MEMORANDUM

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Date: July, 2006
To: Josh Ferris, AES
From: Gus Yates, consulting hydrologist
Cc:
Subject: Detailed Description of Groundwater Model and Basinwide Salt Balance

Groundwater Model

The primary tool used to evaluate potential impacts on groundwater was a groundwater flow and solute transport model developed by San Benito County Water District and San Benito County. The model was first developed and documented in 2002 (Yates and Zhang 2001) but has evolved since then, including modifications implemented specifically to better evaluate impacts of the wastewater project. The model is regional in extent, covering the entire San Benito County part of the Gilroy-Hollister groundwater basin. The groundwater flow component of the model uses the MODFLOW2000 computer program developed by the U. S. Geological Survey (Harbaugh and others, 2000). Groundwater salinity is simulated using the solute transport program MT3DMS (Zheng and Wang, 1999), which functions as an extension to MODFLOW2000. Numerous spreadsheets, geographic information system (GIS) maps and Fortran utility programs were also developed to prepare input data sets for the models and to extract and display selected simulation results.

The finite-difference model grid includes five layers to enable simulation of vertical differences in groundwater levels and salt concentration. Grid cells are 250 x 250 feet near the DWTP and IWTP and increase to 1000 x 1000 feet in the rest of the basin. The model uses quarterly stress periods and was calibrated to measured groundwater levels and stream-aquifer fluxes during 1993-2003. Calibration of the flow component of the model is good, particularly in the San Juan and Hollister West subbasins.

The ability of the solute transport component of the model to correctly simulate existing TDS concentration at any point in the basin is limited. Salinity data are fairly sparse, especially for shallow aquifers. Available data show considerable spatial variability geographically and with depth. Because of this variability, contoured initial concentrations for deep aquifers (model layers two through five) are not highly reliable except near the measurement wells. There were too few points to allow contouring of salinity in shallow aquifers (model layer 1), and an initial concentration equal to the average of all available measurements was used throughout the basin. Furthermore, all salt load sources other than irrigation water were lumped into a single background mass load term that was calibrated using an assumption that existing shallow groundwater salinity is in equilibrium with recharge salinity. Because of these simplifying assumptions, the solute transport component of the model is primarily useful for comparing relative differences among alternatives rather than predicting absolute TDS concentrations.

Additional information regarding the models can be found in Appendix A.

Data and Assumptions for Model Scenarios

Impacts of the wastewater project were evaluated by comparing the results of several simulations representing existing conditions and various configurations of project Phases I and II. For each of these scenarios, water use and wastewater disposal practices were held constant and allowed to operate over a 30-year period of variable hydrologic conditions. That is, the model does not simulate the gradual transition from existing to Phase I and Phase II conditions over a period of 20 years, because variations in natural hydrologic conditions during that period could obscure the effects of the project. For example, if a drought happened to occur during Phase I but conditions were wet during Phase II, it would be difficult to isolate the impacts of the project from the effects of climatic conditions. Also, simulating each scenario over a 30-year period reveals whether the impacts of a given scenario would be particularly severe during droughts or wet periods.

The specifications for key variables in each scenario are listed in Table 1. Scenarios 1, 2 and 3 represent existing, Phase I and Phase II conditions, respectively. Various configurations of municipal water supply and wastewater disposal under Phases I and II are represented by letter suffixes: Scenarios 2a, 2b, 2c, 3a and 3b. In the model, existing conditions correspond to the year 2004, which is the year following the end of the model calibration period. Initial water levels in the model are the ending water levels from the calibration simulation.

Phase I corresponds to the year 2013, with municipal water use and wastewater generation estimated by assuming they both grow at 2.6% per annum in the City of Hollister (Hollister) service area and by 2% per annum in the Sunnyslope County Water District (Sunnyslope) service area. The default assumptions for Phase I are reflected in Scenario 2a. Percolation of domestic wastewater at the IWTP is assumed to be discontinued, and percolation at the DWTP is limited to the east beds only. Excess wastewater is disposed of by irrigation at San Juan Oaks golf course, an existing sod farm at the north end of Flint Road, a sprayfield (heavily-irrigated pasture or alfalfa) at the east end of the Flint Hills, a sprayfield at the north end of the Hollister municipal airport, and an agricultural demonstration project for crop irrigation with recycled water. The size and irrigation demand at each of these locations is listed in Table 2 and their locations are shown in Figure 1. Future increases in municipal water demand are assumed to be supplied entirely by CVP water, which implicitly assumed that the Lessalt treatment plant will be expanded or supplemented with an additional facility.

In the simulations, each disposal site is assumed to operate at its maximum capacity to receive wastewater. The combined capacity of the offsite disposal areas under Phase I is 5,755 af/yr, while the offsite disposal need amounts to only 1,750-2,590 af/yr depending on which DWTP beds are used for percolation. Thus, the simulated impact at each disposal location is the maximum impact that would occur at that location, and in most cases the actual impact would be smaller.

Scenario 2b is the same as Scenario 2a except that percolation at the DWTP is limited to the west beds only, instead of the east beds. Scenario 2c is the same as Scenario 2a except that all future increase in municipal water demand beyond the 3,000 af/yr capacity of the Lessalt treatment plant would be obtained from groundwater. Although this would likely involve the installation of new wells, specific well locations have not been identified. As a surrogate, pumping at all Hollister and Sunnyslope municipal supply wells was assumed to increase by a uniform percentage to meet the indicated demand level.

Phase II corresponds to the year 2013. Municipal water use and wastewater generation are assumed to continue growing at the rates assumed for Phase I. The default assumptions for Phase II are generally the same as for Phase I and are represented by Scenario 3a. A major difference is that the salinity of wastewater is assumed to be 600 mg/l, versus the concentration of 1,300 mg/l used for existing conditions and Phase I. The target salinity for Phase II is 500 mg/l and the maximum would be 700 mg/l. The average of these two endpoints was used in the Phase II simulations. As a result of the lower salinity, disposal of wastewater at the sprayfields would be phased out in favor of using the water for irrigation of agricultural crops. The exact location of this recycling use has not been specified. For the purpose of simulating potential impacts, it is assumed to occur in the Freitas Road area (see Figure 1). This area presently uses groundwater for irrigation and domestic supply. Scenario 3b is the same as Scenario 3a except that future increases in municipal water use are assumed to be supplied by groundwater rather than CVP water (analogous to Scenario 2c for Phase I).

The maximum offsite disposal capacity under Phase II is 8,300 af/yr, whereas the disposal requirement is at most 3,900 af/yr (assuming only the east beds are used for percolation at the DWTP). In Scenarios 3a and 3b, each disposal area is assumed to receive its maximum feasible amount of wastewater, which corresponds to the maximum local impact. In practice, the Flint Hills and airport sprayfields would likely not be used, which reduces offsite disposal capacity to 3,980 af/yr, or almost exactly the required amount.

Reference Simulation for Existing Conditions (Scenario 1)

Scenario 1 (existing conditions) is the reference simulation to which other scenarios are compared to evaluate impacts. Simulated water levels, water budgets and water quality were extracted from model output for locations that could be affected by the project. Figure 2 shows hydrographs of simulated groundwater levels in model layers 1 (to layer) and 5 (bottom layer) at 12 potentially impacted locations. The locations are shown in Figure 1, and some of them do not correspond to existing well locations. Almost all of the hydrographs show two periods of substantial water-level decline followed by recovery to the prior stable level. These two periods correspond to the 1976-1977 and 1987-1992 droughts in the hydrologic timeseries used for the simulations. The magnitudes of these drought declines are relevant because they provide context for evaluating the significance of water-level changes associated with the wastewater project. Several other patterns in the hydrographs are worth noting. For example, water levels near San Juan Oaks golf course show little seasonal or drought-related variations because there is little groundwater extraction in that area. Water levels near the airport sprayfield have an upward trend because water levels in that area are still recovering from historical overdraft. Water levels near the airport are expected to continue rising over at least the next 10 years, with or without the project. In most locations, vertical water-level gradients are small. That is, water levels in model layer 1 are nearly identical to water levels in model layer 5. Notable exceptions are at the DWTP and IWTP, where high rates of recharge elevate groundwater levels in layer 1 and create a relatively large downward gradient.

Figure 3 shows contours of groundwater elevation in model layer 1 (blue contours on left-side plots) and depth to groundwater in model layer 1 (purple and red contours on right-side plots). The upper plots are for December 1990, which in most locations was when water levels were at their lowest point during the 30-year simulation. The lower plots are for March 1998, which was when water levels were highest. Water levels in model layer 1 are shown because the effects of changes in irrigation and decreased percolation at the DWTP and are most pronounced in model layer 1. To avoid cluttering the plots with unnecessary information, the depth-to-water contours are limited to areas where the simulated depth to water is 100 feet or less.

The contours of groundwater elevation reveal the direction of groundwater flow, which is perpendicular to the contour lines. Along the San Benito River, groundwater flows parallel to the river. With the 10-foot contour interval used in the plots, there is a slight indication of the water-table mounds beneath the DWTP and IWTP. Relatively low subsurface permeability in the southeastern part of the San Juan Valley creates a moderate water-table slope from the hills (including San Juan Oaks golf course) toward the river. There are abrupt steps in groundwater elevation across the northern part of the Calaveras Fault west of the airport sprayfield and from south to north across the eastern tip of the Flint Hills, between Buena Vista and Wright Roads. The water table slopes steeply upward as it enters the hills on either side of the valley because the overall permeability of geologic materials is lower in the hills, where valley-floor alluvium is absent.

Comparing the elevation contours for December 1990 and March 1998 reveals that the range of water-level variation in layer 1 under existing conditions is about 15 feet near Lucy Brown Lane and increases to about 40 feet between the DWTP and Nash Road. The range of variation is about 20 feet at the northern edge of the proposed Flint Hills sprayfield location and about 15 feet at the airport sprayfield.

The contours of depth to water reveal potential problems with shallow water table conditions. The contour interval in these plots is 5 feet, which more clearly reveals the recharge mounds along the San Benito River and beneath the IWTP and DWTP. The groundwater model underestimates the extent and severity of shallow groundwater problems for the following reasons:

- Vertical discretization is coarse. The simulated water levels for layer 1 correspond to the mid-point elevation of layer 1, which is over 100 feet thick in most places. In locations with large vertical gradients (such as near percolation ponds), the groundwater elevation at the top of layer 1 would be noticeably higher than at the middle of layer 1.
- The model was calibrated primarily to groundwater levels in deep wells, which in most locations are lower than groundwater levels near the ground surface. There are exceptions in areas with flowing wells near San Juan Bautista and Lovers Lane/San Felipe Lake.
- Some shallow groundwater problems are caused by shallow clay layers that impede the downward flow of irrigation water and infiltrated rainfall. Water levels over these clay layers can be higher than the regional groundwater levels simulated by the model.

In spite of these limitations on accuracy, the simulated depth to water reveals areas where shallow water table is likely to be a problem. Also, a comparison between simulations indicates whether shallow water table problems are likely to improve or worsen under various scenarios.

Areas where the water table is relatively shallow that could be affected by the project include the DWTP, IWTP, an area north of San Juan Oaks golf course, and the west end of the San Juan Valley (near the left edge of the plots). Another shallow groundwater area appears prominently in the upper-right corner of the plots (near Fallon Road), but that area would not be affected by the project. Depth to water is fairly large at the airport sprayfield location (20-35 ft) and the Flint Hills sprayfield location (over 100 feet).

Figure 4 is a stacked-bar graph showing the simulated annual groundwater budgets for the San Juan subbasin under existing conditions during the 30-year simulation period. For the purposes of this analysis, the area included in the subbasin was extended north to the centerline of the Lomerias Muertas/Flint Hills and east to halfway between the DWTP and IWTP. This shift in the eastern boundary allows water budget changes associated with DWTP percolation to be entirely included in the budget summary. Groundwater inflows are represented by bar segments above the zero line on the Y axis. Groundwater inflow from the Hollister West subbasin contributes a constant but fairly small component of inflow. Recharge from rainfall and irrigation water is the largest source of inflow but is also quite variable. This source contributes large amounts of inflow in wet years (for example, 1983 and 1998) and relatively little during droughts (1976-1977 and 1987-1992). Recharge from the San Benito River is greatest in the first normal or wet year following a drought (1978 and 1993) when there is a large amount of vacant groundwater storage capacity available for refilling. Even though river flow was high in 1998, river recharge was only average because the basin was already full. Finally, wastewater percolation at the DWTP contributes a constant annual inflow averaging about 13% of total inflow.

Groundwater extraction by wells is the largest outflow, averaging 61% of total outflow. Groundwater extraction varies noticeably from year to year in response to rainfall conditions and cutbacks in the availability of CVP water during droughts. Groundwater discharge into the lower ends of San Juan Creek and the San Benito River is the only other major outflow. This discharge is relatively small during droughts—when groundwater levels are low—and high during wet periods.

The groundwater budgets for Scenario 1 are also summarized in Figure 5, which compares average annual inflows and outflows for Scenario 1 with the corresponding flows for the other scenarios.

Figure 6 shows contours of simulated concentration of total dissolved solids in model layers 1 and 5 after 30 years under existing conditions. Even after 30 years, the salinity distribution is strongly influenced by the assumed initial conditions, which are very approximate. Errors associated with limitations of the solute transport component of the model apply to all of the scenarios, however, so that differences in concentrations between scenarios are more accurate than the actual concentrations simulated for each scenario. In spite of these limitations, a few salinity patterns are evident and worth noting. Model layer 1 was assumed to have a uniform initial dissolved solids concentration of 2,330 mg/l. Over the 30-year simulation period, percolation along streams and the San Benito River locally diluted layer 1 groundwater to less than 1,000 mg/l. Salinity in layer 1 remained much greater than in layer 5 throughout the simulation. Salinity patterns in layer 5 at the end of the simulation were nearly the same as the initial conditions. There is a swath of low-TDS groundwater along Pacheco Creek derived from creek percolation. A broad zone of relatively high groundwater salinity includes the central and eastern parts of the San Juan Valley.

The simulated trajectory of the contaminant plume at the Whittaker site over a period of 30 years under Scenario 1 is shown as the red lines in Figure 7. Each line represents the path of a water particle originating from one of 40 hypothetical starting locations in the source area along the lower slopes of the hillside south of the DWTP. The blue arrows in the figure are velocity vectors for groundwater in layer 1. There is an 88-fold difference in calibrated permeability between model cells in the hillside area and model cells in the valley floor area, reflecting the relatively high permeability of the alluvial deposits in the valley. The hydraulic gradient beneath the hillside is directly downslope toward the valley floor. The gradient in the valley floor deposits at that location is parallel to the edge of the valley, as indicated by the blue arrows. The arrows are velocity vectors of groundwater movement in layer 1. The arrow points in the direction of flow, and the size of the arrow is proportional to the flow velocity. The arrows clearly reveal the radial flow outward from the east and west bed percolation ponds at the DWTP and also show the relatively high rate of flow down through the relatively permeable channel deposits beneath the San Benito River. Groundwater flowing downvalley beneath the river diverges and spreads out where the alluvial deposits widen into the San Juan Valley. The contaminant plume happens to be at the tip of the gap where the alluvial deposits are narrowest. Because the hillslope and valley-floor gradients are perpendicular to each other at that location, the plume makes a 90-degree left turn as soon as it reaches the alluvium. This pattern is corroborated by field data presented in a recent quarterly monitoring report (Seley pers. comm.). Because of the 90-degree bend, the plume converges to a relatively narrow strip of superimposed particle traces. The traces shown in the figure are in model layer 1. The simulations showed some particles descending into deeper model layers and following essentially the same plan-view trajectory. From the standpoint of project impacts, a key question is whether the groundwater flow direction near the edge of the alluvium is driven by the groundwater mound beneath the DWTP or by divergence of regional groundwater flow as it enters the valley. Simulations for Scenarios 2a and 2b address this question.

Changes in Basinwide Salt Balance

It is difficult to separate impacts of salt mass balance from salt concentration. For example, importation of CVP water and percolation from local streams both add dissolved minerals (salt) to the basin, which from the standpoint of salt balance would appear to be an adverse impact. However, both of those salt inputs are accompanied by large quantities of water so that the concentration is low and has the beneficial effect of decreasing the average concentration in the groundwater basin. As long as these complexities are kept clearly in mind, an evaluation of changes in the average annual salt balance of the basin does provide a useful perspective on the effectiveness of the wastewater project in addressing long-term groundwater salinity issues.

A simple tabulation of salts that enter and leave the basin would fail to address the dominant process affecting long-term groundwater salinity, which is evaporative concentration of salts in irrigation water. Dissolved minerals in groundwater used to irrigate crops are already in the basin, so evaporative concentration of that water does not constitute an addition of salt to the basin. However, with respect to the concentration of salts in groundwater—which is the fundamental issue of concern—removing pure water and leaving its salt content behind is functionally the same as adding those salts to the basin from an external source.

The wastewater project would affect the amount of salt entering and leaving the basin and also affect the evaporative concentration of salts that are already present in the basin. Some components of the salt budget are poorly known, but many of these would not change as a result of the project. Examples include salt loads from groundwater inflow, application of gypsum to agricultural fields, and atmospheric deposition. Rather than attempt to estimate complete basinwide salt balances for each scenario, this analysis considers only salt budget items that would be affected by the project. By summing the effects on each of these items, the net impact on the salt balance is obtained.

The salt budget items that would be affected by the project are shown in Table 3. "New" salt in wastewater excludes salt that originated from groundwater pumped by municipal wells but includes salt in CVP water used for municipal supply. Under Scenarios 2c and 3b, groundwater demineralization would remove more salts than are added from the CVP fraction of municipal supply and from normal salt pickup during municipal use. Evaporation of wastewater includes evaporation during treatment, storage and percolation at the DWTP, plus evaporation at sprayfields and crops irrigated with recycled water. The salt load equivalent to evaporative concentration is 90% of the salt in the irrigation water (at 90% irrigation efficiency, 90% of the water evaporates or is transpired by plants). To estimate evaporative concentration of salts in agricultural irrigation water, the existing basinwide use (roughly 25,000 af/yr) is decreased by the amount of groundwater irrigation that is replaced with recycled-water irrigation (for example, at the sod farm and Freitas Road area). Groundwater used for irrigation is assumed to have an average TDS concentration of 900 mg/l, and the salt content of 90% of the applied water is the equivalent salt load. In urban areas, the equivalent salt load calculation accounts for the fraction of municipal water supplied by groundwater, the fraction of municipal water used for irrigation (60%), and the effect of groundwater demineralization in Scenarios 2c and 3b. Salt export by streams is calculated by the solute transport component of the groundwater model.

Recharge from streams and importation of CVP water are both desirable from a salt management standpoint because their concentrations are low. Rather than calculate the salt load from those sources—which would ignore the low concentration—the change in flow was tabulated. Increases in these flows have a beneficial impact on groundwater salinity.

The top half of the table shows the salt loads and water flows for each scenario, and the bottom half of the table shows the difference between each scenario and the existing condition (Scenario 1). These results indicate that Scenarios 2a and 2b would increase the basinwide salt load, Scenario 3a would result in a small increase, and Scenarios 2c and 3b would decrease the overall salt load because of the physical removal of salt by demineralization. All of the with-project scenarios would increase importation of CVP water and all but one would increase recharge from streams. Scenario 3a would result in a net decrease in stream recharge because of the decrease in groundwater pumping for irrigation in the Freitas Road area. Scenarios 2c and 3b would cause relatively large increases in stream recharge because the greater amount of municipal groundwater pumping would induce additional stream percolation. However, these two scenarios would be associated with the smallest increases in CVP imports. Scenario 3a would result in the largest combined increase in these two beneficial flows, and the totals for the other scenarios are all about half that large.

the most adverse impact on the overall salt budget,

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Seley, Kristina. Water Resource Control Engineer. California Regional Water Quality Control Board, San Luis Obispo, CA. January 23, 2006—e-mail transmittal to Gus Yates of groundwater flow maps from the 2nd quarter 2005 monitoring report for the former Whittaker ordnance facility cleanup program.

Table 1. Hollister-Sunnyslope Water Use and Wastewater Disposal Specifications for Scenarios 1 through 3

	Existing Condition	Phase I			Phase II	
Model scen	1	2a	2b	2c	3a	3b
Year	2004	2013	2013	2013	2023	2023
Hollister-Sunnyslope municipal water supply (af/yr)						
Groundwater	3,946	3,946	3,946	4,935	3,946	7,221
CVP water	2,330	3,989	3,989	3,000	6,275	3,000
Total	6,276	7,935	7,935	7,935	10,221	10,221
IWTP disposal (af/yr)						
Domestic wastewater	516	0	0	0	0	0
Cannery wastewater and stormwater	800	800	800	800	800	800
Evaporation	146	73	73	73	73	73
Net percolation	1,170	727	727	727	727	727
DWTP disposal (af/yr)						
DWTP inflow	2,475	1,490	2,324	1,490	1,490	1,490
Evaporation	347	347	347	347	347	347
East bed percolation	780	1,143	0	1,143	1,143	1,143
West bed percolation	1,348	0	1,977	0	0	0
Total percolation	2,128	1,143	1,977	1,143	1,143	1,143
Domestic wastewater salinity (mg/l TDS)	1,300	1,300	1,300	1,300	600	600
Offsite disposal (af/yr)						
Flint Hills sprayfield	0	3,175	3,175	3,175	3,175	3,175
Airport sprayfield	0	1,154	1,154	1,154	1,154	1,154
San Juan Oaks golf course	0	520	520	520	520	520
Pacific Sod farm	0	792	792	792	792	792
Agricultural demonstration project	0	113	113	113	0	0
Freitas Road area	0	0	0	0	2,660	2,660
Total disposal capacity	0	5,755	5,755	5,755	8,302	8,302

Table 2. Area and Irrigation Demand for Offsite Disposal Areas Simulated in the Model

Location	Area[1] (acres)	Irrigation rate[2] (in/yr)	Irrigation volume[3] (af/yr)	Current irrigation source
Flint Hills sprayfield	762	50	3,175	None
Airport sprayfield	277	50	1,154	None
San Juan Oaks golf course	160	39	520	CVP
Pacific Sod farm	257	37	792	Groundwater
Agricultural demonstration project	68	20	113	Groundwater
Freitas Road area	1,520	21	2,660	Groundwater

Notes:

[1] These are the total areas of the recharge zones used to represent each facility. They slightly exceed irrigated area.

[2] The evapotranspiration multiplier in the soil moisture budget simulation program that creates the recharge file for the groundwater model was adjusted so that simulated irrigation rates approximately matched those assumed for "typical" climatic conditions in the wastewater disposal capacity studies (Van Horne, 2005). These were 50 in/yr for sprayfields, 37 in/yr for turf, and 20 in/yr for crops.

[3] In areas currently irrigated by groundwater, this is the amount by which pumping at local wells was reduced when irrigation was switched to recycled water for Phase I and II scenarios. For the agricultural demonstration project in Phase I, pumping was decreased by only 40% of the indicated amount because recycled water was assumed to be blended with CVP water to achieve a TDS concentration of 700 mg/l.

Table 3. Project Impacts on Selected Salt Budget and Related Water Budget Items

	Existing Condition	Phase I			Phase II	
Model scenario:	1	2a	2b	2c	3a	3b
Year	2004	2013	2013	2013	2023	2023
Affected Salt and Water Budget Items						
Salt Budget (tons/yr)						
New salt in wastewater	1,909	2,869	2,869	-1,396	3,734	-2,434
Evaporative concentration of wastewater	612	4,462	3,138	4,462	2,994	2,994
Evaporative concentration of groundwater						
Agricultural irrigation	27,479	26,485	26,485	26,485	23,685	23,685
Urban irrigation	2,024	2,024	2,024	1,085	2,024	1,587
Salt export by streams	-23,216	-23,164	-23,675	-22,771	-25,320	-24,236
Water Budget (af/yr)						
Recharge from streams	15,097	15,514	15,200	16,119	14,411	16,432
Municipal and agricultural use of CVP water	22,330	23,469	23,469	22,480	25,755	22,480
Change in Budgets Relative to Existing Condition						
Salt Budget (tons/yr)						
New salt in wastewater	n.a.	960	960	-3,305	1,825	-4,343
Evaporative concentration of wastewater	n.a.	3,850	2,526	3,850	2,382	2,382
Evaporative concentration of groundwater						
Agricultural irrigation	n.a.	-995	-995	-995	-3,794	-3,794
Urban irrigation	n.a.	0	0	-939	0	-437
Salt export by streams	n.a.	52	-459	445	-2,104	-1,020
Total		3,815	2,491	-1,389	413	-6,193
Water Budget (af/yr)						
Recharge from streams	n.a.	417	103	1,022	-686	1,335
Total CVP imports	n.a.	1,139	1,139	150	3,425	150

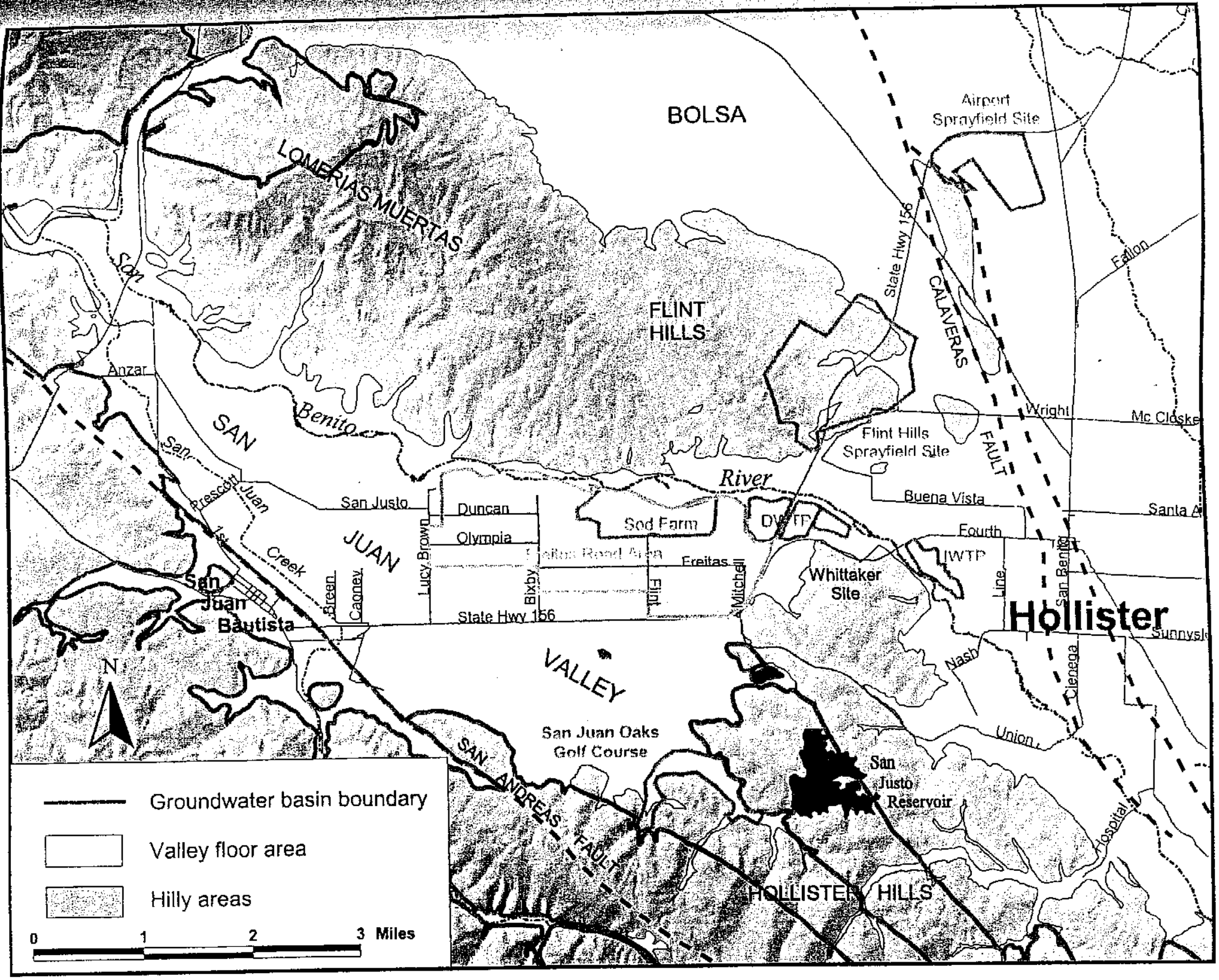


Figure 0-01. Location of Existing and Proposed Wastewater Treatment Facilities and Disposal Areas

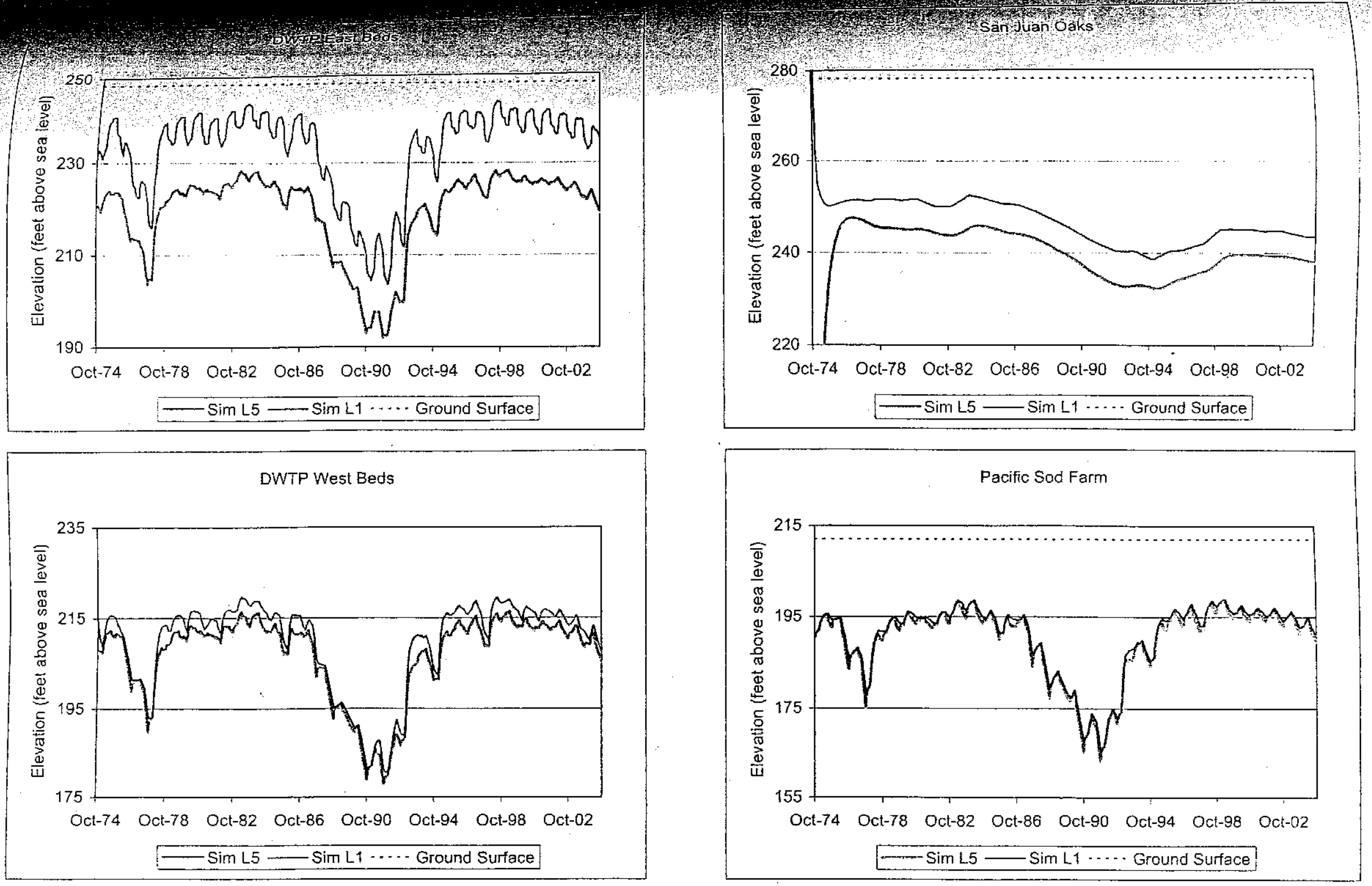
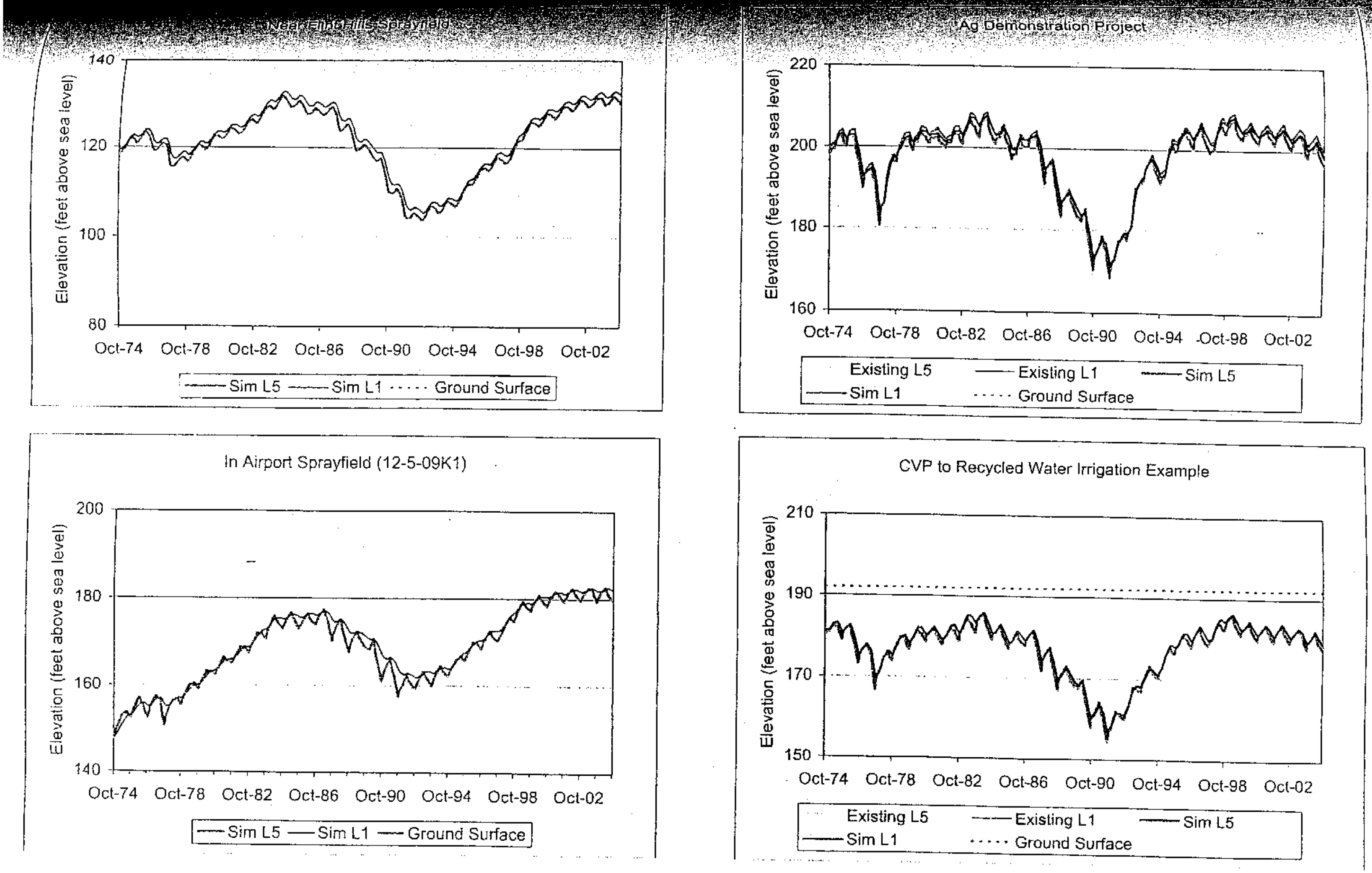


Figure 2. Hydrographs of Simulated Groundwater Elevation in Potentially Affected Locations



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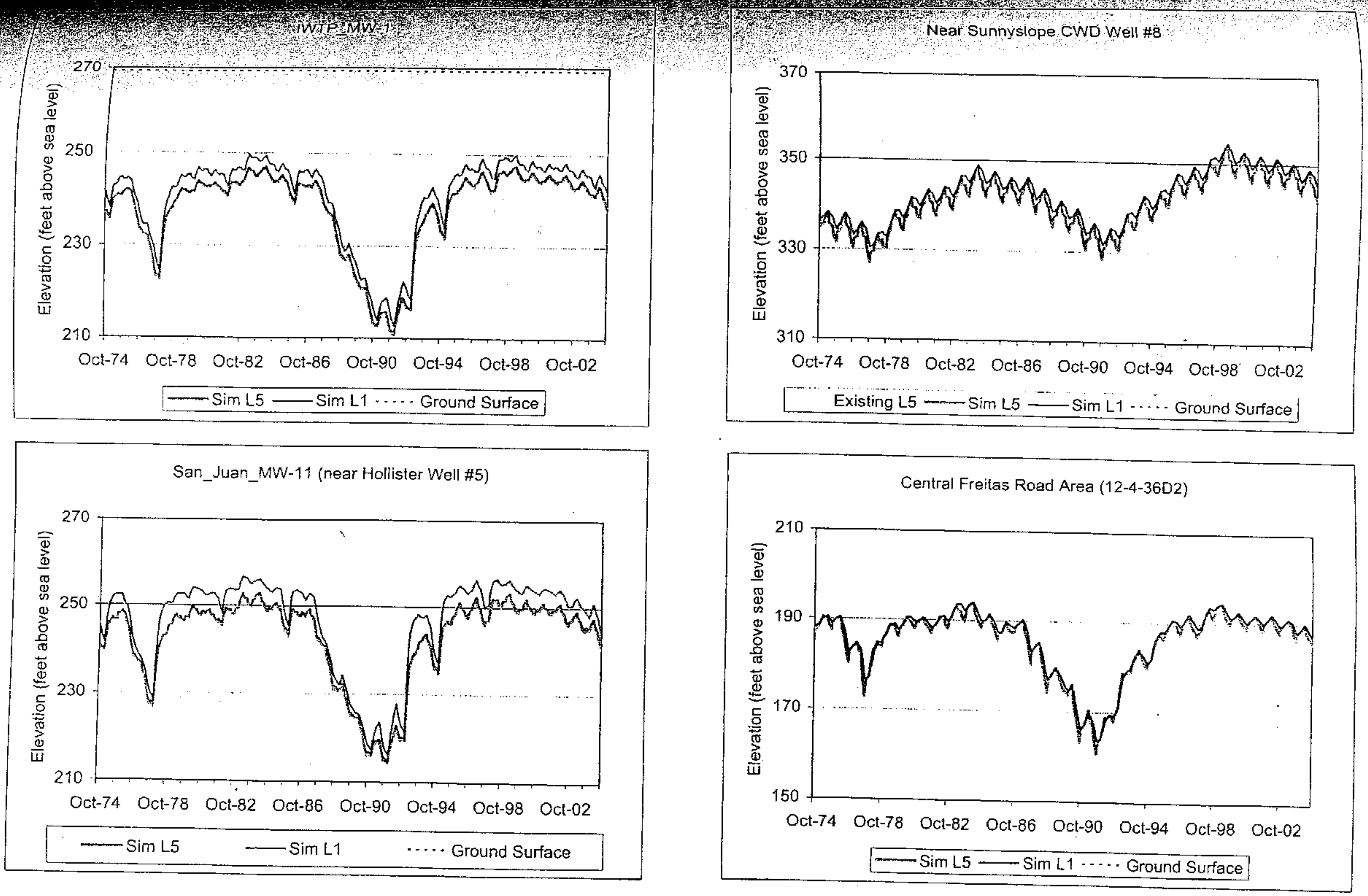


Figure 2 – continued

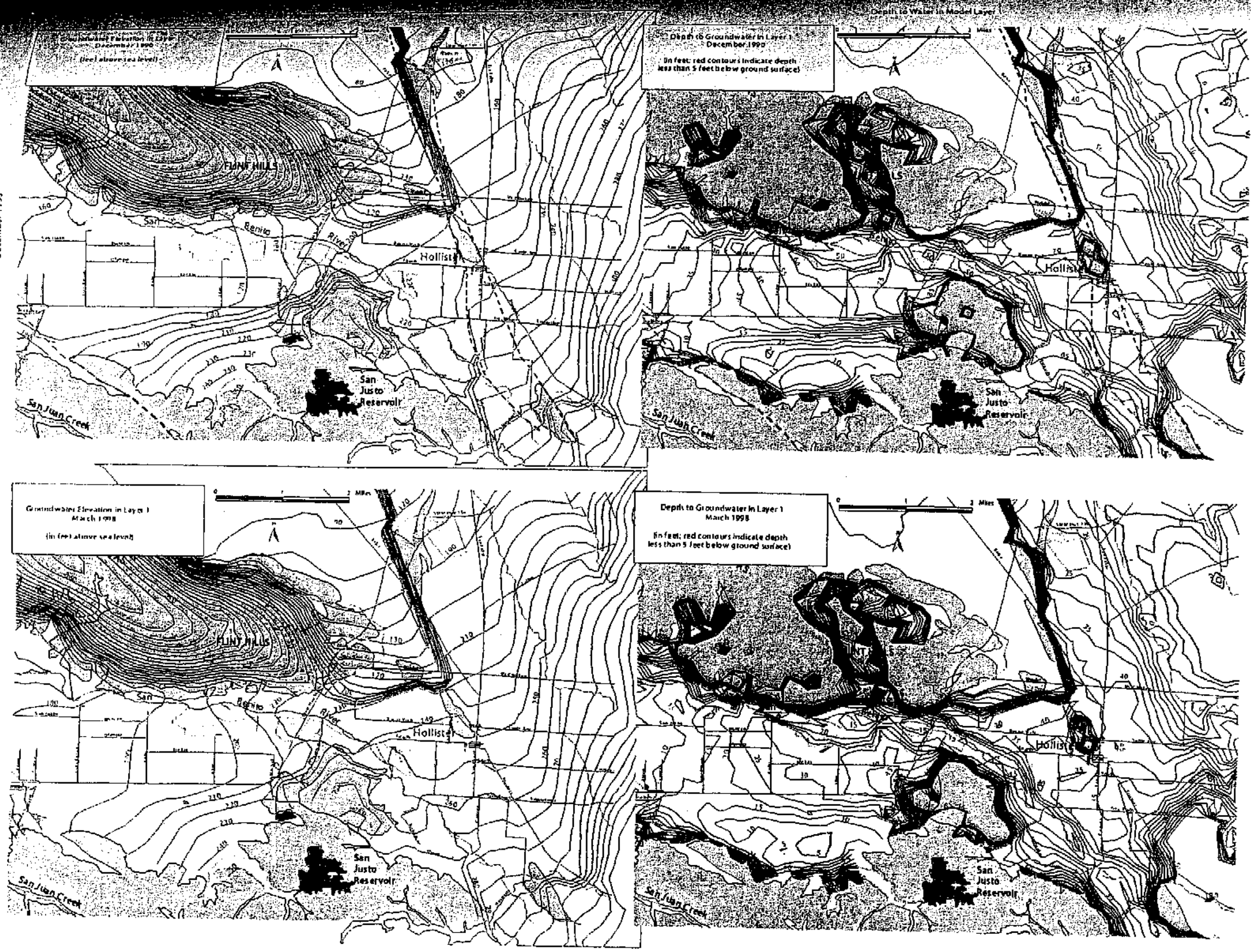


Figure 3. Simulated Groundwater Elevation and Depth to Groundwater in Model Layer 1 under Scenario 1

Scenario 1

Existing conditions
  2005 water use and wastewater gene
  1,300 mg/l wastewater salinity

DWTP percolation
  2,128 ac-ft/yr (1.9 mgd)
  East and west beds

Offsite disposal and recycling
  None

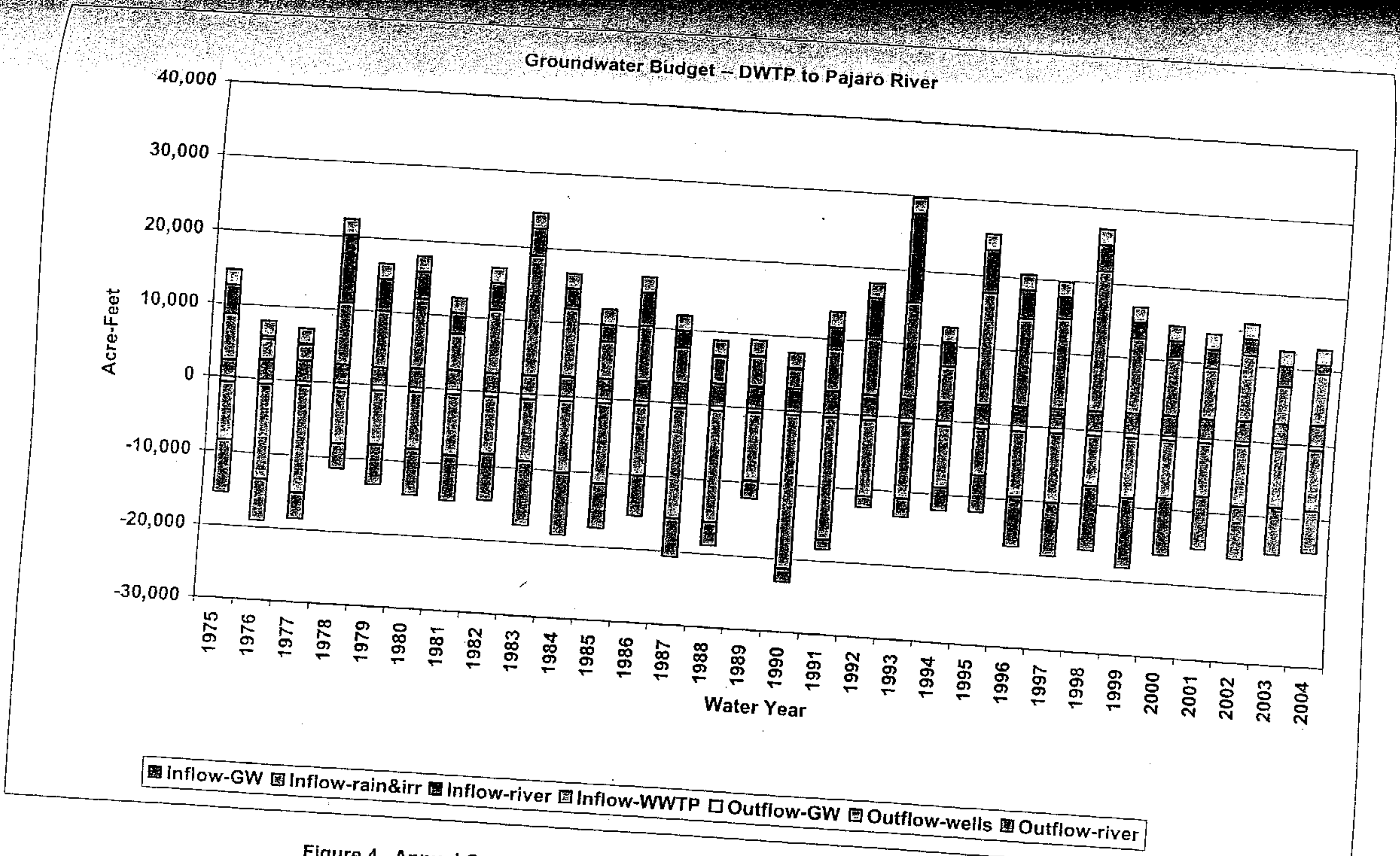


Figure 4. Annual Groundwater Budgets under Scenario 1 with 1975-2004 Hydrolog

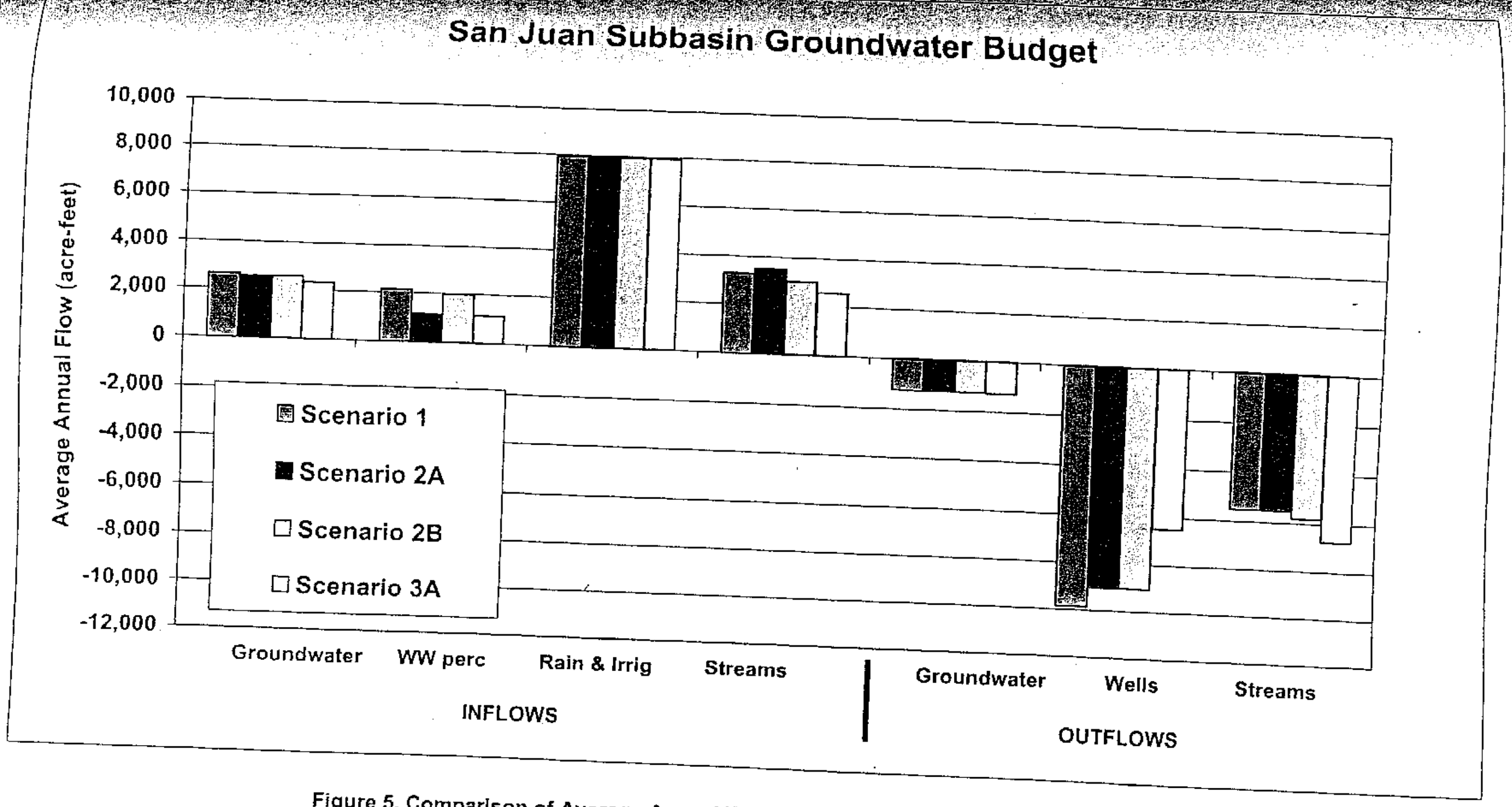
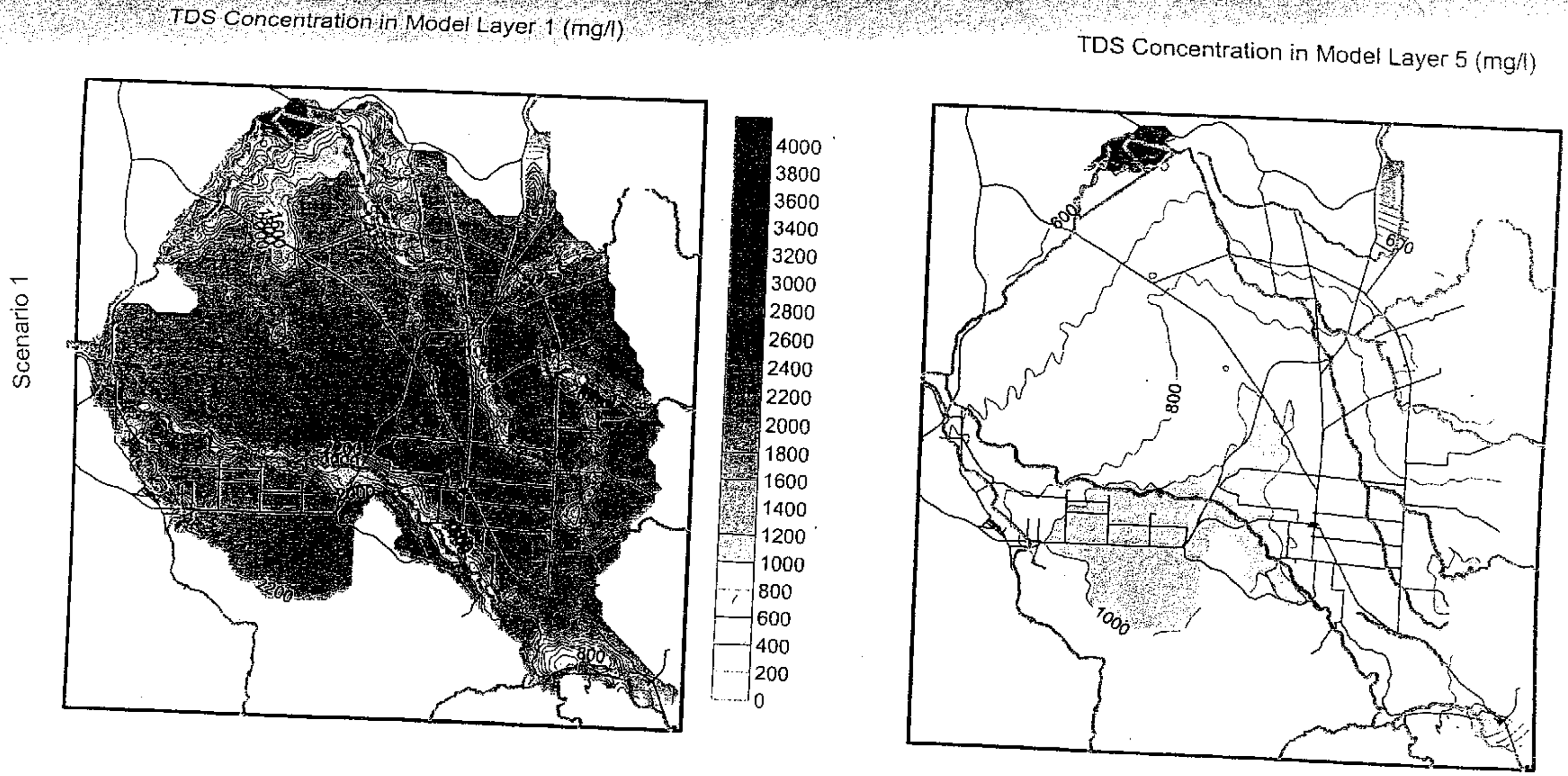


Figure 5. Comparison of Average Annual Water Budgets under Scenarios 1 through 3b


TDS Concentration in Model Layer 1 (mg/l)

TDS Concentration in Model Layer 5 (mg/l)

Figure 6. Contours of Groundwater Salinity after 30 Years under Scenario 1

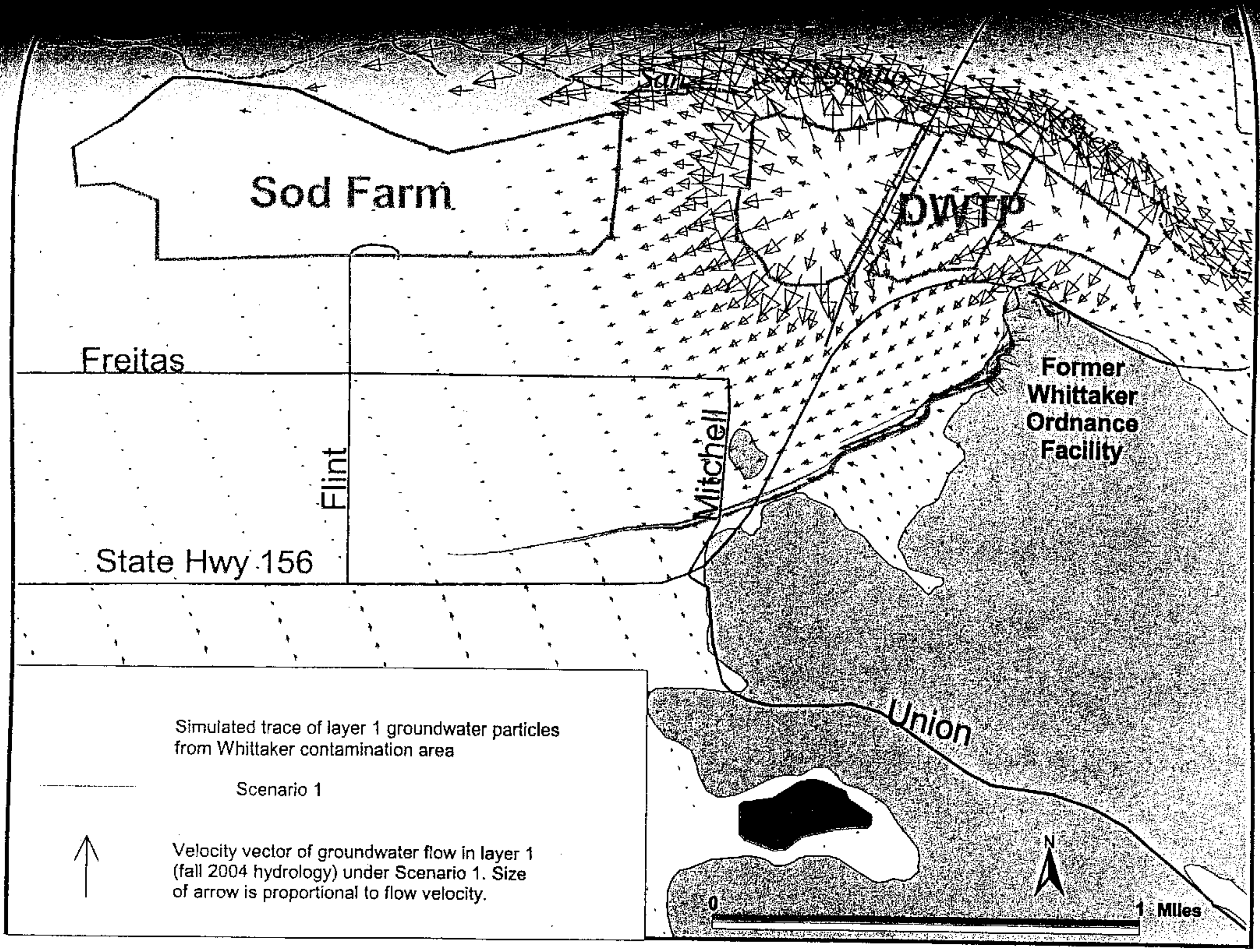


Figure 7. Simulated 30-year Path of Whittaker Contaminant Plume under Scenario 1

Appendix A: Detailed Groundwater Model Description

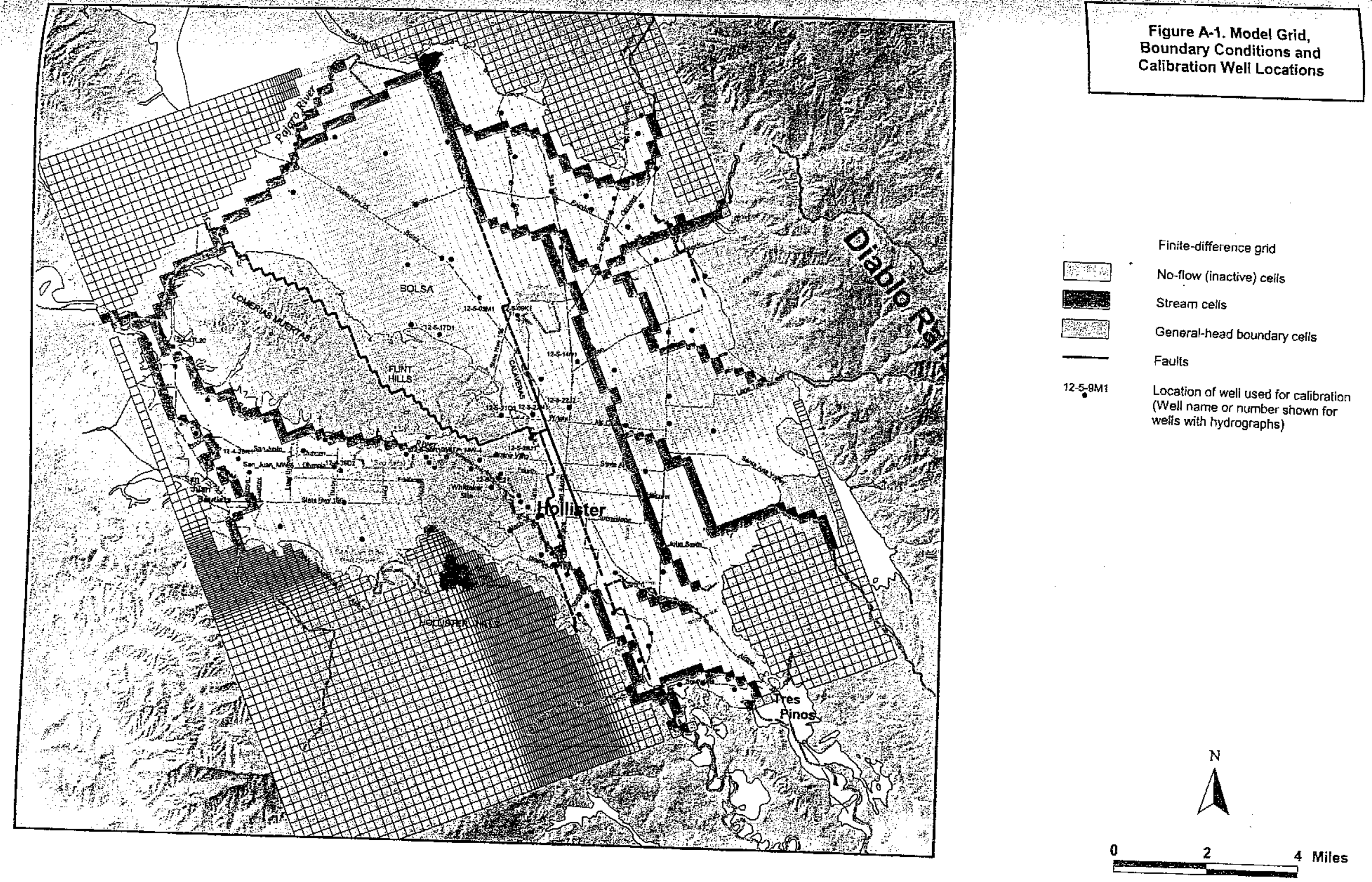
The groundwater model used to evaluate groundwater impacts is a modified version of the regional groundwater flow model developed by San Benito County Water District (SBCWD) and San Benito County in 2001 (Yates and Zhang 2001). Figure A-1 shows the the extent of the model and the finite-difference grid used in the model to simulate water levels at discrete points across the basin. The model has continued to evolve since 2001 as new information becomes available and to improve its capabilities. This includes modifications specifically implemented for the wastewater project. Modifications implemented since 2001 include:

- The grid spacing was decreased in the vicinity of the DWTP and IWTP in order to provide greater detail in simulated water table mounding beneath the percolation ponds.
- The model was divided into five layers in order to represent vertical differences in water levels and salinity. The upper surface of the top layer (layer 1) was shaped to parallel the relatively low water table surface at the start of the calibration period. This helps prevent layer 1 cells from going dry when simulated water levels fall below the bottom elevation of layer 1.
- The original calibration period was January 1993 to September 2000. This was extended through September 2003. The model uses quarterly time intervals for transient simulations.
- The active part of the flow domain was expanded to include the Lomerias Muertas/Flint Hills area and the Hollister Hills area that projects north from near San Justo Reservoir. Subsurface permeability is lower in these hilly areas than in the valley floor areas, but they are all part of a single, continuous groundwater flow system. The original model had excluded these areas. They were added to the model in order to explore potential impacts on the groundwater contaminant plume at the former Whittaker ordnance facility and on groundwater flow and salinity near the proposed Flint Hills sprayfield site.
- The simulation of salt loading was completely revised to include separate loads from individual sources (stream percolation; wastwater percolation; recharge from rainfall and irrigation water, etc.) and to simulate loads on a transient basis. Salt loading by deep percolation of infiltrated rainfall and irrigation water was converted to a spatially variable input by calibrating a "background mass load" based on local groundwater salinity and irrigation water salinity. The background mass load represents all sources of dissolved solids in the deep percolation other than irrigation water (gypsum, fertilizers, atmospheric deposition, and dissolution of soil minerals) and was calibrated so that simulated deep percolation salinity equaled shallow groundwater salinity. Shallow groundwater salinity was set equal to the average of ten shallow wells in the San Juan Valley (2,330 mg/l) because spatial variability and lack of data in other parts of the basin precluded contouring shallow groundwater salinity. Sufficient data were available to contour deep groundwater salinity, and the contouring was smoothed to eliminate the effects of what appeared to be local outliers with high concentrations.

- Recharge zones for future simulations were revised to conform with the 2002 land use survey completed by the California Department of Water Resources and to include separate zones for wastewater disposal and reuse areas. The model calibration period was simulated using the 1997 land use survey.
- The recharge preprocessor was modified to account for recharge on peripheral hills that are not included in the active part of the model flow domain.
- Mathematical functions relating stream depth, width and dissolved-solids concentration to stream flow were greatly improved based on new field data collected by SBCWD in 2004.
- The MODPATH extension to the MODFLOW model code was implemented to simulate the Whittaker contaminant plume path
- The ZONEBUDGET extension to MODFLOW was implemented to obtain water budget information for subregions of the model flow domain.
- Inflow to the basin through alluvium along creeks (Pacheco Creek, Arroyo de las Viboras, Arroyo Dos Picachos, Tres Pinos Creek and the San Benito River was represented by general-head boundaries. Inflow beneath the Pajaro River from the Llagas area was similarly represented. The conductance terms for these inflows were calibrated to obtain reasonable inflow rates comparable to the estimated inflows in water budgets developed for SBCWD annual groundwater reports.
- The model was completely recalibrated. This included redefining zones of hydraulic conductivity and storativity, adjusting their parameter values, adjusting the locations and conductances of faults, and adjusting streambed permeability. Shallow wells were added to the calibration data set to support calibration of vertical hydraulic conductivity.

Hydrographs of simulated and measured water levels at 16 of the 106 well locations used for model calibration are shown in Figure A-2. These are wells located in the area that would be directly affected by the wastwater project, and their locations are labeled in Figure A-1.

Figure A-1. Model Grid, Boundary Conditions and Calibration Well Locations



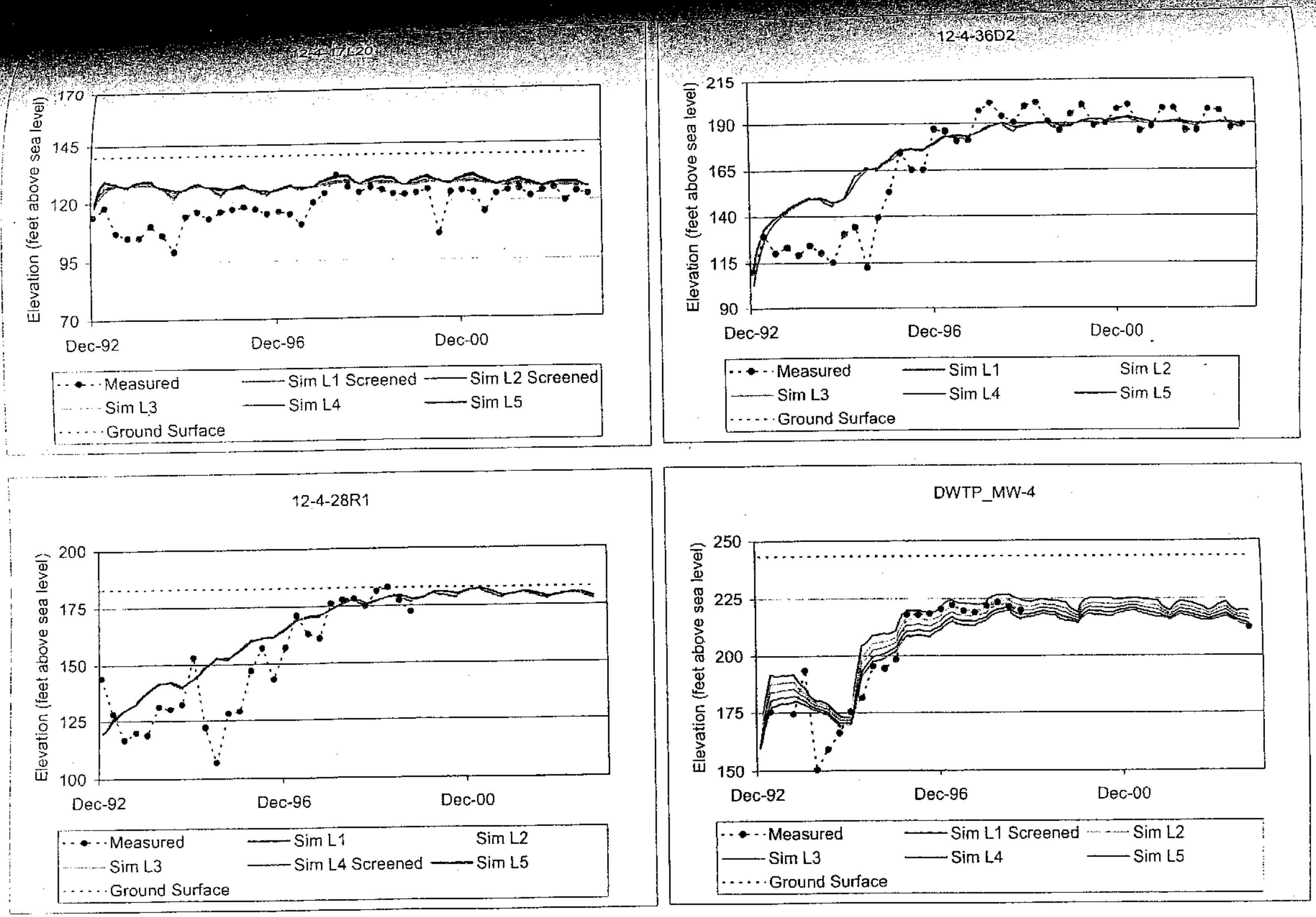


Figure A-2. Hydrographs of Measured and Simulated Groundwater Elevation during 1993-2003 at Selected Calibration Wells

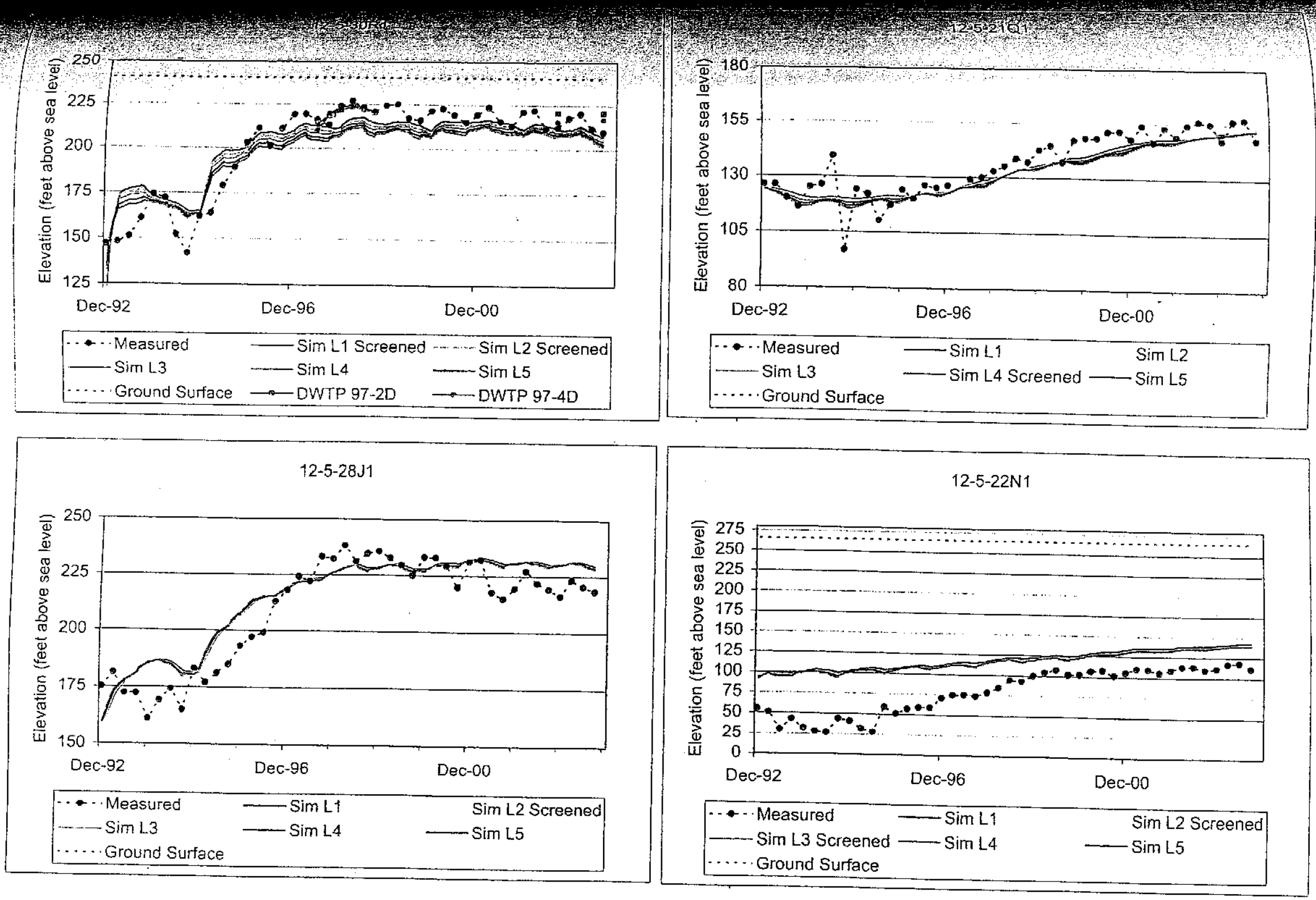


Figure A-2 continued

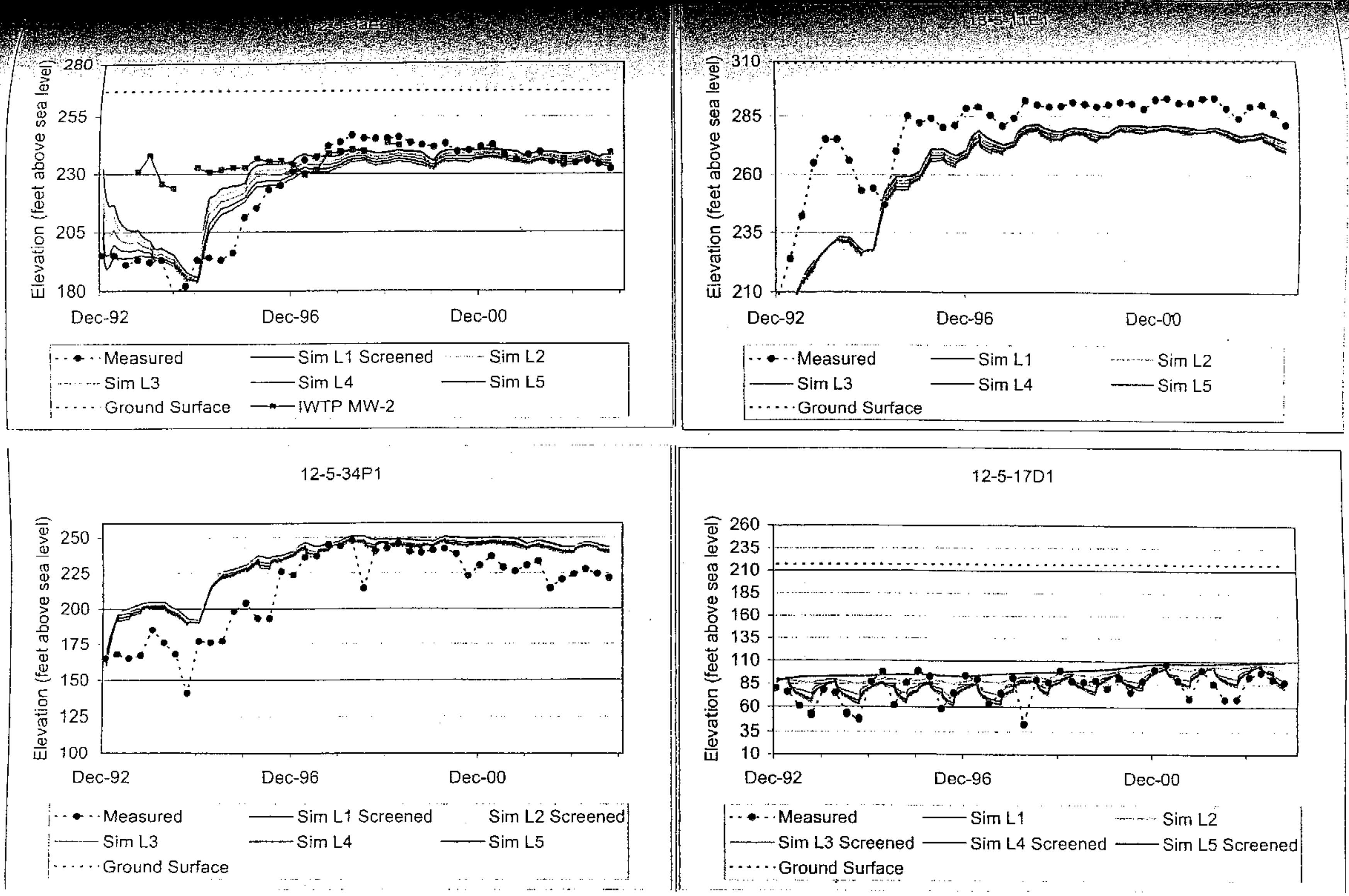
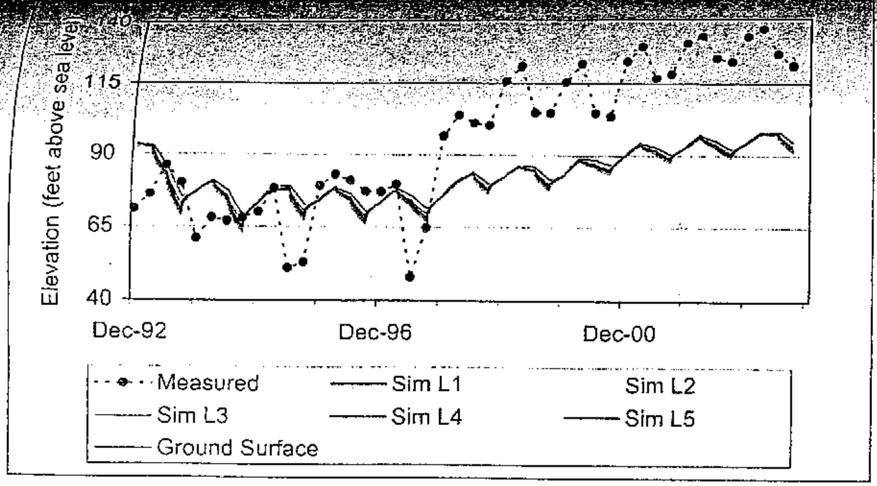
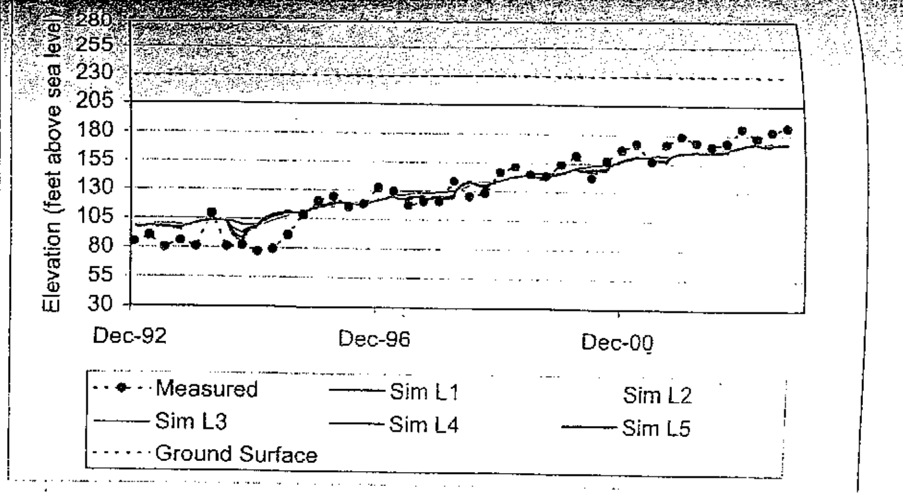
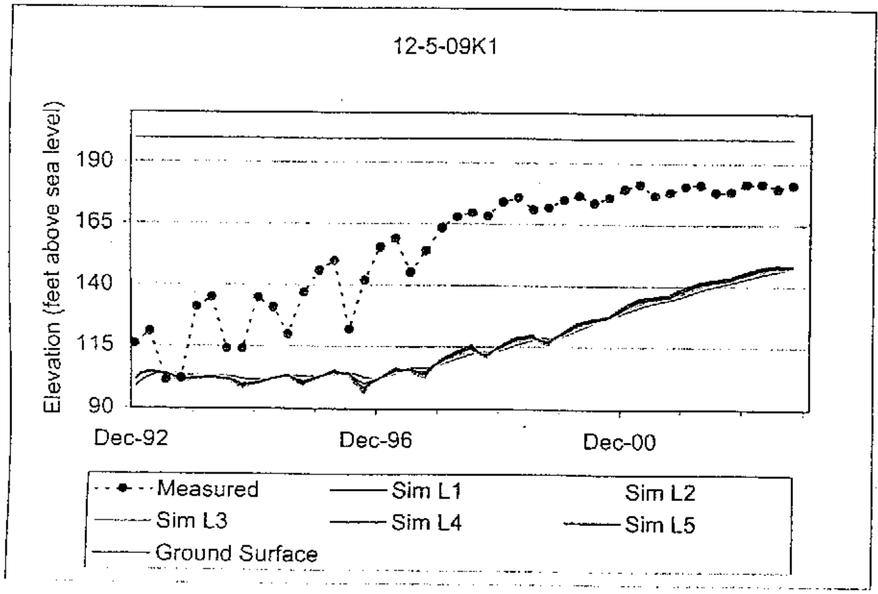


Figure A-2 continued







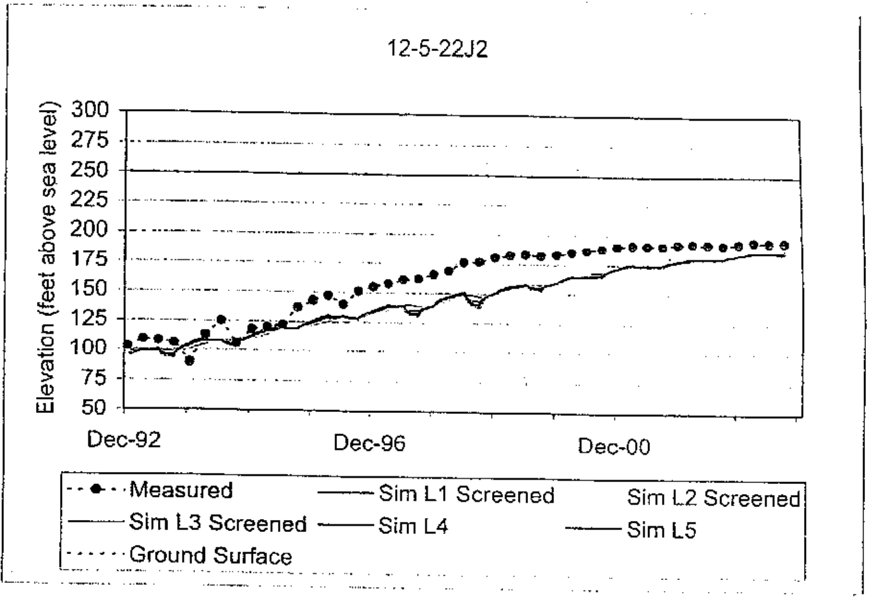


Figure A-2 continued