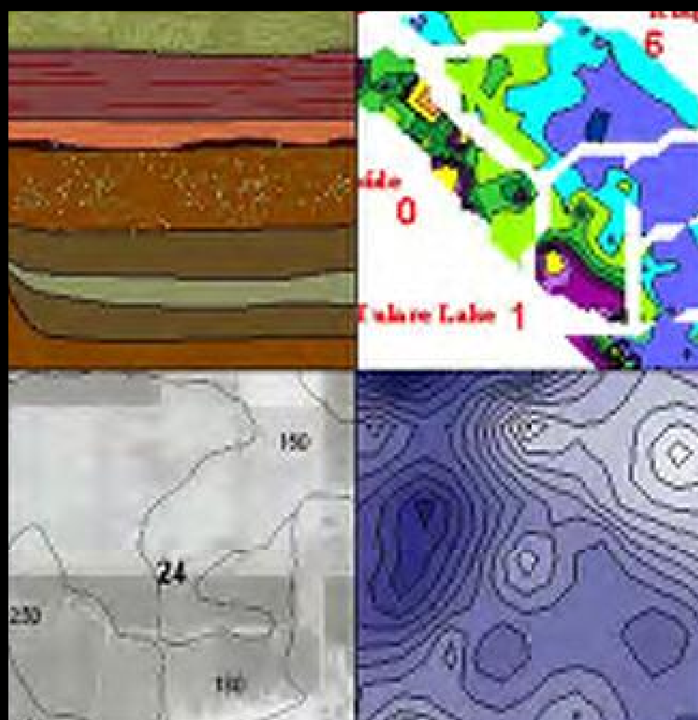
SYSTEM-WIDE CONJUNCTIVE WATER MANAGEMENT

THE HYDROGEOLOGIC SUITABILITY OF POTENTIAL GROUNDWATER BANKING SITES IN THE CENTRAL VALLEY OF CALIFORNIA



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This report and others from this project are available on-line from NHI's website at www.n-h-i.org or contact the Natural Heritage Institute at the address below.

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The Natural Heritage Institute is a non-profit natural resource conservation organization composed of technical and legal specialists and dedicated to the improvement of the laws and institutions that manage our natural heritage both domestically and internationally.

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1.0 Introduction

This report is one product of a technical investigation to design a **Central Valley System-Wide Conjunctive Water Management Program** under an emerging partnership that includes the U.S. Bureau of Reclamation and a consortium of other public water management agencies. As envisioned by this program, conjunctive use entails the integration of groundwater banking with reservoirs that would be reoperated to generate the source water. Other products of the investigation that are now available include:

- ***Feasibility Study of a Maximal Program of Groundwater Banking in California*** (January 1999), which includes an overview of the project and three pilot feasibility studies.
- ***Designing Successful Groundwater Banking Programs In The Central Valley: Lessons From Experience*** (August 2001), which includes extensive analysis of legal and institutional constraints and solutions.

These and other project documents can be viewed and downloaded from the Natural Heritage Institute's website at www.n-h-i.org.

Subject to the availability of financial resources, forthcoming products will include reports on:

- "*In lieu*" groundwater banking site analysis
- Design specifications for local groundwater banking institutions
- The potential for reoperating reservoirs to generate source water for groundwater banking and to restore downstream fluvial processes
- Analysis of institutional, land use, infrastructure, environmental and other factors bearing upon siting decisions for groundwater banks
- Results of "gaming" analysis of a series of conjunctive use configurations in the Central Valley
- Economic optimization analysis
- A final feasibility report and strategic plan

This work is animated by the widespread realization that conjunctive water management will be a prominent feature of California's water future because it is an environmentally acceptable (indeed, environment-enhancing) and cost-competitive way to improve the reliability of water supplies for all sectors. Thus, groundwater banking has emerged as a management concept that can garner broad-based support. As a storage enhancement strategy, groundwater banking is an attractive alternative to many who are reluctant to endorse an ambitious expansion of the state's surface storage infrastructure. Storage increases associated with groundwater banking offer the potential to increase the yield of the California water system—an attractive prospect to the state's water user community. Indeed, the CalFed Record of Decision assigns a larger role to groundwater storage (500,000–1,000,000 acre-feet) than to any of the surface storage options in its plan to increase water supplies. Notably, however, the RoD gives priority to conjunctive use projects that are developed for local benefit and is silent regarding the source of the water to be banked. It is difficult to see how that vision would create new yield not otherwise available in the system. By contrast, the system-wide investigation, of which this report is a part, is oriented toward system-wide benefits (including benefits that accrue in the locale where groundwater banking occurs) and would generate new yield by integrating the water storage with existing reservoirs that would be reoperated so as to increase the space available to capture a larger fraction of annual runoff.

Groundwater banking must, as a practical necessity, be developed with the cooperation and consent of overlying landowners, groundwater appropriators, water districts and groundwater management authorities. Indeed, the recharge and recovery operations will generally be conducted by such local interests. Increasingly those communities that have historically relied on groundwater pumping to meet their needs realize that the best way to assure that local benefits flow from potential groundwater banking projects is to be involved in the project selection and design processes. The apparent convergence of interest between those charged with assuring California's future water supplies and those charged with managing local groundwater resources creates a climate where attempts are being made to identify the most promising groundwater banking opportunities in advance of the design and implementation of actual projects.

As with any water management initiative, the translation of a promising concept into a viable project relies upon a rigorous analysis of site-specific opportunities and constraints. To determine how best to link reservoirs that would provide the recharge water, with groundwater banking sites that would store it, with project beneficiaries who would use it, in a way that proves universally beneficial, it is of course necessary to investigate the most suitable groundwater banking sites. There are many dimensions to that puzzle. To itemize the most prominent factors, the most suitable sites will be those where:

- The target aquifer has the best physical characteristics for the storage and retrieval of banked groundwater;
- The aquifer does not interact with surface water bodies (unless such interaction is a desired characteristic);
- The overlying water districts or groundwater management authority is willing to operate the banks and where effects on unincorporated groundwater users can be avoided;
- The existing patterns of groundwater use in the vicinity of the project are compatible with groundwater banking;
- The legal and institutional setting governing groundwater management, use and export is most congenial;
- The recharge, extraction and conveyance facilities will not conflict with existing land uses;

- The manipulation of groundwater levels will not adversely affect important habitats, crops or structures;
- The project can be easily linked to a water distribution network;
- The project is located down gradient of river reaches through which it is feasible to re-establish geomorphically beneficial peak flows;
- The project is located within the same sub-basin as the demand center that it is intended to serve (so as to minimize the need to transfer the banked water across the delta); and
- The costs of storing and recovering water are relatively attractive.

This report focuses on the first factor only, namely the hydrogeologic suitability of potential groundwater banking sites in the Central Valley. In limiting the scope of the report to this factor, we fully recognize that hydrogeologic suitability may not be the ultimate arbiter of where groundwater banking projects will prosper. The full suite of opportunities and constraints that will bear on any final project selection, as itemized above, will be the subject of other reports emanating from this project. Perhaps most predominant of those is the local receptivity as shaped by the legal and institutional settings of current groundwater utilization—this is treated at length in the companion report, ***Designing Successful Groundwater Banking Programs in the Central Valley: Lessons from Experience***, published by the Natural Heritage Institute in 2001.

Also, in limiting our scope to the Central Valley, we acknowledge that promising groundwater banking opportunities exist both in the Bay Area and on the Southern California Coastal Plain. Our assumption is that these opportunities will be pursued by the water management agencies that overlie those sites as part of their own local resource planning efforts. Here we are attempting to focus on potential groundwater banking projects that through integration with the overall California water system could improve that system's performance, but which are less likely to be included in purely local resource planning initiatives. These sites are located primarily in the Central Valley.

We also need to be clear that the scope of this hydrogeologic suitability analysis is limited to one of several modes of recharging groundwater: active recharge through percolation of water from ponds at the land surface that overlie the aquifer in which water will be stored. Water introduced to these ponds will percolate under gravity through any intervening unsaturated material prior to entering into groundwater storage. Another strategy, which is not treated in this report, involves introducing banked water directly to groundwater storage via wells screened in the target aquifer material. A third approach to groundwater banking is called *in lieu* groundwater banking. Under this approach, historic users of groundwater are provided with a new or expanded supply of surface water that decreases their need to pump groundwater. Groundwater that goes unpumped is considered banked (site suitability analysis for this type of groundwater banking technique will be the subject of a forthcoming report from this investigation). A fourth emerging concept focuses on rivers that will undergo dramatic shifts in their flow regimes as part of ecosystem restoration efforts. In theory, any additional seepage through the bed of these rivers that percolates down to the underlying aquifer system could be considered banked.

Each of the approaches is characterized by technical considerations that define its suitability for a particular location. If, for example, the aquifer targeted for groundwater banking is located below layers of low permeability material, injection wells would represent a more viable option for conveying water to storage than recharge ponds. If such an area has already experienced substantial development of groundwater wells, it might be particularly well-suited for an *in lieu* banking arrangement. For instance, the Tuscan formation below Butte County is highly suitable for *in lieu* groundwater storage because it is overlain with a thick layer of tight geologic material and is already utilized for irrigation. This report focuses exclusively on groundwater banking via recharge ponds. We have limited the scope of our analysis in full recognition that other types of groundwater banking projects are possible, and potentially important, in California. However, we chose to focus on recharge ponds based on several factors:

- The largest existing groundwater banking projects in California, of which the Kern Water Bank is the best known, have generally employed recharge ponds.
- Soil assemblages in the Central Valley, derived largely from the deposition of alluvial fans, often contain soils coarse enough to support recharge ponds.
- While vertical stratification of thin water bearing and flow retarding aquifers does exist in parts of the Central Valley, deep alluvial aquifers receiving recharge from overlying percolation are fairly widespread.

Within this limitation in scope, however, this report provides a methodology to compare sites in the Central Valley in terms of their hydrogeologic suitability for groundwater banking via recharge ponds. Our methodology relies upon utilizing a core set of available data related to geology, groundwater quality, soils and hydrology to develop a Hydrogeologic Suitability Index, which like all indices is the product of both analysis and judgment. In developing this index we were driven by the desire to create a uniform template against which all potential groundwater banking sites could be compared—tempered by the recognition that site-specific factors and data limitations generally complicate the application of a uniform standard. We acknowledge these complications, and make appropriate assumptions in response, because waiting until the definitive information is available to complete our analysis, if ever, is unacceptable in the accelerated state of water planning initiated by the RoD.

One significant complication in applying a single index across the Central Valley stems from the fact that hydrogeologic conditions in the Sacramento and San Joaquin Valleys differ. While regions of prolonged groundwater overdraft characterize the San Joaquin Valley, resulting in the creation of substantial cones of depression, aquifers in the Sacramento Valley are not typically impacted by overdraft and large cones of depression are less common in this region. This difference has implications for the sequence of water storage and recovery that could be implemented as part of a program of groundwater banking. In general, dewatered aquifer space is available for immediate groundwater storage in portions of the San Joaquin Valley while aquifer storage in the Sacramento Valley would generally have to follow the groundwater recovery required to create storage space. The hydrologic parameters useful in evaluating the hydrogeologic suitability of groundwater banking under these two conditions are not identical. As a result, we developed a core index that includes information on geology, groundwater quality and soils that can be applied in both the Sacramento and San Joaquin Valleys, and an extended index that draws upon hydrologic information for use solely in the San Joaquin Valley.

Even in applying the index within the Sacramento or the San Joaquin Valley, however, we confronted the challenge of assigning appropriate weighting factors for the parameters under consideration. These assignments are certainly open to alternative interpretations. To allow for that, we have crafted a methodology that allows others to insert weighting factors that reflect their own judgments or preferences. The result is a spreadsheet that can be manipulated based on any number of assumptions regarding appropriate weighting factors. If suitably disaggregated data is available, the index is also scalable so that it could be applied to the comparison of promising groundwater banking sites within a single county as easily as it has been applied across the Sacramento or San Joaquin Valleys in this report.

We hope this flexibility and scalability will make the index useful to a range of potential users in California. These could include: agency staff charged with prioritizing the range of potential groundwater banking sites across the Central Valley, researchers examining the interactions between groundwater banking and other water management objectives such as flood control and ecosystem restoration, local and private resource managers deciding whether or not a groundwater banking project they are contemplating offers strategic advantages to statewide water planners, and reservoir operators attempting to develop groundwater banking strategies that take into consideration all of the constraints and opportunities listed above. Thus, despite the limitations inherent in adopting an index approach, we trust that our study will provide information useful to all of these actors as they attempt to move the analysis of groundwater banking to a point where consideration of more refined site-specific details of promising sites becomes both necessary and appropriate.

This work is properly viewed as a first screen in identifying the most suitable groundwater banking sites. The scale of analysis is too coarse and the data uncertainties too significant to permit specific parcels of land to be specified as the best locations to construct groundwater recharge or extraction facilities. Nor would we presume so far without the assent of such landowners. Indeed, the uncertainties inherent in the analysis point out areas where additional research carried out with limited public resources would prove beneficial. Refinement of the information on the heterogeneity of geologic and associated aquifer hydraulic properties in the areas that appear most suitable for groundwater banking is a direct benefit that can flow from the development of the index. Continued investment in water quality data acquisition may also be warranted at promising sites as much of the information currently available is decades old. Finally the analysis can lend focus to more targeted analysis that includes the other factors, itemized above, that will necessarily bear upon the selection of optimal sites. With the funds earmarked for conjunctive use beginning to flow from the CalFed Program,Proposition 13 funding, and other federal and state resources, the analysis behind the development of the index can provide useful on where to utilize research dollars intended to facilitate the increasing adoption of conjunctive use as a viable water management strategy.

Two things are clear: 1) the potential for conjunctive water management to contribute to a more secure water supply in California is too large to ignore, and 2) one of the factors that most inhibits the realization of this potential is the lack of definitive information on hydrogeologic suitability. Uncertainties in this regard engender fear of unintended consequences within those communities currently most reliant upon groundwater. Fear creates resistance among those who have most to gain from this water management technique—those landowners who control the aquifers and could manage them as a local public good and those public officials charged with managing our limited water supplies. If we wait for the optimal list of conjunctive use projects, developed from unimpeachable information, to appear, we may miss the opportunity to realize the enormous potential of conjunctive water management. Imperfect as it is, we hope that this document, along with others published by the investigation, will assist as we push toward the realization of actual conjunctive use projects.

2.0 Identification of Potential Groundwater Banking Sites

As stated in Section 1.0, differences in the hydrologic conditions encountered in the Sacramento and San Joaquin Valleys militate in favor of applying the Hydrogeologic Suitability Index separately to these two regions. In both regions a core index, based on geology, groundwater quality and soils considerations, can be applied. An extended index that takes into account hydrologic information can be applied in the San Joaquin Valley. Before applying either index, however, a list of potential groundwater banking sites in both regions of the Central Valley must be developed.

A number of inventories of potential groundwater banking sites have been assembled in recent years. Many of these were synthesized in the list of potential sites reported in *A Feasibility Study of a Maximal Scale Program of Groundwater Banking in California* published by the Natural Heritage Institute in 1999. A less inclusive list of the sites judged to be most feasible from a technical and political vantage point were evaluated for recharge and recovery capacity in the February 2000 *Conjunctive Use Site Assessment* prepared by the Integrated Storage Investigation of the CALFED Bay-Delta Program. In general, these inventories have adopted a broad perspective, leading to the identification of rather large areas as potential banking sites (e.g., Yuba County or the Tuolumne/Merced Basin). A slightly more refined optic was adopted during the development of the Hydrogeologic Suitability Index. Here an attempt was made to identify the actual regions where measured groundwater levels reveal the opportunity to store water within dewatered aquifer material, or areas where in spite of the current high water table conditions, geologic conditions would favor an increase in aquifer management through more ambitious pumping and recharge.

The following steps were taken in the process of identifying potential groundwater banking sites in the Central Valley. Data from the Department of Water Resources semi-annual survey of wells was downloaded for Fall 1992. Using a contouring program, a groundwater head surface was developed for the entire Central Valley. Data from areas that exhibited groundwater head levels lower than that found in the surrounding area were examined in greater detail. Based primarily on the geometry of the mapped depressions, a qualitative assessment was made as to whether the depressions represented water table declines or comparatively low piezometric surfaces in deep water-bearing horizons. In general, water table declines were deemed to exhibit continuity with levels observed in the majority of nearby wells while low piezometric surface readings were associated with "bulls eye" type depressions that exhibited little correlation with nearby wells. Once depressions that appeared to be related to declines in the regional water table were identified, the second step in site identification involved examining soils maps to identify promising sites for recharge basins. This examination, which also relied upon qualitative analysis of existing data, sought to identify four-square-mile blocks of land with the most "promising" assemblage of soils. This involved looking for blocks dominated by sandy soils with a minimum of clay. While this step did not involve statistical analysis of soil assemblages, it was generally possible to visually distinguish sites with generally coarse soil from those dominated by fine-grained material. The four-square-mile blocks of land located over what were considered to be water table depressions were selected as the potential groundwater banking sites.

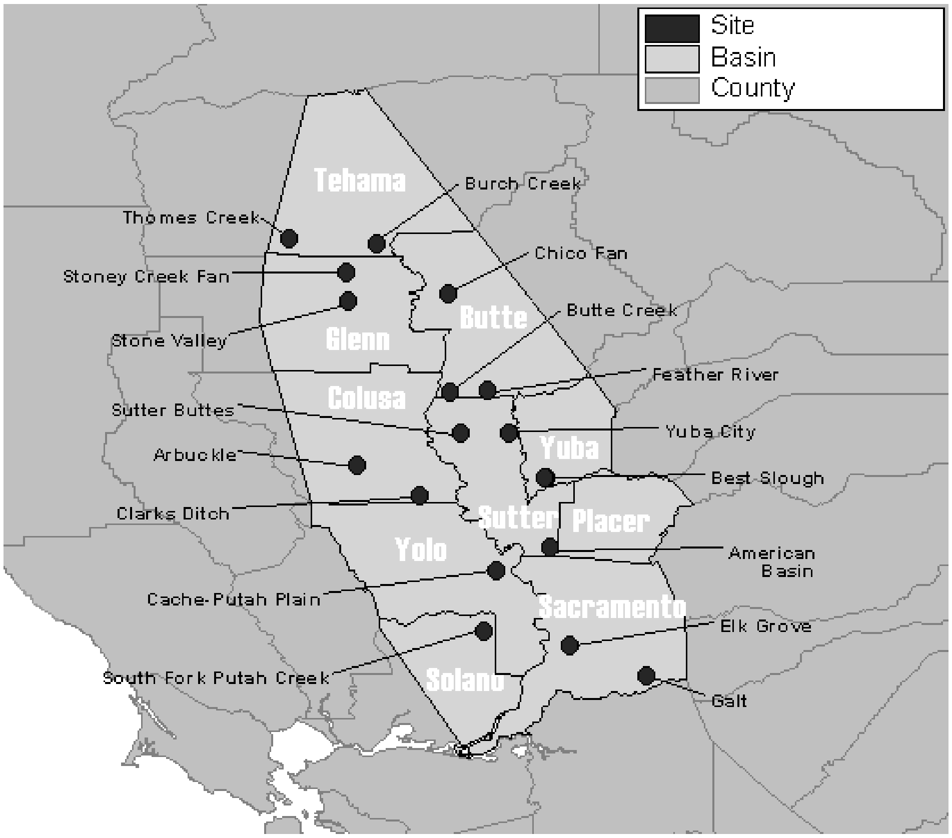
Viewed through this lens, several potential sites emerge within the broad regions previously defined. Figures 2.0.1 and 2.0.2 depict the locations of the sites that were ultimately selected for consideration in the Sacramento and San Joaquin Valleys, respectively. Information on the sites depicted in Figures 2.0.1 and 2.0.2 includes a site name, identifies the groundwater basin where the site is located and provides a reference to the site location based on the California State Land Survey system. The California Department of Water Resources delineated the groundwater basins.

The site names that appear in Figures 2.0.1 and 2.0.2 require some clarification. Information relevant to the Hydrogeologic Suitability Index is available at a variety of scales. In general, however, information on the characteristics of soils overlying potential groundwater banking sites is available at the finest scale (as fine as 1:20,000 in many soils surveys prepared by the United States Soil Conservation Service). In attempting to define important parameters associated with the soil characteristics at potential groundwater banking projects, four-square-mile land sections with the most attractive soil assemblages were identified in the region overlying targeted storage sites. The site names associated with each location are derived from prominent geographic features located near the selected land units. While these names may be less recognizable than Yuba County or the Tuolumne/Merced Basin, all information needed to locate the banking site selected for analysis are included in Figures 2.0.1 and 2.0.2.

In selecting the sites depicted in Figures 2.0.1 and 2.0.2, we anticipate that many readers will find reasons to object to the inclusion of a particular site or the exclusion of another. We make no claim that the lists we developed are complete and comprehensive. We do feel, however, that we have created a sample that reasonably reflects the range of potential groundwater banking sites in the Central Valley. There are sites in the western Sacramento Valley that are associated with the flashy gravel-laden streams that emerge from the Coast Range Mountains. Sites on the east side of the Sacramento Valley are associated with large perennial streams that drain the granite-rich Sierra Nevada. In the San Joaquin Valley there are sites associated with rivers that issue to the Bay-Delta system and others that drain into the Tulare Lake Basin. The only region of the Central Valley not represented is the western San Joaquin Valley, a region plagued by poor groundwater quality that makes it less favorable to groundwater banking based on the use of recharge ponds.

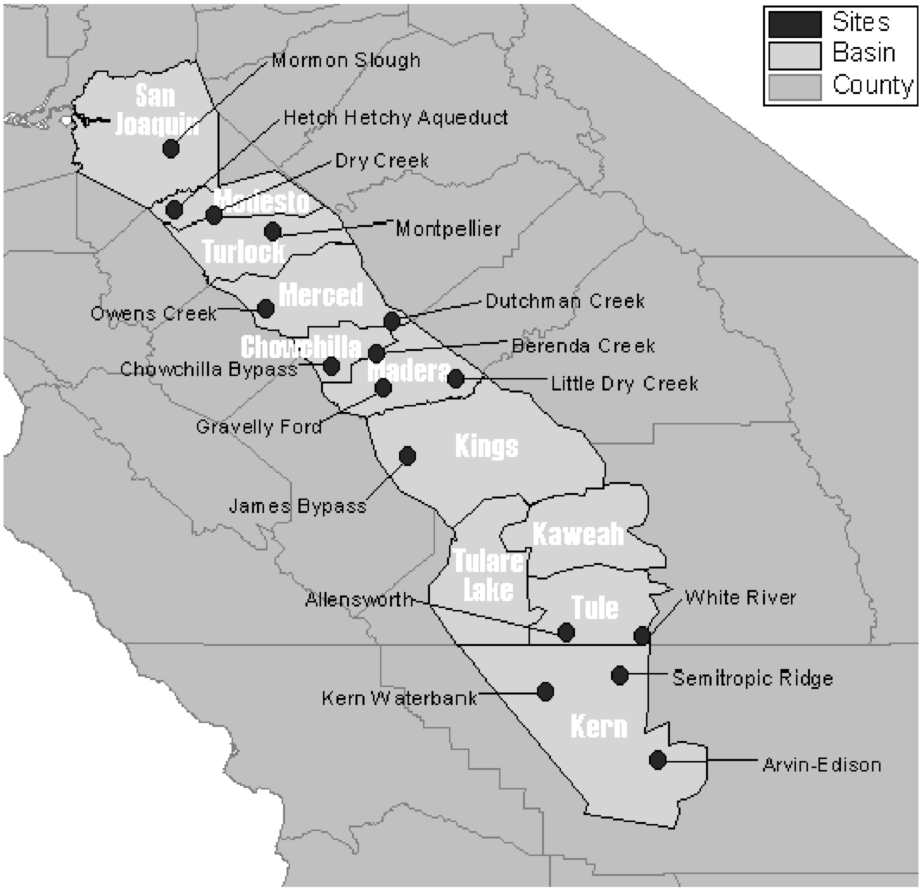
In addition, if others feel that additional sites should be added to the list, it is easy to do so in the spreadsheet developed as part of this project. It is simply a matter of defining the required parameter values and adding the site to the database.

Figure 2.0.1: Potential Groundwater Banking Sites in the Sacramento Valley



Site	Basin	Township, Range	Sections
Thomes Creek	Tehama	T24N, R5W	9, 10, 15, 16
Burch Creek	Tehama	T23N, R2W	17, 18, 19, 20
Stony Creek Fan	Glenn	T22N, R3W	19, 20, 29, 30
Stone Valley	Glenn	T21N, R3W	28, 29, 32, 33
Chico Fan	Butte	T21N, R1E	15, 16, 21, 22
Butte Creek	Butte	T17N, R1E	15, 16, 21, 22
Feather River	Butte	T17N, R2E	14, 15, 22, 23
Sutter Buttes	Sutter	T15N, R1E	1, 2, 11, 12
Yuba City	Sutter	T15N, R3E	4, 5, 8, 9
Arbuckle	Colusa	T14N, R3W	15, 16, 21, 22
Best Slough	Placer-Yuba	T13N, R4E	3, 4
		T14N, R4E	33, 34
Clarks Ditch	Colusa	T13N, R1W	21, 22, 27, 28
American Basin	Sutter	T11N, R4E	26, 27, 34, 35
Cache-Putah Plain	Solano-Yolo	T10N, R2E	24, 25
		T10N, R3E	19, 30
South Fork Putah Creek	Solano-Yolo	T7N, R2E	2, 3, 10, 11
Elk Grove	Sacramento	T7N, R5E	27, 28, 33, 34
Galt	Sacramento	T5N, R7E	1, 12
		T5N, R8E	6, 7

Figure 2.0.2: Potential Groundwater Banking Sites in the San Joaquin Valley



Site	Basin	Township, Range	Sections
Mormon Slough	San Joaquin	T1N, R7E	13, 24
		T1N, R8E	18, 19
Hetch Hetchy Aqueduct	Modesto	T3S, R8E	19, 20, 29, 30
Dry Creek	Modesto	T3S, R9E	25, 26, 35, 36
Montpellier	Turlock	T4S, R12E	19, 20, 29, 30
Owens Creek	Merced	T8S, R11E	13, 14, 23, 24
Dutchman Creek	Merced	T8S, R17E	31, 32
		T9S, R17E	5, 6
Berenda Creek	Chowchilla	T10S, R16E	21, 22, 27, 28
Chowchilla Bypass	Chowchilla	T11S, R14E	2, 3, 10, 11
Gravelly Ford	Madera	T12S, R16E	11, 12, 13, 14
Little Dry Creek	Madera	T11S, R19E	25, 26, 35, 36
James Bypass	Kings	T15S, R17E	23, 24, 25, 26
White River	Tule	T24S, R27E	22, 23, 26, 27
Allensworth	Tule	T24S, R24E	15, 16, 21, 22
Semitropic Ridge	Kern	T26S, R26E	13, 14, 23, 24
Kern Waterbank	Kern	T27S, R23E	10, 11, 14, 15
Arvin-Edison	Kern	T30S, R28E	21, 22, 27, 28

3.0 Description of the Sub-Index Parameters

As mentioned in Section 1.0, conditions encountered in the Sacramento and San Joaquin Valleys are sufficiently distinct to warrant the application of different versions of the Hydrogeologic Suitability Index. One major difference is the degree to which aquifers in the two regions have been drawn down. While the San Joaquin Valley is characterized by substantial cones of depression, surface aquifers in the Sacramento Valley generally exhibit water tables that closely track the land surface profile. This makes it more difficult to speculate how these aquifers would respond to the more intensive management that would accompany groundwater banking. As such, a sub-index related to hydrologic conditions in the target aquifers has been applied only at sites in the San Joaquin Valley.

In both locations, however, a core set of data related to geology, groundwater quality and soils can be used to develop relevant sub-indices. This section describes the parameters included in the core index and a methodology for evaluating their impact on the overall hydrogeologic suitability of potential groundwater banking sites. One of the central challenges in developing these sub-indices was to assign values to their various components. In the geology sub-index, for example, we consider the permeability of water-bearing geologic formations below potential groundwater banking sites. In making this consideration we reviewed numerous reports describing the geology of the target basins. These reports often used terms such as the formation is “highly” or “moderately” permeable. In a few cases, ranges of permeability values were also given, many of which were quite broad.

We did not attempt to translate these observations into a rigorous geo-statistical representation of permeability across the Central Valley. Instead we sought to develop associations between what previous researchers called highly, moderately and non-permeable materials and the range of actual permeability values that were occasionally reported in the literature. While this qualitative approach did not allow us to distinguish between two formations that were deemed to be highly permeable to find the “most promising sites”, it did allow us to confidently sort the geologic formations into broad categories useful in defining the “most promising sites”. This level of refinement was in keeping with the fact that the hydrogeologic suitability of a potential site will be only one factor influencing its ultimate selection for a groundwater banking project. A similar qualitative approach was taken in defining values for certain components of other core sub-indices. While this approach may seem cursory to some, we feel it is in keeping with the intent of this effort, which is to provide insight useful in identifying a suite of potential sites that merit the type of closer consideration that will lead to more refined comparisons among potential groundwater banking project locations.

3.1 Geology Sub-Index

Perhaps the most important factor in evaluating the hydrogeologic suitability of potential groundwater banking sites is the nature of the underlying geologic formations. The characteristics of these formations will control the amount of water that can be stored within a given volume of aquifer material and the ease with which water can be recharged to and extracted from the water-bearing formations. Clearly, an unconsolidated, uncemented, coarse-grained alluvial formation would offer easier access to larger storage volumes than a consolidated, fine-grained, lacustrian formation.

3.1.1 Geology Sub-Index Parameters

Having reviewed some of the voluminous geologic literature available for the Central Valley (see the Geology portion of Section 7.0: References), we decided to employ three parameters to characterize the geologic suitability of formations underlying potential sites for groundwater banking: permeability, the presence of paleosols, and the presence of geologic structures that could enhance or detract from aquifer storage potential. While many other parameters could have been used, we limited our selection based on the availability of data across most of the sites under consideration and on our desire to use parameters that were likely to be independent of one another. For example, we originally considered using both the percent coarse-grained material and the degree of cementation and consolidation of the target aquifer as parameters in the geology sub-index. These were ultimately discarded because they are likely correlated with the permeability of the aquifer formation. Details on the final set of parameters are presented in the following paragraphs.

Permeability

Permeability describes the ease with which water can flow through geologic material. Measured in units of length per time, permeability affects the rate at which water can percolate into the geologic material for storage and also the rate at which it can be pumped out in recovery. In general, the higher the estimated permeability, the better the yield of wells installed in a formation. Increases in well yield would facilitate the recovery of water stored in a potential groundwater banking site, enhancing that site's suitability. Permeability was scored based on textual descriptions of formations from the references cited in Section 7.0. Formations were described as being impermeable, moderately permeable, or highly permeable.

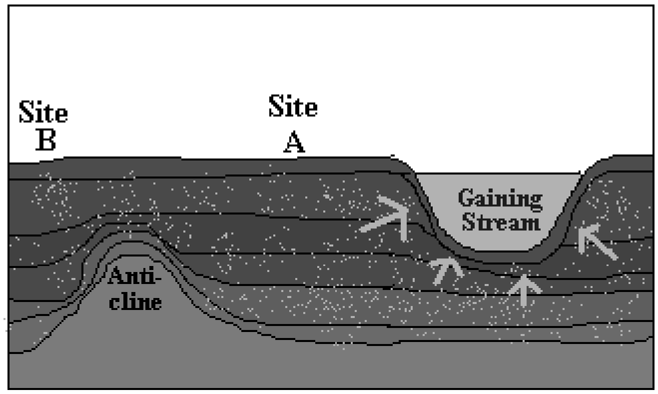
Paleosols

The deposition of sedimentary formations is not a continuous process. At certain periods the forces contributing to deposition are absent, resulting in long-term exposure of the material at the surface of the formation. During these periods, soil development can occur. Paleosols, or fossil soils, are old soil layers that are buried in a geologic formation when the forces contributing to deposition resume. As a high concentration of clay minerals and the potential for hardpan development exist in the paleosols, they can impede the vertical flow of water through a formation. Such an impediment could restrict the access to storage available in the geologic formations below the paleosol layer, thereby reducing the suitability of a potential groundwater banking site.

Geologic Structure

Tectonic forces acting on sedimentary deposits can create structures within a formation. Depending on their location and orientation, folds and faults can serve to isolate stored groundwater from the surrounding aquifer. Figure 3.1.1 depicts a situation where the presence of an anticline in folded sedimentary deposits could isolate stored groundwater from a gaining stream that conveys water away from aquifer storage. By separating Site B from the stream's influence, the anticline structure increases the suitability of that site relative to Site A.

Figure 3.1.1: Influence of Geologic Structure on Geologic Suitability



Groundwater banked at Site A, which is in proximity to a gaining stream, would be subject to higher losses than water banked at Site B, which is isolated from the stream by an anticline structure within the formation.

3.1.2 Geology Sub-Index Weighting Factors

Having described these parameters for each of the formations found below potential groundwater banking sites, we gave them a score on a scale from 0 to 10, with a score of 10 representing characteristics that would make a particular formation a suitable target for groundwater banking. Our scoring system is described in Table 3.1.1.

Having scored each of the parameters, a composite formation score was calculated based on Equation 3.1.

Table 3.1.1: Parameter Weighting Factors Used to Calculate the Geology Sub-Index

Component	0	5	10
Permeability	Impermeable	Moderately permeable	Highly permeable
Paleosols	Contains resistant paleosols	Contains some slightly resistant paleosols	No paleosols
Geologic Structure	Contains structural features that direct stored groundwater toward gaining streams	Contains no structural features	Contains structural features that isolate stored groundwater from gaining streams

$$\text{Formation Score} = 2*(\text{Permeability}) + 0.5*(\text{Paleosols}) + (\text{Geological Structure}) \tag{3.1}$$

Given the relative importance of permeability in terms of evaluating the suitability of a formation for groundwater banking, it was assigned a weighting factor of 2. The existence of paleosols was assigned a weighting coefficient of 0.5 because, although they can act as barriers to the vertical movement of water, they tend to be described as thin and discontinuous in the Central Valley. The geology sub-index values are calculated as the sum of the scores for each of the formations underlying a particular groundwater banking site, weighted by the relative formation thickness within the top several hundred feet of the sub-surface (Equation 3.2). In the Sacramento Valley, several stratified formations were often encountered; in the San Joaquin Valley, undifferentiated alluvial deposits were the norm.

$$\text{Geology Sub-Index} = \Sigma\,(\text{Formation Score}_A * \text{Formation Thickness}_A) \tag{3.2}$$

The preceding equations point out the role that weighting factors play in the calculation of the Hydrogeologic Suitability Index. Scores for both the parameters and the formations rely upon somewhat arbitrary weighting factors. When a formation is ranked as highly permeable, it receives a score twice as high as a moderately permeable formation, and that difference in score is multiplied by 2 in calculating the formation score. It is here that another individual interested in groundwater banking could apply a different set of weighting factors in the spreadsheet developed for this project.

3.2 Water Quality Sub-Index

If water is stored at a potential groundwater banking site, it will commingle with the native groundwater. The quality of this native water will influence the ultimate quality of water stored in and recovered from the aquifer (the quality of stored water will also influence the quality of water available to existing groundwater users). This sub-index attempts to compare sites in terms of the quality of groundwater found at potential sites.

3.2.1 Water Quality Sub-Index Parameters

Four water quality components were selected based on their importance to both urban and agricultural water users and on the availability of data for the potential groundwater banking sites: arsenic, boron, lead and total dissolved solids. These parameters were defined using USGS National Water Information System (NWIS) data collected after 1/1/1970.

Arsenic (As)
Arsenic is a micronutrient for humans. However, long-term exposure to high concentrations of arsenic in drinking water can lead to many dangerous health problems including at least 8 different types of cancer (EPA website, 2001). Arsenic contained in groundwater generally comes from the natural weathering of the local geologic materials, although it can also result from anthropogenic sources such as industrial waste, arsenical pesticides and smelting operations (De Zuane, 1997). The maximum contaminant level for As enforced by the EPA is 50 ppb (or 50 mg/L), though this standard is currently under review and may be lowered to 10 ppb (or 10 mg/L) (EPA website, 2001).

Boron (B)
Boron is a micronutrient required in small amounts by both humans and plants. However, if the concentration of boron in groundwater is too high, it can be toxic for many commercially important crops in California. In general, water used for irrigation of boron-sensitive crops should contain less than 1.0 mg/L (or 1000 mg/L) to prevent toxicity.

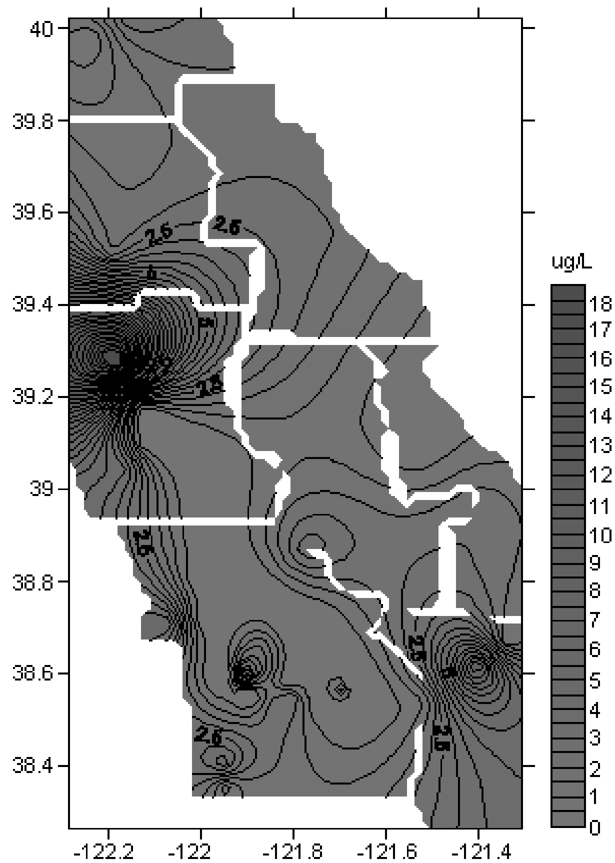
Lead (Pb)
Lead is a metal that can be found in drinking water as a result of natural weathering of local ore deposits. Lead is extremely hazardous and can cause a multitude of health problems including stroke, kidney disease and cancer. It also disrupts normal physical and mental development in infants and children (EPA website, 2001). Due to these extreme effects, the EPA maximum contaminant level for lead is zero; however, the action level at which clean-up takes place is 15 ppb (or 15 mg/L) due to current technological and resource-oriented constraints (EPA website, 2001).

Total Dissolved Solids (TDS)
TDS is not a trace element like the other water quality parameters, but is a measure of the concentration of inorganic salts (primarily Ca, Mg, K, Na, bicarbonates, chlorides and sulfates) and organic material dissolved in water (WHO, 1993). Although there are no specific health problems or regulations associated with high TDS levels, the generally accepted limit for

drinking water is 1000 mg/L (WHO, 1993). For TDS, the EPA sets the National Secondary Drinking Water Regulation, a non-enforceable guideline based on the cosmetic and aesthetic qualities of water, at 500 mg/l (EPA website, 2001).

Data gathered on each of these parameters (see the Water Quality portion of Section 7.0: References) reveal a fair amount of spatial variability across the Central Valley. As an example, measured lead concentrations in groundwater in the Sacramento Valley are shown in Figure 3.2.1. The most elevated levels were observed in Colusa and Sacramento Counties. Contour maps of the three other parameters reveal distinct patterns of spatial variability that could influence the selection of potential groundwater banking sites.

Figure 3.2.1: Lead Contour Map for the Sacramento Valley



3.2.2 Water Quality Sub-Index Weighting Factors

The raw water quality data for the four parameters above is listed in Appendix A. In order to convert these raw parameter values into a water quality sub-index, a method for assigning parameter scores between 1 and 10 was developed. As with the geology sub-index parameters, a score of 10 corresponds with conditions most favorable to groundwater banking. Table 3.2.1 describes the scores assigned to distinct ranges of raw parameter values. In each case, a score of 5 corresponds with the EPA-recommended level.

Table 3.2.1: Parameter Weighting Factors Used to Calculate the Water Quality Sub-Index

	Score	Arsenic µg/L			Boron µg/L			Lead µg/L			TDS mg/L		
Toxic	1	50.00	+		9000.00	+		15.00	+		1000.00	+	
	2	40.00	-	49.99	7000.00	-	8999.00	13.33	-	14.99	875.00	-	999.00
	3	30.00	-	39.99	5000.00	-	6999.00	11.67	-	13.32	750.00	-	874.00
	4	20.00	-	29.99	3000.00	-	4999.00	10.00	-	11.66	625.00	-	749.00
Recommended	5	10.00	-	19.99	1000.00	-	2999.00	8.33	-	9.99	500.00	-	624.00
	6	8.00	-	9.99	800.00	-	999.00	6.67	-	8.32	400.00	-	499.00
	7	6.00	-	7.99	600.00	-	799.00	5.00	-	6.66	300.00	-	399.00
	8	4.00	-	5.99	400.00	-	599.00	3.33	-	4.99	200.00	-	299.00
	9	2.00	-	3.99	200.00	-	399.00	1.67	-	3.32	100.00	-	199.00
	10	0.00	-	1.99	0.00	-	199.00	0.00	-	1.66	0.00	-	99.00

Scores for the individual parameters can be combined to calculate a composite water quality score, as in Equation 3.3. In this case no weighting factors have been employed, although someone interested in a particular parameter could weight that constituent accordingly in the spreadsheet developed as part of this effort.

$$\text{Water Quality Score} = (\text{As Score}) + (\text{B Score}) + (\text{Pb Score}) + (\text{TDS Score}) \quad (3.3)$$

Below a particular groundwater banking site, two water quality scores may be of interest. The first corresponds with the water quality immediately below a potential groundwater banking site and reflects the short-term mixing between recharge water and native groundwater that occurs when they come into contact. Once a significant amount of recharge occurs and water is stored at a banking site for extended periods of time, the potential for longer-term mixing between stored water and the native groundwater extends over a much larger area. Over this time scale, it is the quality of the groundwater in the basin surrounding the potential banking site that is important. Using available data, basin groundwater quality scores were calculated by averaging all the data from the wells within the basin boundaries for a specific component. This same data was then used to create a contour map (similar to Figure 3.2.1) so the approximate water quality score at potential groundwater banking sites could be determined.

Our attempt to capture the full spectrum of potential mixing between banked water and native groundwater led us to define the two components of the water quality sub-index described in Equation 3.4.

$$\text{Water Quality Sub-Index} = 1.5*(\text{Basin Score}) + (\text{Site Score}) \quad (3.4)$$

In this version of the water quality sub-index, the basin score was weighted more heavily than the site score. The heavier weighting on the basin score tends to stress the impact of long-term interactions between banked water and native groundwater. This is in keeping with the utility assigned to most banked groundwater in California—namely that it is to serve as a source of supplemental supply in the relatively infrequent dry and critical water years.

One final point that should be made regarding the water quality sub-index is that the data used to develop water quality contour maps come from wells screened at different depths. Ideally the vertical relationship between water quality observations should be considered along with their relative horizontal positions. We made an attempt to limit the vertical extent of water quality observations by excluding any samples that were noted as having been taken from below the Corcoran Clay in the San Joaquin Valley. As the screened interval in most sampled wells is neither known nor reported, it was difficult to introduce the vertical dimension into our water quality contour maps. Any attempt to screen the samples by depth would have proved much too expensive and time consuming to be undertaken in the current effort. This is another area where more specific analysis of potential sites will be required once the field of potential groundwater banking sites has been thinned.

3.3 Soils Sub-Index

Soil characteristics exert a potentially important control on the overall hydrogeologic suitability of potential groundwater banking projects employing recharge ponds, since the physical properties of the soil profile may limit the percolation rate. Sites with low percolation rates will require larger basins in order to recharge a given volume of water, thereby increasing the overall cost of the project. If the soil chemistry at a site is poor, the quality of banked water might be degraded as it percolates from the recharge basin. In the extreme, problematic soils could be removed from a potential site prior to the construction of recharge basins. However, this would greatly increase the overall cost of the project, potentially making it less attractive with respect to other alternatives.

3.3.1 Soils Sub-Index Parameters

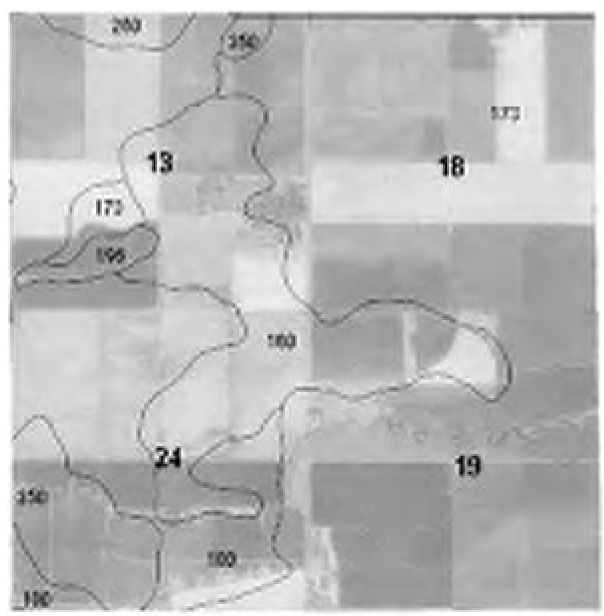
The main data source used to define parameters for this sub-index was the USDA soil survey series for California (see the Soils portion of Section 7.0: References). Each volume of the series covers an area of California (typically a single county) and is composed primarily of detailed maps showing aerial photographs overlain by the delineation of soils found in the area. An example (Figure 3.3.1) is an excerpt from the Soil Survey of San Joaquin County, California (McElhiney, 1992). The large font numbers that appear on the figure (13, 18, 24, 19) are the township and range sections associated with the California Public Lands Survey. The small number found within each soil polygon correlates to a soil type and a series of soil parameters. For example, 180 represents an area covered by Jackstone clay.

From the extensive list of parameters reported for each soil type, we selected four that we feel capture the impacts that the physical and chemical properties of a soil can exert on groundwater banking via recharge ponds: soil thickness, soil permeability, soil pH and the presence or absence of hardpans. These parameters were evaluated for each soil type encountered at potential groundwater banking sites according to the approach described in the following paragraphs.

Thickness

Each soil's thickness was recorded in inches and normalized relative to the maximum soil thickness encountered at the full suite of potential groundwater banking sites to generate a soil thickness score between 0 and 1. A thick soil will magnify any negative effects on percolation or water quality encountered as water flows through the soil column to the underlying aquifer. Similarly, a thick soil will magnify positive soil characteristics.

Figure 3.3.1: Soil Survey Map of Mormon Slough (McElhiney, 1992)



Permeability

Soil permeability is a measure of how easily and quickly water moves through a soil. The USDA soil surveys report permeability in a range in inches of water per hour. We took the average value of the range reported for each soil type encountered at the each of the potential groundwater banking sites and normalized it to arrive at a score between 0 and 1, where a value of 1 is desirable. In cases where no specific permeability value was provided, the permeability was estimated as a function of soil structure and clay content as per the National Soil Survey Handbook (USDA, 1999).

pH

Soil pH is a measure of the acidity of a soil. The USDA assigns categories to pH levels, and we assigned numerical values to the categories in order to include them in the soils sub-index, as shown below in Table 3.3.1. In this case, a neutral pH of 7 corresponds with component score of 1. Increasingly acidic and alkaline soils are awarded decreasing parameter scores. While not a perfect predictor for the types of chemical transformation water percolating from a recharge pond will undergo, pH is a good proxy for a number of potential water quality problems in the soil.

Table 3.3.1: pH Rating Scale

pH reading	USDA category	Suitability Index
3.5 - 4.4	Extremely acid	0
4.5 - 5.0	Very strongly acid	0.2
5.1 - 5.5	Strongly acid	0.4
5.6 - 6.0	Moderately acid	0.6
6.1 - 6.5	Slightly acid	0.8
6.6 - 7.3	Neutral	1.0
7.4 - 7.8	Slightly alkaline	0.8
7.9 - 8.4	Moderately alkaline	0.6
8.5 - 9.0	Strongly alkaline	0.4
9.1 - 11.0	Very strongly alkaline	0.2

Hardpan

Each soil description was checked to see if the presence of a hardpan was reported. A hardpan can impede the percolation of water below a recharge pond, limiting the suitability of a potential project site. If a hardpan was present, a parameter score of 0 was assigned. If there was no hardpan occurrence, then a value of 1 was assigned.

The raw soil data is available in Appendix B. As can be expected when gathering data from diverse sources, not all soil surveys reported the same soil parameters. When a particular piece of data, such as permeability, was not available for a soil type, we attempted to locate the value in a soil survey for an adjacent county before invoking any other approximation method. We will point out where we were forced to approximate a soil parameter in later sections dealing with specific potential groundwater banking sites.

3.3.2 Soils Sub-Index Weighting Factors

Once the parameter scores were developed for each of the soil types at the potential groundwater banking sites, a weighted average parameter score was calculated based on the area of each soil type overlying potential project sites. The area data is available in Appendix C. This produced a score for each site for each of the four soil parameters. The soils sub-index was calculated by applying the weighting factors shown in the following equation:

$$\text{Soils Sub-Index} = (\text{Thickness})*(3*[\text{Permeability}] + [\text{pH}] - 2*[1 - \text{Hardpan}]) \qquad (3.5)$$

In Equation 3.5, permeability was weighted by a factor of 3 and hardpan by a factor of 2 to stress the importance of these components on the ability of water to percolate below recharge basins. Since potentially constraining soil parameters are subtracted in Equation 3.5, it is possible to arrive at negative sub-index values. Once again, another individual interested in groundwater banking could apply a different set of weighting factors in the spreadsheet developed for this project.

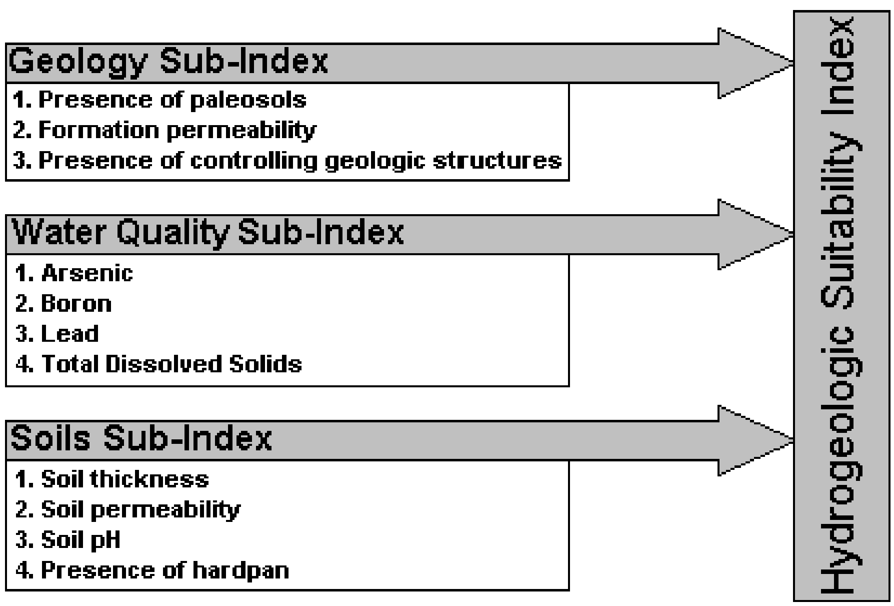
3.4 Application of the Core Hydrogeologic Suitability Index

The sub-indices presented in the previous sections constitute the core of the Hydrogeologic Suitability Index that will be applied to potential groundwater banking sites in both the Sacramento and San Joaquin Valleys. A separate sub-index based on the temporal evolution of the elevation of the water table is applied only in the San Joaquin Valley. Details of this sub-index are presented in Section 5.0 dealing with the application of the index in that region.

4.0 Application of the Hydrogeologic Suitability Index in the Sacramento Valley

As mentioned previously, differences in the hydrologic conditions between the Sacramento and San Joaquin Valleys prompted our decision to apply the Hydrogeologic Suitability Index separately in the two regions. In the Sacramento Valley, a core index that includes sub-indices related to geology, groundwater quality and soils has been applied. Figure 4.0.1 provides a summary flow chart of the information used to develop each of the sub-indices and the overall Hydrogeologic Suitability Index. Descriptions of each of the parameters presented in Figure 4.0.1 are given in Section 3.0, along with a proposed methodology for assigning parameter scores. The following sections present the data used to calculate the sub-indices for each of the potential Sacramento Valley groundwater banking sites shown in Figure 2.0.1.

Figure 4.0.1: Flow Chart of Parameters Analyzed in the Development of Relevant Sub-Indices and the Overall Hydrogeologic Suitability Index in the Sacramento Valley



4.1 Sacramento Valley Geology Sub-Index

In Section 3.1.1, the geology sub-index parameters were discussed. These parameters are permeability, the presence of paleosols, and the presence of any controlling geologic structures. The methodology used to create a weighted average of parameter scores based on the thickness of the formations encountered at a given site was also presented in Equation 3.2. The influence of formation thickness is a particularly important issue in the Sacramento Valley because although there is a tendency to think of Sacramento Valley groundwater in terms of a homogeneous underground reservoir that fluctuates gradually with wet and dry cycles, the reality is more complex. While much of the Sacramento Valley groundwater basin is interconnected, aquifer structure is far from uniform (DWR, 1998). Considering the properties of only the uppermost formation would miss many important controls that this complex geology could exert on the groundwater banking operations using recharge ponds. The vertical sequence of formations must be taken into consideration along with their horizontal extent.

Geology Sub-Index Equation Key

Eq. 3.1: Formation Score = 2*(Permeability) + 0.5*(Paleosols) + (Geological Structure)

Eq. 3.2: Geology Sub-Index = Σ (Formation Score $_A$*Formation Thickness $_A$)

4.1.1 Results of the Sacramento Valley Geology Sub-Index

Table 4.1.1 contains a list of the geologic formations encountered below the potential groundwater banking sites identified for the Sacramento Valley. The table also includes the parameter scores assigned to the formations in terms of permeability, paleosols and geologic structures. The formation scores, as calculated using Equation 3.1, are listed in the Rank column. These scores are then normalized between 0 and 1 according to their relative position between the formation with the highest (Stony Creek Fan with a score of 32) and lowest (Mehrten, Flood Basin Deposits and South Fork Gravels with scores of 14) ranks. The normalized ranks are found in the % column.

Table 4.1.1: Scores for Formations Found in the Sacramento Valley

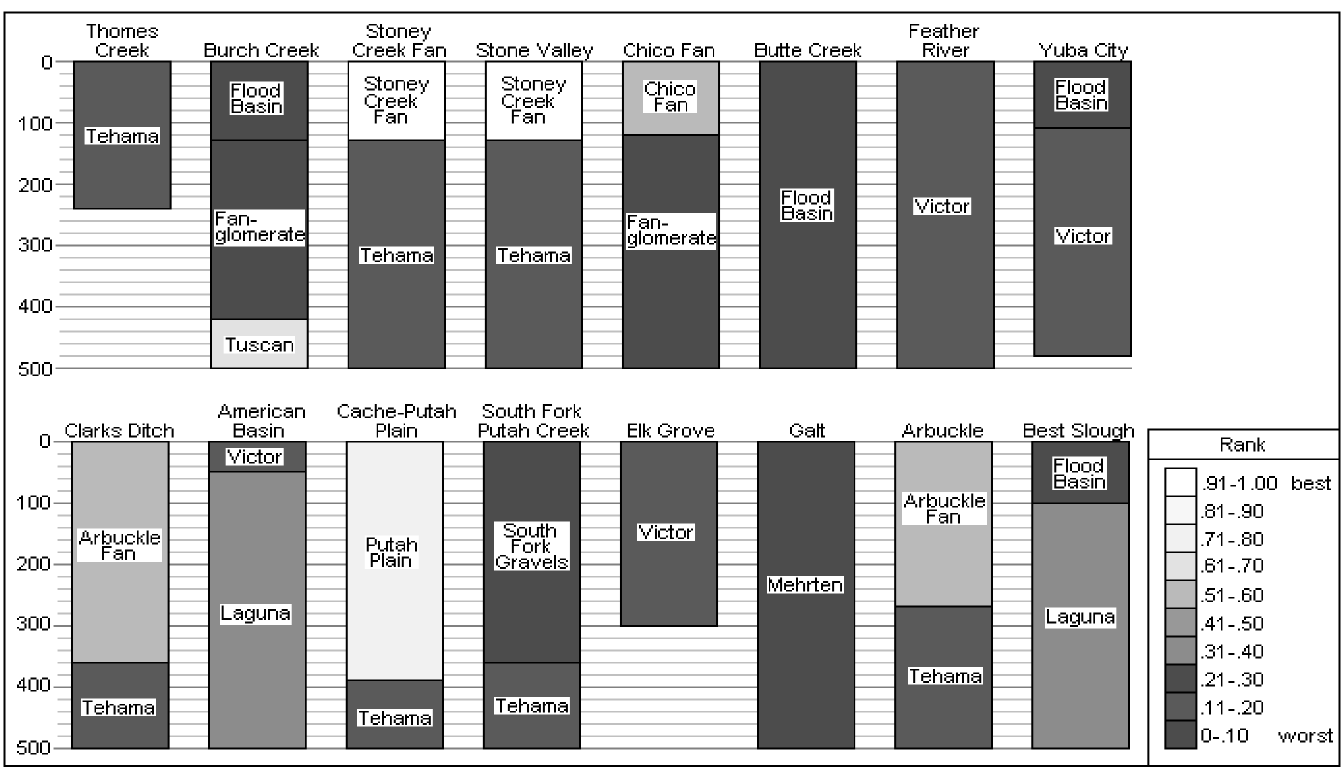
Weighting Coefficient	0.5	2	1		
Formation	**Paleosols**	**Permeability**	**Geo. Strct.**	**Rank**	**%**
Stony Creek Fan	10	8.5	10	32	1.00
Putah Plain	10	6	10	27	0.72
Tuscan	0	10	5	25	0.61
Arbuckle Fan	10	7	5	24	0.56
Chico Fan	10	7	5	24	0.56
Laguna	10	5	5	20	0.33
Victor	0	6	5	17	0.17
Tehama	10	3	5	16	0.11
Fanglomerate	10	2.5	5	15	0.06
Mehrten	10	2	5	14	0.00
Flood Basin	10	2	5	14	0.00
South Fork Gravels	10	2	5	14	0.00

Having ranked the various formations encountered in the Sacramento Valley, we examined the vertical stratification of these units below each of the potential groundwater banking sites located in the Sacramento Valley (as shown in Figure 2.0.1). The formations encountered, which have been color coded according to their formation scores, are shown in Figure 4.1.1. If a program of groundwater banking is based on the use of recharge ponds, then the sequence of formations down from the ground surface at a potential site is critical. If a formation that is poorly suited to groundwater banking overlies one with attractive geologic properties, the opportunity for groundwater banking using recharge ponds is constrained by the poorly suited upper formation. In applying Equation 3.2, the formation sequence was taken into consideration.

Table 4.1.2 contains a list of the potential groundwater banking sites in the Sacramento Valley with the sequence of formations encountered down to a depth of 500 feet listed to the right, along with the formation score and local thickness. The geology sub-index is calculated by applying Equation 3.2 down to and including the first formation that overlies one with a higher score. For example, at the American Basin site, where the Victor Formation with a score of 0.17 overlies the Laguna Formation with a score of 0.33, only the properties and thickness of the overlying Victor Formation are considered in calculating the geology sub-index. This calculation has been carried out based on three assumed operational depths for the proposed groundwater banking projects: 100 ft., 300 ft. and 500 ft.

Figures 4.1.2 through 4.1.4 graphically present the rank associated with each potential site in terms of the geology sub-index under different assumptions regarding operational depth.

Figure 4.1.1: Vertical Stratification of Formations Encountered at Potential Groundwater Banking Sites in the Sacramento Valley



Sacramento Valley

Table 4.1.2: Geology Sub-Index Values Calculated for Potential Groundwater Banking Sites in the Sacramento Valley

	Formation 1			Formation 2			Formation 1			Operational Depth					
										500 ft		300 ft		100 ft	
Site	Formation	Score	Thickness	Formation	Score	Thickness	Formation	Score	Thickness	Score	Normal	Score	Normal	Score	Normal
Cache-Putah Plain	Putah Plain	0.72	390	Tehama	0.11	110				293.9	1.00	216.7	1.00	72.2	0.72
Clarks Ditch	Arbuckle Fan	0.56	360	Tehama	0.11	140				215.6	0.73	166.7	0.77	55.6	0.56
Arbuckle	Arbuckle Fan	0.56	260	Tehama	0.11	240				171.1	0.58	148.9	0.69	55.6	0.56
Stoney Creek Fan	Stony Creek Fan	1.00	130	Tehama	0.11	370				171.1	0.58	148.9	0.69	100.0	1.00
Stone Valley	Stony Creek Fan	1.00	130	Tehama	0.11	370				171.1	0.58	148.9	0.69	100.0	1.00
Chico Fan	Chico Fan	0.56	120	Fanglomerate	0.06	380				87.8	0.30	76.7	0.35	55.6	0.56
Feather River	Victor	0.17	500							83.3	0.28	50.0	0.23	16.7	0.17
Elk Grove	Victor	0.17	300							50.0	0.17	50.0	0.23	16.7	0.17
Thomes Creek	Tehama	0.11	240							26.7	0.09	26.7	0.12	11.1	0.11
American Basin	Victor	0.17	30	Laguna	0.33	470				5.0	0.02	5.0	0.02	5.0	0.05
Best Slough	Flood Basin	0.00	100	Laguna	0.33	400				0.0	0.00	0.0	0.00	0.0	0.00
Burch Creek	Flood Basin	0.00	130	Fanglomerate	0.06	280	Tuscan	0.61	90	0.0	0.00	0.0	0.00	0.0	0.00
Yuba City	Flood Basin	0.00	100	Victor	0.17	400				0.0	0.00	0.0	0.00	0.0	0.00
S. Fork Putah Creek	S. Fork Gravels	0.00	360	Tehama	0.11	140				0.0	0.00	0.0	0.00	0.0	0.00
Butte Creek	Flood Basin	0.00	500							0.0	0.00	0.0	0.00	0.0	0.00
Galt	Mehrten	0.00	500							0.0	0.00	0.0	0.00	0.0	0.00

Figure 4.1.2: Sacramento Valley Geology Sub-Index Values Assuming an Operational Depth of 500 Feet

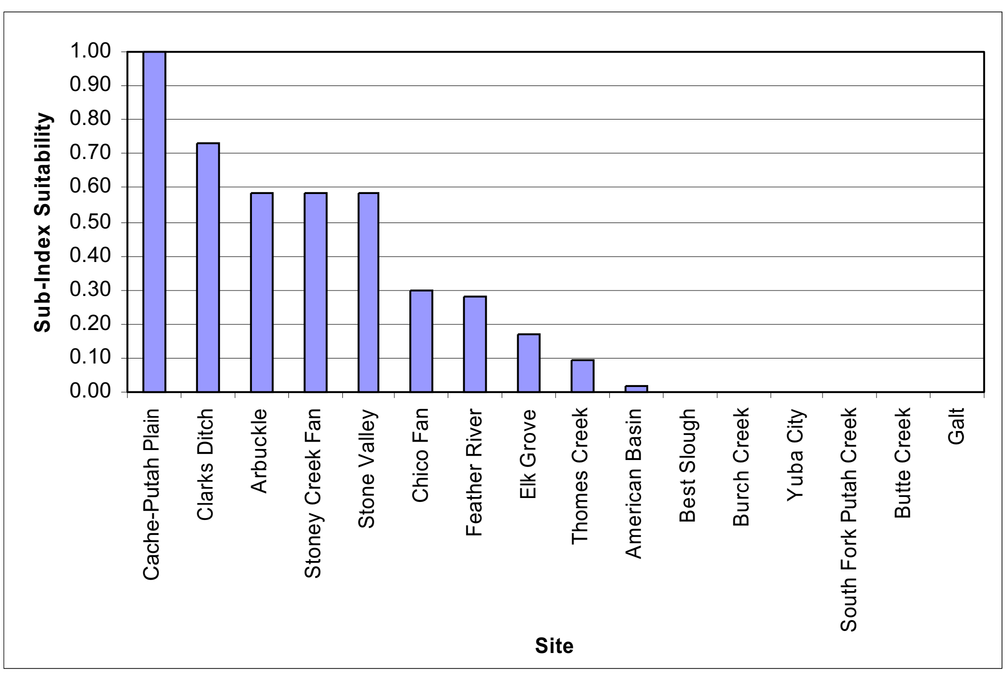


Figure 4.1.3: Sacramento Valley Geology Sub-Index Values Assuming an Operational Depth of 300 Feet

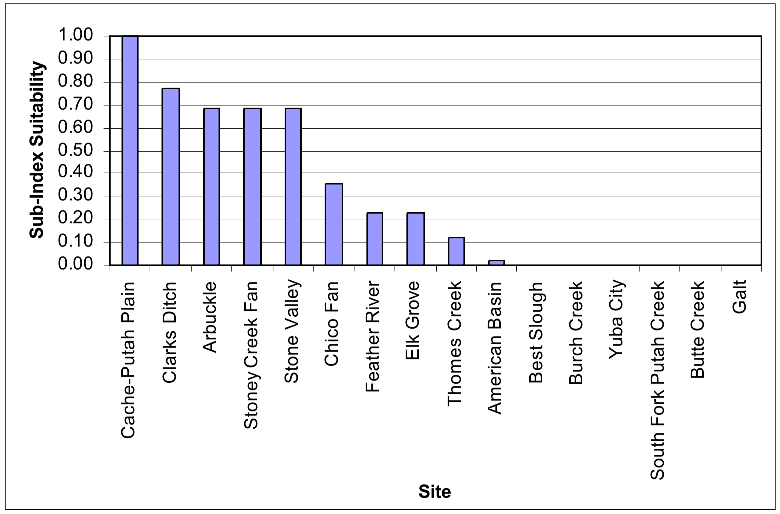
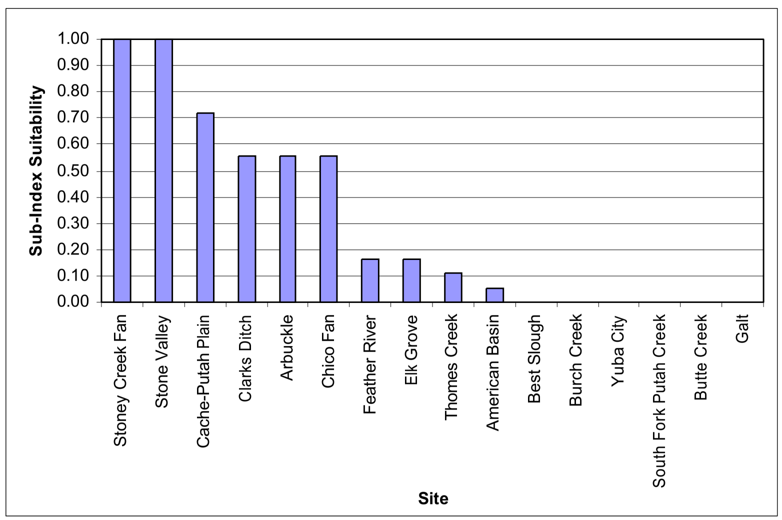
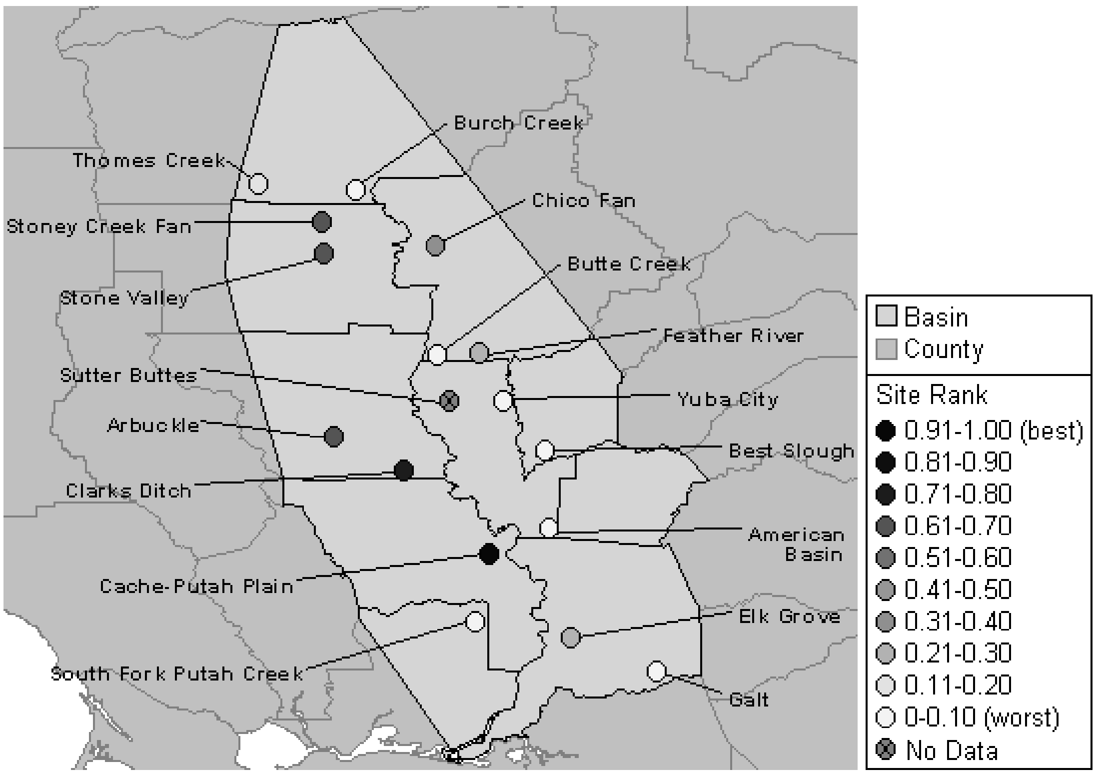


Figure 4.1.4: Sacramento Valley Geology Sub-Index Values Assuming an Operational Depth of 100 Feet



In calculating the overall Hydrogeologic Suitability Index for sites in the Sacramento Valley, geology sub-index values based on an assumed operational depth of 300 ft. are employed. Figure 4.1.5 displays the site comparison of the potential groundwater banking sites with respect to the 300 ft. depth rank.

Figure 4.1.5: Spatial Distribution of 300 Ft. Depth Geology Sub-Index Values Across Potential Groundwater Banking Sites in the Sacramento Valley



4.1.2 Comments on the Geology Sub-Index

Several interesting observations emerge from the results of the geology sub-index. First, sites in the western Sacramento Valley (e.g., Stony Creek Fan, Arbuckle Fan, Cache-Putah Plain) provide excellent geologic settings for groundwater banking. This is an important discovery because the aquifers underlying these sites are generally full. As such, groundwater banking would require some level of enhanced groundwater pumping in order to create the space required for storing banked groundwater—a management sequence that raises legitimate concerns on the part of overlying groundwater users. The relative superiority of these sites in terms of the geology, however, suggest that it may be worth the effort to design the legal and institutional arrangements needed to make these sorts of projects viable.

Sites located in the central and eastern portions of the Sacramento Valley generally fare less well in terms of the geology sub-index. This is due to the prevalence of flood basin deposits and the Victor Formation in the upper portion of the stratigraphic column below these sites. While more promising formations often lie below these units, access to them via recharge basins will be constrained by the less suitable overlying formations. These are areas where groundwater banking via injection wells or *in lieu* arrangements may be the preferred alternative.

4.2 Sacramento Valley Water Quality Sub-Index

As mentioned in Section 3.2, the water quality sub-index was based on the reported concentrations in groundwater of four parameters: arsenic, boron, lead and total dissolved solids.

Water Quality Sub-Index Equation Key

Eq. 3.3: Water Quality Score = [As Score] + [B Score] + [Pb Score] + [TDS Score]
Eq. 3.4: Water Quality Sub-Index = 1.5*[Basin Score] + [Site Score]

4.2.1 Results of the Sacramento Valley Water Quality Sub-Index

For each of the basins in the Sacramento Valley (see Figure 2.0.1), the average of all observations was used to assign a parameter score according to Table 3.2.1. The total water quality scores (in the Rank column), calculated using Equation 3.3, and normalized values between 0 and 1 (in the % column), are shown in Table 4.2.1.

Table 4.2.1: Water Quality Scores for Basins in the Sacramento Valley

Weighting Coefficient	1	1	1	1		
Basin Name	**As**	**B**	**Pb**	**TDS**	**Rank**	**%**
Tehama	10	9	10	8	37	1.00
Yuba	9	10	10	8	37	1.00
Butte	9	10	9	8	36	0.86
Placer	9	8	10	8	35	0.71
Glenn	8	10	9	7	34	0.57
Sutter	7	10	9	7	33	0.43
Colusa	9	9	8	6	32	0.29
Solano	9	8	10	5	32	0.29
Sacramento	7	10	8	8	31	0.14
Yolo	9	5	10	6	30	0.00

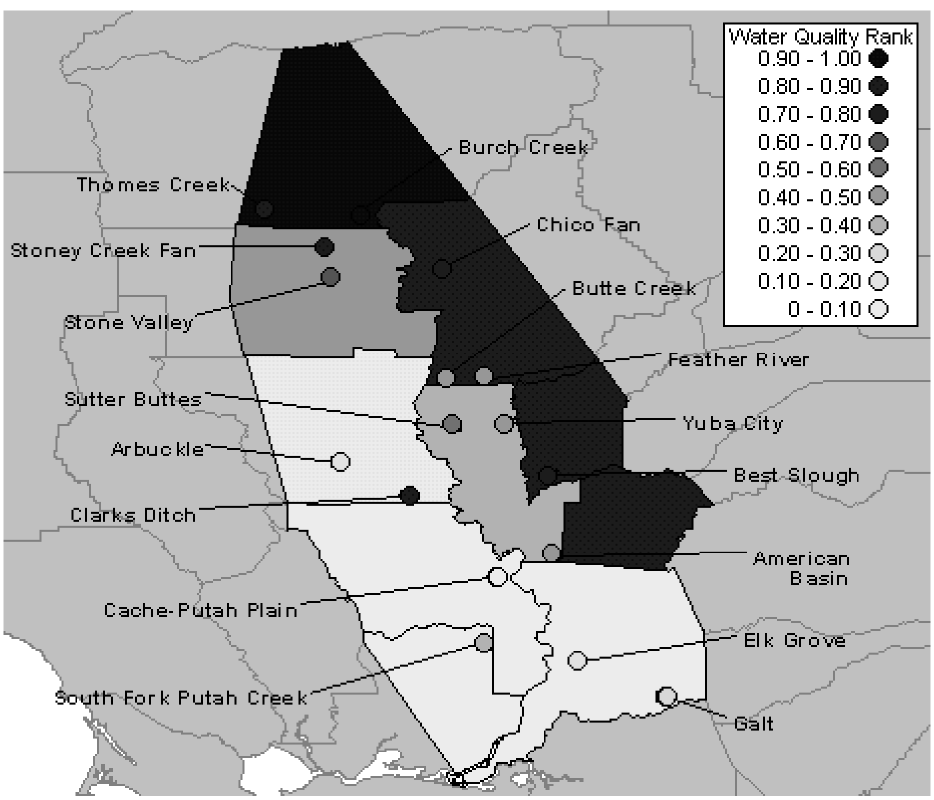
Based on contour maps developed from the available data in each basin, estimated concentrations, parameter scores and normalized values between 0 and 1 were developed for each of the potential Sacramento Valley groundwater banking sites (Table 4.2.2).

The information in both Tables 4.2.1 and 4.2.2 is displayed spatially in Figure 4.2.1.

Table 4.2.2: Water Quality Scores for Sites in the Sacramento Valley

Weighting Coefficient	1	1	1	1		
Site Name	**As**	**B**	**Pb**	**TDS**	**Rank**	**%**
Burch Creek	10	10	10	9	39.00	1.00
Clarks Ditch	10	10	10	8	38.00	0.89
Stoney Creek Fan	10	10	10	8	38.00	0.89
Thomes Creek	10	10	10	8	38.00	0.89
Best Slough	9	10	10	8	37.00	0.78
Chico Fan	10	10	9	8	37.00	0.78
Stone Valley	9	10	9	8	36.00	0.67
Sutter Buttes	6	10	10	9	35.00	0.56
American Basin	7	10	9	8	34.00	0.44
Butte Creek	7	10	9	8	34.00	0.44
Feather River	7	10	10	7	34.00	0.44
Yuba City	6	10	10	8	34.00	0.44
South Fork Putah Creek	8	8	10	7	33.00	0.33
Galt	6	10	8	8	32.00	0.22
Arbuckle	9	6	8	8	31.00	0.11
Elk Grove	5	10	9	7	31.00	0.11
Cache-Putah Plain	8	5	10	7	30.00	0.00

Figure 4.2.1: Spatial Distribution of Basin and Site Water Quality Scores



Sacramento Valley

Based on the water quality scores presented in Tables 4.2.1 and 4.2.2, the water quality sub-index for potential groundwater banking sites in the Sacramento Valley was calculated according to Equation 3.4. These scores were normalized between 0 (corresponding with the poorest groundwater quality at the Cache Putah Plain site) and 1 (corresponding with the best groundwater quality observed at the Burch Creek site). The results are shown in Table 4.2.3.

Table 4.2.3: Water Quality Sub-Index Values for Potential Groundwater Banking Sites in the Sacramento Valley

Weighting Coefficient		1.5	1		
Site Name	**Basin**	**Basin Wide**	**Site Specific**	**Rank**	**%**
Thomes Creek	Tehama	1.00	0.89	2.39	0.96
Burch Creek	Tehama	1.00	1.00	2.50	1.00
Stoney Creek Fan	Glenn	0.57	0.89	1.75	0.70
Stone Valley	Glenn	0.57	0.67	1.52	0.61
Elk Grove	Sacramento	0.14	0.11	0.33	0.13
Butte Creek	Butte	0.86	0.44	1.73	0.69
Feather River	Butte	0.86	0.44	1.73	0.69
Chico Fan	Butte	0.86	0.78	2.06	0.83
American Basin	Sutter	0.43	0.44	1.09	0.43
Galt	Sacramento	0.14	0.22	0.44	0.17
Arbuckle	Colusa	0.29	0.11	0.54	0.22
Sutter Buttes	Sutter	0.43	0.56	1.20	0.48
Yuba City	Sutter	0.43	0.44	1.09	0.43
Clarks Ditch	Colusa	0.29	0.89	1.32	0.53
Cache-Putah Plain	Yolo	0.00	0.00	0.00	0.00
South Fork Putah Creek	Solano	0.29	0.33	0.76	0.30
Best Slough	Yuba	1.00	0.78	2.28	0.91

Figures 4.2.2 and 4.2.3 present the value of the water quality sub-index for potential banking sites in the Sacramento Valley derived from available data in terms of relative rank and spatial distribution, respectively.

4.2.2 Comments on the Water Quality Sub-Index

It is worth noting that the water quality of all sites in the Sacramento Valley is fairly good. However, boron does reach the recommended maximum level for boron-sensitive crops in the Cache-Putah Plain site and is also rather high in the Arbuckle region. There appears to be an area of increased arsenic levels in the northeast part of the valley, though these levels are still below the recommended levels and far below toxicity. Lead levels are very low in the Sacramento Valley, though anything over zero is considered too much by EPA standards. TDS is also very low, though levels seem to rise toward the south. While the Hydrogeologic Suitability Index is applied separately to sites in the Sacramento and San Joaquin Valleys, the relatively good quality of groundwater in the Sacramento Valley suggests that sites in this region are worthy of consideration despite the fact that little or no aquifer storage space currently exists in this region.

Figure 4.2.2: Water Quality Sub-Index Ranking for Potential Groundwater Banking Sites in the Sacramento Valley

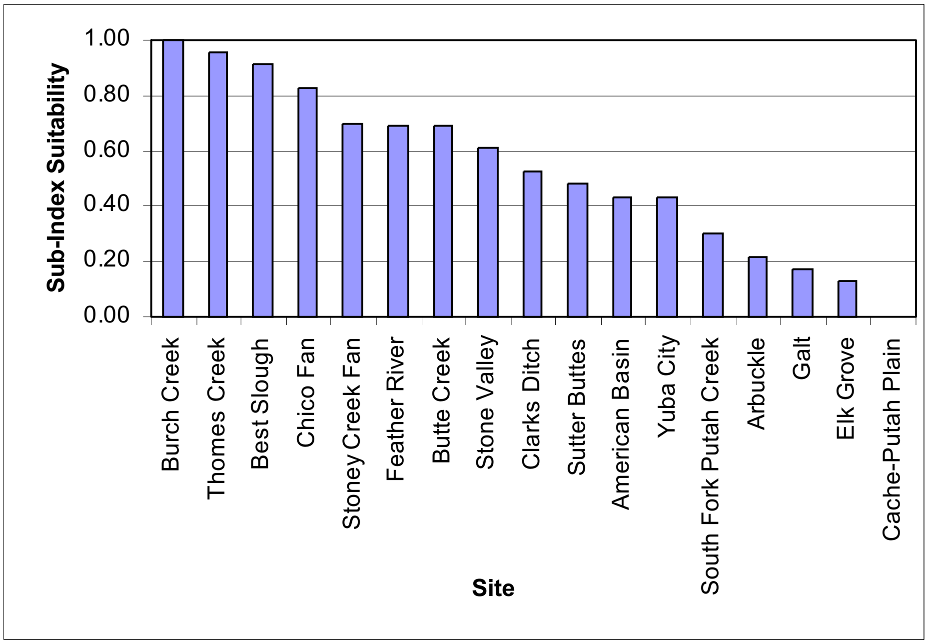
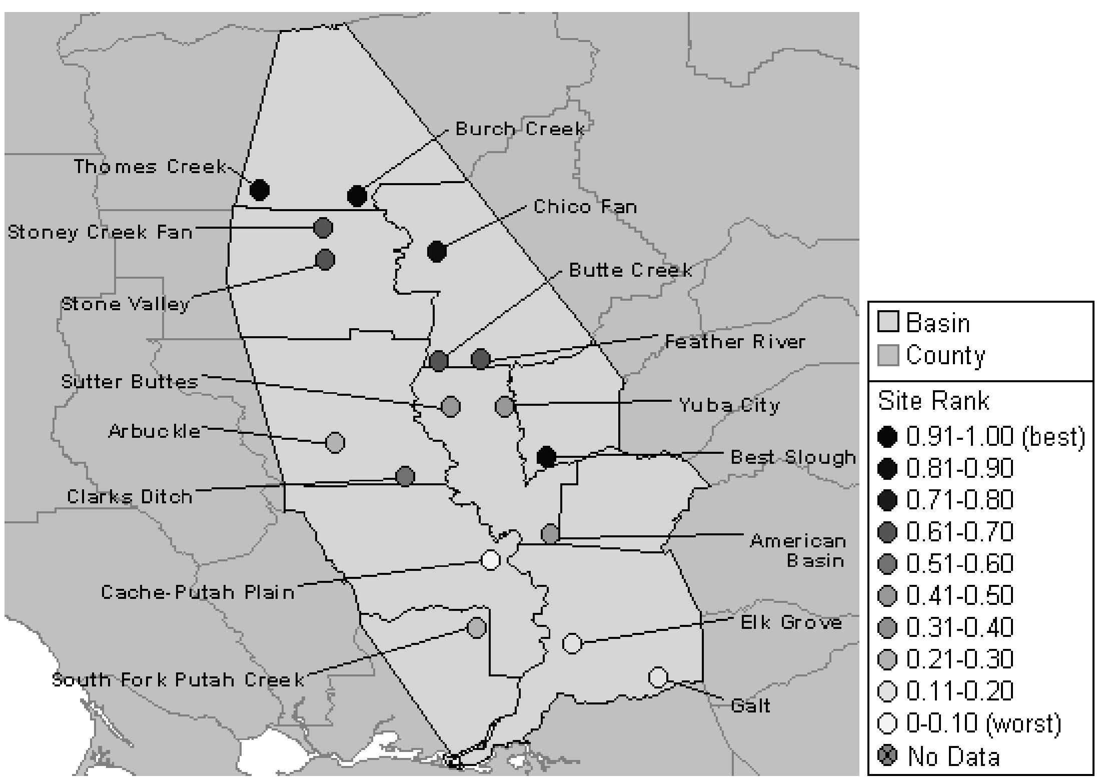


Figure 4.2.3: Spatial Distribution of Water Quality Sub-Index Values Across Potential Groundwater Banking Sites in the Sacramento Valley



4.3 Sacramento Valley Soils Sub-Index

The soils sub-index was calculated as described in Section 3.3. The soil types under a site were identified, evaluated and scored based on the four soil parameters: thickness, pH, permeability and hardpan. The soils sub-index was not calculated directly for several of the sites in the Sacramento Valley owing to a lack of an available soil survey. These sites are listed in Table 4.3.1. For these sites, treatment of the soil sub-index in the calculation of the overall Hydrogeologic Suitability Index is discussed in Section 4.4.

Table 4.3.1: Soil Sites Lacking Available Soil Surveys

Site	Basin
Chico Fan	Butte
Butte Creek	Butte
Feather River	Butte
Arbuckle	Colusa
Clarks Ditch	Colusa

4.3.1 Results for the Sacramento Valley Soils Sub-Index

The soils sub-index values that were calculated using Equation 3.5 are shown in Table 4.3.2, in the column entitled "Rank." Normalized values between 1 (corresponding to the Sutter Buttes site) and 0 (corresponding with the Elk Grove site) are listed in the % column. These results are displayed graphically in terms of their rank and their spatial distribution in Figures 4.3.1 and 4.3.2, respectively.

Soil Sub-Index Equation Key

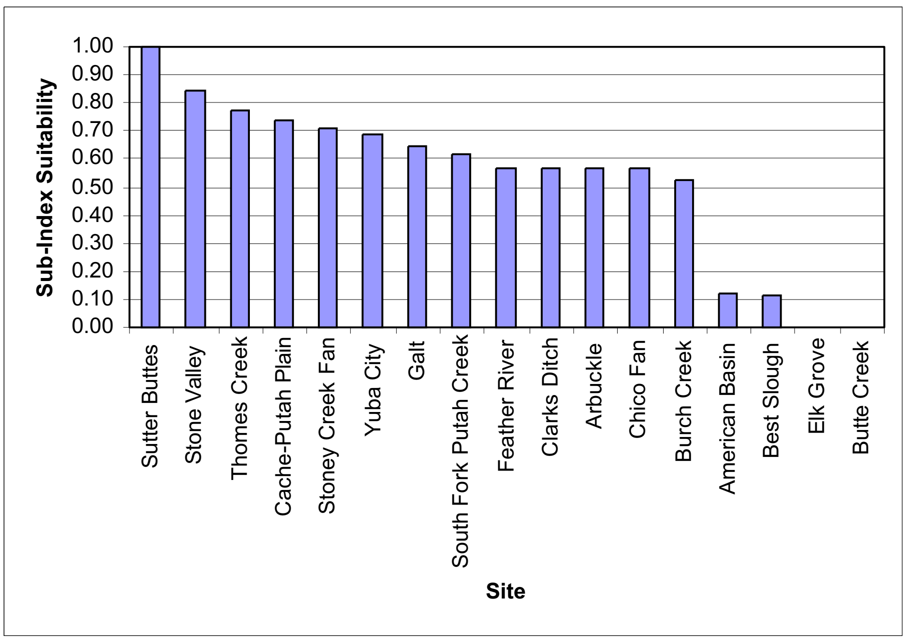
Eq. 3.5: Soils Sub-Index = (Thickness) [3(Permeability) + (pH)– 2(1 – Hardpan)]

Table 4.3.2: Soils Sub-Index Values for Potential Groundwater Banking Sites in the Sacramento Valley

Weighting Coefficient	1	3	2	1		
Site	**Thickness**	**Permeability**	**Hardpan**	**pH**	**Rank**	**%**
Thomes Creek	0.70	0.13	1.00	0.65	1.75	0.78
Stoney Creek Fan	0.75	0.14	0.86	0.71	1.58	0.71
Stone Valley	0.73	0.13	1.00	0.81	1.92	0.85
Sutter Buttes	0.41	0.33	1.00	0.90	2.32	1.00
Galt	0.78	0.08	0.95	0.51	1.41	0.64
Cache-Putah Plain	0.40	0.22	0.96	0.65	1.64	0.73
Yuba City	0.54	0.07	1.00	0.78	1.53	0.69
South Fork Putah Creek	0.66	0.01	1.00	0.65	1.34	0.62
American Basin	0.75	0.08	0.16	0.80	0.09	0.12
Best Slough	0.50	0.06	0.31	0.77	0.07	0.11
Elk Grove	0.75	0.08	0.00	0.79	-0.21	0.07
Burch Creek	0.60	0.11	0.77	0.65	1.11	0.52

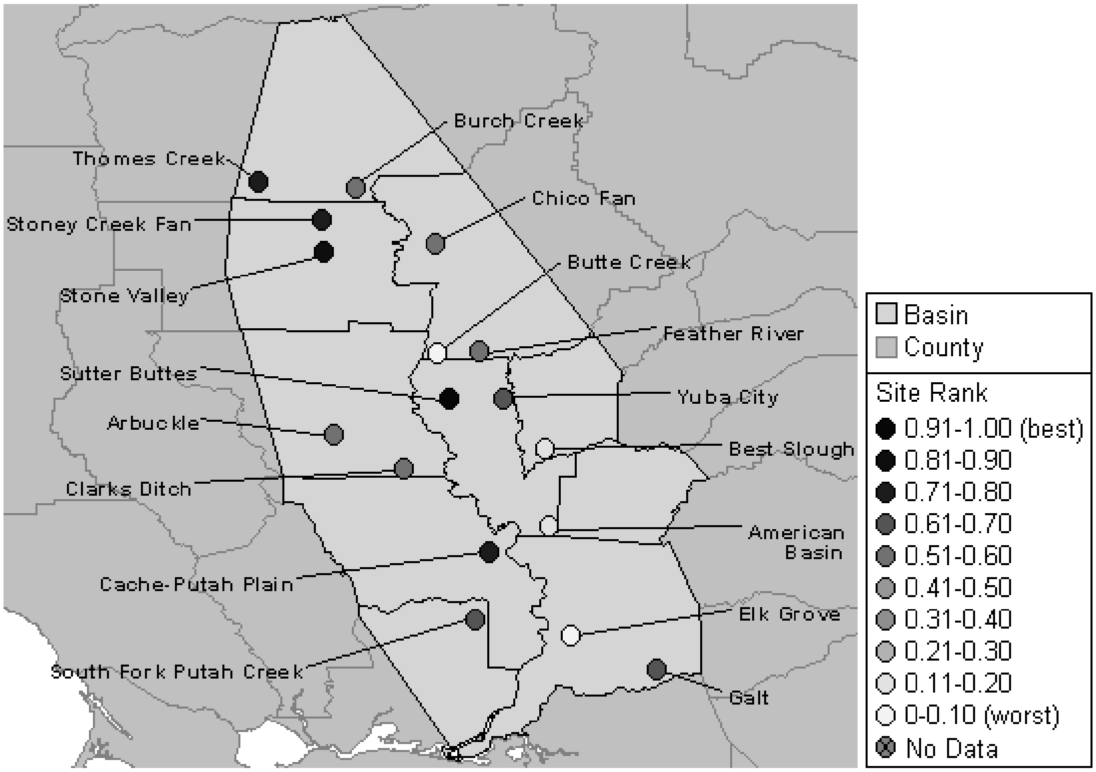
To estimate the soils sub-index for the sites lacking the soil survey data needed for sub-index Equation 3.5, the agricultural crops grown on these sites were identified. Two types of crops were identified on the five sites in Table 4.3.1. The Butte Creek site cultivated rice, which requires clayey soils with extremely low permeabilities. These types of soils are not appropriate for groundwater banking, as discussed in Section 3.3.1, so Butte Creek was given a soils sub-index value of zero. The other four sites from Table 4.3.1 were mainly composed of orchards, which indicate a more average loamy soil with moderate permeability. The score for these sites was calculated by averaging the sub-index scores shown in Table 4.3.2, arriving at an estimated score of 0.56. Figure 4.3.1 shows these estimated values in relation to the values displayed in Table 4.3.2.

Figure 4.3.1: Soils Sub-Index Ranking for Potential Groundwater Banking Sites in the Sacramento Valley



Sacramento Valley

Figure 4.3.2: Spatial Distribution of Soils Sub-Index Values Across Potential Groundwater Banking Sites in the Sacramento Valley



4.3.2 Comments on the Soils Sub-Index

Areas with highly desirable soil characteristics are found primarily in the northern and western regions of the valley. Unfortunately, actual data were not available for much of Butte and Colusa Counties and had to be estimated. The Excel project that accompanies this report would be an appropriate place to input more specific soil data for these sites, should this information become available.

4.4 Sacramento Valley Hydrogeologic Suitability Index

Having evaluated the sites in terms of three relevant sub-indices, we combined the sub-indices to derive the overall Hydrogeologic Suitability Index. The overall index of suitability in the Rank column in Table 4.4.1 was arrived at by applying Equation 4.1.

$$\text{Hydrogeologic Suitability Index} = 2*(\text{Geology}) + 2*(\text{Water Quality}) + (\text{Soils}) \quad (4.1)$$

In this analysis, the geology and water quality sub-indices are weighted by 2 to stress their importance. The characteristics of the underlying formations determine whether water can be stored in an aquifer, and the water quality of the area is crucial if stored water is to be used for agriculture and urban uses. Soils are not weighted as high because problematic soils can be removed as part of project construction, although this would increase the overall cost of the project.

4.4.1 Results for the Sacramento Valley Hydrogeologic Suitability Index

Table 4.4.1 shows the overall Hydrogeologic Suitability Index. Values were normalized between 1 (corresponding to the most suitable site at Stoney Creek Fan) and 0 (corresponding with Elk Grove) in the % column.

The overall Hydrogeologic Suitability Index values for sites in the Sacramento Valley are displayed graphically in terms of their rank and their spatial distribution in Figures 4.4.1 and 4.4.2, respectively.

Table 4.4.1: Sacramento Valley Hydrogeologic Suitability Index

Weighting Coefficient	2	2	1		
Site	**Geology**	**Water Quality**	**Soils**	**Rank**	**%**
Stoney Creek Fan	0.69	0.70	0.71	3.48	1.00
Thomes Creek	0.12	0.96	0.78	2.93	0.80
Stone Valley	0.69	0.61	0.85	3.28	0.93
Chico Fan	0.35	0.83	0.56*	2.92	0.80
Arbuckle	0.69	0.22	0.56*	2.37	0.60
Cache-Putah Plain	1.00	0.00	0.73	2.73	0.73
Feather River	0.23	0.69	0.56*	2.41	0.61
Galt	0.00	0.17	0.64	0.99	0.10
Elk Grove	0.23	0.13	0.00	0.72	0.00
Clarks Ditch	0.77	0.53	0.56*	3.16	0.88
American Basin	0.02	0.43	0.12	1.03	0.11
Sutter Buttes	0.30*	0.48	1.00	2.56	0.67
Yuba City	0.00	0.43	0.69	1.56	0.30
Butte Creek	0.00	0.69	0.00*	1.38	0.24
South Fork Putah Creek	0.00	0.30	0.62	1.23	0.18
Best Slough	0.00	0.91	0.11	1.94	0.44
Burch Creek	0.00	1.00	0.52	2.52	0.65

Figure 4.4.1: Hydrogeologic Suitability Index Ranking for Potential Groundwater Banking Sites in the Sacramento Valley

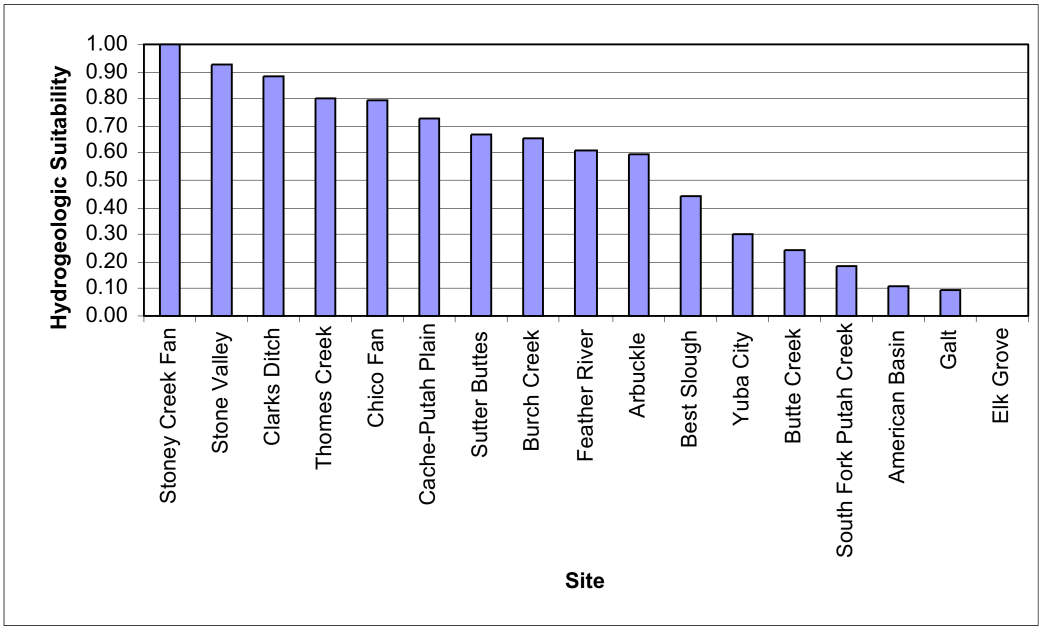
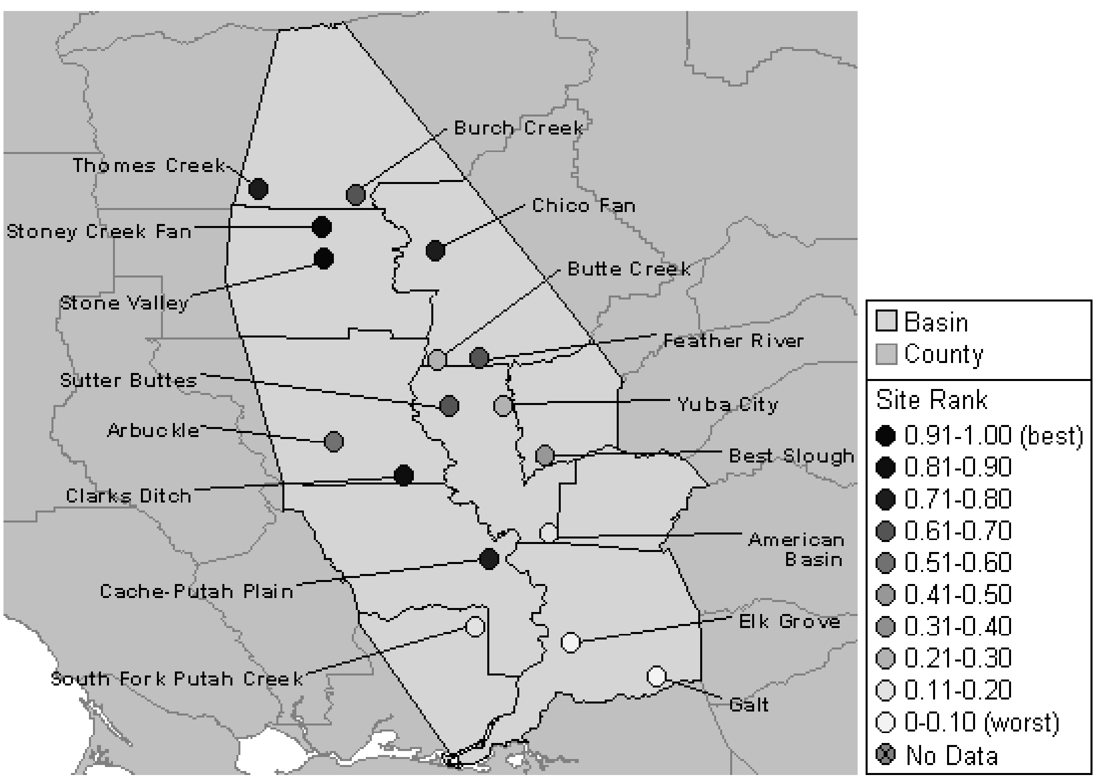


Figure 4.4.2: Spatial Distribution of the Hydrogeologic Suitability Index Values Across Potential Groundwater Banking Sites in the Sacramento Valley



4.4.2 Comments on the Sacramento Valley Hydrogeologic Suitability Index

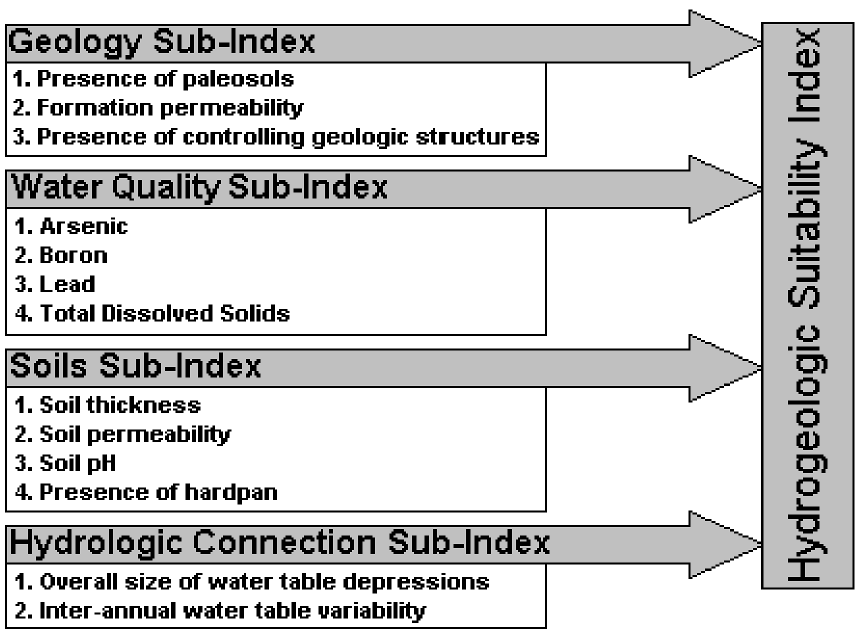
When all of the relevant sub-index values are taken into consideration, there appears to be a trend from the most suitable sites in the northern portion of the Sacramento Valley toward generally less suitable sites in the south. This has important implications in terms of integrating these sites into the state's surface water distribution network, as only Shasta Reservoir physically commands the most northern sites. While Shasta is a large facility, operational constraints associated with temperature control objectives may limit the ability to use Shasta as a direct source for groundwater banking. This suggests that a program of coordinated release from all of the Sacramento Valley reservoirs may be needed to "back" water up into Shasta Reservoir for eventual transfer to northern banking sites.

It should be pointed out that the ranking depicted in Figure 4.4.1 is purely a function of the numerical values assigned to each of the components and the weighting coefficients shown in Equation 4.1. It is possible that others interested in groundwater banking in the Central Valley would apply different component values and weighting coefficients. In order to allow for further exploration of geology, groundwater quality and soils on the suitability of potential groundwater banking sites in the Sacramento Valley, the information used to generate the ranking in Table 4.4.1 has been made available in the spreadsheet developed as part of this effort. In this spreadsheet, any of the values or weighting coefficients applied to the sub-indices may be changed and the new results can be viewed in tables and graphs similar to those in Table 4.4.1 and Figure 4.4.1.

5.0 Application of the Hydrogeologic Suitability Index in the San Joaquin Valley

The second application of the Hydrogeologic Suitability Report is in the San Joaquin Valley. Potential groundwater banking sites in this region are shown in Figure 2.0.2. As in the Sacramento Valley, each of the sites is evaluated in terms of the core index that covers relevant geology, groundwater quality and soils characteristics. In the case of the San Joaquin Valley, however, the index has been expanded to include a sub-index related to observed fluctuations in the water table below potential banking sites. As mentioned in Section 1.0, portions of the San Joaquin Valley have been exposed to prolonged periods of groundwater overdraft, resulting in the creation of significant and persistent cones of depression. These features will likely serve as the locus of groundwater storage in the San Joaquin Valley. The hydrologic connection sub-index is designed to assess the degree to which water deposited by groundwater banking at potential sites will remain available for eventual recovery. Details of this sub-index are presented in Section 5.4. Figure 5.0.1 provides a summary flow chart of the information used to develop and apply the Hydrogeologic Suitability Index in the San Joaquin Valley.

Figure 5.0.1: Flow Chart of Parameters Analyzed in the Development of Relevant Sub-Indices and the Overall Hydrogeologic Suitability Index in the San Joaquin Valley



5.1 San Joaquin Valley Geology Sub-Index

Deep, undifferentiated lacustrian and alluvial deposits characterize San Joaquin Valley geology. This contrasts with the Sacramento Valley, where various formations of differing thickness are encountered with depth below numerous sites. As such, in the San Joaquin Valley it is not generally possible to construct stratigraphic columns similar to those found in Figure 4.1.1. In fact, we assume that the formations encountered at each potential banking site are sufficiently thick to span the entire operational depth of a potential groundwater bank. In this case, the thickness of the single formation encountered at each potential banking site is treated as a parameter in the geology sub-index rather than as a weighting factor applied to the other geologic parameters (as in Equation 3.2). This thickness parameter is scaled as shown below (Table 5.1.1) in the adaptation to the Parameter Weighting Factors Table (Table 3.1.1).

Geology Sub-Index Equation Key

Eq. 3.2: Geology Sub-Index = Σ (Formation Score $_A$*Formation Thickness $_A$)

Table 5.1.1: Parameter Weighting Factors Used to Calculate the Geology Sub-Index, Adapted to Include Thickness as a Parameter for the San Joaquin Valley Hydrogeologic Suitability Index

Component	0	5	10
Permeability	Impermeable	Moderately permeable	Highly permeable
Paleosols	Contains resistant paleosols	Contains some slightly resistant paleosols	No paleosols
Geologic Structure	Contains structural features that direct stored groundwater towards gaining streams	Contains no structural features	Contains structural features that isolate stored groundwater from gaining streams
Thickness	Less than 20 ft. thick	6 = 50 to 80 ft. 3 = 20 to 50 ft.	Equal to or exceeds 100 ft.

5.1.1 Results of the San Joaquin Geology Sub-Index

Parameter scores associated with the formations encountered at potential banking sites in the San Joaquin Valley are shown in Table 5.1.2. As in the Sacramento Valley, a score of 10 is associated with the most favorable characteristics of a given parameter. The geology sub-index (Table 5.1.3) was calculated from parameter scores based on Equation 5.1.

$$\text{Formation Score} = 2*(\text{Permeability}) + 0.5*(\text{Paleosols}) + (\text{Geological Structure}) + (\text{Thickness}) \qquad (5.1)$$

In this equation, permeability was assigned a weighting coefficient of 2 due to its importance in the suitability of a formation for groundwater banking. The existence of paleosols was assigned a weighting coefficient of 0.5 because the extent to which paleosols are described varies between

Table 5.1.2: Scores for Formations Found in the San Joaquin Valley

Weighting Coefficient	0.5	2	1	1	
Formation	**Paleosols**	**Permeability**	**Thickness**	**Geo. Setting**	**Rank**
Turlock Lake	4	6	10	5	29
Tulare Formation	10	7	5	5	29
Modesto	10	6	8	5	30
N.W. Kern Fan	10	5	8	10	33
Alluvial Fan Deposits	10	5	8	5	28

Table 5.1.3: Geology Sub-Index Values for Potential Groundwater Banking Sites in the San Joaquin Valley

Site ID	Basin	Geo Formation	Rank	%
Arvin-Edison	Kern	N.W. Kern Fan	33	1.00
Semitropic Ridge	Kern	N.W. Kern Fan	33	1.00
Berenda Creek	Madera	Modesto	30	0.40
Chowchilla Bypass	Chowchilla	Modesto	30	0.40
Dry Creek	Modesto	Modesto	30	0.40
Hetch Hetchy Aqueduct	Modesto	Modesto	30	0.40
Gravelly Ford	Madera	Modesto	30	0.40
Dutchman Creek	Merced	Modesto	30	0.40
Owens Creek	Merced	Modesto	30	0.40
Mormon Slough	Modesto	Modesto	30	0.40
Little Dry Creek	Madera	Turlock Lake	29	0.20
Montpellier	Turlock	Turlock Lake	29	0.20
Kern Water Bank	Kern	Tulare Formation	29	0.20
James Bypass	Kings	Alluvial Fan Deposits	28	0.00
White River	Tule	Alluvial Fan Deposits	28	0.00
Allensworth	Tule	Alluvial Fan Deposits	28	0.00

information sources, and when they are described they tend to be thin and discontinuous. The resulting score for each of the formations encountered at potential banking sites in the San Joaquin Valley is found in the Rank column in Table 5.1.2.

Having established the formation scores, an association was made between each potential groundwater banking site and the formation encountered at the target location. These associations are shown in Table 5.1.3, along with the normalized value of the geology sub-index site found in the % column. In this case a value of 1 corresponds with sites overlying the northwestern Kern fan deposits, as these were deemed to be most geologically suitable. A value of 0 is assigned to the alluvial fan deposits associated with the James Bypass, White River and Allensworth sites. The results of the geology sub-index are shown graphically for each of the potential banking sites in Figures 5.1.1 and 5.1.2. Respectively, these figures show the results in terms of the relative rank and the spatial distribution.

Figure 5.1.1: Geology Sub-Index Ranking for Potential Groundwater Banking Sites in the San Joaquin Valley

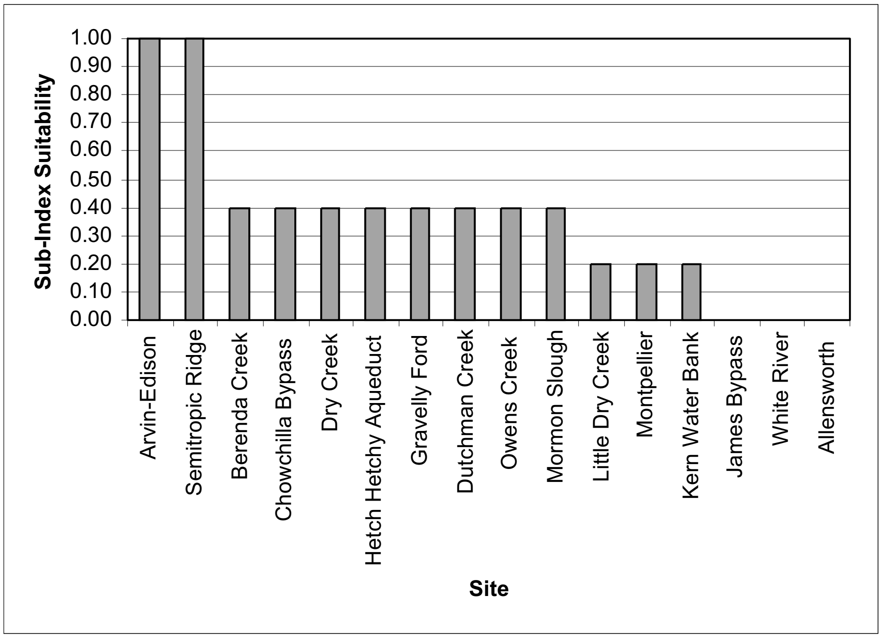
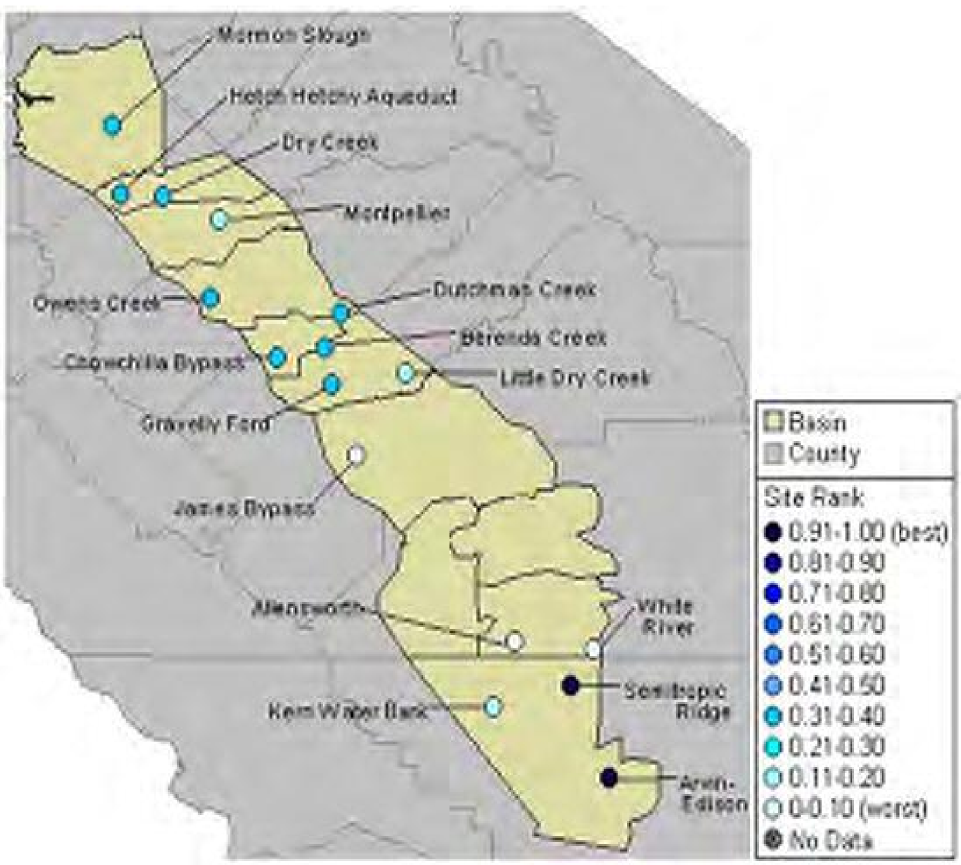


Figure 5.1.2: Spatial Distribution of Geology Sub-Index Values Across Potential Groundwater Banking Sites in the San Joaquin Valley



5.1.2 Comments on the San Joaquin Geology Sub-Index

The eastern Kern Basin sites (Arvin-Edison and Semitropic Ridge) emerge as well-suited for a groundwater banking project owing to the favorable geologic properties of the underlying northwestern Kern fan formation laid down by the Kern River. By comparison, sites on Tule and Kings River alluvial fans rank low. A large part of this discrepancy is due to a relative lack of information in the published literature on the specific alluvial fans associated with the sites. This lack of information forced us to set parameter scores based on fairly coarse descriptions found in regional mapping studies. Given the quality of the data, we erred on the side of caution in assigning the parameter scores. If these sites prove to be extremely suitable based on other components of the index, further research and testing of these alluvial deposits might be warranted.

In general, however, sites in the San Joaquin Valley demonstrate much less geologic variability than those identified in the Sacramento Valley. The influence of the geology sub-index on the overall index, then, should be viewed in comparative rather than absolute terms.

5.2 San Joaquin Valley Water Quality Sub-Index

As in the Sacramento Valley, the water quality sub-index in the San Joaquin Valley comprises four parameters: groundwater concentrations of arsenic, boron, lead and total dissolved solids. The methodology employed to assign scores to each of these parameters and to calculate the sub-index value is found in Section 3.2.

Water Quality Sub-Index Equation Key

Eq. 3.3: Water Quality Score = (As Score) + (B Score) + (Pb Score) + (TDS Score)
Eq. 3.4: Water Quality Sub-Index = 1.5*(Basin Score) + (Site Score)

5.2.1 Results of the San Joaquin Valley Water Quality Sub-Index

Groundwater quality parameter scores for both basins and sites in the San Joaquin Valley are given in Tables 5.2.1 and 5.2.2 respectively. Figure 5.2.1 illustrates these results spatially.

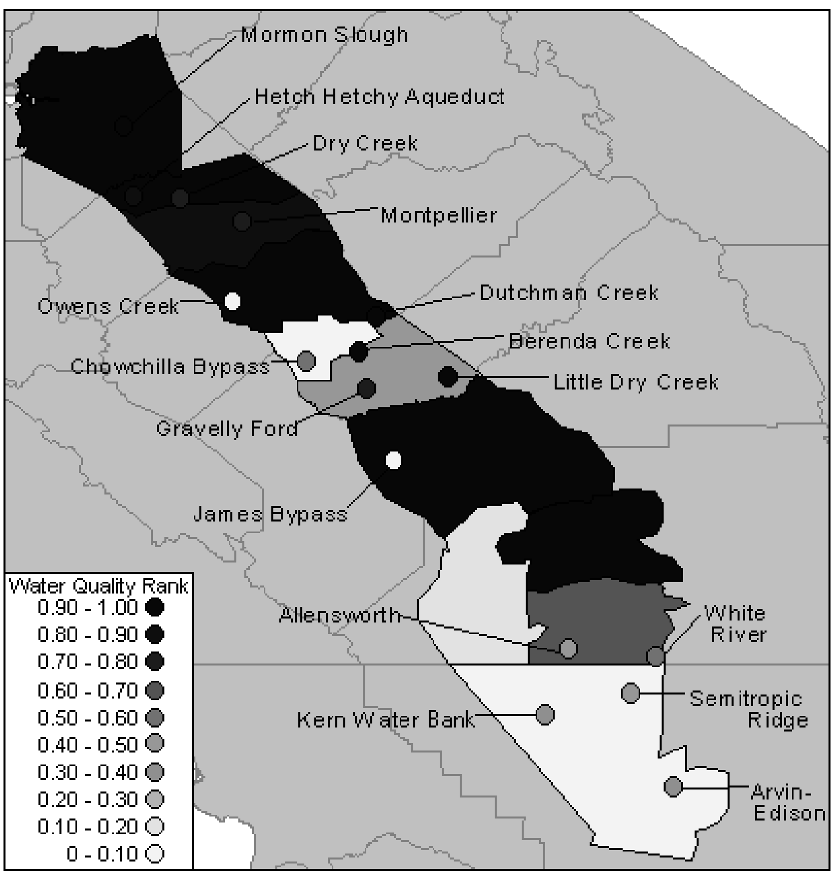
Table 5.2.1: San Joaquin Valley Basin Scores

Weighting Coefficient	1	1	1	1		
Basin Name	**As**	**B**	**Pb**	**TDS**	**Rank**	**%**
Modesto	9	9	7	9	34	1.00
Turlock	9	9	7	8	33	0.89
Merced	8	9	8	9	34	1.00
Chowchilla	6	10	3	6	25	0.00
Madera	7	10	5	7	29	0.44
Kings	9	10	7	8	34	1.00
Tule	5	10	7	9	31	0.67
Kaweah	9	10	7	8	34	1.00
Tulare Lake	5	4	8	9	26	0.11
Kern	3	10	5	7	25	0.00
San Joaquin	7	10	9	8	34	1.00

Table 5.2.2: San Joaquin Valley Site Scores

Weighting Coefficient	1	1	1	1		
Site Name	**As**	**B**	**Pb**	**TDS**	**Rank**	**%**
Dutchman Creek	9	10	8	9	36	1.00
Little Dry Creek	10	10	7	9	36	1.00
Mormon Slough	8	10	8	9	35	0.93
Berenda Creek	9	10	8	8	35	0.93
Hetch Hetchy Aqueduct	9	9	9	7	34	0.87
Dry Creek	9	9	9	6	33	0.80
Gravelly Ford	9	10	8	6	33	0.80
Montpellier	9	10	7	6	32	0.73
Chowchilla Bypass	6	10	7	6	29	0.53
White River	5	9	7	8	29	0.53
Allensworth	3	10	7	8	28	0.47
Semitropic Ridge	4	10	7	7	28	0.47
Kern Water Bank	3	10	8	6	27	0.40
Arvin-Edison	4	10	7	6	27	0.40
Owens Creek	5	5	9	3	22	0.07
James Bypass	8	2	7	4	21	0.00

Figure 5.2.1: Spatial Distribution of Basin and Site Water Quality Scores



These scores were used to calculate the water quality sub-index based on Equation 3.4. The results for potential banking sites in the San Joaquin Valley are found in Table 5.2.3.

In preparation for inclusion in the overall Hydrogeologic Suitability Index for the San Joaquin Valley, water quality sub-index values have been normalized between 1 (corresponding with best groundwater quality at the Dutchman Creek site) and 0 (corresponding with the poorest observed groundwater quality at the Kern Water Bank and Arvin-Edison sites) in the % column. These results are shown with reference to the overall rank and the spatial distribution in Figures 5.2.2 and 5.2.3.

Table 5.2.3: Water Quality Sub-Index Values for Potential Banking Sites in the San Joaquin Valley

Weighting Coefficient		1.5	1		
Site Name	**Basin**	**Basin Wide**	**Site Specific**	**Rank**	**%**
Dutchman Creek	Merced	1.00	1.00	2.50	1.00
Mormon Slough	San Joaquin	1.00	0.93	2.43	0.96
Hetch Hetchy Aqueduct	Modesto	0.87	1.00	2.30	0.89
Dry Creek	Modesto	0.80	1.00	2.20	0.84
Montpellier	Turlock	0.73	0.89	1.99	0.73
Little Dry Creek	Madera	1.00	0.44	1.94	0.71
Gravelly Ford	Madera	0.80	0.44	1.64	0.55
White River	Tule	0.53	0.67	1.47	0.46
Berenda Creek	Chowchilla	0.93	0.00	1.40	0.42
Allensworth	Tule	0.47	0.67	1.37	0.40
Owens Creek	Merced	0.07	1.00	1.10	0.26
James Bypass	Kings	0.00	1.00	1.00	0.21
Chowchilla Bypass	Chowchilla	0.53	0.00	0.80	0.11
Semitropic Ridge	Kern	0.47	0.00	0.70	0.05
Kern Water Bank	Kern	0.40	0.00	0.60	0.00
Arvin-Edison	Kern	0.40	0.00	0.60	0.00

Figure 5.2.2: Water Quality Sub-Index Ranking

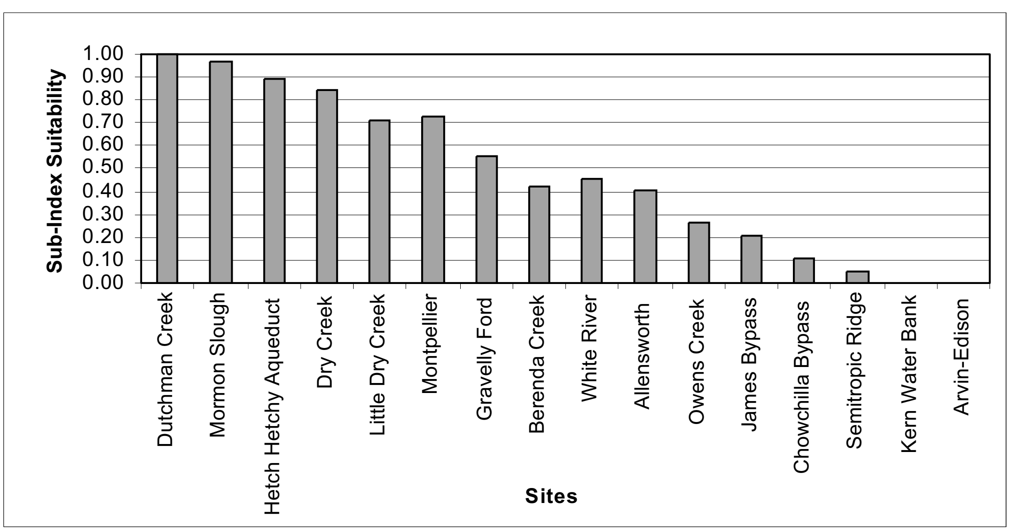
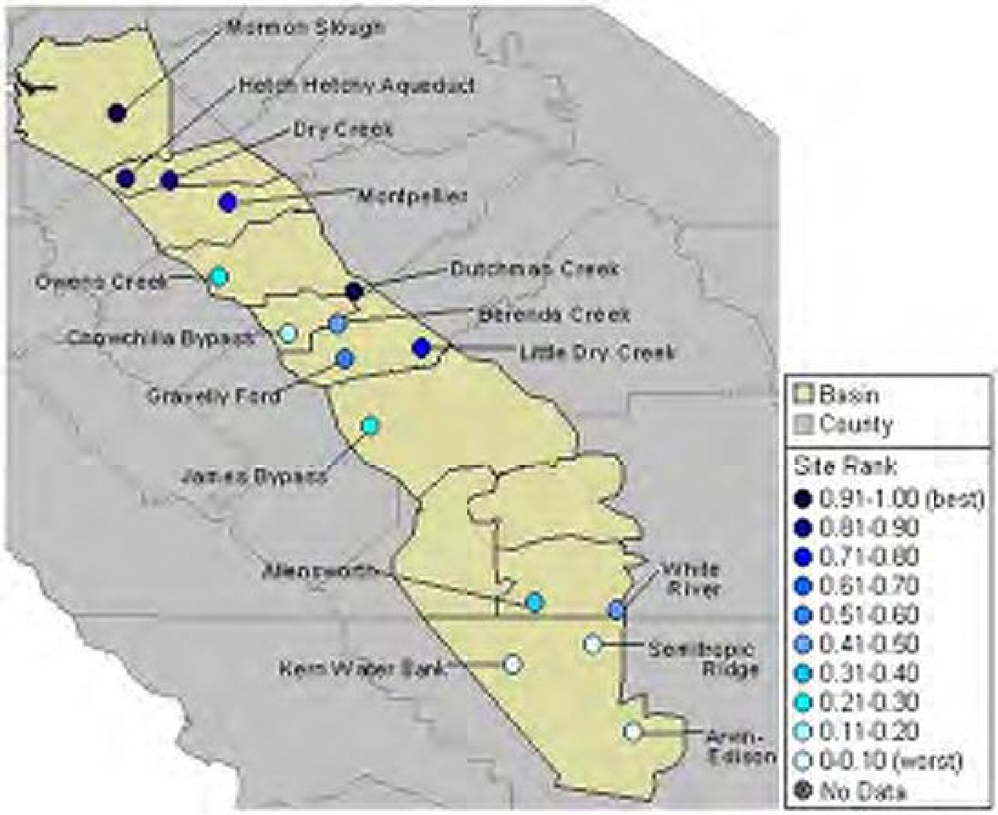


Figure 5.2.3: Spatial Distribution of Water Quality Sub-Index Values



5.2.2 Comments on the Water Quality Sub-Index

Excluding the western San Joaquin Valley, where groundwater quality is generally poor across wide areas and where no potential banking sites have been identified, groundwater in the San Joaquin Valley is characterized by the presence of spots of poor quality. Arsenic levels are particularly high in the southern part of the valley in Kern and Tulare Lake Basins. Boron levels peak in parts of Merced, Kings and Tulare Lake basins, a pattern that is mimicked by the distribution of elevated TDS measurements. Lead concentrations are fairly low throughout the valley.

This spatial pattern of groundwater quality points out the utility of the spreadsheet developed as part of this effort. In general, boron is of greatest concern to agricultural water users while arsenic is particularly problematic for municipal water providers. In calculating the water quality sub-index, equal weighting was given to each of these parameters. Someone interested in evaluating the implications of groundwater banking on either of these user communities may wish to weight the sub-index in favor of one of these parameters over the others.

5.3 San Joaquin Valley Soils Sub-Index

Parameters used to calculate the soils sub-index are described in Section 3.0.

Soils Sub-Index Equation Key

Eq. 3.5: Soils Sub-Index = (Thickness) [3(Permeability) + (pH)– 2(1 – Hardpan)]

5.3.1 Results for the San Joaquin Valley Soils Sub-Index

Parameter scores and the soils sub-index values for selected sites in the San Joaquin Valley are shown below in Table 5.3.1.

Table 5.3.1: Soils Sub-Index

Weighting Coefficient	1	3	2	1		
Site	**Thickness**	**Permeability**	**Hardpan**	**pH**	**Rank**	**%**
Hetch Hetchy Aqueduct	0.80	0.60	1.00	0.83	2.10	1.00
Dry Creek	0.75	0.31	0.96	0.79	1.25	0.71
Montpellier	0.48	0.75	0.85	0.74	1.28	0.72
Semitropic Ridge	0.78	0.20	1.00	0.70	1.01	0.63
Gravelly Ford	0.77	0.24	0.87	0.54	0.77	0.55
Little Dry Creek	0.66	0.40	0.55	0.80	0.73	0.54
Arvin-Edison	0.86	0.03	1.00	0.74	0.71	0.53
Kern Water Bank	0.76	0.01	1.00	0.69	0.55	0.48
Owens Creek	0.75	0.02	1.00	0.41	0.36	0.42
White River	0.52	0.06	0.85	0.80	0.35	0.41
Chowchilla Bypass	0.67	0.13	0.51	0.50	-0.05	0.28
Berenda Creek	0.75	0.23	0.11	0.85	-0.17	0.24
James Bypass	0.77	0.20	0.19	0.51	-0.40	0.16
Dutchman Creek	0.64	0.14	0.23	0.68	-0.27	0.20
Mormon Slough	0.75	0.02	0.00	0.76	-0.88	0.00

The resulting values are normalized between 1 (corresponding with the most favorable soils at the Hetch Hetchy Aqueduct site) and 0 (corresponding with the Mormon Slough site) in the % column. These are presented graphically in Figures 5.3.1 and 5.3.2, which show the relative rank and spatial distribution of the results.

Figure 5.3.1: Soils Sub-Index Rank

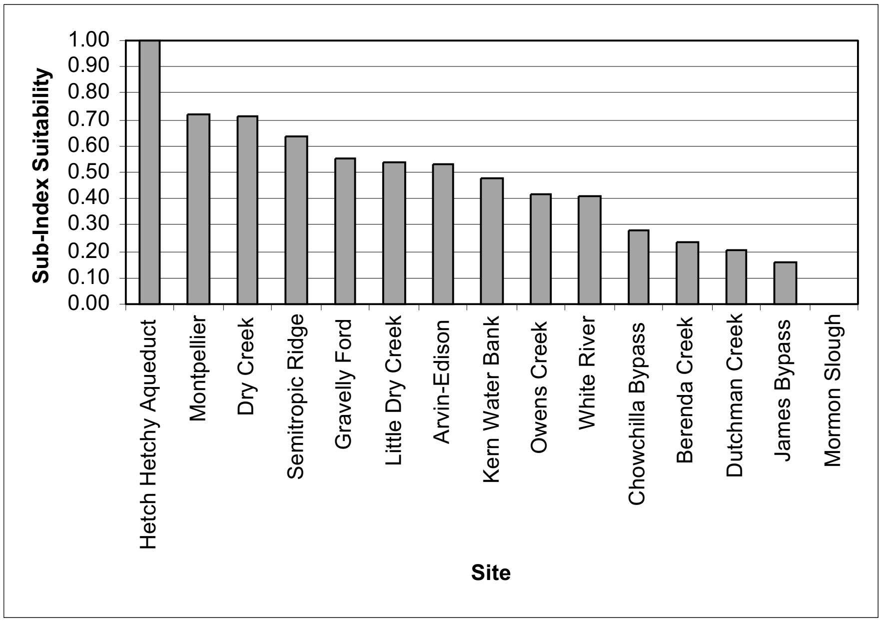
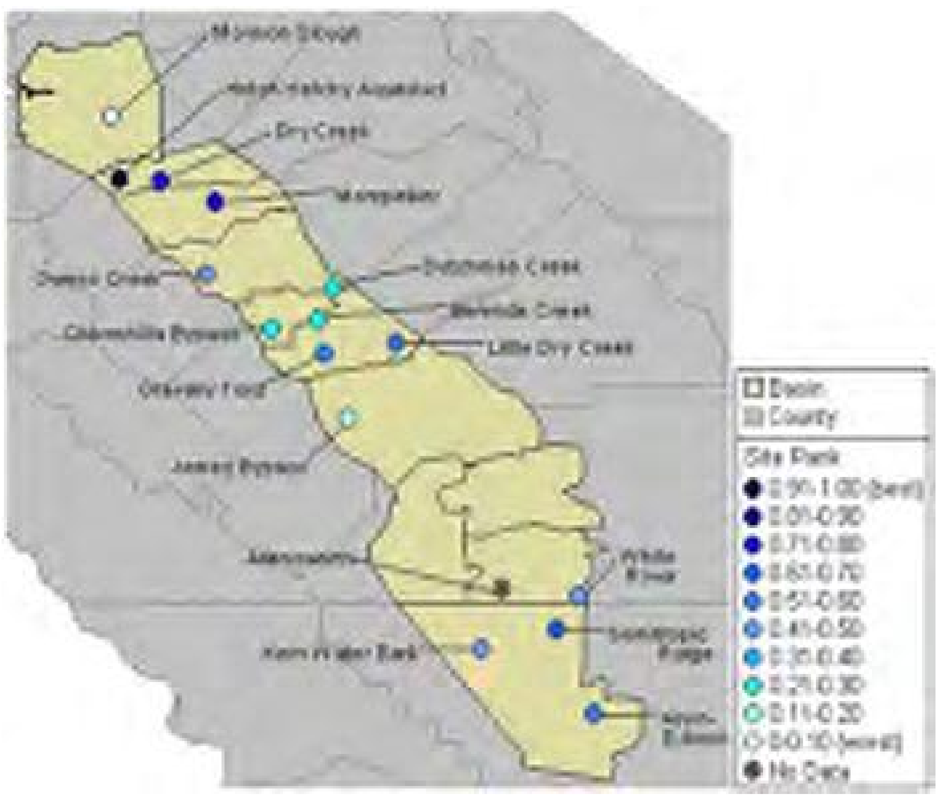


Figure 5.3.2: Spatial Distribution of Soils Sub-Index Values



5.3.2 Comments on the Soils Sub-Index

Based on the selected parameters, the Turlock and Merced basins appear to possess the most suitable soils in the San Joaquin Valley. Soils in this region are derived from material of Sierran origin deposited by the high-energy Tuolumne and Merced Rivers. The result is a generally more coarse assemblage of soils as compared with material deposited by lower-energy streams to the north and south.

While more complete soil data was available for the San Joaquin Valley than in the Sacramento Valley, one site, Allensworth, lacked published soils information. Owing to a lack of data, in calculating the overall Hydrogeologic Suitability Index this site will be assigned a zero in terms of the soils sub-index.

5.4 San Joaquin Valley Hydrologic Connection Sub-Index

In the San Joaquin Valley, an additional sub-index has been added to the core Hydrogeology Suitability Index dealing with the hydrologic connection between potential storage space located within existing cones of depression and the surrounding hydrologic system. Groundwater basins are not surface reservoirs. While exposed to losses due to evaporation and seepage, water stored behind a dam is largely under the direct control of reservoir operators. When water is required, it need only be released from the storage pool. Storage in a groundwater bank does not benefit from the same level of control. Aquifers are open systems within which the existing level of use and conditions in surrounding groundwater basins and overlying surface water bodies influence flow patterns. In such a system, there is no guarantee that water recharged to a groundwater bank will remain within the pore space of the aquifer material immediately below the banking site. In assessing the hydrogeologic suitability of potential sites in the San Joaquin Valley, it is important to understand the way in which banked water would interact with the surrounding hydrologic system.

The most rigorous way to understand these potential interactions is through the use of groundwater models that describe flow patterns within an aquifer under various conditions. While the development of project-specific groundwater models will certainly occur once promising groundwater banking sites are identified and project design begins, it was beyond the scope of the current effort to develop such a tool for all of the potential sites in the San Joaquin Valley. In order to assess the potential for interaction between banked water and the surrounding aquifer, a simple method based on measured water level data was developed.

This methodology begins with the supposition that water banked in the San Joaquin Valley will ideally be stored within <u>large, well-defined, stable</u> drawdown features within an aquifer. This statement is based on two assumptions. First, it is assumed that where such features occur, the existing patterns of groundwater use and aquifer recharge leave a significant portion of the aquifer material perpetually unsaturated and available for long-term storage. Second, it is assumed that once recharge water joins the water table within such a large, well-defined, stable feature, it would be contained within the cone of depression and would not flow away from the recharge site. The methodology used to assess the degree of hydrologic connection between banked water and the surrounding aquifer relies upon analysis of the size and stability of target drawdown features.

5.4.1 San Joaquin Valley Hydrologic Connection Sub-Index Parameters

The components used in the hydrologic connection sub-index were all derived from data included in the semi-annual well survey conducted by the California Department of Water Resources. An example of the type of data contained in the survey is shown in Table 5.4.1.

Table 5.4.1: Water Contour Data for Turlock Basin, 6/1/77 to 12/31/77

UTM East	UTM North	WSE	GSWS	SWN	Meas. Date	UTM Zone
707008	4167178	118.0	82.0	03S12E33L01M	11/04/1977	10
672518	4159172	49.7	12.3	04S08E25D01M	11/01/1977	10
672572	4157724	48.6	9.4	04S08E25N01M	11/01/1977	10
670810	4158643	34.0	16.0	04S08E27H01M	11/01/1977	10
670808	4157564	44.4	8.6	04S08E34A01M	11/01/1977	10
669361	4157504	39.4	10.6	04S08E34D01M	11/01/1977	10
679642	4165707	33.4	24.6	04S09E03B01M	10/18/1977	10
677098	4165374	29.0	39.0	04S09E05H01M	10/14/1977	10

In the table, "UTM East", "UTM North" and "UTM Zone" are used to specify the physical location of wells included in the survey. The column heading SWN denotes the state well number, which makes reference to the California Public Lands Survey. The date of the semi-annual measurement at a well is provided under the heading "Meas. Date". We excluded from our analysis any data for which problems were encountered during measurement (as recorded during data collection). Hydrologic data related to the water surface elevation and the difference between the ground surface elevation and the water surface elevation are found under the "WSE" and "GSWS" headings, respectively (the sum of WSE and GSWS should yield the land surface elevation at the measurement site).

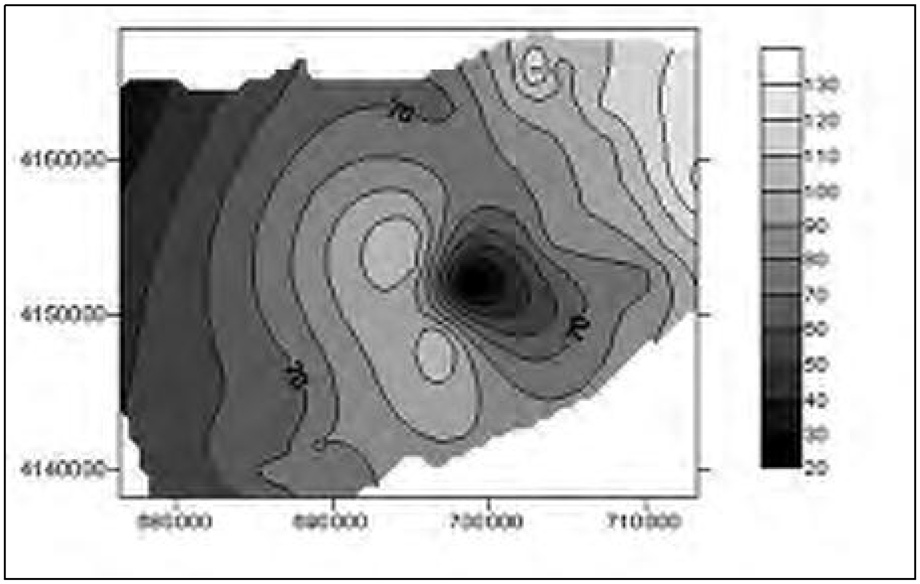
Data highlighted in Table 5.4.1 were used to define the parameters for the hydrologic connection sub-index. Water surface elevation data for the entire San Joaquin Valley were collected from Fall 1977 (selected to represent dry year conditions) and Fall 1997 (a wet water year) surveys. These data were used to develop approximate water table contour maps for each of the basins in the San Joaquin Valley. Figure 5.4.1 is an example of a map developed for the Turlock Basin based on the Fall 1977 survey. The large closed depression in the figure is located beneath the Montpellier site identified in Figure 2.0.2.

These maps should be considered approximate in that the wells included in the semi-annual survey were not specifically designed to track the position of the water table. Most are private wells that are screened across several hundred feet of aquifer material. As such, the water level observed in the well is an integrated sample of heads encountered both at the water table and at depth below the water table. In cases where significant flow-restricting horizons exist in the interval spanned by the well screen, these deeper heads may be quite different than the actual elevation of the water table surface. While an attempt was made to screen out problematic wells, some of the heads used to develop the contour maps most certainly did not reflect the true water table elevation at a given location.

Nonetheless, the contour maps developed as part of this analysis, found in Appendix E, capture the general location and scale of major cones of depression known to exist in the San Joaquin Valley. Lacking the resource to develop more accurate local water table maps, we used our

Figure 5.4.1: Turlock Basin Fall 1977 WSE Contours

(Elevation in feet above MSL)



basin scale maps to estimate the storage volume located within a cone of depression using a standard specific yield estimate of 0.2. In the case of the depression below the Montpellier site, a horizontal plane set at 75 ft. capped approximately 208 TAF of available storage during Fall 1977. Based on the estimated basin scale water table contour maps developed during the fall surveys of 1977 and 1997, two parameters were defined for use in the hydrologic connection sub-index.

Maximum Overall Size of Water Table Depressions

The larger of the estimated available storage volumes calculated based on data from the Fall 1977 and Fall 1997 surveys was selected to represent the maximum overall size of water table depressions parameter. We anticipated the available storage volume would be larger during 1977 owing to the extremely dry conditions encountered at that time. We discovered, however, that some locations manifested larger available storage volumes during the wet 1997 water year. This is presumably due to the fact that groundwater overdraft during the 20 intervening years masked any water table recovery associated with higher levels of aquifer recharge.

Inter-Annual Water Table Change

Nonetheless, changing levels of aquifer recharge do contribute to fluctuations in the water table surface that can be observed between dry and wet periods. Groundwater basins that experience significant changes in water levels, and hence available storage volumes, generally benefit from a high degree of natural recharge during wet periods. If the storage of banked water would limit the ability to capture a portion of this natural recharge, then the project could create conflicts with historic groundwater users. Any such fluctuations can be described in the following equation used to define the inter-annual water table change parameter of the hydrologic connection sub-index.

$$\text{Inter-Annual Change} = (V_{77F} - V_{97F}) / \text{Max. Volume} \quad (5.2)$$

where V_{77F} = volume of a basin in Fall 1977
and V_{97F} = volume of a basin in Fall 1997

Because the effects of long-term overdraft can mask water table recovery associated with enhanced recharge during wet years, Equation 5.2 occasionally produces negative numbers. A site in overdraft provides a unique opportunity for a groundwater banking project because, not only would the site have a large depression available for storage, but the storage of water there could be used to provide benefits to overlying groundwater pumpers if some portion of the banked water could be used to slow down or reverse incipient water table declines.

5.4.2 San Joaquin Valley Hydrologic Connection Sub-Index Weighting Factors

As in the case of the sub-indices included in the core index, calculation of the hydrologic connection sub-index can be influenced by the assignment of appropriate weighting factors. As the size of the cone of depression is the most important feature in determining what scale of a project could be pursued at a potential groundwater banking site, this parameter was weighted by a factor of two. In addition, the inter-annual change parameter should be subtracted from one so that a basin that experiences a small rise in the water table between wet and dry years (suggesting a small amount of hydrologic connection with the surrounding hydrology) would score higher than a basin where large fluctuations occur, presumably in response to significant interaction between the aquifer and the surrounding hydrologic features. In addition, for sites in overdraft (the inter-annual change parameter is negative), where banking could contribute to water table recovery, this subtraction would enhance the suitability of the site. Each of these assumptions is contained in the following equation used to calculate the hydrologic connection sub-index.

$$\text{Hydrologic Connection Sub-Index} = 2*\text{Max. Volume} + (1 - \text{Inter-Annual Change}) \quad (5.3)$$

5.4.3 Results for the San Joaquin Valley Hydrologic Connection Sub-Index

Applying Equation 5.3 to the estimated water table elevation data derived from the available data produces the hydrologic connection sub-index values shown in Table 5.4.2. These values have been normalized between 1 (corresponding with the Kern Water Bank site) and 0 (corresponding with the Dry Creek site) in the % column. Normalized results are shown in terms of relative rank in Figure 5.4.2 and spatial distribution in Figure 5.4.3.

Table 5.4.2: Hydrologic Connectivity Sub-Index Table

Site	Max. Vol.	Annual	Rank	%
Kern Water Bank	21.61	-0.40	44.62	1.00
Allensworth	7.77	-0.83	17.37	0.39
James Bypass	6.13	0.18	13.08	0.29
Semitropic Ridge	6.07	0.79	12.35	0.27
Mormon Slough	5.19	0.67	10.71	0.24
Little Dry Creek	4.37	-0.94	10.68	0.24
Gravelly Ford	3.61	0.06	8.15	0.18
Dutchman Creek	1.54	-0.41	4.49	0.10
Arvin-Edison	1.55	-0.35	4.45	0.10
White River	1.29	0.46	3.12	0.07
Montpellier	1.04	0.22	2.86	0.06
Chowchilla Bypass	0.32	-0.91	2.55	0.05
Owens Creek	0.79	0.25	2.33	0.05
Berenda Creek	0.06	-0.96	2.08	0.04
Hetch Hetchy	0.01	-0.67	1.69	0.03
Dry Creek	0.02	0.87	0.17	0.00

Figure 5.4.2: Hydrologic Connection Sub-Index Rank

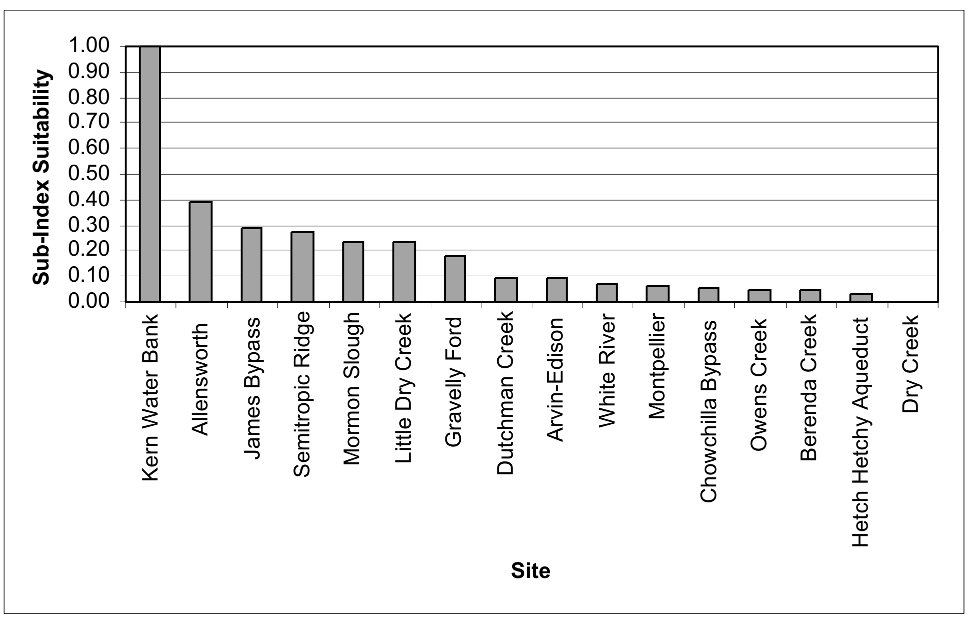
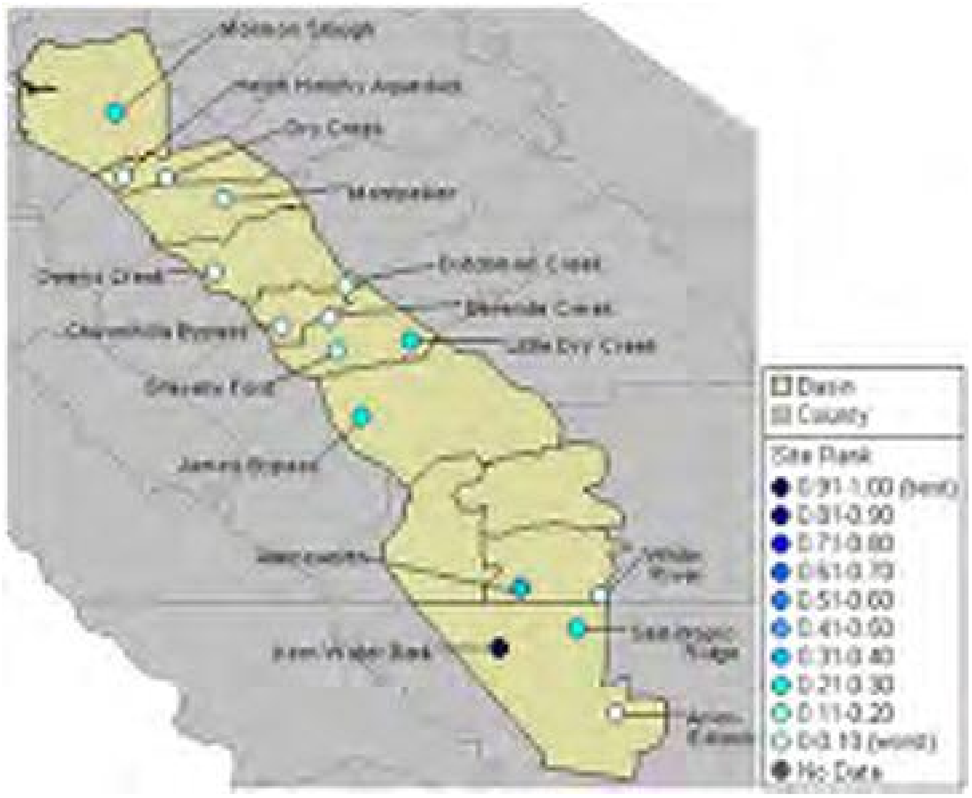


Figure 5.4.3: Spatial Distribution of Hydrologic Connection Sub-Index Values



5.4.4 Comments on the Hydrogeologic Connectivity Index

The Kern Water Bank dwarfs the rest of the potential groundwater banking sites in the San Joaquin Valley with respect to the hydrologic connection sub-index. This site overlies what was a large depression in 1977 and has been the locus of an active groundwater banking project for the past decade. While it no longer merits the label of a potential site, it was included in the analysis for comparative value.

Another cluster of relatively promising sites lies in the vicinity of the San Joaquin River. The Little Dry Creek, Gravelly Ford and James Bypass sites all score relatively high. The opportunity to manage these sites in conjunction with reoperation of Friant Dam on the San Joaquin likely merits additional evaluation.

5.5 San Joaquin Valley Hydrogeologic Suitability Index

Having developed the four relevant sub-indices, the overall Hydrogeologic Suitability Index for potential groundwater banking sites in the San Joaquin Valley was calculated based on the following equation.

$$\text{Hydrogeologic Suitability Index} = (\text{Geology}) + 2*(\text{Water Quality}) + (\text{Soils}) + 0.5*(\text{Hydrologic Connection}) \quad (5.4)$$

The results of this analysis are shown in Table 5.5.1 with the normalized values between 1 (corresponding with the Hetch Hetchy Aqueduct) and 0 (corresponding with James Bypass) shown in the % column. These results are shown graphically in Figures 5.5.1 and 5.5.2, which present the relative rank and spatial distribution, respectively.

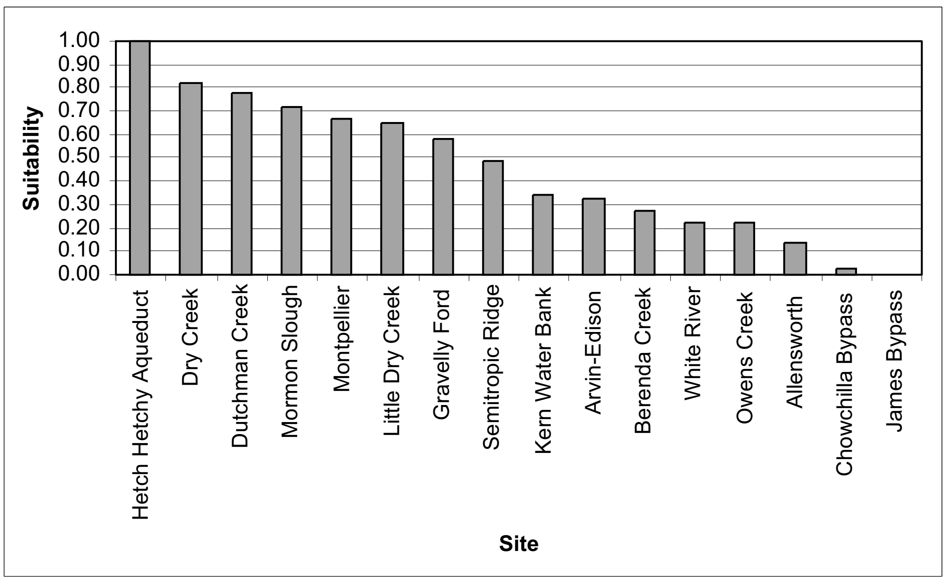
Table 5.5.1: San Joaquin Valley Hydrogeologic Suitability Index

Weighting Coefficient	1	2	1	0.5		
Site	**Geology**	**Water Quality**	**Soils**	**Hydrologic Connectivity**	**Rank**	**%**
Hetch Hetchy Aqueduct	0.40	0.89	1.00	0.03	3.22	1.00
Dry Creek	0.40	0.84	0.71	0.00	2.80	0.82
Dutchman Creek	0.40	1.00	0.20	0.10	2.70	0.78
Mormon Slough	0.40	0.96	0.00	0.24	2.57	0.72
Montpellier	0.20	0.73	0.72	0.06	2.45	0.67
Little Dry Creek	0.20	0.71	0.54	0.24	2.39	0.65
Gravelly Ford	0.40	0.55	0.55	0.18	2.23	0.58
Semitropic Ridge	1.00	0.05	0.63	0.27	2.01	0.48
Kern Water Bank	0.20	0.00	0.48	1.00	1.68	0.34
Arvin-Edison	1.00	0.00	0.53	0.10	1.63	0.32
Berenda Creek	0.40	0.42	0.24	0.04	1.52	0.28
White River	0.00	0.46	0.41	0.07	1.39	0.22
Owens Creek	0.40	0.26	0.42	0.05	1.39	0.22
Allensworth	0.00	0.40	0.00*	0.39	1.19	0.14
Chowchilla Bypass	0.40	0.11	0.28	0.05	0.94	0.03
James Bypass	0.00	0.21	0.16	0.29	0.87	0.00

* In cases where values were missing, the value zero was used.

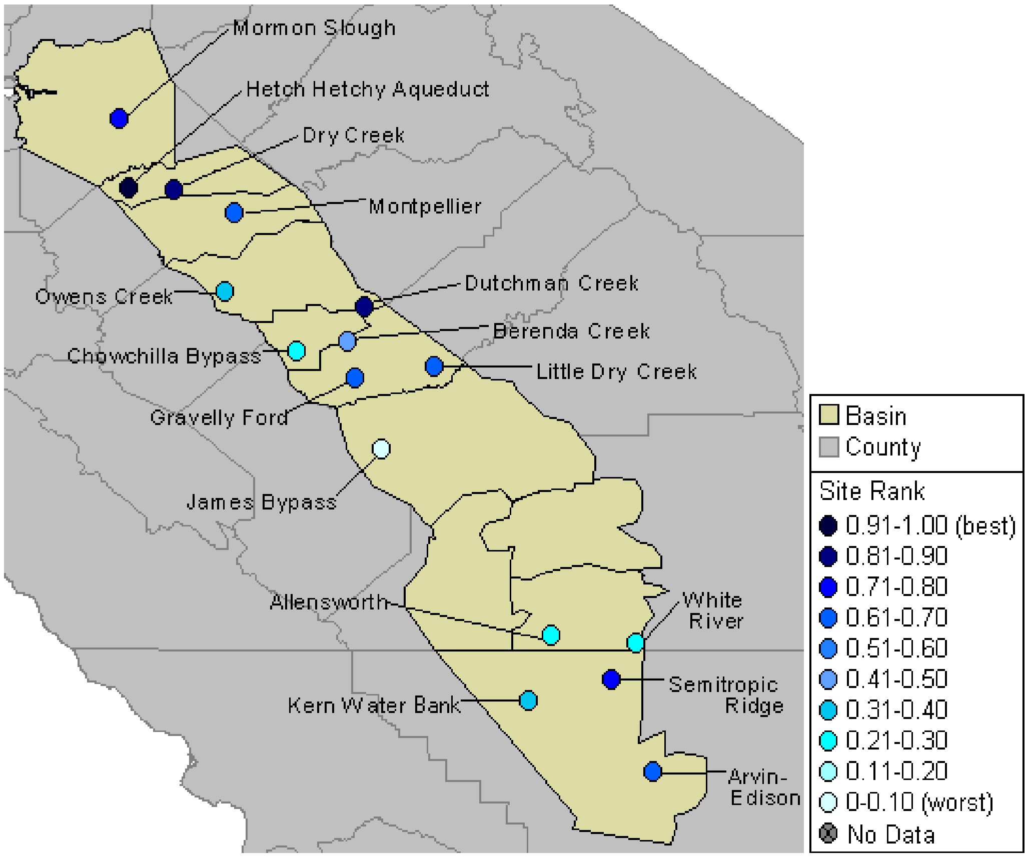
In this analysis, the water quality sub-index was weighted by 2 to stress its importance to the ultimate users of banked groundwater. In the San Joaquin Valley, the geology sub-index only receives a weighting factor of 1 (as opposed to 2 in the Sacramento Valley) in order to reflect the fact that the data do not suggest as clear a differentiation between sites in terms of this important characteristic. Soils receive a weight of 1 to reflect the fact that while they can exert important controls on the operation of recharge basins, problematic soils can be removed as part of project construction, although this would increase the overall cost of the project. The hydrologic connection sub-index receives a weight of 1 because, while the information on the water table depression size and stability is extremely important, the approach taken here is based on the hydrologic response of the system under existing management conditions. The initiation of storage and recovery operations at a potential site would substantially alter these conditions. As previously mentioned, the best way to evaluate this possibility is through the application of groundwater models—an exercise that was beyond the scope of the current investigation. In the event that modeling results become available, it would be possible to increase the weighting on this sub-index.

Figure 5.5.1: San Joaquin Valley Hydrogeologic Suitability Index Rank



It should be pointed out that the ranking depicted in Figure 5.5.1 is purely a function of the numerical values assigned to each of the components and the weighting coefficients shown in Equation 5.4. It is possible that others interested in groundwater banking in the San Joaquin Valley would apply different component values and weighting coefficients. In order to allow for further exploration of geology, groundwater quality, soils and the degree of hydrologic connection on the suitability of potential groundwater banking sites in the San Joaquin Valley, the information used to generate the ranking in Table 5.5.1 has been made available in the spreadsheet developed as part of this effort. In this spreadsheet, any of the values or weighting coefficients applied to the sub-indices may be changed and the new results can be viewed in tables and graphs similar to those in Table 5.5.1 and Figure 5.5.1.

Figure 5.5.2: Spatial Distribution of Hydrogeologic Suitability Index Values



6.0 Conclusions

A recent review of an attempt to develop an Environmental Sustainability Index (ESI) that could be applied to nations across the world (found in the 01/25/01 edition of *The Economist*) seized upon two major problems inherent to the development of comparative indices. First, "a tricky challenge...is to decide how to weigh each indicator". Second, "another challenge remains the paucity of good data. By forging ahead anyway, the report risks lending a quantitative gravitas to conclusions that are based on still-sketchy data".

The first critique stems from the fact that the ESI gives equal weight to all its 22 indicators. The authors of the ESI accepted this criticism, but explained that their database will soon be available on CD-ROM. Critics will then be able to use whatever weightings they prefer. The authors of the ESI responded to the second critique by arguing that they have created a framework that exposes the data deficiencies, and so spurs others to remedy them. Future versions of the report, they point out, can only get better. In fact, the authors conclude "the chief virtue of this index is that it begins the process of shifting environmental debates on to firmer foundations, underpinned by data and a greater degree of analytic rigor".

While our development of a Hydrogeologic Suitability Index for potential groundwater banking sites in the Central Valley is a much less weighty endeavor than the development of the ESI, we anticipate that similar criticisms will be directed at this effort. Rather than weight each of our sub-indices equally, however, we made an attempt to highlight what we perceive to be the relative importance of the geologic setting and water quality sub-indices. By making the afore-mentioned Excel workbook available on the web, we encourage all those interested in groundwater banking in California to use whatever weightings they prefer. While the data used in this effort are likely better than those available to the authors of the ESI, we have pointed out that several compromises were made in order to assemble the minimum suite of data used to develop the Hydrogeologic Suitability Index. We encourage those with access to better information to improve upon our effort by bringing this information to bear on the on-line database. This process of refinement will only improve the quality of our effort.

As a starting point, however, we feel that the Hydrogeologic Suitability Index reveals several interesting findings in terms of potential projects that should be considered for more refined analysis. Notably, we found that the groundwater basins in the Sacramento Valley are generally more favorable in terms of their hydrogeologic suitability for groundwater banking. As has been mentioned on several occasions in this report, this finding raises a number of complicated legal and institutional issues related to the fact that these basins are not currently endowed with substantial volumes of unsaturated aquifer material ready to be used for storage. While these issues will by no means be simple to resolve, the quality of these basins from a purely hydrogeologic perspective suggests strongly that the effort should be made to resolve them.

In the Sacramento Valley, the best opportunities for groundwater banking seem to cluster near the northern end of the valley, with Stone Valley and Stoney Creek Fan leading the pack. The geology in particular under these sites is well-suited for a banking project.

In the San Joaquin Valley, there is no clear geographic gradient of favorable to poor sites. Clusters of favorable sites exist in Modesto, Madera and Kern basins. Both soils and hydrologic connection vary greatly in the San Joaquin Valley, which could account for the discontinuous distribution.

In concluding their review of the Environmental Sustainability Index, the commentators concluded that it "is a thoughtful step in the right direction". While much work remains to be done in translating the promise of groundwater banking to actual yield-enhancing projects, we hope that the Hydrogeologic Suitability Index described in this report will ultimately be viewed in a similar light.

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Appendix A: Raw Water Quality Data

Sacramento Valley

Arsenic Dissolved (µg/L as As)

Longitude	Latitude	Result	Date
-122.2881	39.0125	1	9/19/86
-122.2806	39.0222	1	9/19/86
-122.2794	39.0233	10	9/19/86
-122.5389	40.2806	1	8/9/83
-122.5389	40.2806	1	8/5/83
-122.5389	40.2806	1	7/31/83
-122.5389	40.2806	1	7/12/83
-122.5389	40.2806	1	7/9/83
-121.6128	38.7083	9	9/30/82
-121.3694	38.6414	1	9/29/82
-121.3575	38.6006	2	9/29/82
-121.4028	38.6167	2	9/29/82
-121.42	38.3025	38	9/28/82
-121.4583	38.5233	5	9/28/82
-121.4647	38.5097	4	9/28/82
-121.305	38.6508	1	9/27/82
-121.3322	38.6183	1	9/27/82
-121.4517	38.3889	11	9/24/82
-121.2764	39.0158	1	9/24/82
-121.2764	39.0158	1	9/24/82
-121.4156	38.3803	6	9/24/82
-121.2914	38.5964	1	9/23/82
-121.4372	38.4178	17	9/23/82
-121.4453	38.4364	3	9/23/82
-121.4725	38.4197	11	9/23/82
-121.2861	38.5672	1	9/23/82
-121.2786	38.5439	1	9/23/82
-121.305	38.2628	11	9/22/82
-121.3822	38.6647	2	9/21/82
-121.3847	38.6581	1	9/21/82
-121.38	38.7119	4	9/21/82
-121.5269	38.2408	7	9/20/82
-121.5325	38.2828	16	9/20/82
-121.3086	38.705	1	9/17/82
-121.6025	38.1633	17	9/17/82
-121.2844	38.6842	1	9/17/82
-121.3317	38.6739	1	9/17/82
-121.3411	38.67	2	9/16/82
-121.3267	38.2411	7	9/15/82
-121.5478	38.6011	12	9/10/82
-121.3372	38.8728	2	9/9/82
-121.3372	38.8728	2	9/9/82
-121.2639	38.8858	1	9/9/82
-121.2639	38.8858	1	9/9/82
-121.3736	38.9822	2	9/7/82
-121.3736	38.9822	2	9/7/82
-121.3419	38.4133	4	9/7/82
-121.9878	38.6083	1	9/8/81
-121.9494	38.6675	1	9/8/81
-122.0683	38.7092	5	9/3/81
-122.0333	38.8161	5	9/2/81
-122.0172	38.8061	9	9/2/81
-122.0533	38.7597	2	9/2/81
-121.6181	38.6458	6	9/1/81
-121.5581	38.3708	5	8/31/81
-121.9722	38.56	1	8/28/81
-121.5456	38.5464	1	8/27/81
-121.515	38.5411	1	8/27/81
-121.6514	38.5753	7	8/26/81
-121.7556	38.5319	4	8/26/81
-121.6925	38.5567	4	8/25/81
-121.9111	38.5906	1	8/20/81
-122.0158	38.7442	3	8/19/81
-121.9364	38.7039	2	8/19/81
-122.1978	38.8108	2	8/17/81
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-121.8858	38.7206	16	8/13/81
-121.7103	38.6	16	8/12/81
-121.785	38.6414	2	8/12/81
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-121.9828	38.4975	1	8/26/80
-121.7197	38.5028	5	8/25/80
-121.6925	38.5644	4	8/1/79
-121.6831	38.5822	10	8/1/79
-121.6742	38.5631	4	8/1/79
-121.7589	38.6122	5	7/31/79
-121.9036	38.5728	2	7/31/79
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-121.7797	38.5961	4	7/31/79
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-121.8611	39.0619	25	9/17/75
-121.9028	39.1153	14	9/15/75
-121.8306	39.0411	3	9/15/75
-121.8928	39.1806	9	9/15/75
-121.8233	39.1558	8	9/15/75
-121.7103	38.8806	24	9/11/75
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-121.7856	38.8564	8	9/11/75
-121.7928	38.8067	2	9/10/75
-121.7858	38.7936	1	9/10/75
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-122.1636	40.0178	1	10/1/74
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-122.1919	39.9075	1	9/26/74
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-122.1342	39.7464	1	9/24/74
-122.1222	39.7039	2	9/23/74
-122.1239	39.7103	1	9/23/74
-122.2017	39.7094	1	9/18/74
-122.2383	39.6036	6	9/17/74
-122.1947	39.6189	3	9/17/74
-122.2103	39.4153	4	9/17/74
-122.2114	39.5808	1	9/17/74
-122.1942	39.5097	18	9/17/74
-122.2628	39.1717	2	9/12/74
-122.2617	39.1506	1	9/12/74
-122.2731	39.1369	1	9/12/74
-122.2672	39.1675	1	9/12/74
-122.1597	39.1486	4	9/6/74
-122.2117	39.1089	2	9/6/74
-122.1411	39.1392	1	9/6/74
-122.225	39.1403	1	9/6/74
-122.1394	39.1475	3	9/6/74
-122.2275	39.1514	1	9/6/74
-122.1519	39.1567	2	9/6/74
-122.2261	39.1594	2	9/6/74
-122.1325	39.1756	4	9/6/74
-122.1525	39.1411	2	9/6/74
-122.1594	39.0486	1	9/5/74
-122.1503	39.0719	2	9/5/74
-122.1614	39.0911	2	9/5/74
-122.1419	39.0933	2	9/5/74
-122.1639	39.1	2	9/5/74
-122.1514	39.1108	1	9/5/74
-122.1514	39.1136	1	9/5/74
-122.15	39.1169	1	9/5/74
-122.1936	39.1158	2	9/5/74
-122.1194	39.0125	2	9/4/74
-122.07	39.0158	3	9/4/74
-122.0397	39.0494	6	9/4/74
-122.0772	39.0642	5	8/30/74
-122.0761	39.0494	3	8/30/74
-122.1317	39.0567	2	8/30/74
-122.1231	39.0583	2	8/30/74
-122.0769	39.0636	4	8/30/74
-122.1308	39.0567	4	8/30/74
-122.0892	39.0803	3	8/30/74
-122.095	39.0994	1	8/29/74
-122.0689	39.0958	4	8/29/74
-122.0978	39.0878	2	8/29/74
-122.0967	39.0878	2	8/29/74
-122.1286	39.0853	2	8/29/74
-122.0508	38.92	4	8/27/74
-122.0822	38.9536	2	8/27/74
-122.0478	38.9511	2	8/27/74
-122.0633	38.9436	2	8/27/74
-122.0353	38.9261	6	8/27/74
-122.0644	38.9636	1	8/23/74
-122.0425	38.9575	2	8/23/74
-122.0603	38.9764	2	8/23/74
-122.1019	38.9722	3	8/23/74
-122.0239	38.9664	3	8/23/74
-122.0453	38.9517	3	8/23/74
-122.0689	38.9906	2	8/22/74
-121.9225	38.9286	4	8/21/74
-121.9711	38.9308	2	8/21/74
-121.9453	38.9317	4	8/21/74
-121.9442	38.9319	6	8/21/74
-121.9892	38.935	2	8/21/74
-121.9953	38.9353	4	8/21/74
-122.0261	39.005	4	8/21/74
-122.0778	39.0083	1	8/21/74
-122.0881	39.0106	2	8/21/74
-122.0547	39.0125	3	8/21/74
-121.9844	38.9256	2	8/21/74
-122.02	38.9622	1	8/20/74
-121.9689	38.9589	1	8/20/74
-121.9783	38.955	3	8/20/74
-121.9519	38.9539	1	8/20/74
-121.9867	38.9486	8	8/20/74
-122.0222	38.9481	4	8/20/74
-122.0164	38.9481	3	8/20/74
-121.9692	38.9422	3	8/20/74
-121.9978	38.9403	6	8/20/74
-122.015	38.9264	5	8/20/74
-122.0744	38.9253	2	8/20/74
-121.9889	38.9611	1	8/20/74
-122.0067	38.9992	6	8/13/74
-121.9992	38.9769	6	8/13/74
-121.9842	38.9706	1	8/13/74
-121.9608	38.97	1	8/13/74
-122.0308	38.9222	1	8/13/74
-121.9972	38.9983	31	8/13/74
-121.9892	38.8881	4	8/9/74
-121.9819	38.8911	1	8/9/74
-121.9681	38.8872	2	8/9/74
-121.9767	38.8819	5	8/9/74
-121.9561	38.8747	3	8/9/74
-121.9431	38.8675	4	8/9/74
-121.9778	38.8639	6	8/9/74
-121.9217	38.8411	2	8/9/74
-121.9714	38.8817	2	8/9/74
-122.0231	38.9144	8	8/8/74
-121.9033	38.8247	4	8/8/74
-121.9817	38.9039	1	8/8/74
-121.9861	38.9186	2	8/8/74
-121.9922	38.9144	4	8/8/74
-121.9906	38.9094	2	8/8/74
-121.9217	38.8311	1	8/7/74
-121.8825	38.7981	4	8/7/74
-121.9056	38.8164	4	8/7/74
-121.9014	38.8164	10	8/7/74
-121.9458	38.3514	1	7/10/74
-122.1867	39.2772	1	5/31/74

Boron Dissolved (µg/L as B)

Longitude	Latitude	Result	Date
-122.279	39.0233	4600	9/19/86
-122.288	39.0125	269	9/19/86
-122.281	39.0222	1000	9/19/86
-122.539	40.2806	80	8/9/83
-122.539	40.2806	100	8/5/83
-122.539	40.2806	110	7/31/83
-122.539	40.2806	50	7/12/83
-122.539	40.2806	130	7/9/83
-121.613	38.7083	1600	9/30/82
-121.369	38.6414	20	9/29/82
-121.358	38.6006	10	9/29/82
-121.403	38.6167	20	9/29/82
-121.420	38.3025	60	9/28/82
-121.458	38.5233	40	9/28/82
-121.465	38.5097	30	9/28/82
-121.305	38.6508	60	9/27/82
-121.332	38.6183	10	9/27/82
-121.276	39.0158	10	9/24/82
-121.416	38.3803	30	9/24/82
-121.452	38.3889	40	9/24/82
-121.276	39.0158	10	9/24/82
-121.445	38.4364	400	9/23/82
-121.437	38.4178	40	9/23/82
-121.279	38.5439	40	9/23/82
-121.286	38.5672	20	9/23/82
-121.291	38.5964	20	9/23/82
-121.473	38.4197	40	9/23/82
-121.305	38.2628	160	9/22/82

-121.380	38.7119	20	9/21/82
-121.385	38.6581	510	9/21/82
-121.382	38.6647	100	9/21/82
-121.527	38.2408	1400	9/20/82
-121.533	38.2828	60	9/20/82
-121.309	38.7050	80	9/17/82
-121.284	38.6842	40	9/17/82
-121.332	38.6739	220	9/17/82
-121.603	38.1633	120	9/17/82
-121.341	38.6700	20	9/16/82
-121.327	38.2411	140	9/15/82
-121.548	38.6011	230	9/10/82
-121.337	38.8728	170	9/9/82
-121.337	38.8728	170	9/9/82
-121.264	38.8858	4500	9/9/82
-121.264	38.8858	4500	9/9/82
-121.374	38.9822	530	9/7/82
-121.374	38.9822	530	9/7/82
-121.342	38.4133	140	9/7/82
-121.988	38.6083	180	9/8/81
-121.949	38.6675	1500	9/8/81
-122.068	38.7092	690	9/3/81
-122.053	38.7597	170	9/2/81
-122.017	38.8061	1100	9/2/81
-122.033	38.8161	210	9/2/81
-121.618	38.6458	3000	9/1/81
-121.563	38.6186	100	9/1/81
-121.523	38.3611	70	8/31/81
-121.558	38.3708	430	8/31/81
-121.998	38.5292	230	8/28/81
-121.972	38.5600	270	8/28/81
-121.556	38.5117	230	8/27/81
-121.515	38.5411	70	8/27/81
-121.546	38.5464	1500	8/27/81
-121.581	38.5342	1200	8/27/81
-121.651	38.5753	1300	8/26/81
-121.686	38.5022	590	8/26/81
-121.694	38.5206	860	8/26/81
-121.644	38.5089	1100	8/26/81
-121.756	38.5319	720	8/26/81
-121.693	38.5567	1000	8/25/81
-121.799	38.5461	530	8/24/81
-121.833	38.5506	470	8/20/81
-121.911	38.5906	1100	8/20/81
-121.936	38.7039	2500	8/19/81
-122.016	38.7442	290	8/19/81
-122.198	38.8108	500	8/17/81
-121.869	38.6642	1600	8/13/81
-121.886	38.7206	290	8/13/81
-121.727	38.5828	1100	8/12/81
-121.729	38.6181	1400	8/12/81
-121.785	38.6414	2300	8/12/81
-121.710	38.6000	1200	8/12/81
-121.765	38.6869	1800	8/11/81
-121.761	38.6631	1800	8/11/81
-121.729	38.6625	2000	8/11/81
-121.808	38.6781	1900	8/10/81
-122.059	38.7597	1400	8/10/81
-122.023	38.9150	150	7/30/81
-121.704	38.1597	980	9/23/80
-121.931	38.3247	470	9/16/80
-121.997	38.3411	540	9/12/80
-121.953	38.4039	60	9/12/80
-121.808	38.2467	1800	9/11/80
-121.824	38.2850	650	9/11/80
-121.966	38.4425	40	9/10/80
-121.918	38.4208	0	9/10/80
-121.893	38.3225	530	9/4/80

-121.889	38.4900	540	9/3/80
-121.933	38.3539	260	9/3/80
-121.712	38.3575	1600	9/3/80
-121.858	38.4206	230	9/3/80
-121.693	38.4011	740	9/2/80
-121.803	38.3367	410	9/2/80
-121.804	38.4214	530	8/28/80
-121.722	38.4869	690	8/27/80
-121.725	38.4594	540	8/27/80
-121.897	38.4508	90	8/26/80
-121.983	38.4975	580	8/26/80
-121.720	38.5028	570	8/25/80
-121.683	38.5822	1400	8/1/79
-121.674	38.5631	1300	8/1/79
-121.693	38.5644	1200	8/1/79
-121.674	38.5819	1300	8/1/79
-121.904	38.5728	670	7/31/79
-121.821	38.5836	730	7/31/79
-121.765	38.5839	930	7/31/79
-121.804	38.5475	390	7/31/79
-121.933	38.5967	420	7/31/79
-121.759	38.6122	1400	7/31/79
-121.802	38.6225	1400	7/31/79
-121.780	38.5961	910	7/31/79
-121.982	38.6908	2200	7/26/79
-121.845	38.5300	360	7/26/79
-121.961	38.6306	630	7/26/79
-121.852	38.5150	360	7/26/79
-121.823	38.6911	1600	7/26/79
-121.885	38.5472	410	7/26/79
-121.932	38.8372	200	7/25/79
-121.729	38.7200	2400	7/25/79
-121.722	38.6844	1600	7/25/79
-121.824	38.7647	2000	7/25/79
-121.745	38.7422	1600	7/25/79
-121.957	38.7175	1600	7/25/79
-121.947	38.7158	2200	7/25/79
-122.007	38.7233	1600	7/25/79
-121.858	39.6158	20	6/22/79
-121.802	38.7433	460	6/7/79
-121.820	38.7431	1700	6/7/79
-121.885	38.8161	440	6/7/79
-121.877	38.7714	130	6/7/79
-122.017	38.8061	470	6/7/79
-122.007	38.7233	1600	6/6/79
-121.998	38.7389	1200	6/6/79
-121.950	38.6419	610	6/6/79
-121.779	38.7431	4000	6/6/79
-121.961	38.6306	1900	6/6/79
-121.981	38.6703	500	6/6/79
-121.982	38.6908	2000	6/6/79
-121.988	38.7442	530	6/6/79
-121.957	38.7175	1800	6/6/79
-121.969	38.5808	710	6/6/79
-122.036	38.6928	350	6/6/79
-121.736	38.6625	1700	6/5/79
-121.729	38.7200	470	6/5/79
-121.835	38.5744	560	6/5/79
-121.773	38.6550	1700	6/5/79
-121.722	38.6844	1700	6/5/79
-121.723	38.6272	1500	6/5/79
-121.802	38.6225	1600	6/5/79
-121.756	38.6397	1800	6/5/79
-121.821	38.5836	700	6/5/79
-121.693	38.5644	1200	6/4/79
-121.734	38.6081	580	6/4/79
-121.703	38.5317	1000	6/4/79
-121.804	38.5475	340	6/4/79

-121.772	38.5736	1200	6/4/79
-121.726	38.6533	1000	6/4/79
-121.765	38.5839	1100	6/4/79
-121.767	38.5800	910	6/4/79
-122.126	39.4292	100	8/3/77
-121.762	39.6708	20	9/9/76
-121.764	39.7033	20	9/9/76
-121.795	39.6639	20	9/9/76
-121.801	39.7008	20	9/9/76
-121.799	39.7558	160	9/9/76
-121.669	39.5492	20	9/9/76
-121.645	39.5561	20	9/9/76
-121.686	39.5519	20	9/9/76
-121.778	39.6231	20	9/8/76
-121.699	39.6022	20	9/8/76
-121.744	39.5942	8	9/8/76
-121.613	39.5925	8	9/8/76
-121.711	39.5736	20	9/8/76
-121.764	39.5517	20	9/8/76
-121.711	39.5492	20	9/8/76
-121.668	39.6092	20	9/8/76
-121.699	39.4594	20	9/8/76
-121.487	39.4353	40	9/7/76
-122.011	38.9989	700	9/7/76
-121.544	39.4447	8	9/7/76
-121.583	39.4631	360	9/7/76
-121.689	39.4906	20	9/7/76
-122.045	38.9517	300	9/7/76
-121.650	39.5111	20	9/7/76
-121.613	39.4947	390	9/7/76
-121.595	39.3756	60	9/2/76
-121.519	39.4083	20	9/2/76
-121.671	39.3650	20	9/2/76
-121.581	39.4433	360	9/2/76
-121.706	39.3192	20	9/1/76
-121.787	39.4189	20	9/1/76
-121.757	39.3686	30	9/1/76
-121.692	39.3667	20	9/1/76
-121.793	39.2911	30	9/1/76
-121.593	39.3219	9	8/31/76
-121.645	39.3233	90	8/31/76
-121.664	39.2897	20	8/31/76
-121.603	39.3533	40	8/31/76
-121.581	39.3361	350	8/31/76
-121.562	39.3361	280	8/31/76
-121.533	39.2958	20	8/26/76
-121.370	39.3369	9	8/26/76
-121.413	39.3308	50	8/26/76
-121.407	39.3125	9	8/26/76
-121.495	39.2939	20	8/26/76
-121.388	39.3281	250	8/26/76
-121.596	39.2567	20	8/25/76
-121.558	39.2353	40	8/25/76
-121.453	39.2297	7	8/25/76
-121.453	39.2261	2	8/25/76
-121.481	39.2172	20	8/25/76
-121.689	39.2578	30	8/24/76
-121.884	39.2742	30	8/24/76
-121.890	39.2539	20	8/24/76
-121.781	39.1503	70	8/19/76
-121.715	39.1878	20	8/18/76
-121.620	39.1486	310	8/18/76
-121.688	39.1211	30	8/18/76
-121.643	39.1003	70	8/18/76
-121.570	39.1628	7	8/17/76
-121.572	39.1178	7	8/17/76
-121.373	39.0744	9	8/16/76
-121.465	39.1292	20	8/16/76

-121.536	39.0789	30	8/12/76
-121.492	39.0183	40	8/12/76
-121.555	39.0222	20	8/12/76
-121.633	39.0167	150	8/11/76
-121.671	39.0981	50	8/11/76
-121.609	39.0103	100	8/10/76
-121.672	39.0011	130	8/10/76
-121.688	38.8000	320	8/10/76
-121.679	38.9281	280	8/10/76
-121.794	38.9975	50	8/10/76
-121.490	38.9694	20	8/9/76
-121.403	38.9586	70	8/9/76
-121.523	38.9453	20	8/9/76
-121.436	38.9406	20	8/9/76
-121.470	38.9933	160	8/9/76
-121.466	38.9353	7	8/9/76
-121.577	39.0033	20	8/9/76
-121.567	38.9283	190	8/9/76
-121.403	38.9586	70	8/9/76
-121.487	38.9328	20	8/9/76
-121.402	38.8458	30	8/5/76
-121.451	38.9139	70	8/5/76
-121.400	38.8967	140	8/5/76
-121.433	38.8911	50	8/5/76
-121.402	38.8458	30	8/5/76
-121.433	38.8911	50	8/5/76
-121.400	38.8967	140	8/5/76
-121.451	38.9139	70	8/5/76
-121.451	38.9750	30	8/5/76
-121.486	38.8717	60	8/4/76
-121.577	38.8922	30	8/4/76
-121.566	38.9153	100	8/4/76
-121.605	38.8753	350	8/4/76
-121.593	38.8653	60	8/4/76
-121.450	38.8031	90	8/3/76
-121.407	38.7558	170	8/3/76
-121.450	38.8031	90	8/3/76
-121.488	38.8389	60	8/3/76
-121.407	38.7558	170	8/3/76
-121.494	38.7581	180	8/3/76
-121.590	38.7569	410	8/2/76
-121.534	38.8089	120	8/2/76
-121.617	38.8019	130	8/2/76
-122.038	39.4436	200	7/27/76
-121.486	38.8717	20	6/11/76
-121.879	38.4017	20	6/8/76
-122.187	40.1842	1500	6/3/76
-122.167	39.8092	200	6/1/76
-122.199	40.2561	2100	5/24/76
-121.926	39.9122	20	10/21/75
-122.074	39.9103	160	10/21/75
-121.921	39.9128	20	10/21/75
-122.054	39.9350	150	10/21/75
-121.919	39.9131	20	10/21/75
-122.012	39.9581	140	10/21/75
-122.101	40.0339	390	10/21/75
-122.092	40.0483	420	10/21/75
-122.055	39.9258	110	10/21/75
-122.012	39.9492	90	10/21/75
-121.895	39.8175	20	10/20/75
-121.984	39.8403	20	10/20/75
-121.908	39.8044	40	10/20/75
-121.906	39.8175	30	10/20/75
-122.020	39.8181	80	10/20/75
-121.878	39.8194	20	10/20/75
-121.880	39.8206	9	10/20/75
-121.914	39.8142	20	10/20/75
-121.913	39.8111	30	10/20/75
-121.890	39.8014	110	10/20/75
-121.903	39.7983	130	10/20/75
-121.902	39.7431	110	10/9/75
-122.078	39.4928	110	10/9/75
-121.807	39.7122	7	10/9/75
-121.867	39.7189	110	10/9/75
-121.917	39.7233	130	10/9/75
-121.889	39.7569	110	10/9/75
-121.868	39.7611	130	10/9/75
-121.824	39.7656	30	10/9/75
-121.911	39.7758	190	10/9/75
-121.897	39.7306	150	10/9/75
-121.860	39.7417	160	10/9/75
-122.008	39.6394	120	10/8/75
-122.004	39.7094	110	10/8/75
-121.955	39.7808	30	10/8/75
-121.981	39.7811	20	10/8/75
-121.935	39.7964	50	10/8/75
-122.002	39.7578	130	10/8/75
-122.004	39.6664	160	10/8/75
-121.956	39.7919	20	10/8/75
-121.958	39.7794	20	10/8/75
-122.025	39.6558	120	10/8/75
-121.901	39.6958	110	10/7/75
-122.004	39.5447	200	10/7/75
-121.816	39.6992	40	10/7/75
-121.851	39.6697	50	10/7/75
-121.804	39.6489	30	10/7/75
-121.814	39.6244	30	10/7/75
-121.859	39.6831	40	10/7/75
-121.812	39.7050	40	10/7/75
-122.031	39.5831	100	10/2/75
-122.044	39.5725	160	10/2/75
-122.031	39.4572	170	10/1/75
-122.051	39.4572	160	10/1/75
-122.073	39.4578	110	10/1/75
-122.120	39.2956	420	10/1/75
-122.016	39.5108	110	10/1/75
-122.037	39.4942	180	10/1/75
-122.012	39.5228	150	10/1/75
-122.051	39.4811	120	10/1/75
-122.050	39.4811	130	10/1/75
-122.026	39.5003	90	10/1/75
-121.803	39.4381	20	9/30/75
-122.017	39.4622	100	9/30/75
-121.988	39.4639	120	9/30/75
-122.019	39.4700	290	9/30/75
-121.979	39.4761	100	9/30/75
-121.852	39.4203	40	9/30/75
-121.964	39.4925	140	9/30/75
-122.019	39.4944	130	9/30/75
-121.977	39.5222	130	9/30/75
-121.816	39.4203	20	9/30/75
-122.019	39.4353	130	9/26/75
-121.953	39.4197	90	9/26/75
-121.960	39.3942	70	9/26/75
-122.028	39.4353	150	9/26/75
-122.050	39.4222	60	9/26/75
-121.969	39.4150	220	9/26/75
-121.977	39.4450	100	9/26/75
-122.040	39.4500	230	9/26/75
-121.953	39.4197	80	9/26/75
-122.110	39.3911	80	9/26/75
-122.019	39.2183	200	9/25/75
-122.035	39.2119	340	9/25/75
-122.021	39.2281	420	9/25/75
-122.049	39.2178	200	9/25/75
-122.068	39.1083	220	9/25/75
-122.004	39.1975	300	9/25/75
-122.006	39.1989	320	9/24/75
-122.011	39.2808	150	9/24/75
-122.010	39.2103	220	9/24/75
-121.992	39.2142	370	9/24/75
-122.021	39.2125	220	9/24/75
-121.935	39.1708	140	9/24/75
-121.965	39.4211	120	9/24/75
-121.993	39.3908	170	9/24/75
-122.006	39.1944	310	9/24/75
-122.010	39.1844	350	9/24/75
-121.986	39.0347	170	9/18/75
-121.950	39.0542	220	9/18/75
-122.008	39.0800	250	9/18/75
-121.999	39.1836	340	9/18/75
-122.001	39.0133	410	9/18/75
-121.914	39.1158	90	9/18/75
-121.867	39.0653	330	9/17/75
-121.861	39.0619	330	9/17/75
-121.827	39.0056	170	9/17/75
-121.838	38.9597	90	9/17/75
-121.893	39.1806	70	9/15/75
-121.831	39.0411	50	9/15/75
-121.822	39.1072	80	9/15/75
-121.823	39.1558	40	9/15/75
-121.841	39.1461	40	9/15/75
-121.903	39.1153	90	9/15/75
-121.788	38.9025	160	9/11/75
-121.774	38.8667	630	9/11/75
-121.786	38.8564	290	9/11/75
-121.710	38.8806	760	9/11/75
-121.700	38.8072	800	9/10/75
-121.793	38.8067	8100	9/10/75
-121.786	38.7936	1400	9/10/75
-122.056	39.4819	200	7/28/75
-122.068	39.7967	100	7/26/75
-121.822	39.1072	20	6/6/75
-121.562	39.1125	20	6/5/75
-122.235	39.9753	20	6/5/75
-121.588	39.1517	20	6/5/75
-121.487	39.0636	20	6/4/75
-122.133	39.1756	400	6/4/75
-122.016	38.9481	200	6/2/75
-121.662	39.3811	20	5/28/75
-122.197	40.0539	320	10/2/74
-122.162	40.0267	2	10/2/74
-122.093	39.8881	20	10/1/74
-122.087	39.8811	270	10/1/74
-122.162	40.0186	6	10/1/74
-122.130	39.8986	4	10/1/74
-122.139	39.9231	180	10/1/74
-122.106	39.9319	20	10/1/74
-122.155	39.9753	180	10/1/74
-122.173	39.9772	20	10/1/74
-122.159	40.0086	80	10/1/74
-122.176	40.0106	60	10/1/74
-122.187	40.0125	60	10/1/74
-122.164	40.0178	20	10/1/74
-122.084	39.8678	30	10/1/74
-122.103	39.8286	20	9/30/74
-122.186	39.9381	130	9/30/74
-122.104	39.7981	20	9/30/74
-122.053	39.8006	100	9/30/74
-122.088	39.8056	100	9/30/74
-122.098	39.8111	110	9/30/74
-122.070	39.8125	120	9/30/74
-122.069	39.8142	150	9/30/74
-122.188	39.9469	20	9/30/74

-122.127	39.8264	110	9/30/74
-122.065	39.8089	50	9/30/74
-122.140	39.7986	20	9/26/74
-122.159	39.8542	40	9/26/74
-122.186	39.8786	20	9/26/74
-122.196	39.8833	20	9/26/74
-122.173	39.8956	30	9/26/74
-122.192	39.9075	50	9/26/74
-122.176	39.9078	290	9/26/74
-122.148	39.9142	8	9/26/74
-122.149	39.9172	20	9/26/74
-122.148	39.8358	20	9/26/74
-122.246	39.7797	280	9/25/74
-122.152	39.7975	30	9/25/74
-122.187	39.7869	180	9/25/74
-122.241	39.7594	30	9/25/74
-122.211	39.7586	70	9/25/74
-122.167	39.7550	200	9/25/74
-122.207	39.7525	280	9/25/74
-122.233	39.7475	50	9/25/74
-122.214	39.7472	60	9/25/74
-122.189	39.7358	130	9/25/74
-122.158	39.7283	210	9/25/74
-122.174	39.7258	60	9/25/74
-122.114	39.7242	260	9/25/74
-122.104	39.7208	200	9/25/74
-122.246	39.7872	50	9/25/74
-122.106	39.7311	140	9/24/74
-122.134	39.7108	180	9/24/74
-122.121	39.7361	100	9/24/74
-122.134	39.7464	580	9/24/74
-122.107	39.7475	160	9/24/74
-122.065	39.7972	120	9/24/74
-122.133	39.7611	210	9/24/74
-122.079	39.7672	520	9/24/74
-122.122	39.7722	210	9/24/74
-122.140	39.7747	320	9/24/74
-122.110	39.7578	290	9/24/74
-122.045	39.6664	160	9/23/74
-122.253	39.6675	170	9/23/74
-122.139	39.6744	160	9/23/74
-122.148	39.6744	60	9/23/74
-122.136	39.6786	270	9/23/74
-122.122	39.6811	90	9/23/74
-122.124	39.7103	350	9/23/74
-122.122	39.7039	340	9/23/74
-122.184	39.6642	120	9/23/74
-122.129	39.6889	250	9/23/74
-122.112	39.6892	160	9/23/74
-122.149	39.6564	330	9/23/74
-122.130	39.6467	200	9/23/74
-122.228	39.6461	140	9/23/74
-122.159	39.6381	300	9/23/74
-122.191	39.6833	180	9/18/74
-122.268	39.6047	30	9/18/74
-122.143	39.6978	160	9/18/74
-122.202	39.7094	90	9/18/74
-122.144	39.7128	280	9/18/74
-122.205	39.6836	200	9/18/74
-122.195	39.6189	50	9/17/74
-122.223	39.6131	30	9/17/74
-122.216	39.5208	400	9/17/74
-122.146	39.5964	50	9/17/74
-122.203	39.5356	380	9/17/74
-122.194	39.5097	90	9/17/74
-122.211	39.5808	130	9/17/74
-122.195	39.5289	60	9/17/74
-122.206	39.5775	30	9/17/74
-122.248	39.5697	70	9/17/74
-122.154	39.5542	30	9/17/74
-122.249	39.5386	200	9/17/74
-122.147	39.5542	50	9/17/74
-122.238	39.6036	20	9/17/74
-122.210	39.4153	260	9/17/74
-122.216	39.5247	210	9/17/74
-122.227	39.2814	430	9/17/74
-122.141	39.5964	70	9/17/74
-122.220	39.5814	140	9/17/74
-122.195	39.5944	30	9/17/74
-122.224	39.5844	40	9/17/74
-122.263	39.1717	550	9/12/74
-122.273	39.1369	510	9/12/74
-122.267	39.1675	280	9/12/74
-122.262	39.1506	450	9/12/74
-122.228	39.1514	520	9/6/74
-122.141	39.1392	670	9/6/74
-122.212	39.1089	310	9/6/74
-122.153	39.1411	1300	9/6/74
-122.225	39.1403	250	9/6/74
-122.152	39.1567	510	9/6/74
-122.226	39.1594	500	9/6/74
-122.133	39.1756	400	9/6/74
-122.160	39.1486	420	9/6/74
-122.139	39.1475	430	9/6/74
-122.150	39.1169	140	9/5/74
-122.161	39.0911	150	9/5/74
-122.142	39.0933	140	9/5/74
-122.159	39.0486	260	9/5/74
-122.179	40.1947	900	9/5/74
-122.151	39.1136	270	9/5/74
-122.194	39.1158	260	9/5/74
-122.164	39.1000	340	9/5/74
-122.150	39.0719	570	9/5/74
-122.151	39.1108	400	9/5/74
-122.040	39.0494	80	9/4/74
-122.070	39.0158	880	9/4/74
-122.119	39.0125	20	9/4/74
-122.076	39.0494	60	8/30/74
-122.077	39.0642	100	8/30/74
-122.123	39.0583	20	8/30/74
-122.132	39.0567	70	8/30/74
-122.131	39.0567	120	8/30/74
-122.089	39.0803	130	8/30/74
-122.077	39.0636	70	8/30/74
-122.069	39.0958	80	8/29/74
-122.095	39.0994	260	8/29/74
-122.129	39.0853	160	8/29/74
-122.098	39.0878	140	8/29/74
-122.125	39.0969	80	8/29/74
-122.097	39.0878	160	8/29/74
-122.082	38.9536	2700	8/27/74
-122.048	38.9511	360	8/27/74
-122.063	38.9436	1300	8/27/74
-122.035	38.9261	200	8/27/74
-122.102	38.9722	70	8/23/74
-122.045	38.9517	220	8/23/74
-122.043	38.9575	330	8/23/74
-122.024	38.9664	260	8/23/74
-122.064	38.9636	580	8/23/74
-122.060	38.9764	2900	8/23/74
-122.069	38.9906	1000	8/22/74
-121.923	38.9286	330	8/21/74
-122.055	39.0125	400	8/21/74
-121.971	38.9308	120	8/21/74
-121.945	38.9317	280	8/21/74
-122.088	39.0106	20	8/21/74
-121.984	38.9256	200	8/21/74
-121.944	38.9319	310	8/21/74
-121.989	38.9350	240	8/21/74
-121.995	38.9353	100	8/21/74
-122.026	39.0050	850	8/21/74
-122.078	39.0083	20	8/21/74
-121.989	38.9611	140	8/20/74
-122.015	38.9264	290	8/20/74
-121.978	38.9550	20	8/20/74
-121.952	38.9539	410	8/20/74
-121.987	38.9486	330	8/20/74
-122.022	38.9481	140	8/20/74
-122.016	38.9481	160	8/20/74
-121.969	38.9589	320	8/20/74
-122.074	38.9253	590	8/20/74
-122.020	38.9622	170	8/20/74
-121.998	38.9403	60	8/20/74
-121.969	38.9422	260	8/20/74
-121.830	38.5472	200	8/14/74
-121.961	38.9700	110	8/13/74
-121.662	38.5533	600	8/13/74
-122.031	38.9222	120	8/13/74
-122.007	38.9992	510	8/13/74
-121.997	38.9983	460	8/13/74
-121.999	38.9769	160	8/13/74
-121.984	38.9706	230	8/13/74
-121.978	38.8639	370	8/9/74
-121.922	38.8411	510	8/9/74
-121.943	38.8675	130	8/9/74
-121.982	38.8911	250	8/9/74
-121.989	38.8881	970	8/9/74
-121.977	38.8819	90	8/9/74
-121.971	38.8817	280	8/9/74
-121.956	38.8747	320	8/9/74
-121.968	38.8872	250	8/9/74
-121.903	38.8247	530	8/8/74
-121.538	38.5781	1500	8/8/74
-121.982	38.9039	400	8/8/74
-121.991	38.9094	80	8/8/74
-121.986	38.9186	240	8/8/74
-122.023	38.9144	170	8/8/74
-121.992	38.9144	660	8/8/74
-121.922	38.8311	530	8/7/74
-121.906	38.8164	290	8/7/74
-121.901	38.8164	660	8/7/74
-121.883	38.7981	1100	8/7/74
-121.969	39.4150	200	7/11/74
-121.468	39.1294	20	7/2/74
-121.466	39.0667	20	7/1/74
-122.155	40.0628	20	6/10/74
-122.232	39.9169	20	6/7/74
-121.997	38.9983	500	6/3/74
-122.152	39.0808	100	5/31/74
-121.923	38.9286	300	5/30/74
-121.987	39.2069	200	5/29/74
-121.883	39.6906	20	5/23/74
-121.944	39.6364	20	5/22/74
-122.199	40.2561	200	8/22/73
-122.079	39.6753	20	7/23/73
-122.038	39.4436	100	7/19/73
-122.276	39.6128	20	7/18/73
-122.164	39.6992	100	7/18/73
-122.031	39.2167	200	7/13/73
-121.997	38.9983	400	7/12/73
-122.008	39.3497	100	7/10/73
-122.104	40.1233	100	6/29/73
-122.102	40.0728	200	6/29/73
-122.235	39.9753	20	6/27/73

-122.179	40.1947	1000	6/25/73
-121.814	39.6244	20	6/15/73
-122.097	39.0342	20	5/10/73
-122.157	39.0575	100	5/10/73
-122.276	39.6128	20	5/10/73
-122.187	39.2772	200	3/28/73
-121.890	38.8197	400	8/30/72
-122.031	39.2167	300	8/27/72
-121.932	38.3978	0	8/23/72
-122.051	39.0158	500	8/22/72
-122.152	39.0808	0	8/22/72
-122.157	39.0575	200	8/22/72
-121.768	38.5736	900	8/16/72
-121.903	38.8247	500	8/15/72
-121.940	38.7378	500	8/15/72
-121.974	38.4178	0	8/14/72
-121.548	38.4150	1700	8/14/72
-122.185	39.8258	100	8/14/72
-121.543	38.5339	1800	8/14/72
-122.004	39.7397	200	7/26/72
-122.179	40.1947	1200	7/20/72
-122.120	39.5361	0	6/28/72
-122.042	38.7442	100	8/18/71
-121.671	38.6719	1900	8/13/71
-121.489	38.7556	200	8/13/71
-121.913	39.1444	100	8/12/71
-121.884	39.2742	0	8/11/71
-121.398	38.9231	100	8/5/71
-121.398	38.9231	100	8/5/71
-121.372	38.5839	0	8/4/71
-121.741	38.4156	0	8/3/71
-122.187	40.1842	1100	7/29/71
-122.013	39.5222	100	7/28/71
-122.008	39.6394	100	7/28/71
-122.279	39.4475	0	7/14/71
-122.004	39.7397	100	7/14/71
-122.031	39.5831	0	7/14/71
-122.038	39.4436	100	7/14/71
-122.068	39.7967	100	7/12/71
-122.131	40.0347	0	7/8/71
-122.155	40.0633	0	7/7/71
-122.149	40.0597	0	7/7/71
-121.984	39.8617	0	6/29/71
-122.151	39.0858	200	6/23/71
-122.016	39.2281	200	6/22/71
-122.120	39.2956	200	6/21/71
-122.133	39.1756	400	6/21/71
-121.883	39.6906	0	6/20/71
-121.861	39.0619	400	9/11/70
-122.133	39.1756	500	9/10/70
-122.016	38.9481	300	9/10/70
-121.940	38.7378	600	9/10/70
-122.008	38.9983	500	9/10/70
-122.011	38.9989	700	9/10/70
-122.120	39.2956	400	9/4/70
-121.903	38.8247	500	9/4/70
-122.227	39.2814	200	9/4/70
-121.987	39.2069	200	9/3/70
-121.548	38.4150	1700	9/3/70
-121.543	38.5339	1600	9/3/70
-121.535	39.3272	0	9/2/70
-121.662	39.3811	0	9/2/70
-121.823	39.1558	0	9/1/70
-121.814	39.6244	0	8/31/70
-121.883	39.6906	0	8/31/70
-121.466	39.0667	0	8/30/70
-121.555	39.1869	0	8/17/70
-121.510	39.2144	0	8/17/70
-121.559	39.0514	0	8/14/70
-121.493	39.1308	0	8/14/70
-121.470	38.9933	200	8/13/70
-121.402	38.8458	0	8/11/70
-121.402	38.8458	0	8/11/70
-121.497	38.6828	0	8/10/70
-121.468	38.5244	0	8/7/70
-121.334	38.4433	0	8/6/70
-121.969	39.4150	200	7/30/70
-122.166	39.4667	200	7/30/70
-122.013	39.5222	100	7/30/70
-122.008	39.6394	100	7/30/70
-122.068	39.7964	0	7/29/70
-122.164	39.6992	100	7/29/70
-122.102	40.0728	0	7/14/70
-122.131	40.0347	0	7/3/70
-122.155	40.0628	0	7/3/70
-122.191	40.0453	0	7/3/70
-122.054	39.9339	400	6/5/70
-122.104	39.8833	300	6/4/70
-122.187	40.1842	1200	6/3/70

Lead Dissolved (µg/L as Pb)

Longitude	Latitude	Result	Date
-122.288	39.0125	5	9/19/86
-122.281	39.0222	5	9/19/86
-122.279	39.0233	5	9/19/86
-121.403	38.6167	9	9/29/82
-121.305	38.2628	4	9/22/82
-121.309	38.7050	1	9/17/82
-121.341	38.6700	1	9/16/82
-122.068	38.7092	5	9/3/81
-121.515	38.5411	1	8/27/81
-121.756	38.5319	0	8/26/81
-121.911	38.5906	7	8/20/81
-121.869	38.6642	2	8/13/81
-121.931	38.3247	1	9/16/80
-121.953	38.4039	4	9/12/80
-121.693	38.5644	2	8/1/79
-121.674	38.5631	0	8/1/79
-121.683	38.5822	0	8/1/79
-121.933	38.5967	0	7/31/79
-121.759	38.6122	0	7/31/79
-121.780	38.5961	0	7/31/79
-121.904	38.5728	0	7/31/79
-121.804	38.5475	2	7/31/79
-121.821	38.5836	0	7/31/79
-121.885	38.5472	0	7/26/79
-121.982	38.6908	0	7/26/79
-121.845	38.5300	2	7/26/79
-121.823	38.6911	0	7/26/79
-121.932	38.8372	0	7/25/79
-121.947	38.7158	0	7/25/79
-121.824	38.7647	0	7/25/79
-121.802	38.7433	0	6/7/79
-122.017	38.8061	0	6/7/79
-121.885	38.8161	0	6/7/79
-121.969	38.5808	0	6/6/79
-121.950	38.6419	0	6/6/79
-121.982	38.6908	0	6/6/79
-121.988	38.7442	0	6/6/79
-122.007	38.7233	0	6/6/79
-121.756	38.6397	0	6/5/79
-121.802	38.6225	0	6/5/79
-121.821	38.5836	0	6/5/79
-121.729	38.7200	0	6/5/79
-121.736	38.6625	0	6/5/79
-121.734	38.6081	0	6/4/79
-121.767	38.5800	0	6/4/79
-121.703	38.5317	0	6/4/79
-121.711	39.5492	2	9/8/76
-121.413	39.3308	0	8/26/76
-121.536	39.0789	0	8/12/76
-121.403	38.9586	2	8/9/76
-121.403	38.9586	2	8/9/76
-121.774	38.8667	3	9/11/75
-121.562	39.1125	0	6/5/75
-122.235	39.9753	0	6/5/75
-122.133	39.1756	0	6/4/75
-122.016	38.9481	0	6/2/75
-122.162	40.0186	3	10/1/74
-122.194	39.5097	2	9/17/74
-122.159	39.0486	4	9/5/74
-122.125	39.0969	0	8/29/74
-121.946	38.3514	0	7/10/74
-122.187	39.2772	20	5/31/74

Solids, Sum of Constituents, Dissolved (mg/L)

Longitude	Latitude	Result	Date
-122.294	39.7822	307	7/26/75
-122.288	39.0125	870	9/19/86
-122.281	39.0222	1200	9/19/86
-122.279	39.0233	1000	9/19/86
-122.279	39.4475	767	7/14/71
-122.276	39.6128	221	7/18/73
-122.273	39.1369	822	9/12/74
-122.267	39.1675	460	9/12/74
-122.263	39.1717	463	9/12/74
-122.262	39.1506	917	9/12/74
-122.238	39.6036	221	9/17/74
-122.235	39.9753	407	6/5/75
-122.235	39.9753	310	6/27/73
-122.228	39.1514	565	9/6/74
-122.227	39.2814	341	9/4/70
-122.226	39.1594	568	9/6/74
-122.225	39.1403	443	9/6/74
-122.212	39.1089	450	9/6/74
-122.211	39.5808	299	9/17/74
-122.210	39.4153	423	9/17/74
-122.207	39.7525	309	9/25/74
-122.202	39.7094	299	9/18/74
-122.199	40.2561	389	5/24/76
-122.199	40.2561	284	8/22/73
-122.198	38.8108	771	8/17/81
-122.195	39.6189	202	9/17/74
-122.194	39.1158	398	9/5/74
-122.192	39.9075	141	9/26/74
-122.191	40.0453	216	7/3/70
-122.187	40.1842	312	6/3/76
-122.187	40.1842	307	7/29/71
-122.187	40.1842	266	6/3/70
-122.187	39.2772	578	3/28/73
-122.179	40.1947	398	9/5/74
-122.179	40.1947	444	6/25/73
-122.179	40.1947	330	7/20/72
-122.176	39.9078	147	9/26/74
-122.167	39.8092	217	6/1/76
-122.166	39.4667	394	7/30/70
-122.164	39.1000	384	9/5/74
-122.164	39.6992	410	7/18/73
-122.164	39.6992	378	7/29/70

-122.164	40.0178	219	10/1/74
-122.162	40.0186	208	10/1/74
-122.161	39.0911	322	9/5/74
-122.160	39.1486	569	9/6/74
-122.159	39.0486	598	9/5/74
-122.157	39.0575	352	5/10/73
-122.157	39.0575	538	8/22/72
-122.155	40.0633	222	7/7/71
-122.155	40.0628	310	6/10/74
-122.155	40.0628	216	7/3/70
-122.153	39.1411	348	9/6/74
-122.152	39.0808	321	5/31/74
-122.152	39.1567	781	9/6/74
-122.151	39.1108	450	9/5/74
-122.151	39.1136	470	9/5/74
-122.151	39.0858	340	6/23/71
-122.150	39.0719	268	9/5/74
-122.150	39.1169	320	9/5/74
-122.149	40.0597	212	7/7/71
-122.142	39.0933	310	9/5/74
-122.141	39.1392	599	9/6/74
-122.139	39.1475	574	9/6/74
-122.134	39.7464	327	9/24/74
-122.133	39.1756	622	6/4/75
-122.133	39.1756	634	9/6/74
-122.133	39.1756	603	6/21/71
-122.133	39.1756	612	9/10/70
-122.132	39.0567	285	8/30/74
-122.131	39.0567	233	8/30/74
-122.131	40.0347	399	7/8/71
-122.131	40.0347	380	7/3/70
-122.129	39.0853	287	8/29/74
-122.126	39.4292	358	8/3/77
-122.125	39.0969	378	8/29/74
-122.124	39.7103	297	9/23/74
-122.123	39.0583	114	8/30/74
-122.122	39.7039	348	9/23/74
-122.120	39.2956	1170	10/1/75
-122.120	39.2956	1130	6/21/71
-122.120	39.2956	1130	9/4/70
-122.120	39.5361	172	6/28/72
-122.119	39.0125	229	9/4/74
-122.110	39.3911	189	9/26/75
-122.106	39.9319	221	10/1/74
-122.104	39.8833	187	6/4/70
-122.102	38.9722	279	8/23/74
-122.102	40.0728	206	7/14/70
-122.098	39.0878	269	8/29/74
-122.097	39.0342	158	5/10/73
-122.097	39.0878	346	8/29/74
-122.095	39.0994	309	8/29/74
-122.089	39.0803	245	8/30/74
-122.088	39.0106	302	8/21/74
-122.084	39.8678	241	10/1/74
-122.082	38.9536	506	8/27/74
-122.079	39.7672	307	9/24/74
-122.079	39.6753	380	7/23/73
-122.078	39.0083	226	8/21/74
-122.077	39.0642	211	8/30/74
-122.077	39.0636	216	8/30/74
-122.076	39.0494	161	8/30/74
-122.074	38.9253	344	8/20/74
-122.074	39.9103	347	10/21/75
-122.073	39.4578	205	10/1/75
-122.070	39.0158	455	9/4/74
-122.070	39.8125	283	9/30/74
-122.069	38.9906	366	8/22/74
-122.069	39.0958	444	8/29/74
-122.069	39.8142	243	9/30/74
-122.068	38.7092	631	9/3/81
-122.068	39.1083	437	9/25/75
-122.068	39.7964	350	7/29/70
-122.068	39.7967	386	7/26/75
-122.068	39.7967	349	7/12/71
-122.065	39.8089	281	9/30/74
-122.064	38.9636	446	8/23/74
-122.063	38.9436	401	8/27/74
-122.060	38.9764	615	8/23/74
-122.059	38.7597	436	8/10/81
-122.056	39.4819	590	7/28/75
-122.055	39.0125	295	8/21/74
-122.054	39.9350	233	10/21/75
-122.054	39.9339	263	6/5/70
-122.053	38.7597	301	9/2/81
-122.051	39.4572	379	10/1/75
-122.051	39.4811	444	10/1/75
-122.051	38.9200	361	8/27/74
-122.048	38.9511	413	8/27/74
-122.045	38.9517	386	9/7/76
-122.045	38.9517	407	8/23/74
-122.043	38.9575	390	8/23/74
-122.042	38.7442	270	8/18/71
-122.040	39.4500	599	9/26/75
-122.040	39.0494	232	9/4/74
-122.038	39.4436	461	7/27/76
-122.038	39.4436	198	7/19/73
-122.038	39.4436	437	7/14/71
-122.037	39.4942	391	10/1/75
-122.036	38.6928	287	6/6/79
-122.035	38.9261	300	8/27/74
-122.033	38.8161	345	9/2/81
-122.031	39.5831	257	7/14/71
-122.031	38.9222	307	8/13/74
-122.031	39.2167	517	7/13/73
-122.031	39.2167	584	8/27/72
-122.026	39.0050	435	8/21/74
-122.025	39.6558	262	10/8/75
-122.024	38.9664	301	8/23/74
-122.023	38.9150	305	7/30/81
-122.023	38.9144	290	8/8/74
-122.022	38.9481	298	8/20/74
-122.021	39.2125	346	9/24/75
-122.020	38.9622	326	8/20/74
-122.020	39.8181	210	10/20/75
-122.019	39.4944	242	9/30/75
-122.019	39.4353	284	9/26/75
-122.017	38.8061	585	9/2/81
-122.017	38.8061	402	6/7/79
-122.017	39.4622	268	9/30/75
-122.016	38.9481	252	6/2/75
-122.016	38.9481	247	8/20/74
-122.016	38.9481	232	9/10/70
-122.016	38.7442	372	8/19/81
-122.016	39.2281	249	6/22/71
-122.015	38.9264	374	8/20/74
-122.013	39.5222	160	7/28/71
-122.013	39.5222	212	7/30/70
-122.012	39.5228	297	10/1/75
-122.011	38.9989	777	9/7/76
-122.011	38.9989	893	9/10/70
-122.011	39.2808	409	9/24/75
-122.010	39.1844	1750	9/24/75
-122.010	39.2103	331	9/24/75
-122.008	38.9983	1040	9/10/70
-122.008	39.0800	806	9/18/75
-122.008	39.3497	204	7/10/73
-122.008	39.6394	244	10/8/75
-122.008	39.6394	213	7/28/71
-122.008	39.6394	209	7/30/70
-122.007	38.7233	318	7/25/79
-122.007	38.7233	319	6/6/79
-122.007	38.9992	735	8/13/74
-122.006	39.1989	525	9/24/75
-122.004	39.7397	225	7/27/76
-122.004	39.7397	335	7/18/73
-122.004	39.7397	333	7/26/72
-122.004	39.7397	314	7/14/71
-122.004	39.1975	400	9/25/75
-121.999	38.9769	353	8/13/74
-121.998	38.5292	272	8/28/81
-121.998	38.7389	350	6/6/79
-121.998	38.9403	257	8/20/74
-121.997	38.3411	714	9/12/80
-121.997	38.9983	847	8/13/74
-121.997	38.9983	771	6/3/74
-121.997	38.9983	1120	7/12/73
-121.995	38.9353	282	8/21/74
-121.992	38.9144	302	8/8/74
-121.991	38.9094	288	8/8/74
-121.989	38.8881	288	8/9/74
-121.989	38.9350	345	8/21/74
-121.989	38.9611	261	8/20/74
-121.988	38.6083	380	9/8/81
-121.988	38.7442	324	6/6/79
-121.987	38.9486	223	8/20/74
-121.987	39.2069	223	9/8/76
-121.987	39.2069	273	5/29/74
-121.987	39.2069	238	9/3/70
-121.986	38.9186	241	8/8/74
-121.986	39.0347	228	9/18/75
-121.984	38.9256	210	8/21/74
-121.984	38.9706	282	8/13/74
-121.984	39.8617	386	6/29/71
-121.984	39.8403	232	10/20/75
-121.983	38.4975	328	8/26/80
-121.982	38.8911	206	8/9/74
-121.982	38.6908	624	7/26/79
-121.982	38.6908	482	6/6/79
-121.982	38.9039	322	8/8/74
-121.981	38.6703	514	6/6/79
-121.981	39.7811	300	10/8/75
-121.979	39.4761	264	9/30/75
-121.978	38.9550	222	8/20/74
-121.978	38.8639	333	8/9/74
-121.977	39.4450	280	9/26/75
-121.977	38.8819	250	8/9/74
-121.974	38.4178	240	8/14/72
-121.972	38.5600	437	8/28/81
-121.971	38.8817	245	8/9/74
-121.971	38.9308	252	8/21/74
-121.969	38.5808	427	6/6/79
-121.969	38.9422	250	8/20/74
-121.969	38.9589	290	8/20/74
-121.969	39.4150	258	7/11/74
-121.969	39.4150	247	7/30/70
-121.968	38.8872	248	8/9/74
-121.966	38.4425	255	9/10/80
-121.965	39.4211	405	9/24/75
-121.961	38.6306	477	7/26/79
-121.961	38.6306	483	6/6/79
-121.961	38.9700	335	8/13/74
-121.958	39.7794	286	10/8/75
-121.957	38.7175	605	7/25/79
-121.957	38.7175	556	6/6/79

-121.956	39.7919	430	10/8/75
-121.956	38.8747	233	8/9/74
-121.953	38.4039	282	9/12/80
-121.953	39.4197	291	9/26/75
-121.952	38.9539	331	8/20/74
-121.950	38.6419	401	6/6/79
-121.949	38.6675	665	9/8/81
-121.947	38.7158	655	7/25/79
-121.945	38.9317	282	8/21/74
-121.944	38.9319	277	8/21/74
-121.944	39.6364	342	5/22/74
-121.943	38.8675	320	8/9/74
-121.940	38.7378	220	9/10/70
-121.936	38.7039	484	8/19/81
-121.935	39.1708	188	9/24/75
-121.935	39.7964	292	10/8/75
-121.933	38.5967	381	7/31/79
-121.933	38.3539	451	9/3/80
-121.932	38.3978	278	8/23/72
-121.932	38.8372	348	7/25/79
-121.931	38.3247	433	9/16/80
-121.923	38.9286	312	8/21/74
-121.923	38.9286	320	5/30/74
-121.922	38.8311	402	8/7/74
-121.922	38.8411	378	8/9/74
-121.918	38.4208	561	9/10/80
-121.917	39.7233	258	10/9/75
-121.914	39.8142	253	10/20/75
-121.914	39.1158	261	9/18/75
-121.913	39.1444	290	8/12/71
-121.911	38.5906	704	8/20/81
-121.906	38.8164	325	8/7/74
-121.906	39.8175	159	10/20/75
-121.904	38.5728	642	7/31/79
-121.903	38.8247	381	8/8/74
-121.903	38.8247	461	9/4/70
-121.903	39.1153	220	9/15/75
-121.902	39.7431	192	10/9/75
-121.901	39.6958	594	10/7/75
-121.897	38.4508	302	8/26/80
-121.893	38.3225	600	9/4/80
-121.893	39.1806	244	9/15/75
-121.890	39.2539	176	8/24/76
-121.890	38.8197	290	8/30/72
-121.889	38.4900	325	9/3/80
-121.886	38.7206	213	8/13/81
-121.885	38.5472	477	7/26/79
-121.885	38.8161	301	6/7/79
-121.884	39.2742	270	8/11/71
-121.883	39.6906	541	5/23/74
-121.883	39.6906	412	6/20/71
-121.883	39.6906	372	8/31/70
-121.883	38.7981	463	8/7/74
-121.880	39.8206	137	10/20/75
-121.879	38.4017	317	6/8/76
-121.877	38.7714	175	6/7/79
-121.869	38.6642	462	8/13/81
-121.864	38.1189	1480	9/22/80
-121.861	39.0619	371	9/17/75
-121.861	39.0619	355	9/11/70
-121.859	39.6831	257	10/7/75
-121.858	38.4206	527	9/3/80
-121.852	38.5150	318	7/26/79
-121.846	38.2233	731	9/17/80
-121.845	38.5300	310	7/26/79
-121.838	38.9597	241	9/17/75
-121.835	38.5744	468	6/5/79
-121.833	38.5506	343	8/20/81
-121.831	39.0411	98	9/15/75
-121.830	38.5472	303	8/14/74
-121.824	38.2850	514	9/11/80
-121.824	38.7647	500	7/25/79
-121.823	39.1558	129	9/15/75
-121.823	39.1558	215	9/1/70
-121.823	38.6911	424	7/26/79
-121.822	39.1072	326	6/6/75
-121.821	38.5836	495	7/31/79
-121.821	38.5836	517	6/5/79
-121.820	38.7431	402	6/7/79
-121.816	39.6992	194	10/7/75
-121.814	39.6244	261	10/7/75
-121.814	39.6244	492	6/15/73
-121.814	39.6244	413	8/31/70
-121.808	38.2467	759	9/11/80
-121.808	38.6781	604	8/10/81
-121.804	39.6489	174	10/7/75
-121.804	38.1586	684	9/17/80
-121.804	38.4214	494	8/28/80
-121.804	38.5475	335	7/31/79
-121.804	38.5475	320	6/4/79
-121.804	38.1864	565	9/17/80
-121.803	39.4381	528	9/30/75
-121.803	38.3367	434	9/2/80
-121.802	38.6225	460	7/31/79
-121.802	38.6225	521	6/5/79
-121.802	38.7433	548	6/7/79
-121.799	38.5461	687	8/24/81
-121.795	39.6639	157	9/9/76
-121.794	38.9975	145	8/10/76
-121.793	38.8067	1420	9/10/75
-121.787	39.4189	219	9/1/76
-121.786	38.7936	323	9/10/75
-121.786	38.8564	268	9/11/75
-121.785	38.6414	586	8/12/81
-121.780	38.5961	471	7/31/79
-121.779	38.7431	800	6/6/79
-121.774	38.8667	442	9/11/75
-121.773	38.6550	407	6/5/79
-121.772	38.5736	588	6/4/79
-121.768	38.5736	448	8/16/72
-121.767	38.5800	508	6/4/79
-121.765	38.6869	475	8/11/81
-121.765	38.5839	502	7/31/79
-121.765	38.5839	535	6/4/79
-121.764	39.7033	173	9/9/76
-121.762	39.6708	145	9/9/76
-121.761	38.6631	441	8/11/81
-121.759	38.6122	475	7/31/79
-121.756	38.6397	449	6/5/79
-121.756	38.5319	350	8/26/81
-121.745	38.7422	440	7/25/79
-121.744	39.5942	76	9/8/76
-121.741	38.4156	237	8/3/71
-121.736	38.6625	408	6/5/79
-121.734	38.6081	822	6/4/79
-121.729	38.6181	459	8/12/81
-121.729	38.7200	532	7/25/79
-121.729	38.7200	523	6/5/79
-121.729	38.6625	583	8/11/81
-121.727	38.5828	581	8/12/81
-121.726	38.6533	653	6/4/79
-121.725	38.4594	506	8/27/80
-121.723	38.6272	367	6/5/79
-121.722	38.4869	722	8/27/80
-121.722	38.6844	365	7/25/79
-121.722	38.6844	380	6/5/79
-121.720	38.5028	459	8/25/80
-121.714	38.1986	317	9/17/80
-121.712	38.3575	1500	9/3/80
-121.711	39.5492	177	9/8/76
-121.710	38.6000	398	8/12/81
-121.710	38.8806	1170	9/11/75
-121.704	38.1597	257	9/23/80
-121.703	38.5317	1090	6/4/79
-121.699	39.4594	173	9/8/76
-121.698	38.5392	731	8/17/71
-121.694	38.5206	644	8/26/81
-121.693	38.4011	534	9/2/80
-121.693	38.5567	718	8/25/81
-121.693	38.5644	711	8/1/79
-121.693	38.5644	736	6/4/79
-121.689	39.2578	252	8/24/76
-121.688	38.8000	190	8/10/76
-121.686	38.5022	509	8/26/81
-121.686	39.5519	161	9/9/76
-121.683	38.5822	434	8/1/79
-121.674	38.5631	744	8/1/79
-121.674	38.5819	415	8/1/79
-121.672	39.0011	1570	8/10/76
-121.671	38.6719	333	8/13/71
-121.668	39.6092	180	9/8/76
-121.662	38.5533	479	8/13/74
-121.662	39.3811	169	5/28/75
-121.662	39.3811	157	9/2/70
-121.651	38.5753	560	8/26/81
-121.645	39.5561	182	9/9/76
-121.645	39.3233	723	8/31/76
-121.644	38.5089	621	8/26/81
-121.643	39.1003	524	8/18/76
-121.633	39.0167	303	8/11/76
-121.618	38.6458	819	9/1/81
-121.617	38.8019	521	8/2/76
-121.613	39.4947	178	9/7/76
-121.613	38.7083	539	9/30/82
-121.605	38.8753	1360	8/4/76
-121.603	38.1633	165	9/17/82
-121.588	39.1517	254	6/5/75
-121.583	39.4631	231	9/7/76
-121.581	39.3361	262	8/31/76
-121.581	38.5342	385	8/27/81
-121.581	39.4433	196	9/2/76
-121.577	38.8922	262	8/4/76
-121.572	39.1178	685	8/17/76
-121.570	39.1628	210	8/17/76
-121.567	38.9283	549	8/9/76
-121.563	38.6186	137	9/1/81
-121.562	39.1125	183	7/14/76
-121.562	39.1125	173	6/5/75
-121.562	39.1125	171	7/2/74
-121.559	39.0514	152	8/14/70
-121.558	38.3708	439	8/31/81
-121.556	38.5117	330	8/27/81
-121.555	39.1869	180	8/17/70
-121.548	38.4150	1660	9/3/70
-121.548	38.6011	176	9/10/82
-121.546	38.5464	629	8/27/81
-121.543	38.5339	601	9/3/70
-121.538	38.5781	1280	8/8/74
-121.536	39.0789	187	8/12/76
-121.535	39.3272	198	9/2/70
-121.533	39.2958	161	8/26/76
-121.533	38.2828	160	9/20/82
-121.523	38.3611	186	8/31/81
-121.515	38.5411	224	8/27/81

-121.510	39.2144	142	8/17/70
-121.497	38.6828	192	8/10/70
-121.493	39.1308	137	7/2/74
-121.493	39.1308	97	8/14/70
-121.492	39.0183	276	8/12/76
-121.489	38.7556	194	8/13/71
-121.488	38.8389	218	8/3/76
-121.487	39.0636	174	6/4/75
-121.486	38.8717	221	8/4/76
-121.486	38.8717	242	6/11/76
-121.481	39.2172	201	8/25/76
-121.470	38.9933	586	8/9/76
-121.470	38.9933	530	8/13/70
-121.468	39.1294	198	9/5/74
-121.468	39.1294	179	7/2/74
-121.468	39.1375	197	11/7/75
-121.468	38.5244	161	8/7/70
-121.466	39.0667	165	7/1/74
-121.466	39.0667	115	8/30/70
-121.466	38.9353	184	8/9/76
-121.465	39.1403	147	11/7/75
-121.465	38.5097	244	9/28/82
-121.464	39.1339	146	11/13/75
-121.460	38.9872	462	7/25/70
-121.458	38.5233	252	9/28/82
-121.453	39.2261	150	8/25/76
-121.451	38.9139	187	8/5/76
-121.451	38.9139	187	8/5/76
-121.450	38.8031	172	8/3/76
-121.450	38.8031	172	8/3/76
-121.413	39.3308	360	8/26/76
-121.403	38.9586	180	8/9/76
-121.403	38.9586	180	8/9/76
-121.402	38.8458	203	8/5/76
-121.402	38.8458	203	8/5/76
-121.402	38.8458	164	8/11/70
-121.402	38.8458	164	8/11/70
-121.400	38.8967	192	8/5/76
-121.400	38.8967	192	8/5/76
-121.398	38.9231	148	8/5/71
-121.398	38.9231	148	8/5/71
-121.388	39.3281	448	8/26/76
-121.385	38.6581	319	9/21/82
-121.382	38.6647	226	9/21/82
-121.374	38.9822	266	9/7/82
-121.374	38.9822	266	9/7/82
-121.373	39.0744	177	8/16/76
-121.372	38.5839	165	8/4/71
-121.369	38.6414	249	9/29/82
-121.358	38.6006	162	9/29/82
-121.337	38.8728	222	9/9/82
-121.337	38.8728	222	9/9/82
-121.334	38.4433	146	8/6/70
-121.332	38.6183	173	9/27/82
-121.332	38.6739	302	9/17/82
-121.327	38.2411	350	9/15/82
-121.309	38.7050	301	9/17/82
-121.291	38.5964	285	9/23/82
-121.284	38.6842	228	9/17/82
-121.276	39.0158	160	9/24/82
-121.276	39.0158	160	9/24/82
-121.264	38.8858	501	9/9/82
-121.264	38.8858	501	9/9/82

San Joaquin Valley

Arsenic Dissolved (µg/L as As)

Longitude	Latitude	Result	Date
-121.548	37.8017	6	6/6/79
-121.548	37.8017	6	6/6/79
-121.499	37.7589	5	5/5/84
-121.499	37.7589	5	5/5/84
-121.435	37.7961	3	6/6/79
-121.435	37.7961	3	6/6/79
-121.432	37.7792	5	5/5/84
-121.432	37.7792	5	5/5/84
-121.400	37.7244	1	5/23/79
-121.400	37.7244	1	5/23/79
-121.398	38.2083	15	5/17/78
-121.398	38.2083	15	5/17/78
-121.361	37.6864	1	6/12/79
-121.361	37.6864	1	6/12/79
-121.361	37.6458	1	6/13/79
-121.361	37.6458	1	6/13/79
-121.360	37.6933	1	3/11/85
-121.360	37.6933	1	3/11/85
-121.352	38.1547	26	5/18/78
-121.352	38.1547	26	5/18/78
-121.341	38.0319	12	6/14/78
-121.341	38.0319	12	6/14/78
-121.339	38.1181	12	6/1/78
-121.339	38.1181	12	6/1/78
-121.333	37.6011	1	6/14/79
-121.333	37.6011	1	6/14/79
-121.322	37.5992	1	3/13/85
-121.311	37.7139	1	5/14/84
-121.311	37.7139	1	5/14/84
-121.305	38.1272	10	5/31/78
-121.305	38.1272	10	5/31/78
-121.261	37.9392	10	7/22/70
-121.261	37.9392	10	7/22/70
-121.248	38.0317	2	6/14/78
-121.248	38.0317	2	6/14/78
-121.246	37.9214	11	5/8/79
-121.246	37.9214	11	5/8/79
-121.243	38.1339	1	6/6/78
-121.243	38.1339	1	6/6/78
-121.232	37.6281	1	5/5/84
-121.215	37.9319	15	6/29/78
-121.215	37.9319	15	6/29/78
-121.215	37.6150	1	5/6/84
-121.213	37.9800	4	6/22/78
-121.213	37.9800	4	6/22/78
-121.209	37.9642	11	6/29/78
-121.209	37.9642	11	6/29/78
-121.207	37.5839	18	5/6/84
-121.207	38.1878	4	5/22/78
-121.207	38.1878	4	5/22/78
-121.200	37.5494	3	3/12/85
-121.194	37.7361	8	5/17/79
-121.194	37.7361	8	5/17/79
-121.186	38.0317	2	6/14/78
-121.186	38.0317	2	6/14/78
-121.184	37.4786	1	5/16/85
-121.174	37.7989	9	5/9/79
-121.174	37.7989	9	5/9/79
-121.174	37.8647	5	5/8/79
-121.174	37.8647	5	5/8/79
-121.163	37.9914	2	6/21/78
-121.163	37.9914	2	6/21/78
-121.156	37.5433	1	5/1/85
-121.144	37.5375	1	3/13/85
-121.143	37.7400	6	5/17/79
-121.143	37.7400	6	5/17/79
-121.142	37.4361	1	5/16/85
-121.133	37.5967	2	7/2/85
-121.109	37.4561	1	4/30/85
-121.106	37.7456	1	6/19/74
-121.106	37.7456	1	6/19/74
-121.101	38.1225	5	6/7/78
-121.101	38.1225	5	6/7/78
-121.093	37.4850	1	5/5/84
-121.082	37.4550	1	5/6/84
-121.079	37.4936	5	11/17/88
-121.079	37.4653	2	5/4/84
-121.079	37.4939	1	11/17/88
-121.079	37.4908	3	4/30/85
-121.076	37.2753	3	5/7/84
-121.075	37.2897	1	5/13/85
-121.058	37.4303	1	5/5/84
-121.053	37.1881	1	5/6/84
-121.053	37.8781	3	5/9/79
-121.053	37.8781	3	5/9/79
-121.051	37.3917	1	5/7/84
-121.049	37.1881	2	5/6/84
-121.048	37.2742	1	5/7/84
-121.048	38.0267	1	6/22/78
-121.048	38.0267	1	6/22/78
-121.047	37.6044	3	5/1/85
-121.039	38.1533	2	5/25/78
-121.039	38.1533	2	5/25/78
-121.021	37.3758	2	5/7/84
-121.013	37.2322	2	5/7/84
-121.012	37.4311	40	11/16/88
-121.008	37.2275	1	5/5/84
-121.006	37.2533	1	9/12/85
-120.999	37.2425	1	3/27/85
-120.997	37.5206	6	7/18/95
-120.996	37.2533	1	9/12/85
-120.992	37.4386	1	5/15/85
-120.991	37.1883	2	5/8/84
-120.991	37.3317	1	5/7/84
-120.988	37.7989	4	5/15/79
-120.988	37.7989	4	5/15/79
-120.984	37.7981	4	5/16/79
-120.984	37.7981	4	5/16/79
-120.984	37.3558	1	5/5/84
-120.981	37.2917	1	5/5/84
-120.980	37.4342	1	5/21/85
-120.978	37.2897	3	5/7/84
-120.975	37.3508	3	11/15/88
-120.959	37.0997	5	5/7/84
-120.956	37.1453	1	3/28/85
-120.956	37.1453	1	3/28/85
-120.949	37.2842	2	5/21/84
-120.944	38.0458	2	6/27/78
-120.944	38.0458	2	6/27/78
-120.938	37.0644	15	5/6/84
-120.925	37.0817	6	5/8/84
-120.914	37.0922	7	5/6/84
-120.906	37.3539	1	6/27/85
-120.906	37.3539	1	6/19/84
-120.906	37.3539	1	7/27/83
-120.896	37.3092	1	5/13/85
-120.895	37.1139	4	4/9/85
-120.895	37.2456	1	8/9/84
-120.853	37.0522	7	9/11/85
-120.853	37.0522	7	9/11/85
-120.843	37.1000	12	4/9/85
-120.839	37.0561	9	4/11/85
-120.839	37.0561	9	4/11/85

-120.837	37.3344	38	5/14/85
-120.836	37.0125	2	5/6/84
-120.836	36.9956	1	5/5/84
-120.836	37.4286	2	6/27/85
-120.836	37.4286	2	6/19/84
-120.836	37.4286	3	7/27/83
-120.836	36.9986	1	5/9/84
-120.821	37.0997	1	8/9/84
-120.820	37.1000	2	8/9/84
-120.818	36.9542	1	5/14/84
-120.818	36.9267	2	5/15/84
-120.813	37.1600	3	4/10/85
-120.800	36.9314	1	5/14/84
-120.792	37.5442	3	7/28/94
-120.776	36.9228	1	5/15/84
-120.760	37.0786	1	5/10/84
-120.753	36.8939	1	5/21/84
-120.753	36.8939	2	5/10/84
-120.746	36.9022	1	5/10/84
-120.736	36.9044	1	5/10/84
-120.687	37.1858	6	4/10/85
-120.677	37.5889	4	5/20/87
-120.670	37.0975	3	5/10/84
-120.657	36.8067	1	5/9/84
-120.657	36.8344	1	4/11/85
-120.657	36.8344	1	4/11/85
-120.657	36.8344	1	4/11/85
-120.657	36.8344	1	4/11/85
-120.657	36.8344	1	4/10/85
-120.657	36.8344	1	4/10/85
-120.657	36.8344	1	4/10/85
-120.657	36.8344	1	4/10/85
-120.657	36.8344	1	4/10/85
-120.657	36.8344	1	4/10/85
-120.657	36.8344	1	4/10/85
-120.657	36.8344	1	4/10/85
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-120.657	36.8344	1	4/10/85
-120.655	36.8358	1	5/16/84
-120.653	36.8797	1	5/21/84
-120.653	36.9961	13	5/8/84
-120.643	37.3531	1	6/25/85
-120.643	37.3531	2	6/28/84
-120.643	37.3531	2	7/25/83
-120.635	37.0467	8	4/29/85
-120.632	37.4797	3	7/26/83
-120.626	37.3164	2	6/25/85
-120.626	37.3164	2	6/28/84
-120.626	37.3164	3	7/25/83
-120.626	36.8497	1	5/16/84
-120.616	36.8503	1	5/15/84
-120.616	36.9817	1	5/8/84
-120.616	37.0481	2	5/8/84
-120.616	37.0828	3	5/8/84
-120.615	37.0550	4	5/7/84
-120.600	36.8683	1	5/8/84
-120.600	37.2728	4	6/4/87
-120.599	36.9672	2	5/9/84
-120.595	37.3711	1	6/25/85
-120.595	37.3711	1	6/28/84
-120.595	37.3711	4	7/26/83
-120.588	37.3019	7	5/21/87
-120.584	36.8506	2	5/15/84
-120.584	36.9900	2	5/14/84
-120.583	36.8464	3	7/29/87
-120.583	36.8464	3	7/29/87
-120.583	36.8464	4	7/29/87
-120.583	36.8464	2	7/29/87
-120.583	36.8478	6	9/2/87
-120.583	36.8486	2	7/30/87
-120.583	36.8494	2	7/8/87
-120.583	36.9306	3	7/30/87
-120.582	37.6394	3	5/20/87
-120.580	36.8506	1	4/4/85
-120.580	36.8506	1	4/4/85
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-120.580	36.8506	1	4/4/85
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-120.580	36.8506	1	4/3/85
-120.580	36.8506	2	4/3/85
-120.580	36.8506	2	4/3/85
-120.580	36.8506	2	4/3/85
-120.580	36.8506	1	4/3/85
-120.580	36.8506	1	4/3/85
-120.580	36.8506	1	4/3/85
-120.580	36.8506	2	4/2/85
-120.580	36.8506	1	4/2/85
-120.580	36.8506	1	4/2/85
-120.580	36.8506	2	4/2/85
-120.580	36.8506	1	4/2/85
-120.571	37.0292	11	4/30/85
-120.562	36.9958	29	5/9/84
-120.557	37.0875	15	5/14/85
-120.546	36.9261	2	5/9/84
-120.533	36.8089	1	5/9/84
-120.524	36.8383	2	8/31/89
-120.524	36.8383	5	8/31/89
-120.524	36.8383	1	8/27/87
-120.524	36.8383	1	3/18/87
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-120.524	36.8383	1	3/17/87
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-120.524	36.8383	1	3/21/85
-120.524	36.8383	1	3/21/85
-120.524	36.8383	1	3/21/85
-120.524	36.8383	1	3/21/85
-120.524	36.8383	1	3/21/85
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-120.524	36.8383	1	3/20/85
-120.524	36.8383	1	3/20/85
-120.524	36.8383	1	3/20/85
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-120.524	36.8383	1	3/19/85
-120.524	36.8383	1	3/19/85
-120.524	36.8383	1	3/18/85
-120.504	36.8581	1	5/15/84
-120.490	36.8947	1	5/9/84
-120.490	36.9275	11	5/9/84
-120.486	36.9064	2	11/5/85
-120.486	36.9064	1	5/15/85
-120.478	36.6322	2	3/21/86
-120.476	36.7783	1	5/16/84
-120.474	36.8211	1	5/9/84
-120.456	36.5311	7	11/5/85
-120.456	36.5311	1	3/26/85
-120.450	37.2336	6	7/20/87
-120.445	37.1492	2	7/25/83
-120.442	36.6033	1	5/18/84
-120.440	36.7194	1	5/20/84
-120.435	37.2844	4	6/26/85
-120.435	37.2844	4	6/29/84
-120.435	37.2844	6	7/26/83
-120.432	36.6542	1	8/7/84
-120.427	36.8333	1	5/15/85
-120.414	36.6467	1	8/6/84
-120.413	36.6517	2	7/1/87
-120.413	36.6517	2	6/11/87
-120.413	36.6517	4	6/11/87
-120.413	36.6517	4	6/11/87
-120.413	36.6517	3	6/10/87
-120.413	36.6517	5	6/10/87
-120.413	36.6517	4	6/10/87
-120.413	36.6517	3	6/9/87
-120.413	36.6517	4	6/9/87
-120.413	36.6517	1	2/4/86
-120.413	36.6517	2	2/4/86
-120.413	36.6517	2	2/4/86
-120.413	36.6517	2	2/3/86
-120.413	36.6517	4	1/31/86
-120.413	36.6542	1	8/7/84
-120.410	36.6517	2	7/30/86
-120.410	36.6517	2	7/30/86
-120.410	36.6517	2	7/30/86
-120.410	36.6517	2	7/17/86
-120.410	36.6517	2	7/17/86
-120.410	36.6517	2	7/17/86
-120.410	36.6517	2	2/4/86
-120.410	36.6517	2	2/4/86
-120.407	36.6506	2	8/14/86
-120.407	36.6506	3	8/14/86
-120.407	36.6506	3	8/14/86
-120.407	36.6506	9	8/13/86
-120.407	36.6506	3	8/13/86
-120.407	36.6506	2	8/13/86
-120.407	36.6506	3	8/13/86
-120.407	36.6506	3	8/13/86
-120.407	36.6506	2	8/12/86
-120.407	36.6506	3	8/12/86
-120.407	36.6506	3	8/12/86
-120.407	36.6506	3	8/12/86
-120.407	36.6506	3	8/11/86
-120.407	36.6506	4	7/31/86

-120.407	36.6506	13	7/31/86	-120.407	36.6506	3	2/6/86	-120.276	36.1558	2	8/13/86
-120.407	36.6506	4	7/31/86	-120.407	36.6506	4	2/6/86	-120.247	36.4572	2	5/18/84
-120.407	36.6506	2	7/30/86	-120.407	36.6506	2	2/6/86	-120.246	36.6519	13	5/14/85
-120.407	36.6506	2	7/30/86	-120.407	36.6506	4	2/6/86	-120.246	36.6519	14	3/25/85
-120.407	36.6506	2	7/30/86	-120.407	36.6506	2	2/6/86	-120.224	36.5019	2	5/17/84
-120.407	36.6506	2	7/30/86	-120.407	36.6506	3	2/5/86	-120.223	36.7322	5	7/6/87
-120.407	36.6506	3	7/29/86	-120.407	36.6506	2	2/5/86	-120.223	36.7322	7	7/6/87
-120.407	36.6506	3	7/29/86	-120.407	36.6506	3	2/5/86	-120.211	36.3997	1	5/15/84
-120.407	36.6506	3	7/29/86	-120.407	36.6506	1	2/5/86	-120.210	36.4583	2	5/18/84
-120.407	36.6506	2	7/29/86	-120.407	36.6506	2	2/5/86	-120.206	36.5311	1	5/17/84
-120.407	36.6506	3	7/29/86	-120.407	36.6506	2	2/4/86	-120.193	36.3997	2	5/16/84
-120.407	36.6506	1	7/29/86	-120.406	36.6542	13	10/15/87	-120.187	36.4878	2	5/17/84
-120.407	36.6506	3	7/29/86	-120.406	36.6542	2	7/31/87	-120.178	36.4297	1	5/16/84
-120.407	36.6506	3	7/29/86	-120.406	36.6542	2	6/30/87	-120.156	36.4292	2	5/16/84
-120.407	36.6506	3	7/29/86	-120.406	36.6542	1	5/7/87	-120.156	36.4586	2	5/17/84
-120.407	36.6506	3	7/29/86	-120.406	36.6542	1	4/16/87	-120.128	36.4417	1	5/16/85
-120.407	36.6506	4	7/28/86	-120.406	36.6542	1	3/27/87	-120.112	36.3358	1	3/27/85
-120.407	36.6506	3	7/28/86	-120.406	36.6542	2	9/26/86	-120.112	36.3386	1	5/15/85
-120.407	36.6506	3	7/28/86	-120.406	36.6542	2	6/10/86	-120.112	36.3386	1	3/27/85
-120.407	36.6506	1	7/28/86	-120.406	36.6542	2	5/29/86	-120.104	36.4156	4	5/17/84
-120.407	36.6506	3	7/28/86	-120.405	36.6475	3	4/1/86	-120.103	36.4453	1	5/16/84
-120.407	36.6506	15	7/17/86	-120.405	36.6467	3	5/10/84	-120.098	36.3856	1	5/19/84
-120.407	36.6506	2	7/17/86	-120.397	36.6394	1	8/7/84	-120.096	35.9900	7	8/12/86
-120.407	36.6506	3	7/16/86	-120.386	36.6331	5	5/10/84	-120.093	36.1017	1	8/8/86
-120.407	36.6506	2	7/16/86	-120.378	37.2633	2	7/25/95	-120.092	36.1164	1	8/8/86
-120.407	36.6506	4	7/16/86	-120.376	36.7703	1	8/8/84	-120.092	36.1164	1	7/1/85
-120.407	36.6506	3	7/16/86	-120.376	36.7703	1	8/8/84	-120.085	36.4294	2	5/17/84
-120.407	36.6506	3	7/16/86	-120.376	36.7703	1	1/24/84	-120.085	36.4403	2	5/19/84
-120.407	36.6506	3	7/16/86	-120.376	36.7964	1	5/13/85	-120.073	36.8225	2	6/17/87
-120.407	36.6506	3	7/16/86	-120.372	36.7556	2	8/28/90	-120.073	36.8225	30	6/17/87
-120.407	36.6506	5	7/16/86	-120.372	36.7556	4	8/26/90	-120.065	36.4158	1	5/17/84
-120.407	36.6506	3	7/15/86	-120.372	36.7556	1	8/23/90	-120.058	35.9061	7	8/13/86
-120.407	36.6506	3	7/15/86	-120.370	36.5436	2	5/16/84	-120.029	36.1478	1	5/15/85
-120.407	36.6506	1	7/15/86	-120.369	37.2864	5	6/26/85	-120.029	36.3139	1	7/19/79
-120.407	36.6506	21	7/15/86	-120.369	37.2864	4	6/29/84	-120.029	36.3867	2	5/17/84
-120.407	36.6506	3	7/15/86	-120.369	37.2864	5	7/26/83	-120.024	37.0400	1	6/5/87
-120.407	36.6506	3	7/15/86	-120.369	36.5750	4	5/16/84	-120.007	36.0947	1	5/20/84
-120.407	36.6506	3	7/15/86	-120.369	36.6464	3	8/7/84	-120.006	36.5458	5	7/8/87
-120.407	36.6506	2	5/23/86	-120.369	36.5744	12	5/14/84	-119.998	36.8500	1	6/17/87
-120.407	36.6506	3	5/23/86	-120.361	36.5733	3	5/16/84	-119.994	36.3581	2	5/17/84
-120.407	36.6506	5	5/22/86	-120.360	36.7050	1	8/8/84	-119.994	36.3286	2	5/17/84
-120.407	36.6506	3	5/22/86	-120.360	36.7050	1	1/24/84	-119.994	36.3433	82	5/17/84
-120.407	36.6506	3	5/22/86	-120.360	36.7306	1	8/8/84	-119.984	36.0803	1	5/20/84
-120.407	36.6506	3	5/21/86	-120.360	36.7306	1	1/24/84	-119.984	36.0944	2	5/19/84
-120.407	36.6506	1	5/21/86	-120.360	36.6464	4	8/6/84	-119.983	36.1378	1	5/17/84
-120.407	36.6506	2	5/21/86	-120.360	36.7194	1	8/8/84	-119.980	36.4853	1	5/16/85
-120.407	36.6506	3	3/6/86	-120.360	36.7194	1	1/24/84	-119.978	36.3306	1	5/20/84
-120.407	36.6506	4	3/6/86	-120.359	36.7200	1	5/8/84	-119.976	36.4008	1	5/16/85
-120.407	36.6506	3	3/6/86	-120.352	36.6903	2	8/8/84	-119.960	36.0072	15	8/9/86
-120.407	36.6506	5	3/6/86	-120.352	36.6903	1	1/24/84	-119.957	36.0508	1	5/18/84
-120.407	36.6506	2	3/6/86	-120.351	36.6464	2	8/7/84	-119.948	35.9928	10	8/9/86
-120.407	36.6506	3	3/5/86	-120.351	36.6319	4	5/20/84	-119.948	36.0944	1	5/18/84
-120.407	36.6506	2	3/5/86	-120.351	36.6903	1	5/8/84	-119.947	36.3233	1	7/2/85
-120.407	36.6506	1	3/5/86	-120.351	36.5453	1	5/15/84	-119.940	36.2267	2	5/20/84
-120.407	36.6506	1	2/28/86	-120.343	36.6758	1	8/8/84	-119.930	36.0800	2	5/18/84
-120.407	36.6506	1	2/28/86	-120.343	36.6758	2	1/24/84	-119.926	36.4856	9	8/3/87
-120.407	36.6506	2	2/27/86	-120.342	36.6464	3	8/6/84	-119.923	36.1381	1	5/18/84
-120.407	36.6506	2	2/27/86	-120.334	36.6611	4	8/8/84	-119.921	36.2556	2	5/18/84
-120.407	36.6506	1	2/27/86	-120.333	36.6464	3	8/7/84	-119.915	36.2661	1	8/19/86
-120.407	36.6506	3	2/26/86	-120.326	36.6467	1	8/8/84	-119.905	36.1381	1	5/18/84
-120.407	36.6506	4	2/26/86	-120.326	36.6467	1	1/24/84	-119.905	36.1522	1	5/18/84
-120.407	36.6506	2	2/26/86	-120.326	36.6464	29	8/6/84	-119.904	36.2550	1	5/18/84
-120.407	36.6506	4	2/26/86	-120.323	37.2894	4	6/25/85	-119.904	36.2261	1	5/19/84
-120.407	36.6506	2	2/25/86	-120.316	36.7564	1	3/26/85	-119.896	36.4475	30	7/18/79
-120.407	36.6506	3	2/11/86	-120.311	36.1572	1	8/13/86	-119.891	36.9789	1	6/16/87
-120.407	36.6506	3	2/11/86	-120.284	36.5742	1	5/15/84	-119.886	36.1892	3	5/18/84
-120.407	36.6506	1	2/11/86	-120.279	36.5450	2	5/16/84	-119.873	36.3881	21	5/15/85
-120.407	36.6506	3	2/6/86	-120.278	36.6019	3	5/15/84	-119.868	36.2769	3	5/19/84

-119.851	36.3656	1	12/3/84
-119.851	36.3656	1	7/23/84
-119.850	36.2697	8	12/5/84
-119.844	36.1897	10	12/6/84
-119.844	36.1897	15	7/26/84
-119.833	36.2411	18	12/5/84
-119.833	36.2411	32	7/26/84
-119.827	36.2039	17	12/6/84
-119.827	36.2039	20	7/26/84
-119.824	36.3303	1	7/23/84
-119.819	36.8444	3	6/18/87
-119.815	36.3133	3	12/4/84
-119.815	36.3133	10	7/24/84
-119.814	36.1606	1	8/13/86
-119.810	36.3117	11	12/4/84
-119.810	36.3117	13	7/27/84
-119.798	36.2400	2	8/13/86
-119.798	36.1831	15	12/5/84
-119.798	36.1831	11	7/26/84
-119.789	36.5089	3	7/21/87
-119.779	36.2400	11	7/25/84
-119.779	36.2111	1	12/6/84
-119.779	36.2111	1	7/25/84
-119.772	36.4967	13	7/21/87
-119.763	36.5625	1	7/17/79
-119.753	36.4269	6	6/28/95
-119.753	36.4269	1	6/28/95
-119.743	36.2106	10	7/25/84
-119.707	36.3189	5	8/19/86
-119.706	36.3147	140	8/19/86
-119.703	36.2097	1	8/12/86
-119.666	36.5831	2	7/17/79
-119.664	36.4467	3	7/22/87
-119.658	36.4456	1	7/22/87
-119.648	36.7164	1	9/1/94
-119.648	36.7164	1	8/31/94
-119.648	36.7164	2	8/31/94
-119.646	37.2811	1	10/27/93
-119.637	37.3639	1	10/27/93
-119.634	36.7161	1	8/4/94
-119.624	36.7153	1	8/3/94
-119.624	36.7153	2	8/3/94
-119.624	36.7153	1	6/16/94
-119.609	36.3831	8	7/23/87
-119.602	36.7211	2	8/4/94
-119.596	36.7272	2	8/30/94
-119.596	36.7272	3	8/30/94
-119.596	36.7272	2	6/17/94
-119.574	36.7533	2	8/5/87
-119.538	36.7128	1	6/24/87
-119.525	35.7175	33	8/10/86
-119.525	35.7175	33	8/10/86
-119.486	36.4556	2	7/23/87
-119.486	36.4556	2	7/23/87
-119.467	36.2281	1	6/27/95
-119.467	36.2281	2	6/27/95
-119.467	36.2281	2	6/27/95
-119.467	36.2281	1	6/27/95
-119.435	36.4336	4	7/23/87
-119.435	36.4336	4	7/23/87
-119.428	35.7978	64	8/9/86
-119.428	35.7978	64	8/9/86
-119.418	36.3464	8	7/29/87
-119.418	36.3464	8	7/29/87
-119.408	36.0508	4	8/26/86
-119.408	36.0508	4	8/26/86
-119.403	36.2906	1	5/23/95
-119.403	36.2906	1	5/23/95
-119.395	36.2881	1	6/26/95
-119.395	36.2881	1	6/26/95
-119.395	36.2881	1	6/26/95
-119.395	36.2881	1	6/26/95
-119.383	35.8050	46	8/12/86
-119.383	35.8050	46	8/12/86
-119.336	36.2242	2	7/28/87
-119.336	36.2242	2	7/28/87
-119.308	36.0614	7	8/27/86
-119.308	36.0614	7	8/27/86
-119.291	36.2267	1	7/28/87
-119.291	36.2267	1	7/28/87
-119.276	36.4400	5	7/29/87
-119.276	36.4400	5	7/29/87
-119.274	36.6250	1	7/10/87
-119.274	36.6250	1	7/10/87
-119.197	35.9422	3	8/6/86
-119.197	35.9422	3	8/6/86
-119.197	36.0214	1	8/13/86
-119.197	36.0214	1	8/13/86
-119.152	36.2139	5	7/30/87
-119.152	36.2139	5	7/30/87
-119.146	36.0589	1	8/27/86
-119.146	36.0589	1	8/27/86
-119.095	36.4006	3	8/4/87
-119.095	36.4006	2	8/4/87
-119.095	36.4006	3	8/4/87
-119.095	36.4006	2	8/4/87
-119.071	35.8978	2	8/7/86
-119.071	35.8978	2	8/7/86
-119.048	35.8942	8	8/8/86
-119.048	35.8942	8	8/8/86
-119.046	36.0964	1	8/27/86
-119.046	36.0964	1	8/27/86
-119.043	35.9033	18	8/6/86
-119.043	35.9033	18	8/6/86
-119.043	35.9033	18	8/6/86
-119.043	35.9033	18	8/6/86

Boron Dissolved (µg/L as B)

Longitude	Latitude	Result	Date
-121.548	37.8017	10000	6/6/79
-121.548	37.8017	10000	6/6/79
-121.499	37.7589	2500	5/5/84
-121.499	37.7589	2500	5/5/84
-121.468	38.2256	500	5/15/78
-121.468	38.2256	500	5/15/78
-121.435	37.7961	200	6/6/79
-121.435	37.7961	200	6/6/79
-121.432	37.7792	2000	5/5/84
-121.432	37.7792	2000	5/5/84
-121.400	37.7244	1400	5/23/79
-121.400	37.7244	1400	5/23/79
-121.398	38.2083	200	5/17/78
-121.398	38.2083	200	5/17/78
-121.378	37.7161	1900	5/23/79
-121.378	37.7161	1900	5/23/79
-121.366	37.8553	400	6/6/79
-121.366	37.8553	400	6/6/79
-121.361	37.6864	900	6/12/79
-121.361	37.6864	900	6/12/79
-121.361	37.6864	1000	7/21/70
-121.361	37.6864	1000	7/21/70
-121.361	37.6458	500	6/13/79
-121.361	37.6458	500	6/13/79
-121.360	37.6933	1600	3/11/85
-121.360	37.6933	1600	3/11/85
-121.360	37.7325	800	5/23/79
-121.360	37.7325	800	5/23/79
-121.358	38.0314	20	6/14/78
-121.358	38.0314	20	6/14/78
-121.358	38.0314	0	7/27/70
-121.358	38.0314	0	7/27/70
-121.352	38.1547	30	5/18/78
-121.352	38.1547	30	5/18/78
-121.342	38.0739	20	6/5/78
-121.342	38.0739	20	6/5/78
-121.341	38.0319	20	6/14/78
-121.341	38.0319	20	6/14/78
-121.339	38.0869	20	5/31/78
-121.339	38.0869	20	5/31/78
-121.339	38.1181	20	6/1/78
-121.339	38.1181	20	6/1/78
-121.334	37.9439	700	5/2/79
-121.334	37.9439	700	5/2/79
-121.333	37.6011	500	6/14/79
-121.333	37.6011	500	6/14/79
-121.327	37.6711	900	6/13/79
-121.327	37.6711	900	6/13/79
-121.325	38.0250	0	5/13/71
-121.325	38.0250	0	5/13/71
-121.322	37.5992	430	3/13/85
-121.311	37.7139	2800	5/14/84
-121.311	37.7139	2800	5/14/84
-121.308	38.0281	100	6/29/78
-121.308	38.0281	100	6/29/78
-121.305	38.1272	20	5/31/78
-121.305	38.1272	20	5/31/78
-121.297	38.1458	20	5/18/78
-121.297	38.1458	20	5/18/78
-121.285	37.8400	200	5/13/71
-121.285	37.8400	200	5/13/71
-121.275	38.2439	20	5/15/78
-121.275	38.2439	20	5/15/78
-121.261	37.9392	20	5/2/79
-121.261	37.9392	20	5/2/79
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-121.258	38.0942	20	6/6/78
-121.258	38.0942	20	6/6/78
-121.248	38.0317	20	6/14/78
-121.248	38.0317	20	6/14/78
-121.248	38.0317	0	7/27/70
-121.248	38.0317	0	7/27/70
-121.246	37.9214	20	5/8/79
-121.246	37.9214	20	5/8/79
-121.245	38.0372	20	6/14/78
-121.245	38.0372	20	6/14/78
-121.243	38.1339	20	6/6/78
-121.243	38.1339	20	6/6/78
-121.237	37.7697	100	6/10/75
-121.237	37.7697	100	6/10/75
-121.236	38.0094	20	6/20/78
-121.236	38.0094	20	6/20/78
-121.232	37.6281	3600	5/5/84
-121.215	37.9319	500	6/29/78
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-121.215	37.6150	1100	5/6/84
-121.213	37.9800	40	6/22/78
-121.213	37.9800	40	6/22/78
-121.209	37.9642	100	6/29/78
-121.209	37.9642	100	6/29/78
-121.207	37.5839	1200	5/6/84
-121.207	38.1878	20	5/22/78

-121.207	38.1878	20	5/22/78
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-121.194	37.7361	100	5/17/79
-121.194	37.7361	100	5/17/79
-121.186	38.0317	20	6/14/78
-121.186	38.0317	20	6/14/78
-121.184	37.4786	1200	5/16/85
-121.180	37.9728	20	6/21/78
-121.180	37.9728	20	6/21/78
-121.174	37.7989	100	5/9/79
-121.174	37.7989	100	5/9/79
-121.174	37.8647	100	5/8/79
-121.174	37.8647	100	5/8/79
-121.165	38.2344	20	5/18/78
-121.165	38.2344	20	5/18/78
-121.165	37.9061	20	5/3/79
-121.165	37.9061	20	5/3/79
-121.165	37.9061	100	7/24/70
-121.165	37.9061	100	7/24/70
-121.163	37.9914	20	6/21/78
-121.163	37.9914	20	6/21/78
-121.163	37.9914	0	7/28/70
-121.163	37.9914	0	7/28/70
-121.156	37.5433	580	5/1/85
-121.155	37.9453	20	5/8/79
-121.155	37.9453	20	5/8/79
-121.150	38.0361	20	6/20/78
-121.150	38.0361	20	6/20/78
-121.150	38.0361	100	7/23/71
-121.150	38.0361	100	7/23/71
-121.144	37.5375	590	3/13/85
-121.143	37.7400	100	5/17/79
-121.143	37.7400	100	5/17/79
-121.143	37.7400	100	7/20/70
-121.143	37.7400	100	7/20/70
-121.142	37.4361	860	5/16/85
-121.133	37.5967	480	7/2/85
-121.111	38.1667	20	5/24/78
-121.111	38.1667	20	5/24/78
-121.109	37.4561	670	4/30/85
-121.106	37.7456	100	5/17/79
-121.106	37.7456	100	5/17/79
-121.106	37.7456	20	6/19/74
-121.106	37.7456	20	6/19/74
-121.106	37.7456	200	7/21/72
-121.106	37.7456	200	7/21/72
-121.101	38.1225	20	6/7/78
-121.101	38.1225	20	6/7/78
-121.093	37.4850	1800	5/5/84
-121.082	37.4550	1200	5/6/84
-121.079	37.4936	2400	11/17/88
-121.079	37.4653	540	5/4/84
-121.079	37.4939	2500	11/17/88
-121.079	37.4908	2200	4/30/85
-121.076	37.2753	430	5/7/84
-121.075	37.2897	470	5/13/85
-121.058	37.4303	600	5/5/84
-121.053	37.1881	870	5/6/84
-121.053	37.8781	100	5/9/79
-121.053	37.8781	100	5/9/79
-121.052	37.8481	20	5/9/79
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-121.052	37.8481	0	7/23/70
-121.052	37.8481	0	7/23/70
-121.051	37.3917	230	5/7/84
-121.049	37.1881	290	5/6/84
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-121.048	38.0267	0	7/28/70
-121.047	37.6044	60	5/1/85
-121.039	38.1533	20	5/25/78
-121.039	38.1533	20	5/25/78
-121.021	37.3758	1400	5/7/84
-121.017	37.3156	430	8/8/79
-121.016	38.0344	20	6/22/78
-121.016	38.0344	20	6/22/78
-121.013	37.2322	580	5/7/84
-121.012	37.4311	340	11/16/88
-121.008	37.2275	300	5/5/84
-121.006	37.2533	410	9/12/85
-120.999	37.2425	470	3/27/85
-120.999	37.6511	220	8/6/79
-120.996	37.2533	380	9/12/85
-120.995	37.6375	390	9/8/71
-120.995	37.6375	700	6/8/70
-120.995	37.6375	200	3/12/70
-120.992	37.9394	20	6/27/78
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-120.992	37.4386	290	5/15/85
-120.991	37.1883	2000	5/8/84
-120.991	37.3317	1900	5/7/84
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-120.988	37.7989	0	8/18/72
-120.984	37.7981	20	5/16/79
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-120.980	37.4342	540	5/21/85
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-120.854	37.0461	670	8/8/79
-120.853	37.0522	590	9/11/85
-120.853	37.0522	710	9/11/85
-120.843	37.1000	2100	4/9/85
-120.839	37.0561	740	4/11/85
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-119.815	36.3133	250	7/24/84
-119.814	36.1606	260	8/13/86
-119.814	36.1606	270	8/17/79
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-119.772	36.4967	50	7/21/87
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-119.658	36.4456	20	7/22/87
-119.646	37.2811	30	10/27/93
-119.637	37.3639	1500	10/27/93
-119.609	36.3831	20	7/23/87
-119.574	36.7533	20	8/5/87
-119.574	36.7181	30	7/16/79
-119.538	36.7128	10	6/24/87
-119.525	35.7175	70	8/10/86
-119.525	35.7175	70	8/10/86
-119.491	36.1058	50	8/23/79
-119.491	36.1058	50	8/23/79
-119.486	36.4556	40	7/23/87
-119.486	36.4556	40	7/23/87
-119.435	36.4336	40	7/23/87
-119.435	36.4336	40	7/23/87
-119.428	35.7978	100	8/9/86
-119.428	35.7978	100	8/9/86
-119.418	36.3464	20	7/29/87
-119.418	36.3464	20	7/29/87
-119.408	36.0508	90	8/26/86

-119.408	36.0508	90	8/26/86
-119.385	35.8578	210	8/22/79
-119.385	35.8578	210	8/22/79
-119.383	35.8050	90	8/12/86
-119.383	35.8050	90	8/12/86
-119.339	36.2078	20	8/23/79
-119.339	36.2078	20	8/23/79
-119.336	36.2242	30	7/28/87
-119.336	36.2242	30	7/28/87
-119.334	36.2147	20	8/23/79
-119.334	36.2147	20	8/23/79
-119.308	36.0614	70	8/27/86
-119.308	36.0614	70	8/27/86
-119.291	36.2267	20	7/28/87
-119.291	36.2267	20	7/28/87
-119.276	36.4400	133	7/29/87
-119.276	36.4400	133	7/29/87
-119.274	36.6250	20	7/10/87
-119.274	36.6250	20	7/10/87
-119.215	35.9144	50	8/22/79
-119.215	35.9144	50	8/22/79
-119.197	35.9422	40	8/6/86
-119.197	35.9422	40	8/6/86
-119.197	36.0214	70	8/13/86
-119.197	36.0214	70	8/13/86
-119.152	36.2139	120	7/30/87
-119.152	36.2139	120	7/30/87
-119.146	36.0589	140	8/27/86
-119.146	36.0589	140	8/27/86
-119.095	36.4006	20	8/4/87
-119.095	36.4006	10	8/4/87
-119.095	36.4006	20	8/4/87
-119.095	36.4006	10	8/4/87
-119.071	35.8978	50	8/7/86
-119.071	35.8978	50	8/7/86
-119.048	35.8942	570	8/8/86
-119.048	35.8942	570	8/8/86
-119.046	36.0964	130	8/27/86
-119.046	36.0964	130	8/27/86
-119.046	36.0964	80	8/22/79
-119.046	36.0964	80	8/22/79
-119.043	35.9033	70	8/6/86
-119.043	35.9033	70	8/6/86
-119.043	35.9033	70	8/6/86
-119.043	35.9033	70	8/6/86

Lead Dissolved (µg/L as Pb)

Longitude	Latitude	Result	Date
-121.499	37.7589	1	5/5/84
-121.499	37.7589	1	5/5/84
-121.432	37.7792	3	5/5/84
-121.432	37.7792	3	5/5/84
-121.360	37.6933	1	3/11/85
-121.360	37.6933	1	3/11/85
-121.322	37.5992	1	3/13/85
-121.311	37.7139	3	5/14/84
-121.311	37.7139	3	5/14/84
-121.261	37.9392	0	7/22/70
-121.261	37.9392	0	7/22/70
-121.232	37.6281	1	5/5/84
-121.215	37.9319	4	6/29/78
-121.215	37.9319	4	6/29/78
-121.215	37.6150	1	5/6/84
-121.207	37.5839	1	5/6/84
-121.200	37.5494	1	3/12/85
-121.184	37.4786	5	5/16/85
-121.156	37.5433	1	5/1/85
-121.144	37.5375	1	3/13/85
-121.142	37.4361	3	5/16/85
-121.133	37.5967	4	7/2/85
-121.109	37.4561	1	4/30/85
-121.106	37.7456	0	6/19/74
-121.106	37.7456	0	6/19/74
-121.093	37.4850	1	5/5/84
-121.082	37.4550	1	5/6/84
-121.079	37.4936	5	11/17/88
-121.079	37.4653	1	5/4/84
-121.079	37.4939	5	11/17/88
-121.079	37.4908	1	4/30/85
-121.076	37.2753	1	5/7/84
-121.075	37.2897	1	5/13/85
-121.058	37.4303	1	5/5/84
-121.053	37.1881	1	5/6/84
-121.051	37.3917	3	5/7/84
-121.049	37.1881	1	5/6/84
-121.048	37.2742	1	5/7/84
-121.047	37.6044	1	5/1/85
-121.021	37.3758	1	5/7/84
-121.013	37.2322	4	5/7/84
-121.012	37.4311	5	11/16/88
-121.008	37.2275	1	5/5/84
-121.006	37.2533	2	9/12/85
-120.999	37.2425	2	3/27/85
-120.997	37.5206	1	7/18/95
-120.996	37.2533	1	9/12/85
-120.992	37.4386	4	5/15/85
-120.991	37.1883	2	5/8/84
-120.991	37.3317	5	5/7/84
-120.984	37.3558	1	5/5/84
-120.981	37.2917	1	5/5/84
-120.980	37.4342	1	5/21/85
-120.978	37.2897	1	5/7/84
-120.975	37.3508	5	11/15/88
-120.959	37.0997	1	5/7/84
-120.956	37.1453	4	3/28/85
-120.956	37.1453	1	3/28/85
-120.949	37.2842	1	5/21/84
-120.938	37.0644	1	5/6/84
-120.925	37.0817	5	5/8/84
-120.914	37.0922	1	5/6/84
-120.906	37.3539	1	6/27/85
-120.896	37.3092	4	5/13/85
-120.895	37.1139	2	4/9/85
-120.895	37.2456	1	8/9/84
-120.853	37.0522	3	9/11/85
-120.853	37.0522	3	9/11/85
-120.843	37.1000	2	4/9/85
-120.839	37.0561	6	4/11/85
-120.839	37.0561	5	4/11/85
-120.837	37.3344	1	5/14/85
-120.836	37.0125	1	5/6/84
-120.836	36.9956	2	5/5/84
-120.836	37.4286	1	6/27/85
-120.836	36.9986	1	5/9/84
-120.821	37.0997	1	8/9/84
-120.820	37.1000	1	8/9/84
-120.818	36.9542	1	5/14/84
-120.818	36.9267	1	5/15/84
-120.813	37.1600	4	4/10/85
-120.800	36.9314	1	5/14/84
-120.792	37.5442	9	7/28/94
-120.776	36.9228	5	5/15/84
-120.760	37.0786	3	5/10/84
-120.753	36.8939	1	5/21/84
-120.753	36.8939	6	5/10/84
-120.746	36.9022	2	5/10/84
-120.736	36.9044	1	5/10/84
-120.687	37.1858	2	4/10/85
-120.677	37.5889	5	5/20/87
-120.670	37.0975	5	5/10/84
-120.657	36.8067	1	5/9/84
-120.657	36.8344	4	4/11/85
-120.657	36.8344	4	4/11/85
-120.657	36.8344	4	4/11/85
-120.657	36.8344	2	4/10/85
-120.657	36.8344	1	4/10/85
-120.657	36.8344	1	4/10/85
-120.657	36.8344	5	4/10/85
-120.657	36.8344	5	4/10/85
-120.657	36.8344	3	4/10/85
-120.657	36.8344	1	4/10/85
-120.657	36.8344	6	4/10/85
-120.657	36.8344	4	4/10/85
-120.655	36.8358	1	5/16/84
-120.653	36.8797	2	5/21/84
-120.653	36.9961	5	5/8/84
-120.643	37.3531	2	6/25/85
-120.635	37.0467	1	4/29/85
-120.626	37.3164	1	6/25/85
-120.626	36.8497	1	5/16/84
-120.616	36.8503	1	5/15/84
-120.616	36.9817	1	5/8/84
-120.616	37.0481	5	5/8/84
-120.616	37.0828	6	5/8/84
-120.615	37.0550	12	5/7/84
-120.600	36.8683	1	5/8/84
-120.600	37.2728	5	6/4/87
-120.599	36.9672	2	5/9/84
-120.595	37.3711	1	6/25/85
-120.592	36.8503	1	5/15/84
-120.588	37.3019	5	5/21/87
-120.584	36.8506	1	5/15/84
-120.584	36.9900	1	5/14/84
-120.582	37.6394	5	5/20/87
-120.580	36.8506	3	4/4/85
-120.580	36.8506	1	4/4/85
-120.580	36.8506	1	4/4/85
-120.580	36.8506	1	4/4/85
-120.580	36.8506	3	4/4/85
-120.580	36.8506	1	4/4/85
-120.580	36.8506	1	4/4/85
-120.580	36.8506	1	4/4/85
-120.580	36.8506	1	4/4/85
-120.580	36.8506	1	4/4/85
-120.580	36.8506	1	4/4/85
-120.580	36.8506	1	4/4/85
-120.580	36.8506	1	4/3/85
-120.580	36.8506	1	4/3/85
-120.580	36.8506	4	4/3/85
-120.580	36.8506	4	4/3/85
-120.580	36.8506	1	4/3/85
-120.580	36.8506	2	4/3/85
-120.580	36.8506	1	4/3/85
-120.580	36.8506	2	4/3/85
-120.580	36.8506	5	4/3/85
-120.580	36.8506	1	4/2/85
-120.580	36.8506	1	4/2/85
-120.580	36.8506	4	4/2/85
-120.580	36.8506	5	4/2/85
-120.580	36.8506	3	4/2/85
-120.580	36.8506	4	4/2/85
-120.571	37.0292	1	4/30/85

-120.562	36.9958	3	5/9/84
-120.557	37.0875	7	5/14/85
-120.546	36.9261	3	5/9/84
-120.533	36.8089	4	5/9/84
-120.524	36.8383	1	8/31/89
-120.524	36.8383	1	8/31/89
-120.524	36.8383	1	3/21/85
-120.524	36.8383	3	3/21/85
-120.524	36.8383	1	3/21/85
-120.524	36.8383	1	3/21/85
-120.524	36.8383	3	3/21/85
-120.524	36.8383	1	3/21/85
-120.524	36.8383	1	3/21/85
-120.524	36.8383	1	3/21/85
-120.524	36.8383	1	3/21/85
-120.524	36.8383	1	3/20/85
-120.524	36.8383	1	3/20/85
-120.524	36.8383	1	3/20/85
-120.524	36.8383	1	3/20/85
-120.524	36.8383	1	3/20/85
-120.524	36.8383	4	3/20/85
-120.524	36.8383	2	3/20/85
-120.524	36.8383	1	3/20/85
-120.524	36.8383	1	3/19/85
-120.524	36.8383	1	3/19/85
-120.524	36.8383	5	3/19/85
-120.524	36.8383	8	3/19/85
-120.524	36.8383	8	3/19/85
-120.524	36.8383	7	3/19/85
-120.524	36.8383	6	3/18/85
-120.524	36.8383	9	3/18/85
-120.504	36.8581	1	5/15/84
-120.490	36.8947	3	5/9/84
-120.490	36.9275	6	5/9/84
-120.486	36.9064	1	11/5/85
-120.486	36.9064	1	5/15/85
-120.478	36.6322	2	3/21/86
-120.476	36.7783	2	5/16/84
-120.474	36.8211	1	5/9/84
-120.456	36.5311	1	11/5/85
-120.456	36.5311	1	3/26/85
-120.450	37.2336	12	7/20/87
-120.442	36.6033	2	5/18/84
-120.440	36.7194	1	5/20/84
-120.435	37.2844	1	6/26/85
-120.432	36.6542	1	8/7/84
-120.427	36.8333	3	5/15/85
-120.414	36.6467	1	8/6/84
-120.413	36.6542	1	8/7/84
-120.407	36.6506	1	5/23/86
-120.407	36.6506	1	5/23/86
-120.407	36.6506	1	5/22/86
-120.407	36.6506	1	5/22/86
-120.407	36.6506	1	5/22/86
-120.407	36.6506	1	5/21/86
-120.407	36.6506	1	5/21/86
-120.407	36.6506	1	5/21/86
-120.406	36.6542	1	5/29/86
-120.405	36.6475	1	4/1/86
-120.405	36.6467	2	5/10/84
-120.397	36.6394	1	8/7/84
-120.386	36.6331	4	5/10/84
-120.378	37.2633	1	7/25/95
-120.376	36.7703	1	8/8/84
-120.376	36.7703	1	8/8/84
-120.376	36.7703	16	1/24/84
-120.376	36.7964	1	5/13/85
-120.372	36.7556	1	8/28/90
-120.372	36.7556	1	8/26/90
-120.372	36.7556	1	8/23/90
-120.370	36.5436	4	5/16/84
-120.369	37.2864	1	6/26/85
-120.369	36.5750	3	5/16/84
-120.369	36.6464	1	8/7/84
-120.369	36.5744	1	5/14/84
-120.361	36.5733	3	5/16/84
-120.360	36.7050	8	8/8/84
-120.360	36.7050	2	1/24/84
-120.360	36.7306	1	8/8/84
-120.360	36.7306	1	1/24/84
-120.360	36.6464	1	8/6/84
-120.360	36.7194	1	8/8/84
-120.360	36.7194	2	1/24/84
-120.359	36.7200	4	5/8/84
-120.352	36.6903	1	8/8/84
-120.352	36.6903	11	1/24/84
-120.351	36.6464	2	8/7/84
-120.351	36.6319	3	5/20/84
-120.351	36.6903	1	5/8/84
-120.351	36.5453	1	5/15/84
-120.343	36.6758	2	8/8/84
-120.343	36.6758	4	1/24/84
-120.342	36.6464	1	8/6/84
-120.334	36.6611	2	8/8/84
-120.333	36.6464	1	8/7/84
-120.326	36.6467	2	8/8/84
-120.326	36.6467	1	1/24/84
-120.326	36.6464	1	8/6/84
-120.323	37.2894	1	6/25/85
-120.316	36.7564	1	3/26/85
-120.311	36.1572	5	8/13/86
-120.284	36.5742	1	5/15/84
-120.279	36.5450	1	5/16/84
-120.278	36.6019	1	5/15/84
-120.276	36.1558	5	8/13/86
-120.247	36.4572	1	5/18/84
-120.246	36.6519	7	5/14/85
-120.246	36.6519	1	3/25/85
-120.224	36.5019	8	5/17/84
-120.223	36.7322	5	7/6/87
-120.223	36.7322	5	7/6/87
-120.211	36.3997	4	5/15/84
-120.210	36.4583	1	5/18/84
-120.206	36.5311	5	5/17/84
-120.193	36.3997	3	5/16/84
-120.187	36.4878	5	5/17/84
-120.178	36.4297	3	5/16/84
-120.156	36.4292	17	5/16/84
-120.156	36.4586	13	5/17/84
-120.128	36.4417	5	5/16/85
-120.112	36.3358	1	3/27/85
-120.112	36.3386	1	3/27/85
-120.104	36.4156	1	5/17/84
-120.103	36.4453	2	5/16/84
-120.098	36.3856	2	5/19/84
-120.096	35.9900	5	8/12/86
-120.093	36.1017	5	8/8/86
-120.092	36.1164	5	8/8/86
-120.092	36.1164	6	7/1/85
-120.085	36.4294	1	5/17/84
-120.085	36.4403	5	5/19/84
-120.073	36.8225	5	6/17/87
-120.073	36.8225	5	6/17/87
-120.065	36.4158	3	5/17/84
-120.058	35.9061	5	8/13/86
-120.029	36.1478	6	5/15/85
-120.029	36.3139	0	7/19/79
-120.029	36.3867	1	5/17/84
-120.024	37.0400	5	6/5/87
-120.007	36.0947	2	5/20/84
-120.006	36.5458	5	7/8/87
-119.998	36.8500	5	6/17/87
-119.994	36.3581	5	5/17/84
-119.994	36.3286	4	5/17/84
-119.994	36.3433	1	5/17/84
-119.984	36.0803	1	5/20/84
-119.984	36.0944	1	5/19/84
-119.983	36.1378	3	5/17/84
-119.980	36.4853	2	5/16/85
-119.978	36.3306	1	5/20/84
-119.976	36.4008	1	5/16/85
-119.960	36.0072	5	8/9/86
-119.957	36.0508	6	5/18/84
-119.948	35.9928	5	8/9/86
-119.948	36.0944	8	5/18/84
-119.947	36.3233	6	7/2/85
-119.940	36.2267	3	5/20/84
-119.930	36.0800	3	5/18/84
-119.926	36.4856	5	8/3/87
-119.923	36.1381	3	5/18/84
-119.921	36.2556	5	5/18/84
-119.915	36.2661	5	8/19/86
-119.905	36.1381	3	5/18/84
-119.905	36.1522	4	5/18/84
-119.904	36.2550	4	5/18/84
-119.904	36.2261	1	5/19/84
-119.896	36.4475	0	7/18/79
-119.891	36.9789	5	6/16/87
-119.886	36.1892	1	5/18/84
-119.873	36.3881	3	5/15/85
-119.868	36.2769	1	5/19/84
-119.851	36.3656	2	12/3/84
-119.851	36.3656	2	7/23/84
-119.850	36.2697	4	12/5/84
-119.844	36.1897	1	12/6/84
-119.844	36.1897	3	7/26/84
-119.833	36.2411	2	12/5/84
-119.833	36.2411	2	7/26/84
-119.827	36.2039	1	12/6/84
-119.827	36.2039	1	7/26/84
-119.824	36.3303	1	7/23/84
-119.819	36.8444	5	6/18/87
-119.815	36.3133	1	12/4/84
-119.815	36.3133	1	7/24/84
-119.814	36.1606	5	8/13/86
-119.810	36.3117	3	12/4/84
-119.810	36.3117	6	7/27/84
-119.798	36.2400	6	8/13/86
-119.798	36.1831	1	12/5/84
-119.798	36.1831	2	7/26/84
-119.789	36.5089	5	7/21/87
-119.779	36.2400	2	7/25/84
-119.779	36.2111	1	12/6/84
-119.779	36.2111	2	7/25/84
-119.772	36.4967	5	7/21/87
-119.763	36.5625	0	7/17/79
-119.753	36.4269	1	6/28/95
-119.753	36.4269	1	6/28/95
-119.743	36.2106	1	7/25/84
-119.707	36.3189	5	8/19/86
-119.706	36.3147	5	8/19/86
-119.703	36.2097	5	8/12/86
-119.666	36.5831	0	7/17/79
-119.664	36.4467	9	7/22/87

-119.658	36.4456	5	7/22/87
-119.648	36.7164	4	9/1/94
-119.648	36.7164	1	8/31/94
-119.648	36.7164	13	8/31/94
-119.646	37.2811	10	10/27/93
-119.637	37.3639	30	10/27/93
-119.634	36.7161	1	8/4/94
-119.624	36.7153	1	8/3/94
-119.624	36.7153	1	8/3/94
-119.624	36.7153	1	6/16/94
-119.609	36.3831	5	7/23/87
-119.602	36.7211	1	8/4/94
-119.596	36.7272	1	8/30/94
-119.596	36.7272	1	8/30/94
-119.596	36.7272	1	6/17/94
-119.574	36.7533	5	8/5/87
-119.538	36.7128	5	6/24/87
-119.525	35.7175	5	8/10/86
-119.525	35.7175	5	8/10/86
-119.486	36.4556	5	7/23/87
-119.486	36.4556	5	7/23/87
-119.467	36.2281	1	6/27/95
-119.467	36.2281	1	6/27/95
-119.467	36.2281	1	6/27/95
-119.467	36.2281	1	6/27/95
-119.435	36.4336	5	7/23/87
-119.435	36.4336	5	7/23/87
-119.428	35.7978	5	8/9/86
-119.428	35.7978	5	8/9/86
-119.418	36.3464	5	7/29/87
-119.418	36.3464	5	7/29/87
-119.408	36.0508	5	8/26/86
-119.408	36.0508	5	8/26/86
-119.403	36.2906	1	5/23/95
-119.403	36.2906	1	5/23/95
-119.395	36.2881	1	6/26/95
-119.395	36.2881	1	6/26/95
-119.395	36.2881	1	6/26/95
-119.395	36.2881	1	6/26/95
-119.383	35.8050	5	8/12/86
-119.383	35.8050	5	8/12/86
-119.336	36.2242	5	7/28/87
-119.336	36.2242	5	7/28/87
-119.308	36.0614	5	8/27/86
-119.308	36.0614	5	8/27/86
-119.291	36.2267	5	7/28/87
-119.291	36.2267	5	7/28/87
-119.276	36.4400	5	7/29/87
-119.276	36.4400	5	7/29/87
-119.274	36.6250	5	7/10/87
-119.274	36.6250	5	7/10/87
-119.197	35.9422	5	8/6/86
-119.197	35.9422	5	8/6/86
-119.197	36.0214	5	8/13/86
-119.197	36.0214	5	8/13/86
-119.152	36.2139	5	7/30/87
-119.152	36.2139	5	7/30/87
-119.146	36.0589	5	8/27/86
-119.146	36.0589	5	8/27/86
-119.095	36.4006	5	8/4/87
-119.095	36.4006	5	8/4/87
-119.095	36.4006	5	8/4/87
-119.095	36.4006	5	8/4/87
-119.071	35.8978	5	8/7/86
-119.071	35.8978	5	8/7/86
-119.048	35.8942	5	8/8/86
-119.048	35.8942	5	8/8/86
-119.046	36.0964	5	8/27/86
-119.046	36.0964	5	8/27/86
-119.043	35.9033	5	8/6/86
-119.043	35.9033	5	8/6/86
-119.043	35.9033	5	8/6/86
-119.043	35.9033	5	8/6/86

Solids, Sum of Constituents, Dissolved (mg/L)

Longitude	Latitude	Result	Date
-121.361	37.6864	1190	7/21/70
-121.361	37.6864	1190	7/21/70
-121.358	38.0314	276	7/27/70
-121.358	38.0314	276	7/27/70
-121.352	38.1547	127	5/18/78
-121.352	38.1547	127	5/18/78
-121.327	37.6711	524	6/13/79
-121.327	37.6711	524	6/13/79
-121.325	38.0250	374	5/13/71
-121.325	38.0250	374	5/13/71
-121.285	37.8400	324	5/13/71
-121.285	37.8400	324	5/13/71
-121.261	37.9392	200	7/22/70
-121.261	37.9392	200	7/22/70
-121.248	38.0317	165	7/27/70
-121.248	38.0317	165	7/27/70
-121.243	38.1339	161	6/6/78
-121.243	38.1339	161	6/6/78
-121.237	37.7697	370	6/10/75
-121.237	37.7697	370	6/10/75
-121.213	37.9800	372	6/22/78
-121.213	37.9800	372	6/22/78
-121.165	37.9061	158	7/24/70
-121.165	37.9061	158	7/24/70
-121.163	37.9914	151	7/28/70
-121.163	37.9914	151	7/28/70
-121.156	37.5433	827	5/1/85
-121.150	38.0361	548	7/23/71
-121.150	38.0361	548	7/23/71
-121.144	37.5375	726	3/13/85
-121.143	37.7400	198	7/20/70
-121.143	37.7400	198	7/20/70
-121.106	37.7456	288	6/19/74
-121.106	37.7456	288	6/19/74
-121.106	37.7456	252	7/21/72
-121.106	37.7456	252	7/21/72
-121.101	38.1225	156	6/7/78
-121.101	38.1225	156	6/7/78
-121.052	37.8481	263	7/23/70
-121.052	37.8481	263	7/23/70
-121.048	38.0267	200	6/22/78
-121.048	38.0267	200	6/22/78
-121.048	38.0267	140	7/28/70
-121.048	38.0267	140	7/28/70
-121.017	37.3156	555	8/8/79
-121.011	37.6117	390	12/12/78
-121.011	37.6531	305	12/11/78
-120.999	37.6511	404	8/6/79
-120.999	37.6511	410	12/12/74
-120.995	37.6375	650	12/12/74
-120.995	37.6375	1080	6/8/70
-120.993	37.6208	474	12/8/77
-120.988	37.7989	214	8/18/72
-120.988	37.7989	214	8/18/72
-120.986	37.6558	264	12/11/78
-120.983	37.5981	529	12/11/78
-120.956	37.1453	2310	3/28/85
-120.947	37.9147	184	7/24/70
-120.947	37.9147	184	7/24/70
-120.944	37.8617	192	6/24/74
-120.944	37.8617	192	6/24/74
-120.944	37.8617	173	7/23/70
-120.944	37.8617	173	7/23/70
-120.921	37.4025	1660	8/8/79
-120.854	37.0461	938	8/8/79
-120.839	37.0561	670	4/11/85
-120.813	37.1600	1180	4/10/85
-120.709	37.1022	564	8/9/79
-120.707	36.8361	1560	8/13/79
-120.576	37.3597	195	1/14/70
-120.574	37.3081	130	1/14/70
-120.573	36.9733	807	8/14/79
-120.567	36.6242	873	8/4/81
-120.500	36.9828	584	8/14/79
-120.486	36.9064	518	11/5/85
-120.456	36.5311	3670	11/5/85
-120.373	36.4944	964	8/4/81
-120.346	36.4575	1010	8/14/79
-120.327	37.1322	186	8/10/79
-120.244	37.2361	191	8/13/79
-120.091	36.1375	974	8/5/81
-120.029	36.3139	1400	7/19/79
-119.896	36.4475	362	7/18/79
-119.835	36.5333	689	7/17/79
-119.814	36.1606	420	8/17/79
-119.798	36.5297	243	7/17/79
-119.794	36.8861	115	8/15/79
-119.763	36.5625	317	7/17/79
-119.666	36.5831	85	7/17/79
-119.574	36.7181	328	7/16/79
-119.491	36.1058	204	8/23/79
-119.491	36.1058	204	8/23/79
-119.385	35.8578	225	8/22/79
-119.385	35.8578	225	8/22/79
-119.339	36.2078	123	8/23/79
-119.339	36.2078	123	8/23/79
-119.334	36.2147	97	8/23/79
-119.334	36.2147	97	8/23/79
-119.215	35.9144	188	8/22/79
-119.215	35.9144	188	8/22/79
-119.046	36.0964	356	8/22/79
-119.046	36.0964	356	8/22/79

Appendix B: Raw Soil Data

Soil Name	Thickness (in.)	Permeability	pH (rank from Table 5.2)	Hardpan (rank as described in Section 5.1)
Marvin silty clay	60	0.50	80	1.00
Zamora silty clay loam	60	0.50	80	1.00
Clear Lake clay	60	0.12	90	1.00
Altamont clay	35	0.12	100	1.00
Cortina gravelly fine sandy loam	72	10.00	45	1.00
Maywood loam	62	1.64	80	1.00
Perkins gravelly loam	60	1.64	70	1.00
Alamo-Fiddyment complex	37	0.12	75	0.00
Cometa-Fiddyment complex	60	1.02	70	1.00
Cometa-Ramona sandy loams	73	1.02	80	1.00
San Joaquin-Cometa sandy loams	60	1.02	70	0.00
Corning complex	62	1.02	50	1.00
Redding loam	66	1.02	60	0.00
Redding gravelly loam	66	1.02	60	0.00
Bruella sandy loam	61	3.00	90	0.00
Galt-urban land complex	60	0.12	75	0.00
Galt clay	60	0.12	75	0.00
Madera-Galt complex	60	0.12	75	0.00
San Joaquin silt loam	60	1.02	80	0.00
San Joaquin-Galt complex	60	1.02	75	0.00
San Joaquin-urban land complex	60	1.02	80	0.00
San Joaquin-Xerarents complex	60	1.02	80	1.00
Live oak sandy clay loam	60	3.29	75	1.00
Exeter sandy loam	60	1.10	80	1.00
Marcum clay loam	60	0.33	80	1.00
San Joaquin sandy loam	60	1.02	80	0.00
San Joaquin-Arents-Durochrepts complex	60	1.02	80	0.00
Madera fine sandy loam	60	3.02	85	0.00
Madera loam	60	1.02	85	0.00
Madera-Alamo complex	60	3.02	85	0.00
Alamo clay	60	0.12	75	0.00
Atwater loamy sand	60	6.25	90	1.00
Greenfield sandy loam	72	3.75	90	1.00
Lewis loam	60	1.02	60	0.00
Ramona sandy loam	60	2.59	90	1.00
Ramona sandy loam w/H	60	2.59	90	0.00
Atwater loamy sand w/H	60	6.25	90	0.00
Chino clay loam	64	3.46	90	1.00
Calhi loamy sand w/H	60	7.50	40	0.00
Calhi loamy sand	60	7.50	40	1.00
Fresno and El Peco loams	60	1.27	30	0.00
Artois loam	60	1.27	90	1.00
Artois gravelly loam	60	1.27	90	1.00
Cortina gravelly loam	60	10.00	80	1.00
Hillgate clay loam	54	1.27	80	1.00
Myers clay	60	0.12	100	1.00
Pleasanton gravelly loam	54	0.50	70	1.00
Pleasanton very gravelly sandy loam	54	0.50	70	1.00
Delano sandy loam	63	3.09	70	1.00
Zerker loam	62	1.10	70	1.00
Chanac clay loam	60	1.10	70	1.00
Wasco sandy loam	60	4.00	80	1.00
Borden loam	60	1.35	85	1.00
Grangeville sandy loam	60	3.75	70	1.00
Greenfield coarse sandy loam	60	3.75	100	1.00
Dinuba-El Peco fine sandy loams	60	2.52	55	1.00
Arbuckle gravelly loam	60	1.64	60	1.00
Corning gravelly loam	60	1.64	60	1.00
Cortina very gravelly sandy loam	60	10.00	70	1.00
Kimball loam	60	1.64	90	0.00
Kimball gravelly loam	60	1.64	90	1.00
Hillgate loam	54	1.64	60	1.00
Tehama loam	60	1.64	70	1.00
Tehama silt loam	60	0.12	90	1.00
Hillgate gravelly loam	54	1.64	60	1.00
Wyo gravelly loam	60	3.75	100	1.00
Sycamore complex	44	1.10	80	1.00
Sycamore silty loam	60	1.31	60	1.00
Maria silt loam	60	1.31	60	1.00
Merritt silty clay loam	42	0.41	60	1.00
Pescadero silty clay	40	0.12	50	1.00
Laugenour very fine sandy loam	20	4.15	70	1.00
Willows clay	60	0.12	60	1.00
Nacimiento-Newville complex	35	1.27	80	1.00
Newville gravelly loam	56	1.64	70	1.00
Newville-Dibble-gullied land complex	56	1.27	70	1.00
Wyo loam	42	3.75	100	1.00
Cortina complex	72	10.00	80	1.00
Orland loam	60	1.64	80	1.00
Perkins-Kimball gravelly loams	60	1.10	70	1.00
Arbuckle-Tehama complex	60	1.31	80	1.00
Altamont-Dibble complex	52	0.33	80	1.00
Capay silty clay	60	0.12	80	1.00
Ocraig very stony coarse sandy loam	8	4.00	90	1.00
Olashes sandy loam	60	10.10	100	1.00
Palls-Stohlman stony sandy loams	31	4.00	90	1.00
San Joaquin loam	29	1.00	75	0.00
Hollenbeck silty clay loam	65	0.33	80	1.00
Conejo loam	65	1.10	100	1.00
Conejo-Tisdale complex	42	1.10	75	1.00
Tisdale clay loam	31	0.40	75	1.00
Gridley clay loam	37	0.33	75	1.00
Marcum-Gridley clay loams	43	0.33	75	1.00
Antioch-San Ysidro complex	19	0.38	70	1.00
Capay silty clay loam	60	0.12	70	1.00
Capay clay	60	0.12	70	1.00

Pescadero clay loam	34	0.12	40	1.00
Yolo silty clay loam	36	0.41	70	1.00
Fresno, El Peco, and Chino soils	64	3.17	60	0.00
Fresno and El Peco fine sandy loams	63	1.27	30	0.00
Tujunga loamy sand	67	13.00	100	1.00
Borden fine sandy loam	60	1.35	70	1.00
Pachappa sandy loam	63	3.46	80	1.00
Cajon loamy sand	63	13.00	70	1.00
San Joaquin-Alamo complex	60	1.02	80	1.00
Trigo fine sandy loam	16	13.00	75	1.00
Cometa sandy loam	60	1.02	80	1.00
Hanford sandy loam w/H	60	3.75	90	1.00
Montpellier coarse sandy loam	60	3.02	80	1.00
Whitney and Rocklin sandy loams	36	11.00	70	1.00
Whitney fine sandy loam	28	13.00	90	1.00
Greenfield sandy loam w/H	72	3.75	90	0.00
Hollenbeck silty clay	60	0.33	80	0.00
Jacktone clay	60	0.33	70	0.00
Manteca fine sandy loam	74	3.29	70	0.00
Stockton clay	60	0.12	70	0.00
Chualar sandy loam	72	0.50	80	1.00
Delhi loamy sand	60	13.00	90	1.00
Delhi sand	60	13.00	90	1.00
Dello loamy sand	60	13.00	80	1.00
Dinuba sandy loam	60	13.00	75	1.00
Dinuba fine sandy loam	60	13.00	75	1.00
Fresno fine sandy loam	63	1.27	65	0.00
Modesto clay loam	62	0.40	80	1.00
Modesto loam	62	0.40	80	1.00
Meikle clay	60	0.03	90	1.00
Hanford sandy loam	60	4.15	80	1.00
Hilmar loamy sand	66	10.02	60	1.00
Oakdale sandy loam	70	3.46	100	1.00
Waukena fine sandy loam	61	1.27	60	1.00
Rocklin sandy loam	60	2.52	60	0.00
Hopeton clay loam	38	0.40	75	1.00
Madera sandy loam	60	0.12	65	0.00
Whitney sandy loam	31	13.00	80	1.00
Hanford fine sandy loam	60	4.15	80	1.00
Wyman clay loam	60	3.09	80	1.00
Bear Creek clay loam	53	0.03	90	1.00
Honcut clay loam	60	0.03	80	1.00
Cajon coarse sandy loam	60	7.50	50	1.00
Fresno sandy loam	63	2.59	50	0.00
Fresno clay loam	63	2.59	50	0.00
Fresno-Traver complex	63	2.52	45	0.00
Hesperia sandy loam	63	2.59	65	1.00
Pond fine sandy loam	60	2.59	30	1.00
Armona loam	60	10.10	50	1.00
Rossi fine sandy loam	65	1.27	30	1.00
Traver sandy loam	60	2.59	30	1.00
Traver fine sandy loam	60	2.59	30	1.00
Boggs sandy loam	60	1.29	50	1.00
Homeland fine sandy loam	60	3.29	60	1.00
Twisselman silty clay	60	1.02	60	1.00
Tulare clay	60	0.05	60	1.00
Westcamp loam	72	1.02	40	1.00
Chino loam	64	2.90	80	1.00
Chino fine sandy loam	60	3.46	80	1.00
Fresno, El Peco, and Pozo soils	60	1.27	45	0.35
Grangeville fine sandy loam	60	3.29	70	1.00
Pachappa fine sandy loam	63	3.46	80	1.00
Pozo loam	36	0.40	80	1.00
Traver loam	64	2.59	20	1.00
Visalia sandy loam	60	6.25	80	1.00
Wunjey very fine sandy loam	66	1.64	50	1.00
Centerville clay	37	0.12	80	1.00
Exeter loam	60	3.09	80	0.00
Havala loam	64	3.09	80	1.00
Buttonwillow clay	64	3.02	60	1.00
Garces loam	60	0.33	50	1.00
Jerryslu loam	60	0.05	50	0.00
Kimberlina fine sandy loam	71	0.35	80	1.00
Lerdo complex	60	0.07	50	1.00
Milham sandy loam	60	0.14	70	1.00
Marguerite loam	60	0.40	90	1.00
Snelling sandy loam	80	13.00	100	1.00
Raynor cobbly clay	48	0.40	100	1.00
Whitney and Rocklin soils	60	11.00	75	1.00
Lewis silty clay loam	60	0.12	60	1.00
Merced clay	60	0.40	80	1.00
Rossi clay	60	0.40	30	1.00
Rossi clay loam	60	0.40	30	1.00
Waukena loam	60	0.12	60	1.00
Panoche clay loam	60	0.40	50	1.00

Appendix C: Soil Area Data by Site

The percent area each soil makes up out of the total site area is listed below. Together with the information in Appendix D, this information was used to determine the Soils Sub-Index results given in Section 4.

Sacramento Valley

Site ID	Soil	%
Thomes Creek	Arbuckle gravelly loam	20.7
	Arbuckle-Tehama complex	0.1
	Corning gravelly loam	31.5
	Cortina complex	1
	Hillgate loam	7.9
	Nacimiento-Newville complex	9.7
	Newville gravelly loam	26.9
	Newville-Dibble-gullied land complex	0.4
	Orland loam	0.9
	Perkins-Kimball gravelly loams	0.1
	Tehama loam	0.6
	Wyo loam	0.3
Burch Creek	Altamont clay	6.5
	Clear Lake clay	0.1
	Corning gravelly loam	13.6
	Cortina gravelly fine sandy loam	1
	Hillgate loam	20.8
	Kimball gravelly loam	30.7
	Kimball loam	7.8
	Maywood loam	0.4
	Perkins gravelly loam	3.7
Stone Valley	Altamont clay	3.8
	Artois loam	0.9
	Capay clay	2.1
	Cortina gravelly loam	2.1
	Cortina very gravelly sandy loam	9.4
	Hillgate gravelly loam	0.7
	Hillgate loam	18.1
	Maywood loam	1.9
	Myers clay	0.5
	Tehama loam	6
	Tehama silt loam	54.4
	Zamora silty clay loam	0.2
Stoney Creek Fan	Arbuckle gravelly loam	56.9
	Corning gravelly loam	0.1
	Cortina very gravelly sandy loam	4.3
	Hillgate loam	1.9
	Kimball gravelly loam	3.5
Stoney Creek Fan (...cont'd)	Kimball loam	14.4
	Tehama loam	2.2
	Tehama silt loam	16.7
	Wyo gravelly loam	0.1
Sutter Buttes	Altamont-Dibble complex	5.8
	Ocraig very stony course sandy loam	7.6
	Olashes sandy loam	9.1
	Palls-Stohlman stony sandy loams	77.4
Yuba City	Conejo loam	10.3
	Conejo-Tisdale complex	56.8
	Gridley clay loam	3.5
	Live oak sandy clay loam	1.8
	Marcum-Gridley clay loams	16.6
	Tisdale clay loam	11
American Basin	Exeter sandy loam	13.7
	Galt clay	4.1
	Marcum clay loam	1.9
	San Joaquin sandy loam	56.7
	San Joaquin-Arents-Durochrepts complex	23.6
Best Slough	Conejo loam	3.7
	Hollenbeck silty clay loam	26.9
	Kimball loam	0.1
	San Joaquin loam	69.2
Elk Grove	Bruella sandy loam	4.9
	Galt clay	5.6
	Galt-urban land complex	0.5
	Madera-Galt complex	0.3
	San Joaquin silt loam	53.1
	San Joaquin-Galt complex	34.8
	San Joaquin-urban land complex	0.7
	San Joaquin-Xerarents complex	0.2
Galt	Corning complex	94.6
	Redding gravelly loam	0.9
	Redding loam	4.5
South Fork Putah Creek	Antioch-San Ysidro complex	4.4
	Capay clay	40.7
	Capay silty clay loam	32.5
	Clear Lake clay	0.1
	Pescadero clay loam	16.6
	Yolo silty clay loam	5.7

San Joaquin Valley

Site	Soil	%
Mormon Slough	Galt clay	16.7
	Hollenbeck silty clay	52.2
	Jacktone clay	23.6
	Manteca fine sandy loam	1
	Stockton clay	6.5
Dry Creek	Bear Creek clay loam	1.2
	Dinuba fine sandy loam	0.9
	Greenfield sandy loam	12.7
	Greenfield sandy loam w/H	0.3
	Hanford fine sandy loam	31.5
	Hanford sandy loam	46.3
	Honcut clay loam	0.2
	Madera sandy loam	0.2
	Oakdale sandy loam	1.1
	Terrace escarpments	3
	Tujunga loamy sand	1.4
	Wyman clay loam	1.2
Montpellier	Greenfield sandy loam	1.8
	Hopeton clay loam	7.4
	Madera sandy loam	1.5
	Montpellier coarse sandy loam	0.4
	Rocklin sandy loam	13.7
	Whitney and Rocklin sandy loams	26.2
	Whitney sandy loam	49
Owens Creek	Lewis silty clay loam	32.9
	Merced clay	0.3
	Rossi clay	18
	Rossi clay loam	44.5
	Waukena loam	4.4
Dutchman Creek	Alamo clay	0.6
	Greenfield sandy loam	0.5
	Madera fine sandy loam	0.2
	Madera sandy loam	33.7
	Marguerite loam	1.9
	Raynor cobbly clay	0.2
	Redding gravelly loam	0.4
	San Joaquin loam	21.8
	San Joaquin sandy loam	20
	San Joaquin-Alamo complex	10.4
	Snelling sandy loam	4.7
	Whitney and Rocklin soils	4.5
	Whitney sandy loam	1.1
Berenda Creek	Alamo clay	0.2
	Atwater loamy sand	0.2
	Atwater loamy sand w/H	7.3
	Greenfield sandy loam	2.7
Berenda Creek (...cont'd)	Lewis loam	0.1
	Madera fine sandy loam	67
	Madera loam	9.2
	Madera-Alamo complex	1.5
	Ramona sandy loam	8.3
	Ramona sandy loam w/H	2.6
Chowchilla Bypass	Chino clay loam	0.6
	Chino fine sandy loam	3.3
	Chino loam	13.9
	Fresno and El Peco fine sandy loams	6.9
	Fresno and El Peco loams	34.8
	Fresno, El Peco, and Chino soils	2.1
	Fresno, El Peco, and Pozo soils	5
	Grangeville fine sandy loam	3.7
	Pachappa fine sandy loam	1.8
	Pachappa sandy loam	1.8
	Pozo loam	18
	Traver loam	6.8
	Visalia sandy loam	0.6
	Wunjey very fine sandy loam	0.7
Gravelly Ford	Borden loam	7.2
	Dinuba-El Peco fine sandy loams	14.9
	Fresno and El Peco fine sandy loams	7.2
	Fresno and El Peco loams	4.6
	Grangeville fine sandy loam	3.8
	Grangeville sandy loam	0
	Greenfield coarse sandy loam	0
	Hanford sandy loam	2.6
	Pachappa fine sandy loam	25.8
	Traver loam	28.5
	Tujunga loamy sand	4.6
Little Dry Creek	Alamo clay	0.6
	Atwater loamy sand	10.5
	Atwater loamy sand w/H	0.7
	Cometa sandy loam	1.5
	Greenfield sandy loam	0.5
	Greenfield sandy loam w/H	3.4
	Hanford sandy loam w/H	6.7
	Montpellier coarse sandy loam	0.2
	Ramona sandy loam	4
	San Joaquin sandy loam	40.1
	San Joaquin-Alamo complex	0.8
	Trigo fine sandy loam	0.8
	Whitney and Rocklin sandy loams	26.8
	Whitney fine sandy loam	3.6

James Bypass	Cajon coarse sandy loam	3.4
	Calhi loamy sand	5.8
	Fresno clay loam	23.4
	Fresno fine sandy loam	31.6
	Fresno sandy loam	19.4
	Fresno-Traver complex	5.3
	Hesperia sandy loam	0.5
	Pond fine sandy loam	3.7
	Rossi fine sandy loam	0.3
	Traver fine sandy loam	0.4
	Traver sandy loam	4.6
White River	Centerville clay	79.7
	Exeter loam	14.8
	Havala loam	5.4
Semitropic Ridge	Chanac clay loam	16.6
	Delano sandy loam	69
	Wasco sandy loam	2.9
	Zerker loam	11.5
Arvin-Edison	Kimberlina fine sandy loam	81
	Panoche clay loam	19

Appendix D: Water storage volumes used in the San Joaquin Valley hydrologic connectivity sub-index

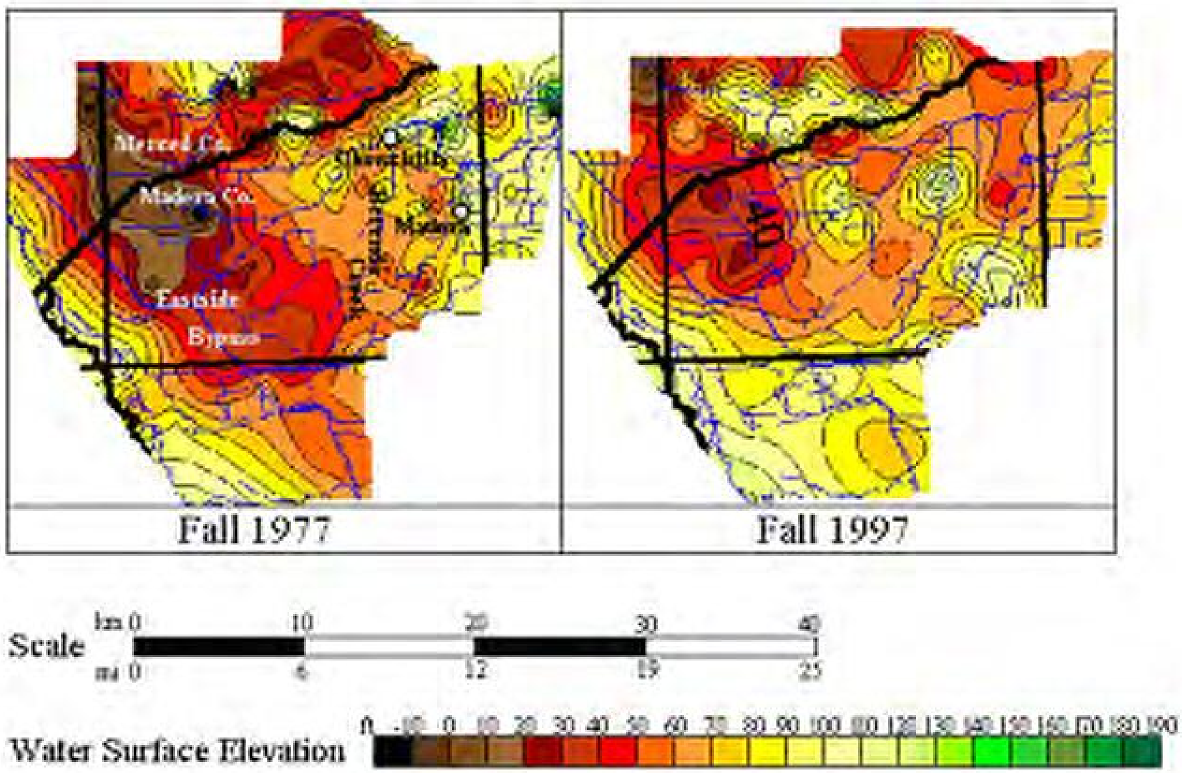
All values reported in million acre-feet

Site	Fall 1977	Spring 1997	Fall 1997
Allensworth	1.30	5.96	7.77
Arvin-Edison	1.01	1.11	1.55
Berenda Creek	0.00	0.19	0.06
Chowchilla Bypass	0.03	0.53	0.32
Dry Creek	0.02	0.00	0.00
Dutchman Creek	0.91	1.41	1.54
Gravelly Ford	3.61	3.38	2.04
Hetch Hetchy Aqueduct	0.00	0.01	0.01
James Bypass	6.13	2.50	5.01
Kern Water Bank	13.05	14.45	21.61
Little Dry Creek	0.28	1.29	4.37
Montpellier	1.04	0.31	0.81
Mormon Slough	5.19	0.79	1.71
Owens Creek	0.79	0.44	0.59
Semitropic Ridge	6.07	0.89	1.30
White River	1.29	0.15	0.70

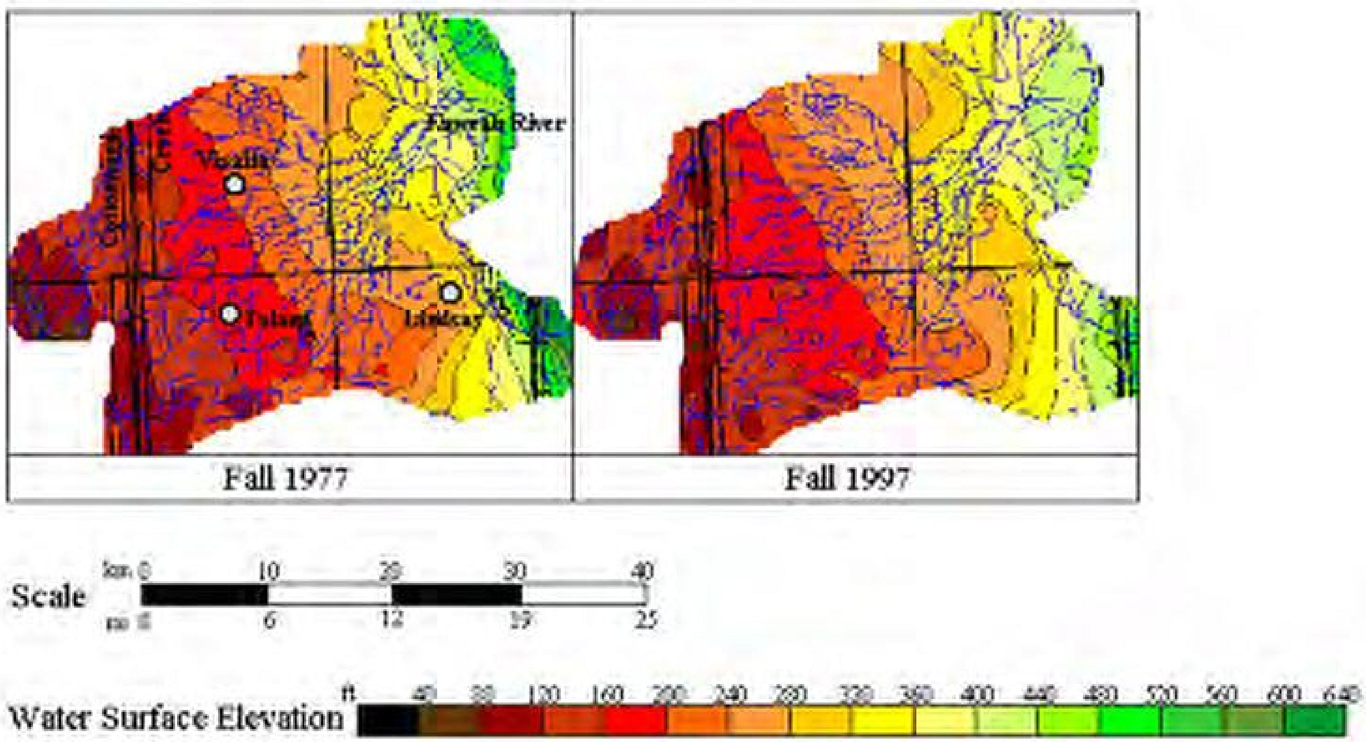
Appendix E: Basin Maps

The following maps show water surface contours for each of the basins in the San Joaquin Valley in Fall 1977 and in Fall 1997.

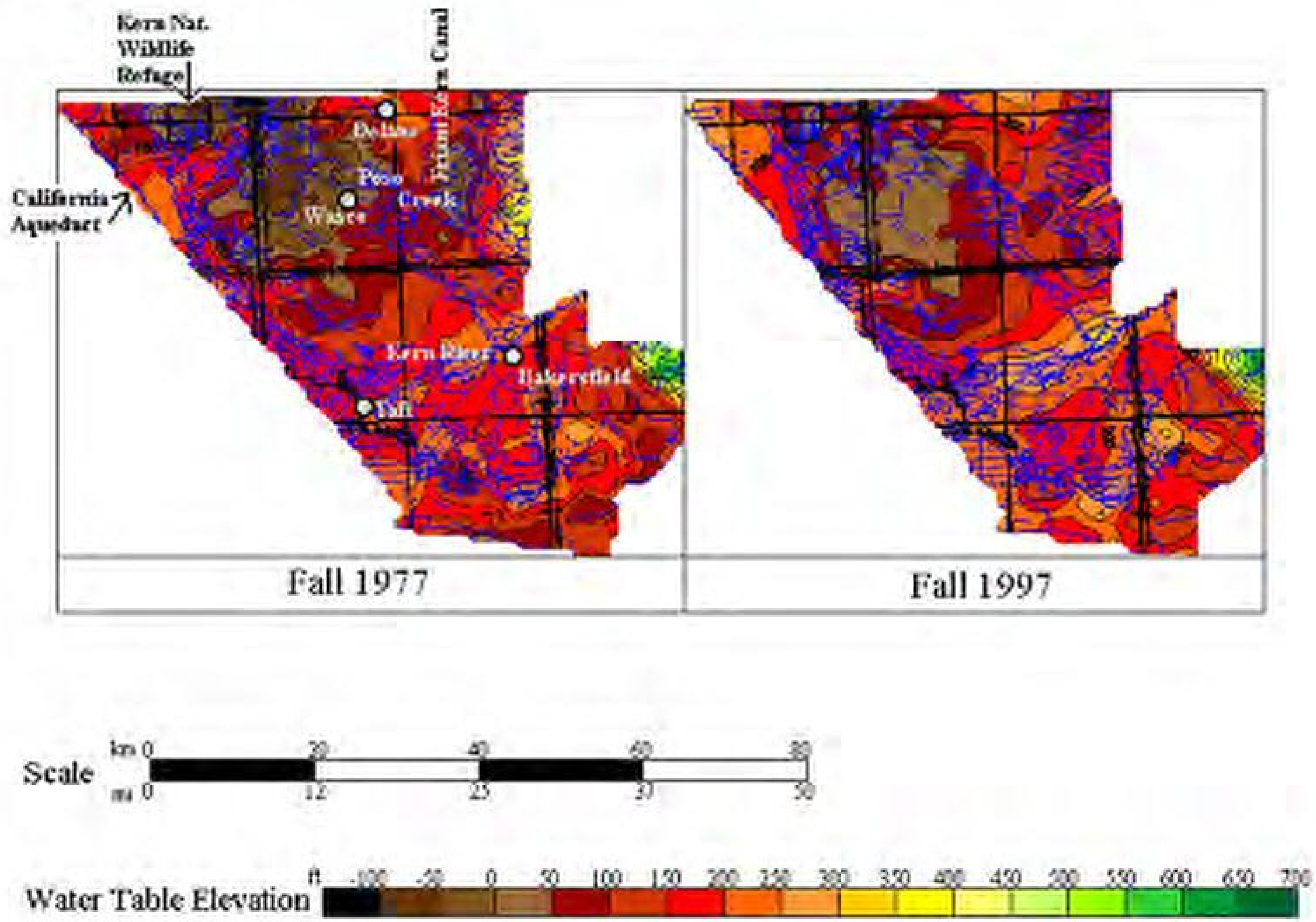
Chowchilla Basin

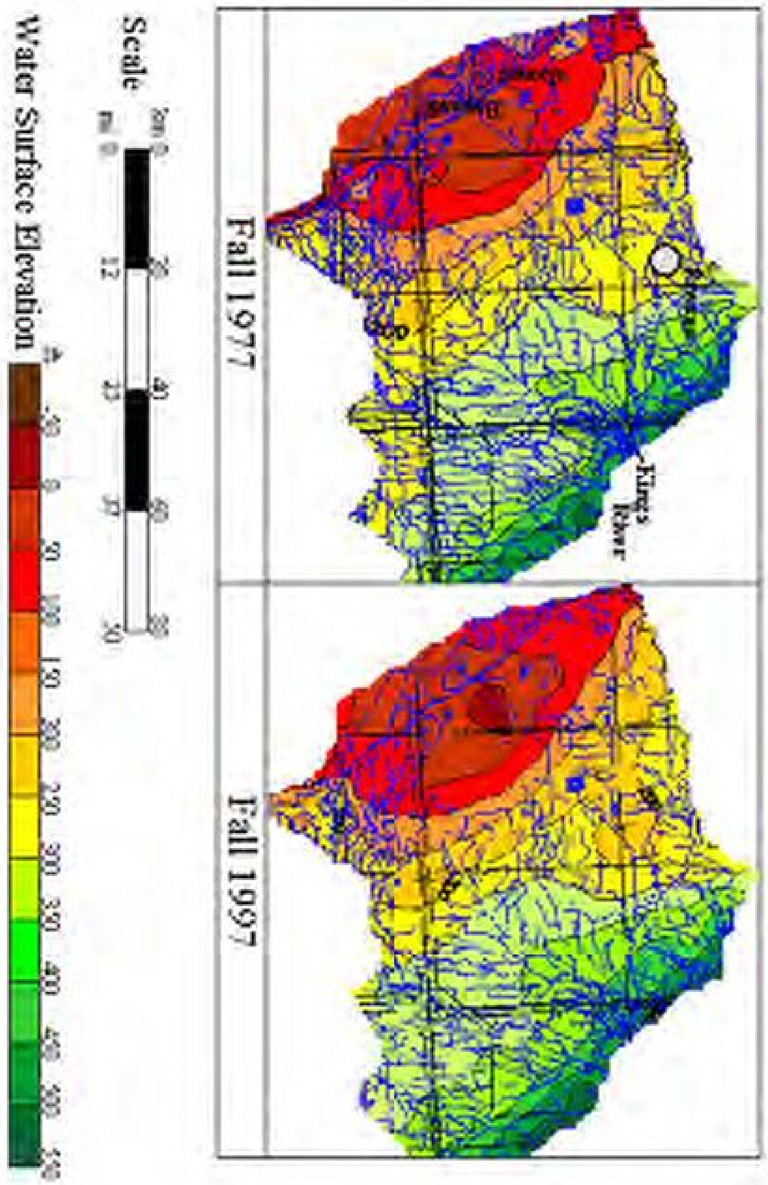


Kaweah Basin



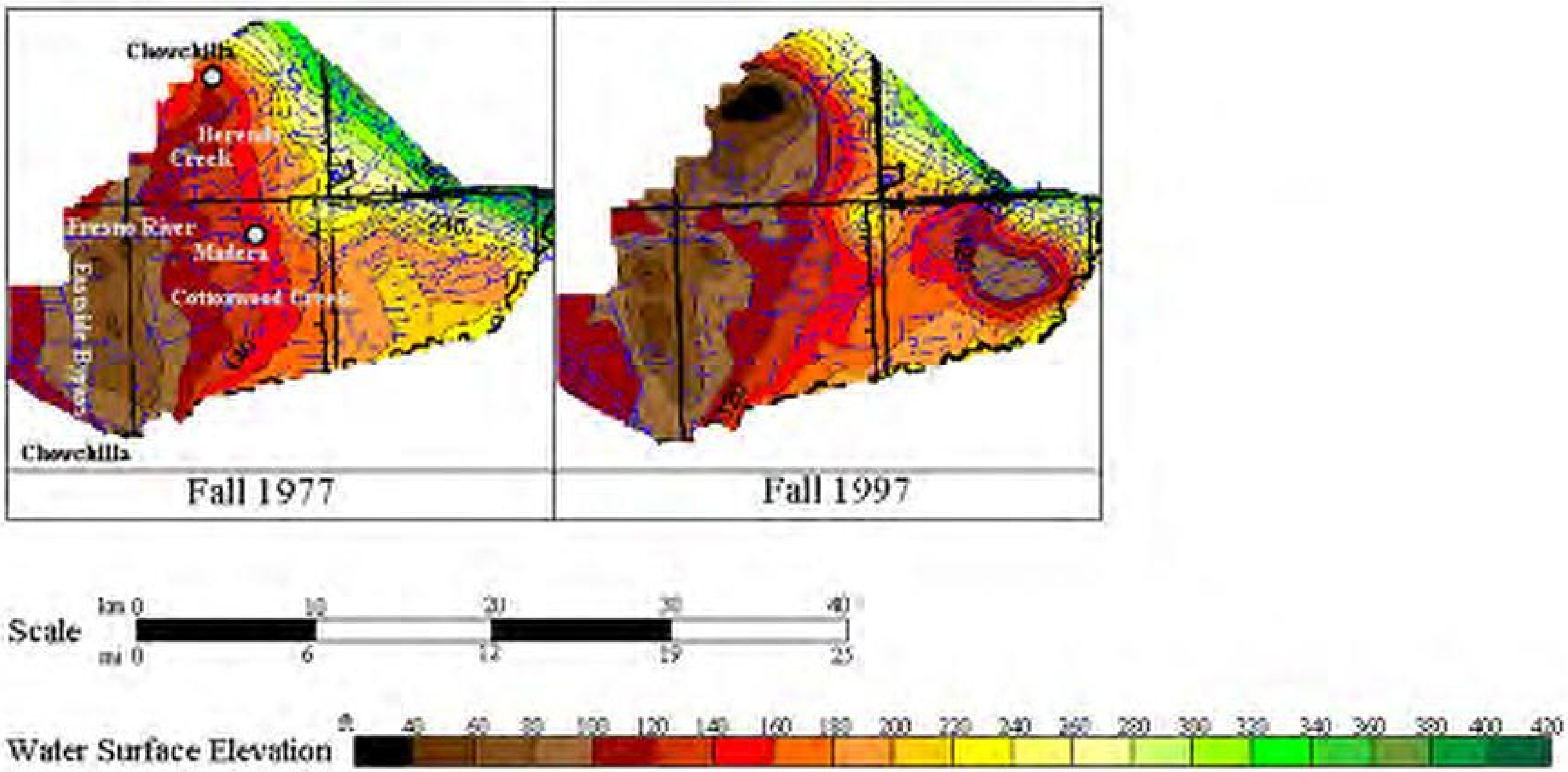
Kern Basin


Kern Nat. Wildlife Refuge
California Aqueduct
Delano
Poso Creek
Wasco
Friant Kern Canal
Kern River
Bakersfield
Taft
Fall 1977
Fall 1997
Scale
km 0 20 40 60 80
mi 0 12 25 37 50
Water Table Elevation
ft -100 -50 0 50 100 150 200 250 300 350 400 450 500 550 600 650 700

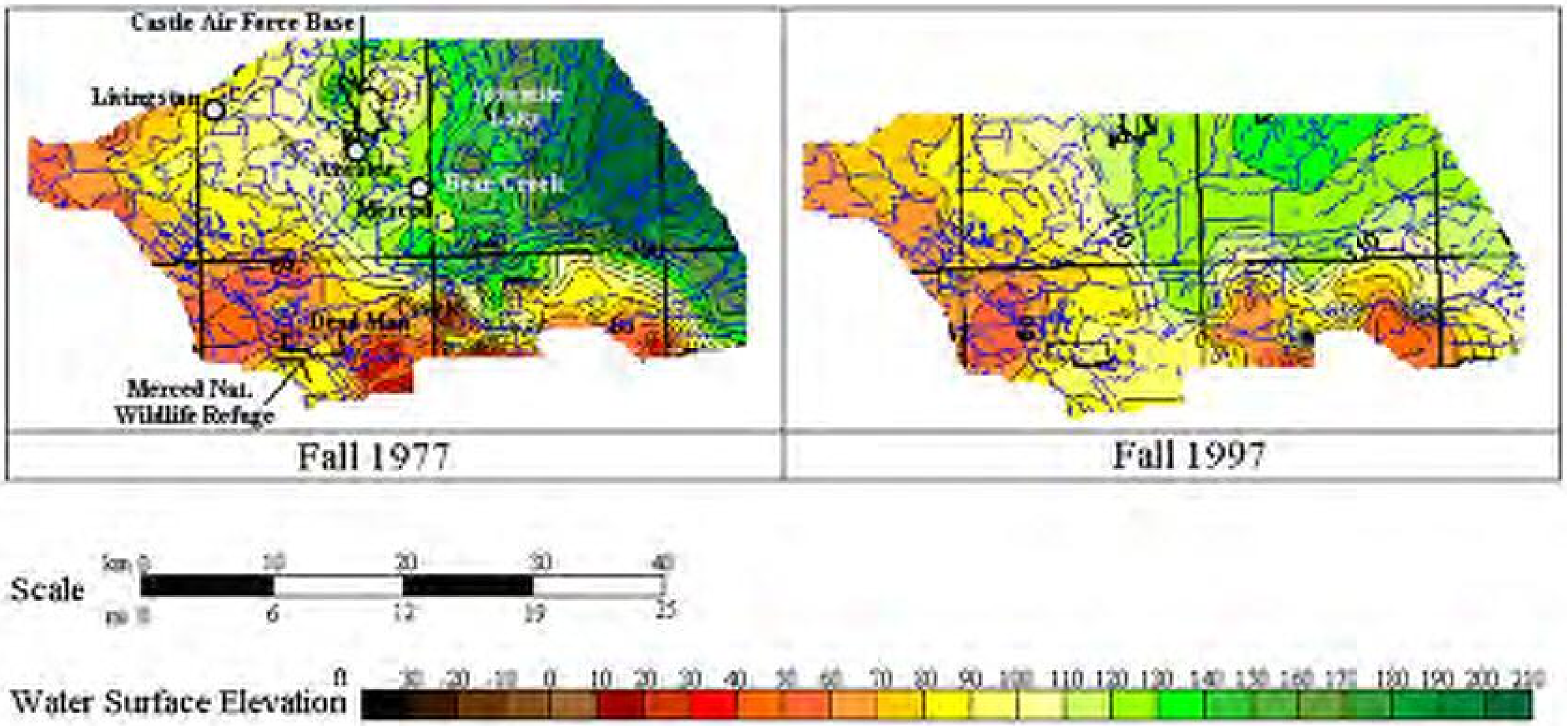


Kings Basin
Fall 1977
Fall 1997
Kings River
Scale
Water Surface Elevation

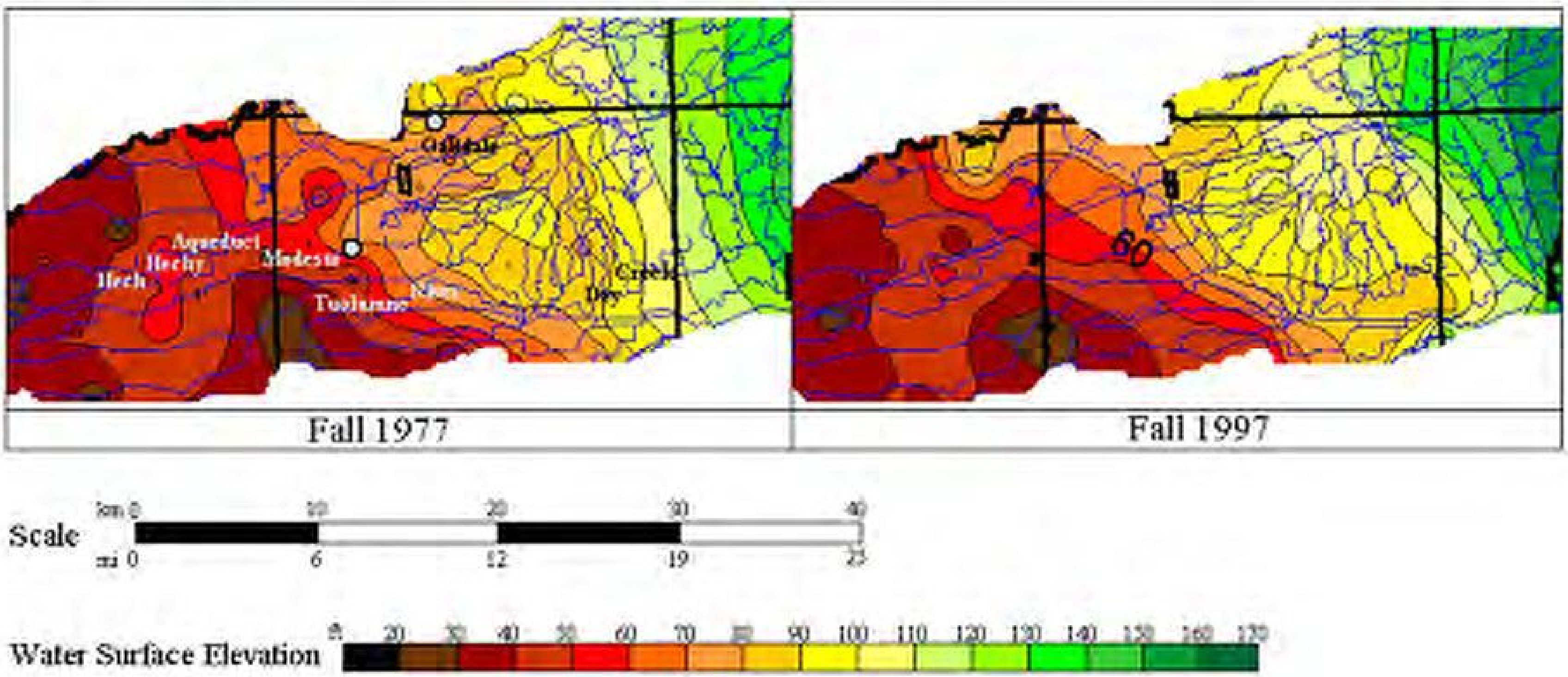
Madera Basin



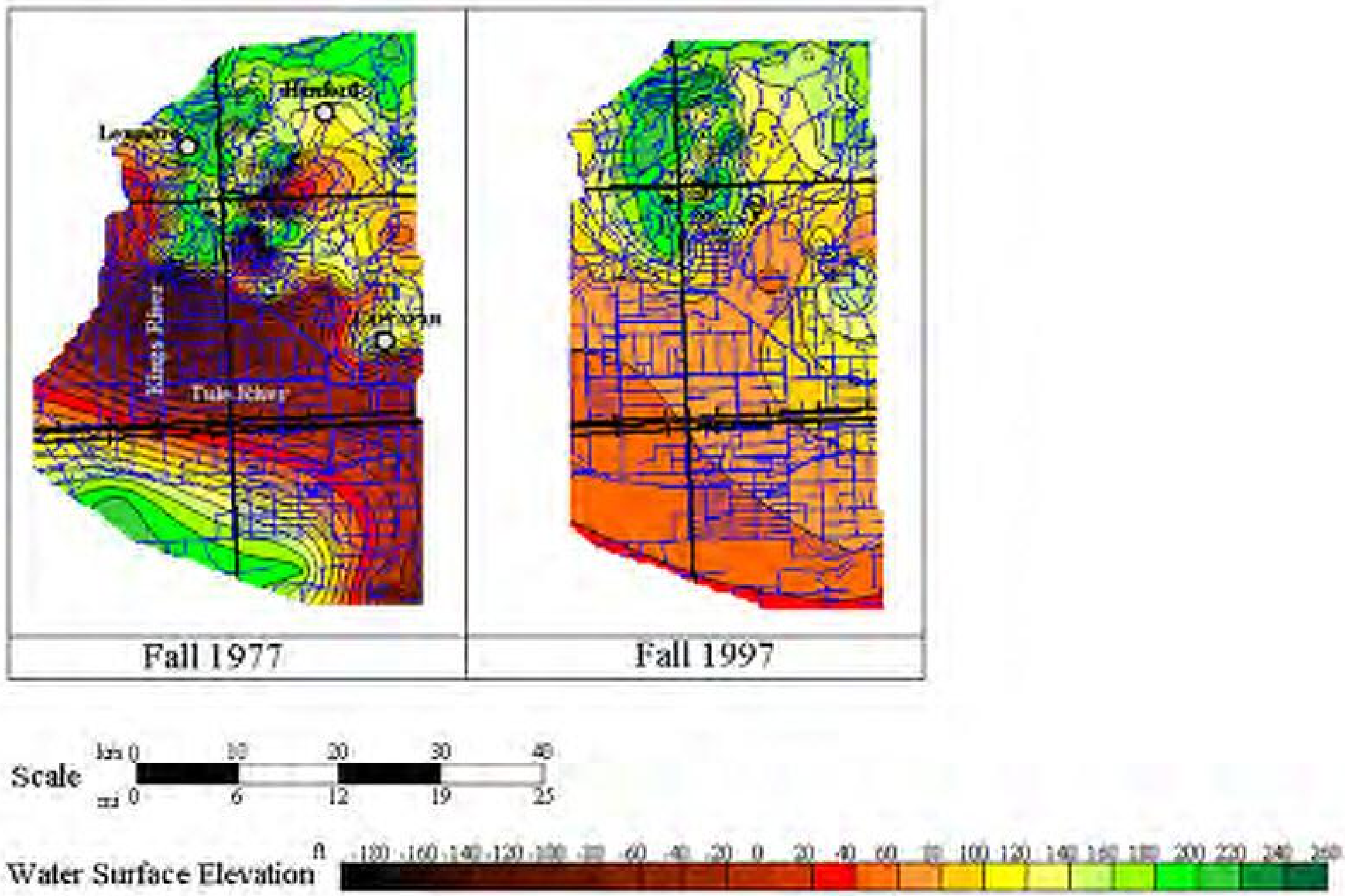
Merced Basin



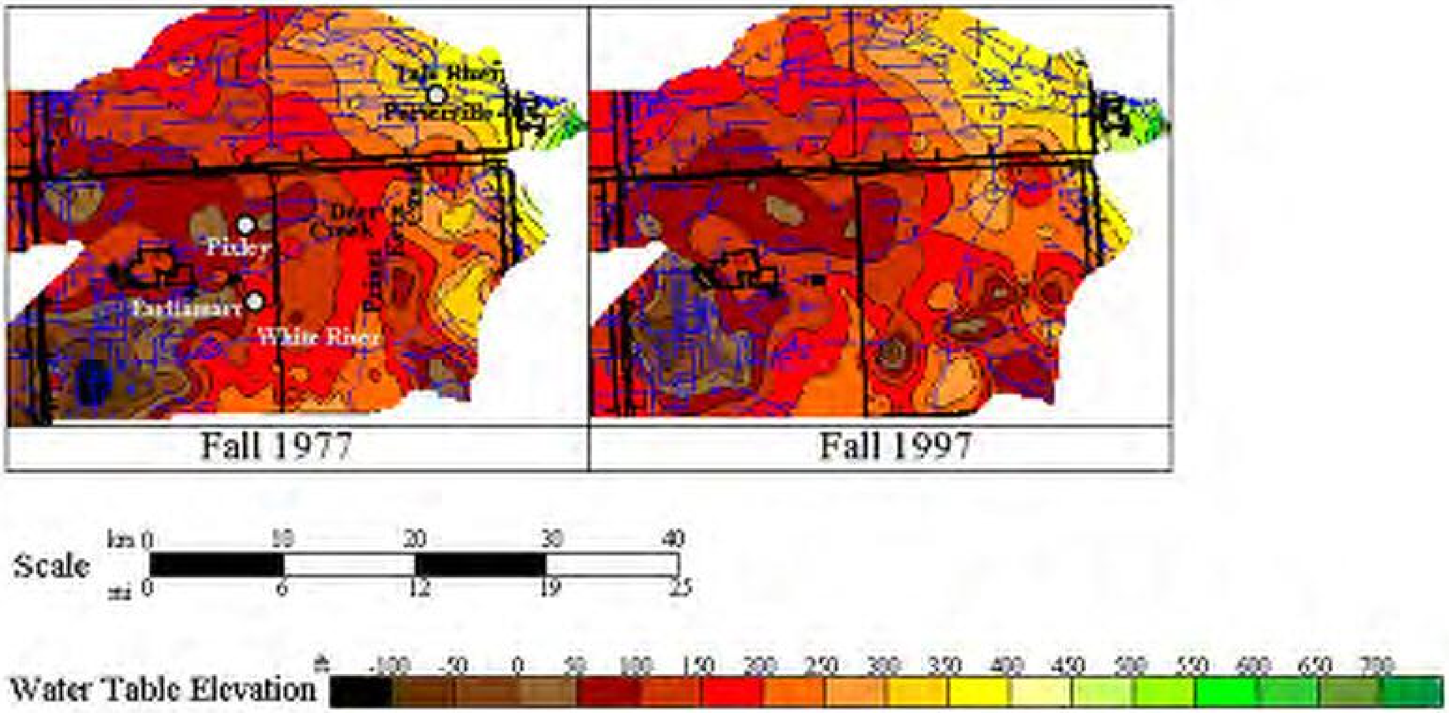
Modesto Basin



Tulare Lake Basin

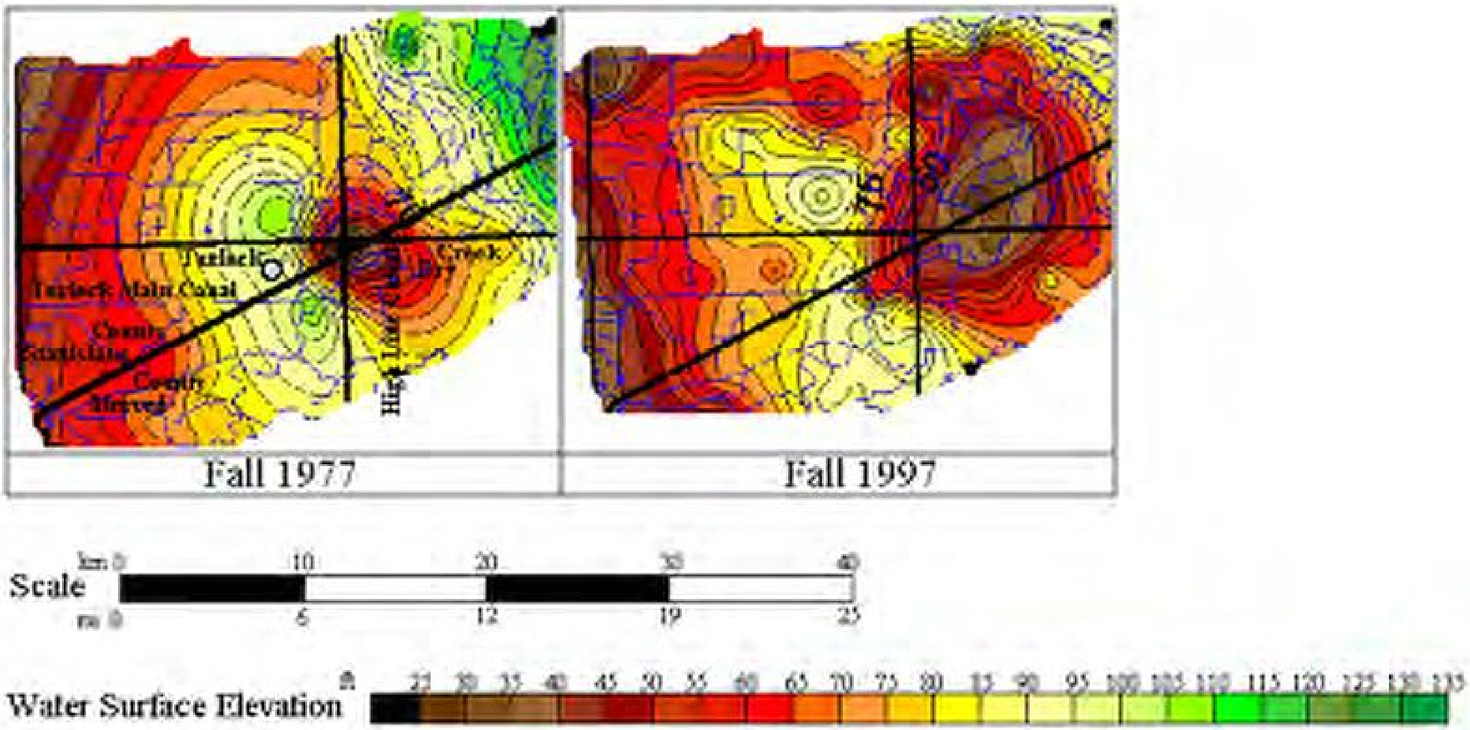


Tule Basin



Tule River
Porterville
Deer Creek
Pixley
Earlimart
White River
Fall 1977
Fall 1997
Scale
km 0 10 20 30 40
mi 0 6 12 19 25
Water Table Elevation
ft -100 -50 0 50 100 150 200 250 300 350 400 450 500 550 600 650 700

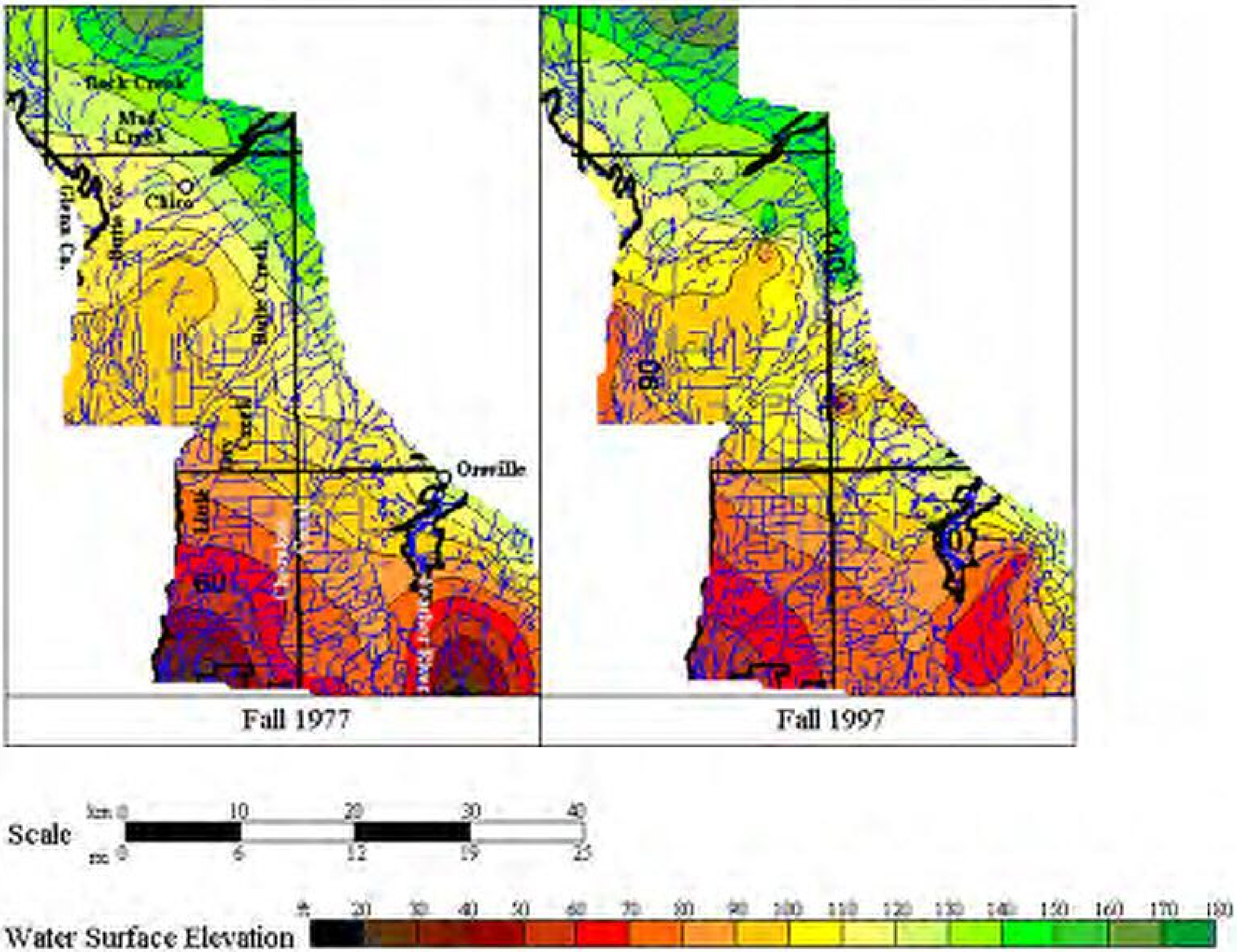
Turlock Basin



Appendix F: Basin Maps

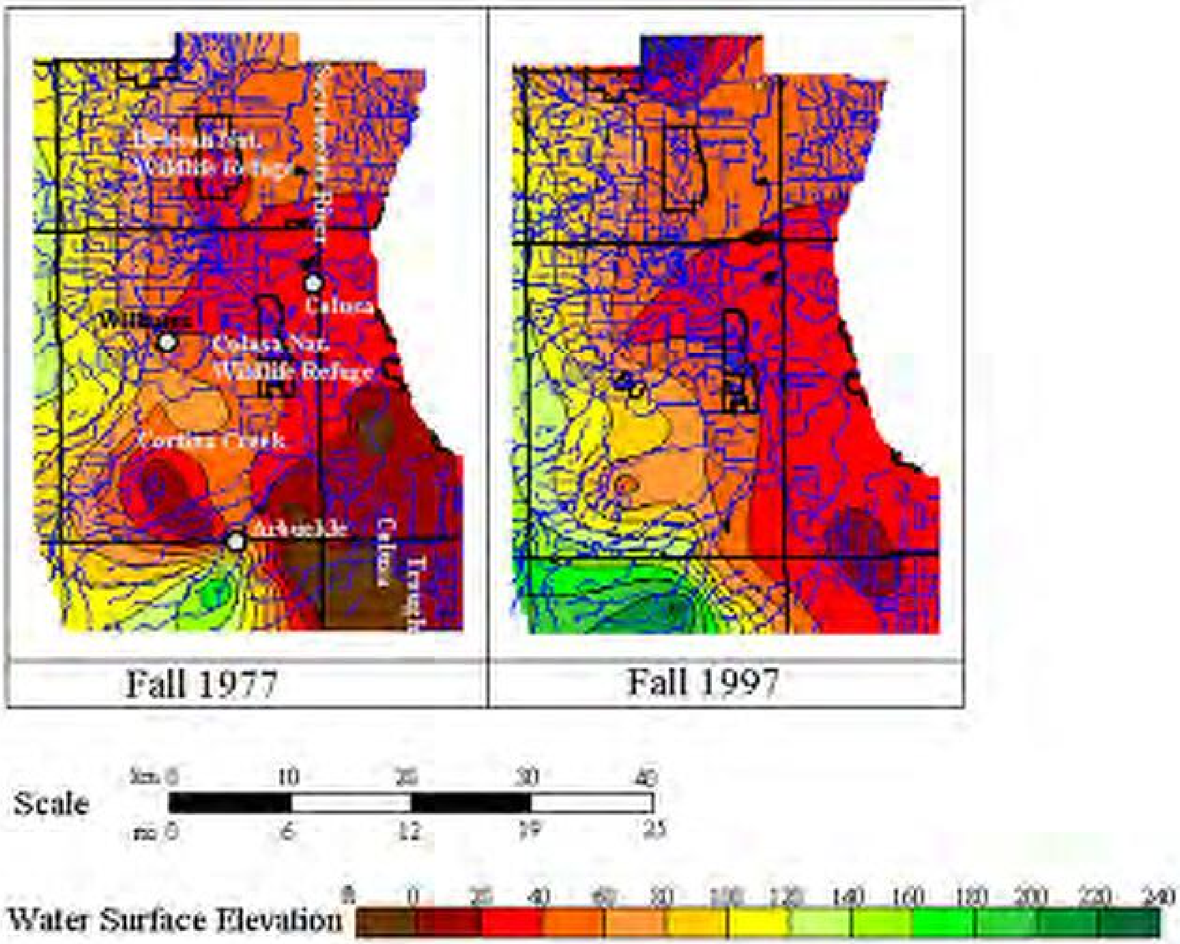
Even though the Sacramento Valley index did not include a Hydrologic Conductivity Sub-Index, we have included the water basin maps for Fall 1977 and Fall 1997 for comparative purposes.

Butte Basin

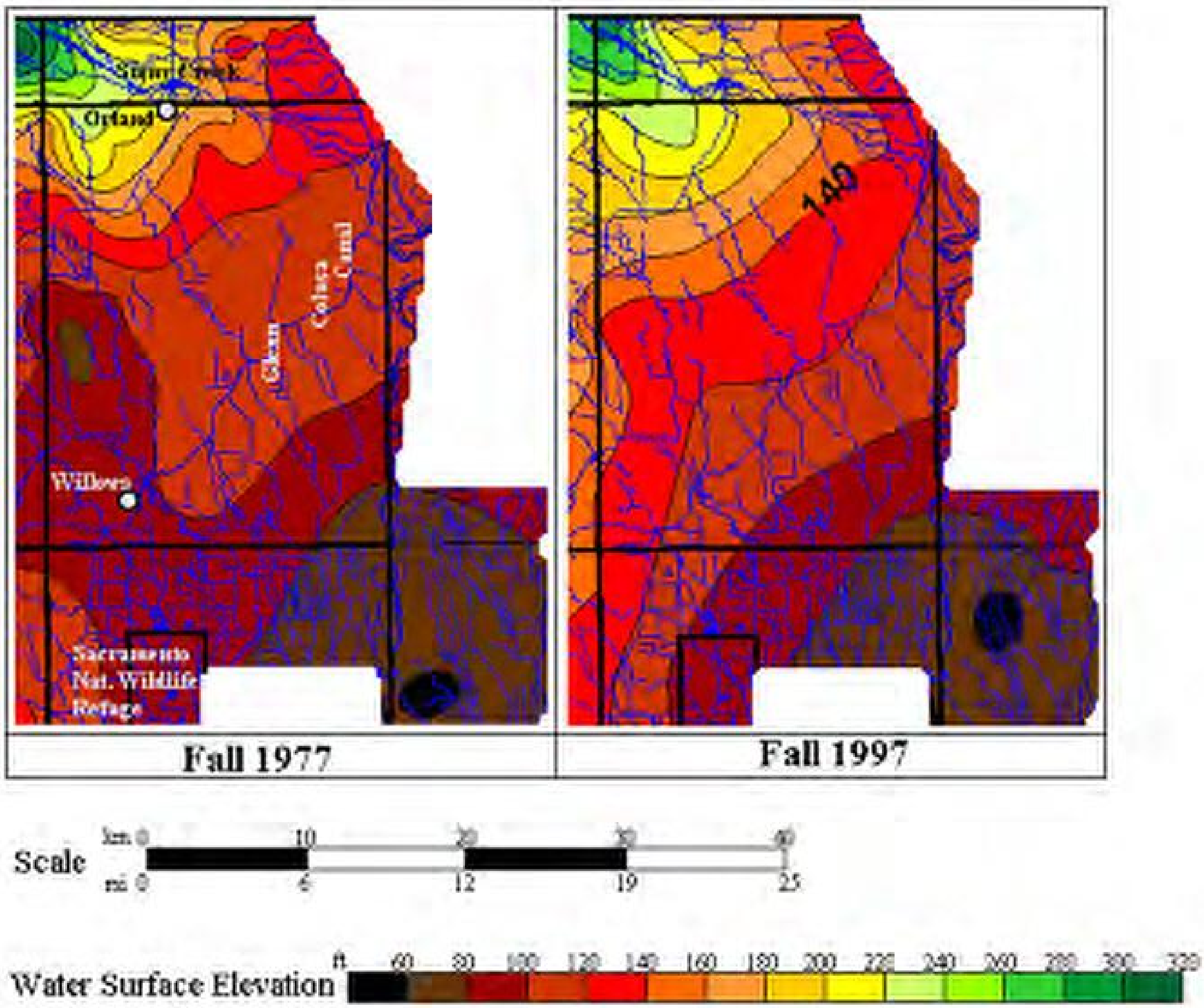


Rock Creek
Mud Creek
Chico
Glenn Co.
Butte Co.
Butte Creek
Dry Creek
Little
Oroville
60
90
140
Fall 1977
Fall 1997
Scale
km 0 10 20 30 40
mi 0 6 12 19 25
Water Surface Elevation
20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180

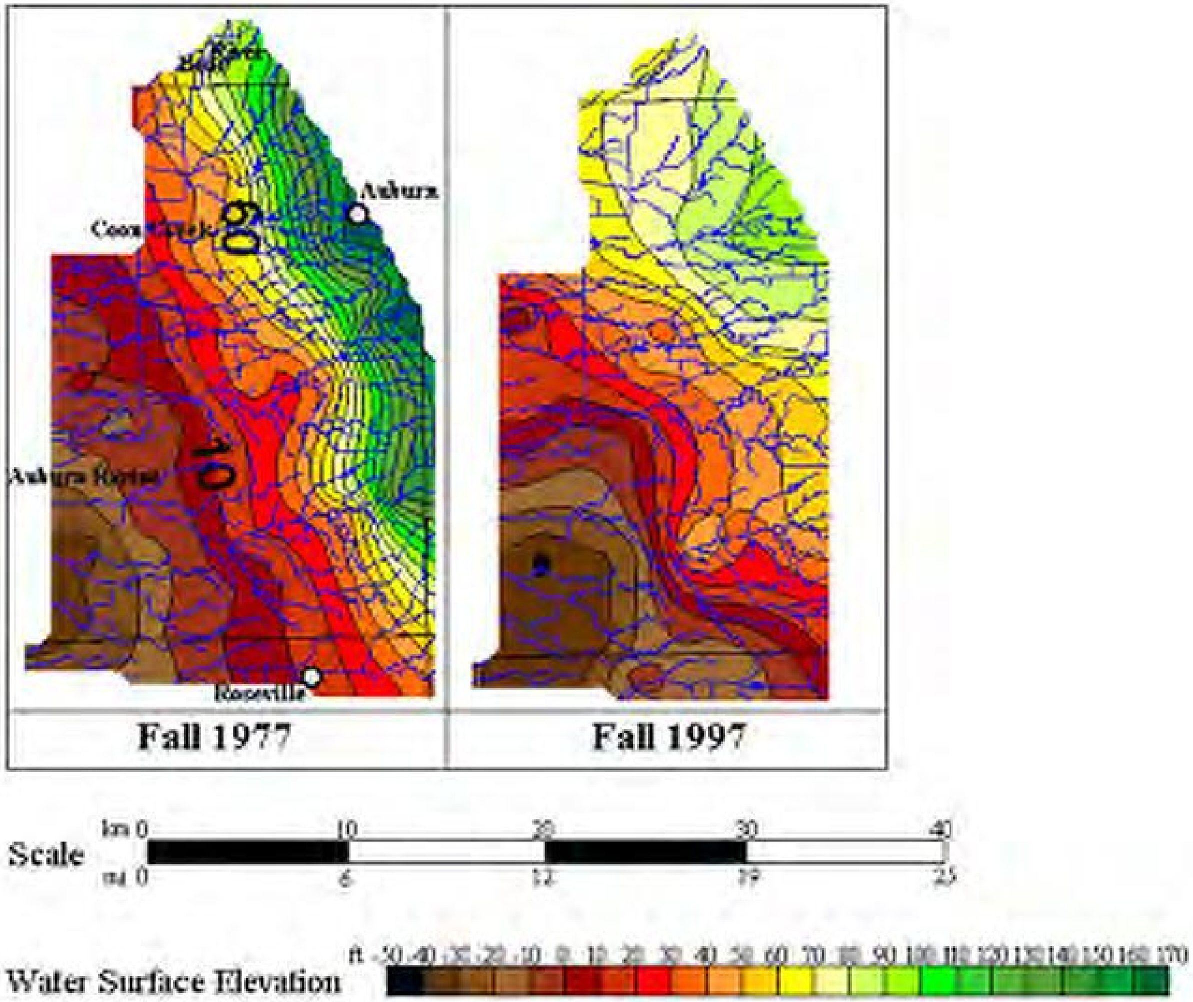
Colusa Basin



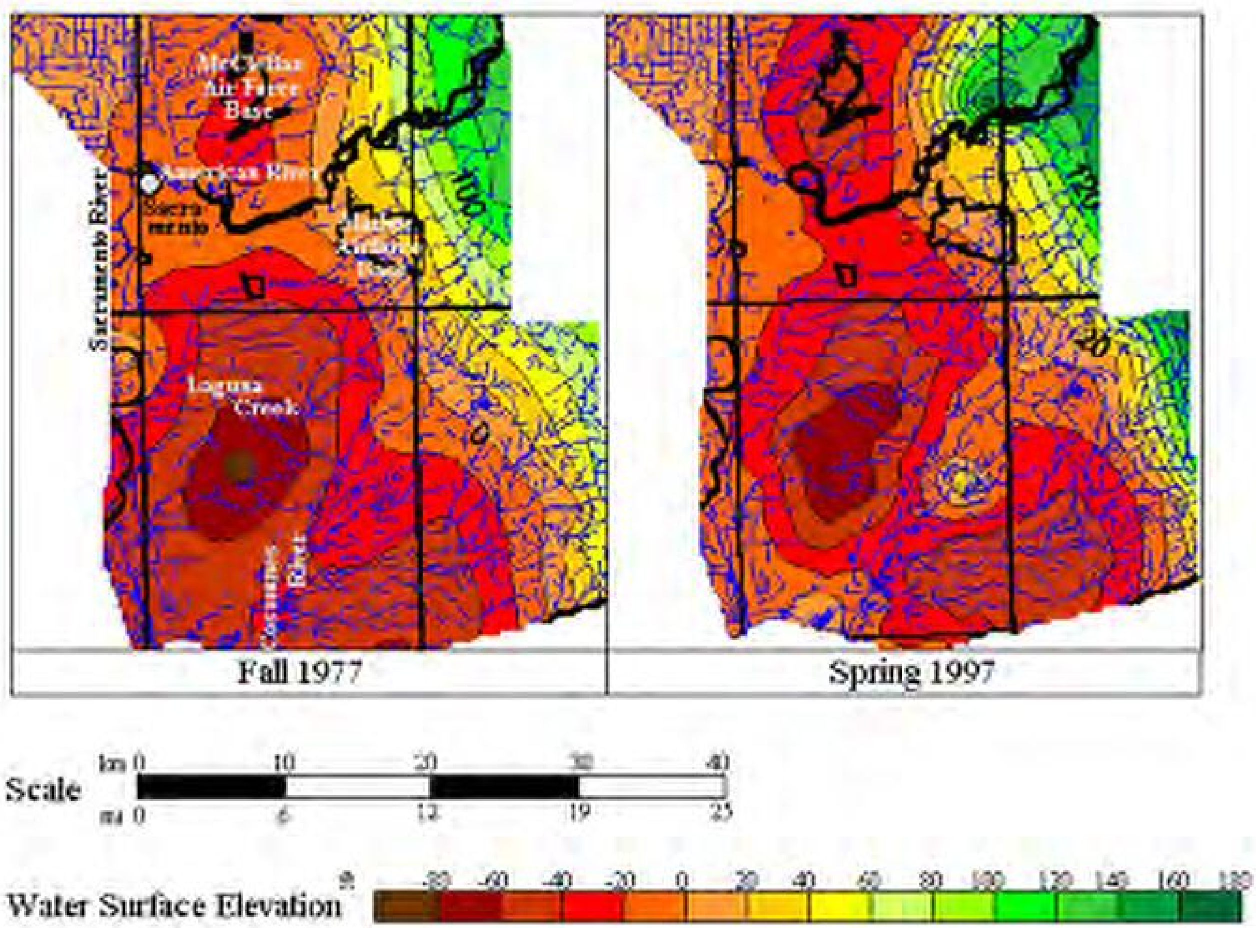
Glenn Basin


Stony Creek
Orland
Glenn
Colusa Canal
Willows
Sacramento Nat. Wildlife Refuge
140
Fall 1977
Fall 1997
Scale
km 0 10 20 30 40
mi 0 6 12 19 25
Water Surface Elevation
ft 60 80 100 120 140 160 180 200 220 240 260 280 300 320

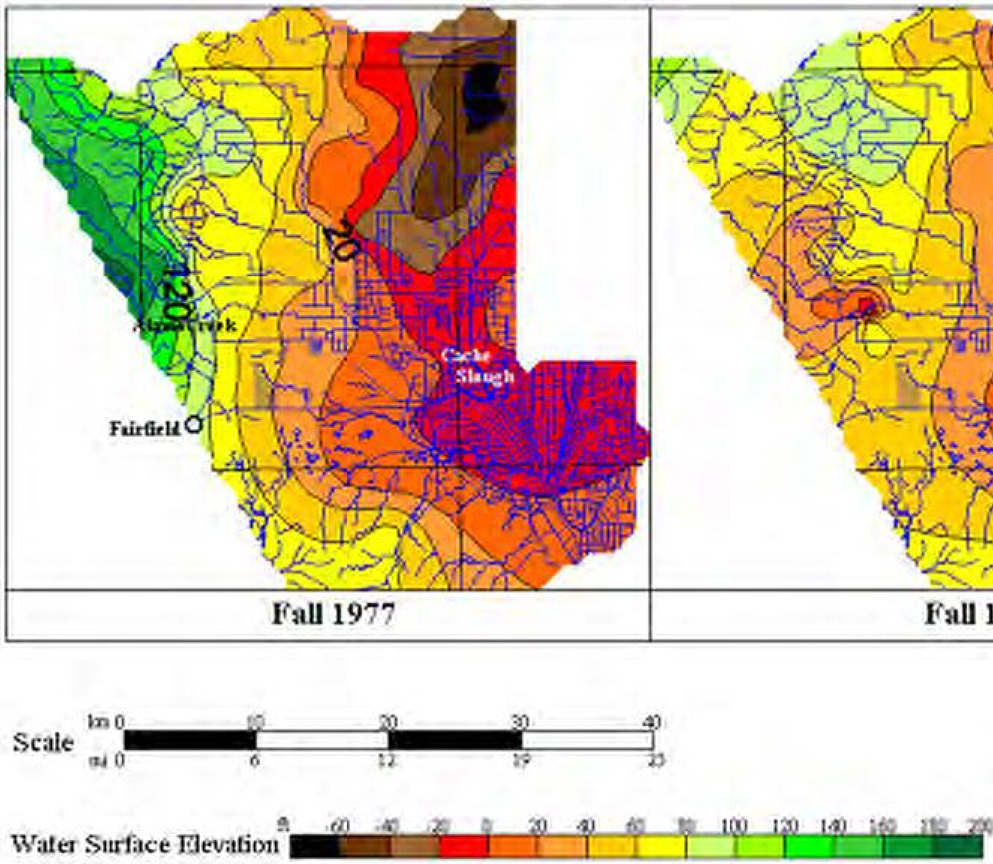
Placer Basin



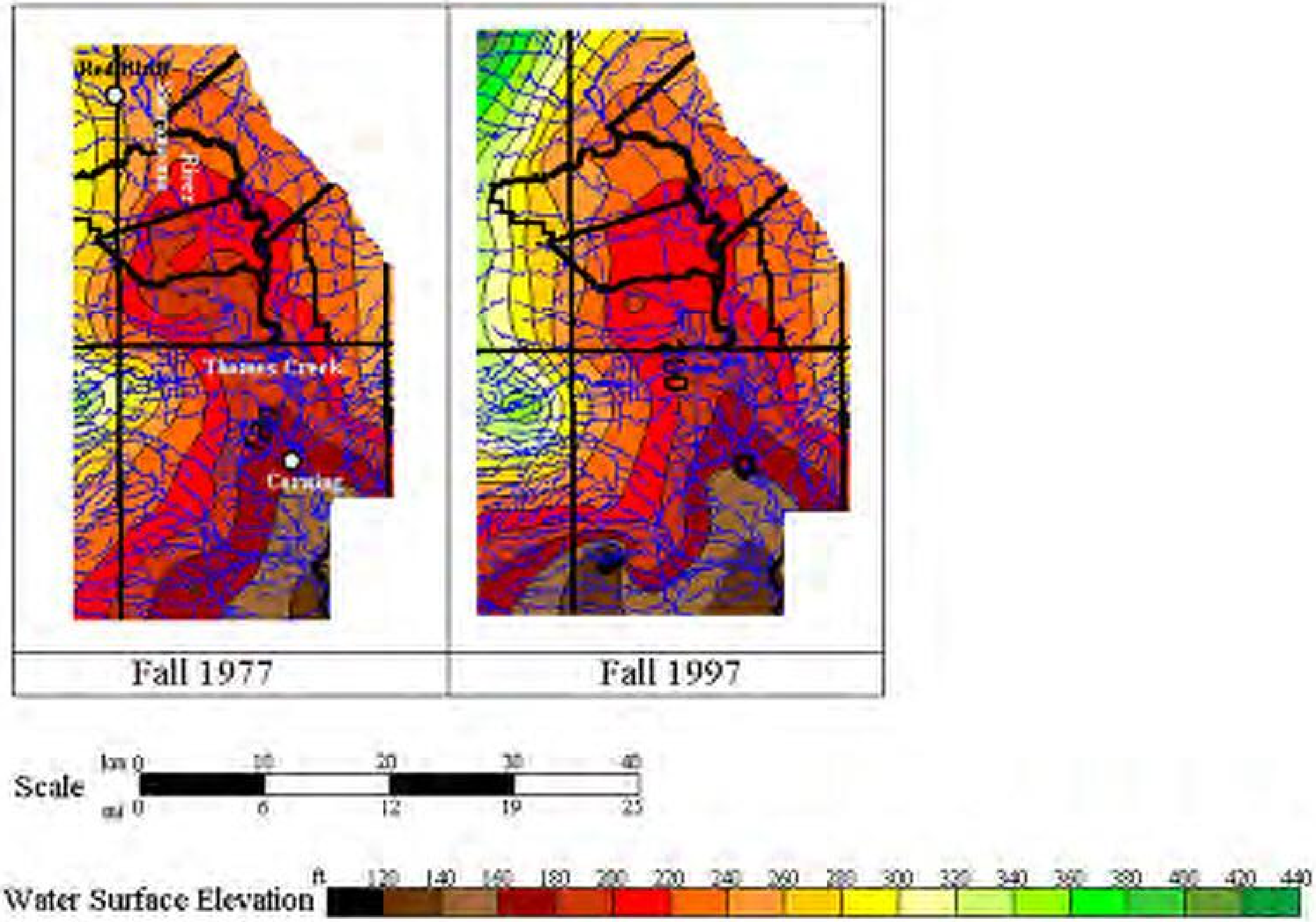
Sacramento Basin



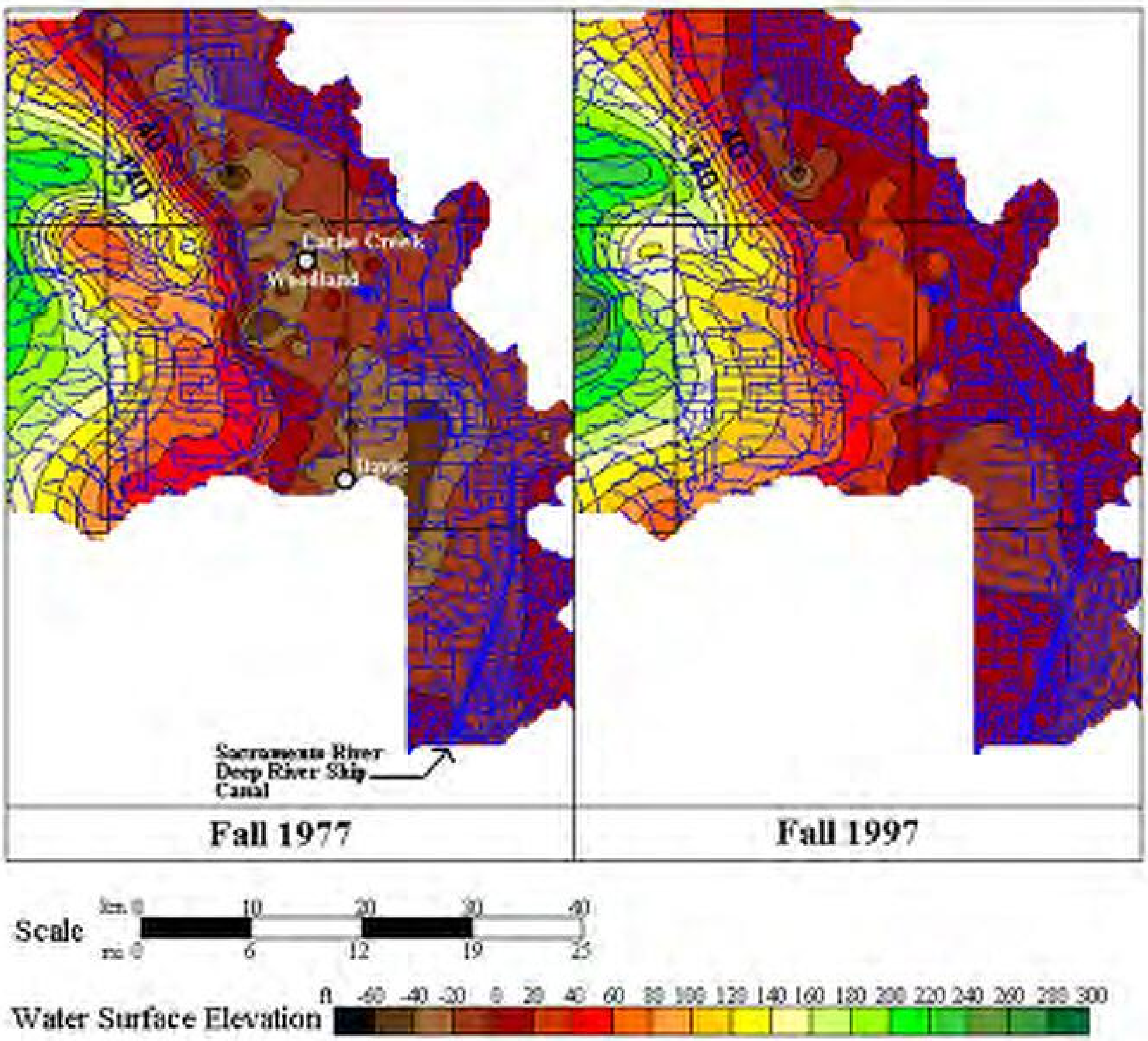
Solano Basin



Tehama Basin

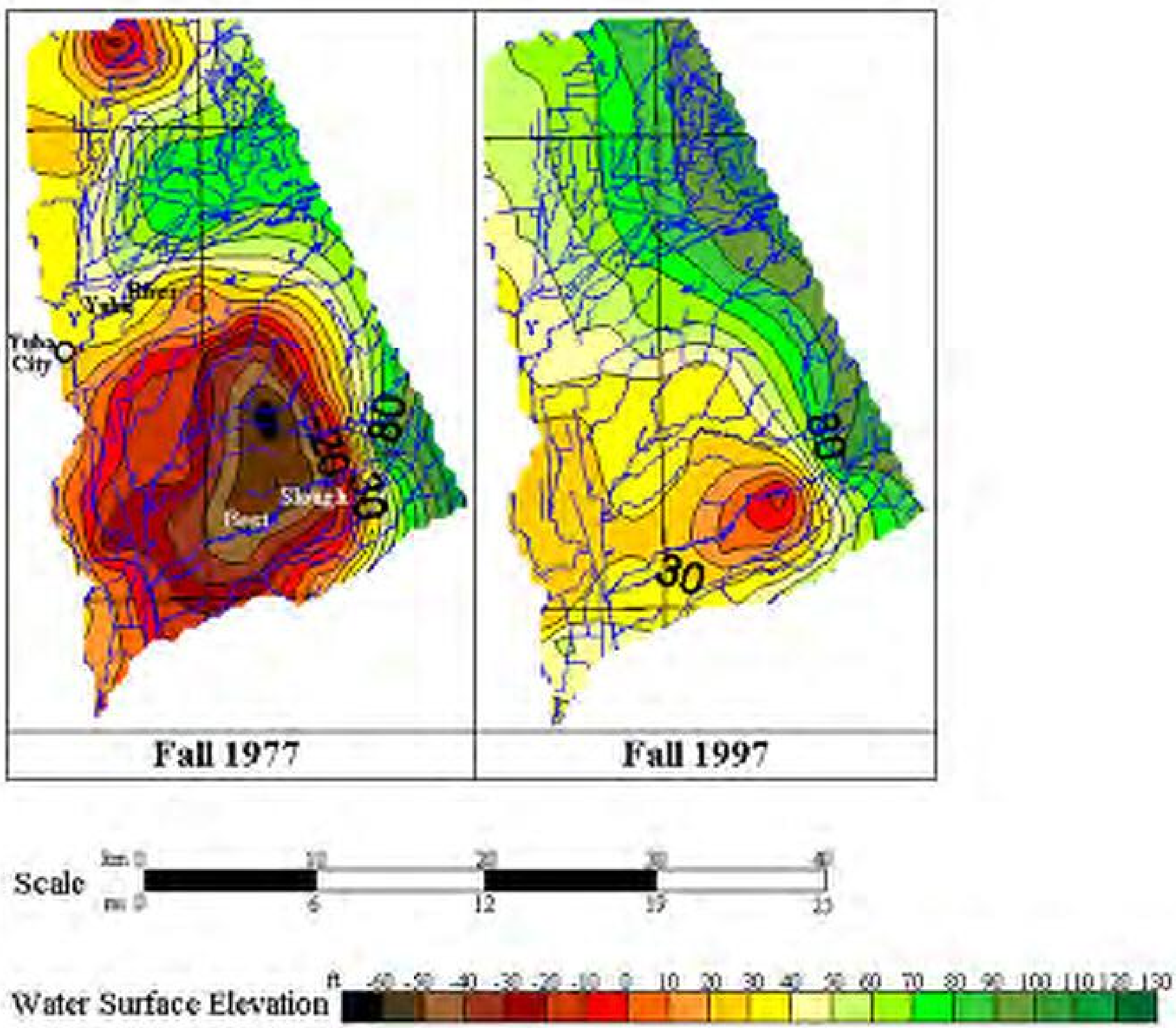


Yolo Basin



40
140
Cache Creek
Woodland
Davis
Sacramento River Deep River Ship Canal
Fall 1977
Fall 1997
Scale
km 0 10 20 30 40
mi 0 6 12 19 25
Water Surface Elevation
ft -60 -40 -20 0 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300

Yuba Basin



Yuba City
Yuba River
Bear
Slough
80
20
30
80
30
Fall 1977
Fall 1997
Scale
km 0
10
20
30
40
mi 0
6
12
19
25
Water Surface Elevation
ft
-60 -50 -40 -30 -20 -10 0 10 20 30 40 50 60 70 80 90 100 110 120 130