

**RESPONSE TO REGULATORY COMMENTS ON DRAFT SITE ASSESSMENT/EXTENDED SITE ASSESSMENT REPORT
FOR 18 POINTS OF INTEREST, NAVAL TRAINING CENTER, SAN DIEGO, CALIFORNIA
CTO-0122**

N00247.000491
NTC SAN DIEGO
SSIC # 5090.3

Comments from Martin Hausladen

Written on 15 August 1997

Mr. Martin Hausladen
United States Environmental Protection Agency

COMMENTS

Comment 1: Sections 2.4.1 and 2.4.2. It would be helpful to provide a map with topographic contours. This would help the reader understand text references (e.g., the "flat area that may represent a natural terrace" and the reference to the topographic slope break).

Comment 2: Sections 3.5.1 and 3.5.2. Please specify the filter size and method.

Comment 3: Analytical tables in Section 4 only present concentrations above detection limits, leaving many table fields blank. Non detect results (e.g., < 0.5 mg/kg) should also be included in the tables. If a compound was not analyzed for a particular sample this should be indicated with NA.

Comment 4: At many sites arsenic was detected at concentrations exceeding the project-specific threshold level. However, the report attributed the arsenic to natural processes since the arsenic was generally detected within "background" concentrations established in several other investigations. Please provide a summary and discussion of these investigations and an analysis of their applicability to the NTC study area. A comparison of the geologic units used to establish the background levels to geologic units in the NTC study area should be included.

Response 1: Please refer to Figure 2-5, Northern NTC Cross Section, for a view of the elevation changes across the base. This figure shows the text references, including the "natural terrace."

Response 2: All samples for metals analyses were filtered using a 0.45-micron filter that was placed in-line with the peristaltic pump used for the collection of the samples. These specifications will be given in Sections 3.5.1 and 3.5.2.

Response 3: For clarity the tables in Section 4 are presented showing only the analytical results reported above the detection limits. The complete tables of all analytical results including those reported below the detection limits are presented in Appendix H. If all results, including those below the detection limits, were reported in the tables, they become difficult to read and understand due to the increased size. As requested by the Regional Water Quality Control Board (RWQCB) and agreed to by the Navy, Table 4-18 only will be revised to include nondetect results for those analytes with at least one result reported above the detection limit.

Response 4: NTC is located on the western slope of the Point Loma Peninsula. Part of the base is located on the in-place or slope deposits derived from the Bay Point Formation, a sequence of shallow marine, estuarine sediments. The lower (eastern) part of NTC is situated on dredged material from San Diego Bay, hydraulically placed over the salt marsh and salt flat deposits in the old mouth of the San Diego River.

Two other Navy bases in the San Diego area have substantial portions of their land surface made up of fill hydraulically dredged from San Diego Bay - Naval Air Station North Island, and Naval Station San Diego. Both of these bases have had background studies performed for the hydraulic fill material.

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Comment 4 (continued)**Response 4 (continued)**

At the Naval Station San Diego, 210 uncontaminated samples were statistically analyzed, and the 95th percentile of the arsenic concentrations was selected, in conjunction with regulatory agencies, as the background. At the Naval Station San Diego, 210 uncontaminated samples were statistically analyzed, and the 95th percentile of the arsenic concentrations was selected, in conjunction with regulatory agencies, as the background threshold. This threshold value was 9.05 mg/kg. (BNI 1996a)

At the Naval Air Station North Island, immediately across San Diego Bay from NTC, 56 specifically selected "background samples" were analyzed for arsenic and the data were statistically analyzed. The 99th percentile of the arsenic concentrations was chosen, in conjunction with regulatory agencies, as the background threshold. This threshold value was 5.62 mg/kg. (JEG 1995)

A specific background study has not been performed for the various members of the Bay Point Formation (i.e., fine-grained shaley layers and coarser layers), but some data are available from studies at several sites on Point Loma. In particular, a fine-grained sample from approximately 40 feet below ground surface, with no contamination above it, exhibited 57 mg/kg of arsenic. Coarser-grained samples from the same location, as expected, had concentrations of arsenic generally less than 10 mg/kg. (BNI 1996b)

US EPA opinions are expressed in a 1992 "Issue Paper" titled "Options for Addressing High Background Levels of Hazardous Substances at CERCLA Sites". Among others, they refer to a 1975 US Geological Survey study designed to help with the issue of natural metals concentrations for various regions of the United States (Conner and Shacklette 1975), and a Journal of Environmental Quality article on Selenium, Fluorine and Arsenic (Shacklette et al. 1983). Looking at these references, the natural range of arsenic for the U.S. is suggested to be <0.2 to 97 mg/kg and the mean value for the western U.S. is estimated at 6.1 mg/kg.

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Comment 4 (continued)

Comment 5: Section 4.4., pg. 4-10, paragraph 1. The second sentence is not written clearly. The sentence should state how risk was estimated using the maximum detected concentration and the PRG.

Comment 6: Section 4.4, p. 4-11, paragraph 3. A tidal mixing factor of 30 is overly optimistic because several invalid assumptions were used in the methodology as presented in Appendix A. It is possible that tidal dilution within the aquifer can influence chemical concentrations prior to discharge to marine water, but unlikely that the mixing factor would be as high as 30. A general discussion of the tidal mixing and how it could influence chemical concentrations and risk could be retained but references to specific mixing factors should be deleted.

Comment 7: Section 4.8.6, p. 4-42, second bullet. The text states "that soil and groundwater are not contaminated with chemicals associated with machinery operations or maintenance," but low concentrations of several organic compounds that may be associated with the site were detected. It would be more correct to state that the results of the investigation indicate that the contaminants detected at the site are at concentrations that do not present an excess risk and that the extent of contamination is limited.

Comment 8: Section 4.9.1, p. 4-43, paragraph 2. The Building 160 demolition date in the text does not match the demolition dates on Figures 4-9 and 4-10. Please clarify whether demolition occurred in 1984 or 1994 and revise either the text or the figures.

Response 4 (continued)

The project-specific threshold level for arsenic in soil is 0.38 mg/kg, which is the 1996 U.S. EPA Region IX PRG for residential land use. As discussed above, naturally occurring arsenic levels in soils in the San Diego area would be expected to exceed this extremely low value. For the 18 POIs investigated in the SA/ESA, the arsenic concentrations reported in soils are well within the expected background arsenic levels found in the San Diego area.

References to the documents cited above are included as Attachment A.

Response 5: The text will be revised to state that detailed information about the procedures and results are included in Appendix I.

Response 6: All references to the tidal mixing factor will be removed from the Final Report. However, it should be noted that the tidal mixing factor and the discussion regarding it was included in the SA/ESA Work Plan, which was reviewed and approved by the regulatory agencies. It is an essential part of any investigatory program to produce reports which are consistent with the procedures (especially DQOs) defined and agreed to in work plan documents.

Response 7: The bullet will be reworded to state that the contaminants do not present an excess risk and the extent of the reported contamination is limited.

Response 8: Building 160 was demolished in 1994. Figures 4-9 and 4-10 will be revised to the appropriate date.

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Comment 9: Section 4.10.2, p. 4-58, paragraph 1. Please clarify the number of wells used for the SVE system.

Response 9: Sentence 4 in paragraph 1 will be revised to state: "According to a report by OHM, ... 14 wells are being utilized for the SVE system. Of these 14 wells, 7 wells are located within Building 228, and 7 wells are located on the northwest and northeast sides of the building."

Comment 10: Section 4.11.6, p. 4-81, first bullet. Please show IRP Site 2 well MW-3 on Figures 4-15 and 4-16.

Response 10: Figures 4-15 and 4-16 will be revised to show IRP Site 2, well MW-3.

Comment 11: Section 4.12.6, p. 4-88, second bullet. The project-specific threshold level was incorrectly used as an indication of whether a release did or did not occur. Small releases or releases that have dissipated could result in the detection of analytes at concentrations below the project-specific threshold levels. Petroleum hydrocarbons are most likely not natural. Please change this bullet to indicate that the results of the investigation indicate that releases at the site, if they occurred, resulted in minimal contamination.

Response 11: The second bullet will be revised to read, "Based on the comparison of the soil and groundwater sample concentrations with project-specific threshold levels, contaminants at POI 19 do not present an excess risk, and the extent of the reported contamination is limited."

Comment 12: Section 4.16.6, p. 4-128, second and third bullets. There is some evidence for small releases of contamination to soil and groundwater. Toluene and TRPH were detected in soil and the solvent trichlorofluoromethane was detected in groundwater. Please revise these two bullets to indicate that there is evidence for small releases.

Response 12: The bullet will be reworded to state that although the contaminants are present, they do not present an excess risk, and the extent of the reported contamination is limited.

Comment 13: Figure 4-31, p. 4-134. Two samples were collected at location P72-B1. However, the results from only one sample are shown. Please include all analytical results on this figure.

Response 13: The results from the surface soil sample taken at P72-B1 were inadvertently omitted from the figure and will be added.

Comment 14: Figure 4-33, p. 4-139. The analytical results for P76-B1 are presented in a confusing format. Two sets of results for xylenes and toluene are presented for soil samples even though duplicate soil samples were not collected. Please change the presentation of the data to eliminate this confusion.

Response 14: The presentation of the groundwater results will be changed to eliminate the apparent confusion.

Comment 15: Section 4.18.5, p. 4-140, last paragraph. Comparisons of analyte concentrations to project-specific threshold were incorrectly used as an indication of whether a release occurred. Project-specific threshold levels are an indication of risk regardless of whether a release occurred. Please correct the statement.

Response 15: The sentences will be reworded to read, "Concentrations of toluene and xylenes reported above detection limits in groundwater were significantly below project-specific threshold levels and were also reported in the associated method blanks. Therefore, due to the absence of TPH reported in both soil and groundwater and the very low concentrations of xylenes and toluene reported in groundwater, there is ..."

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Comment 16: Section 4.19.5, p. 4-146, paragraph 3. The last sentence of the paragraph is poorly written. Threshold levels are incorrectly used as an indication of releases and the sentence seems to imply that soil and groundwater results can be ignored as an indication of a release because there is a "lack of other indications of a release." Please rewrite this sentence.

Comment 17: Section 4.22, Figure 4-40 and Tables 4-18 and 4-19. The distinction between filtered and unfiltered sample results is central to the analysis of the groundwater data. Please clearly distinguish between filtered and unfiltered sample results on these tables and figures; if unfiltered data is not included, please provide this data so the reader can compare concentrations of filtered and unfiltered metals.

Comment 18: Section 4.22.5, p. 4-176, paragraph 3. The text states that the detected concentration of hexavalent chromium exceeds the project-specific threshold level in one sample; however, this sample could not be found on Table 4-18. Please clarify.

Comment 19: Section 4.22.5, p. 4-179, paragraphs 1 and 2. Copper and zinc were used as historic antifouling additives to paint. Locations where painting or sandblasting of marine equipment was done, where paint was stored, or where spent sandblast abrasive or dredge were used as fill would likely have elevated levels of copper and/or zinc. These contaminants would be detected in groundwater from the impacted area and in downgradient monitor wells.

Comment 20: Appendix A, page A-13, Tidal Mixing Factor Equation. There are many assumptions implied in the tidal mixing method which are not discussed. These assumptions should be stated so that applicability of these assumptions to site-specific conditions can be evaluated. Some of these assumptions appear to invalidate the method used to calculate the tidal mixing factors. The principal objections to the tidal mixing method are listed below:

- a) The marine-aquifer boundary is assumed to be a vertical boundary. It is more likely that the boundary will be a sloping boundary and not a vertical boundary. A sloping boundary condition would reduce the tidal flux to the aquifer.

Response 16: The last sentence will be rewritten to read, "However, these metals are not typically associated with printing facility activities and are not reported above threshold levels in the soil. The soil and groundwater results indicate that activities conducted at Building 11 have not resulted in a release to soil or groundwater at POI 85."

Response 17: All groundwater samples collected for metals were filtered. There are no unfiltered groundwater metals data from this investigation. Figure 4-40, Tables 4-18 and 4-19 will be revised to clarify this fact.

Response 18: Hexavalent chromium was reported above the detection limit in one of the groundwater samples, but it was below the project-specific threshold level. The sentence has been revised to read, "Of the 14 samples collected (13 direct-push and 1 monitoring well), aluminum (5 samples), copper (3 samples), and zinc (2 samples) exceeded"

Response 19: Comment noted.

Response 20:

- a) For purposes of calculating the tidal flux to the aquifer, the aquifer flow is assumed to be at a right angle to the marine-aquifer boundary which is assumed to be vertical. This assumption is valid even though it is a simplification of the actual boundary conditions. While the tidal flux is reduced by the actual angle of the sloping marine-aquifer boundary (by the sin of alpha) the aquifer flux is proportionally reduced by the same angle; therefore, while the vertical marine-aquifer boundary is a simplification, it is a valid assumption.

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- b) The methodology used to calculate a specific tidal mixing factor assumes complete mixing of fresh groundwater and saline marine water within the aquifer. This is highly unlikely due to the density differences between the relatively fresh groundwater and saline marine water. It is more likely that groundwater and marine water will not mix than that complete mixing will occur; therefore, the calculated tidal mixing factors, if not invalid, are extremely optimistic.
- c) The method appears assumes almost instantaneous mixing at the aquifer boundary. The tidal flux is a function of the distance from the marine/aquifer interface (x), where the greater the distance (x), the lower the tidal flux value and lower the calculated tidal mixing factor. The instantaneous mixing assumption seems unreasonable.

- b) Tidal flux of marine water into the freshwater aquifer occurs with the natural diurnal tidal changes. The tidal-mixing factor depends on the characteristics of the tide and the hydraulic characteristics of the groundwater system. During the flood tide, the amount of influence tidal flux has on the aquifer varies on a gradient based on the distance from the boundary interface. This gradient indicates mixing of marine and freshwater, despite the differences in water density, with the greatest degree of mixing taking place closest to the boundary. During the ebb tide, this mixed water is discharged to the marine system. Therefore, over a complete tidal cycle, the average value is as calculated regardless of the degree of mixing. Also, since the water quality objectives used to determine compliance with the Ocean Plan or the Enclosed Bays and Estuaries Plan are to be applied to 3-day or 30 day averages, the average value, as calculated, is appropriate. The equations presented in Appendix A, page A-13 were used to calculate this mixing factor within the aquifer.
- c) The method used to calculate the tidal mixing factor does not assume almost instantaneous mixing at the aquifer boundary. As stated in Comment 20, part b mixing is assumed to occur within the aquifer over the period of a complete tidal cycle. Based on the calculation, a tidal mixing factor of 30 is estimated to occur in the sediments during one complete tidal cycle.

Comment 21: Appendix A, page A-13, Tidal Mixing Factor Equation. The tidal mixing factor does not appear to be necessary to recommend no further action, so EPA recommends that all references to the tidal mixing factor be deleted from the SA/ESA.

Comment 22: Appendix G. The original GPR records or traces referenced in the last sentence of the first page of the NORCAL letter were not included in Appendix A of the geophysical letter report.

Response 21: See response to Comment 6.

Response 22: As noted on the cover page of Appendix F, the NORCAL GPR records and traces (originally Appendix D) were not included in the SA/ESA report. The original GPR records and traces did not contribute to the conclusions.

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Comment 23: Appendix G. The daily field reports (Appendix D) of the letter report were not included, and the text does not include a discussion of calibration procedures or base-station procedures. Please discuss procedures used to set up and calibrate the magnetometer. Also discuss whether base station readings were made, the frequency of those readings, and the location of the base station. Since only gradiometer measurements were made, base station measurements for diurnal variation are unnecessary, but are often useful to evaluate cultural interference.

Comment 24: Appendix G. The plates from two investigation reports were mixed together and Plate 2 from the first investigation report was missing. It would be much easier to understand the geophysical report if the second report and associated figures were together in one place and either preceded or followed the first report.

Comment 25: Appendix H. Please provide an explanation of abbreviations and data qualifiers at the beginning of the analytical tables.

Response 23: Daily calibration was performed as indicated on the attached NORCAL "Equipment Functional Checks" sheet (Attachment B). Calibration records are contained in the survey electronic file and were not included in the report. Daily reports and calibration records are available for review by advanced notice from the files at the NORCAL office.

Response 24: The main report and supplemental report were combined to avoid duplication in the Draft SA/ESA. They will be included as separate reports in the Final SA/ESA report, as requested.

Response 25: Explanations of the abbreviations and data qualifiers will be included at the beginning of the Appendix H analytical tables in the Final SA/ESA.

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Comments from Aaron Yue

Written on 17 September 1997

Mr. Aaron Yue
Remedial Project Manager
California Environmental Protection Agency
Department of Toxic Substances Control

SPECIFIC COMMENTS

Comment 1: page 4-10, second to last paragraph, **Cancer Risks.** Cancer risk between 1×10^{-4} and 1×10^{-6} is considered to be within risk management decisions which must be justified by the assumed use of the property, and other exposure factors. It should not be categorized as "generally acceptable." Rationale for "No Further Action" based on potential exposure should be included for all POIs within this risk range.

Comment 2: page 4-10, last sentence of page. Typographical error, please remove "a" before "present."

Comment 3: page 4-11, third paragraph, **Tidal Mixing Factor.** DTSC does not agree with the use of Tidal Mixing Factor of 30 times the concentrations of the Bay and Estuaries Plan. The issue was discussed and resolved during the BRAC Cleanup Team's review of the result for POI 38 (Steam Tunnels). DTSC will, however, defer the final decision on the appropriateness of the use of tidal mixing factors to the Regional Water Quality Control Board (RWQCB).

Comment 4: page 4-131, Section 4.17.3, first paragraph. Typographical error on spelling of "Southeast."

Response 1: The first sentence of the fourth paragraph will be reworded to state: "...one additional cancer risk in 1,000,000 to one additional cancer risk in 10,000 (1×10^{-6} to 1×10^{-4}) is considered 'generally acceptable' after a thorough review of numerous exposure factors; and less than" Section 4.5, Conclusions and Recommendations, discusses the criteria that was reviewed for each POI where applicable, and incorporated in the "Further Action/No Further Action" recommendations.

Response 2: The "a" will be removed.

Response 3: All references to the tidal mixing factor will be removed from the Final Report. However, it should be noted that the tidal mixing factor and the discussion regarding it was included in the SA/ESA Work Plan, which was reviewed and approved by the regulatory agencies. It is an essential part of any investigatory program to produce reports which are consistent with the procedures (especially DQOs) defined and agreed to in work plan documents.

Response 4: The typographical error will be corrected.

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Comments from Aaron Yue

Comment 5: Appendix I, Table 1-2, Preliminary Remediation Goals (PRGs). The PRG values cited in Table 1-2 are consistently one order of magnitude greater than the EPA Region IX's published PRGs. Please verify the proper PRG values and recalculate the risks for the POIs as part of the Screening Risk Analysis.

Response 5: The PRGs listed as project-specific threshold levels (PSTLs) in Table 4-1 are correct and were those used in the risk assessment calculations. The risk calculations and risk numbers in Appendix I, Table 1-2 have been checked and are correct. The PRGs in Table 1-2 are indeed one order of magnitude greater. This is due to a problem with Microsoft software when a conversion is attempted between Excel and Word. During direct conversion between Excel and Word, numbers that are in exponential notation are increased by an order of magnitude. The calculations for the risk values were performed by an independent program outside of Excel and were inserted into the table after the conversion to Word. This software conversion problem was recently discovered. Table 1-2 will be revised to include the correct PRG values.

Comment 6: Summary of Conclusions and Recommendations. Since the RWQCB has been designated as the lead agency for underground petroleum storage tanks, DTSC will defer the final decision to agree or disagree with the findings of POI 69, POI 18, and POI 58 to the RWQCB.

Response 6: Comment Noted.

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Comments from John P. Anderson

Written on 16 October 1997

Mr. John P. Anderson
Senior Engineering Geologist, Site Mitigation and Cleanup Unit
California Regional Water Quality Control Board, San Diego Region

GENERAL COMMENTS

Comment 1: As discussed in previous NTC site assessment meetings and in written comments, the RWQCB does not concur with assumptions made in the "Tidal Mixing Factor" equation or its application to these sites. The Final SA/ESA should remove any reference to the "Tidal Mixing Factor" and its use as a project-specific threshold level (PSTL) criteria. As you may know, the RWQCB has established guidance for petroleum impacted sites in a guidance memorandum entitled "Interim Guidance on Required Cleanup at Low-Risk Fuel Contaminated Sites" dated April 1, 1996, revised February 29, 1996 [sic]. In the future please refer to this guidance in developing PSTL at petroleum impacted sites.

Response 1: All references to the tidal mixing factor will be removed from the Final Report. However, it should be noted that the tidal mixing factor and the discussion regarding it was included in the SA/ESA Work Plan, which was reviewed and approved by the regulatory agencies. It is an essential part of any investigatory program to produce reports which are consistent with the procedures (especially DQOs) defined and agreed to in work plan documents.

SPECIFIC COMMENTS

Comment 1: Page 4-4, Table 4-1, Project-Specific Threshold Level. "Chromium, total" groundwater Water Quality Criteria number should indicate "50 ppb," same as hexavalent chromium. Reference: Saltwater Aquatic Life Protection 4-Day Average, California EB&E Plan. Make change on all appropriate Tables.

Response 1: According to the California Enclosed Bays and Estuaries Plan, the value for hexavalent chromium for aquatic life may be used as an option for total chromium at the "discharger's" discretion. Chromium was speciated; thus the more stringent hexavalent chromium value for total chromium did not have to be used. Therefore, since chromium was speciated, no value for aquatic life exists for total chromium.

Comment 2: Page 4-9, Section 4.4, Threshold Levels and Risk Evaluation. Delete "local agencies" from reference of regulatory agencies with jurisdiction for regulation of petroleum hydrocarbon sites at NTC. The San Diego RWQCB maintains the lead on petroleum hydrocarbon sites at NTC.

Response 2: The first sentence of the fourth paragraph will be changed to, "Project-specific threshold levels have been developed for TPH and TRPH in soil and groundwater consistent with previous POI investigations at NTC, as well as with the County of San Diego SAM Division guidelines (SAM 1996)."

Comment 3: Page 4-11, Section 4.4, Threshold Levels and Risk Evaluation. The San Diego RWQCB does not concur with the use of a "Tidal Mixing Factor" for use in developing project-specific threshold levels.

Response 3: See Response to General Comment 1.

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Comment 4: Page 4-54, Section 4.9.6, POI 15/69. Provide an estimate of the volume of residual soil contamination left *in situ* and supporting data, drawings, etc. Include range and average concentration of TPH (specify carbon range), and BTEX data.

Response 4: An estimate of the volume of residual soil contamination left *in situ* has been made and is presented in the table at the end of this response. This table summarizes soil contamination for POIs 15/69, 26, and 58. Hydrocarbon contamination is related to two clusters of former underground fuel tanks. The tank locations on Figure 4-10 are scaled from small-scale maps and should be considered approximate locations. Attempts at using geophysics to identify the backfilled tank pits were unsuccessful due to disturbances caused by subsequent construction. Sampling has concentrated on an area downgradient from the actual tank locations, which have been largely covered by a building. Refer to Figures 4-10 and 4-11 for sampling locations and results.

Two tank locations at former Building 160 contained a maximum of 34.8 mg/kg TPH in an isolated sample (P15-B2), and will not be included in the volume estimate.

TPH was found in soil from two of four boreholes drilled downgradient from the former tank cluster under Building 195. Boring P69-B3 had a strong fuel odor over a 3-foot interval (13-16 feet). One of the three soil samples collected from this boring (14.9-15.5 feet) contained the maximum hydrocarbon concentration of 81,600 mg/kg at C₈-C₁₇. The other two soil samples, 0.5 feet above and 1.5 feet below this interval, had no detectable hydrocarbons. Borings offset 22 to 25 feet laterally had no more than 6.8 mg/kg in a zone of stained soil at the water table. This indicates a highly localized body of contaminated soil, possibly the floor of the tank pit itself. Benzene was not detected. Ethylbenzene was found at 17 mg/kg. Total xylenes were found at 53 mg/kg.

The volume of contaminated soil at POI 69 is estimated generously at twice the length and width of the nearest 550-gallon tank pit, or 30 by 20 feet, and 3 feet deep. This results in a volume of 67 cubic yards. Applying the average concentration of 40,800 mg/kg results in an estimate of 1,750 gallons of hydrocarbon, which vastly overestimates the volume. Applying a more realistic concentration of 5,000 mg/kg results in a estimated hydrocarbon mass of 215 gallons.

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Comment 4 (continued):

Comment 5: Page 4-75, Section 4.11.4, POI 18, third paragraph. Correct Appendix C reference to Appendix D, and in the fourth paragraph correct Appendix F reference to Appendix H.

Comment 6: Page 4-75, Section 4.11.5, POI 18. Indicate when constituents of concern with detection limits greater than the project-specific threshold levels are measured in groundwater (i.e., copper).

Comment 7: Page 4-89, Section 4.13.1, POI 26. Indicate distance site is located from Boat Channel (San Diego Bay).

Comment 8: Page 4-92, Section 4.13.6, POI 26. Provide an estimate of the volume of residual soil contamination left *in situ* and supporting data, drawings, etc. Include range and average concentration of TRPH, TPH (specify carbon range), and BTEX data.

Response 4 (continued):**Summary of Soil Contamination**

	POI 15/69	POI 26	POI 58
Soil Volume (cubic yards)	67	10	185
Average Concentration (mg/kg)	5,000	13,000	32
Carbon Range	C ₈ -C ₁₇	C ₁₈ -C ₄₀	C ₁₄ -C ₄₀
Maximum Concentration (mg/kg)	81,600	13,000	72.9
BTEX Concentration (mg/kg)	EB 17 X 53	ND	EB 1.1 X 2.17
Hydrocarbon Volume	215 gallons	80 gallons	4 gallons

Response 5: The references to the Appendices will be corrected.

Response 6: As stated in Section 4.4. "For analytes with reported laboratory detection limits that are higher than the criterion, the detection limit has been used as the project-specific threshold level (refer to bolded values on Table 4-1). A summary of the project-specific threshold levels used to evaluate the SA/ESA data is provided in Table 4-1."

Response 7: POI 26 is approximately 200 feet from the edge of the boat channel. This distance will be included in the Site Description.

Response 8: An estimate of the volume of residual soil contamination left *in situ* has been made. Refer to the table presented at the end of Response 4. Contamination remaining in the ground is adjacent to a vehicle lift. Borings 10 feet and 16 feet away from the lift (P26-B1 and P26-B2) contained no visible staining or detectable hydrocarbon contamination. Refer to Figures 4-21 and 4-22 for sampling locations and results.

Contamination was identified as petroleum hydrocarbons, other than gas or diesel. An appropriate carbon range would be C₁₈-C₄₀. Aromatic hydrocarbons were analyzed for by U.S. EPA Method 8020, but were not detected. Boring log and analytical data indicate continuous samples from

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Comment 8 (continued):

Response 8 (continued):

5.7 to 6.7 feet bgs average 62 mg/kg of TPH. This interval is not significant and is not included in the estimated volume of contaminated soil. A sample collected from 7.0 to 7.5 contained 13,000 mg/kg of TPH. No deeper samples were collected, but there is a clayey silt reported at a depth of 8.3 feet bgs.

Assuming a radius of influence of 8 feet, half the distance to the farther boring, and a thickness of 1.3 feet (the distance from the top of the sample to the lower bounding clayey sand), there would be 10 cubic yards of contaminated soil with a concentration of 13,000 mg/kg TPH, or 80 gallons of hydrocarbon with a carbon range of C₁₈-C₄₀.

Comment 9: Page 4-119, Section 4.15.6, POI 58. Same comment as POI 26.

Response 9: An estimate of the volume of residual soil contamination left *in situ* has been made. Refer to the table presented at the end of Response 4.

Hydrocarbon in soil contamination is related to a former underground storage tank. Historical maps identify the tank as a gasoline tank, but analytical data indicate carbon ranges of C₇-C₄₀, with higher concentrations in the C₁₂-C₄₀ range. Refer to Figures 4-26 and 4-27 for sampling locations and results.

All samples with concentrations of hydrocarbons reported above detection limits were collected within the stained and odorous zone located approximately at the water table. A reasonable estimate of the affected area is a triangle with a base of 50 feet and a height of 80 feet. This results in a 185 cubic yards volume of contaminated soil. Three of five soil borings (P58-B1, P58-B2, and P58-B4) reported an arithmetic average of 32 mg/kg of TPH with a carbon range of C₇-C₄₀. This indicates a volume of 4 gallons of hydrocarbon. Boring P58-B2 had the highest hydrocarbon concentration at 72.9 mg/kg in the C₁₄-C₄₀ range. Benzene was not detected in soil. Ethylbenzene was reported at 1.1 mg/kg. Total xylene was reported at 2.17 mg/kg.

**RESPONSE TO REGULATORY COMMENTS ON DRAFT SITE ASSESSMENT/EXTENDED SITE ASSESSMENT REPORT
FOR 18 POINTS OF INTEREST, NAVAL TRAINING CENTER, SAN DIEGO, CALIFORNIA
CTO-0122**

Comments from Aaron Yue

Written on 26 December 1997

Received by facsimile on 05 January 1998

Mr. Aaron Yue

RPM, California Environmental Protection Agency

Department of Toxic Substances Control

COMMENTS

Comment 1: Section 4, Conclusions and Recommendations. A general statement is made as a rationale for several POIs that "Arsenic ... appears to be naturally occurring at NTC and other Navy bases in the San Diego area ...". The background concentrations of Arsenic and other naturally occurring metals at NTC have not been substantiated by the Navy through background studies; therefore, the use of this rationale as a conclusion for No Further Action is not acceptable. For most POIs, the deletion of this rationale from the conclusion will not change the appropriateness of "No Further Action" because of the result of the residential risk screening evaluation. It is recommended that references to "naturally occurring" metals be removed from the conclusions of this report for all POIs.

Comment 2: Section 4, Conclusions and Recommendations. For each bullet that discusses soil risk screening results, please specify if the conclusion is based on carcinogenic or non-carcinogenic risks. For example, the conclusion for POI 19, the third bullet should indicate that the result of total carcinogenic risk is between 10^{-4} and 10^{-6} .

Comment 3: Section 4, Conclusions and Recommendations. The State disagrees with the hypothesis of page 4-179, paragraph 2 as a rationale for the high metal concentrations in the Northeast groundwater study. The Navy suggested that the "water in the Boat Channel may be contributing to the higher metals in groundwater (near the boat channel)." It is unlikely that the water in the Boat Channel can be causing the high concentration of metals detected in the groundwater in light of the variability found throughout NTC. If this is the Navy's theory, it should be justified by citing surface water metal concentrations from the Boat Channel. Current groundwater gradients indicate that the groundwater, in general, is flowing toward the Boat Channel. Please delete this paragraph.

Response 1: As agreed at the 27 January meeting with Corey Walsh from the RWQCB and Martin Hausladen from the U.S. EPA, an appendix discussing levels of arsenic in soils reported from various studies in southern California and the U.S. will be included and referenced in the final SA/ESA report. This draft appendix is included as Attachment 1.

Note: The draft appendix has been finalized as Appendix M in the final SA/ESA Report for POIs.

Response 2: The conclusions for each POI that discusses soil risk screening results will be revised to specify whether the conclusion is based on carcinogenic or noncarcinogenic risk.

Response 3: The statement will be removed. As agreed in the 27 January meeting, because the Northeast Area Groundwater is not a POI, the three POIs associated with this area (POIs 7, 20, and 26) will be recommended for NFA and the general issue of groundwater quality at NTC will be addressed further under a different study. This will be clearly stated in the final SA/ESA report.

APPENDIX M

**NATURAL LEVELS OF ARSENIC IN SOILS AT
NAVAL TRAINING CENTER SAN DIEGO**

Appendix M

NATURAL LEVELS OF ARSENIC IN SOILS AT NAVAL TRAINING CENTER SAN DIEGO

The Site Assessment/Extended Site Assessment (SA/ESA) for 18 points of interest (POIs) at the Naval Training Center (NTC) San Diego examined risks associated with the chemicals of potential concern identified at the sites. Arsenic was reported above the project-specific threshold level (1.0 milligram per kilogram [mg/kg]) in the majority of soil samples collected from the POIs where soils were analyzed for arsenic. These arsenic levels are similar, however, to naturally occurring levels of arsenic found at other Navy bases in the San Diego area and in the southern California region. This appendix provides an overview of various background studies and their relevance to arsenic levels at NTC.

The former NTC San Diego is located on the eastern slope of the Point Loma Peninsula. The lower (eastern) part of NTC is situated on dredged material from San Diego Bay, hydraulically placed over the salt marsh and salt flat deposits in the old mouth of the San Diego River. Part of the base is located on the in-place or slope deposits derived from the Bay Point Formation, a sequence of shallow marine, estuarine sediments.

In addition to these two principal types of NTC soils, there are various places on NTC where conventionally placed fill soils were imported for construction purposes. These conventional fill deposits are usually shallow, surface grading applications and do not constitute a major fraction of the base soils.

M1 HYDRAULIC FILL BACKGROUND ARSENIC LEVELS

Two other Navy bases in the San Diego area have substantial portions of their land surface made up of fill hydraulically dredged from San Diego Bay: Naval Air Station (NAS) North Island, and Naval Station, San Diego. Both of these bases have had background studies performed for the hydraulic fill material found in those areas. The attached table (Table 3-3 from BNI 1996a) is a summary of background concentrations of metals in soils, as calculated for NAS North Island, Naval Station, and other bases in southern California.

To develop the background level for arsenic at Naval Station, San Diego, 210 uncontaminated samples were statistically analyzed, and the 95th percentile of the arsenic concentrations was selected, with regulatory agencies concurrence, as the background threshold. This threshold value was 9.05 mg/kg (BNI 1996a).

To develop the background level for arsenic at NAS North Island, immediately across San Diego Bay from NTC, 56 specifically selected "background samples" were statistically analyzed for arsenic, and the 99th percentile of the arsenic concentrations was chosen, with regulatory agencies concurrence, as the background threshold. This threshold value was 5.62 mg/kg (JEG 1995a).

M2 BAY POINT FORMATION ARSENIC LEVELS

A specific background study has not been performed for the various layers of the Bay Point Formation (i.e., fine-grained shaley layers and coarser layers), but some data are available from studies at several sites on Point Loma. In particular, a fine-grained sample from approximately 46 feet below ground surface, which was within native soils and not associated with waste materials at the site, was reported at a concentration of 57 mg/kg of arsenic. Coarser-grained samples from the same location, as expected, had reported concentrations of arsenic generally less than 10 mg/kg (BNI 1996b).

For general information and comparison, a background study at Vandenberg Air Force Base on the coast in Santa Barbara County was examined. The "bedrock" at Vandenberg Air Force Base is the Monterey Formation, a sequence of Cretaceous marine sandstones, shales and conglomerates (JEG 1995b; CDMG 1977). The Geologic Map of California (CDMG 1977), depicts the Bay Point Formation also as a sequence of Cretaceous sandstones, shales and conglomerates, suggesting a similar origin and possibly chemical makeup. The background study at Vandenberg Air Force Base looked at three geomorphic areas and three soil types in each area as shown in the attached Figures ES-1 and ES-2 of the study (JEG 1995b). The threshold values for arsenic, as shown in attached Table 3-1 of the study (JEG 1995b), did not depend on the geomorphic area, but only on surface versus subsurface, and geologic unit. The table shows that the bedrock (similar to the Bay Point Formation) has an arsenic threshold of 38.4 mg/kg.

M3 ADDITIONAL GENERAL ARSENIC BACKGROUND CONSIDERATIONS

Several state and federal agencies have looked at the concentrations of arsenic that might be found naturally in California soils. Studies have been conducted by the following agencies:

- Kearny Foundation, University of California/Cal-EPA, DTSC;
- U.S. Geological Survey (USGS); and
- U.S. Environmental Protection Agency.

The Kearny Foundation study (KF 1996) determined background concentrations of 46 trace and major elements in "50 benchmark soils selected from throughout the state." The first two pages of Table 2 from that study are attached to show the arsenic values from the 50 samples plus the average, mean, and range of the values. Arsenic has a geometric mean of 2.8 mg/kg for the 50 samples, and the maximum concentration was 11.0 mg/kg. The sample with the maximum concentration of 11.0 mg/kg was a fine-grained, clayey loam soil sample that is similar to a soil likely derived from the Bay Point Formation.

Appendix M Natural Levels of Arsenic in Soils at Naval Training Center San Diego

The USGS and its staff has produced the following published works on background concentrations of metals. Averages and ranges of concentrations are presented for the entire United States and specific regions:

- USGS Professional Paper 574-F (Shacklette and Conner 1975),
- USGS Professional Paper 1270 (Shacklette and Boerngen 1984),
- Shacklette et al., in the *Journal of Environmental Quality*, Vol. 12, No. 1 (1983).

U.S. EPA opinions are expressed in a 1992 "Issue Paper" titled "Options for Addressing High Background Levels of Hazardous Substances at CERCLA Sites." The principal recommendations include reviewing published information on natural ranges of metals in soils. Among others, they refer to the 1975 USGS study designed to help with the issue of natural metals concentrations for various regions of the United States (Conner and Shacklette 1975); and the *Journal of Environmental Quality* article on Selenium, Fluorine and Arsenic (Shacklette et al. 1983), both discussed above.

Therefore, after reviewing all of the previous referenced studies, the natural range of arsenic is suggested to be:

- from a mean value estimated at 6.1 mg/kg up to 97 mg/kg in the western U.S., based on USGS studies;
- up to 11 mg/kg in California (San Diego sample), based on the Kearny Foundation study; and
- up to 57 mg/kg in the San Diego area, based on the Point Loma study (BNI 1996b).

M4 CONCLUSIONS FOR THE 18 POIS AT FORMER NTC

Eighteen POIs were investigated during the SA/ESA. Soil samples were collected and analyzed for arsenic at 6 of the 18 POIs investigated (POI 14, 18, 19, 71, 85, and 87). The following are observations from this investigation.

- The U.S. EPA Region IX preliminary remediation goal (PRG) for arsenic under residential land use scenario is 0.38 mg/kg.
- The project-specific arsenic threshold level for the SA/ESA is 1.0 mg/kg.
- Out of a total of 37 soil samples obtained from the six POIs where soil samples were analyzed for arsenic:
 - all soil samples had reported concentrations above the PRG of 0.38 mg/kg;
 - ten soil samples had reported concentrations of arsenic below the project-specific threshold level of 1.0 mg/kg; and
 - the remaining 27 soil samples had reported concentrations of arsenic ranging from 1.0 mg/kg to 17.4 mg/kg.

Appendix M Natural Levels of Arsenic in Soils at Naval Training Center San Diego

This range of reported arsenic concentrations (1.0 to 17.4 mg/kg) is consistent with the range of arsenic found in the various studies discussed above. Therefore, the arsenic levels reported at the former NTC are indicative of naturally occurring arsenic and not of an arsenic release.

M6 REFERENCES

Bechtel National, Inc. 1996a. Background Study Report Naval Station San Diego, Prepared for Southwest Division Naval Facilities Engineering Command.

———. 1996b. Extended Site Inspection, Sites 5, 10 and 20, Naval Command, Control and Ocean Surveillance Center, Point Loma, Prepared for Southwest Division, Naval Facilities Engineering Command.

BNI. *See* Bechtel National, Inc.

Bradford, G.R., A.C. Chang, A.L. Page, D. Bakhar, J.A. Frampton, and H. Wright. 1996. Background Concentrations of Trace and Major Elements in California Soils, Kearny Foundation Special Report, Division of Agriculture and Natural Resources, University of California.

California Division of Mines and Geology. 1977. Geologic Map of California.

CDMG. *See* California Division of Mines and Geology.

Conner and Shacklette. 1975. Background Geochemistry of Some Rocks, Soils, Plants and Vegetables in the Conterminous United States. U.S. Geological Survey Professional Paper 574-F.

Jacobs Engineering Group. 1995a. Naval Air Station North Island Background Soil Sampling Report, Prepared for Southwest Division, Naval Facilities Engineering Command.

———. 1995b. Background Concentrations of Metals in Soil. Vandenberg Air Force Base, California.

JEG. *See* Jacobs Engineering Group.

KF. 1996. *See* Bradford, G.R., A.C. Chang, A.L. Page, D. Bakhar, J.A. Frampton, and H. Wright.

Shacklette, H.T., J. G. Boerngen, and J. R. Keith. 1983. Selenium, Fluorine, and Arsenic in Surficial Materials of the Conterminous United States. *Journal of Environmental Quality*, Vol. 12, No. 1.

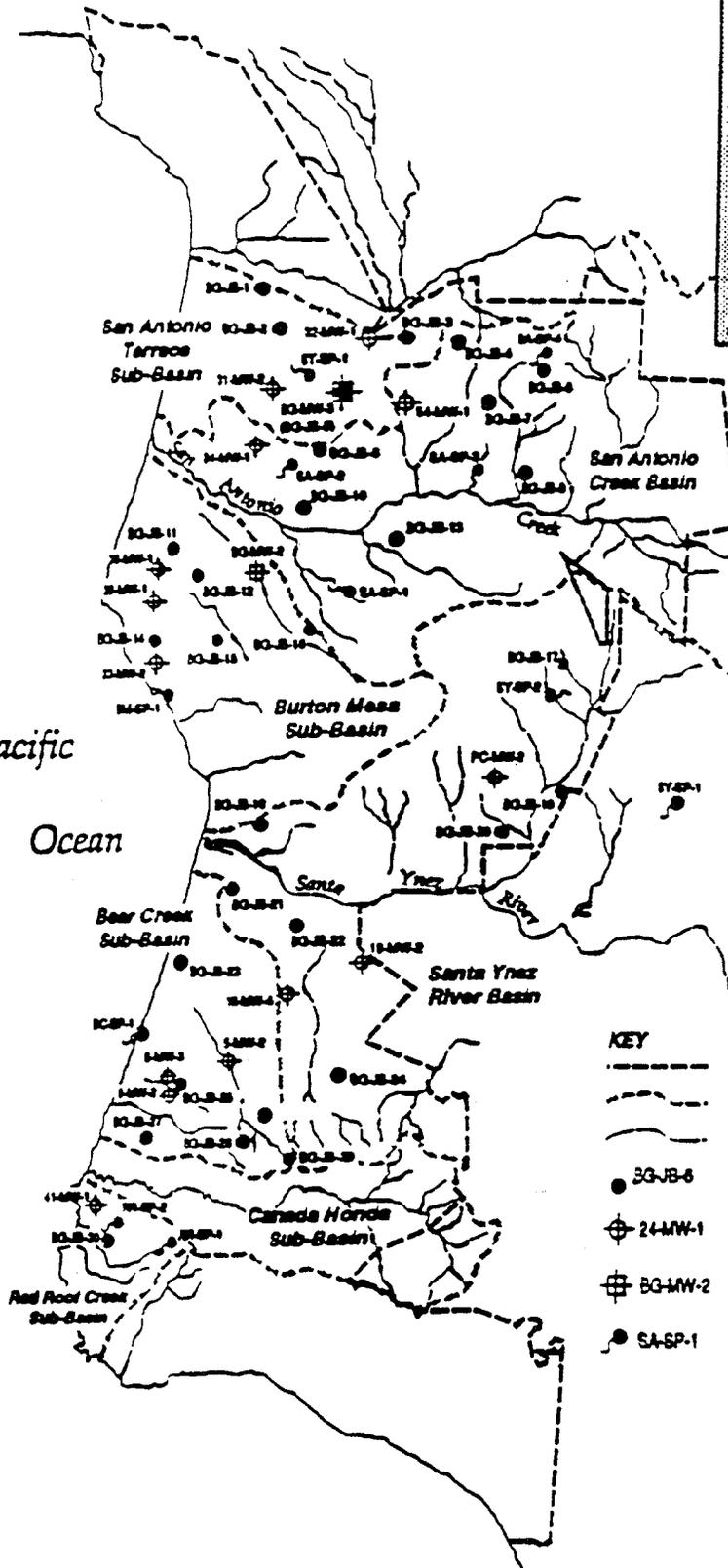
Shacklette, H.T. and J. G. Boerngen. 1984. Element Concentrations in Soils and Other Surficial Materials of the Conterminous United States, U.S. Geological Survey Professional Paper 1270.

SAN ANTONIO TERRACE
PHYSIOGRAPHIC
REGION

BURTON MESA
PHYSIOGRAPHIC
REGION

LOMPOC TERRACE
PHYSIOGRAPHIC
REGION

Pacific
Ocean

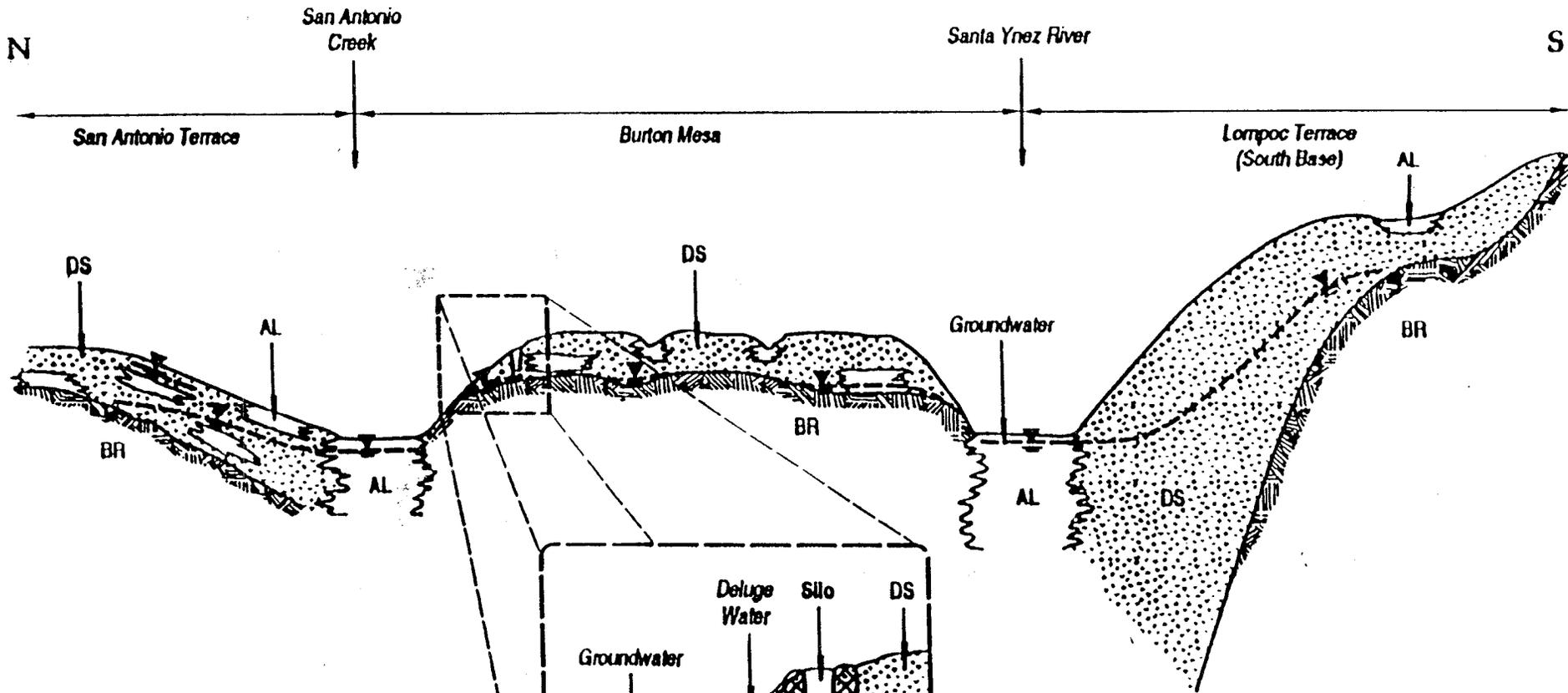


KEY

- VAFB Boundary
- Drainage Basin Boundary
- Wet Drainage Route
- 10-B-6 Soil Boring Location
- 24-MW-1 Upgradient IRP Well
- BG-MW-2 Background Boring Completed as Monitoring Well
- SA-SP-1 Spring Sample Location



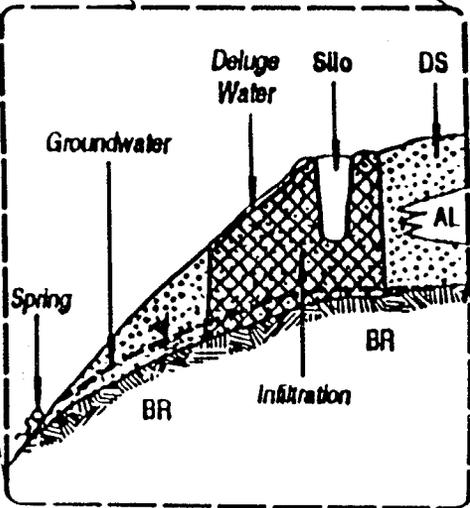
Prepped by: E. Accardi Reviewed by: T. Balfour Checked by: WHL/Pastor Date: 11/28/03	JACOBS ENGINEERING GROUP INC. PASADENA, CALIFORNIA VANDENBERG AIR FORCE BASE, CALIFORNIA OVERVIEW OF BACKGROUND SAMPLING PROGRAM, VANDENBERG AIR FORCE BASE
File No: ES01.dwg Date: 11/28/03	Project No: 06-0106-00
FIGURE ES-1	



GEOLOGIC UNITS

- DS Dune Sand
- AL Alluvium (Sand, Clay, Silt, and Gravel)
- BR Consolidated Bedrock Formations (i.e.: Monterey)

Not To Scale



LAUNCH SITE DETAIL

PROJ. MGR: N. Acedera	JE JACOBS ENGINEERING GROUP INC. PASADENA, CALIFORNIA
PROJ. ENG: T. Bathey	
DRAWN BY: Wm. Pasini	VANDENBERG AIR FORCE BASE, CALIFORNIA
MADE FROM:	CONCEPTUAL CROSS SECTION VANDENBERG AIR FORCE BASE
FILE NO: E9CON.cdr	PROJ. NO. 06-0106-00
DATE: 11 MAR 03	FIGURE ES-2

**Table 3-3
Summary of Background Concentrations of Metals in Soils**

Base Source	Salton Sea Test Base Background Table 3-1 1995	Marine Corps Air Ground Combat Center Background Report 10/94	Naval Air Station El Centro Background Letter 5/95	Long Beach Naval Shipyard Appendix B Table B-6 5/11/95	Naval Station San Diego BNT ^c 8/96	Naval Air Station North Island Background Table 6/95	Naval Weapons Station Seal Beach Table 2-1 ULBV 2 May 1996	Marine Corps Air Station Tustin Presentation Oct. 11, 1995	Industrial Preliminary Remediation Goals U. S. EPA ^e , Region IX 2nd Half 1995
Statistical Methodology	UTL ^a (95,95)	99%, trimmed	95%	UTL (95,95)	95th quantile	99%, w/o outliers	99th Percentile	UTL (95,95)	
Units	mg/kg ^b	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Aluminum		13,000				22,814.23	36,271	24,400.49	
Antimony	7.21	15.8		9.66		14.17		BELOW DETECTION LIMIT	680
Arsenic	15.8	8.24	6.3	12	9.05	5.62	15.38	12.42	2.4
Barium	302	93.1		234.59		202.5		226.54	100,000
Beryllium	2.64	1.35	1.1	1.25	3.55	2.02	2.11	BELOW DETECTION LIMIT	1.10
Cadmium	0.55	1.21	4.6	1.66		2.22 ^d	2.22	BELOW DETECTION LIMIT	850
Calcium		49,800				52,205.42			
Total chromium	24.4	14.7	17	50	43.33	26.91	46.24	37.23	450
Chromium VI	NOT APPLICABLE	NOT APPLICABLE	NOT APPLICABLE			NOT APPLICABLE		BELOW DETECTION LIMIT	NOT APPLICABLE
Cobalt	12	7.76		25		6.40		11.05	97,000
Copper	28.3	15.7	25	639.94	188.85	36.96	39.04	37.63	63,000
Cyanide		NOT APPLICABLE				0.58			8,500
Iron		17,700				17,574.42			
Lead	16.9	12.5	17	233.58	94.03	405.11	35.7	22.30	1,000
Magnesium		5,820				4,573.47			
Manganese		236		397.60		368.70	1,103		7,800
Mercury	NONDETECT	0.27		1.61		0.42	0.30	BELOW DETECTION LIMIT	510
Molybdenum	3.4	NOT APPLICABLE				2.33		BELOW DETECTION LIMIT	8,500
Nickel	23.7	12.5	20	33.22		9.84 ^d	32.49	21.84	34,000
Potassium		3,710				4648.1			
Selenium	1.06	1.55		1.87		2.4	0.44	BELOW DETECTION LIMIT	8,500
Silver	0.57	2.68	0.6	1.51		0.50		BELOW DETECTION LIMIT	8,500
Sodium		4,040				541.84			
Thallium	NONDETECT	0.99		4.68	11.11	0.46		BELOW DETECTION LIMIT	140
Tin		NOT APPLICABLE				23.33			
Titanium		NOT APPLICABLE				968.44			
Vanadium	44.6	48.6		50.26		33.21	85.95	69.64	12,000
Zinc	80.1	41.5	70	693.94		146.11 ^f	177.17	102.01	100,000

Notes:

- ^a UTL – upper tolerance limit
- ^b mg/kg – milligrams per kilogram
- ^c BNI – Bechtel National, Inc.
- ^d UCL – upper confidence level
- ^e U.S. EPA – United States Environmental Protection Agency
- ^f California-Modified preliminary remediation goal

Table ES-1
Threshold Values for Soil (mg/kg)

Analyte	Surface		Subsurface		
	DS	AL	DS	AL	BR
Aluminum	7,010	16,400	11,200	24,700	28,900
Antimony	1.0*	1.0*	1.0*	1.0*	1.0*
Arsenic	2.5	2.5	4.0	4.0	38.4
Barium	109	109	29.1	240	1,110
Beryllium	0.7	0.7	0.8	0.8	3.8
Boron	6.9	6.9	3.1	16.1	19.9
Cadmium	1.0	1.0	2.3	2.3	21.4
Calcium	3,920	3,920	1,830	19,700	33,200
Chromium, SAT	27.7	27.7	13.4	62.9	147
Chromium, BME	27.7	27.7	13.4	62.9	147
Chromium, LTE	27.7	27.7	108	62.9	147
Cobalt	8.9	8.9	5.0*	5.0*	12.0
Copper	46.8	46.8	42.2	135	180
Iron	13,500	13,500	14,800	33,800	122,000
Lead	4.5	13.2	4.0	9.9	21.8
Magnesium	3,900	3,900	6.95	7,710	14,400
Manganese	523	523	233	233	1,940
Mercury	0.18	0.18	1.0	1.0	2.3
Molybdenum	10.0*	10.0*	10.0*	10.0*	48.1
Nickel	30.1	30.1	7.8	37.7	578
Potassium, SAT	655	1,680	586	2,060	10,500
Potassium, BME	655	1,680	586	4,680	10,500
Potassium, LTE	655	1,680	586	2,060	10,500
Selenium	0.5*	0.5*	0.5*	0.5*	0.5*
Silver	0.2	0.2	2.4	2.4	0.3
Sodium, SAT	634	634	363	5,850	17,000
Sodium, BME	634	634	363	5,850	17,000
Sodium, LTE	634	634	363	1,670	17,000
Thallium	0.5*	0.5*	0.5*	0.5*	2.2
Vanadium	25.5	75.8	41.6	71.0	98.7
Zinc	107	107	98.4	221	2,120
Chloride	94.2	94.2	131	2,490	26,000
Fluoride	8.1	8.1	7.8	24.8	127
Nitrate	10.0*	10.0*	10.0*	10.0*	10.0*
Sulfate	104	104	51.3	250	3,890

* The projected practical quantitation limit (PQL) was used as the threshold value. For each population in which 100% of the samples had no measurable concentration of the analyte. The actual PQL values depend on moisture content and are provided in Appendix N.

Geographic Areas

SAT = San Antonio Terrace

BME = Burton Mesa

LTE = Lompoc Terrace

Geologic Units

DS = Dune Sand

AL = Alluvium

BR = Bedrock

Table 2
Total Concentrations of Elements in Benchmark Soils

Soil No.	Ag	Al	As	B	Ba	Be	Bl	Ca	Cd	Ce	Co	Cr
	mg/Kg	%	-----mg/Kg-----									
1	0.21	8.3	11.0	23	738	2.19	0.80	7360	0.11	305	8.8	36
2	0.37	8.1	8.3	17	654	1.20	0.38	5680	0.18	138	15.0	47
3	0.27	9.9	8.0	45	764	1.90	0.42	6948	0.44	121	24.1	110
4	0.37	9.7	3.9	16	659	1.90	0.25	6758	0.25	177	34.8	115
5	0.22	7.1	3.9	7	438	1.90	0.27	3782	0.95	217	38.8	242
6	0.22	9.6	1.2	1	260	1.10	0.24	6795	0.19	94	13.1	45
7	0.12	6.3	1.2	2	533	0.80	0.21	25090	0.16	292	6.9	35
8	0.28	7.6	4.2	74	526	1.25	0.39	22035	0.52	213	9.3	42
9	0.41	6.6	0.8	5	379	0.64	0.37	9587	0.05	161	4.3	26
10	0.80	6.3	1.1	13	517	1.38	0.29	17967	0.40	141	7.1	89
11	0.52	9.0	1.2	4	472	1.51	0.33	11081	0.31	184	7.6	27
12	4.30	8.3	0.6	10	250	0.60	0.24	24524	0.13	122	15.8	29
13	0.40	9.5	2.1	2	625	1.53	0.20	8592	0.36	208	10.8	26
14	3.30	8.7	6.9	34	358	1.43	0.34	16494	0.36	167	22.7	108
15	0.48	7.6	1.2	19	258	1.45	0.19	16658	0.56	85	18.3	107
16	0.42	6.8	5.7	27	375	1.70	0.39	2903	0.15	133	29.9	214
17	2.60	8.0	9.6	26	796	0.93	0.37	6488	0.20	173	15.9	73
18	0.16	6.4	5.2	36	371	1.48	0.45	36400	0.58	189	11.3	40
19	0.37	6.7	4.7	44	392	2.26	0.52	45577	0.43	216	10.0	52
20	0.43	5.9	5.4	33	385	1.76	0.41	41649	0.62	188	8.3	45
21	0.55	6.1	1.8	28	1400	1.14	0.34	15295	0.30	140	10.1	86
22	0.34	6.8	4.0	19	556	0.77	0.25	8243	1.70	115	8.1	50
23	8.30	6.9	4.4	19	677	0.83	0.31	20015	1.00	147	11.9	129
24	0.49	9.9	1.4	4	403	1.78	0.29	17812	1.10	154	26.6	92
25	0.18	8.5	1.7	5	248	0.66	0.28	24070	0.29	119	46.9	1579
26	0.22	10.6	1.4	3	525	1.17	0.33	9408	0.05	127	14.5	51
27	0.44	8.8	4.5	25	720	2.70	0.65	4559	0.44	240	14.2	102
28	0.28	5.8	1.0	5	576	0.68	0.60	15054	0.32	214	11.6	67
29	0.42	8.0	6.3	46	434	1.84	0.39	2777	0.31	153	26.4	181

Soil No.	Ag mg/Kg	Al %	As	B	Ba	Be	mg/Kg					
							Bl	Ca	Cd	Ce	Co	Cr
30	0.16	7.1	3.2	16	461	1.49	0.39	2451	0.13	107	12.9	70
31	3.80	7.7	6.8	30	440	1.47	0.30	2495	0.16	141	26.0	190
32	0.39	7.8	6.7	44	493	1.75	0.52	24853	0.14	234	8.7	38
33	0.27	8.3	3.9	26	552	1.45	0.58	11610	0.14	173	11.6	88
34	0.40	8.4	2.1	20	684	1.51	0.37	16160	0.05	158	16.0	68
35	0.12	6.9	3.8	11	571	1.10	0.39	16311	0.05	243	8.7	23
36	0.16	4.0	2.4	9	710	1.91	0.38	11229	0.14	239	8.0	47
37	2.50	10.4	1.7	17	221	0.86	0.64	29095	0.45	114	18.8	36
38	0.22	6.9	1.0	5	730	1.13	0.14	7653	0.05	155	7.9	49
39	0.63	5.0	2.1	8	158	0.92	0.25	2762	0.30	88	12.0	221
40	0.80	3.0	2.4	5	133	0.25	0.23	3422	0.11	83	8.8	102
41	0.13	7.0	1.4	8	531	0.50	0.29	14362	0.26	122	9.6	47
42	0.35	8.0	1.8	9	540	1.25	0.28	14131	0.24	167	10.8	50
43	0.16	5.2	1.4	7	571	1.42	0.35	3763	0.39	182	8.4	121
44	0.63	5.3	1.9	15	767	1.28	0.25	2570	0.18	148	9.2	129
45	0.22	4.9	1.1	9	565	0.68	0.11	6600	0.71	113	2.7	87
46	0.53	7.5	4.5	23	511	1.30	0.33	6076	0.21	114	22.1	397
47	0.58	7.5	3.0	22	361	1.03	0.20	10770	0.18	117	26.1	271
48	0.10	7.5	6.0	49	522	1.23	0.44	12531	0.18	139	17.8	147
49	0.20	3.5	4.7	25	324	0.25	0.34	24175	0.73	78	8.8	49
50	0.35	4.4	2.2	18	328	1.18	0.25	26824	0.58	121	4.3	29
AVG	0.80	7.3	3.5	19	509	1.28	0.35	14466	0.36	159	14.9	122
GEOM.												
MEAN	0.41	7.1	2.8	14	468	1.14	0.33	10849	0.26	151	12.6	76
MAX	8.30	10.6	11.0	74	1400	2.70	0.80	45577	1.70	305	46.9	1579
MIN	0.10	3.0	0.6	1	133	0.25	0.11	2451	0.05	78	2.7	23
RANGE	8.20	7.6	10.4	73	1267	2.45	0.69	43126	1.65	227	44.2	1556
Est.D.Lim. ¹	0.015	0.001	0.2	2	1	0.5	0.1	25	0.10	0.15	2.5	1

¹Est.D.Lim. denotes the estimated detection limit for each element. In this table, concentrations less than the Est.D.Lim. are reported as one-half of the Est.D.Lim. Descriptive statistics are calculated accordingly.