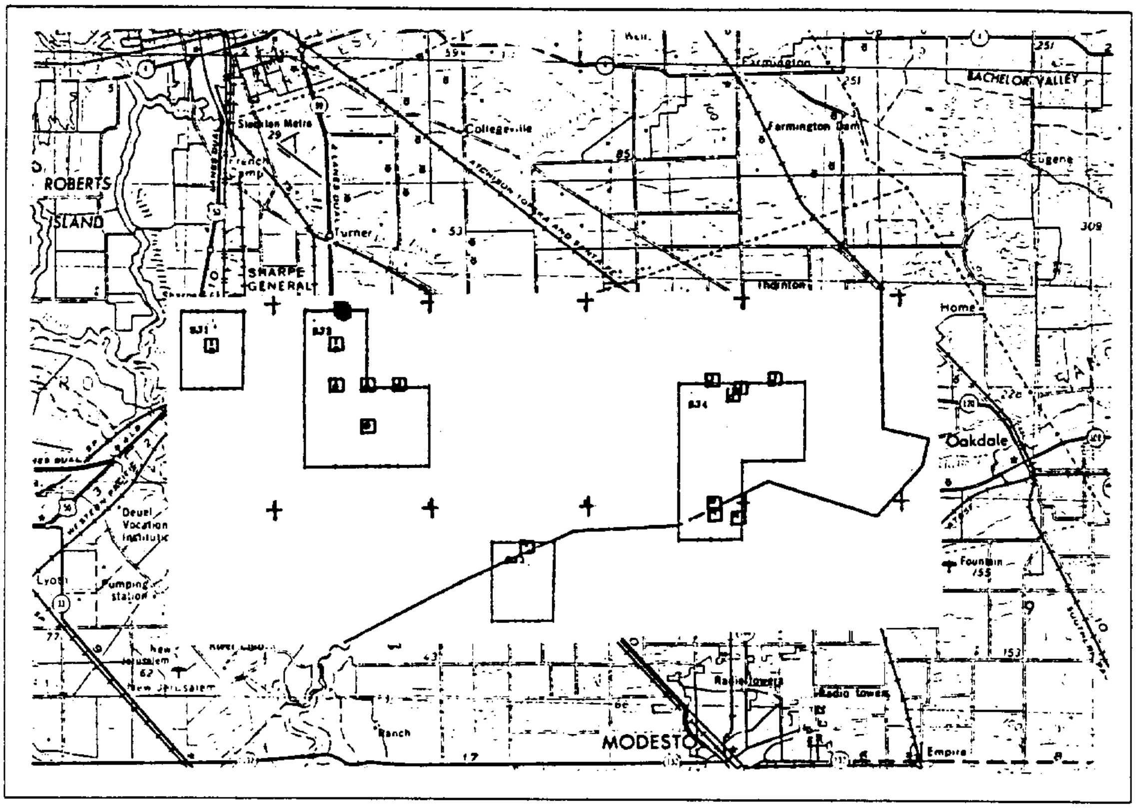
REPORT NUMBER 90-4 WQ

FEASIBILITY STUDY:



AUTOMATED SCREENING OF GROUND WATER POLLUTION PROBLEMS

OCTOBER 1990

STATE WATER RESOURCES CONTROL BOARD
DIVISION OF WATER QUALITY

STATE WATER RESOURCES CONTROL BOARD
DIVISION OF WATER QUALITY

Paul R. Bonderson Building
901 P Street
Sacramento, CA 95801

FEASIBILITY STUDY:

AUTOMATED SCREENING OF GROUND WATER POLLUTION PROBLEMS

by
OSCAR BALAGUER
GLENN BROWNING

Jesse M. Diaz, Chief
Division of Water Quality

Edward C. Anton, Chief
Regulation Branch

June 1990

ACKNOWLEDGEMENTS

A report of this kind is always a team effort. John Ladd originally supported the idea for the study. Jean Ladyman kept it ensconced in the structure of a changing funding situation. Numerous program managers and staff contributed invaluable technical comments, and staff of the Water Quality Planning Unit provided forbearing oversight. Tom Howard generously authorized staff time to complete the report. A special thanks goes to Phil Daniels and Suzanne Lewin of the Data Management Branch for their patient assistance in understanding and using the State Water Resource Control Board's STORET database.

This report was funded by the U.S. Environmental Protection Agency through a Section 205(j) Water Quality Planning grant.

TABLE OF CONTENTS

1. SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

1.1 SUMMARY

1. STUDY OBJECTIVE

The objective of this study is to develop and assess a way to automatically define and rate ground water quality problems, using existing information in electronic databases.

2. BACKGROUND

Ground water quality management requires definition and screening of individual problems. A large amount of data must be analyzed to characterize even a single problem such as a polluted basin or a water supply well. No standard way to conduct this data analysis has been available. Characterization of ground water problems is therefore expensive, and has been conducted only for the highest-visibility problems. However, since most ground water quality data is computerized, the initial data analysis could be automated and done statewide.

3. OVERVIEW

a. Capabilities of the Procedure

This Feasibility Study: Automated Screening of Ground Water Pollution Problems presents and assesses a way to characterize problems using existing water quality data. The procedure can be written into an automated computer program which will directly access and analyze raw water quality data in electronic databases.

The procedure will summarize available data, geographically define individual problem areas, generate data summaries and maps, and produce a numerical problem severity rating for each identified problem area. The rating is based on (1) the geographic size of the problem, (2) the concentration of the pollutant(s) relative to the water quality objective, and (3) the number of beneficial uses affected.

The procedure was developed for nonpoint source problems but can be used for point sources also. It can also be used to identify the relative severity of pollution problems statewide, by region, by county, by aquifer, or by any other user-defined geographic area. Problems may be defined to include any pollutant(s) of interest.

b. Limitations of the Procedure

As currently designed, the procedure deals with water quality information only. It does not consider other information which might be used to set management priorities, such as affected population, availability of alternative water supplies, or hydrogeologic features. The water quality ratings produced by this procedure can be considered in conjunction with such other factors. To the extent such other data are available in electronic form, they could be added to the procedure.

Any analysis, whether done automatically or manually, is constrained by the quality and quantity of available data. This procedure does not replace detailed evaluation of pollution problems, but provides an efficient way of identifying and rating problems for further attention.

4. SUMMARY OF EACH SECTION

Section 1 of the Feasibility Study is this summary.

Section 2 reviews available databases and concludes that STORET should be used for problem characterization since it is it is the only centralized database in California containing data from different agencies.

Section 3 presents the conceptual framework of the algorithm used to define and characterize ground water pollution problems. To define a problem the algorithm establishes (1) problem boundaries as defined by a grid system, (2) pollutant categories, (3) a pollutant concentration index based on the data values relative to the water quality objective, (4) the chronologic distribution of data, and (5) the number of beneficial uses impaired. Options for data summary and map displays are presented. Computation of the problem severity rating for one or more pollutants is discussed. Problem severity ratings for localized problems may be summed to derive ratings for larger areas. An example calculation of a problem severity rating is shown for a hypothetical problem area. The basic algorithm may easily be modified to include other factors.

Section 4 reviews previous work in order to identify other rating procedures applicable to this study. The State Water Resources Control Board's Well Investigation Program uses a method to rank ground water basins for investigation. This method and other studies are reviewed. The procedure presented in this report does not duplicate any of the other reviewed work.

Section 5 identifies a ground water basin and pollutants on which to test the algorithm. A subset of the data is identified to conduct a pilot demonstration of the algorithm as part of this Feasibility Study. The full data set would be used for testing if further development of the algorithm is undertaken and a computer program is developed.

Section 6 presents the pilot demonstration of the algorithm using actual data for DBCP pollution of ground water in southern San Joaquin County.

Appendices A, B, and C provide supplementary technical information. Appendix D is the raw STORET data used for the pilot demonstration. Appendix E summarizes staff review comments on the Feasibility Study and documents the resulting changes to the document.

1.2 CONCLUSION

It is feasible to automatically define and rate the severity of ground water problems using existing water quality data. Screening the large amount of data currently in electronic databases would support statewide ground water assessment. The procedure does not eliminate the need for more detailed review of the most severe problems and does not consider all factors potentially useful in setting management priorities. Implementation of the procedure requires that a computer program be written, tested, and refined.

1.3 RECOMMENDATIONS

1. The screening tool discussed in this Feasibility Study should be considered for application as part of the State Board's Water Quality Assessment and Clean Water Strategy.

2. Any further automation of this procedure should be conducted by the State Board's Data Management Branch. Supporting federal funds could be made available through the State Board's Ground Water and/or Nonpoint Source Programs.

2. SELECT DATABASE(S)

2.0 INTRODUCTION

The objective of Section 2 is to review computerized databases that contain ground water quality data to determine which database(s) should be used to characterize and rate ground water problems. Fortunately, the majority of electronically-stored data from all sources is now stored in a single database, the Statewide Water Quality Information System which is maintained by the State Board's Data Management Branch and utilizes the STORET database of the U.S. Environmental Protection Agency (EPA).

2.1 REVIEW OF EXISTING DATABASES

1. STORET (STOrage and RETrieval)

STORET is a national computerized database for water quality data which has operated since 1964. In 1970 the EPA was established and given responsibility for maintaining STORET. STORET's Water Quality File is the largest component of the database and contains data on both surface and ground water chemistry.

In 1977, the State Board selected STORET as the database to be used for the Statewide Water Quality Information System which was mandated by the State Legislature in Section 13166 of the California Water Code:

> The state board, with the assistance of the regional boards, shall prepare and implement a statewide water quality information storage and retrieval program. Such program shall be coordinated and integrated to the maximum extent practicable with data storage and retrieval programs of other agencies.

At present STORET contains ground water quality data from more than 700,000 samples taken from over 55,000 wells in California. Well locations are identified by latitude and longitude coordinates.

The largest source of water quality data in STORET is the Water Data Information System (WDIS) database of the Department of Water Resources (DWR). Next is data from the Department of Health Services (DHS), including AB 1803 data. This is followed by the WATSTORE database of the U.S. Geological Survey (USGS). Other major contributors to the system are the EPA, Los Angeles County Flood Control District, and Orange County.

Utilization of STORET is increasing, but not all state agencies participate at present. For example, the Well Inventory Data Base of the Department of Food and Agriculture (DFA) has not yet been added to the database. Regional Board participation has also been minimal, with Region 7 being a notable exception. Several reports (see Section 4) have raised questions about the accuracy of some of the entries in the STORET database. Quality control seems to be a problem because some agencies have submitted data of dubious value or have neglected to proofread printouts of the data after it was entered.

2. WATER DATA INFORMATION SYSTEM (WDIS)

WDIS is DWR's database containing surface and ground water quality data. DWR maintains WDIS as a separate database but since 1978 has provided data to the State Board for entry into STORET. Wells in the system are identified by state well number which locates them by township/range/section/tract (T/R/S/T). Data Management Branch staff have developed an algorithm which translates well locations from T/R/S/T to latitude/longitude. This introduces some error (up to one-half mile) but this is minor on a state-wide or regional scale. DWR has begun the process of assigning accurate latitude/longitude coordinates to its wells, but this task is still incomplete.

3. DHS (Sanitary Engineering Branch) DATABASE

The Sanitary Engineering Branch of the Department of Health Services maintained a computerized database for ground water data from 1974 to 1979. Since 1981, DHS has been entering data directly into STORET rather than maintaining a separate database. Up until recently, this included AB 1803 data,which is now the major source of data from DHS.

4. WELL INVENTORY DATA BASE (WIDB)

The Department of Food and Agriculture maintains a database of wells sampled for pesticide residues presumed to originate from agricultural nonpoint sources. Some data goes back to 1975, although most was collected after 1979 when DBCP residues were first discovered in ground water. The passage of AB 2021, which became effective on January 1, 1986, required DFA to intensify pesticide data collection and standardize minimum well sample reporting requirements. Data was gathered from a variety of sources including WDIS, WATSTORE, and DHS. Selected AB 1803 data (agricultural chemicals) obtained from STORET was added to the database in 1986 and 1987. With the exception of AB 1803 data, all data collected prior to 1986 was screened to determine whether pesticide residues were the result of point or nonpoint sources. Any data associated with a known point source was excluded from the database.

The WIDB database (including AB 2021 data) has not yet been incorporated into STORET, but much of the data may already have been entered by the source agency. A major exception to this would be data collected by DFA itself. The State Board's Data Management Branch has received a tape of AB 2021 data, some of which will be entered in STORET. Unfortunately many of the wells sampled prior to 1986 do not have state well numbers and so cannot be located with sufficient precision for inclusion in the database. It is hoped that in the future DFA's AB 2021 data will be provided to the State Board on a regular basis for entry into STORET.

5. WATSTORE

WATSTORE was established by the USGS in 1971. WATSTORE data is now being added to STORET with the exception of the Ground Water Site Inventory (GWSI) database. GWSI contains site data on USGS wells including information on drilling, well construction, and geology, but contains no water quality information.

2.2 CONCLUSION

Since most electronically-stored ground water quality data is already included in STORET, that database will be utilized exclusively for the purposes of this project. Once the conceptualization process is complete, the task of coding an algorithm will be greatly simplified by using a single database. If other suitable computerized databases are discovered, they could be added to STORET by the Data Management Branch. Questions regarding the completeness and quality of STORET data are a concern for all users and need to be addressed. But since STORET is the only centralized database containing California water quality data from different agencies, it is the best available option.

3. IDENTIFY PARAMETERS

3.0 INTRODUCTION

The purpose of Section 3 is to develop the conceptual framework of an algorithm designed to simplify, summarize, and interpret the large volume of ground water quality data stored in electronic databases. To do this it is necessary to first select the parameters to be used to define and characterize ground water problems. Although the primary emphasis of this study is nonpoint source pollution, the basic algorithm will be applicable to any ground water contamination problem.

The selected parameters are discussed in Section 3.1, and the remainder of Section 3 outlines the methodology that will be used to define and analyze problem areas. For each problem area, the outputs of this methodology will be:

- o A tabular summary of the data
- o A plot of the problem area on a map or map overlay
- o A numerical rating of the problem severity

The purpose of this methodology is to make the data more accessible for management purposes and to thereby support and facilitate efforts to compare and rank problems.

3.1 DEFINITION OF A GROUND WATER PROBLEM

The parameters that will be used to define ground water contamination problems are listed below and discussed in this section:

- o Geographical boundaries and grid system
- o Pollutant categories
- o Concentration indices
- o Chronologic distribution of data
- o Beneficial uses impaired

Also discussed are well perforation depths which were considered as a parameter but will not be used.

1. GEOGRAPHICAL BOUNDARIES AND GRID SYSTEM

   Defining the geographical boundaries of ground water quality problems is more difficult than for surface water problems because physical boundaries are relatively absent, mixing is slower, and data is relatively sparse. A geographical definition is essential to any analysis, but in the absence of a detailed field study, it must be to some degree arbitrary.

In order to systematize the analysis of ground water problems, a grid system must be superimposed on the region or basin to be studied. The elements of the proposed grid system are discussed below.

a. Coordinate System

The grid system for this project will be based on latitude and longitude coordinates. Methods of numbering this grid are presented in **Appendix A**, along with a discussion of the relative advantages and disadvantages of the latitude/longitude versus township/range systems.

b. Grid Size

Initially a grid element 6 minutes on a side (approximately 6 miles) will be used as the basic unit for defining problem areas. The 6 minute grid size was selected because it is an appropriate size for a regional-scale study and is similar to a township, which is a familiar management unit. If greater resolution is required, each 6 minute element can be divided into 1 minute elements (similar to sections).

c. Definition of Problem Area

For a given pollutant or group of pollutants, a ground water "problem area" will be defined as the contiguous 6 minute grid elements which each contain at least one well with a pollutant concentration above a user determined threshold level. If no threshold concentration is specified, the default concentration will be the Minimum Detection Limit (MDL) reported for the pollutant in STORET. See **Figure 1** for a sketch of a hypothetical problem area.

d. Extent of Problem Area

The problem area "extent" will be reported as the surface area (in square miles) of the contiguous 6 minute grid elements which comprise the problem area. Ideally the "volume of ground water impaired" would be used to determine the "EXTENT" of the problem, but this cannot be estimated with sufficient accuracy at present. See **Appendix B** for a discussion of storage capacity data.

2. POLLUTANT CATEGORIES

As mentioned above, a ground water problem area can be defined either for a single pollutant or a group of pollutants. Pollutants reported in the database can be grouped into categories such as those developed for the nonpoint source surface water database. Categories which apply to ground water are listed below:

ACI - Acid and other pH affects

COL - Coliform bacteria or other microbes

DIS - Dissolved solids: carbonates, bicarbonates, chlorides, sulfates, and phosphates of calcium, magnesium, sodium, and potassium

HER - Herbicides, except trace elements; includes algicides

MET - Metals, except trace elements

NIT - Nitrate

NON - Non-metallic elements other than dissolved solids and trace elements, including fluoride and borate

PES - Pesticides, except trace elements; includes insecticides, nematocides, fungicides

PET - Petroleum distillates

SYN - Synthetic organics, except herbicides and pesticides

TRA - Trace elements: aluminum, arsenic, cadmium, chromium, copper, lead, mercury, manganese, nickel, selenium, silver, titanium, and zinc

OTH - Other

Eventually a datafile can be established to assign a category to each constituent in the STORET database.

3. CONCENTRATION INDICES

For management purposes, it may be necessary to compare the severity of ground water problems involving pollutants with different water quality standards. A Concentration Index is a classification system which will allow comparisons between pollutants with different standards in a summary or rating pollutants with different standards in a summary or rating system. Elements of a proposed Concentration Index system are discussed below.

a. Pollutants With Numerical Standards

For each pollutant with an established water quality standard, a Well Concentration Index will be computed for each well according to a scale based on the ratio (in percent) of the measured concentration to the standard. The scale to be used in determining concentration indices will have five classes as follows

Class 0: <Detectable limit
Class 1: <50% of standard
Class 2: 50 - 90% of standard
Class 3: 90 - 110% of standard
Class 4: >110% of standard

This scale brackets the standard because readings are never completely reliable and any concentration near the standard is of increased concern to ground water managers. For discussion of the different types of water quality standards see **Appendix C.**

b. Pollutants Without Numerical Standards

When no standard has been established for a given constituent, it will be more difficult to determine a concentration index. A statistical standard such as the Elevated Data Levels (used in TSMP reporting) or a user-defined concentration level will be needed if the constituent is to be included in the rating. Development of appropriate concentration indices for pollutants without standards will be postponed until the implementation phase of the project.

4. CHRONOLOGIC DISTRIBUTION OF DATA

Ground water data in STORET varies considerably in age, and for wells that have been sampled more than once, the question arises of how to treat data from samples taken at different times. Since the current status of a problem is of primary concern, for most purposes data from the most recent sample available is the most significant. However, error due to cyclical or anomalous data could bias the results if data from only one sample is considered in the analysis. Therefore, for wells with multiple data points, a two-year mean will be used to determine the concentration index for each well unless otherwise specified by the user. The most recent sample reported for each well will be averaged with other data available for the two years prior to the date of the most recent sample. If any data point in this two year period is above the standard, a flag will be used to insure that a current water quality problem is not overlooked. To limit the impact of older data, data collected prior to 1975 (or any user-specified date) will be ignored.

5. BENEFICIAL USES IMPAIRED

Beneficial Uses (BU's) for ground water basins will be determined from Water Quality Control Plans (basin plans) or per Regional Water Quality Control Board advice. Of the standard BU categories, those applicable to ground water are:

- MUN - municipal and domestic supply
- AGR - agricultural supply
- IND - industrial service supply
- PROC - industrial process supply

Beneficial use impairment will be determined using a Parameter-BU relationship matrix (see **Table 1**).

GENERAL BU-PARAMETER RELATIONSHIPS
FOR GROUND WATER

PARA	MUN	AGR	IND	PROC
ACI	X	_	X	X
COL	X	_	_	_
DIS	X	X	X	X
HER	X	X	_	X
MET	X	_	_	X
NON	X	X	_	X
NIT	X	_	_	X
PES	X	_	_	X
PET	X	X	X	X
SYN	X	X	_	X
TRA	X	X	_	X

TABLE 1

6. WELL PERFORATION DEPTHS

In a multi-aquifer system, knowledge of well perforation depths would be needed to determine which aquifer was the source of a particular water quality sample. Unfortunately the lack of data on well perforation intervals in STORET makes this three-dimensional analysis of ground water problems impractical at present. However, for the preliminary analysis which is the purpose of this project, well perforation depths are not essential.

3.2 DATA SUMMARY

Once a problem area of one or more contiguous 6 minute grid elements has been delineated, a tabular summary of the data for that area will be used to provide an overview of the problem. The mainframe capabilities of STORET allow considerable flexibility in reducing and summarizing data. The components of the summary can be selected by the user from options which include (but are not limited to) the following:

(1) Geographical Information

- (a) DWR ground water basin name
- (b) County
- (c) Lat/long coordinates
- (d) Extent of problem

(2) Pollutant Information

- (a) Pollutant name(s)
- (b) Pollutant category
- (c) Other pollutants found
- (d) Other pollutants analyzed for (not found)

(3) Pollutant Concentrations

- (a) Pollutant standard
- (b) Standard type (MCL, State Action Level, etc.)
- (c) Maximum concentration found
- (d) Mean concentration
- (e) Concentration index

(4) Sampling Distribution and History

- (a) Total number of wells sampled
- (b) Number of positives
- (c) Number of negatives
- (d) Date of most recent sample
- (e) Date of oldest sample

(5) Beneficial Uses Impaired

(6) Problem Severity Rating

The Data Management Branch is already able to provide much of this information directly from STORET, and in addition can produce a complete statistical analysis of the data.

3.3 PROBLEM AREA MAPS

A map or map overlay is another option available through the Data Management Branch for presenting STORET data in a simple and concise manner. The amount of information depicted on a map can be determined by the user, limited only by readability at the scale selected. On a map of a single problem area it may be useful to pinpoint individual well locations with a symbol depicting their concentration indices. On a basin-wide scale, the outline of the problem areas and the problem area rating could be plotted. On a state-wide scale, a symbol could be used to mark the location of each problem area in the state. Maps can also include additional information such as basin or county boundaries, population centers, etc.

3.4 PROBLEM SEVERITY RATING

Finally, the algorithm will compute a numerical problem severity rating for each problem area. Used in conjunction with the data summaries and plots discussed above, numerical ratings will make it possible to compare problems in a relatively unsophisticated but consistent way. The rating formula described below should be systematic enough to make valid comparisons possible. Simplicity is important because a complex formula would imply greater precision than is justified given the general scarcity of data. See **Figure 2** for a hypothetical problem severity rating computation for the hypothetical problem area in **Figure 1**.

1. RATING FORMULA

The basic equation to be used for the problem rating will be:

PROBLEM RATING = EXTENT x CONCENTRATION INDEX x BU's IMPAIRED

Where:

EXTENT	=	The surface area (in square miles) of the contiguous 6 minute grid elements which comprise the problem area.
PROBLEM CONCENTRATION INDEX	=	The mean of the individual Well Concentration Indices for a single pollutant for all tested wells in the problem area.
BU's IMPAIRED	=	The number of Beneficial Uses impaired by the contamination. (The degree of impairment is accounted for by the concentration index component.)

Weighting factors can be used with each rating component to increase or decrease its relative weight in the rating. The appropriate values for weighting factors (if any) will be determined after the equation has been tested on the pilot basin.

2. RATING COMBINATIONS

A separate severity rating will be computed for each pollutant in each problem area. Ratings for single pollutants in a problem area can be summed to attain an overall rating for multiple constituents or a category of pollutants. Likewise, the ratings for individual problem areas can also be summed to obtain an overall rating for a basin or subbasin.

3. ADDITIONAL RATING COMPONENTS

Unlimited possibilities exist for future modifications of this basic equation. For example, additional components could be added such as a distribution term that would reflect the relative clumping or dispersion of contaminated wells. Another possibility is a term to reflect the total number of contaminated wells in a problem area.

3.5 CONCLUSION

The algorithm discussed above is intended to make ground water quality data in computerized databases more accessible to managers. The data summaries, maps, and numerical rating system will provide a simple tool for preliminary assessments and comparisons of ground water quality problems.

HYPOTHETICAL PROBLEM AREA

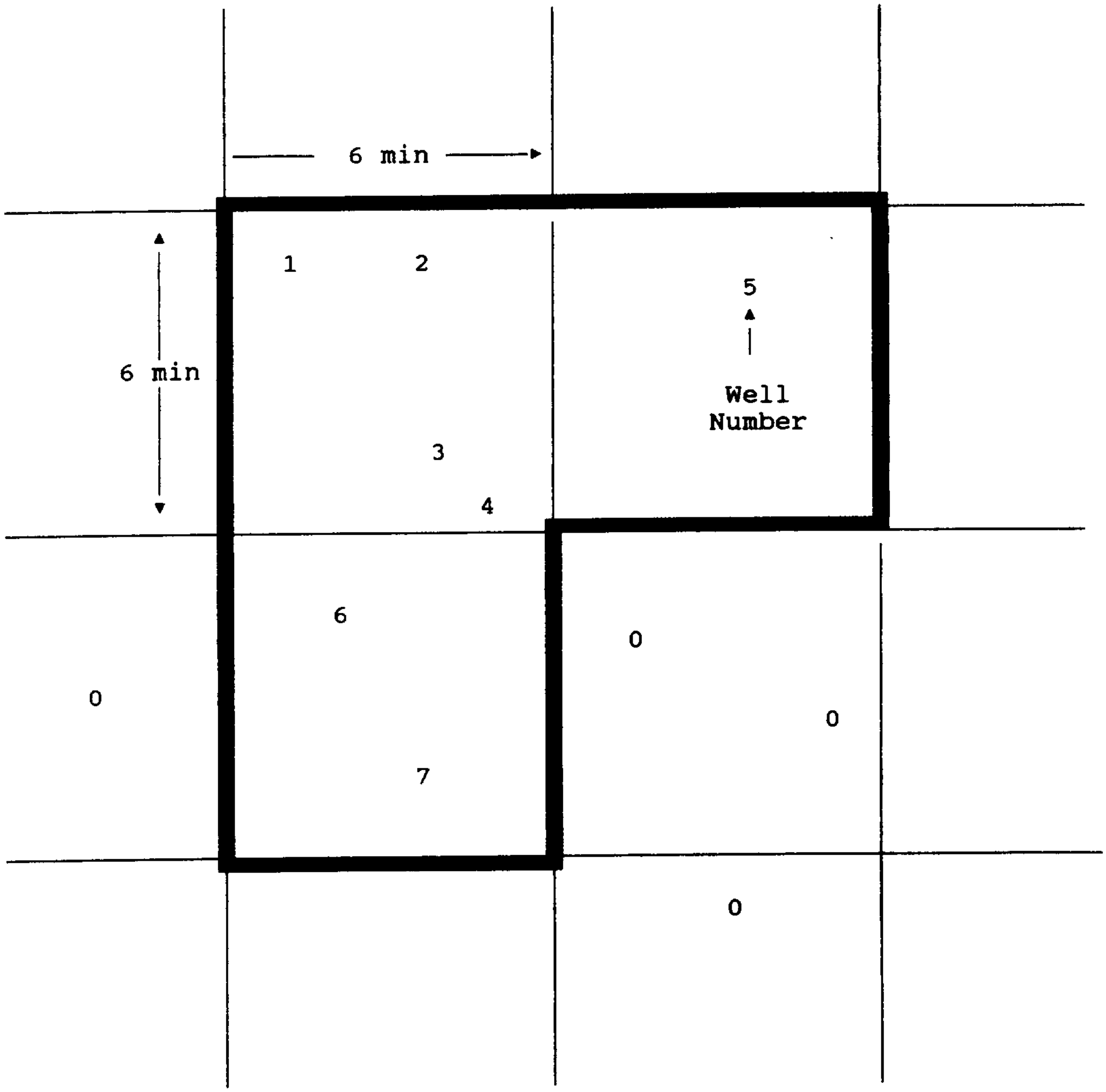


FIGURE 1

HYPOTHETICAL PROBLEM SEVERITY RATING

PROBLEM EXTENT

EXTENT = 3 x 36 sq. miles = 108 sq. miles
(Assume 1 minute = 1 mile)

PROBLEM CONCENTRATION INDEX

POLLUTANT = DBCP
STATE ACTION LEVEL = 1 ppb

WELL NUMBER	POLLUTANT CONCENTRATION (2-year mean)	WELL CONCENTRATION INDEX
1	< MDL	0
2	0.1 ppb	1
3	1.0 ppb	3
4	1.3 ppb	4
5	0.4 ppb	1
6	< MDL	0
7	0.6 ppb	2
		SUM = 11

PROBLEM CONCENTRATION INDEX = Mean of Well Concentration Indices
" " " = 11/7 = 1.57

BENEFICIAL USE IMPAIRMENT

BU's IMPAIRED = MUN + PROC = 2

PROBLEM SEVERITY RATING

PROBLEM RATING = EXTENT x CONCENTRATION INDEX x BU's IMPAIRED
" " = 108 x 1.57 x 2 = 339

FIGURE 2

4: REVIEW EXISTING PROCEDURES

4.0 INTRODUCTION

The purpose of this section is to review previous work on nonpoint source contamination of ground water to find information or procedures applicable to this project. Existing procedures designed to systematically characterize or rate individual ground water pollution problems were not found, but the State Water Resource Control Board's Well Investigation Program has developed a ranking scheme, discussed below, to prioritize ground water basins for investigation. Several reports were also valuable because they provide models for the use of ground water quality data in STORET and other computerized databases. Though a number of reports contained useful information (see **Bibliography**), only the four most relevant are mentioned here. The DRASTIC Index is also discussed, because it is the best known classification system applicable to ground water.

4.1 RANKING SYSTEM FOR WELL INVESTIGATION PROGRAM (WIP)

1. DESCRIPTION OF WIP RANKING SYSTEM

The system used by WIP uses the following criteria to rank ground water basins:

- o Population density,
- o Use of ground water by public water supply systems,
- o Public water supply systems use of total ground water and surface water supplies,
- o Alternate sources of water,
- o Number of Priority IA, IB, and II wells, and
- o Percent of degraded water systems.

The above data categories have been identified for WIP purposes as the ones which ought to be considered in basin ranking. Data for some of these categories are difficult to get and are often not available. Available data are obtained from published reports and computer files developed by the Department of Water Resources, the U.S. Geologic Survey, and the U.S. Census Bureau. Priority IA wells exceed action levels (AL) or maximum contaminant levels (MCL); Priority IB wells contain a mix of pollutants, some of which have not been assigned an AL or MCL; Priority II wells show pollutants below the AL or MCL. The data are manually input to a Lotus spreadsheet file and uncertainty values are assigned to some data elements. Some of the data is reduced by distributing the raw values into class groups, each of which has an assigned scoring value. The data (class values or raw data values) are summed to calculate an overall ranking score for the basin. Uncertainty values are summed separately.

2. COMPARISON OF WIP RANKING SYSTEM WITH SCREENING PROCEDURE

The WIP ranking system and the screening procedure presented in this Feasibility Study have some conceptual similarities. Both approaches use computerized data, both distribute data into class groups, and both use an algorithm to systematically establish a numeric rating for ground water problems.

However, there are important differences in the goals and capabilities of the two approaches. These are outlined below:

a. Goals

The goal of the WIP system is to rank ground water basins. The goal of the screening tool is to summarize, screen, and display ground water quality information in a way that facilitates comparisons between use-defined problems.

b. Types of Data Used

The WIP system uses the variety of data listed above (population, use of ground water, etc.). The screening tool uses water quality data only.

c. Use of Water Quality Data

The WIP system does not use water quality data *per se;* instead, it uses the number of public supply wells in a basin which have been assigned to Priorities 1A, 1B, and II. The screening tool directly uses raw ground water quality data, which can be displayed at any desired level of detail.

d. Geographic Area Covered

The WIP system applies specifically to entire (DWR defined) ground water basins. The screening tool applies to any user-defined geographic area.

e. Computer Systems

The WIP system uses a relatively small data set which is manually entered to a Lotus file on a personal computer.

The screening tool accesses a large water quality database on a mainframe computer.

f. Capabilities

The WIP system performs a single function: to rank ground water basins using the various factors listed above and applying a particular rating scheme. The screening tool uses a single data type: water quality. Because the screening tool accesses all the raw data and the mainframe capabilities of STORET, it can analyze and display water quality data in a variety of ways, including:

- o for individual problems ("hotspots") within a basin
- o for any geographic area
- o for any pollutant(s)
- o for any period of record.

4.2 LITERATURE REVIEW

1. Groundwater Contamination by Pesticides: A California Assessment by Y.J. Litwin, et al. 1983. Prepared by Ramlit Associates for State Water Resources Control Board.

The State Board contracted with Ramlit Associates in 1982 to assess ground water contamination by pesticides in the wake of the discovery of widespread DBCP residues. The authors utilized STORET as the largest single source of pesticide residue data, but some data had to be obtained directly from the source agency. One potentially significant data set which was not in any computerized database deals with pesticide contamination from point sources and was obtained from the Regional Water Quality Control Boards. Access to data of this type would be needed in order to distinguish between point and nonpoint sources of contamination.

Though pesticide residue data was generally sparse, the authors still found evidence of contamination by more than 50 different pesticides in 23 counties. These findings are summarized in tables and on maps. The report also contains considerable material of a general nature about pesticides in ground water, including information on pesticide use, mobility, and migration to ground water.

2. Water Quality and Pesticides: A California Risk Assessment Program by D.B. Cohen and G.W. Bowes. 1984. Toxic Substances Control Program, State Water Resources Control Board.

This study is a follow-up to the Ramlit report and its objectives include verification and expansion of the Ramlit report findings. It is a comprehensive look at pesticide contamination of California's ground water with an emphasis on priority pesticides responsible for most known pesticide residue problems. It also contains considerable information about the role of state and federal agencies in addressing these problems.

A portion of the study is devoted to the selection of priority chemicals based on toxic risk assessment criteria. Chemicals were ranked according to a semi-quantitative scale (low, medium, high) for each of 13 risk assessment criteria. The 6 agricultural chemicals that received the highest rating were designated priority pesticides and covered more fully in the report.

Like the Ramlit report, this study points out limitations of the STORET database and makes recommendations for improvements. Quality control and the difficulty of verifying many STORET entries were found to be significant problems. Another difficulty is that not all agencies that collect ground water data are utilizing the database, so information on some contamination incidents had to be obtained directly from the source agency.

The data is summarized in tabular form and displayed graphically on maps and plots. One map (page 63) is similar to those proposed by the present study. It shows townships in the Fresno area shaded according to the percent of wells exceeding the DHS action level for DBCP.

3. Sampling For Pesticide Residues in California Well Water: 1986 Well Inventory Data Base by M. Brown, et al. 1986. Environmental Hazards Assessment Program, Department of Food and Agriculture.

This is the first annual report required by the Pesticide Contamination Prevention Act (AB 2021) and contains the results of all sampling for pesticide residues in ground water obtained by DFA through August, 1986. The Well Inventory Database includes data from the previous DFA report Agricultural Pesticide Residues in California Ground Water (1985). AB 1803 data is now the largest component of the database. Data other than AB 1803 was screened to exclude samples containing residues believed to originate from point sources. The data is summarized by county and displayed in tables and on maps.

4. Program for Water Quality Surveillance and Monitoring in California by T. Lavenda. 1986. Section 305(b) Report. State Water Resources Control Board.

   This report includes a water quality classification system that is applied to both surface and ground water. Water quality is ranked as good, medium, or poor based on the estimated level of pollution severity. The system relies partially on subjective criteria such as professional judgement but also makes use of biological and chemical data. The chemical criteria are based on the percentage of analyses exceeding a water quality standard. The ground water assessment looked at 139 ground water basins and found poor water quality in all or part of 21 basins. The surface area of basins assessed poor is grouped according to the estimated source of pollution, with agricultural and nonpoint sources considered as separate categories. This assessment is updated biennially and provides an overview of ground water quality in the state.

5. DRASTIC: A Standardized System for Evaluating Groundwater Pollution Potential Using Hydrogeologic Settings. 1985. U.S. Environmental Protection Agency

   DRASTIC is a system designed to classify hydrogeologic settings according to their vulnerability to ground water pollution. The system was developed by the National Water Well Association under contract to EPA. DRASTIC is an acronym which represents the 7 factors considered most important for determining pollution vulnerability:

   D - Depth to water
   R - (Net) Recharge
   A - Aquifer media
   S - Soil media
   T - Topography (slope)
   I - Impact of the vadose zone
   C - (Hydraulic) Conductivity of the aquifer

   A DRASTIC Index for a mappable hydrogeologic unit is determined by first assigning a rating between 1 and 10 to each factor, based on predetermined guidelines. The factors are multiplied by weighting coefficients and then added to determine the DRASTIC Index.

   DRASTIC is an important tool but bears few similarities to the problem area rating system being considered here. The DRASTIC index measures vulnerability to ground water pollution, not actual pollution problems, and it is a relatively sophisticated classification system which requires substantial data collection and interpretation rather than depending on existing computerized data. One similarity between the two systems is that both are tools for relative evaluation, useful only for comparing one area with another.

4.2 CONCLUSION

The WIP system for ranking ground water basins and the water quality screening tool discussed in this Feasibility Study have different goals and capabilities. They each present different types of information and each approach has its own strengths. Which approach to use would depend on the needs of a particular situation. The approaches are not mutually exclusive and could be used in tandem to provide an overview of the status of a particular basin.

With the exception of DRASTIC, the reports reviewed make use of water quality data in computerized databases and summarize it in tabular and graphical forms. They provide essential background for the algorithm proposed here which would make more detailed use of ground water data in STORET. These studies also point out several problems with the database which must be considered when drawing conclusions based on STORET data.

5. SELECT PILOT CONSTITUENTS AND BASIN

5.0 INTRODUCTION

The purpose of Section 5 is to select a pilot basin and constituents to be used to test the algorithm on actual STORET data. Two sets of data will be selected for testing: (1) a small data set for initial manual analysis to be conducted as part of this Feasibility Study, and (2) a larger data set for subsequent computerized analysis to be conducted if further testing is warranted. Abundance of data will be the primary objective in making these selections. Other selection criteria are discussed below:

5.1 PILOT CONSTITUENT SELECTION

One chemical constituent will be chosen for initial manual analysis. Two constituents will be chosen for the possible subsequent computerized test of the program. Using two constituents will provide some diversity and allow the concept of rating combinations to be tested.

1. CONSTITUENT SELECTION CRITERIA

   a. Nonpoint Source Related

      The constituents must be nonpoint source related. Many pollutants have both point and nonpoint sources, but generally one or the other predominates. By choosing constituents primarily associated with nonpoint sources, the problem of distinguishing between source type is minimized.

   b. Established Water Quality Standard

      Each constituent must have an established federal or state water quality standard.

   c. Sufficient Data Points

      The constituents must have sufficient, varied data points in the pilot basin. The data should exhibit a range of concentrations, geographic distribution, and chronologic distribution.

2. CONSTITUENTS SELECTED

DBCP and nitrate will be chosen as the constituents that best satisfy the above criteria. DBCP will be used for the initial manual test.

a. DBCP

DBCP (Dibromochloropropane) was used widely as a soil nematicide from the time it was introduced in 1955 until it was banned in 1977. Extensive monitoring for DBCP began after it was discovered in ground water in the San Joaquin Valley in 1979. Since that time, DBCP contamination of ground water has been found to be the most widespread of all known pesticide leaching problems. Therefore DBCP data is plentiful and all of it is relatively recent. DHS has established an action level for DBCP of one part per billion.

b. Nitrate

Nitrate is a different type of contaminant which has also been found extensively in ground water. It originates from a variety of nonpoint sources including fertilizers, livestock wastes, and septic tanks. The State Maximum Contaminant Level for nitrate is 45 mg/liter. Because nitrate monitoring has a long history, nitrate data has a broad chronological and spatial distribution.

5.2 PILOT BASIN SELECTION

Selection of a pilot basin will be based on the following criteria:

1. BASIN SELECTION CRITERIA

a. Sufficient Well Data

The pilot basin must contain a sufficient number of wells where DBCP and nitrate have been monitored for and found to be present in ground water.

b. DWR-defined Basin

The basin must be a DWR-defined ground water basin or subbasin. This presupposes that assessment will ultimately be conducted at the basin level.

c. <u>No Major Point Sources</u>

The basin must not contain major point sources of the pilot constituents. The presence of known point sources is an unnecessary complication at this stage of the project.

2. BASIN SELECTED: EASTERN SAN JOAQUIN COUNTY BASIN

The Eastern San Joaquin County Basin seems to meet these criteria and will be used in the test. This "basin" is actually a subbasin of the San Joaquin Basin as defined by DWR. STORET contains abundant DBCP and nitrate data for this basin, and spatial distribution of the wells appears to be adequate.

5.3 CONCLUSION

The algorithm will first be tested in southern San Joaquin County with DBCP as the pilot constituent. If further testing is conducted, the algorithm will be coded for automated application and tested on a larger portion of this same Basin with both DBCP and nitrate as the pilot constituents. This trial will represent one of the extremes that the algorithm must be able to handle, that of an abundance of data. The other extreme (inadequate data) is more common and can also be produced in this basin by using different constituents or a subset of the same constituents.

6. PILOT DEMONSTRATION

6.0 INTRODUCTION

The purpose of Section 6 is to conduct a pilot demonstration using real data to illustrate some types of information the algorithm can generate and to identify possible problems in its application.

6.1 PROCEDURE

1. PRIMARY DATA SET

   As discussed in Section 5, the demonstration was run for the parameter DBCP in the ground water basin underlying the southern half of San Joaquin County (south of latitude 37 degrees, 50 minutes). Storet was queried for all relevant data. These are shown in **Appendix D.**

2. PLOTTING OF DATA

   Data were plotted using the graphics capabilities of STORET. **Figure** 3 is a plot of the pilot demonstration area showing county boundaries and the location of wells with positive DBCP findings. In **Figure 4** the plot has been manually superimposed on a map of the study area. A grid element size of 2 minutes was chosen for the pilot to distinguish discrete problem areas within the relatively small demonstration area. At this scale, using the procedure for defining problems described in Section 3.1, four problem areas are distinguishable. They are designated as SJ1 through SJ4 for the purposes of this study. **Figure** 5 is a plot of the Problem Areas.

   It was found that a number of wells were plotted only to the nearest minute and are thus shown as occurring on the boundary of a two-minute grid element. For the purposes of this demonstration the conservative assumption was made that these boundary wells were located within the grid element already known from other data to be affected. Problem Area SJ3 was defined by only one well, which was located on a grid element boundary. A convention was adopted which put this problem into the southernmost of the two potentially affected grid elements.

   It is probable that more extensive testing of the algorithm will reveal other situations requiring the adoption of similar conventions. Such conventions, consistently applied, should not affect the ability of the screening tool to effectively conduct a preliminary analysis of a large amount of data. They do, however, underscore the need to review data in more detail once problem areas have been identified.

2. DATA REDUCTION

Data were reduced in accordance with the procedure described in Section 3.1 and illustrated in Figures 1 and 2. **Table 2** shows wells tested for DBCP, grouped by Problem Area. Per the screening procedure, several wells which historically contained DBCP are given a Well Concentration Index of "0" because they have not shown any pollution during their most recent two years of record. A number of wells show both positive and negative readings over their two years of record. Readings below the detection limit were assumed to be at one-half the detection limit for the purposes of calculating the Well Concentration Indices for these wells.

TABLE 2

WELLS TESTED FOR DBCP
WITHIN DEFINED PROBLEM AREAS IN SOUTHERN SAN JOAQUIN COUNTY

PROBLEM AREA	WELL NUMBER	LATITUDE	LONGITUDE	WELL NAME	MEAN WELL CONCENTRATION (uG/L)	WELL CONCENTRATION INDEX
SJ1	01S/06E-25M02 M	37 49 00.0	121 16 00.0	WELL 04	0.0	0
	01S/06E-26H01 M	37 49 00.0	121 16 00.0	WELL 01	0.0	0
	01S/06E-26L01 M	37 49 00.0	121 17 00.0	WELL 03	0.0125	1
SJ2	01S/07E-21M01 M	37 49 52.0	121 12 50.0	RAYNUS VILLAGE NO. 1	0.0288	1
	01S/07E-21M02 M	37 49 48.0	121 12 45.0	RAYNUS VILLAGE NO. 2	0.1500	1
	01S/07E-28E01 M	37 49 14.0	121 12 47.0	WELL NO 01	0.0	0
	01S/07E-29G01 M	37 49 00.0	121 13 00.0	WELL 12	0.1027	1
	01S/07E-32H02 M	37 48 00.0	121 13 00.0	WELL 08	0.0103	1
	01S/07E-32P01 M	37 48 00.0	121 14 00.0	WELL 04	0.0	0
	01S/07E-33J01 M	37 48 00.0	121 12 00.0	WELL 06	0.8567	2
	01S/07E-33L01 M	37 48 00.0	121 12 00.0	WELL 10	0.0	0
	01S/07E-33N01 M	37 48 00.0	121 13 00.0	WELL 03	0.0	0
	01S/07E-34E02 M	37 48 24.0	121 11 48.0	WELL NO 01	0.0	0
	01S/07E-34L01 M	37 48 00.0	121 11 00.0	WELL 11	0.4025	1
	02S/07E-04F01 M	37 47 00.0	121 12 00.0	WELL 07	0.1300	1
	02S/07E-04N01 M	37 47 18.0	121 12 47.0	WELL 13	0.0	0
	02S/07E-05A01 M	37 48 00.0	121 13 00.0	WELL 01	0.0	0
	02S/07E-05A02 M	37 48 00.0	121 13 00.0	WELL 02	0.0	0
	02S/07E-05B01 M	37 48 00.0	121 13 00.0	WELL 05	0.0050	1
	02S/07E-05E01 M	37 47 00.0	121 14 00.0	WELL 09 (ABD)	0.0	0
	02S/07E-10G01 M	37 46 39.0	121 11 07.0	WELL NO 01	0.0	0
SJ3	02S/08E-19R02 M	37 44 00.0	121 07 00.0	WELL 04	0.0200	1
	02S/08E-20N01 M	37 44 00.0	121 07 00.0	WELL 02	0.0040	1
	02S/08E-29D01 M	37 44 00.0	121 07 00.0	WELL 01	0.0	0
	02S/08E-30C01 M	37 44 00.0	121 08 00.0	WELL 03	0.0	0
	02S/08E-30H01 M	37 44 00.0	121 07 00.0	WELL 06	0.0	0
SJ4	01S/09E-32A01 M	37 48 38.0	120 59 52.0	WELL NO 01	0.0	0
	01S/09E-32J02 M	37 48 00.0	121 01 00.0	WELL 06	0.2103	1
	02S/09E-04B01 M	37 48 00.0	120 59 00.0	WELL 04	0.0	0
	02S/09E-04C01 M	37 48 00.0	120 59 00.0	WELL 02	0.1137	1
	02S/09E-04E01 M	37 48 00.0	121 00 00.0	WELL 01	0.0	0
	02S/09E-04F01 M	37 48 00.0	120 59 00.0	WELL 03	1.4278	4
	02S/09E-04G01 M	37 48 00.0	120 59 00.0	WELL 05	0.0	0
	02S/09E-05B01 M	37 47 48.0	121 00 05.0	WELL 07	0.3272	1
	02S/09E-05F01 M	37 47 38.0	121 00 21.0	WELL 08	4.2450	4
	02S/09E-19J01 M	37 44 44.0	121 00 59.0	WELL NO. 82 - DEL RIO	0.0080	1
	02S/09E-19R01 M	37 45 00.0	121 01 00.0	HILLCREST ESTATES WELL	0.1900	1
	02S/09E-20P01 M	37 44 38.0	121 00 14.0	SOUTH WELL	0.3633	1
	02S/09E-20P02 M	37 44 38.0	121 00 14.0	CLUBHOUSE	0.0	0

Mean Well Concentrations are based on the most recent two years of data for each well. For wells with both positive and negative readings during the two-year period, readings below the detection limit were assumed to be at one-half the detection limit. The method for assigning Well Concentration Indices is discussed in Section 3.1.

TABLE 3

DBCP PROBLEM AREAS
SOUTHERN SAN JOAQUIN COUNTY

PROBLEM AREA	**EXTENT** (SQUARE MILES)	x	**PROBLEM CONC'N INDEX**	x	**NO. OF BUs**	=	**PROBLEM SEVERITY RATING**
SJI	4		0.33		2		2.6
SJ2	12		0.5		2		12.0
SJ3	4		0.4		2		3.2
SJ4	12		1.08		2		25.9

In calculating Problem Extent, each one-minute grid element was assumed to equal one square mile (see Appendix A for a discussion of the conversion from minutes to miles). The Problem Concentration Index is the arithmetic mean of the Concentration Indices of the wells in the problem area, as shown in Table 2. Two beneficial uses, Municipal Use and Industrial Process Supply, are impaired or threatened by pesticide pollution.

TABLE 4

DBCP PROBLEM AREAS
SOUTHERN SAN JOAQUIN COUNTY
ORDERED BY SEVERITY RATING

PROBLEM AREA	**PROBLEM SEVERITY RATING**
SJ4	25.9
SJ2	12.0
SJ3	3.2
SJ1	2.6

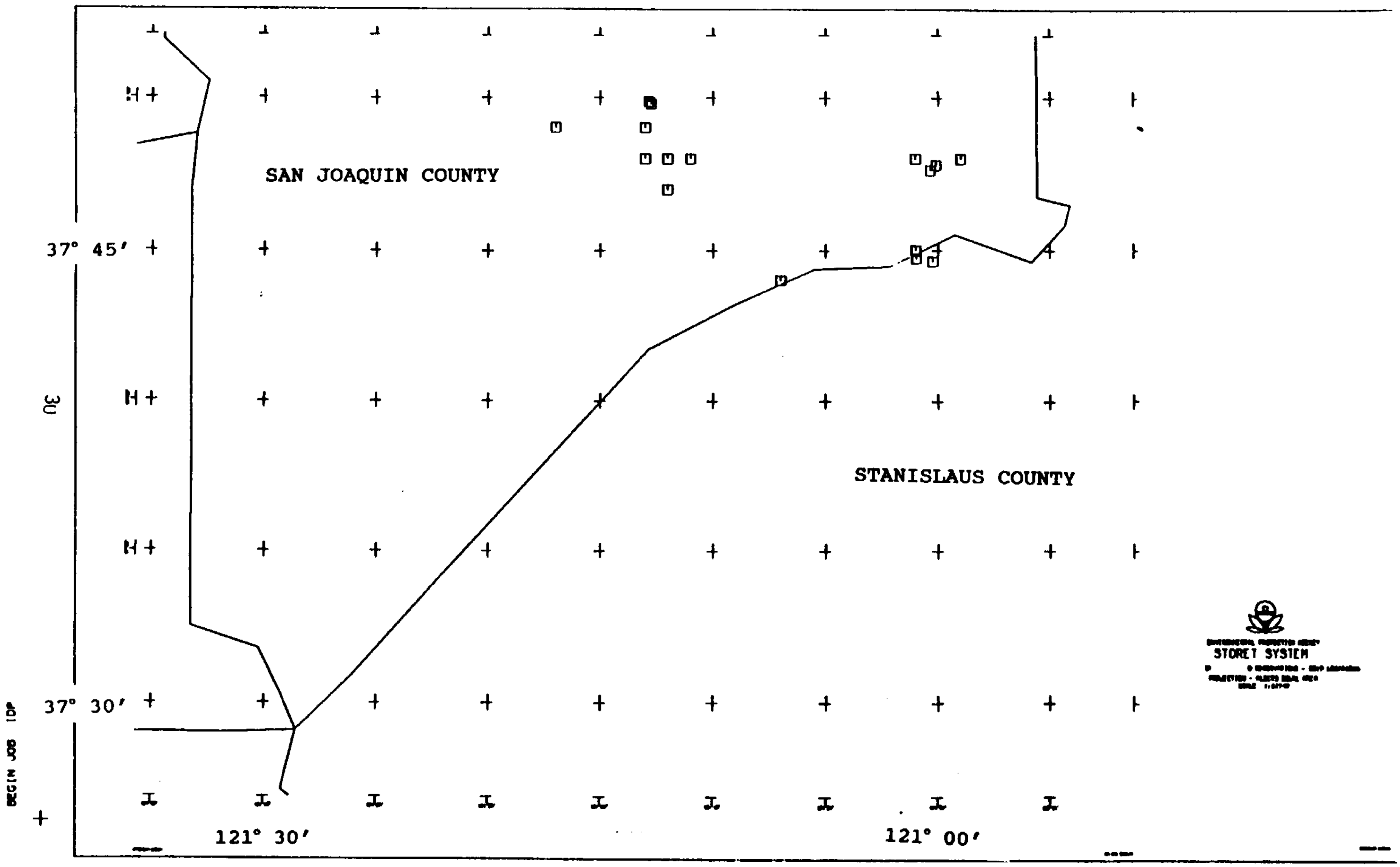


FIGURE 3. WELLS TESTING POSITIVE FOR DBCP

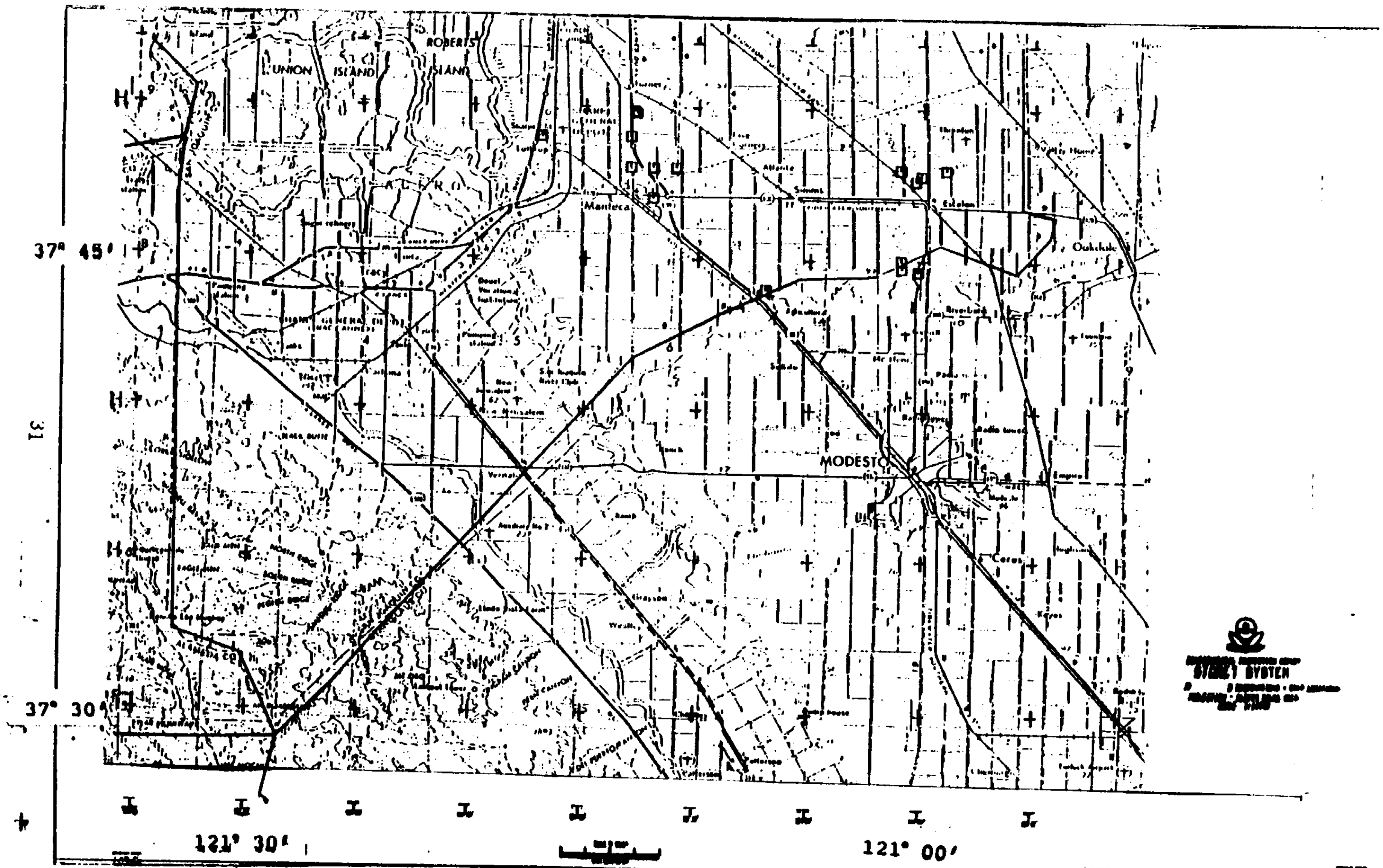


FIGURE 4. WELLS TESTING POSITIVE FOR DBCP

The plot has been superimposed on a map of the pilot demonstration area.

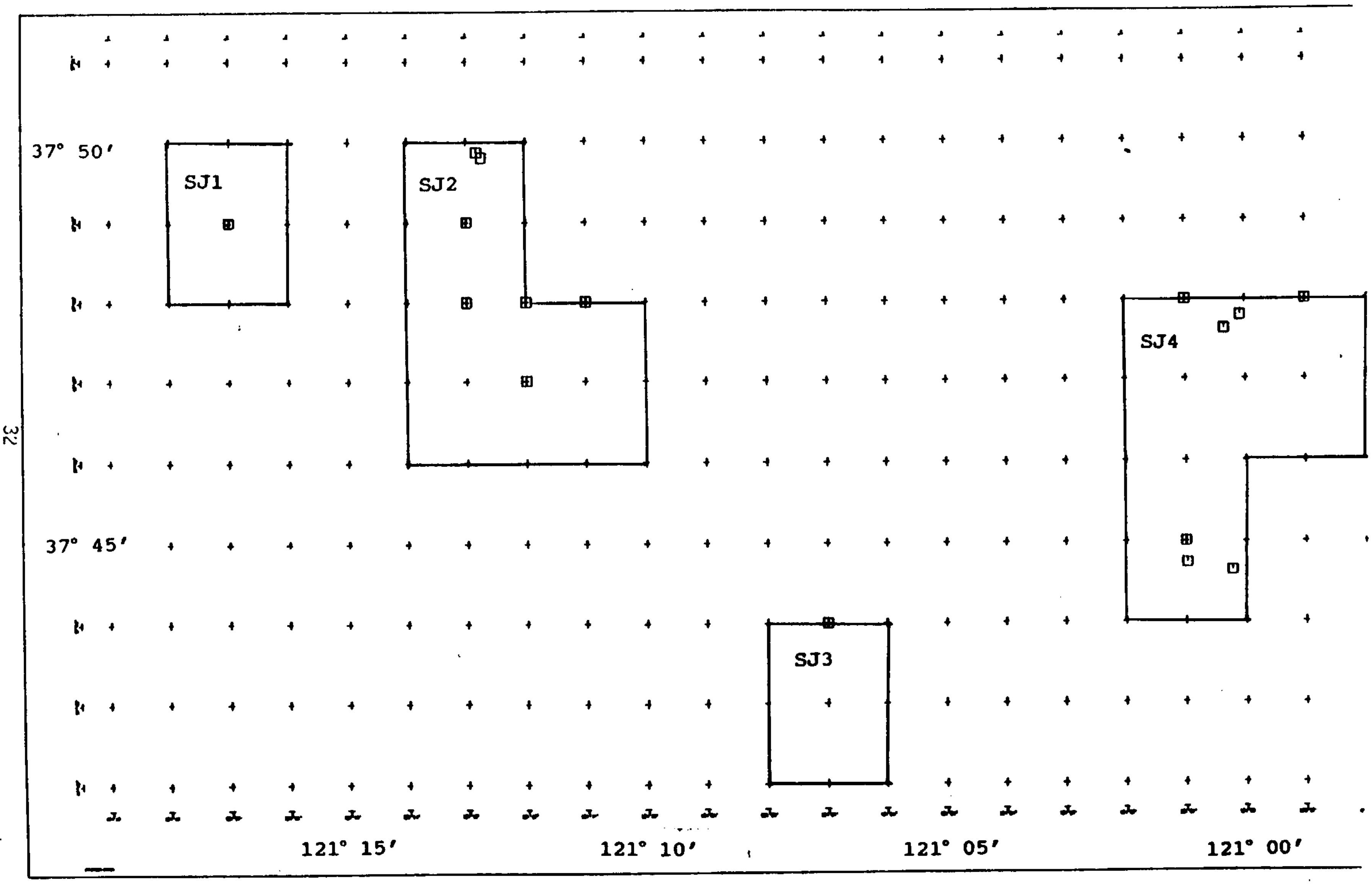


FIGURE 5. PROBLEM AREAS DEFINED BY SCREENING PROCEDURE

Problem Areas are defined by two-minute grid elements superimposed on a plot of wells polluted by DBCP.

BIBLIOGRAPHY

Brown, M., C. Cardozo, S. Nicosia, J. Troiano, and S. Ali. 1986. Sampling for Pesticide Residues in California Well Water: 1986 Well Inventory Data Base. Environmental Hazards Assessment Program, Department of Food and Agriculture.

Cohen, D.B. and G.W. Bowes. 1984. Water Quality and Pesticides: A California Risk Assessment Program. Vol. 1. Special Projects Report No. 84-6SP. Toxic Substances Control Program, State Water Resources Control Board.

Department of Water Resources. 1975. California's Ground Water. Bulletin 118.

1980. Ground Water Basins in California - A Report to the Legislature in Response to Water Code Section 12924. Bulletin 118-80.

1986. Ground Water Pollution Investigations in California - Report to the Legislature.

Fagundes, S. 1986. Workplan for Statewide Ground Water Quality Monitoring Program. Surveillance and Monitoring Unit, Division of Water Quality, State Water Resources Control Board.

Holden, P.W. 1986. Pesticides and Groundwater Quality -Issues and Problems in Four States. Prepared for the Board on Agriculture, National Research Council. Washington, D.C.: National Academy Press.

Lavenda, T. 1986. Water Quality Assessment for Water Years 1984 and 1985. Section 305(b) Report. Water Quality Monitoring Report No. 86-5WQ. State Water Resources Control Board.

Litwin, Y.J., N.N. Huntzsche, and N.A. George. 1983. Ground Water Contamination by Pesticides: A California Assessment. Prepared by Ramlit Associates for Toxic Substances Control Program, State Water Resources Control Board.

Marshack, J.B. 1985. Water Quality Objectives and Hazardous and Designated Levels for Chemical Constituents. Central Valley Region, California Regional Water Quality Control Board.

Price, P., W. Umino, et al. 1985. The Leaching Fields: A Nonpoint Threat to Groundwater. Assembly Office of Research.

State Water Resources Control Board. 1987. Preliminary Strategy - Ground Water Quality Protection.

3. PROBLEM SUMMARY

Table 3 summarizes the characteristics of the four Problem Areas identified in this pilot demonstration and shows the Problem Severity Rating for each. **Table 4** lists the four areas in order of their Problem Severity Ratings.

6.2 CONCLUSION

This demonstration indicates that it is feasible to apply a screening algorithm to STORET data to identify, analyze, and characterize ground water problems. At the small scale chosen for the pilot demonstration, the algorithm is of less practical use because it is possible to conduct a manual review of the small data set used (193 data points). Once written as a computer program, the algorithm could rapidly screen the large amounts of groundwater data available in STORET (or any electronic database), in response to particular management needs.

The Conservation Foundation. 1987. Groundwater Protection - Groundwater: Saving the Unseen Resource, and A Guide to Groundwater Pollution: Problems, Causes, and Government Responses. Washington, D.C.: The Conservation Foundation.

U.S. Environmental Protection Agency. 1985. DRASTIC: A Standardized System for Evaluating Groundwater Pollution Potential Using Hydrogeologic Settings. Robert S. Kerr Environmental Research Laboratory. Ada, Oklahoma. EPA/600/2-85/018.

1986. Guidelines for Ground-Water Classification Under the EPA Ground-Water Protection Strategy. Office of Ground-Water Protection, Office of Water, U.S. Environmental Protection Agency.

APPENDIX A: COORDINATE SYSTEMS

1.0 GRID SYSTEM NUMBERING

A latitude/longitude (lat/long) grid system does not have a predetermined numbering system as does the township/range system. Lat/long grid elements can be numbered using a 9 digit number to identify the lat/long coordinate at the lower right-hand corner of the element. The first 4 digits specify the latitude in degrees and minutes, and the last 5 digits represent the longitude in degrees and minutes. For example, the coordinate 3806/12130 would identify a grid element with its lower right-hand corner located at latitude 38.06 and longitude 121.30. If more than one grid size is used, the coordinate can be preceded by a number that specifies the grid size in minutes.

2.0 TOWNSHIP/RANGE VERSUS LATITUDE/LONGITUDE

Most wells in STORET have township/range coordinates because these are included in the state well number. Some USGS wells do not have this information, but it could be assigned with an algorithm. This provides the option of using township/range instead of (or in addition to) lat/long. The advantages of the township/range system are that it is more familiar to most people and has a grid system that is already established and numbered. Disadvantages are that township sizes and shapes vary and it is more difficult to determine township/range coordinates at basin boundaries (which are already defined by lat/long in STORET).

Latitude and longitude is a more logical and universal system that offers a flexible grid size. One disadvantage is that the conversion from minutes to miles is not exact. Between latitude lines, 1 minute equals about 1.14 miles. The distance between longitude lines in California varies from north to south by approximately 13%. At the Oregon border (42 degrees north), 1 minute equals approximately 0.85 miles. Near San Diego (33 degrees north), 1 minute is about 0.97 miles. Because of the logical nature of the lat/long system, the algorithm could include a factor to convert accurately between minutes and miles at different latitudes.

All wells reported in STORET are located by their lat/long coordinates. Federal agencies such as the USGS supplied these coordinates when they entered the data. Wells sampled by DWR and most other state agencies contained only township/range coordinates initially. The lat/long coordinates were assigned by the State Board's Data Management Branch by means of an algorithm. The translation produces an error of up 1/2 mile in the well location but this accuracy is adequate for the purposes of this project.

APPENDIX B: STORAGE CAPACITY

Because of the great variability in aquifer storage capacity, the volume of water impaired would be a better measure of the "extent" of a ground water pollution problem than the surface area of the problem. However, considerable research would likely be required to obtain a satisfactory estimate of this ground water volume.

DWR Bulletin 118 (1975) has estimates of storage capacity (in acre-feet) for most ground water basins as they were defined at that time. But this information was not included in the updated document (Bulletin 118-80) which redefined basin boundaries and divided some basins into subbasins. The original storage capacity estimates have not been updated and there is no longer a centralized compilation of storage capacity data.

Where storage capacity estimates are available, they could be used in the algorithm to estimate the volume of water impaired, which would be the most appropriate measure of "extent" to use in the rating. Storage capacity data is not available for all basins at present, but it might be feasible to switch back and forth between volume and area in the rating system. One method would be to use an extent index which would apply a classification system to different size problems, similar to the concentration index.

APPENDIX C: WATER QUALITY CRITERIA[1]

Water quality criteria established by the Regional Water Quality Control Boards and set forth in the regional Water Quality Control Plans (basin plans) will be used to determine concentration indices. A datafile will be set up to associate each constituent with the appropriate criterion. Where no basin plan criterion exists for a given constituent, a decision must be made as to whether other criteria should be used. Since the rating system is not intended for enforcement purposes, it may be acceptable to utilize criteria not included in the basin plans, if such criteria are available. The following criteria from "Water Quality Objectives" (July 1985)[2] by Jon Marshack of the Central Valley Regional Water Quality Control Board might have application to ground water. However, this study recognizes that the application of human health-based ground water criteria may not be appropriate if we are to maximize the beneficial uses of our ground water basins.

(1) Human Health and Welfare

(a) Drinking Water Criteria - Maximum Contaminant Levels (EPA)

Primary
Secondary
Recommended

(b) State Action Level (DHS)

(c) Suggested No-Adverse-Response Levels (SNARLs)

EPA
National Academy of Sciences (NAS)

(d) No-Adverse-Effect Level (EPA)

(e) One-in-a-Million Cancer Risk Levels

EPA
NAS

(f) Water Quality Criteria (EPA), based on:

Toxicity
Taste and Odor

(2) Human Health, Ecological, and Freshwater Aquatic Life

(a) Estimated Permissible Ambient Goal (EPA), based on:

Health Effects
Ecological Effects

(3) Other Water Quality Criteria (e.g., 'Safe level for most crops' for Boron)

It may be necessary to establish a hierarchy for the few cases where different criteria exist for a single Beneficial Use.

---

1. Section 303 of the Federal Water Pollution Control Act (Clean Water Act) directs the States to develop and periodically review water quality standards, which include the beneficial uses of the water and water quality criteria based upon the uses (criteria may be numeric or narrative, however, only numeric criteria are useful for the screening procedure described in this report). In California, the enforceable criteria adopted as part of the State's water quality standards are generally referred to as "water quality objectives". Clean Water Act Section 304 directs EPA to disseminate criteria which reflect scientific knowledge on the effects of water quality pollutants on the environment. Such criteria are not enforceable unless adopted as part of the State's water quality standards. Other water quality criteria are promulgated by diverse State and federal agencies.

2. This report has been subsequently updated.

APPENDIX D

STORET DATA FOR DBCP IN GROUNDWATER
SOUTHERN SAN JOAQUIN COUNTY, CALIFORNIA:
'HIT' INDICATES POSITIVE ANALYSIS,
OTHER VALUES ARE DETECTION LIMIT

	LATITUDE	LONGITUDE	WELL NAME	SAMPLE DATE	DBCP (uG/L)	HIT
** WELL NO. 01S/06E-25C01 M						
	37 49 09.0	121 15 44.0	WELL 05	790717	0.0050	
	37 49 09.0	121 15 44.0	WELL 05	821021	0.0010	
	37 49 09.0	121 15 44.0	WELL 05	840827	0.0100	
	37 49 09.0	121 15 44.0	WELL 05	850906	0.0100	
** WELL NO. 01S/06E-25M02 M						
	37 49 00.0	121 16 00.0	WELL 04	790717	0.0050	
	37 49 00.0	121 16 00.0	WELL 04	820719	0.0010	
	37 49 00.0	121 16 00.0	WELL 04	821021	0.0010	
	37 49 00.0	121 16 00.0	WELL 04	840827	0.0100	
	37 49 00.0	121 16 00.0	WELL 04	850906	0.0100	
** WELL NO. 01S/06E-26H01 M						
	37 49 00.0	121 16 00.0	WELL 01	790717	0.0050	
	37 49 00.0	121 16 00.0	WELL 01	820719	0.0010	
	37 49 00.0	121 16 00.0	WELL 01	821021	0.0010	
** WELL NO. 01S/06E-26L01 M						
	37 49 00.0	121 17 00.0	WELL 03	790717	0.0800	HIT
	37 49 00.0	121 17 00.0	WELL 03	790830	0.0560	HIT
	37 49 00.0	121 17 00.0	WELL 03	820719	0.0010	
	37 49 00.0	121 17 00.0	WELL 03	821021	0.0170	HIT
	37 49 00.0	121 17 00.0	WELL 03	840827	0.0100	
	37 49 00.0	121 17 00.0	WELL 03	850906	0.0200	HIT
** WELL NO. 01S/07E-21M01 M						
	37 49 52.0	121 12 50.0	RAYMUS VILLAGE NO. 1	800219	0.0020	HIT
	37 49 52.0	121 12 50.0	RAYMUS VILLAGE NO. 1	820810	0.0570	HIT
	37 49 52.0	121 12 50.0	RAYMUS VILLAGE NO. 1	821026	0.0010	
** WELL NO. 01S/07E-21M02 M						
	37 49 48.0	121 12 45.0	RAYMUS VILLAGE NO. 2	800219	0.6700	HIT
	37 49 48.0	121 12 45.0	RAYMUS VILLAGE NO. 2	820810	0.3000	HIT
	37 49 48.0	121 12 45.0	RAYMUS VILLAGE NO. 2	821026	0.3000	HIT
** WELL NO. 01S/07E-28E01 M						
	37 49 14.0	121 12 47.0	WELL NO 01	860701	0.0100	
** WELL NO. 01S/07E-29G01 M						
	37 49 00.0	121 13 00.0	WELL 12	820726	0.2420	HIT
	37 49 00.0	121 13 00.0	WELL 12	821019	0.0610	HIT
	37 49 00.0	121 13 00.0	WELL 12	840928	0.0100	
** WELL NO. 01S/07E-32H02 M						
	37 48 00.0	121 13 00.0	WELL 08	801030	0.0300	HIT

	37 48 00.0	121 13 00.0	WELL 08	820726	0.0010	
	37 48 00.0	121 13 00.0	WELL 08	821019	0.0010	
** WELL NO. 01S/07E-32P01 M						
	37 48 00.0	121 14 00.0	WELL 04	790830	0.0010	
	37 48 00.0	121 14 00.0	WELL 04	820726	0.0010	
	37 48 00.0	121 14 00.0	WELL 04	821019	0.0010	
	37 48 00.0	121 14 00.0	WELL 04	840928	0.0100	
** WELL NO. 01S/07E-33J01 M						
	37 48 00.0	121 12 00.0	WELL 06	801030	0.3900	HIT
	37 48 00.0	121 12 00.0	WELL 06	820726	0.9900	HIT
	37 48 00.0	121 12 00.0	WELL 06	821019	1.1000	HIT
	37 48 00.0	121 12 00.0	WELL 06	821201	0.2900	HIT
	37 48 00.0	121 12 00.0	WELL 06	830420	0.5900	HIT
	37 48 00.0	121 12 00.0	WELL 06	840928	1.5800	HIT
	37 48 00.0	121 12 00.0	WELL 06	850416	0.4000	HIT
** WELL NO. 01S/07E-33L01 M						
	37 48 00.0	121 12 00.0	WELL 10	790830	0.0010	
	37 48 00.0	121 12 00.0	WELL 10	820726	0.0010	
	37 48 00.0	121 12 00.0	WELL 10	821019	0.0010	
** WELL NO. 01S/07E-33N01 M						
	37 48 00.0	121 13 00.0	WELL 03	790605	0.0050	
	37 48 00.0	121 13 00.0	WELL 03	820726	0.0010	
	37 48 00.0	121 13 00.0	WELL 03	821019	0.0010	
** WELL NO. 01S/07E-34E02 M						
	37 48 24.0	121 11 48.0	WELL NO 01	860701	0.0100	
** WELL NO. 01S/07E-34L01 M						
	37 48 00.0	121 11 00.0	WELL 11	790830	1.2000	HIT
	37 48 00.0	121 11 00.0	WELL 11	790911	2.1000	HIT
	37 48 00.0	121 11 00.0	WELL 11	800117	2.2000	HIT
	37 48 00.0	121 11 00.0	WELL 11	800117	2.2000	HIT
	37 48 00.0	121 11 00.0	WELL 11	800117	1.9400	HIT
	37 48 00.0	121 11 00.0	WELL 11	800117	1.9400	HIT
	37 48 00.0	121 11 00.0	WELL 11	800117	2.0000	HIT
	37 48 00.0	121 11 00.0	WELL 11	800117	2.1000	HIT
	37 48 00.0	121 11 00.0	WELL 11	800117	2.2000	HIT
	37 48 00.0	121 11 00.0	WELL 11	800117	2.1600	HIT
	37 48 00.0	121 11 00.0	WELL 11	800118	2.1600	HIT
	37 48 00.0	121 11 00.0	WELL 11	800118	2.3700	HIT
	37 48 00.0	121 11 00.0	WELL 11	800221	1.8200	HIT
	37 48 00.0	121 11 00.0	WELL 11	800307	1.5000	HIT
	37 48 00.0	121 11 00.0	WELL 11	800321	1.2000	HIT
	37 48 00.0	121 11 00.0	WELL 11	800930	0.7900	HIT
	37 48 00.0	121 11 00.0	WELL 11	800930	1.1000	HIT
	37 48 00.0	121 11 00.0	WELL 11	820726	1.1600	HIT
	37 48 00.0	121 11 00.0	WELL 11	820817	2.5000	HIT
	37 48 00.0	121 11 00.0	WELL 11	821019	1.1000	HIT
	37 48 00.0	121 11 00.0	WELL 11	821201	0.3300	HIT
	37 48 00.0	121 11 00.0	WELL 11	830420	0.9800	HIT
	37 48 00.0	121 11 00.0	WELL 11	840928	0.0100	

37 48 00.0	121 11 00.0	WELL 11	870304	0.1700	HIT
37 48 00.0	121 11 00.0	WELL 11	870618	0.0100	HIT

** WELL NO. 01S/09E-32A01 M

37 48 38.0	120 59 52.0	WELL NO 01	860630	0.0100	

** WELL NO. 01S/09E-32J02 M

37 48 00.0	121 01 00.0	WELL 06	810715	0.6300	HIT
37 48 00.0	121 01 00.0	WELL 06	820726	0.0010	
37 48 00.0	121 01 00.0	WELL 06	821027	0.0010	

** WELL NO. 02S/05E-20R01 M

37 45 00.0	121 26 00.0	LEWIS MANOR WELL	790717	0.0050	
37 45 00.0	121 26 00.0	LEWIS MANOR WELL	820803	0.0010	

** WELL NO. 02S/05E-21D01 M

37 45 00.0	121 26 00.0	BALL PARK WELL	800130	0.0020	
37 45 00.0	121 26 00.0	BALL PARK WELL	820803	0.0010	
37 45 00.0	121 26 00.0	BALL PARK WELL	841211	0.0100	

** WELL NO. 02S/05E-21Q01 M

37 45 00.0	121 25 00.0	LINCOLN PARK WELL	790830	0.0010	
37 45 00.0	121 25 00.0	LINCOLN PARK WELL	820803	0.0010	

** WELL NO. 02S/05E-21R01 M

37 45 00.0	121 25 00.0	FINE WELL	790830	0.0010	
37 45 00.0	121 25 00.0	FINE WELL	820803	0.0010	
37 45 00.0	121 25 00.0	FINE WELL	841211	0.0100	

** WELL NO. 02S/05E-28A01 M

37 44 00.0	121 25 00.0	WAINWRITE WELL	790831	0.0010	
37 44 00.0	121 25 00.0	WAINWRITE WELL	820803	0.0010	

** WELL NO. 02S/05E-28E01 M

37 44 00.0	121 26 00.0	TIDEWATER WELL	800130	0.0020	
37 44 00.0	121 26 00.0	TIDEWATER WELL	820803	0.0010	

** WELL NO. 02S/05E-28L01 M

37 44 00.0	121 25 00.0	MC DONALD WELL	790611	0.0050	
37 44 00.0	121 25 00.0	MC DONALD WELL	790717	0.0050	
37 44 00.0	121 25 00.0	MC DONALD WELL	820803	0.0010	

** WELL NO. 02S/05E-33L01 M

37 43 02.0	121 25 31.0	SOUTH AREA WELL	841008	0.0050	

** WELL NO. 02S/06E-02B01 M

37 47 48.0	121 16 38.0	WELL NO 01	860701	0.0100	

** WELL NO. 02S/07E-04F01 M

37 47 00.0	121 12 00.0	WELL 07	801030	0.0070	HIT
37 47 00.0	121 12 00.0	WELL 07	820726	0.0020	
37 47 00.0	121 12 00.0	WELL 07	821019	1.2000	HIT
37 47 00.0	121 12 00.0	WELL 07	821201	0.0020	
37 47 00.0	121 12 00.0	WELL 07	830420	0.0020	HIT
37 47 00.0	121 12 00.0	WELL 07	870618	0.1300	HIT

** WELL NO. 02S/07E-04N01 M

37 47 18.0	121 12 47.0	WELL 13	820726	0.0010	
37 47 18.0	121 12 47.0	WELL 13	821019	0.0010	
37 47 18.0	121 12 47.0	WELL 13	840928	0.0100	

** WELL NO. 02S/07E-05A01 M

37 48 00.0	121 13 00.0	WELL 01	801030	0.0040	
37 48 00.0	121 13 00.0	WELL 01	821019	0.0010	

** WELL NO. 02S/07E-05A02 M

37 48 00.0	121 13 00.0	WELL 02	801030	0.0020	
37 48 00.0	121 13 00.0	WELL 02	840928	0.0100	

** WELL NO. 02S/07E-05B01 M

37 48 00.0	121 13 00.0	WELL 05	790830	0.0330	HIT
37 48 00.0	121 13 00.0	WELL 05	820726	0.0090	HIT
37 48 00.0	121 13 00.0	WELL 05	821019	0.0010	

** WELL NO. 02S/07E-05E01 M

37 47 00.0	121 14 00.0	WELL 09 (ABD)	801030	0.0070	
37 47 00.0	121 14 00.0	WELL 09 (ABD)	820726	0.0010	
37 47 00.0	121 14 00.0	WELL 09 (ABD)	821019	0.0010	

** WELL NO. 02S/07E-10G01 M

37 46 39.0	121 11 07.0	WELL NO 01	860701	0.0100	

** WELL NO. 02S/08E-19D01 M

37 45 09.0	121 08 22.0	WELL NO 01	860630	0.0100	

** WELL NO. 02S/08E-19J01 M

37 45 00.0	121 07 00.0	WELL 05	790717	0.0050	

** WELL NO. 02S/08E-19R02 M

37 44 00.0	121 07 00.0	WELL 04	790717	0.0400	HIT
37 44 00.0	121 07 00.0	WELL 04	820727	0.0200	HIT

** WELL NO. 02S/08E-20N01 M

37 44 00.0	121 07 00.0	WELL 02	790830	0.0040	HIT

** WELL NO. 02S/08E-20P01 M

37 44 23.0	121 07 00.0	CITY OF RIPON NO. 7	790717	0.1900	HIT
37 44 23.0	121 07 00.0	CITY OF RIPON NO. 7	820727	0.4600	HIT
37 44 23.0	121 07 00.0	CITY OF RIPON NO. 7	850213	0.0100	

** WELL NO. 02S/08E-29D01 M

37 44 00.0	121 07 00.0	WELL 01	790611	0.0050	
37 44 00.0	121 07 00.0	WELL 01	820727	0.0010	

** WELL NO. 02S/08E-30C01 M

37 44 00.0	121 08 00.0	WELL 03	790830	0.0010	
37 44 00.0	121 08 00.0	WELL 03	820727	0.0010	

** WELL NO. 02S/08E-30H01 M

37 44 00.0	121 07 00.0	WELL 06	790717	0.0050	

37 44 00.0	121 07 00.0	WELL 06	820727	0.0010	
37 44 00.0	121 07 00.0	WELL 06	850213	0.0100	
** WELL NO. 02S/09E-04B01 M					
37 48 00.0	120 59 00.0	WELL 04	801030	0.0020	
37 48 00.0	120 59 00.0	WELL 04	820726	0.0010	
37 48 00.0	120 59 00.0	WELL 04	821027	0.0010	
** WELL NO. 02S/09E-04C01 M					
37 48 00.0	120 59 00.0	WELL 02	790611	0.0050	
37 48 00.0	120 59 00.0	WELL 02	800121	0.0190	HIT
37 48 00.0	120 59 00.0	WELL 02	820726	0.0010	
37 48 00.0	120 59 00.0	WELL 02	821027	0.3400	HIT
37 48 00.0	120 59 00.0	WELL 02	821201	0.0010	
** WELL NO. 02S/09E-04E01 M					
37 48 00.0	121 00 00.0	WELL 01	790830	0.0280	HIT
37 48 00.0	121 00 00.0	WELL 01	800121	0.0010	
37 48 00.0	121 00 00.0	WELL 01	820823	0.0010	
37 48 00.0	121 00 00.0	WELL 01	821027	0.0010	
37 48 00.0	121 00 00.0	WELL 01	850213	0.0100	
** WELL NO. 02S/09E-04F01 M					
37 48 00.0	120 59 00.0	WELL 03	790830	0.5100	HIT
37 48 00.0	120 59 00.0	WELL 03	800129	0.0010	
37 48 00.0	120 59 00.0	WELL 03	801014	2.8000	HIT
37 48 00.0	120 59 00.0	WELL 03	810715	2.4200	HIT
37 48 00.0	120 59 00.0	WELL 03	810821	3.5000	HIT
37 48 00.0	120 59 00.0	WELL 03	810923	1.0000	HIT
37 48 00.0	120 59 00.0	WELL 03	820119	1.2000	HIT
37 48 00.0	120 59 00.0	WELL 03	820316	0.9600	HIT
37 48 00.0	120 59 00.0	WELL 03	820726	0.8400	HIT
37 48 00.0	120 59 00.0	WELL 03	821027	0.9500	HIT
37 48 00.0	120 59 00.0	WELL 03	821201	0.7800	HIT
37 48 00.0	120 59 00.0	WELL 03	830419	2.9000	HIT
37 48 00.0	120 59 00.0	WELL 03	830815	0.7200	HIT
** WELL NO. 02S/09E-04G01 M					
37 48 00.0	120 59 00.0	WELL 05	800715	0.0100	
37 48 00.0	120 59 00.0	WELL 05	820726	0.0010	
37 48 00.0	120 59 00.0	WELL 05	821027	0.0010	
** WELL NO. 02S/09E-05B01 M					
37 47 48.0	121 00 05.0	WELL 07	810715	0.0100	
37 47 48.0	121 00 05.0	WELL 07	820112	0.5300	HIT
37 47 48.0	121 00 05.0	WELL 07	820726	0.1500	HIT
37 47 48.0	121 00 05.0	WELL 07	821027	0.9000	HIT
37 47 48.0	121 00 05.0	WELL 07	830419	0.0510	HIT
** WELL NO. 02S/09E-05F01 M					
37 47 38.0	121 00 21.0	WELL 08	810715	5.1400	HIT
37 47 38.0	121 00 21.0	WELL 08	810821	14.1000	HIT
37 47 38.0	121 00 21.0	WELL 08	810923	7.9000	HIT
37 47 38.0	121 00 21.0	WELL 08	820119	2.7000	HIT
37 47 38.0	121 00 21.0	WELL 08	820316	2.8500	HIT

37 47 38.0	121 00 21.0	WELL 08	820726	7.6500	HIT
37 47 38.0	121 00 21.0	WELL 08	820825	4.6000	HIT
37 47 38.0	121 00 21.0	WELL 08	821027	5.7000	HIT
37 47 38.0	121 00 21.0	WELL 08	821201	5.9000	HIT
37 47 38.0	121 00 21.0	WELL 08	830418	2.9000	HIT
37 47 38.0	121 00 21.0	WELL 08	830815	1.8000	HIT
37 47 38.0	121 00 21.0	WELL 08	831003	1.3000	HIT
37 47 38.0	121 00 21.0	WELL 08	840529	4.1100	HIT
** WELL NO. 02S/09E-19J01 M					
37 44 44.0	121 00 59.0	WELL NO. 82 - DEL RIO	820809	0.0080	HIT
** WELL NO. 02S/09E-19R01 M					
37 45 00.0	121 01 00.0	HILLCREST ESTATES WELL	790620	0.1000	HIT
37 45 00.0	121 01 00.0	HILLCREST ESTATES WELL	820809	0.1900	HIT
** WELL NO. 02S/09E-20P01 M					
37 44 38.0	121 00 14.0	SOUTH WELL	860915	0.3600	HIT
37 44 38.0	121 00 14.0	SOUTH WELL	861008	0.3800	HIT
37 44 38.0	121 00 14.0	SOUTH WELL	861028	0.3500	HIT
** WELL NO. 02S/09E-20P02 M					
37 44 38.0	121 00 14.0	CLUBHOUSE	861008	0.0100	
** WELL NO. 03S/06E-14A03 M					
37 41 00.0	121 16 00.0	WELL 01	801030	0.0020	
37 41 00.0	121 16 00.0	WELL 01	820728	0.0010	
** WELL NO. 03S/06E-14A04 M					
37 41 00.0	121 16 00.0	WELL 02	801030	0.0050	
37 41 00.0	121 16 00.0	WELL 02	820728	0.0010	
37 41 00.0	121 16 00.0	WELL 02	841228	0.0100	
** WELL NO. 03S/06E-14H01 M					
37 40 32.0	121 16 18.0	WELL NO. 03	801030	0.0020	
37 40 32.0	121 16 18.0	WELL NO. 03	820728	0.0010	

APPENDIX E

STATE WATER RESOURCES CONTROL BOARD
DIVISION OF WATER QUALITY

RESPONSIVENESS SUMMARY
FOR
FEASIBILITY STUDY REPORT:

PROTOTYPE SCREENING TOOL FOR
GROUND WATER POLLUTION PROBLEMS

Section 205(j)(2) Planning Study

May 1990

CONTENTS

INTRODUCTION

This Responsiveness Summary documents comments received from State Water Resources Control Board staff on the Section 205(j)(2) study entitled Feasibility Study: A Prototype Screening Tool for Ground Water Pollution Problems. A meeting to discuss the study was held and written comments were submitted. Comments were collated and organized into four major issues as outlined in the "Table of Contents" of this Responsiveness Summary. A number of subissues were identified and coded for easy reference. The "List of Commentors" section of this Responsiveness Summary lists all commentors, assigns a code number to each commentor, and indicates to which issues and sub-issues their comments were assigned. In the "Comments and Responses" section of this Responsiveness Summary the relevant commentor code numbers are shown in parenthesis after each comment.

COMMENTS AND RESPONSES

1. NEED FOR A SYSTEM TO CHARACTERIZE AND SCREEN GROUND WATER CONDITIONS

1.1. Such a System is Needed

A systematic procedure to screen data and characterize ground water conditions would be useful (1, 2, 5). Staff discussion at the November 27, 1989 meeting indicates a need does exist (4).

Response: Comment noted.

1.2. Need for Consistency with Clean Water Strategy

Any ranking system would have to be consistent with the Clean Water Strategy (1, 2).

Response: Agree. The output of the proposed procedure could support any ranking system eventually developed by the Clean Water Strategy.

1.3. Needs of Clean Water Strategy

It's unclear whether such a ranking system will be needed to supplement the Clean Water Strategy (1). More time is needed for consensus to be reached on an acceptable ranking strategy for ground water (2). The

Water Quality Assessment database will fill the need in support of the Clean Water Strategy (5).

Response: How the Clean Water Strategy will rank groundwater problems is unknown at this time. It is therefore impossible to say definitively how the proposed procedure (or any other) could be used by the Clean Water Strategy. However, as discussed in the responses to Comments 2.3 and 2.8 below, it seems likely that the parameters analyzed by the proposed procedure would be considered in any ranking scheme. Therefore, the procedure appears potentially useful in developing the Clean Water Strategy ranking system for ground water.

1.4. Need to Evaluate Other Available Tools

An evaluation of other available tools is warranted before this procedure is developed further (4).

Response: The Feasibility Study includes a review of existing tools to determine which are applicable to the goals of the study (Section 3, "Review Existing Procedures", p. 13 ff.)[1]. State Board reviewers were recently asked whether a similar procedure is available or being developed. Except for the Water Quality Assessment/Clean Water Strategy process (see Comments 1.2 and 1.3 above) and the basin ranking system used by the Well Investigation Program (WIP) no other procedures were identified. A discussion of the WIP basin ranking system was added to the Feasibility Study.

2. TECHNICAL ADEQUACY OF APPROACH

2.1. Procedure Appears Adequate

The procedure appears to be sound enough for its intended use (1). STORET is the most appropriate database to use, although much information is also stored in other agency and private databases (4).

Response: Comment noted.

[1] The section and page numbers cited in this Responsiveness Summary refer to the draft version of the Feasibility Study. In the the final version a new Section 1. was added and subsequent sections were renumbered.

2.2. Need to Characterize All Ground Water Basins

The proposed approach should be adapted to catalog good as well as problem basins (1, 2), and point as well as nonpoint source problems (3, 5).

Response: No adaptation is necessary. The proposed approach could be used to identify basins (or other geographical areas) which have no water quality problems at all and, as stated in Section 2.0 of the report (p. 4), "Although the primary emphasis of this study is nonpoint source pollution, the basic algorithm will be applicable to any ground water...problem".

2.3. Data is Inadequate to Allow Ranking

To say that this procedure "screens" rather than "ranks" problems would be more accurate (3). The procedure could be improved by using STORET data to indicate ground water pollution patterns rather than as a means of ranking (5). The procedure is inadequate for ranking in that the database to be used, STORET, is limited to water quality information and does not contain factors such as population affected, alternate water supplies, hydrogeologic factors, per capita capacity of the basin, need for assessment or preventative work, etc. (2, 5).

Response: Agree. As stated in Section 2.0 (p. 4) of the Feasibility Study, the purpose of this study is to "...develop the conceptual framework of an algorithm designed to simplify, summarize, and interpret the large volume of ground water quality data stored in electronic databases...to facilitate efforts to compare and rank problems". The output of the algorithm is described in the Feasibility Study (Section 2.4, p. 9) as a "Problem Severity Rating" based on water quality data. If ranking includes consideration of ground water quality data, the proposed procedure will support ranking; if ranking involves considerations other than ground water quality, the proposed procedure will not by itself be adequate for ranking. Incidental references to "ranking" in the Feasibility Study have been edited to make this more clear.

2.4. More Than One Test Basin Needed

More than one test basin should be included in the test program (2).

Response: More than one basin could be used as a pilot. A definitive answer to how much testing and refinement is necessary must await initial test results.

2.5. Use of Grid System to Define Area of Problems

Use of a grid system is a reasonable idea (3). Although easy to implement, use of an arbitrary grid system to define pollution problems ignores subsurface hydrogeology (2). A "basin, sub-basin" approach may be better (4).

Response: The algorithm presented in the Feasibility Study could be applied to any desired geographical area, including entire ground water basins, sub-basins, or smaller areas defined though detailed knowledge of subsurface hydrogeology. However, in many cases the entire basin is larger than the areal extent of the observed problem(s) but we do not have the detailed hydrogeologic data necessary for precise geographic problem definition. In such a case a grid system allows systematic definition of a usefully sized study area or management unit. Because the problem areas are systematically defined, valid comparison is easier. Wording has been added to Section 2.1 of the Feasibility Study to clarify this point.

2.6. Size of Grid Elements

The basic grid size of 36 square miles is too large (2, 3).

Response: As indicated in Section 2.1.b (p. 5) of the Feasibility Study, "If greater resolution is required, each 6 minute element can be divided into 1 minute elements...." (about one square mile). Any other user-defined area is also possible.

2.7. Need to Identify Data Quality

A rating of uncertainties in the data (data quality) would be informative (2).

Response: Unfortunately, STORET does not include this information.

2.8. Use of Numeric Analysis

State Water Resources Control Board management does not care for an approach using numbers (weighting factors) (1, 5).

Response: The proposed procedure does not use "weighting factors", i.e. arithmetic factors that reflect staff judgement on the relative importance of the parameters defining a problem (although such factors could be added to the basic algorithm). Since no weighting factors are used and the procedure is entirely confined to the analysis and display of objective data derived from an official State database, it is assumed that management would not object.

In any case, it is not possible to entirely avoid the use of numbers in analysis of ground water condition since our basic information is numeric: parts per million of pollutant, percent of water quality objective observed in analyzed samples, percent of analyses in which objectives are exceeded, number of wells in which pollutants are found, number of wells in which objectives are exceeded, area over which pollution is observed, and number of beneficial uses affected. The use of such parameters in assessing ground water condition is of course universal in professional practice and is widely discussed in the technical literature (see response to Comment 1.4 above). It is difficult to conceive of a scientifically valid problem analysis which is not based on the numeric values of these or similar parameters, or a technically defensible ranking system which does not incorporate them.

3. RECOMMENDATION FOR IMPLEMENTATION

3.1. Recommend Bifurcated Approach

I recommend a bifurcation: development of the Clean Water Strategy ranking procedure for ground water should move forward and the proposed procedure should be developed to support the Strategy as needed (1).

Response: Agree.

4. OTHER

4.1. Geographical Information System (GIS)

The State Board needs to make a commitment to a GIS (2).

Response: The Feasibility Study does not address the State Board's need of a GIS. Although a GIS is not needed for the proposed procedure, a GIS would facilitate the use of the algorithm.

4.2. Standard for Nitrate

The cited U.S. Environmental Protection Agency standard is actually the State Maximum Contaminant Level.

Response: A correction has been made to the Feasibility Study.

4.3. Update of Referenced Document

The report cited on p. 21 (Marshack, 1985) has been updated (4).

Response: A footnote referencing the update has been added to the Feasibility Study.

4.4. Editorial Comments

The report title should characterize this study as "developing a prototype screening tool for ground water pollution problems". In Appendix C, "objectives" should replace "standard" (4). The word "challenges" could replace the word "problems" (3).

Response: A number of changes have been made to the Feasibility study in response to these editorial comments.

LIST OF COMMENTORS

The comment numbers assigned to each set of comments are shown.

1. Jeffrey L. Barnickol, Manager
   Clean Water Strategy
   Executive

   December 8, 1989 memorandum;
   Comments 1.1, 1.2, 1.3, 2.1, 2.2, 2.8, and 3.1.

2. Barbara L. Evoy, Manager
   Well Investigation Program
   Division of Water Quality

   December 19, 1989 memorandum;
   Comments 1.1, 1.2, 1.3, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, and 4.1.

3. Tom Lavenda
   Monitoring and Assessment Unit
   Division of Water Quality

   November 27, 1989 informal written comments;
   Comments 2.2, 2.3, 2.5, 2.6, and 4.4.

4. John Sarna et al
   Groundwater Unit
   Division of Water Quality

   December 9, 1989 informal written comments;
   Comments 1.1, 1.4, 2.1, 2.5, 4.3, and 4.4.

5. Mary Tappel
   Monitoring and Assessment Unit
   Division of Water Quality

   December 27, 1989 memorandum;
   Comments 1.1. 1.3, 2.2, 2.3, and 2.8.