STATE OF CALIFORNIA—ENVIRONMENTAL PROTECTION AGENCY

DEPARTMENT OF TOXIC SUBSTANCES CONTROL
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April 19, 1994

Mr. Hubert H. S. Chan
Remedial Project Manager
Western Division
Naval Facilities Engineering Command
BRAC Environmental Program, Code T4A
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San Bruno, California 94066-2402

NAVAL AUXILIARY LANDING FIELD (NALF), CROWS LANDING, SITE INVESTIGATION, DRAFT FINAL FIELD WORK PLAN ADDENDUM (ADDENDUM) AND FIELD INVESTIGATIONS, DRAFT FINAL QUALITY ASSURANCE PROJECT PLAN (QAPjP)

Dear Mr. Chan:

This letter transmits the comments of the California Environmental Protection Agency (Cal/EPA), Regional Water Quality Control Board, Central Valley Region (RWQCBCVR), and Department of Toxic Substances Control (DTSC) on the subject reports submitted January 28, 1994. These reports have been previously discussed and commented upon by Cal/EPA during a January 21, 1994 conference call with PRC Environmental Management, Inc. and the Navy, and a March 4, 1994 Remedial Project Manager's meeting. Please find two enclosures which are the comments of RWQCBCVR and DTSC on the subject reports. Other DTSC comments are presented below.

ADDENDUM COMMENTS

1) Figure 4, page 12 - two soil borings identified as 17-SB-3 are presented. One of these soil borings must be corrected to 17-SB-2.

QAPjP COMMENTS

1) Section 3.5.2 Accuracy, page 13 - Appendix C must be submitted for regulatory review,

KS.kl
KS52.044/5

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If there are any questions or comments regarding this matter, please contact me at (916) 255-3705.

Sincerely,

Kent Strong

Kent Strong
Remedial Project Manager
Office of Military Facilities

Enclosures

cc: Ms. Karen Bessette
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3443 Routier Road
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STATE OF CALIFORNIA - Environmental Protection Agency PETE WILSON, Governor

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Mr. Kent Strong
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13 April 1994

SITE INVESTIGATION DRAFT FINAL FIELD WORK PLAN ADDENDUM AND FIELD INVESTIGATIONS DRAFT FINAL QUALITY ASSURANCE PROJECT PLAN, NAVAL AUXILIARY LANDING FIELD (NALF) CROWS LANDING, STANISLAUS COUNTY

We have completed our review of the Site Investigation Draft Final Field Work Plan Addendum (Work Plan) submitted on 11 February 1994. Please find the details of our comments in the enclosed memorandum which must be addressed in the Final Field Work Plan Addendum. We have deferred formal review and comment on the Field Investigations Draft Final Quality Assurance Project Plan to the Department of Toxic Substances Control.

Our comments focus on general site investigation data needs and the proposed field activities at the demolished hangar area (Site 17). As you are aware, during the 4 March 1994 Project Manager Meeting, we provided our approval to proceed with field activities at the firing range area (Site 18) as proposed in the Work Plan. This was to allow fieldwork at Site 18 to begin prior to 1 April 1994 to avoid interfering with the base agriculture lessee's spring planting schedule.

Our main concerns with the Work Plan are that the proposals to collect ground water elevation and background data are too limited to provide the data necessary to make decisions regarding existing or potential ground water contaminantion at NALF Crows Landing. The Work Plan proposes only two additional rounds of ground water level data to be collected from the existing and proposed monitor wells. A consistent and comprehensive ground water monitoring program, which includes annual and quarterly reporting, needs to be implemented at this facility to establish an adequate historical water level and quality data base. The background soil investigation proposed in the Work Plan must be revised in order to obtain representative data from throughout the unsaturated zone for use in a water quality assessment. Also, as discussed during the 4 March 1994 Project Manager Meeting, the samples collected from the background soil borings should be analyzed for both total and soluble concentrations.

In addition, a soil gas survey should be performed at Site 17 as soil boring samples are inadequate to properly assess potential contamination by volatile organic constituents.

We have other technical concerns with the Work Plan which are also discussed in the enclosed memorandum. We are available to discuss these, as well as the foregoing primary concerns, prior to completion of the Final Work Plan Addendum.

If you have any questions, please call me at (916) 255-3066.

Karen Bessette
Project Engineer

KAB:kb

Enclosures

MEMORANDUM

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD • CENTRAL VALLEY REGION

3443 Routier Road, Suite A
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Phone: (916) 255-3000
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TO: Antonia K. J. Vorster
Senior WRC Engineer

Karen Bessette
Project Engineer

FROM: Camilla Williams
Engineering Geologist

DATE: 12 April 1994

SIGNATURE: Camilla Williams

SUBJECT: *REVIEW OF SITE INVESTIGATION, DRAFT FINAL FIELD WORK PLAN ADDENDUM, NAVAL AUXILIARY LANDING FIELD (NALF) CROWS LANDING, STANISLAUS COUNTY*

I have reviewed the Site Investigation Draft Final Field Work Plan Addendum (Work Plan) for NALF Crows Landing submitted on 11 February 1994. It is my understanding that portions of the Work Plan have been previously approved during conference calls. I have provided comments on the document which are discussed in more detail below.

PRIMARY CONCERNS

Ground Water Monitoring Program

The Work Plan indicates that two rounds of ground water elevation data will be collected from existing and proposed monitor wells from across the entire site (pages 5 and 9). This proposal is inadequate. A consistent and comprehensive ground water monitoring program needs to be implemented at this site. This program is needed to establish an adequate historical data base which can be used to fully evaluate hydrogeologic conditions and trends and to base conclusions on contaminant migration. The ground water data should be reported using an annual and quarterly reporting system. Attached is the Long Term Ground Water Monitoring Program Guidance which has been prepared by the California Base Closure Environmental Committee which should be considered by NALF Crows Landing to establish a comprehensive and long term monitoring program.

The Work Plan indicates that localized reversals in the ground water flow have been observed in the area of the site due to seasonal irrigation effects (page 5). The proposal to conduct only two more rounds of ground water elevations will not confirm this observation. Consistent quarterly measurements are needed, preferably over a two year period, to confirm the seasonal affects due to irrigation practices, prior to any reduction in the frequency or number of wells used in the ground water monitoring program. In addition, two of the quarterly measurements should be conducted during the height of the wet and dry seasons to confirm seasonal changes due to irrigation practices. Monthly ground water level measurements may be warranted for a period of one year if there are conflicting or anomalous ground water elevations.

Section 4.3 of the Work Plan (page 21) indicates that nine of the 27 existing wells were dry during the November 1993 ground water level survey and that these wells would be assumed to have insufficient water for sampling. It is unclear if the nine wells will continue to be measured for ground water levels. Until an adequate historical water level and quality data base is established for this site, all existing and proposed monitor wells should be monitored for water levels and quality. The decision of whether or not to sample the well must be made on a well by well basis during each quarterly round. Therefore, the proposal to not sample nine of the 27 existing monitor wells is unacceptable.

Background Soil Investigation

The Work Plan proposes to install three background soil borings as depicted on Figure 3 (page 10). Two of the locations, BG-SB-1 and BG-SB-3 are located near the ends of the runways for the landing field. The locations of the background soil borings, which are to be converted to monitoring wells, may need to be moved away from the flight lines. Potential contamination by polynuclear aromatics (PNAs) may exist in these areas due to the incomplete combustion of jet fuels. Background borings/wells should be installed in areas unaffected by waste disposal activities.

The Work Plan proposes to drill three soil borings to 65 feet. Six soil samples will be collected from each boring to a maximum depth of 11 feet below ground surface (bgs). The soil samples will be analyzed for total metals concentrations in order to establish background levels (page 16). The soil samples should be grab and not composite. The proposals for depth of collection and method of analysis for the 18 soil samples needs to be revised in order obtain representative data for use in a water quality assessment. Other than the surface sample, the remaining five soil samples per boring (a total of 15) should be collected every ten feet with the last sample collected just above the water table (depth to ground water is approximately 50 feet). Collection of soil samples throughout the unsaturated zone will provide a vertical profile of background concentrations and should account for varying lithologies with depth. This will provide a larger data base for background conditions.

The Work Plan proposes to analyze for metals to establish background (Table 1, page 17). Soil samples should also be analyzed for pH, electrical conductivity (EC) and total dissolved solids (TDS) as an indicator of background levels of other inorganic constituents. Analyses for pH, EC and TDS at sites with inorganic contamination may ultimately be necessary to define the extent of contamination at waste disposal sites, to establish cleanup levels that are protective of water quality and if the site is remediated by excavation and off-site disposal of the contaminated soils. Background concentrations of pH, EC and TDS would therefore be necessary under the first two circumstances.

The samples collected from the background soil borings should be analyzed for both total and soluble concentrations. Background soluble concentrations are needed in order to compare to the concentrations of soil samples collected from contaminated areas. In the event that the total concentrations of a contaminated soil sample exceed total background concentrations, comparisons between soluble concentrations should also be made as not all of the contamination may be leachable. Soluble concentrations of contaminants which threaten ground water quality ultimately

need to be determined in a remedial investigation (RI) for each disposal area so that cleanup levels which are protective of ground water quality can be determined.

It is my understanding that in previous conversations with NALF Crows Landing, the Board agreed to allow only two out of six soil samples per boring be analyzed for soluble concentrations. However, the Board informed NALF Crows Landing that this approach may result in the need for additional sampling and analyses for soluble concentrations at a later date. Although analyses for soluble concentrations in only two samples per boring is not optimal for development of a good background data base, the soil samples to be analyzed for soluble and total concentrations should be from varying lithologies collected at varying depths in the unsaturated zone. Both total and soluble concentrations should be analyzed on these particular soil samples in order to establish a ratio between these concentrations. Surface soil samples need only be analyzed for total concentrations, as these are critical for conducting a health based risk assessment.

The Work Plan proposes to analyze for oraganochlorine pesticides (Method 8080) in the background surface soil samples (page 16). It is unclear why analyses for pesticides need to be performed for these constituents when pesticides are not naturally occurring. Clarification is needed in the text of this Work Plan if this proposal was made because the area immediately surrounding NALF Crows Landing is primarily used for agricultural purposes (page 3). If this is not the case, then analyses for pesticides, like other potential organic contaminants, would not be required because the background concentrations would be assumed to be non-detect.

OTHER TECHNICAL CONCERNS

1. Nine of the 18 existing monitor wells were reported as dry during the November 1993 ground water level survey. If samples from any of these wells historically had shown concentrations of contaminants, particularly if the contamination was confirmed, then NALF Crows Landing will need to install replacement wells to continue to monitor the lateral and vertical extent of contamination.

2. Figure 6A (page 23) of the Work Plan shows the location of the monitor wells in relation to the underground storage tanks (USTs) at UST Cluster 2. The direction of the regional ground water flow in the area of NALF Crows Landing is reported to be to the northeast (page 5). Based on this Figure, none of the existing monitor wells appear to have been installed on the down gradient side of the USTs. MW-4 and MW-5 appear to be on the up gradient side of the tanks and MW-6 appears to be cross gradient. The location of the monitor wells may not be critical if the soil boring data indicate that the contamination does not extend to the ground water table. However, if soil contamination appears to occur throughout the unsaturated zone, then ground water may have been impacted and therefore, additional monitor wells may need to be installed down gradient of these USTs in order to define the extent of contamination.

3. The Work Plan proposes to conduct analyses for background concentrations on background ground water samples. Analyses for only dissolved metals is proposed (Table 2, page 28). Analyses for all 17 Title 22 metals should be performed on background water quality samples

which would include arsenic, lead, mercury, and selenium using atomic absorption method of analysis in addition to the metals analyzed using the Inductively Coupled Plasma (ICP) method. Additionally, analyses for general (or standard) minerals should be performed on background water quality samples. This information is useful in determining potential inorganic contamination and for fingerprinting different water bearing zones. In addition, analyses for total concentrations in ground water may need to be performed in order to develop data for a health based risk assessment.

4. The Work Plan proposes that one boring each be installed at the former building locations at Site 17 (page 11). The approximate size of these buildings is 200 feet by 125 feet for a surface area of 25,000 square feet each. If possible, NALF Crows Landing should consider installing two borings in each building foundation, possibly at opposite ends, rather than one boring, to better assess potential contamination.

5. Potential contamination by volatile organic constituents (VOCs) is proposed to be assessed using analyses for soil boring samples at Site 17 (Table 1, page 17). Site 17 is a demolished hangar area where assembly and repair of aircraft reportedly occurred (page 5). A more appropriate method of assessment would be a soil gas survey rather than soil borings because the contaminants can volatilize during sampling leading to an underestimation of the concentration and volume of contamination. For sites where VOC contamination is determined to exist in concentrations that threaten or have impacted water quality, then commonly, the unsaturated zone is remediated using vapor extraction. This treatment technology is used to remediate the vapor phase contamination. Therefore, in order to properly assess vapor phase contamination either for the purposes of definition of extent or verification of cleanup, then a soil gas survey would be more appropriate. Active (versus passive) soil gas surveys should be performed using deep probes as VOC contamination in the upper portions of unsaturated zone would be expected to have dissipated. In addition, soil gas surveys can also be used to assess contamination by fuels which are also potential contaminants at Site 17.

6. Table 1 (page 17) of the Work Plan proposes that the soil samples at Site 17 be analyzed for volatile and semi-volatile organic constituents (Methods 8240 and 8270, respectively). This is acceptable because PNAs are detected with these methods. However, should the analytical methods be changed, then PNAs and polychlorinated biphenyls (PCBs) should be analyzed using Methods 8100 and 8080.

7. The proposals for the investigation of Site 18 are discussed in Sections 4.1.1 (page 13) and 4.1.2 (page 15) of the Work Plan. Because this site was a firing range, a geophysical survey (metal detector) may be adequate for the investigation. However, it should be verified what types of metals will be detected by this tool (iron versus lead). In addition, it may not be necessary to analyze the soil samples for all heavy metals, but only for metals commonly associated with gun powders, including antimony, barium and lead.

8. The Work Plan indicates that the Leaking Underground Fuel Tank (LUFT) Manual is being used as guidance for the investigation of USTs containing fuels (page 16). The Tri-Regional Board Staff Recommendations for Preliminary Evaluation and Investigation of Underground Tank Sites and the accompanying Appendix A, should be used instead of the LUFT Manual for the investigation of Site 17.

9. Monitoring well construction is discussed in Section 4.2.2 (page 20) of the Work Plan. There are three areas of concern with the proposals.

   a. It is unclear why two inch wells will be installed. Four inch monitor wells are preferred due to the service flexibility of the well and the potential conversion to an extraction well. However, if four inch wells are installed, then the diameter of the augers must be increased from 8 inches to 10 inches to assure an adequate annular space.

   b. The Work Plan also indicates that 24 hours are needed to allow both the bentonite seal to hydrate prior to placement of the cement in the annulus and for the cement prior to well development. Less time may be needed for the bentonite to hydrate but more time (48 to 72 hours) should be provided for development of compressive strength and to avoid development of microannulus in the cement annular seal.

   c. It is unclear whether the protective steel casing or the well casing will be marked to establish a permanent measuring point reference. It is assumed that the well casing will be marked. The text of the document should be revised to reflect this.

Attachment

STATE OF CALIFORNIA—ENVIRONMENTAL PROTECTION AGENCY

PETE WILSON, *Governor*

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M E M O R A N D U M

TO: Kent Strong
Waste Management Engineer

FROM: Brad Parsons
Senior Hazardous Materials Specialist
Site Mitigation Branch

DATE: *March 1,1994*

SUBJECT: Technical Request to Review Quality Assurance Project Plan: Crows Landing NALP

Review Activities

Reviewed the document titled, "Naval Auxiliary Landing Field, Crows Landing, California, Field Investigations, Draft Final Quality Assurance Project Plan" prepared by PRC Environmental Management and dated February 11, 1994.

Discussion/Analysis

Page 2, Section 2.1: Project Organization. A flow chart should be provided showing the chain of command. It should be clear who reports to whom. It would also be helpful if the phone numbers of the project team were provided.

Page 12, Section 3.5.2: Accuracy. Specific accuracy goals for the project should be stated.

Page 15, Table 4-1. PH method 9040 or 150.1 should be substituted for method 360.1. The latest revised analytical methods should be used (i.e. 8010A, 8150A, 8240A & 8270A).

Page 14, Section 4.0: Sample Collection Procedures. It is suggested that samples collected for VOC analyses be cooled first with ice immediately following placement in a protective bag or container. After cooling the samples may be placed with blue ice for shipment. This will help insure the samples are properly chilled.

Page 32, Table 6-4: Quantitation Limits. This and the tables that follow listing the analytes and reporting limits

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should be reevaluated once suspected contaminants have been identified in the sampling plans. Otherwise the contaminants of concern should be provided in this document. Regardless of the specific lists of analytes, the largest 10 peaks of nontarget compounds detected should be reported out as tentatively identified compounds (TIC).

Page 42, Section 6.1.8: Metals. Alternative methods should be specified when low level concentrations are needed to detect at or below MCL (i.e. arsenic, lead, selenium). Mercury is not listed. Should it be?

Page 44, Section 6.1.11: Geochemical Analyses. The analytes should be correlated to soil type as logged. Some laboratory soils classification should be conducted as quality control over the field classifications.

Page 47, Table 6-14: Field Equipment Calibration. Calibration frequency for the Specific Electric Conductance Meter (EC) calls for use of a calibration gas. What gas is used to calibrate the EC?

Page 67, Section 8.2: Corrective Action Procedures. Documentation procedure of corrective actions should be described. It is suggested that a one page form be used which documents when a problem is identified and by whom, action taken, and confirmation that the problem was solved. This should become a part of the quality assurance reports.

Page 70, Section 9.3: Final Field Investigation Report. The significant QA problems encountered section should be expanded to include a summary of the QA portions of the progress reports. At the very least this summary should be found with the final data/report package in some form.

Comments and Recommendations

The above comments are submitted for consideration. It is important that the overall accuracy and precision needs for the project be discussed based on the final use of the data. The specific analytical methods and necessary detection levels depend on clearly identifying the contaminants of concern. As more information is obtained changes may be necessary.

Overall the major elements for an adequate quality assurance plan are contained in this plan. It should be approved after considering the comments.

LONG-TERM GROUND WATER MONITORING PROGRAM GUIDANCE

Prepared for:
THE CALIFORNIA BASE CLOSURE ENVIRONMENTAL COMMITTEE

Submitted by:
SITE CHARACTERIZATION PROCESS ACTION TEAM

MARCH 1994

PREFACE

The Base Realignment and Closure Act (BRAC) encourages the timely restoration and earliest possible reuse of military properties. The state of California, faced with the closure of many military bases, recognized the need to establish a base closure environmental committee to foster an ongoing dialogue and exchange of ideas between federal and state governmental bodies responsible for ensuring that closure and transfer occur in an environmentally safe and expeditious manner. Accordingly, the California Base Closure Environmental Committee (CBCEC) was formed. The committee includes representatives of the California Environmental Protection Agency (Department of Toxic Substances Control, the State Water Resources Control Board, and the Regional Water Quality Control Boards); the Governor's Office of Planning and Research; U.S. Environmental Protection Agency's Region IX office; the Departments of the Army, Navy, and Air Force; and the Department of Defence. The CBCEC's ultimate goal is to address issues affecting timely cleanup and reuse of closing military bases and to identify methods and techniques that promote accelerated restoration and expedited transfer of BRAC properties.

To help expedite completion of the committee's mission, it created several ad hoc subcommittees, called process action team (PAT), to investigate specific issues and to report back to the CBCEC with conclusions and recommendations. In several instances, PATs concluded that CBCEC sponsored guidance documents would provide the most appropriate means to expedite the safe closure and transfer of military bases. This manual is one of those documents.

Because the issues investigated by the Site Characterization PAT, the Technology Matching PAT, and the Mixed Waste PAT are interrelated, the guidance manuals developed by these PATs are intended to be complementary and should be used together when appropriate. To date, the Site Characterization PAT has produced two manuals entitled ***Recommended Content and Presentation of reporting Hydrogeologic Data During Site Investigations*** and ***Long-Term Ground Water Monitoring Program Guidance***, which are directly related to each other, and the Technology Matching PAT has produced a manual entitled ***Treatment Technologies Applications Matrix for Base Closure Activities***, which should be used in conjunction with the other two guidance manuals. In addition, these guidance manuals will be supplemented with Tech Memos that will be developed as circumstances and technological considerations dictate.

The first document developed by the Site Characterization PAT, ***Recommended Content and Presentation for Reporting Hydrogeologic Data During Site Investigations***, specifies data content and presentation methods needed to support hydrogeologic investigations. The document calls for ongoing development and review of hydrogeologic technical memoranda (Tech Memos) as an investigation progresses. The Tech Memos provide for development and

ongoing amendment of site-specific and installation-wide working hydrogeologic models to guide site investigations.

The second document, ***Long-Term Ground Water Monitoring Program Guidance***, calls for developing a ground water sampling plan to economically provide ground water elevation and chemical data needed to support site investigations, feasibility studies, remedial designs, remedial actions and long-term operation and maintenance activities. The document emphasizes development of a dynamic sampling program that provides for amendment of sampling frequencies and constituents analyzed to reflect changing data needs as a project progresses. The document provides for Quarterly and Annual Reports as the mechanism for reporting ground water elevation and chemistry data.

The Tech Memo, and the Quarterly and Annual Reports should be incorporated into one submittal to prevent the duplication of data reporting and evaluation. The content of this submittal will vary according to the hydrogeologic work performed during the reporting period. The minimum reporting requirement is the Quarterly and Annual Reports.

ACKNOWLEDGEMENTS

This document was made possible by the collaborative efforts of the members of the Site Characterization Process Action Team:

James Cornelius (Chair)	Cal EPA/State Water Resouces Control Board
Antonia Vorster Victor Izzo * Diane Nork	Cal EPA/Regional Water Quality Control Board
Mark Vest John Woodling	Cal EPA/Department of Toxic Substance Control
Jim Brown	United States Navy
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Any questions concerning the general use of this document should be directed to Bud Eagle (916) 227-4363.

LONG-TERM GROUND WATER MONITORING PROGRAM

Table of Contents

I. INTRODUCTION 1

II. GROUND WATER MONITORING PLAN CONTENT

A. Background Information 1

B. Sampling Plan 2

1. Establishing Background Water Quality Conditions 2

2. Frequency of Water Level Measurements 3

3. Constituents Analyzed 3

4. Sampling Frequency 4

5. Inspection and Well Maintenance 5

6. Sampling Schedule 5

C. Field Procedures 5

D. Quality Assurance/Quality Control Plan 5

E. Data Management Plan 6

F. Statisical Analysis 6

G. Reporting 6

1. Quarterly Report 6

2. Annual Report 7

H. Appendices 8

1. Water Elevation Data 8

2. Ground Water Quality Data 9

3. Physical Data 9

4. Field Procedures Sections 9

5. Quality Assurance/Quality Control Plan Sections 9

I. INTRODUCTION

The Long-Term Ground Water Monitoring Program is a strategy for assessing ground water contamination. This document provides guidance for developing and implementing a Long-Term Ground Water Monitoring Plan as the formal mechanism and timetable for assessing extent and movement of ground water contamination.

The Long-Term Ground Water Monitoring Plan provides rationale and scope for continuing ground water monitoring throughout Remedial Investigation/Feasibility Study (RI/FS), Remedial Design (RD), and Remedial Action (RA) phases. The plan produced according to this guidance should be reviewed and updated at least annually, and more often if necessary to remain consistent with progress on the RI/FS, RD and RA. Updates should evaluate the objectives and goals of the monitoring effort as site investigation moves to remediation. Implementation of the plan should meet the following objectives:

- Identify the lateral and vertical extent of groundwater contamination;
- Track rate and direction of horizontal and vertical plume movement, to determine the impact on beneficial uses and the threat to nearby receptors;
- Provide a long-term ground water monitoring strategy that includes the constituents of concern, monitoring locations, frequency, and analytical methods;
- Develop a program which has documentable quality assurance/quality control (QA/QC) and defined procedures for sample collection, analysis, and well maintenance;
- Specify a method and frequency for collecting ground water level measurements to perform hydraulic analyses that include the determination of flow directions, gradients, and potential seasonal variations in the hydraulic system;
- Improve understanding of the site hydrogeologic conceptual model;
- Validate and optimize the effectiveness of ground water remedial measures;
- Determine when remedial objectives have been met;
- Ensure ground water sampling is performed in a cost effective manner;
- Provide a system for effective data management.

II. GROUND WATER MONITORING PLAN CONTENT

A Ground Water Monitoring Plan should address the ground water monitoring needs of the entire installation, and account for sampling objectives that result from different site-specific conditions and stages of investigation and remediation. The following information should be addressed in the plan.

A. Background Information

Background information should include past chemical uses and previous ground water investigations at the installation. In addition, individual site and facility-wide hydrogeological conceptual models should be presented. The following are subjects to be covered in narrative form, supported by summary tables or graphics where appropriate.

1. Overview of regulatory framework, history of site operation (including chemical use and waste disposal), previous investigations and remedial measures.

2. A presentation of the working hydrogeological model. This is necessary to support ground water sampling and analysis, and should include the following:

   a. Site stratigraphy and aquifer designation (supported by hydrogeological cross sections).
   b. Monitoring, water supply, and other wells, including site map with well locations. For sites with multiple aquifers a well map should be constructed for each aquifer.
   c. A table with rationale for monitoring well locations, along with the site map featuring well placement.
   d. Ground water flow direction in each aquifer (supported by potentiometric surface maps)
   e. Site hydrogeological conceptual model. (This section should discuss the interpretation of the existing data with respect to the interaction between aquifers and relative rates of ground water and contaminant movement.)

3. History of ground water monitoring (include data summary for each well as an appendix).

4. Nature and extent of ground water contamination, specifically:

   a. Description of the ground water contaminants present
   b. Description of individual ground water contamination plumes (with isoconcentration maps)
   c. Other sites at the facility with related contamination

5. An evaluation and discussion of data gaps.

Discussions of the above subjects should be supported by graphical data presentation such as isoconcentration maps, ground water elevation contour maps, water elevation hydrographs, and cross-sections. Graphical presentation detail is presented in *Recommended Content and Presentation for Reporting Hydrogeologic Data During Hazardous Waste Site Investigations*, The California Base Closure Environmental Committee, August 5, 1993.

B. Sampling Plan

The Sampling Plan should describe the rationale for selecting particular monitoring wells for sampling, constituents to be analyzed, and the sampling frequency. The Sampling Plan should also provide criteria for a systematic decision process that would be used every year to update the Ground Water Monitoring Plan. The following are the minimum components of the Sampling Plan.

1. Establishing Background Water Quality

   Background conditions are used as a baseline to evaluate water quality potentially impacted by installation operations. Background conditions should be established by:

a. Using monitoring wells upgradient of any possible contaminant discharge by the installation;
b. Obtaining ground water samples representative of each water bearing zone that is impacted or threatened;
c. Sampling upgradient wells for a broad spectrum of constituents, such as minerals, metals, chemical of concerns, etc.;
d. Obtaining sufficient number of samples for statistical analysis.

2. Frequency of Water Level Measurements

Water level measurements should be taken to establish installation wide and site specific ground water gradients. These measurements would be used to determine the relationship between the monitoring well and a plume (side, cross-gradient, or other); the position of new wells to fill data gaps; seasonal variations; and the capture zone of a ground water treatment system. Guidelines for the frequency of taking water level measurements are as follows:

a. Initially, water levels should be measured monthly in all monitoring wells at the site for a minimum of one year. This should establish an indication of seasonal variations and a baseline to evaluate future ground water gradients.

b. Water levels should be measured prior to purging any well.

c. All water levels should be obtained within as short a time period of each other as practicable.

d. The frequency of water level measurements should be considered for reduction if variation of flow direction and rate has been quantified. Reducing the frequency of measurements to quarterly after one year is recommended.

Note that the frequency of water level measurements should be dependent on local climatic, cultural, and hydrologic conditions and other site specific objectives to the program. Examples of conditions to consider include but are not limited to:

- More frequent measurements during wet season to understand the effects of precipation;
- Irrigation patterns;
- Proximity to a stream or river;
- Tidal influences.

3. Constituents Analyzed

This section of the Sampling Plan should identify the constituents to be analyzed at each site and the analytical method and detection limits to achieve data quality objectives. A systematic decision process should be established by means of a logic diagram (decision tree). The following are recommendations for decision criteria:

a. Proposed constituents should be based on chemicals used or disposed at the si. and associated breakdown products, beneficial uses of ground water, and results of past sampling and analyses.

b. Analytical methods should provide detection limits to satisfy regulatory requirements.

4. Sampling Frequency

A systematic decision process should be developed with a logic diagram. Figure 1 shows an example decision tree, but the decision should be site-specific and rationale should be presented. The decision process will provide an objective approach to removing or adding constituents or wells and changing sampling frequency. Sampling frequency should be consistent with all other non-CERCLA sampling requirements. The following guidelines are provided as a starting point in the development of the decision process:

a. New Wells - All new wells should be incorporated into the monitoring system and sampled quarterly for at least four consecutive quarters. Additional quarterly sampling should be conducted if wide fluxations are observed.

b. Downgradient Wells - Quarterly sampling should be conducted to monitor the downgradient margins (leading edges) of a contaminant plume. Downgradient wells should be selected for each water-bearing zone impacted or threatened, and for each specific contaminant plume.

c. Guard Wells - Quarterly sampling should be conducted of wells used as an early warning to detect contaminants for the protection of private and municipal wells.

d. Wells in Plume - Semi-annual sampling should be conducted to monitor highly contaminated interior portions of a plume that have shown little variation in contaminant concentrations during the previous year.

e. Crossgradient Wells - Semi-annual sampling should be conducted if supported by consistent ground water flow direction; semi-annual sampling of crossgradient wells should be designed to monitor the lateral margins of a plume.

f. Background Wells - Annual sampling should be conducted to monitor background water quality.

g. Where adjacent wells are screened in the same water-bearing zone, one may be sampled at a reduced frequency after demonstrating that the two wells are providing redundant data. The demonstration should be based on an assessment of water chemistry, potentiometric data, and stratigraphy in the vicinity of the wells.

h. Every 24 to 36 months, samples from each well should be analyzed for all constituents historically detected in ground water or soil at a specific site.

i. Upon activation or deactivation of an extraction system, samples should be obtained and analyzed from each well comprising the extraction and monitoring system, and thereafter quarterly for at least four consecutive quarters. More frequent sampling may be required during startup.

j. If a well is determined unnecessary and it is anticipated that the well will not be used during any time during the monitoring program, that well should be proposed for abandoment according to relevant regulations.

5. Inspection and Well Maintenance

a. The condition of wells should be inspected at each sampling event, but not less than annually.

b. Specific well conditions to check:

- Surface seal
- Well locks
- Casing integrity
- Total depth of well
- Any other relevant conditions

c. Any necessary repairs should be made prior to the next quarterly sampling event.

d. If a well can not be properly repaired, it should be replaced or abandon.

6. Sampling Schedule

a. A proposed first year sampling program should be incorporated into the Sampling Plan. The sampling program would be based on the above systematic decision process.

b. A sampling schedule should be prepared showing dates on which sampling will occur.

C. Field Procedures

The Long-Term Ground Water Monitoring Plan should include standard operating procedures for the field activities necessary to meet the objectives of the ground water monitoring program. A Field Sampling Plan (FSP) should have been developed for the facility (See *EPA Interim Final Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA,* October 1988). Relevant sections of the FSP should be provided as an appendix to the Long-Term Ground Water Monitoring Plan. If not developed, a FSP should be developed as part of this Long-Term Ground

Water Monitoring Plan. The FSP should include detailed procedures for water level measurement, purging, sampling, sample preservation, and well abandonment to be followed by field personnel.

D. Quality Assurance/ Quality Control (QA/QC) Plan

A Quality Assurance Project Plan (QAPP) should have been developed for the facility. Relevant sections of the QAPP should be provided as an appendix to the Long-Term Ground Water Monitoring Plan (See *EPA Interim Final Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA*, October 1988). If not developed, a QA/QC Plan should be developed as part of this Long-Term Ground Water Monitoring Plan

E. Data Management Plan

A Ground Water Data Management Plan should be developed describing the methods that will be used to manage all ground water data. The Data Management Plan should assure the data are organized based on site-specific information, are easily retrievable, and are entered into the system on a regular basis. The Data Management Plan must also consider future needs for manipulation of data and ongoing reporting needs (refer to Section B). An electronic copy of the data and software used to create tables and graphics should be available at the facility on software agreed to by the project team. This data should be provided to regulatory agencies upon request.

F. Statisical Analysis

Statisical methods should be used to evaluate water quality data. They should be described in Long-Term Ground Water Monitoring Plan. The sampling plan should identify the type and amount of data required by the statistical methods to be used.

G. Reporting

The reporting requirements discussed below focus on water level and water quality data. However, during periods of site investigation and remediation when other hydrogeologic data are generated (boring logs, well construction, etc.), these additional data need to be reported and evaluated with respect to the site model as described in the August 5, 1993 *Recommended Content and Presentation for Reporting Hydrogeologic Data During Site Investigations.* Technical Memorandums (Tech Memos) described in the above document, and Quarterly and Annual Reports described below should be submitted together as a single document. The content of this submittal will vary according to the hydrogeologic work performed during the reporting period, the Quarterly and Annual Reports being the minimum requirements for reporting.

1. Quarterly Report

The Quarterly Report is a written data presentation including a brief discussion and interpretation of the last quarter's sampling results. The last quarter's data, in summary table form, should include the following:

a. Water level data

b. Water quality data

c. Map or maps showing ground water elevation contours and contaminant concentrations, with isoconcentration contours (individual maps should be provided for each separate water-bearing zone)

d. Brief discussion or summary of the following:

1) Data collection problems and deviations from plan
2) Data anomalies
3) Obvious changes in water levels and water quality
4) Recommendations (if any) for future actions and improvement to the monitoring program

e. A summary of the QA/QC results, and in the case of cleanup, a summary of remediation system(s) operation and effectiveness

f. Field sampling logs and records

2. Annual Report

An Annual Report should include a detailed evaluation and discussion of the analytical data and results of the past four quarters, a discussion of anomalous data, and an evaluation and discussion of site-wide hydrogeologic data and remediation system(s). The Annual Report should:

a. Present and discuss changes in aquifer(s) potentiometric levels and gradients, and:

1) Incorporate the last four quarters of data with all the past years' data, and present this compilation in tabular form (include in appendices [see section H]). The table should include the elevations of well screen and filter pack intervals.

2) Update hydrographs for each well and present the last four quarters of ground water elevation contour maps (potentiometric surface maps) (include in appendices [see section H]),

3) Discuss potentiometric results (trends should be identified and discussed, and supported by hydrographs and ground water elevation maps).

b. Present water quality data with a discussion of plume(s) configuration, and:

1) Incorporate the last four quarters of data with all the past years data and present the compilation in tabular form (include in appendices [see section H]).

2) Provide an updated assessment of the nature, extent, and rate of migration of ground water contamination.

3) Discuss analytical results and identify and discuss trends.

c. Discuss any changes in the hydrogeologic conceptual model and update cross-sections based on well logs from new wells or borings.

d. Evaluate and discuss ground water remediation systems, such as:

1) The effectiveness of plume capture by the existing system(s),

2) Modifications to pumping regimes if necessary, including the addition of new wells to maintain hydraulic control, and

3) Effectiveness of remediation systems supported by graphs and tabular summaries.

e. Identify data gaps and potential deficiencies in the monitoring system or reporting program based on the above data.

f. Update the ground water Sampling Plan for sampling frequency and analyses. The update should:

1) Propose the subsequent revised sampling program using the systematic decision process developed in the ground water sampling plan.

2) Provide support for the adequacy of the proposed sampling.

H. Appendices

The appendices to the plan should be updated annually. Tables and graphics should be updated and presented in the annual report. The appendices should contain all hydrogeological and water quality data. The following should be included in the Ground Water Monitoring Plan appendices at a minimum:

1. Water Elevation Data

    a. Water elevation data presented by well in tabular form with historical data

    b. Ground water elevation contour maps

    c. Hydrographs (including precipitation data)

2. Ground Water Quality Data

    a. Water quality data presented by well in tabular form with all historical data

    b. Plot contaminant concentration versus time for each well and constituent

    c. Isoconcentration maps

    d. Cross section with concentration profiles

3. Physical Data

    a. All geologic cross-sections

    b. Well Locations and boring/well logs

        1) Facility wide map with well locations

        2) Site maps with well locations

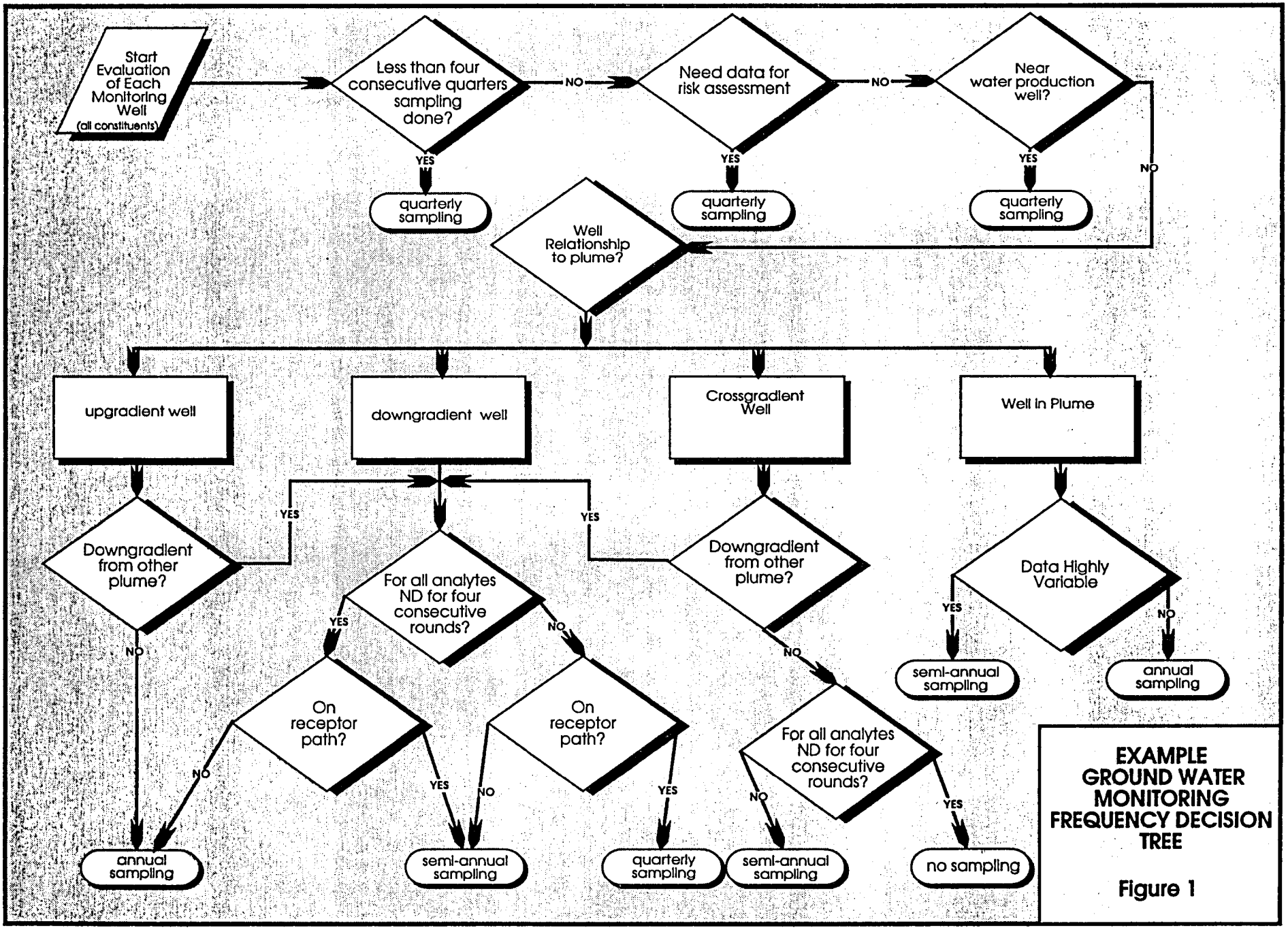
        3) Boring and well construction logs

        4) Well construction summary tables

    c. Structure contour maps

4. Field Procedures Sections

5. QA/QC Plan Sections



EXAMPLE GROUND WATER MONITORING FREQUENCY DECISION TREE

Figure 1