DEVELOPMENT OF A CHEMICAL USE MANAGEMENT PLAN
A CASE STUDY OF THE RESORT AT SQUAW CREEK
SQUAW VALLEY, CALIFORNIA

by

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Abstract. In 1983, Perini Land and Development Company proposed to construct a hotel-golf course complex at Squaw Valley, California. Because of the scenic and environmentally sensitive area, residents and local authorities requested a study of the potential environmental impact. The principal concern was the effect, if any, herbicides, pesticides, and fertilizers used on the golf course greens and fairways would have on surface and ground water. The initial step in the evaluation process was to establish baseline concentrations of the existing chemical constituents in the basin's ground water. Representative fertilizers and pesticides were evaluated for persistence, mobility, toxicity, and efficiency. The data used in the evaluation were obtained from a toxicological review of existing data, leach column testing, and operation of a test green.

Results of the study indicated that the potential environmental impact from pesticides could be mitigated through special golf course design considerations and the restriction of the types and amounts of the products used in the operation of the course. The test green was constructed and operated for 2-1/2 years. Modeling data showed that long-term distribution of nitrate increases in ground water would have a relatively low potential impact on ground water in the area, provided the recommended fertilizer application rates are followed.

Introduction

This paper summarizes the methods of study used by Kleinfelder to develop a chemical use management plan for the proposed hotel and 18-hole golf course associated with the Resort at Squaw Creek. The study was conducted to alleviate concerns regarding the effect that chemicals used on the golf course would have on the area's alpine environment.

The project site is located near the Lake Tahoe Basin, which is a world class recreation area and which was the site for the 1960 winter Olympic games. Figure 1 shows the general configuration of the valley and surrounding area.

Background

In 1983, Perini Land Development Company proposed to build a hotel-golf course resort complex at Squaw Valley. Announcement of the project sparked immediate opposition by local residents and environmental groups, including The Sierra Club. the parties opposed to the project filed suit against Perini, charging that the impact of the project on the environment had not been fully studied. An agreement was eventually reached between Perini and the project opponents, wherein Perini agreed to meet 128 conditions to protect the environment of the valley (Placer County, 1985). In exchange, the opposition agreed not to oppose the project if it could

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be demonstrated that the project could be managed to reduce or eliminate significant damage to the environment. Kleinfelder was selected for the study because of its experience and familiarity with the Lake Tahoe Basin. The study was subject to the scrutiny and approval of a Technical Review Committee (TRC) mandated by the courts (Perini, 1985). The TRC consisted of representatives from both the proponents and the opponents of the project.

Site Description

Squaw Valley is an 8 square mile (5,100 acre) watershed in the Truckee River Basin located between Tahoe City and Truckee, California. Present uses of the valley include approximately 800 residential units, an Olympic ski area, and limited commercial development. Water supplies are drawn exclusively from within the watershed, nearly entirely from wells at the western end of the valley floor. The principal source of water for the valley is an aquifer of unconsolidated glacial and post-glacial sediments beneath the 400-acre valley floor. The estimated average thickness of the aquifer is about 80 feet. Previous geophysical studies in the valley suggest that the maximum depth to bedrock varies from about 120 to 180 feet along the longitudinal axis of the basin (Gasch 1973).

Baseline Environmental Study

The initial phase of work consisted of establishing baseline conditions in the valley prior to construction of the proposed development. The scope of work used to assess the baseline conditions is presented in the following subsections.

Surface Water

Development of an accurate baseline required that samples be collected during all 4 seasons of the year. Due to the alpine setting, collecting samples of stream flows was difficult and even dangerous at times. A telemetry system was set up on the banks of Squaw Creek for remote monitoring during periods when access was inhibited. Close monitoring was necessary because runoff caused wide fluctuations in the rate of sediment transport. The amount of sediment in suspension was found to affect the nutrient level in the stream and, therefore, the baseline water quality values of the stream. Data collected over 2 years of operation spanned one unusually wet year and one unusually dry year.

Soil Mapping

Prior to constructing the test green, the natural soil conditions in the area were studied. Soil samples were collected at numerous locations within the valley. Several samples of material for column leach studies were collected near the proposed test green site.

Analytical testing indicates that these soils are predominantly calcic with fairly neutral pH conditions. As expected, the cation exchange capacity directly correlated with the content of organic material.

Ground Water

Ground water monitoring wells were installed at the locations shown in Figure 1 to evaluate pre-project ground water quality. A total of 36 paired wells (1 shallow and 1 deep) were installed to aid in the identification of multiple aquifers. The high TDS observed in samples from the deeper wells is speculated to be the result of hydrothermal solutions migrating upward through fracture zones. The deeper wells generally exhibit higher sulfate values than the shallower wells. The well installation specifications followed standard Environmental Protection Agency protocol. The wells were secured using 5-foot high security caps to facilitate access during the snowy winter season. Hydrographs for 3 wells located adjacent to the test green are presented in Figure 2.

Pesticide Use Evaluation

The evaluation of potential pesticides for use on the golf course consisted of a 4-step process. Each step in the process was designed to provide additional information on the viability of each compound with respect to the negotiated pesticide selection criteria. This criteria consisted of evaluating pesticide candidates for the following: toxicity, mobility, persistence, and efficiency. The evaluation process is discussed in the following subsections.

Toxicity

Literature collection on the toxicity, mobility, persistence and efficiency of the active ingredients began with a Toxline computerized literature search at the National Library of Medicine. Complete copies of all relevant papers were then obtained from the University of California Library. Additional references were identified from bibliographies of the papers identified in the Toxline search and from the card catalogue of the University of California Library. About 774 published articles were provided to the TRC.

Concurrent with the search of open literature, the EPA was consulted for copies of all relevant studies on environmental fate and toxicity. These studies were provided on microfiche and represented the final reports of studies conducted by the registrant of each active ingredient to support registration with the EPA. A total of 1,391 pages of microfiche, containing up to 60 pages of original documents per page of microfiche, were provided to members of the TRC. In addition, the members of the TRC received copies of summaries and evaluations of data gaps provided by the EPA and the California Department of Food and Agriculture.

The literature for each active ingredient was organized by subject (e.g., acute toxicity, subchronic toxicity, etc.) and then organized chronologically within each subject. The documents were read and summarized. An overall summary of all databases, with an identification of data gaps, was prepared for each active ingredient. Finally, interactions between chemicals, including fertilizers, were evaluated.

The toxicological review resulted in the identification of four candidate pesticides, which are:

2,4-d [2,4-dichlorophenoxy acetic acid] A herbicide used in Weed-B-Gon by Ortho, this chemical is fairly mobile in soils and approximately 95% of it is absorbed by plants. It does not bioaccumulate in the flood chains and is quickly degraded by microbes in approximately six weeks.

Mecoprop (MCPP) [2-(4-chloro-methyl) phenoxy-propionic acid] A co-constituent of Weed-B-Gon, this is mobile in soil and readily absorbed by plants. For biodegration, it has a half-life of approximately 2 weeks.

Chloroneb [1,4-dichloro - 2,5-dimethoxy - benzene] A fungicide used under the trade name Fungicide II by Scotts, that is immobile in soil. Its biodegration half-life is approximately 2 to 5 weeks.

Glyphosate [N - (phosphoromethly) glycine] A herbicide used in Round-up by Monsanto that is immobile in soil. It is rapidly absorbed by plants and biodegrades slowly.

Mobility

The mobility of the candidate pesticides identified in the toxicological literature review was evaluated in the laboratory by leach column testing prior to field testing. The leach columns were packed with soil obtained from the site. A schematic representation of the leach columns is shown in Figure 3. To decrease the observation time required to observe breakthrough, the tests were expedited by using relatively small samples, high aliquot concentrations, and large hydraulic heads. Test results indicated that the mobility of the candidate pesticides under actual field conditions would be very low.

Persistence and Efficiency

The third step in the evaluation process was the construction of a prototype green/fairway area to field test the compounds that appeared acceptable, based on data obtained from the toxicological evaluation and leach column testing.

The test green was constructed with both a lined and unlined section (See Figure 4). The fill section for the unlined portion of the test green was engineered fill, which consisted of recompacted native soils from a proposed pond borrow site. Rocks larger than 12 inches in diameter were screened out and the remaining material was placed as engineered fill within 12 in. of finished rough grade. The fill was compacted to a minimum of 85% relative compaction, in accordance with ASTM D-1557-78 Standards. A 6 in. thick section of washed 3/4 in. gravel was placed over the native fill. A subdrain was placed within the gravel layer by installing 4 in. diameter perforated pipes running along the centerline of each of the 4 unlined cells. Solid 4 in. PVC collector pipes were attached to the subdrains and daylighted in a catch basin at the west side of the fairway. A 12 in. thick surface layer consisting of sand and rice hulls (as specified by the golf course architect, Robert Trent Jones II) was placed above the gravel layer and served as the turf-growing medium. Corrugated fiberglass panels were installed vertically between each cell to function as impermeable dividers to inhibit vadose zone water migration between cells.

The lined portion of the test green was constructed separately from the adjacent unlined green. Two liner types were evaluated: a compacted soil liner consisting of mixing the native soils with about 10-15% bentonite clay, and a synthetic membrane. The cost differential between the 2 types of liners justified an evaluation of both types of liner systems.

Construction of the lined section of the test screen proceeded as follows:

Initially, an 18 in. section of the engineered fill, as previously described, was placed and compacted above the native ground. Next, an impermeable membrane of 30 mil hypalon was placed on the engineered fill section following the removal of surface rocks. Three inches of clean sand was spread across the liner surface prior to the placement of a 6 in. thick section of washed 3/4 in. gravel. Another liner was placed above the gravel layer and consisted of a 9 in. thick section of a compacted soil/clay mixture of 15% bentonite by weight, plus sand and gravel, with a maximum of 10% passing the 3/8 in. sieve. Another 6 in. of washed 3/4 in. gravel was placed above the soil/clay liner. The area was covered with the same 12 inches of sand and rice hull turf-growing medium. Subsurface drainage was installed in both gravel layers using 4 in. perforated pipes. Each layer flows into collector pipes that daylight in catch basins located on the east side of the fairway.

The vadose zone of both the lined and unlined portions of the test green was monitored by analyzing samples from pressure-vacuum lysimeters. The lysimeters were installed 0.5 ft above the desired depth using a hollow-stem auger; then a split-spoon sampler was driven to the desired depth and the unit installed within the split-spoon cavity. Flexible tubing connected the lysimeters to a central sample collection point. Pressure/vacuum lysimeters were installed at 2 locations in each of the 5 cells. At each of the 10 locations, 4 lysimeters were placed at various depths. In each configuration, a shallow lysimeter was placed in the gravel drain layer, while 3 deeper lysimeters were placed at successive 2 ft depth increments. Flexible polyethylene tubing was used to connect the lysimeters to a central sample collection point. The sample tubing was buried at locations where freezing was possible. The lysimeters were set by drawing a vacuum for 3 to 7 days. Samples were collected by displacing the collected fluid with argon. Ceramic lysimeters were selected because of their reliable performance in granular materials, such as those occurring beneath the site. Some loss in the efficiency of sampling large molecule herbicides or pesticides could conceivably occur, but their use over lysimeters constructed of Teflon appeared justified in light of the overall superior performance of ceramic samplers.

Minor amounts of leachate placed under the lined test plots were collected from drain pipes that had been installed above the liners. Leachate migrating from above the liners was collected in lined basin. The volume of leachate was computed from the record of the water level within the basin and graphically recorded by a Type F water-level recorder.

Samples of surface sheet flow were periodically collected and related to instantaneous discharge or seasonal parameters. The constituents of surface water runoff were assessed from water samples collected in Gerlach troughs.

Modeling

The ultimate goal of the study was to assess the potential impact of golf course operations on the local surface water and ground water environment. The impact on surface water will be controlled by a network of surface water runoff collectors and activated carbon treatment facilities. To study the impact on ground water, the Konikow and Bredehoft Version 2.5, March 1988, model was used to simulate ground water movement and solute transport within the ground water regime. The hydrologic assumptions used for construction of the model are listed in Table 1. These assumptions were based on the results of data collected during previous field investigations at the site. The values used in the model were designed to represent a worst case scenario. For example, nitrate was used as the indicator species for the model because it is the most mobile of all the products identified for potential use. Based on lysimeter data, the nitrogen introduced into the system by fertilization tended to concentrate in the B lysimeter elevation. Although the test green was operated for 2 years, the end point for this concentration of nitrate was not reached during its operation. Similar studies of crop land in the mid-west indicate that this buildup of nitrogen in the subsurface can exceed 20 years (Jacobsen 1987). The nitrogen loading used in the model assumed that all of the nitrogen applied to the greens would eventually end up in the ground water, thus ignoring biological or other uptake mechanisms. Use of the worst case values made the final model very conservative.

Conclusions

* The existing ground water quality in the Olympic Valley Basin is generally acceptable; however, poor water quality with arsenic in excess of drinking water standards can be found in localized areas.

* The nutrient contents of surface water flows in Squaw Creek are highly dependent on the amount of suspended sediment and, therefore, stream flows. Squaw Creek appears to be supporting an unusually large amount of sediment, which is probably a result of manmade stream modifications during historic time.

* The only compounds that satisfied the pesticide selection criteria for the project consisted of 2,4-D, glyphosate, MCPP, and chloroneb.

* Test green operation for 2 years shows that the optimum fertilizer application rate for the types of turf selected is 0.5 lb of nitrogen per 1,000 ft^2.

* Based on computer models of the recommended application rates and the hydrologic parameters developed for the project, it appears that the project can operate within the waste discharge requirements set by the Lahontan Regional Water Quality Control Board of 0.5 ppm allowable increase in nitrate nitrogen (CRWQCB, Lahontan District, 1986). An isopleth map plotting the predicted increases in nitrogen content is depicted in Figure 5.

Literature Cited

California Regional Water Quality Control Board - Lahontan Region 1986. "Revised Waste Discharge Requirements for the Resort at Squaw Creek, Placer County." Board Order No. 6-86-52, California.

Gash & Associates, December 1973. "Squaw Valley County Water District Sewage Treatment Plant Hydrology Investigation."

Jacobsen, Roger 1987. Personal Communication with Geochemist, University of Nevada-Reno. Reno, Nevada

Perini 1985. Perini vs. Pierucci et al., a legal settlement.

Placer County 1985. "Conditions of Approval - Tentative Map - Resort at Squaw Creek."

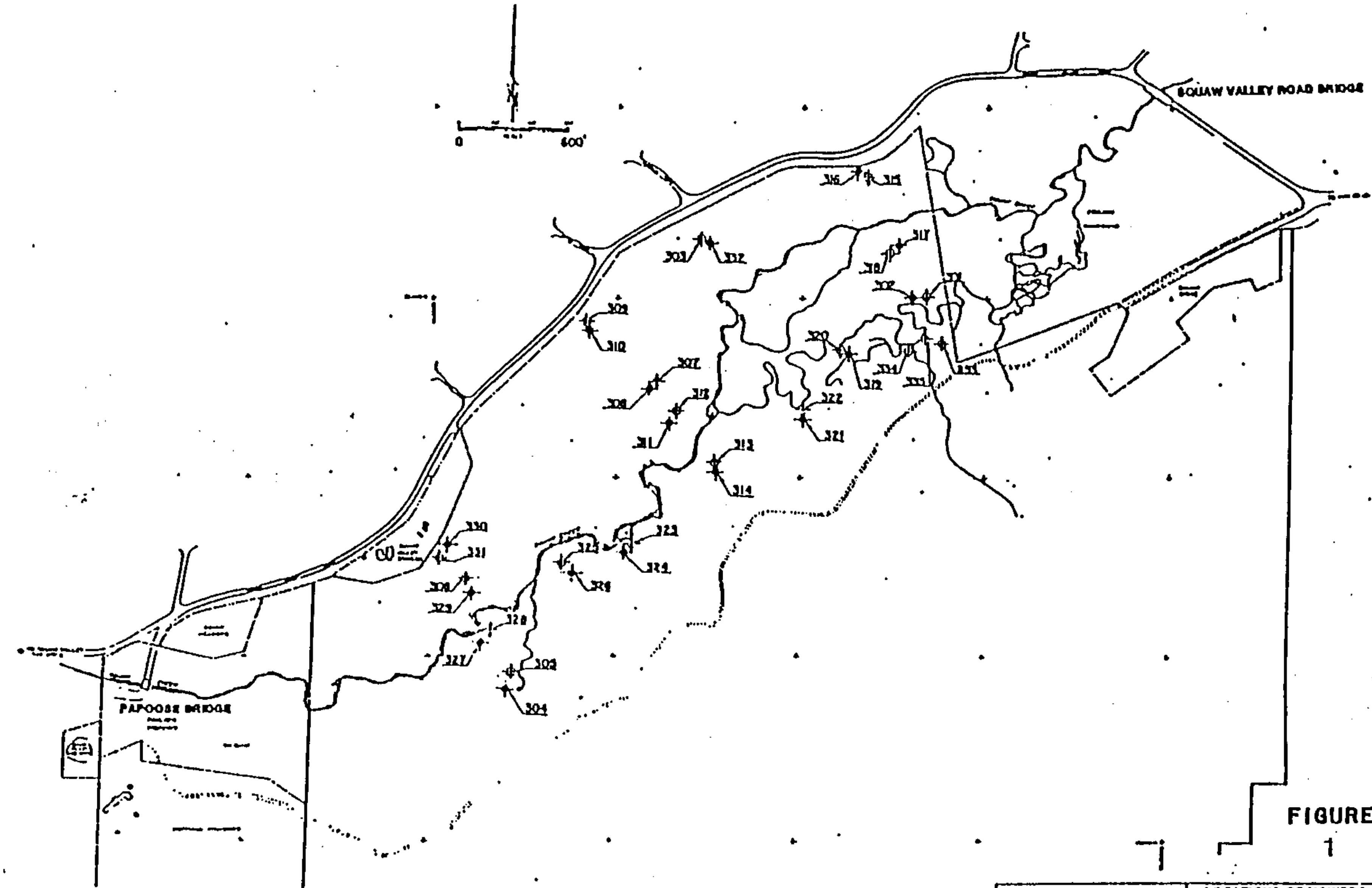
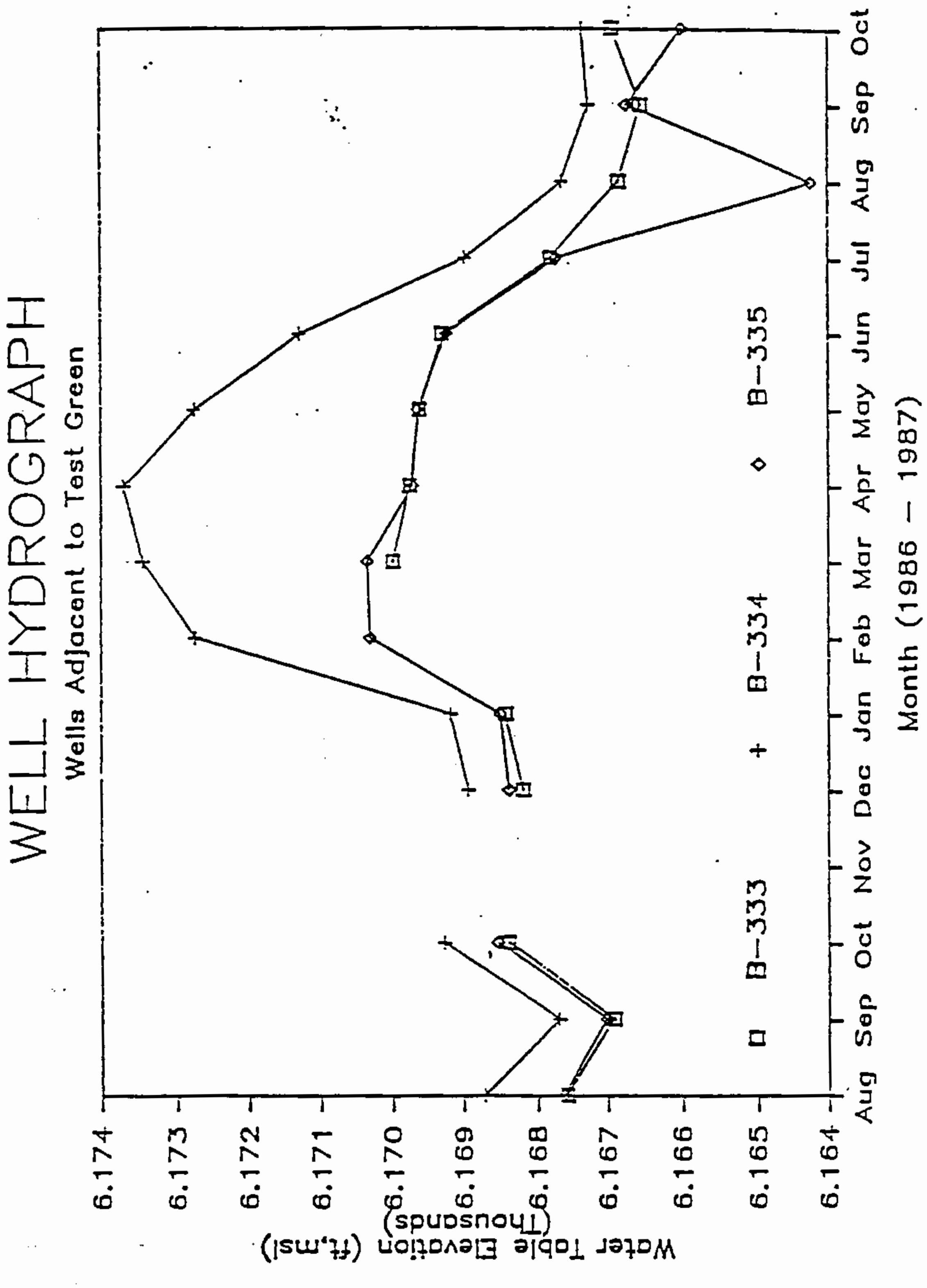


FIGURE 1

LOCATIONS OF MONITOR WELLS AT SQUAW VALLEY



J.H. KLEINFELDER & ASSOCIATES GEOTECHNICAL & ENVIRONMENTAL CONSULTANTS MATERIALS TESTING – LAND AND WATER RESOURCES	RESORT AT SQUAW CREEK Hydrograph for Wells 333, 334 and 335	FIGURE 2
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TYPICAL SOIL COLUMN APPARATUS USED IN LABORATORY INVESTIGATIONS

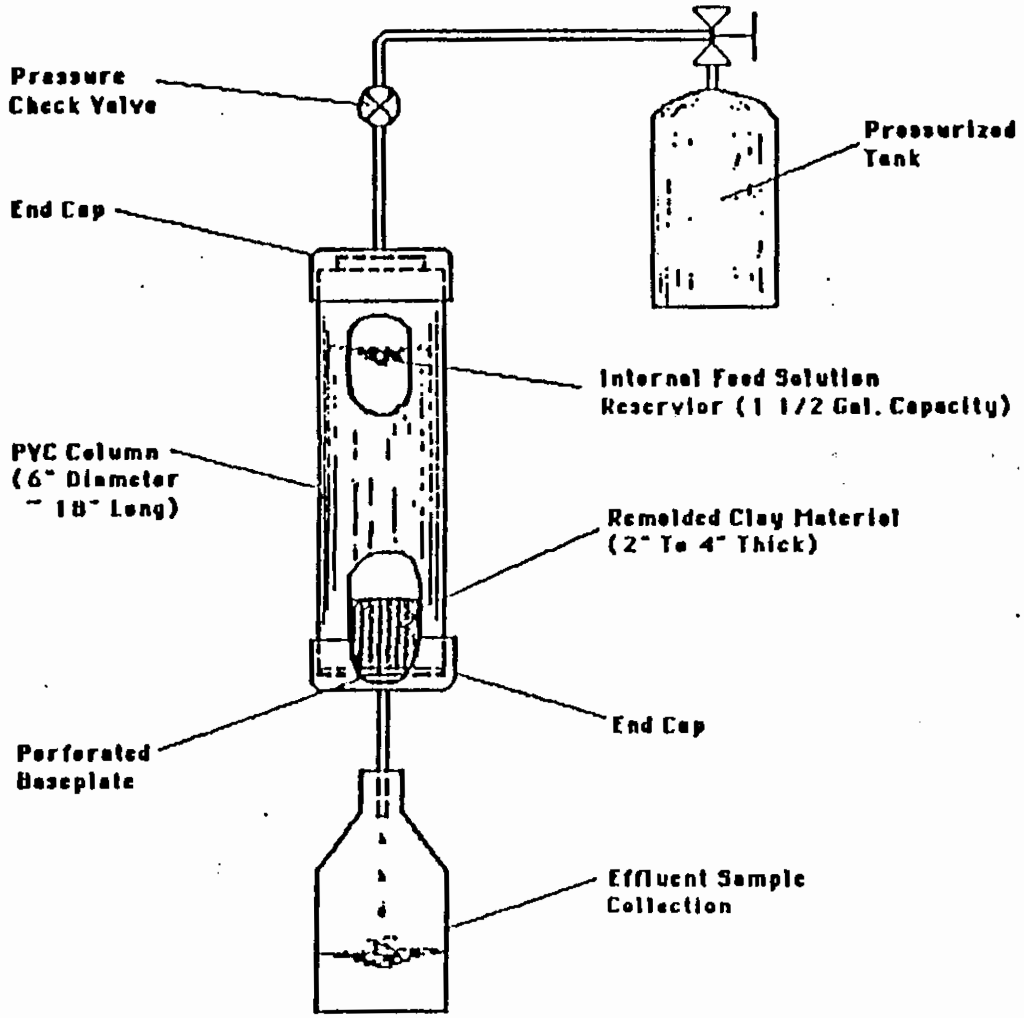

FIGURE 3

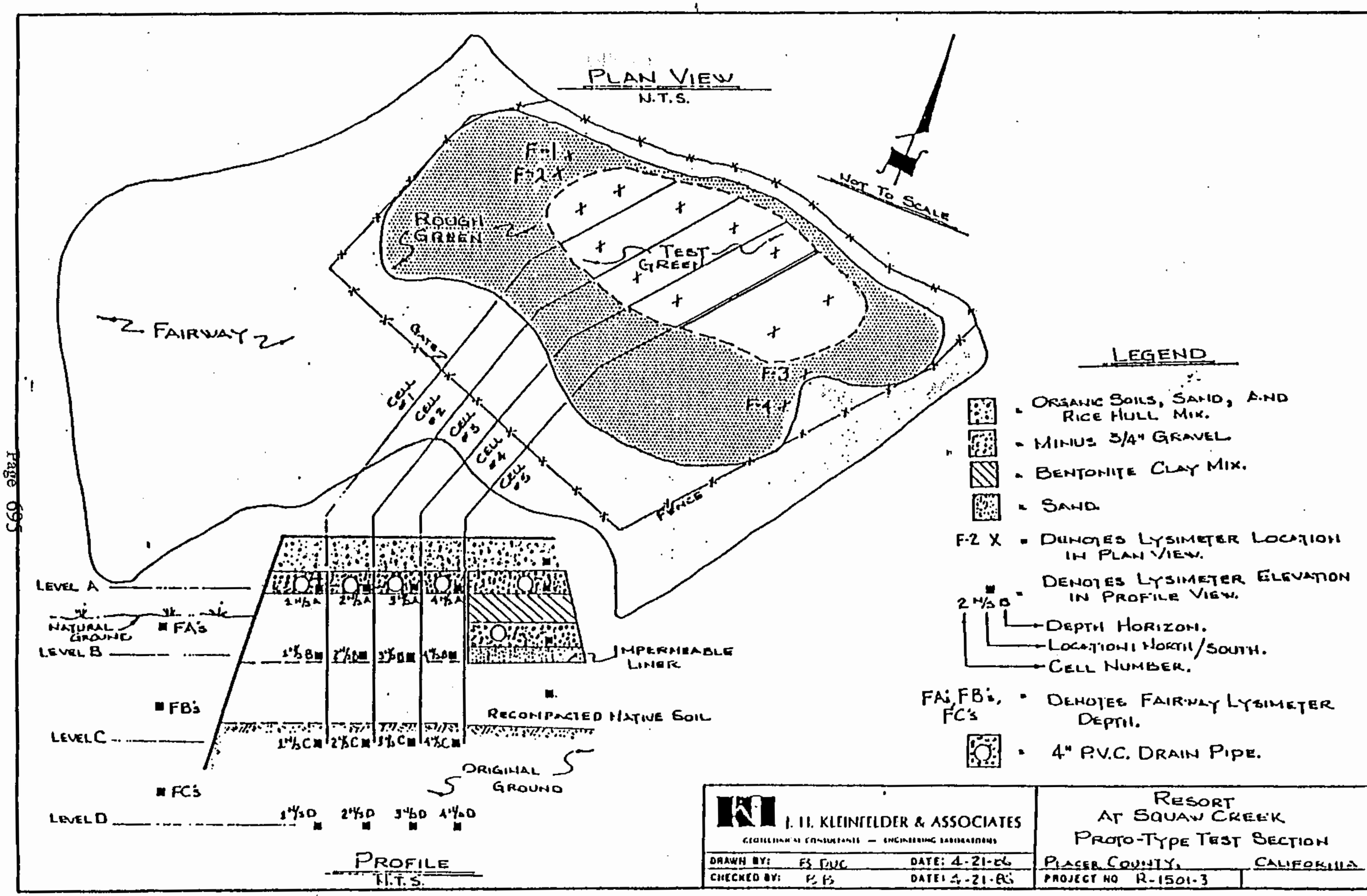

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FIGURE
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TABLE 1

1. Aquifer conditions

Hydraulic conductivity	
Bedrock	200 ft/yr
Shallow Alluvium	600 ft/yr
Glacial Valley Fill	1980 ft/yr
Thickness (Areal Models)	30 feet
Porosity	
Areal	25%
Cross Section	30%
Infiltration to ground water	0.96 ft/yr
Interflow from hillsides at valley edge cells	1.5 ft/yr
Flow from bedrock	
Areal Models	No flow
Cross Sections	Flow allowed through constant head cells and a low permeability zone

2. Squaw Creek

Average annual water levels

3. Solute (Nitrogen Concentrations)

Injected at an average annual value with infiltration on cells underlying fairways and greens and at cells at valley edge receiving interflow from fairways or greens uphill from the cell.

Total nitrogen concentration of infiltrating water calculated as follows:

Fairways	0.8 x .90 = 0.72
Greens	1.9 x .10 = 0.19
	.91 mg/l

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RESORT AT SQUAW CREEK

Hydrologic Assumptions

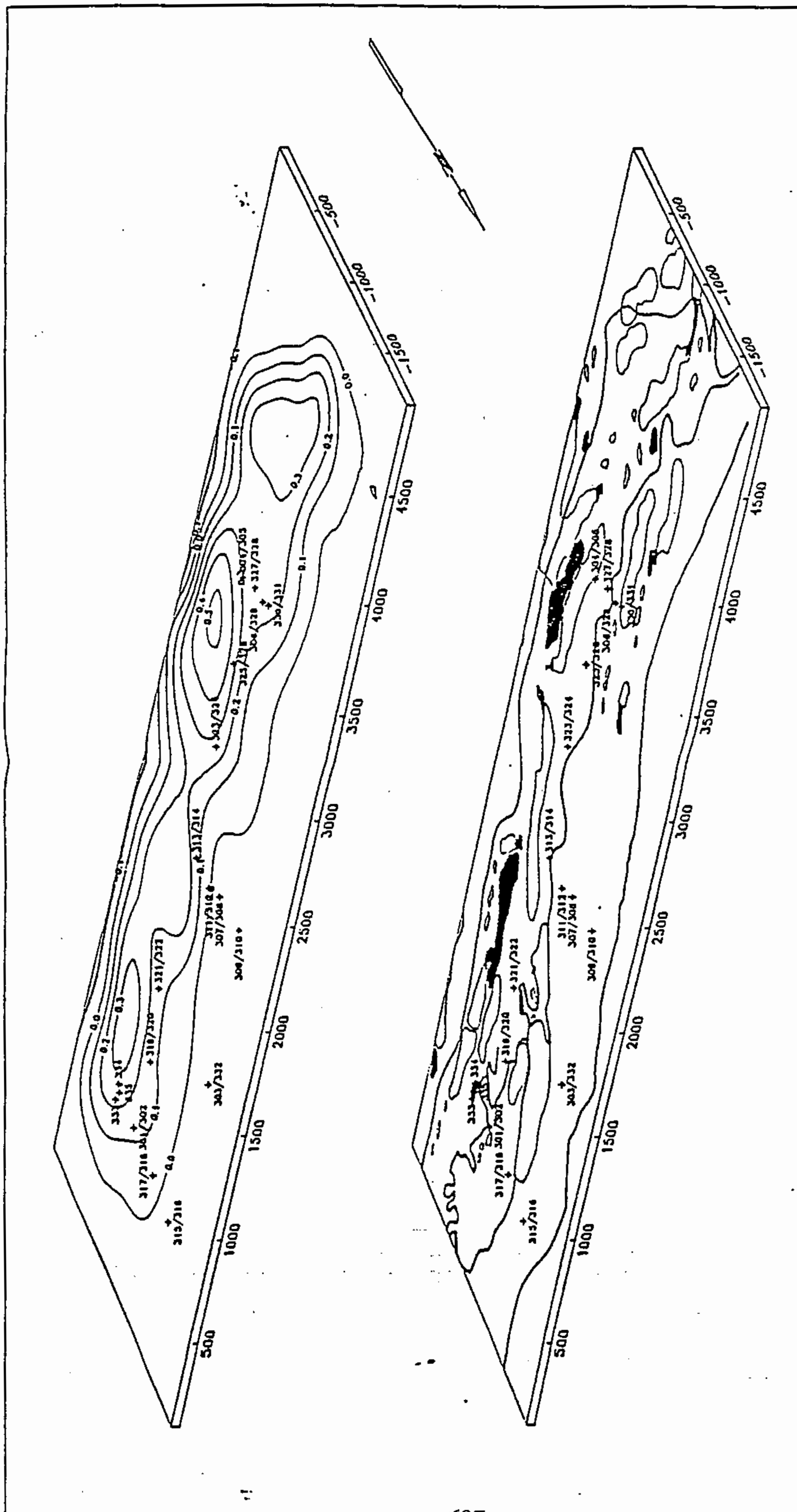

FIGURE 5
Areal Simulation
Squaw Valley Floor