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FINAL
HORIZONTAL CONDUIT STUDY
TECHNICAL MEMORANDUM
RESPONSE TO COMMENTS

August 4, 1995

MOFFETT FEDERAL AIRFIELD
CALIFORNIA
(FORMERLY NAVAL AIR STATION MOFFETT FIELD)

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MOFFETT FEDERAL AIRFIELD
HORIZONTAL CONDUIT STUDY
RESPONSE TO AGENCY COMMENTS

1.0 INTRODUCTION

This document presents point-by-point responses to comments on the Horizontal Conduct Study Technical Memorandum for Moffett Federal Airfield. Comments on the technical memorandum were submitted by the U.S. Environmental Protection Agency (U.S. EPA); the California Environmental Protection Agency, Department of Toxic Substances Control (DTSC); and the California Water Quality Control Board, San Francisco Bay Region, CWQCB).

This response to comments is organized by commenting agency, and includes general and specific comment responses.

2.0 U.S. ENVIRONMENTAL PROTECTION AGENCY COMMENTS

This section contains general and specific comments from the U.S. EPA and Navy responses.

2.1 GENERAL COMMENTS

The U.S. EPA did not submit general comments.

2.2 SPECIFIC COMMENTS

Comment 1: Section 8.6.1, Page 47, Paragraph 1. Most, but not all of the flow measurement samples were taken downstream beyond a confluence of manholes. Some exceptions are manholes 1.6, 1.7, and 4.3. All samples should be taken beyond the point of confluence. Is it possible that these locations are where cumulative flow errors exist?

Response: *These are the only exceptions and they occurred during Phase I. They do not create an opportunity for cumulative errors but do create an opportunity for interpretive error. The purpose of the flow measurement location at manhole 4.3 during Phase I was an attempt to isolate the flow in line 5. The flow was very low, less than 1 gallon*

per minute (gpm). During Phase II, flow at the outlet of manhole 4.3 was measured to determine combined flow in the manhole.

Manhole 1.7 was not originally part of Phase I plans so no flow measurements were taken during this phase. In manhole 1.6, there was no apparent flow from the NASA cooling tower so inlet and outlet readings were the same.

Comment 2: Section 8.6.2, Page 59, Paragraph 1. Why was the report released before VOC [volatile organic compound] sampling data was validated?

Response: *The report was released before the VOC sampling data were validated to expedite presentation of the draft.*

Comment 3: Section 9.11, Page 77. When this report is completed, what will its purpose be? What is the next step? Will the conclusions reached by the study impact the ongoing remedial activities at Moffett Field? These questions should be addressed in the conclusion.

Response: *The purpose is as stated in the introduction of the report. The report provides information for modeling efforts and for understanding the effects of infrastructure when studying fate and transport of contaminants.*

Information gathered during the course of the horizontal conduit study has been used to initiate two remedial efforts called the Sanitary Sewer Action and the Storm Drain Action. The Sanitary Sewer Action entailed lining line G of the sanitary sewer system to reduce tetrachloroethene (PCE) infiltration. Some infiltration is still suspected through service lines and associated connections.

The Storm Drain Action involves transporting water from the Hangar 1 and Electrical Vault 5 sumps to the Building 45 treatment system (a component of the Site 9 source control measure). The water will be treated and released to the storm drain system.

The conclusion of this report was edited to discuss the results as they relate to the purpose of the horizontal conduct study.

3.0 STATE OF CALIFORNIA ENVIRONMENTAL PROTECTION AGENCY, DEPARTMENT OF TOXIC SUBSTANCES CONTROL, COMMENTS

This section contains DTSC general and specific comments and Navy responses.

3.1 GENERAL COMMENTS

The water chemistry data included groundwater, sewer wastewater, storm water, and soil chemistry data suggest that VOCs contamination is localized along the sewage and storm drain lines on the stretch of the west edge of Hangar 1. The contaminant pathway study along the utility lines is not conclusive.

Response: *The final version of the horizontal conduct study contains further study of the sanitary sewer and storm drain along the western side of Hangar 1. This additional study includes:*

- *Reporting of validated data where nonvalidated data was used previously*
- *Developing potential infiltration and exfiltration maps using time appropriate water level data*
- *Including isoconcentration maps for both the Navy Plume and Regional VOC Plume, including the area along the western side of Hangar 1*
- *Analyzing the vertical relationship of storm drain, and sanitary sewer lines along the western side of Hangar 1, Electrical Vault 5, and Tunnel 1 and dry season and wet season water levels*

The results of this analysis are found in Sections 8.0 and 9.0.

3.2 SPECIFIC COMMENTS

Comment 1: Figure 5.1. The equal concentration lines for PCE or TCE in the regional plume should be shown on Figure 5.1.

Response: *Isoconcentration lines for PCE have been included on Figures 8-15 and 8-16. Isoconcentration lines for TCE have been included on Figures 8-13 and 8-14.*

Comment 2: Page 23, Sanitary Sewer System. It is stated that flow in the sewer system was almost doubled in wet season; 337 gpm (gallons per minute) for dry season and 650 gpm for wet season (1994 measurements). Since major portions of the sanitary system are below the water table, the flow in the sewer system should not be affected significantly in rainy season. Please explain why the flow in the sanitary system increases so much in wet season.

Response: *This variation was also noted in the 1986 ERM report referenced in Section 7.3.2. The Navy does not know the cause of this increase.*

Comment 3: Appendix A. In Appendix A-1, the table shows "Appendix B." This title is confusing. Water samples and sediment samples should be separated and shown in different concentration units, μg/L [micrograms per liter] and ppm [parts per million], respectively. The indicated "State Levels" are applicable to water only.

a. In Appendix A-6, Flow Analysis Data (Graphs and Daily Summary Tables) are not included.

b. In the summary table, the year of data collection should be noted. Only calendar dates are shown.

c. The detailed sample sites should be shown in Figure 7-1 or 7-4.

Response: *This table was Appendix B in the report titled "Storm Water Study - Tasks 4-6." This clarification has been added to the cover sheet labeled A-1. The purpose of Appendix A is to report the data as they were originally presented. Because of this, Table A-1 was not changed. The comment regarding "state levels" is noted.*

a. The flow analysis data have been included in the final report.

b. The study period is shown on the title page of the study. This period is February 15 to 22, 1994.

c. *The exact sampling sites are unknown. However, the map provided as part of the NASA study would lead the reader to conclude that points of measurement for Sites 1, 3, 4, 5, and 6 are manholes 10, G-3, F-2, E-1, and C-1, respectively, all sites measured in the horizontal conduit study. The location of Site 7 is beyond the scope of this study.*

Comment 4: Figure 7.4. The title of Figure 7.4 should read as "Previous Study VOC Sampling Results for Sanitary Sewer System."

Response: *The title has been revised as suggested.*

Comment 5: Table A-3 in Appendix A. Please provide a column with regulatory limits of concentration for Table A-3.

Response: *Table A-3 presents water quality data for storm water discharges at both the Settling Basin and Building 191. Storm water discharges are regulated under the Amended National Pollutant Discharge Elimination System (NPDES) General Permit for Discharge of Storm Water Associated with Industrial Activity in Santa Clara County to South San Francisco Bay or its tributaries. This permit was issued by RWQCB on February 3, 1993. The permit does not state discharge limits. The permit requires a storm water pollution prevention plan and authorizes or prohibits certain types of discharges.*

Comment 6: Page 29, Section 7.5, Sediment Quality. No sediment sample SL-2 is listed in Table A-1. Please further clarify the concentrations of diesel and motor oil mentioned in the same paragraph.

Response: *The reference in the text to SL-2 should have read SL-5. The sampling results in SL-5 are included in Table A-1. The text has been corrected.*

Comment 7: Page 32, Section 8.3, Backfill Composition and Permeability. The depths of soil samples collected for size analysis are not shown in Figure 8.3 nor in Appendix C. The relative depths of sanitary system and storm drain line should be included.

The two backfill material samples around the sanitary system are away from the major segment of contamination. More backfill materials along the west edge of Hangar 1 should be explored to investigate VOCs contamination. Field soil classification of explored samples should be incorporated.

Response: *The depths of soil samples collected for sieve analysis have been included in Appendix C. The depths of the storm drain and sanitary sewer system have been included in Appendix B. There is no need to collect backfill samples along the sanitary sewer system along Hangar 1 because it lies below the piezometric surface in both the regional VOC plume and the Navy PCE plume.*

Comment 8: Page 41, Section 8.4, Areas of Potential Infiltration and Exfiltration. Please explain the invert elevations with notations of "in," "out," and "thru" which were not explained in Appendix B. Otherwise, it is difficult to review the above figures.

Response: *"In" refers to a pipeline carrying water flowing into the manhole. "Out" refers to a pipeline carrying water flowing out from a manhole. "Thru" means there is a single line entering the manhole and a single pipeline exiting the manhole, with the same invert elevation. A list of terms has been added to Appendix B.*

Comment 9: Page 45, Last Sentence. The report stated that the third video survey of storm drain and sanitary sewer line systems was conducted in 1993. The result of this survey should be incorporated.

Response: *The results of the NASA video survey are included as Appendix F.*

Comment 10: Figure 8.8. Flow measurements and VOC analyses indicate that water in the sanitary sewer line along the west edge of Hangar 1 generally contains high VOCs. Abnormal water chemistry pattern along the line has been observed. Along the flow direction from up to low gradients, water at Manhole E-1 has high VOCs and at Manhole F-2 the intermediate location has low VOCs, then at Manhole S-36A down gradient at Manhole F-2, has high VOCs; further down gradient at Manhole 9-B2 has a low VOCs content in water and at Manhole 10 has a high VOCs content in water. This

unusual pattern should be adequately assessed. The source of the VOCs should be clearly explained.

Response: *Regional VOC plume isoconcentration lines have been added to Figure 8.8 and Figure 8.9 and a discussion of the results of the NASA Sanitary Sewer Video Survey has been added to Section 8.5. The variations in VOC composition and levels are a function of the VOC levels in the underlying plume, structural integrity of the pipeline, and elevation of that line with respect to the piezometric level.*

Line E-1 between manholes E-11 and E-1 is subject to continuous infiltration in an area of the regional VOC plume where concentrations range between 100 and 1,000 μg/L. VOC levels at E-1 reflect this. Line F is unusual in that it begins in an area of the regional VOC plume where levels are expected to be greater than 1,000 μg/L and terminates near (or in) an anomalously low area where contaminant levels are less than 100 μg/L. The material in this pipeline in the area of high plume TCE levels is made of polyvinyl chloride (PVC) and has structural integrity. This line most likely receives infiltration in or near the area where TCE readings in the underlying plume are anomalously low. Water samples from F-2 reflects this. Line G lies in the Navy PCE plume (Figure 8.10) and water samples from G-2 confirm infiltration.

Water samples from 9-B2 indicate infiltration between North Warehouse and South Warehouse Roads. Line H is at a higher elevation than the line between manholes S77 and S74. This would indicate that most infiltration occurs in the line between manholes S77 and S74, an area where TCE levels are expected to be less than 100 μg/L. Water quality data at manhole 9-B2 reflect this. Contaminant levels in samples from manholes S36A and 10 represent cumulative values for the entire system.

Comment 11: Figure 8.9. The water analysis in the storm drain along the west edge of Hangar 1 shows high VOCs content (Manholes 7.1, 7.3, 7.4, and Electrical Vault 5). Since the water in sewer line and storm drain along the edge of Hangar 1 are both contaminated with VOCs, it may suggest that soil along this stretch is also contaminated. Contaminated surface and groundwater may be entering sewer and storm drains in this

area. The theory of VOC contribution from the regional plume into the sewer water and the storm drain water should be further evaluated.

Response: *Soils within the groundwater plume are most certainly contaminated. The anion/cation data, NASA video survey data, invert elevation data, and sump data all point to groundwater infiltration. However, no data indicate that soil above the groundwater table is contaminated. Soil samples collected with the Geoprobe along the northern end of line 7 did not indicate this type of contamination. There are also no known sources other than the Building 88 area which would indicate soil contamination.*

Comment 12: Tables 8-2A and 8-2B. Dates of flow measurements and sampling should be noted in these tables. These tables are now labeled as 8-3 and 8-4.

Response: *Dates of flow measurements and sampling have been noted on both tables.*

Comment 13: Page 63, Section 8.6.3, 4th Line. Building 566, wells W9-46 and W61-1 should be shown in Figure 5.1 and readers should be directed to this figure.

Response: *These features have been included on Figure 5-1 and the reader has been directed to Figures 5-1, 8-19 and 8-20.*

Comment 14: Page 67, 4th Paragraph. The anomaly shown in the Stiff diagram may be related to VOC contents, pH and redox condition. Therefore, more detailed investigation of water data should be conducted.

Response: *VOCs in the concentrations measured during the course of the horizontal conduit study will not change the pH of contaminated water. This is borne out by the VOC concentrations in samples from and Stiff diagrams for manholes 1.7 and G-8. The Stiff diagram for both manholes 1.7 and G-8 are indicative of groundwater quality. However, VOC levels for the corresponding samples of 1.7 and G-8 are less and greater, respectively, than the sample collected for manhole 7.6. Manhole G-8 is located within 5 feet of manhole 7.6. If both collect groundwater from the same area,*

they would have the same fingerprint shown in the Stiff diagram. This anomaly suggests a source of water other than groundwater.

Comment 15: Page 72, Section 9.1, Historical Review. On page 32, last paragraph, it is mentioned that the storm drain and the sanitary systems were constructed in the mid-1930s. However, it is not stated in the historical review.

Response: *The wording on page 32 has been changed to read "the majority of the storm drain and sanitary sewer systems on the western side of MFA date back to the mid-1930s."*

Comment 16: Page 73, Section 9.2. This section described three sumps which are below the ground water table. The report should lead the reader to the reference figure. Water samples from Electrical Vault 5 and Hangar 1 sump were collected and analyzed, however, no samples have been taken from another vault. If the study concluded that storm drain water contamination is due to collection of contaminated groundwater in the sumps, further study of this vault should be performed.

Response: *The comment has been noted. The other vault is anticipated to have little effect on contaminant transport.*

Comment 17: Page 73, Section 9.3. According to Figure 8.6, Line E and Line C are subject to continuous infiltration of groundwater within the regional plume. In comparison with water chemistry in line G which is also subject to continuous infiltration, water in lines E and C has much less TCE and PCE concentration (see Figures 5.1, 8.6 and 8.8). When attributing contamination originating from the regional plume, the above difference should be properly interpreted.

Response: *Section 9.3 was intended to be a brief discussion of the spatial relationship with seasonal potentiometric surfaces only. The VOC discussion appears in Section 9.6.*

Comment 18: Page 74, Section 9.5, and, Figures 8.6 and 8.8. It is stated that "flow rates tended to increase where lines were subject to infiltration and to decrease in area where the pipelines were subject to exfiltration". The flow rates shown in Figure 8.8 do not exhibit apparent increase of flow at Manholes F-2, TB-4, and C-8 are subject to

continuous infiltration. This is different from the above description and needs further explanation.

Response: *Manholes TB-4 and C-8 are upstream of manhole C-1. The lines upstream of TB-4 include only a short footage of pipe subject to seasonal infiltration. Likewise, lines upstream of manhole C-8 include only a short footage that is subject to seasonal infiltration and a short footage subject to continuous infiltration. The combined flow rate of these two manholes during Phase II was 10 gpm. The lines between manholes TB-4 and C-1, and C-8 and C-1 are subject to continuous infiltration. The flow rate at manhole C-1 is 40 gpm, four times the combined flow rate of C-8 and TB-4. This gain substantiates the referenced statement.*

There is no reference point with respect to F-2 in line F, except one would assume that the flowrate at the upper end is 0 gpm. Pipeline F material of construction upstream of F-3 is PVC which would not typically allow infiltration ar exfiltration. The pipeline from F-3 to F-2 is vitrified clay with cracks; this is the most likely place for infiltration to occur (GELCO 1993). Also, there is a 2-foot drop from manhole F-2 to manhole 5A which would indicate that the hydraulic gradient is less, thereby allowing for less infiltration. In summary, although the flows are low, they still increase.

Comment 19: Page 74, Section 9.6, and Figure 8.9. In this section, PCE contamination in lines 4 and 7 has been attributed to the sumps in Hangar 1 Tunnel sumps and Electrical Vault 5. Please identify the source of the high concentration of PCE detected in Manhole 7.4 which is upgradient of the sump and Electrical Vault 5.

Response: *Manhole 7.4 is in a section of pipeline subject to seasonal infiltration. The water sample shown on Figure 8-11 was collected during the wet season. Based on the low flow rate, this line apparently was at the piezometric level of the A1 aquifer zone at the time of sampling. This is supported by the anion and cation data for this same sample (see anion and cation discussion in Section 8.0), which indicates a groundwater source.*

Comment 20: Page 75, Section 9.8. **It is mentioned that PCE in soil may be caused from volatilization of the underlying plume. Please evaluate its significance by using Henry's Law constants.**

Response: *Henry's Law states that the partial pressure of a gas or volatile compound in the air above a dilute aqueous solution is directly proportional to its concentration in the solution. The constant for this ratio is referred to as Henry's Law Constant. VOCs having Henry's Law Constants above 10 atmospheres (atm) are considered readily air strippable. Any constant larger than this can be considered representative of a relatively fugacious chemical (tendency to escape from water). Henry's Law Constants for PCE and TCE are 1,100 and 550 atm, respectively (Freeman 1989). Analysis of fugacity through a clay soil is hampered, however, by low void space and the tendency of both PCE and TCE to adsorb to clay. This was why the word "may" was added to the sentence.*

Geoprobe soil sampling data associated with manhole 4.6, 7.2, and 7.3 (see Figure 8.21) suggest volatility as a possible fate. If PCE and TCE were exfiltrating, contaminants would be in the sample pair next to the pipe only. Yet, the sample results showed detections of these chemicals away from the pipeline. In the sample associated with manhole 7.2, the highest detections are approximately 13 feet away from the pipeline, indicating a source other than exfiltration.

Comment 21: Page 77, 2nd Line. Please identify the location of steam vault sump at Wescoat Road.

Response: *The location of the steam vault sump at Wescoat Road has been added to Figure 8.2. The text has been changed to indicate this.*

4.0 CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD, SAN FRANCISCO BAY REGION, COMMENTS

This section contains RWQCB Comments and Navy responses.

4.1 GENERAL COMMENTS

Comment 1: The title of this draft document, *Horizontal Conduit Study Technical Memorandum*, could be inferred to mean all types of subsurface conduits. Consider including a discussion in the introductory paragraph on the rationale for precluding other potential conduits such as the Utility Tunnel from Building 10 to Hangar 1 and the french drains in the runway and in the Site 5 Fuel Farm areas. It may be helpful to reference other documents that have previously investigated other horizontal conduit areas.

Response: *The introductory paragraph has been changed to read "This investigation was conducted to evaluate whether subsurface infrastructure contribute to contaminated groundwater transport at MFA." A more detailed explanation for not including specific infrastructure is included in Section 8.1.*

Comment 2: Additional horizontal conduit investigation may be required to assess the impact on groundwater flow by the Utility tunnel connecting Building 10 to Hangar 1 and the system of french drains in the runway area and Site 5 Fuel Farm area.

Please include a cross section running parallel to Cummins Avenue from sanitary sewer manhole G-4 to G-6. The sanitary sewer, the storm drain system, all sumps and manholes associated with each system, the range of depth to groundwater, and the Utility Tunnel should be in the cross section.

Provide dimensions of the Utility Tunnel and evaluate its influence on the transport of contaminants. Include the location of the Utility Tunnel on all appropriate conduit study maps or figures.

In the areas of the french drains, provide a cross section of each area and a diagram illustrating how the drains work.

Provide historical background and survey data for each area. Document the nonexistence of subsurface fuel pipe lines.

Response: *Additional investigation has been conducted regarding Tunnel 1 and the french drain system. Additional investigation data are included throughout the report.*

Not much is known about the historical section of Tunnel 1 except that it was part of the original construction at MFA. The location of Tunnel 1 has been included on all appropriate maps or figures. A cross section running parallel to Cummins Avenue, including all of the above mentioned items, has been included in the report as Figure 8-12. A full discussion of the tunnel appears in Section 8.1 and 8.8.

Similarly, not much is known about the french drain system except that it has been present since at least 1945. A discussion of the french drain system appears in Section 8.4.

The Site 5 fuel farm area is not in the horizontal conduit study area, so no information was included. The pipelines associated with the high speed refueling area will be discussed in the report titled "Active Petroleum Sites Investigation Draft Technical Memorandum" (PRC 1995a). Building 29 piping is discussed in Section 5.2, Site 9 area of the horizontal conduit study.

Comment 3: Determination of preferential contaminant conduits in the saturated zone requires the comparative analysis of contaminant concentrations within the conduit and ambient concentrations in the surrounding areas that do not provide preferential transport. Without comparative ambient data included in the report, further analytical investigation appears to be required for this determination. Additionally, providing contaminant isocontour maps would be beneficial for this comparison.

Response: *Contaminant isocontour maps and associated discussion have been added to Section 8.0 of the report.*

Comment 4: The graphical presentation of data is very useful; the employment of multi-color graphics in the infiltration/exfiltration figures is especially noteworthy.

Response: *Comment noted.*

Comment 5: It may be appropriate to note the renaming of NAS Moffett Field to Moffett Federal Airfield (Moffett).

Response: *All references to NAS Moffett Field have been changed to Moffett Federal Airfield.*

4.2 SPECIFIC COMMENTS

Comment 6: Page 2, 2.0, Second Bullet. Tunnels are defined as potential horizontal conduits but have not been fully investigated. Provide the rationale for their exclusion.

Response: *A more detailed discussion of the tunnels has been included in Section 8.1.*

Comment 7: Page 2, 2.0, Second Paragraph. Provide documentation of the depth of all shallow utilities and state the associated groundwater depth in such areas.

Response: *Documenting the depth of all shallow utilities would involve surveying every utility. This would cause Navy to incur a large unnecessary expense. Section 8.1 has been expanded to include a discussion regarding why each utility was or was not studied further. There are general references to utility depths in this section. Depth to groundwater west of Hangar 1 generally ranges from 7 to 10 feet below ground surface (bgs). This number is less in the NEX gas station area and in the northern part of the base (1 foot in the area of the diverter box).*

Comment 8: Page 3, 3.1, Second Paragraph. Document if any subsurface pipe lines have been identified as part of the high-speed refueling facilities. Include a figure with all past and present subsurface pipe lines if substantive.

Response: *The high speed refueling area is discussed in an investigation titled "Active Petroleum Sites Investigation Draft Technical Memorandum (PRC 1995a)." The pipes are*

localized and will be discussed in that investigation. The high speed refueling area is not part of this investigation.

Comment 9: Page 6, 4.0, Third Paragraph. Include a brief statement stating the intent of the ROD [record of decision] to clarify the deletion of OU-4 and modification of OU-5.

Response: *The intent of the ROD is to mitigate the release and threatened release of hazardous substances at or from the Middlefields-Ellis-Whisman (MEW) study area. This includes the groundwater plume emanating from this area and extending north of the Bayshore freeway underneath MFA. This statement has been included in the text of the report.*

Comment 10: Page 8, 4.0. Include a list of the OUs as they have been revised.

Response: *The revised list of OUs includes:*

OU1	-	*Soils and Groundwater at Sites 1 and 2*
OU2-West	-	*Soils at Sites 8, 10 (Chase Park), 14-North, 16, 17, and 18*
OU2-East	-	*Soils at Sites 3, 4, 6, 7, 10 (runways), 11, and 13*
OU5	-	*Aquifers on the eastern side of MFA*
OU6	-	*Wetlands areas*
Petroleum Sites	-	*Sites 5, 9, 12, 14-South, 15, and 19*
Station-Wide	-	*Sites 20 to 24, and Weapons Storage Bunkers, Industrial Wastewater Flux Ponds, and Potential Runway Wetland*

This list has been included in the report.

Comment 11: Page 9, 5.0. Include the ranges of contaminant concentration levels detected in the soil and groundwater for each site identified as a known source or an area of interest.

Response: *Known sources and area of interest were selected for inclusion in the horizontal conduct study based on known or suspected direct connection with the storm drain*

system or known or suspected contribution to a petroleum or VOC plume. Groundwater plumes were shown on Figure 5-1. The Navy PCE plume and the regional VOC plume, with isoconcentration lines, are shown on several exhibits in Section 8.0. They have been added to aid in analyzing the effect of MFA infrastructure on contaminant transport.

Comment 12: Page 9, 5.1. Identify the OU which is designated for the PCE plume originating from the Building 88 site.

Response: *No OU has been specifically designated for the PCE plume originating from the Building 88 site. The plume is included as part of the regional plume. A full discussion of OUs is included in Section 4.0.*

Comment 13: Page 11, 5.2, First Paragraph. How extensive was the piping system at the Building 29 site. Include the sizing and the depth of the piping.

Response: *The location of the piping system emanating from the Building 29 area is shown on Figure 5-2. The sizing and depth of piping is unknown.*

Comment 14: Page 13, 6.0. Provide a listing of the contaminant concentration ranges associated with the MEW plume as detected in the uppermost aquifer zones at Moffett.

Response: *Contaminant concentration ranges for TCE in the regional VOC plume in the A1 aquifer are shown on Figures 8-13 and 8-14. Ranges for the A2 are given in Section 6.0 of the report.*

Comment 15: Page 14, 7.0. The Historical Review should include the Utility tunnel and the French Drains.

Response: *There is no information available regarding the construction and operation of Tunnel 1 and the french drains. There is an old drawing which indicates that both terminal points of Tunnel 1 (Building 10: the steam plant, and Hangar 1) and the french drains were already constructed by 1945. Tunnel 1 appears to be part of this original construction. This information has been added to Section 7.0.*

Comment 16: Page 19, 7.2.1, First Full Paragraph. Document the status of the piping to the former west-side sanitary sewer and storm drain system outfall located east of the current intersection of Patrol and Marriage Roads and determine if a horizontal conduit investigation in this area is necessary. Locate this outfall on appropriate maps.

Response: *The exact location of the outfall is not known (see RWQCB Specific Comment 58). The general location of confluence between the storm drain and sanitary sewer systems is shown on Figure 7.2.*

A horizontal conduit investigation is not believed necessary because both storm water and wastewater from the western side have not discharged to this area for more than 40 years. The general area of the outfall is hydraulically separated by the influence of the bay (salt water intrusion) and the pumping action of building 191 (constructed in 1952). Contamination that may have been introduced in this area is most likely gone. This was verified during the modeling effort associated with the OU5 investigation (PRC 1995b).

Comment 17: Page 20, 7.2.2.1. The importance of the varying precipitation time frames regarding infiltration and exfiltration from the horizontal conduits predicates a discussion defining the parameters of dry and wet; periods, weather, and seasons.

Response: *The usage of the phrases "periods of heavy rain," "peak wet weather periods," is ERM's and was retained for consistency. The context would suggest that these phrases refer to a single rainstorm or a series of rainstorms in quick succession. No clarification of ERM wording has been provided in the text. Dry and wet periods and seasons, where used elsewhere in the report, have been clarified.*

Comment 18: Page 22, 7.2.2.2, Eastern Side, First Paragraph. Document the rates of regional subsidence and, if available, site subsidence. These values may help provide an understanding of the historical and future groundwater behavior with respect to the horizontal conduits and mean sea level.

Response: *Regional subsidence at Moffett Federal Field has ranged between 4 and 6 feet between 1934 and 1967, depending on what part of the airfield one is referencing. Subsequent measurements by Navy have shown that subsidence at U.S. Geological Survey (USGS) Benchmark H-111, located in the southern entrance to Hangar 1, has dropped from 18.025 feet to 17.61 feet above mean sea level (0.42 feet) between 1963 and 1992 (JMM 1992). The drop is thought to be due to gradual settlement rather than the effects of the Loma Prieta Earthquake, which occurred in 1989. This response has been added to the text.*

Comment 19: Page 23, 7.3.1. Document defining parameters for dry weather and wet weather.

Response: *Dry and wet weather, as used in this section, refer to short time periods measured as a day or days. The period referred to in each report is defined in each of the summaries. Clarification of these terms has been added to the introductory paragraph of Section 7.3.1.*

Comment 20: Page 23, 7.3.1. Sanitary Sewer System: Document the amount of rainfall and determine if rainfall is directly entering the sanitary sewer system.

Response: *Daily precipitation amounts were 0 inches for February 15, 0.88 inches for February 16, 0.62 inches for February 17, 0.31 inches for February 18, 0.73 inches for February 19, 0.08 inches for February 20, 0.26 inches for February 21, and 0 inches for February 22 (NOAA 1995). This is the time period covered by the BASMI study case and included in Table A.6 in Appendix A of the horizontal conduct study. The conclusion inferred from the report is that the entire sanitary sewer system is responsive to an isolated rain event. This is in agreement with the ERM report summarized in Section 7.3.2. The BASMI report also infers that there is infiltration of groundwater into the sanitary sewer system during dry periods (dry day in the BASMI report). This also is in agreement with the ERM report (flow measurement after several months of no rainfall). The pathway for rainfall to enter the sanitary sewer system is not known.*

Comment 21: Page 23, 7.3.1, Diverted Box. Verify reported dates and flow rates, 1,800 gpm is noteworthy.

Response: *The reported dates have been corrected. The correct monitoring period is January 26, 1991, to February 1, 1991. The peak flow rate in the referenced Storm Water Study was 2.6 million gallons per day (gpd). This converts to 1,806 gpm.*

Comment 22: Page 23, 7.3.1, Building 191. Provide a description of the Rain Bird pump slide rule and how it is used.

Response: *The Rain Bird Pump slide rule is a device which calculates the output from a pump in gpm given the brake horsepower of the pump, efficiency of the pump, and the discharge head from the pump. Rain Bird no longer makes this slide rule. The reference to the slide rule has been deleted from the text.*

Comment 23: Page 29, 7.4.2, Eastern Side, Second Paragraph. Identify the wet well.

Response: *Building 191 is constructed with an exterior wet well on the western side and an interior wet well beneath the building. Water enters the wet well from the Navy Ditch and two storm drain lines. This water flows through a circular opening which is covered with a screen placed for trash removal. Water is then pumped from the interior wet well by the Building 191 pumps into the Northern Channel. This information has been added to the text. A figure showing Building 191 features is also included in Table A-4 of Appendix A.*

Comment 24: Page 29, 7.4.2, Eastern Side, Third Paragraph. Document how the water sample collected in association with a storm event was collected. Describe the storm event, i.e. rainfall amount.

Response: *The Navy does not know how NASA collected the water sample. According to precipitation data collected at MFA, 0.04 inches and 0.17 inches of rain fell on February 16 and 17, 1993, respectively. This information has been added to the report.*

Comment 25: Page 29, 7.5. Verify diesel and motor oil detected concentrations of 109 ppm for each analysis.

Response: *The concentrations of diesel and fuel motor oil are as reported in the 1991 Storm Water Study Report (see Table A-1 in Appendix A) (PRC and JMM 1991).*

Comment 26: Page 30, 8.1, First Paragraph. Identify the utility conduit in Electrical Vault 5 which enters below the "water line" and describe what is meant by the water line.

Response: *The word "high" was added before the words "water line." The high water line was determined by noting where discoloration ceased on the vault sidewalls. The discoloration is presumed due to mineral deposits on the sidewalls from infiltrating water. The conduit entering below the high water line enters the vault from the southern end at the bottom of the vault. This information has been included in the text. It is unknown where the conduit or related ducts lead to. The duct most likely connects with Electrical Vault 6. Electrical Vault 6 is located at the southwestern corner of Hangar 1. If this duct is the same, it enters Electrical Vault 6 above the high water line. The duct may have been constructed so that it would pass underneath Tunnel 1 and was brought up above the high water line on the southern side of Tunnel 1.*

Comment 27: Page 30, 8.1, Second Paragraph. What is the depth variation as the steam line crosses under Wescoat Road. Include location of the steam line crossing Wescoat Road on appropriate map.

Response: *The steam trench on either side of the crossing is 4.3 feet bgs. The depth of the vault at the road crossing is 11.4 feet bgs. This information has been added to Section 8.1 of the report. The location of the steam line crossing has been shown on appropriate figures.*

Comment 28: Page 30, 8.1, Third Paragraph. Include a description of a manhole bench.

Response: *A manhole is constructed with a level bottom which is interrupted by a channel traversing from one side to another. The level part of the bottom is commonly referred to as a bench. The text now refers only to the bottom of the manholes.*

Comment 29: Page 32, 8.2, First Paragraph. Has a reference horizontal coordinate system for the site been established?

Response: *The California State Coordinate System, North American Datum 1927 (NAD-27), Zone 3, is the horizontal coordinate system utilized. The Navy has determined that the elevation of H111 is 17.61 feet above mean sea level (msl). The text has been clarified.*

Comment 30: Page 36, 8.3. Include the dates when field activities were performed in each site subsection and explain the time gap between some sample collection and testing, e.g. Sample VHHC-1-4-SP collected on May 26, 1993, and tested on July 14, 1993.

Response: *Backfill samples of excavation Sites 1 through 3, 4, and 5 and 6 were collected on May 26, 1993, May 27, 1993, and January 24, 1994, respectively. This information has been added to the report. The permeability samples were collected by driving a precleaned, 2.5-inch by 6-inch brass sleeve into the bottom of the excavation. The recovered sleeve was capped on each end with a tight fitting plastic cap, sealed with filament tape, and subsequently transported to a soil laboratory for analysis. There was a delay in transporting permeability samples VHHC-1, 2, 4, and 5 to the laboratory so these samples were not tested until the middle of July 1993.*

Comment 31: Page 37, 8.3.1, First Full Paragraph. Include a description of a spring line.

Response: *Spring line refers to the horizontal axis of the pipe. This information has been added to the text.*

Comment 32: Page 39, 8.3.3, First Paragraph. This paragraph details the only information regarding the Utility Tunnel and would be sufficient for this section if it was thoroughly described earlier in the investigation.

Response: *The comment has been noted. Section 8.1 has been revised to discuss the utility tunnel in greater detail.*

Comment 33: Page 40, 8.3.4, First Paragraph. Describe in what direction from the pipeline the final excavation (VHHC-9) was subsequently conducted.

Response: *VHHC-9 was completed 5 feet south of VHHC-8 and south of the pipeline. The text was clarified to reflect this.*

Comment 34: Page 40, 8.3.5, Second Paragraph. Describe in what direction from the pipeline the final excavation (VHHC-11) was subsequently conducted.

Response: *VHHC-11 was completed 5 feet west of the pipeline. The text was clarified to reflect this.*

Comment 35: Page 40, 8.3.6, Second Paragraph. Verify VHHC-12 location. Describe pipe bedding. Additionally, verify the medium to fine silty sand soil description; the log and grain analysis indicate medium to coarse grain distribution.

Response: *Pipe bedding is the material that forms a foundation or bottom layer for the pipe, and is normally provided up to the spring line when used. To describe the VHHC-12 location, the text has been revised to read, "The first excavation (VHHC-12) at Site 6 was completed approximately 0.5 feet north of Manhole 1.10.... A coarse to medium sand was encountered adjacent to the concrete bedding..." At VHHC-12, the concrete bedding was encountered at the spring line of the pipe.*

Comment 36: Page 41, 8.3.6. The text states, "Medium to fine sand, encountered in VHHC-122 is possibly part of a paleo-channel which is running through the area." Verify the medium to fine sand description and provide documentation of the paleo-channel determination. The next sentence refers to ". . .cracks in the concrete bedding." Describe the size and occurrence of these cracks. Indicate what direction from the pipeline VHHC-13 was conducted.

Response: *The laboratory description for the material, as a result of a sieve analysis, is brown sand with silt (SP-SM). After reviewing well logs and the Draft West Side Aquifers Field Investigation Technical Memorandum (PRC 1993), the text was changed to read "Brown sand with silt (SP-SM) encountered in VHHC-12 appears to indicate the*

presence of engineered backfill along this line." Cracks were observed in the concrete bedding exposed in the VacHoe excavation. The frequency and occurrence beyond the excavation is unknown. VHHC-13 was located 5 feet to the west of VHHC-12 (see the map in appendix C for locations of VHHC-12 and VHHC-13).

Comment 37: Page 41, 8.4, Second Paragraph. Document defining parameters for dry season and wet season. Provide season verses weather clarification in that February 1993 is stated as a wet season but on page 23 the 7-day period from January 26 to February 1 (1991 or 1992-unclear) is stated as dry weather. Typo - equifer to aquifer.

Response: *The wet season is defined as the period from November through March. Approximately 85 percent of the annual precipitation received at Moffett Field occurs during this time period. The remaining period, April through November, is considered the dry period. Piezometric levels of select wells demonstrate that the uppermost aquifer experiences water level highs and lows in the wet and dry seasons, respectively. Supporting text, tables, and figures have been added to Section 8.4.*

Comment 38: Page 45, 8.4. Clarify the location of the small oval-shaped section area.

Response: *The statement now reads that ". . . a section of the storm drain line, along line 2, is subject to continuous infiltration."*

Comment 39: Page 45, 8.5. Include the results of third video survey conducted by NASA.

Response: *The results of the video survey conducted by NASA have been included as Appendix F.*

Comment 40: Page 47, 8.6. Document defining parameters for choosing Phase I (July 27 through 28, 1993) and Phase II (January 31 through February 2, 1994) time frames. Describe if these are dry or wet; periods, weather, or seasons.

Response: *Phase I was conducted during the dry season. Phase II was conducted during the wet season. This information has been added to the report.*

Comment 41: Page 47, 8.6.1, Second Paragraph, Fourth Sentence. Verify if text ". . . north of manhole 36A", should it read . . . north of manhole S36A?

Response: *The text should read north of manhole S36A. The text has been corrected.*

Comment 42: Page 47, 8.6.1, Second Paragraph, First Sentence. Verify if text ". . . C-1 plus C-1 plus F-2", should it read . . . C-1 plus E-1 plus F-2?

Response: *The text should read C-1 plus E-1 plus F-2. The text has been corrected.*

Comment 43: Page 47, 8.6.1, Second Paragraph, Sixth Sentence. Verify if text ". . . manholes 9-B2, 5-36A, and G-3", should read . . . manholes 9-B2, S36A, and G-3.

Response: *The text should read 9-B2, S36A, and G-3. The text has been corrected.*

Comment 44: Page 59, 8.6.2. The text states that, "After validation, some of these values may no longer be included." The RWQCB would prefer the inclusion of all values on all appropriate analytical tables but will allow their omission if included in a data validation section.

Response: *Nonvalidated and validated data are included in Appendix D and discussed in Appendix E. Only validated data are included in the body of the report.*

Comment 45: Page 63, 8.2. These analytical results clearly indicate that the Utility Tunnel is an area of warranted concern is worthy of future investigation.

Response: *The utility tunnel was investigated further. The results of this investigation are included in Section 8.1.*

Comment 46: Page 63, 8.6.3. Rainwater and bay water should have been chemically analyzed for comparative purposes in addition to groundwater and tap water.

Response: *The comment is noted.*

Comment 47: Page 67, Third Paragraph. The text states "The Hangar 1 sump is believed to discharge to line 4 just upstream of manhole 4.8." Include a discussion detailing why this location cannot be identified.

Response: *The actual service connection is not at the manhole and therefore cannot be seen. However, information is available which indicates that the service connection is between manhole 4.8 and 4.9 of the storm drain system. On February 2, 1994, the pump in the Hangar 1 sump was observed as continuously discharging through a line that entered the Hangar on the eastern side. Flow rates were measured at manholes 4.8 and 4.9 to try to determine what the flow rate from the sump was. Manhole 4.9 was dry. The flow rate at manhole 4.8 was measured at 7.2 gpm.*

Flow from the sump was measured again on May 3, 1994. On this date the pump was observed cycling on and off with a corresponding fall and rise of the water level in the sump. The average rate of flow into the sump was 6.77 gpm (PRC 1994) as calculated by determining the change in volume of water in the sump when the pump cycle was on and considering the lapse of time between on cycles.

Finally, according to a report prepared for NASA by the Bentley Company (1994), a dye test was conducted at this sump and dye was subsequently identified at manhole 4.8 of the storm drain system. This information indicates that the Hangar 1 sump does discharge to line 4 just upstream of manhole 4.8. This discussion has been included in the report.

Comment 48: Page 69, 8.7, Top Paragraph. The catch basin may be an appropriate sampling location if the surface or subsurface origin of contamination has not been defined.

Response: *The catch basin was originally thought to be part of the piping associated with Sump 61. This sump was an area of interest rather than a known source. There is no known surface or subsurface contamination associated with this sump. The purpose of the Geoprobe sampling was to see if possible exfiltration of contaminants from Sump 61 could be detected. According to the Tank and Sump Removal Report (PRC 1991), "two storm drain lines that carried effluent from Sump 61 were present in the excavation at approximately 9 feet bgs." This statement appears incorrect*

since the receiving storm drain line, line 7, is only 6 feet bgs in this area. The line was originally thought to be part of the storm drain system because a storm drain catch basin further west, 7G.2 on Figure 8.2, drained into the sump. It is now believed that this sump was connected with the sanitary sewer system, most likely at manhole G-4. The sanitary sewer system is 9.5 feet bgs in this area.

Comment 49: Page 69, 8.7, Last Paragraph. Document the rationale for collecting and analyzing both samples within each set. (Two sets, with each set having two samples within 0.5 feet of each other, one set near the pipeline and the other approximately 5 feet away from the pipeline.)

Response: *The purpose of two sets of two samples was to develop a vertical grid through which the path of VOCs could be detected. The grid was to be located below the invert of the pipeline but above the highest piezometric surface. This grid was located adjacent to manholes and manhole connections which are often sources of leaks. If VOCs were exfiltrating from the line, they would be expected to adsorb to soil particles in the vertical line below the pipeline. Therefore, higher concentrations would be detected closer to the line. The set of samples 5 feet away from the line would be out of the sphere of influence of the line and would not show this pattern.*

On the other hand, if VOCs from the plume were volatilizing through the soil, they would be expected to adsorb to soil particles in both sets with the samples closest to the line having the highest concentrations. Samples were collected just below the invert elevations and just above the high piezometric levels. This information has been added to the report.

Comment 50: Page 69, 8.7, Last Paragraph. Documentation of non-existence and/or non-use at Moffett is required to demonstrate that the "lab contaminants" detected are not a chemical of concern.

Response: *There is no documented use of acetone or methylene chloride at Moffett Field. However, isolated uses or spills may have occurred. The data in the final report have been validated according to EPA protocol (EPA 1990). Neither acetone nor methylene chloride were detected in this data set.*

Comment 51: Page 69, 8.7, Last Paragraph. PCE was not listed on page 13 as a constituent of the MEW plume.

Response: *PCE is a constituent of the MEW plume. The text on page 13 has been corrected.*

Comment 52: Page 71, 8.8, Second Paragraph. Documentation of non-existence and/or non-use at Moffett is required to demonstrate that the "lab contaminants" detected are not a chemical of concern. Additionally, include analytical detection limits in the text.

Response: *There is no documented use of bis(2-ethylhexyl) phthalate or butylbenzyl phthalate at Moffett Federal Airfield. However, isolated spills or uses may have occurred. The data in the final report has been validated according to EPA protocol (EPA 1990). Neither bis(2-ethylhexyl) phthalate or butylbenzyl phthalate were detected in this data set.*

Comment 53: Page 71, 8.8, Third paragraph. Would it be appropriate to include a reference to the increased presence of PAHs [polynuclear aromatic hydrocarbons] in motor oils with respect to longer usage?

Response: *The sentence in the third paragraph now reads, "PAHs are most commonly produced as a combustion by-product, are exuded by road tar, and form in motor oil with extended use."*

Comment 54: Page 73, 9.4, Last Sentence. Include a discussion regarding the depositional environment of sands observed in Sample VHHC-12 collected at Excavation Site 6.

Response: *Please refer to the response to RWQCB comment 36.*

Comment 55: Page 76, 9.10, Second Paragraph. Identify storm drain line 7 as the line the which PCE contaminated water is entering.

Response: *The sentence has been revised to read, "PCE-contaminated water also enters storm drain lines 7 and 4 primarily by way of the Electrical Vault 5 sump and the Hangar 1 sump, respectively.*

Comment 56: Page 77, 9.11. Discuss the origin of the contaminants detected in the groundwater discharged from Sump 1 and Electric Vault 5, (local or regional). Explore the possibility of the Utility Tunnel acting as a dam with a leak caused by the intersecting of the sanitary sewer and storm drain systems near storm drain catch basin 7J-1. This leaky dam model might help explain the unusual 10 foot contour line as seen in Figure 8.4 just to the north of the Utility Tunnel and the elevated contaminant concentrations in this area.

Response: *Figure 8.4 was developed through the use of a computer program which creates contour maps from water level data. Since there is no well control in that area, it is most likely an artifact of the computer generation process. In order for a leaky dam model to apply, the tunnel would need to fully penetrate the aquifer. This is not the case. The tunnel is only 9 feet deep while the upper aquifer is 60 feet deep. An analogy from a hydraulic stand point would be an inverted siphon. In an inverted siphon, water would enter at one end, flow down around the bend and back up the side. The water level on either side of the siphon, or tunnel in this case, would be essentially the same.*

Comment 57: Page E-1. Data validation will be review upon its completion.

Response: *The comment has been noted.*

Comment 58: Figure 4.1. Include Flux Ponds in Site 4 description. Identify Building 88 in Site 18 description. Locate the Sanitary and Storm outfall identified existing up to 1942. Locate Utility Tunnel.

Response: *The former industrial wastewater surface impoundments are next to the flux ponds. The flux ponds are now shown on Figure 4-1. Site 18 is Sump 66 rather than Building 88. The location of Building 88 has been referenced on Figure 8.1. The general location of the common sanitary sewer and storm drain outfall has been added to Figure 7.2. The exact location is unknown. The corner of the reference map, where the location of this outfall is shown, is missing. Tunnel 1 has been located on Figure 4.1.*

Comment 59: Figure 5.1. Include contaminant isocontours in plume area.

Response: *Isoconcentration lines for PCE have been included on Figures 8.14 and 8.15. Isoconcentration lines for TCE have been included on Figures 8.12 and 8.13.*

Comment 60: Figure 8.1. Verify all Sanitary Sewer System figures for the direction of flow between manhole 7B and the area of manholes 5, 5A, and S24.

Response: *The arrow indicating the direction of flow between manholes S24 and 7B is incorrect; this arrow now indicates that wastewater flows from manhole S24 to manhole 7B.*

Comment 61: Figures 8.4 and 8.5. Include Utility Tunnel location and all other utilities on potentiometric surface map.

Response: *Tunnel 1 has been included on Figures 8-13, 8-14, and 8-16. Other utilities have been addressed in Section 8.1, preliminary screening.*

Comment 62: Figures 8.14 and 8.15. Include laboratory data qualifiers in legend.

Response: *Laboratory data qualifiers have been included on Figures 8-20 and 8-22. These figures were formerly 8.14 and 8.15.*

Comment 63: Table 8-1. Items to be included: sample collection date, full sample identification, and sample depth. Note (a) states that soils are classified by field observation only but Samples VHHC-4-6.25, VHHC-5-6-SP, VHHC-6-8S, VHHC-7-4S, VHHC-8-5S, VHHC-9-5S are listed as clays (CL) but are field classified as silts (ML). Sample VHHC-12-5.5 is listed as a poorly graded, clayey sand (SB-SC) but is field classified as a poorly graded, silty sand (SP-SM).

Response: *Table 8-1 has been renamed Table 8-2. Table 8-1, which contains the sample identification and the depth at which the sample was collected, has been added to the report. The sample identification for samples submitted to the laboratory were the letters VHHC followed by the excavation number, then the depth in feet, and then the suffix S or SP, depending on whether a sieve analysis or a permeability test was*

needed. The laboratory did not report the sample identification in this manner. Since a maximum of one sieve analysis and one permeability sample were taken per excavation, the letters VHHC and the excavation number are reported only.

The unified Soil Classification System (USCS) designations in the table reflected assumptions regarding Atterburg limits. Since Atterburg limits were not requested, the table was changed to reflect the laboratory description of the soil as a result of the sieve analysis. The descriptions in the log remained as is, even though the classifications used also necessitate use of Atterburg limits. These are the impressions of the field geologist and will remained unchanged. The reader should note that the only difference between the USCS classification CL and SM are Atterburg limits. The grain size distribution is the same.

Comment 64: Table 8-2A. Include all units in the notes.

Response: *All units have now been included in the notes.*

Comment 65: Boring logs. Verify times on Boring Logs and identify the location of samples submitted for each analysis. Define gleyed. Identify water elevations if encountered.
Log VHHC-7 at 2 feet; gravel (GW) mislabeled as silt (ML).
Log VHHC-10 at 5.0 - 5.5 feet; clay (CL) mislabeled as a silt (ML).
Log VHHC-11 at 4.0 - 5.0 feet; clay (CL) mislabeled as a silt (ML).
Log VHHC-12 at 4 feet; typo- change course to coarse.

Response: *The times were accurate except for boring logs VHHC-10, VHHC-11, VHHC-12, and VHHC-13. These times were not recorded and have been so noted. The samples submitted for analysis have been noted on the appropriate logs. Gleyed is defined as a sticky bluish-gray soil layer formed under the influence of excessive moisture. Where elevations were difficult to determine because of the low permeability of the soil material, the holes were not left open long enough to allow the water level in the hole to stabilize. Moisture conditions, for the most part, were recorded on the logs. All of the changes suggested for VHHC-7, VHHC-10, VHHC-11, and VHHC-12 have been made.*

5.0 REFERENCES

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