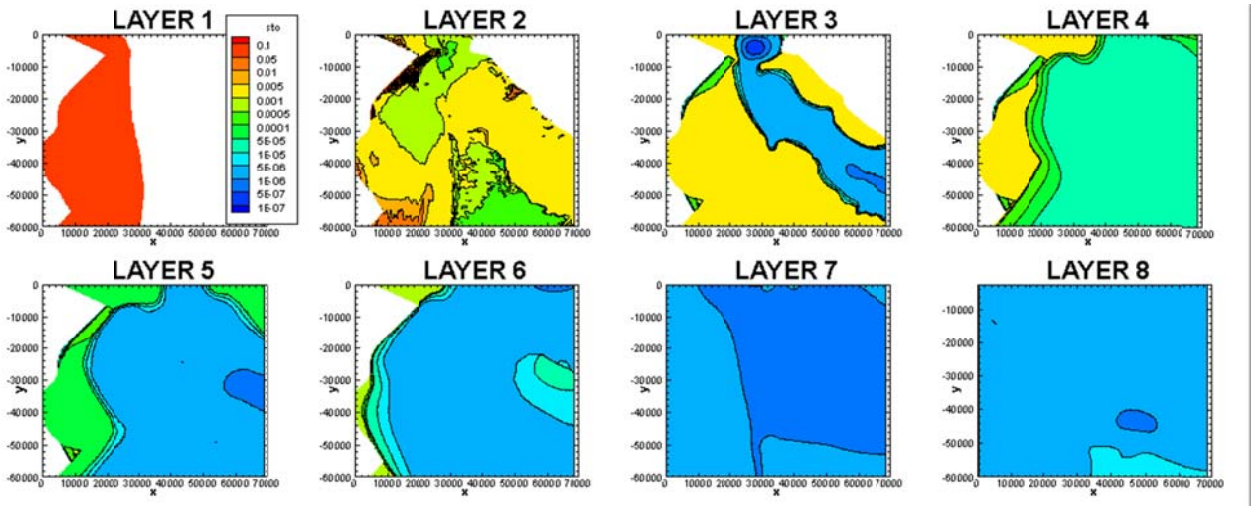


Figure B1. *Storativity distribution in each layer of the NMGWM, plotted from nm_sce3n_1.lpf. Compared to Figure 33 of App. E2, these storativity values tend to be lower.*

MT3DMS input files

NAM – name file with file names of all other input files

BTN – basic transport package. Includes spatial distributions of DELZ, porosity, flag ICUBUND, and initial concentration. DELZ values are consistent with Figures 20-26 of App. E2, except for layer 2, where the values show much more variability than the figure. However, this could be because the data were smoothed to create a more visually pleasing contour plot. Porosity values are consistent with Figure 34 of App. E2. Initial concentrations are consistent with Figure 35 of App. E2.

ADV- advection flags – not mentioned in App. E2.

DSP – dispersion information. Uniform dispersivity (20 ft); uniform horizontal dispersivity ratio (0.1), uniform vertical dispersivity ratio (0.01), zero molecular diffusion. Consistent with App. E2.

SSM – source, sink, mixing. Not checked.

GCG – conjugate gradient solver parameters – not mentioned in App. E2.

FTL –binary output file from MODFLOW – not examined.

SEAWAT input files

NAM – name file with file names of all other input files

Flow part

BAS – basic input. For each layer identifies each cell in the 540 by 540 array as being variable head, no flow, or constant head. Provides initial head values for all cells. Cell identifiers and initial heads plotted and found to be consistent with NMGWM.

DIS – discretization information. Provides number of cells as 540 by 540, uniform lateral discretization: 20 ft by 20 ft; depth distributions of 12 model layers. Bottom elevation of each layer plotted and found to be consistent with NMGWM elevations shown in Figure 19 of App. E2.

LPF – layer properties. Provides distributions of hydraulic conductivity, vertical hydraulic conductivity, and primary storage for 12 model layers. CEMEX property distributions of each layer plotted and found to be consistent with NMGWM property distributions plotted from nm_lpf files.

WEL – well package – Roughly 188,000 entries for each of 252 stress periods (number of entries varies by stress period); taken from NMGWM; not checked in detail.

GHB – general head boundary package – 23,716 entries for each of 252 stress periods; taken from NMGWM; not checked in detail.

RCH – recharge package – – 291,600=540*540 entries (one for each cell in top layer of model) for each of 252 stress periods; taken from NMGWM; not checked in detail.

OC – output specifications. Specify 252 one-month long stress periods for each 20-year simulation. Consistent with App. E2.

PCG – preconditioned conjugate-gradient package – not mentioned in App. E2.

ZONE – zone information – not mentioned in App. E2.

Transport part

BTN – basic transport package. Includes spatial distributions of DELZ, porosity, flag ICUBUND, and initial concentration. Porosity uniform in all layers except layer 5. DELZ, porosity, and initial concentration of each layer plotted and found to be consistent with NMGWM distributions.

ADV – advection flags – not mentioned in App. E2.

DSP – dispersion information. Uniform dispersivity (20 ft); uniform horizontal dispersivity ratio (0.1), uniform vertical dispersivity ratio (0.01), zero molecular diffusion. Consistent with App. E2.

SSM – source, sink, mixing – 155,597 entries for each of 252 stress periods, information not found in App. E2; not checked in detail.

GCG – conjugate gradient solver parameters – not mentioned in App. E2.

VDF – variable density flags – not mentioned in App. E2.

Appendix C. Groundwater modeling

Task 3: Run NMGWM/CEMEX models and confirm output is consistent with results reported by the CPUC CEQA Team. Ensure the models run as described and that they produce reasonable results.

In file names below, NM stands for the North Marina Groundwater Model, which uses MODFLOW and MT3DMS. CEMEX stands for the Cemex Model, which uses SEAWAT.

Executables

MODFLOW: mf2k.exe - Flow model used for NMGWM simulations. Runs only on a 64-bit Windows computer.

MT3DMS: mt3dms4b.exe – Transport model used for NMGWM simulations. Runs on either a 32-bit or 64-bit Windows computer.

SEAWAT: sw_v4x64.exe – Combined flow and transport model used for CEMEX simulations. Runs only on a 64-bit Windows computer when the file "msvcr100.dll" is present (downloaded from https://www.dll-files.com/msvcr100.dll.html; a reputable site according to PC Advisor, an online magazine published by IDG).

Notes on standard executables available for download from official USGS sites.

MODFLOW: The current version of MODFLOW available from *water.usgs.gov/ogw/**modflow**/* is mf2005.exe. It will not read the input files used for mf2k.exe; apparently file naming and content structure has changed since the mf2k.exe version.

MT3DMS: The current version of MT3DMS available from *hydro.geo.ua.edu/**mt3d**/* is mt3dms5b.exe. It was used for the second calibration run (nm_cali_2), and produced no significant differences in the main output file: printout header format is different, and the convention for counting point sources and sinks is slightly different, but all simulation results are identical.

SEAWAT: The current version of SEAWAT available from *water.**usgs**.gov/ogw/**seawat**/* is sw_v4x64.exe. It is identical to the version provided on the hard drive.

Input files

The files received include input for the NMGWM/CEMEX models in two forms.

1. Huge self-contained files that contain all input required for the MODFLOW pre-processor Groundwater Vista for the NMGWM calibration run and one predictive scenario each for NMGWM and CEMEX. We do not have the Groundwater Vistas program, so we are not able to use these.
2. Folders that contain all the files for using MODFLOW, MT3DMS, and SEAWAT directly. These are the files we used.

In Folder “(0)MPWSP_Model_Files_for_TD” of the hard drive, there is one NMGWM calibration case that includes two simulation periods (1979 – 2000 and 2000 – 2011) and 17 NMGWM predictive cases, each of which includes three 20-year-long simulation periods (15 cases cover 2011-2032, 2032-2053, 2053-2074; two “rebound” cases cover 2075-2096, 2096-2117, 2117-2137). There are two CEMEX predictive cases, each of which includes three 20-year-long simulation periods (2011-2032, 2032-2053, 2053-2074).

Calibration Case

1. NM_CALI

Predictive Cases

North Marina Groundwater Model (NMGWM)

No project

1. NM_SCE1N
2. NM_SCE2F
3. NM_SCE2AF

Project at Cemex Site

4. NM_SCE3N
5. NM_SCE3NCB
6. NM_SCE3NC
7. NM_SCE4F
8. NM_SCE4RF
9. NM_SCE5N
10. NM_SCE5NCB
11. NM_SCE5NC
12. NM-SCE5F

Project at Potrero Rd Site

13. NM_SCE6SN
14. NM_SCE7SF
15. NM_SCE7SRF
16. NM_SCE8SN
17. NM_SCE8SF

Cemex Model

1. CEMEX_SCE4F
2. CEMEX_SCE3N

Running the Codes

On the hard drive, each NMGWM simulation period of each case is in a separate folder and includes 37 files, but these are both input and output files for MODFLOW and MT3DMS. For MODFLOW, there are 10 required input files and the code produces 2 user-readable output files: *.GLO and *.LST. MODFLOW also produces a binary file *.FTL that is read by MT3DMS, and binary files with heads (*.HDS), drawdowns (*.DDN), and cell-by-cell flows (*.CBB) in binary format, but the binary files were not examined in the present study. For MT3DMS, there are 7 required input files and the simulation produces 3 user-readable output files: MT3D.CNF, MT3D001.MAS, and *.OUT; and a binary file *.UCN. For each simulation period of the two CEMEX cases using SEAWAT, there are 16 required input files and the simulation produces 5 user-readable output files: MT3D.CNF, MT3D001.MAS, MT3D001.OBS, *.GLO and *.LST; and 4 binary files: *.HDS, *.DDN, and *.CBB.

Programs were run by copying the executable into a folder where only the input files for that executable were present (separate folders for MODFLOW and MT3DMS for each of the three time periods for each of the 17 NMGWM cases). The programs begin by prompting the user for the name of the file that lists all the input files and data files required to run the code. These files must be present in the folder.

The computer used has an Intel Xeon® CPU with 2.50 GHz speed. It has a 64-bit operating system running Windows 7 Professional, and 8 GB RAM. Each 20-year part of the predictive simulations required about 20 minutes of CPU time for MODFLOW about 35 minutes of CPU time for MT3DMS. The SEAWAT simulations were significantly slower, with each 20-year time period requiring about 4 days.

All the MT3DMS and SEAWAT simulations ran successfully. All but one of the MODFLOW simulations ran successfully. Predictive scenario NM_SCE5N, time period 1, failed to run, producing an error message when reading the LPF input file. Examination of the LPF file showed that it was corrupted. Since the LPF file contains layer information that does not vary between different time periods, the LPF file from NM_SCE5N, time period 2, was copied into the folder for the time period 1 simulation, which then ran successfully.

Comparison of New and Original Output Files

MODFLOW

The GLO (global) file identifies file names and unit number being assigned, and prints out basic input data for the simulation. It is small (604 lines) and could be examined directly, using the Windows DIFF command. Unit number assignments differed between the new simulations and the original simulations, but this should not affect the actual simulation results in any way. No other differences were found. All the basic input data for the simulations agree with that reported in Appenidx E2, including number of model layers (8), rows (300), columns (345), and stress periods (252); lateral dimensions of cells (200 ft by 200 ft); stress period duration 30.4 days (1 month); layers are confined; hydraulic conductivity is horizontally isotropic.

The LST (list) file is the main MODFLOW simulation output. It is so big (about 1 GB, containing about 25 million lines) that it was inconvenient to work with it directly to compare the new simulation results to the original simulation results. Thus a utility program (readlst2.f) was created to read the LST file and write the water balance information for each of 252 stress periods to a summary file that is only 2 MB (about 18,000 lines). **Figure C1** shows the portion of a summary file, showing the volumetric water budget at the end of the first year.

Then a second utility program (comp2.f) read the new and original summary files, and calculated the difference of all the components of the water budget for each stress period (both "cumulative volumes" shown in the left hand column and "rates for this time step" shown in the right hand column). To facilitate comparison of different terms, a relative difference was used, defined as

$$(C_1 - C_2)/\max(C_1, C_2, \varepsilon)$$

where C_1 is a component of the water budget in the original LST file, C_2 is the corresponding component in the new LST file, and $\varepsilon = 10^{-5}$ is included to prevent dividing by zero in case C_1 and C_2 are both zero. The utility program output the maximum difference for each stress period (partial example shown in **Figure C2**) and the maximum difference for the entire simulation. The latter values are presented in **Table C1** for all the NMGWM calibration and predictive runs.

To get a better sense of the significance of the relative differences for the MODFLOW simulations, histograms of the relative differences for five selected cases are presented in **Figures C3a – C3e**. It is apparent that most of the relative differences are quite small, with the histogram peaks in the 10^{-5} to 10^{-4} range. Checking the individual MODFLOW water budgets shows that the larger relative differences only arise when the value of the term itself is quite small. Such terms are generally storage terms in the "rates for this time step" column. For example, for the largest relative difference (0.062), which occurs during stress period 126 in case nm_sce5f_2, "storage in" is 1.9155 for the original simulation and 1.7973 for the new simulation, whereas the "total in" terms (of which "storage in" is one component) are 26109390 and 26108476, respectively, with a relative difference of only 3.5E-5. Our conclusion is that differences in MODFLOW simulation results can probably be attributed to machine round-off and cancellation errors.

In addition to the components of the water balance, MODFLOW outputs the difference of total input and total output ("IN – OUT" line in **Figure C1**). This quantity is a measure of model error and is orders of magnitude smaller than the individual components making up the water balance, hence it is subject to numerical errors. Not surprisingly, values of this quantity, also shown in **Table C1** (DMAXM and DMAXMALL), can differ significantly between the original and new simulations.

```
NM_sce3n_1 new simulation
 OUTPUT CONTROL FOR STRESS PERIOD   12   TIME STEP   1

     CUMULATIVE VOLUMES      L**3       RATES FOR THIS TIME STEP      L**3/T

           IN:                                      IN:
             STORAGE =   634788032.0000               STORAGE =      250851.6562
       CONSTANT HEAD =  2431358464.0000         CONSTANT HEAD =     5508881.0000
               WELLS =   658728832.0000                 WELLS =     2562273.5000
     HEAD DEP BOUNDS =  4960042496.0000       HEAD DEP BOUNDS =    12399316.0000
            RECHARGE =  2540330496.0000              RECHARGE =     7270796.5000
            TOTAL IN = 11225247744.0000              TOTAL IN =    27992118.0000

          OUT:                                     OUT:
             STORAGE =  1837821440.0000               STORAGE =     1033678.8750
       CONSTANT HEAD =   540294400.0000         CONSTANT HEAD =     1504761.3750
               WELLS =  4650597376.0000                 WELLS =    14654779.0000
     HEAD DEP BOUNDS =  4112643072.0000       HEAD DEP BOUNDS =    10538483.0000
            RECHARGE =    84051560.0000              RECHARGE =      240196.7969
           TOTAL OUT = 11225408512.0000             TOTAL OUT =    27971900.0000

            IN - OUT =     -160768.0000              IN - OUT =       20218.0000
```

```
NM_sce3n_1 original simulation
OUTPUT CONTROL FOR STRESS PERIOD     12   TIME STEP      1

     CUMULATIVE VOLUMES      L**3       RATES FOR THIS TIME STEP      L**3/T

           IN:                                      IN:
             STORAGE =   634788096.0000               STORAGE =      250851.9375
       CONSTANT HEAD =  2431358464.0000         CONSTANT HEAD =     5508881.0000
               WELLS =   658728832.0000                 WELLS =     2562273.5000
     HEAD DEP BOUNDS =  4960042496.0000       HEAD DEP BOUNDS =    12399316.0000
            RECHARGE =  2540330496.0000              RECHARGE =     7270796.5000

            TOTAL IN = 11225247744.0000              TOTAL IN =    27992118.0000

          OUT:                                     OUT:
             STORAGE =  1837821312.0000               STORAGE =     1033679.3125
       CONSTANT HEAD =   540294400.0000         CONSTANT HEAD =     1504761.3750
               WELLS =  4650597376.0000                 WELLS =    14654779.0000
     HEAD DEP BOUNDS =  4112643072.0000       HEAD DEP BOUNDS =    10538483.0000
            RECHARGE =    84051560.0000              RECHARGE =      240196.7969

           TOTAL OUT = 11225407488.0000             TOTAL OUT =    27971900.0000

            IN - OUT =     -159744.0000              IN - OUT =       20218.000
```

Figure C1. *Portion of the summary file for the NMGWM predictive simulations. Each 20-year time period contains 252 such water budgets. Top: new simulation; bottom: original simulation.*

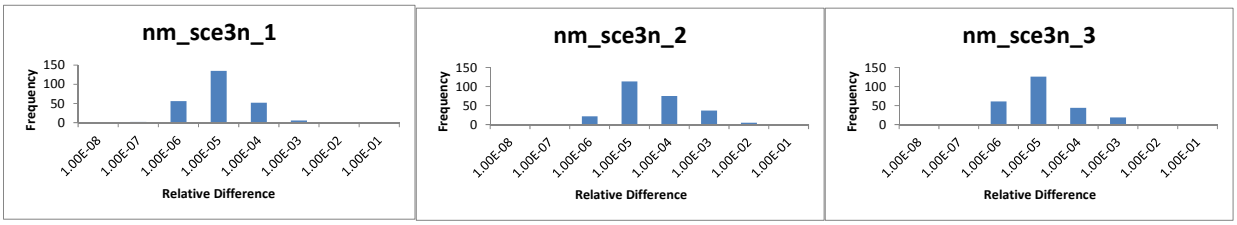
```
NM_sce3n_1
 icount=    1 dmax= .1092E-06 dmaxm= .1208E-03
 icount=    2 dmax= .2350E-06 dmaxm= .7098E-04
 icount=    3 dmax= .2350E-06 dmaxm= .1506E-03
 icount=    4 dmax= .2160E-05 dmaxm= .1012E-03
 icount=    5 dmax= .1091E-06 dmaxm= .1852E-03
 icount=    6 dmax= .8229E-07 dmaxm= .6720E-04
 icount=    7 dmax= .9328E-07 dmaxm= .1158E-03
 icount=    8 dmax= .2264E-06 dmaxm= .1249E-03
 icount=    9 dmax= .2692E-06 dmaxm= .2929E-04
 icount=   10 dmax= .8357E-06 dmaxm= .3965E-04
 icount=   11 dmax= .9849E-06 dmaxm= .1024E-03
…
 icount=  110 dmax= .4261E-05 dmaxm= .1000E+00
 icount=  111 dmax= .2037E-05 dmaxm= .1447E+00
 icount=  112 dmax= .2000E-05 dmaxm= .1942E+00
 icount=  113 dmax= .3517E-03 dmaxm= .2247E+00
 icount=  114 dmax= .9218E-03 dmaxm= .2571E+00
 icount=  115 dmax= .3192E-02 dmaxm= .3043E-01
 icount=  116 dmax= .5612E-04 dmaxm= .2581E-01
 icount=  117 dmax= .2645E-03 dmaxm= .1530E-01
 icount=  118 dmax= .6112E-04 dmaxm= .7946E-02
 icount=  119 dmax= .2079E-04 dmaxm= .5736E-02
 icount=  120 dmax= .1072E-04 dmaxm= .8318E-02
…
 icount=  241 dmax= .6976E-05 dmaxm= .1181E-02
 icount=  242 dmax= .5137E-05 dmaxm= .1800E-02
 icount=  243 dmax= .7680E-06 dmaxm= .1208E-02
 icount=  244 dmax= .7680E-06 dmaxm= .1232E-02
 icount=  245 dmax= .7613E-06 dmaxm= .1208E-02
 icount=  246 dmax= .7524E-06 dmaxm= .1174E-02
 icount=  247 dmax= .7475E-06 dmaxm= .1747E-02
 icount=  248 dmax= .7433E-06 dmaxm= .1704E-02
 icount=  249 dmax= .1245E-04 dmaxm= .3663E-02
 icount=  250 dmax= .7679E-05 dmaxm= .1094E-02
 icount=  251 dmax= .8461E-05 dmaxm= .1601E-02
 icount=  252 dmax= .9257E-06 dmaxm= .2052E-02

 DMAXALL= .3192E-02 DMAXMALL= .1692E+01
```

Figure C2. *Part of the output of utility program comp2.f, showing the maximum relative difference of each term in the water budget (dmax) and the maximum relative difference of model error "IN – OUT" (dmaxm) for each stress period. The overall maximum of all 252 stress periods is shown at the bottom (DMAXALL and DMAXMALL); these are the values that appear in* ***Table C1****.*

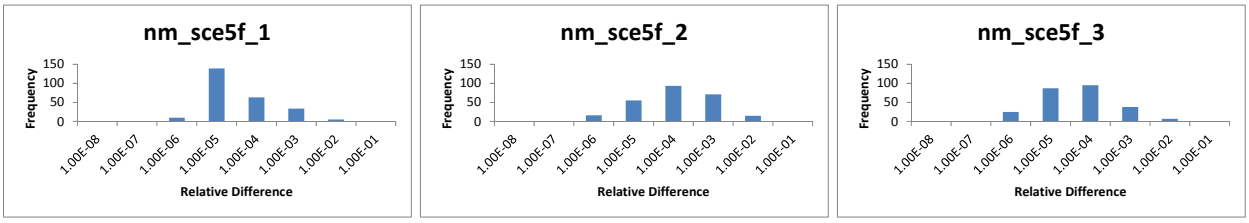
Table C1. *Maximum relative difference of components of water budget for calibration and predictive simulations of the NMGWM, shown separately for each 20-year time period.*

Case	**DMAXALL (water budget components)**			**DMAXMALL (model error)**		
	Period 1	Period 2	Period 3	Period 1	Period 2	Period 3
Calibration	8.8E-5	1.2E-4	-	0.32	0.13	-
Prediction - No Project						
NM_SCE1N	2.6E-3	9.3E-3	6.9E-3	0.65	0.15	0.55
NM_SCE2F	1.2E-3	5.5E-3	7.3E-4	1.1	2.0	0.20
NM_SCE2AF	1.3E-2	9.8E-3	5.0E-3	0.53	0.22	0.16
Prediction - Project at Cemex Site						
NM_SCE3N	3.2E-3	7.8E-3	1.4E-3	1.7	0.15	1.6
NM_SCE3NCB	3.2E-3	4.0E-3	6.5E-4	0.40	0.15	1.0
NM_SCE3NC	3.3E-3	8.1E-3	9.9E-4	0.15	0.15	1.0
NM_SCE4F	8.9e-3	2.5E-2	3.5E-3	1.2	2.0	0.15
NM_SCE4RF	7.9E-3	8.5E-3	3.1E-3	1.3	1.9	0.21
NM_SCE5N	5.7E-3	1.9E-2	5.6E-3	0.93	0.43	1.4
NM_SCE5NCB	3.0E-3	7.2E-3	7.6E-3	1.5	0.47	1.8
NM_SCE5NC	2.9E-3	5.6E-3	5.4E-3	1.0	0.59	1.8
NM-SCE5F	2.7E-3	6.2E-2	4.6E-3	0.85	1.8	1.0
Prediction - Project at Potrero Road Site						
NM_SCE6SN	1.4E-4	3.6E-3	6.8E-3	0.039	0.20	0.16
NM_SCE7SF	1.9E-3	4.4E-2	9.1E-3	0.78	1.3	0.16
NM_SCE7SRF	7.4E-3	1.4E-2	1.6E-3	1.7	1.2	0.19
NM_SCE8SN	3.8E-3	5.8E-3	1.2E-2	1.5	1.3	1.6
NM_SCE8SF	5.0E-3	1.3E-2	5.3E-3	0.70	1.8	0.82

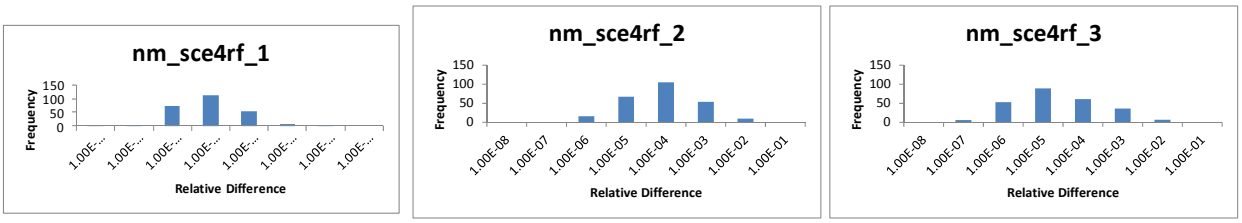
(a)



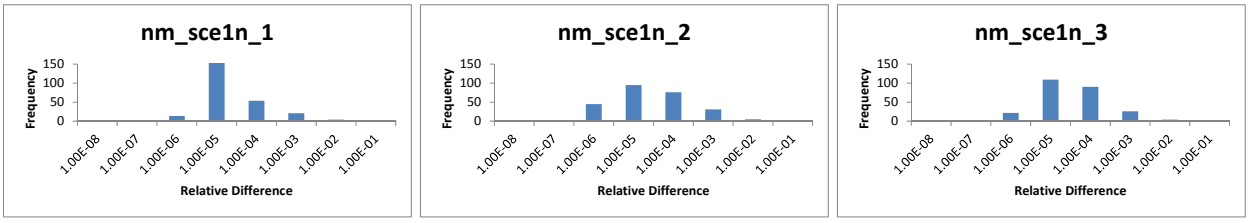
(b)



(c)



(d)



(e)

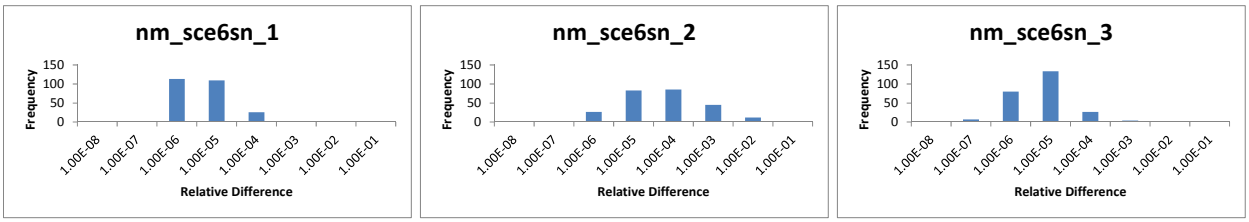
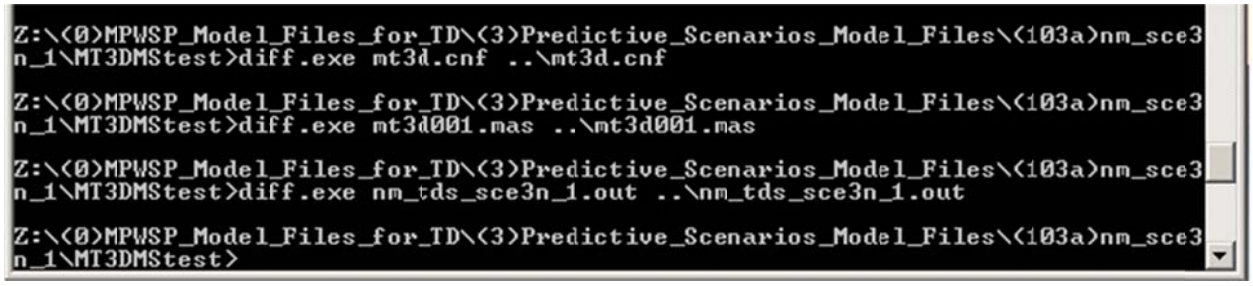


Figure C3. *Histograms of relative differences between new and original MODFLOW simulations for selected cases: (a) nm_sce3n: base case for CEMEX site, (b) nm_sce5f: case with biggest relative error, (c) nm_sce4rf: rebound case; (d) nm_sce1n: no project case; (e) nm_sce6sn: Potrero Road case. For each case, relative differences for the three 20-year time periods are shown separately*

MT3DMS

The sizes of the three user-readable output files produced by each MT3DMS simulation, *.CNF, *.MAS, and *.OUT, were identical to the size of the corresponding original output files. The Windows DIFF command was used to compare the files, and for every time period for every case for the NMGWM calibration and predictive runs, zero differences were found, indicating that the results of the new simulations were identical to the results of the original simulations. **Figure C4** shows a screen shot of using the DIFF command after a MT3DMS simulation.



```
Z:\(0)MPWSP_Model_Files_for_TD\(3)Predictive_Scenarios_Model_Files\(103a)nm_sce3
n_1\MT3DMStest>diff.exe mt3d.cnf ..\mt3d.cnf

Z:\(0)MPWSP_Model_Files_for_TD\(3)Predictive_Scenarios_Model_Files\(103a)nm_sce3
n_1\MT3DMStest>diff.exe mt3d001.mas ..\mt3d001.mas

Z:\(0)MPWSP_Model_Files_for_TD\(3)Predictive_Scenarios_Model_Files\(103a)nm_sce3
n_1\MT3DMStest>diff.exe nm_tds_sce3n_1.out ..\nm_tds_sce3n_1.out

Z:\(0)MPWSP_Model_Files_for_TD\(3)Predictive_Scenarios_Model_Files\(103a)nm_sce3
n_1\MT3DMStest>
```

Figure C4. *Screen shot of using the DIFF command on the three main output files of MT3DMS. The new output is in the current directory and the original output is in the parent directory (accessed by ..\). The blank line after the command indicates that no differences were found between the files.*

MT3DMS also produces a binary file *.UCN, containing dissolved concentration in each cell. The DIFF command was also used to compare new and original versions of this file for selected cases, and they were always identical.

SEAWAT

The two SEAWAT simulations are complete. For all three time periods of both cases, cemex_sce4f and cemex_sce3n, the DIFF command indicated that four small output files were identical to original versions, as illustrated in **Figure C5** for the first time period. The binary files *.UCN were also identical. The main output files, *.LST, were 5.5 GB each, which is too big for the DIFF command. These files were broken into 500 MB parts, and each part produced zero differences when compared to the original files with the DIFF command.

```
Z:\(0)MPWSP_Model_Files_for_TD\(3)Predictive_Scenarios_Model_Files\(64d)cemex_sc
e4f_1\SWtest>diff mt3d001.mas ..\mt3d001.mas

Z:\(0)MPWSP_Model_Files_for_TD\(3)Predictive_Scenarios_Model_Files\(64d)cemex_sc
e4f_1\SWtest>diff mt3d001.obs ..\mt3d001.obs

Z:\(0)MPWSP_Model_Files_for_TD\(3)Predictive_Scenarios_Model_Files\(64d)cemex_sc
e4f_1\SWtest>diff mt3d.cnf ..\mt3d.cnf

Z:\(0)MPWSP_Model_Files_for_TD\(3)Predictive_Scenarios_Model_Files\(64d)cemex_sc
e4f_1\SWtest>diff cemex_sce4_1.glo ..\cemex_sce4_1.glo

Z:\(0)MPWSP_Model_Files_for_TD\(3)Predictive_Scenarios_Model_Files\(64d)cemex_sc
e4f_1\SWtest>
```

Figure C5. *Screen shot of using the DIFF command on 4 small output files of SEAWAT. The new output is in the current directory and the original output is in the parent directory (accessed by ..\). The blank line after the command indicates that no differences were found between the files.*

Comparison of Water Budget Components to App. E2

In Appendix E2, a series of attached tables show the annual water budgets for each case. To convert the model results, given as cumulative volumes once per month and illustrated in **Figure C1**, to the format of the tables, the following steps were taken.

1. Read only multiples of 12 water balances (12th month = 1st year, 24th month = 2nd year, 36th month = 3rd year, etc.).

2. Convert all quantities in cubic feet to acre-feet by dividing by 43,559.9.

3. Assume the following equivalences between quantities in the MODFLOW output (left hand side of equation) and Appendix E2 water budget table (right hand side of equation, with column number labeled)

    a. Head Dep Bounds In – Head Dep Bounds Out = [1] Northern, Eastern, and Southern, Model Boundary (Underflow)

    b. Recharge In + Wells In = [2]Stream Recharge and Deep Percolation from Precipitation and Applied Water (Irrigation) + [3] MPWSP with Injection Returning Basin Water

    c. Constant Head In = [4] Ocean Inflow

    d. Sum of a, b, c = [5] Total Inflow

    e. Wells Out = [6] Non-Project Groundwater Pumping + [7] Marina Coast Water District Desalination Pumping + [8] MPWSP Project Slant Well Pumping

    f. Recharge Out = [9] Aquifer Loss to Streams

g. Constant Head Out = [10] Ocean Outflow

h. Sum of e, f, g = [11] Total Outflow

i. Difference of d and h = [12] Change in Groundwater Storage (labeled In – Out)

j. Storage In – Storage Out = [12] Alternative means of calculating Change in Groundwater Storage (labeled Dstorage)

4. Calculate the difference between a through j for each year and the previous year (except for the first year of each 20-year time period, which is used directly).

The results of steps 1 – 4 are shown in Appendix E for each predictive case. The table number of the relevant table from DEIR Appendix E2 is shown in parentheses in the table title, and the column numbers to compare to are shown above the column headers.

The comparisons of the new simulation results to the tables are all reasonable, but the numerical values are not all identical, which is expected based on the differences between new simulation results and original simulation results described in Section 4.4.1 above. As a consistency check, the original simulation results for case nm_sce3n were processed as above. The results are shown in Appendix E just after the new simulation results for case nm_sce3n.

The original-simulation results are not identical, but are very similar, to the new-simulation results (generally, single digit differences in the final decimal place). The relative differences between the simulation results and entries in the Appendix E2 tables are generally in the 10^{-5} to 10^{-3} range for all entries except column [12]. This increase over the relative differences in the MODFLOW simulations themselves (most relative differences in the range 10^{-5} to 10^{-4}, as illustrated in **Figure C3**) is due to the fact that the quantities in the water budget tables are all derived from differences of simulation results (from one year to the next), so relative difference becomes larger.

An extreme version of this relative difference increase is apparent in column [12], which shows change in groundwater storage. This quantity is a difference of differences (Total Outflow – Total Inflow, from one year to the next). As the errors of individual terms are added and the value of the term itself gets smaller, relative difference can grow dramatically. This growth is illustrated in the tables shown in Appendix E, where the change in groundwater storage is calculated in two different ways: column [12] is the difference of column [5] and column [11], whereas [alt 12] is calculated directly from “STORAGE” terms in the MODFLOW water budgets (**Figure C1**). The differences between these two columns are indicative of the cancellation and round-off error occurring within a single numerical simulation. These differences are comparable to the differences between the new simulation results and those shown in column [12] in the Appendix E2 tables, indicating that it would be unrealistic to expect any closer agreement between distinct numerical simulations. Although differences appear large for small entries, when viewed in the context of the dominant terms in the water budgets, they are actually quite small.

Appendix D. Groundwater Conceptual Model

Hydrostratigraphy

Having reported on our groundwater modeling review above, we turn now to a review of the conceptual model of the hydrostratigraphic units in the vicinity of the CEMEX site. This hydrostratigraphy is discussed in the section "Pressure Area Aquifers and Aquitards" from pages 4.4-5 to 4.4-11. With increasing depth from the ground surface in the vicinity of the CEMEX site, this section describes the Dune Sand Aquifer, the 180-Foot Equivalent Aquifer (180-FTE), the 180/400-Foot Aquitard, the 400-Foot and 900-Foot Aquifers.

The hydrostratigraphy in the vicinity of the CEMEX site is represented on east-west cross section 1-1' and north-south section A-A' in Appendix E2. The portion of Section 1-1' shown on **Figure D1** indicates there is an aquitard between the Dune Sand and 180-FTE aquifers approximately two miles east of the site. It is possible this aquitard extends to the CEMEX site as there are no logs plotted on the section between the interpreted western edge of this aquitard and the site. There is also a well log plotted at the eastern edge of the CEMEX site (14S/2E-18E1) that has a 25-foot thick clay at the approximate position of this aquitard.

The eastern edge of this aquitard is shown on Section 1-1' as disconnected from the Salinas Valley Aquitard (SVA). However no log is plotted between the easternmost well with this aquitard (14S/2E-21E01) and the westernmost well with the SVA (14S/2E-21F02) to support this interpretation.

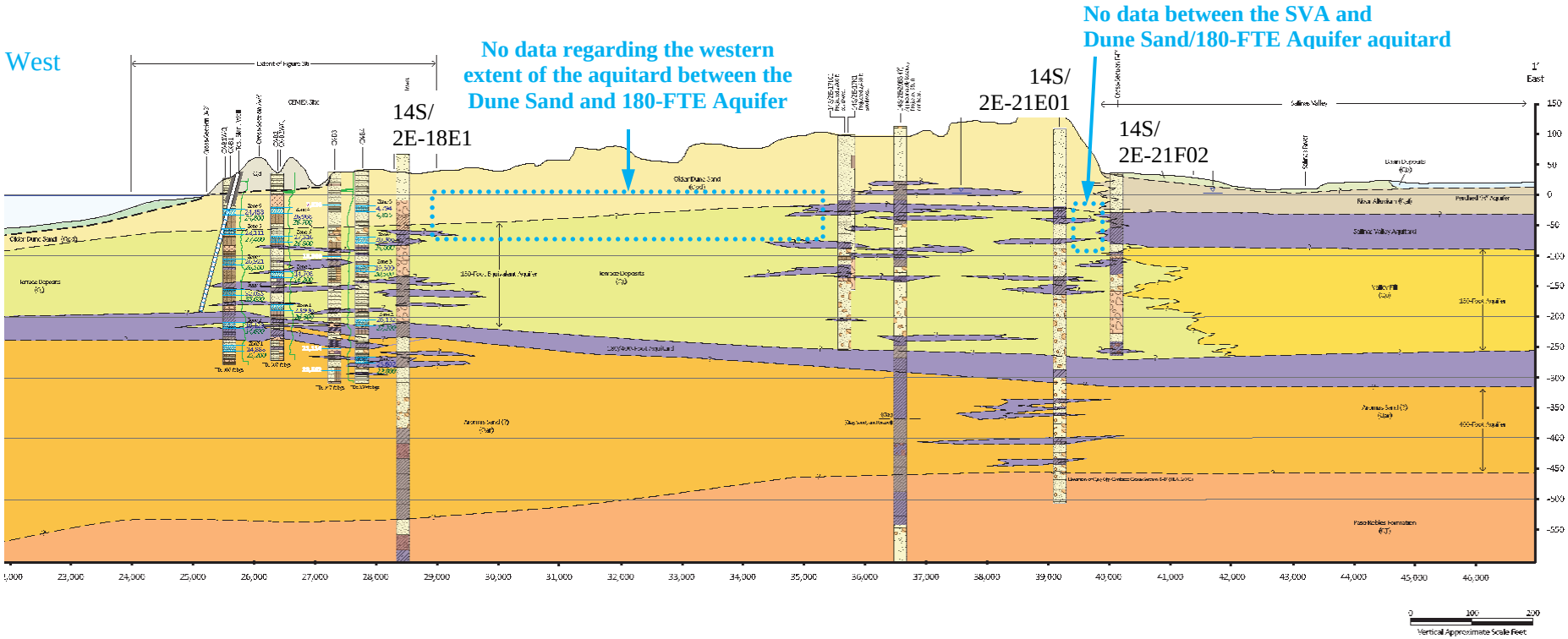


Figure D1. *The eastern half of Section 1-1' with data gaps regarding continuity of the aquitard between the Dune Sand and 180-FTE Aquifer indicated.*

The southern portion of Section A-A' is in generally the same location as southern portion of Section B-B' of Kennedy/Jenks Consultants (2004), which is referenced in the DEIR, as shown on **Figure D2**. Section A-A' interprets no aquitard at the contact between the Dune Sand and 180-FTE aquifers. Section B-B' does interpret an aquitard between these two aquifers, and interprets it as continuous with the SVA. The sections plot some of the same lithologic logs in their southern portions, including those indicated on **Figure D2**. The portion of these sections including these wells is shown in **Figure D2**.

Section B-B' interprets ~50 ft of sandy clay and ~20 ft of clay at depths of about 150 ft encountered in each of these borings, respectively, as separating the Dune Sand from the 180' Aquifer in the terminology of that report (Kennedy/Jenks Consultants, 2004). Section A-A' interprets these materials as within the 180-FTE Aquifer, and the 180/400-Foot Aquitard as passing through gravel and sand in those borings. The interpretation of Kennedy/Jenks Consultants (2004) is considerably more credible given the data.

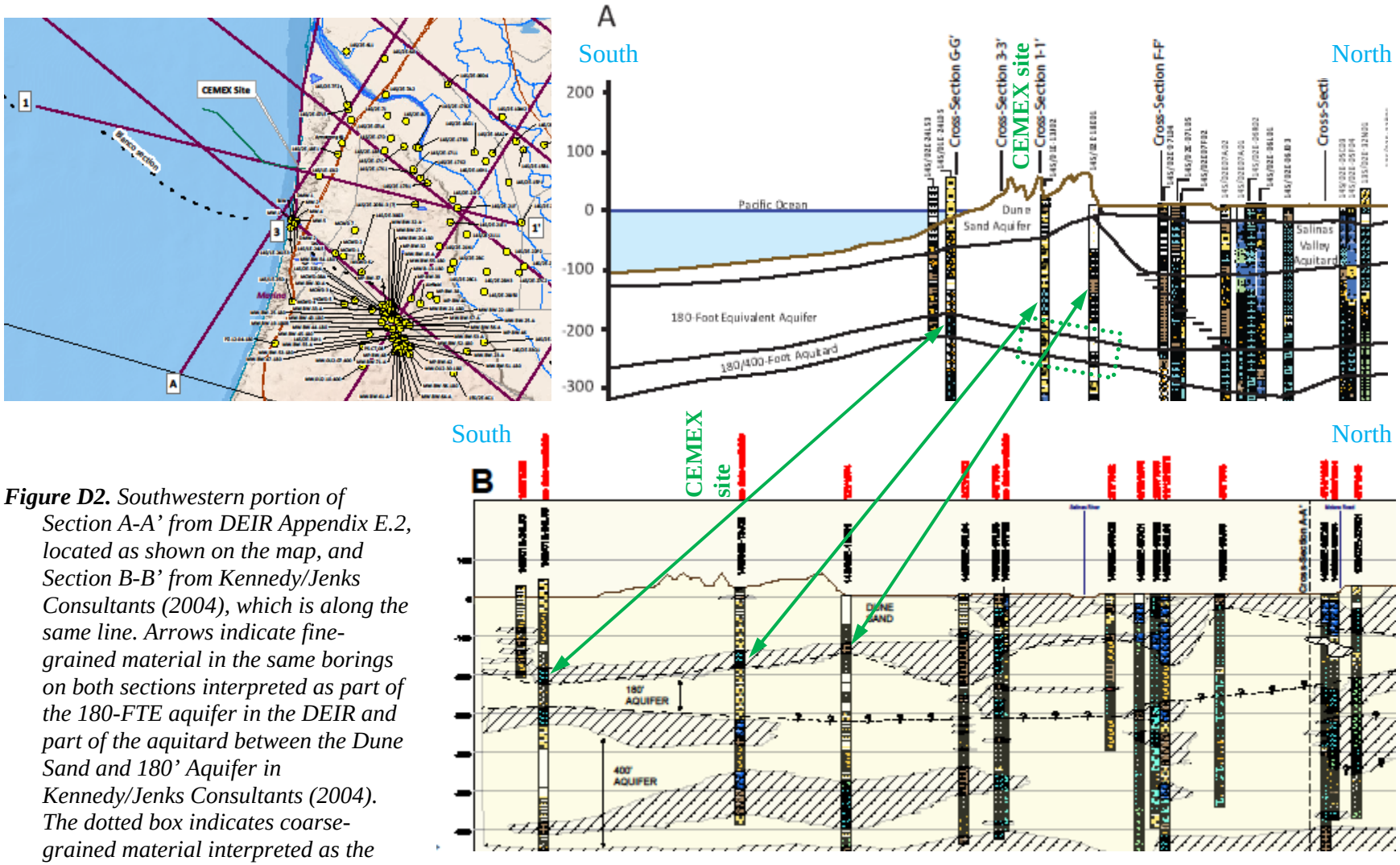


Figure D2. *Southwestern portion of Section A-A' from DEIR Appendix E.2, located as shown on the map, and Section B-B' from Kennedy/Jenks Consultants (2004), which is along the same line. Arrows indicate fine-grained material in the same borings on both sections interpreted as part of the 180-FTE aquifer in the DEIR and part of the aquitard between the Dune Sand and 180' Aquifer in Kennedy/Jenks Consultants (2004). The dotted box indicates coarse-grained material interpreted as the 180/400 Aquitard in the DEIR section.*

Beyond the references cited regarding the hydrogeology in the vicinity of the CEMEX site, no reference is made to reports resulting from remedial investigation of the former Fort Ord Army Base ("the former Base"). In particular, Harding Lawson Associates (1995) characterizes the hydrogeology of the former base.

Harding Lawson Associates (1995) defines an unconfined A-aquifer comprising primarily older dune sand. This is separated from the underlying 180-foot aquifer by the FO-SVA over most of the base. Harding Lawson Associates (1995) suggests the western edge of the FO-SVA is approximately two km east of the proposed slant well site. To the east of this location, the 180-foot aquifer is confined. To the west it is in hydraulic connection with the overlying A-aquifer, and so unconfined. In contrast the western edge of an aquitard in this stratigraphic position is more than three km east on section 1-1' in **Figure D1**, and does not appear to be included at all in the NMGWM, and Kennedy/Jenks Consultants (2004) interpret this aquitard extending to the CEMEX site and beneath the sea bed beyond.

Harding Lawson Associates (1995) divides the 180-foot aquifer into an Upper and a Lower portion based upon water level data. It finds the two are hydraulically disconnected by the intervening Intermediate 180-foot aquitard, and the Lower 180-foot aquifer is hydraulically connected to the 400-foot aquifer.

The 180-FTE aquifer is confined by the FO-SVA within the area with greater than one foot of water level drawdown predicted by the numerical simulation, as shown on Figure 4.4-14 in the DEIR. The absence of the FO-SVA in the numerical model allows areal recharge to the 180-FTE aquifer by the portion of precipitation that infiltrates past the root zone. This would tend to decrease the area with at least one foot of drawdown in the 180-FTE aquifer predicted by the model as compared to reality. However the gradient in the Dune Sand aquifer within a portion of the predicted drawdown area is toward the west, so a portion of the areal recharge in this area will still flow toward the proposed extraction wells where the FO-SVA is present, albeit through the smaller transmissivity of the Dune Sand aquifer alone as compared to that of the combined Dune Sand and 180-FTE aquifers in the model.

Depending upon how much the gradient in the A-aquifer in the modeled capture area is toward the west, the location of the capture zone that develops may not be substantially different from that modeled. However the area with greater than one foot of drawdown in the Dune Sand aquifer, which is only a portion of the capture zone, may be greater if the 180-FTE aquifer is confined at the edge of the FO-SVA. In this case, gradients in the Dune Sand aquifer over the FO-SVA will be greater than modeled and so water levels decline more within the capture zone. However in the case that the 180-FTE aquifer is unconfined at the edge of the FO-SVA, there will be no decline in water levels in the overlying Dune Sand aquifer. In this case, the input of areal recharge to the 180-FTE at the edge of the FO-SVA will not increase in response to extraction, and so the area of the capture zone in the 180-FTE aquifer will increase.

Consequently the distribution of water level drawdowns due to the proposed extraction will be different than those predicted by the model. The portion of the total volume of water extracted that is from beneath onshore is also likely to be different.

Hydraulic Parameters

Appendix E2 to the DEIR provides the hydraulic conductivities used in the simulation and indicates they are the result of textural correlations. **Table D1** compares these to hydraulic conductivities measured in a variety of tests reported in Harding Lawson Associates (1995) and Jordan et al. (2005).

Table D1. *Comparison of hydraulic conductivities based on textural correlations used in the NMGWM compared to calibrated values in that model and measured values reported by Harding Lawson Associates (1995) and Jordan et al. (2005). All values in ft/day.*

Aquifer	Appendix E2[1]				Harding Lawson Associates (1995)					Jordan et al. (2005)	
	Horizontal		Vertical		Slug		Specific capacity		Constant Discharge	Hori-zontal	Ver-tical
	I[4]	C[5]	I[4]	C[5]	R[6]	M[7]	R[6]	M[7]	R[6]		
Dune Sand (A-)[2]	109-304 (207)	270	8.16-11.87 (10.02)	10.02	6.4-95.0 (13)	28.1			1.6-41.1 (3)	7-10[a]	1-4[b]
180-FTE (Upper 180-foot)[3]	71-216 (143)	160	0.11-0.21 (0.16)	0.21-0.40	0.04-311 (25)	12.7	30-366 (10)	106[8]	0.32-44.0 (3)		

[1]Calibrated values for the portion of the NMGWM under the former Fort Ord near the CEMEX site

[2]Calibrated hydraulic conductivities from NMGWM layer 2

[3]Calibrated hydraulic conductivities from NMGWM layer 4

[4]Initial hydraulic conductivity range (and mean) input to the NMGWM model

[5]Hydraulic conductivity range calibrated by the NMGWM model to match well hydrographs

[6]Range (number of tests in parentheses)

[7]Geometric mean

[8]Given as 300, but value shown recalculated from individual test results

[a]Given in executive summary based on four different data types ranging from near-well to plume (~1 km) scale

[b]From natural and engineered recharge transients, rounded to one significant figure

Based on the results in **Table 2**, the vertical and horizontal hydraulic conductivity values for the Dune Sand and 180-FTE aquifer used to initialize the NMGWM and the resulting hydraulic conductivities calibrated by the NMGWM to match the well hydrographs appear too large. Additionally, the greater than two orders of magnitude larger horizontal than vertical hydraulic conductivity values for the 180-FTE aquifer is more than typical for a single hydrostratigraphic unit. These large ratios may be needed to compensate for the lack of the FO-SVA in the model. It may be that the values produced by a model including the FO-SVA are closer to those measured, particularly using those measured values as a starting point for calibration.

Storativity was also calibrated by the NMGWM. **Table D2** compares these values to those from earlier studies.

Table D2. *Comparison of storativities calibrated by the NMGWM for the Dune Sand (A-) aquifer compared to those reported by Harding Lawson Associates (1995) and Jordan et al. (2005).*

Appendix E2[1]	Harding Lawson Associates (1995)[2]	Jordan et al. (2005)[3]
0.065-0.1	0.0082-0.24 (0.106)	0.20-0.27

[1]Calibrated values for the portion of the NMGWM layer 2 under the former Fort Ord near the CEMEX site

[2]Value in parentheses is the mean

[3]Specific yield, which is virtually the same as storativity for an unconfined aquifer

Table D2 suggests the storativity values used for the A-aquifer in the model are smaller than the values based on field data in the other references. Given that this value has a strong effect on the propagation rate of drawdown in the unconfined Dune Sand aquifer, the NMGWM should also be run with higher initial storativities to determine how sensitive drawdown is to the value of this parameter.

Appendix E. Additional Appendix E2 Tables

(Separate Document)