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HUNTERS POINT
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Department of Toxic Substances Control

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Febuary 7, 2001

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1220 Pacific Highway
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Attention:Richard Mach

REVISED INFORMATION PACKAGE FOR THE PHASE I GROUNDWATER DATA GAP INVESTIGATION,

FIELD SAMPLING PLAN AND QUALITY ASSURANCE PROJECT PLAN ADDENDA FOR PHASE II GROUNDWATER DATA GAP INVESTIGATION,

HUNTERS POINT SHIPYARD, SAN FRANCISCO, CALIFORNIA

Dear Mr. Mach:

California Department of Toxic Substances Control has completed the review of above-mentioned documents. Our commments are provided below. Because of the close relationship between the Plan and the information package, comments on both are somewhat intertwined.

Field Sampling Plan Addendum (FSP)

1. Data gap: soil to groundwater screening. Both the Phase I and the Phase II groundwater data gap plans did not include evaluation of potential threats to groundwater from soil. That is, leaching of contaminants from soil to groundwater was not a pathway of migration considered. For the sake of clarification, this plan should explicitly state that the data gap of soil to groundwater screening (for potential human health and ecological effects) has not been addressed. The Navy's plans for addressing this data gap should be summarized. For example, will this data gap be addressed in Phase III?

DTSC is concerned that the plan implies that all groundwater data

gaps have been taken into consideration in the plan, and that the agencies have agreed that the scope of the plan is complete. For example, the plan states (page 3, paragraph 1, last sentence): "Note that groundwater data gaps have been identified at Parcel E on the basis of results of working meetings with the BCT [Base Realignment Closure Team] similar to the working meetings conducted for Parcels C and D." Please note that, at meetings and in written comments, the additional data gaps of soil to groundwater screening, and NAPL extent (next comment) have been emphasized by DTSC and other agencies, but are not addressed in this document.

2. Data gap: non-aqueous phase liquids (NAPLs). Data gaps due to both dense and light non-aqueous phase liquids (DNAPLs and LNAPLs) are not evaluated or addressed in Phase I and Phase II groundwater data gaps plans. The plan should explicitly state that these data gaps have not been addressed.

Presumably, the nature and extent of LNAPL will de determined as part of the Regional Water Quality Control Board's (RWQCB's) Corrective Action Program (CAP) for the site.

What is the Navy's plan for investigating the extent of DNAPL? Will DNAPL be addressed in Phase III?

3. Screening criteria. Parcels C and D were screened against drinking water criteria only--but Parcel E was screened against both drinking water criteria and NAWQCs. Why were different criteria used for different parcels? As beneficial uses for aquifers are determined at each parcel, a boundary between drinking water and non-drinking water will be established. In Parcel E, the non-drinking water (with high TDS) is presumed to be essentially Bay water (i.e., inside the tidally influenced zone), where NAWQCs are appropriate screening criteria. It is not apparent why a different rationale is appropriate for Parcels C and D.

If screening for ecological criteria and Bay protection is required in Parcels C and D and is not accomplished at this time, then a data gap will exist on Parcels C and D. This data gap will need to be addressed in Phase III.

RWQCB's criteria for total petroleum hydrocarbons (TPH) should be included, and the criterion for methyl tert-butyl ether (MTBE).

4. HGALs. For the B aquifer, HGALs should be determined. Current

HGALs apply to the shallow A-aquifer only, and are not appropriate screening criteria for deeper wells. For the A aquifer, HGALs may need to be revisited occasionally, as the groundwater data set expands.

5. Monitored natural attenuation (MNA). The Navy has included MNA parameters as analytes for some wells in this plan. However, MNA has not been formally proposed as such. That is, the FSP/QAPP does not contain a rationale for selecting and interpreting MNA parameters. It is not clear how the Navy plans to use the data collected to support their MNA proposals, or if the data collected will be of sufficient or appropriate quality.

DTSC has developed an approach for reviewing MNA proposals at sites which is summarized in a checklist (Attachment 1). This checklist will be used by DTSC to evaluate any MNA proposals from the Navy. It is recommended that MNA proposals from the Navy follow the approach outlined in the checklist. That is, the Navy should review the checklist, make any necessary changes in its MNA program, and design proposals and field reports to answer questions raised in the checklist.

6. Pumping effects

A very widespread effect on control of groundwater flow due to Pump Station A (especially in Parcels D and E) is implied on Figure 6 of the information package. Similarly, large depressions of the water table in the same area are shown on Figures 2 through 5, for other measurement events. However, such a widespread effect from Pump Station A is unlikely.

The depression is undoubtedly due to combined effects of Pump Station A and tidal fluctuations, and is not as broad or persistent as implied in the figures. On the figures, ground water level measurements were collected at high tide, and depict flow away from the Bay. Groundwater levels collected at low tide would indicate flow towards the Bay over a large area, and a significantly smaller depression. In order to distinguish pumping effects from tidal effects, groundwater level measurements should be collected at both high tide and low tide.

The groundwater contours on Figure 6 also suggest that Pump Station A may be associated with potential salt water intrusion, since the area of depression centered at Pump Station A extends to the Bay margin. However, at low tide, an association of Pump Station A with salt water intrusion is not likely to be demonstrated.

To better characterize groundwater flow, both high and low tide measurements are required. For Phase II, figures for both high and low tide should be presented.

Will Pump Station A be maintained in perpetuity? If so, it is essentially functioning as a pump and treat system for groundwater control, and should be evaluated as such. Alternatively, if Pump Station A is to be shut down, then groundwater flow patterns (and plume boundaries) are likely to change substantially, and monitoring will be required at least until new patterns stabilize.

The effect of Pump Station A to the north of the station is not shown on Figure 6. A steep groundwater gradient on the hill to the north is to be expected. Wells should be added north of the station.

Has it been determined whether Pump Station A has any effect on deeper groundwater? Deeper wells in the vicinity of Pump Station A should be considered.

For the sake of clarification, Figures 2 to 6 should indicate that measurements were taken at high tide. Tidal zones should be added to Figure 6.

Any other pumping systems operating at the site that may impact groundwater flow should be discussed in the text and included on Figure 6. For example, pumping wells near sheet pile walls should be shown. Will these wells be maintained in perpetuity? Similarly, operating soil vapor extraction systems that may cause mounding effects should be discussed in the text and noted on Figure 6. The effect of pumping on plume boundaries should be explicitly discussed.

Discharge rates for pumping operations should be included.

7. <u>Anomalous flow regions</u>

Areas of persistent anomalous highs and lows were reviewed (Figures 2 through 6 of the information package). Groundwater level measurements at the following wells should be added to provide more coverage in anomalous areas.

* At well IR02MW146A (located in Parcel E near IR03), the water level elevation is 4.30 feet below mean sea level. This low is likely related to the nearby sheetpile wall and to tidal effects. Please add

wells on both sides of the seawall--e.g., IR03MW369A, IR03MW0-1, and IR03MW0-2.

* At well PA50MW07A (located near Berth 15 of the South Berthing Slip), the water level elevation is 2.37 feet below mean sea level. This low may be associated with the nearby concrete seawall wall and with tidal effects. Was this well included in the tidal influence study? (It is outside the tidal zone in Figures 2 through 5 of the information packet.) Please add nearby wells: IR70MW07A, IR70MW12A, and IR50MW02A.

* Two areas of persistent highs are near IR01MW38A and IR11MW25A. Please include these two wells.

* Is there an explanation for the groundwater mound near PA50MW06A?

* At well IR02MW298A, leakage from a salt water fire line is speculated. Are salt water lines still charged? Might they be associated with other anomalous ground water elevation highs--or with areas of high total dissolved solids (TDS)? Are these lines supplied by pumping at the Bay margin? If not, where are the cisterns/storage tanks for fire fighting?

* Another potential source of anomalies is testing of fire fighting systems, which may involve large releases of water. This effect has been observed at Mare Island. The schedule for groundwater elevation measurements should not coincide with hydrant testing (for salt and fresh water). Generally annual testing is performed.

8. Sheet Pile Walls. The effectiveness of sheet pile walls and other seawalls to control groundwater flow should be evaluated. While sheetpile walls (and seawalls) may serve to dampen flow or retard tidal effects, very low zones adjacent to such walls may indicate that the walls are permeable. To evaluate permeability, groundwater elevation data should be collected at low tide as well as high tide in the vicinity of the walls. Deeper wells in the vicinity of walls should be included in the water level measurement program to check for vertical gradients near walls.

9. Information packages. Information packages are scheduled at the conclusion of Phase II. The term "information package" implies a data dump: data dumps are not acceptable. Please note that DTSC expects significant evaluation of the Phase I and Phase II (and Phase III) data.

The term "report" is preferred over "information package".

10. Table 4-1, Results of Well Condition Survey

According to the Navy, about 78 wells are "not available" for sampling, 34 wells are "abandoned" and 9 wells are not located.

As previously noted by DTSC, "abandonment" of wells is not permissible under state law. Wells that are missing or abandoned may serve as conduits for contamination, may be physical hazards, and may provide opportunity for mischief, including illegal disposal down the well, etc. State law requires that all wells must be properly "decommissioned". Please discontinue use of the term "abandonment", since it implies malfeasance. Accordingly, please change the wording of this table (and other tables) and the text of this document (and the information package).

How is the Navy planning to locate missing wells?

Other problems with wells include: damaged wells, lids that could not be opened, and one dry well with obstructed access. What are the Navy's plans for correcting these problems? Is the dry well always dry? What is the access problem? (See also Information Package comment 10.)

The date of the survey should be included on the table.

The FSP states that the data gap "assess conditions of all existing wells" is "completed". The FSP indicates that significant work has been performed (Section 4.1 and Table 4-1). However, the records of the assessment are not sufficient, and it is not clear that all problems (see above) have been attended to. The Navy should prepare a well condition report for all wells, which includes: monitoring well inspection forms, corrective actions taken on wells, well decommissioning details, well construction details, surveyed well locations, etc.

Were there any historic fire fighting or water supply wells located on site? If so, they should be included in the report.

Regarding wells with free product, please see Information Package comment 4.

11. Table 4-2: Wells for Water Level Measurements. All wells for chemical analytical sampling will be measured for groundwater elevations. The table should distinguish those wells used for water level

measurements only (i.e., note which wells are not included in the chemical analytical program). A footnote on the table should indicate those wells which were dropped from Phase II but which were included in Phase I.

12. Well construction table. Please provide a table showing well construction details for all old and new wells in the Phase I and Phase II program. The table should include: date of installation, surveyed well locations, well screen interval, screen materials, total depth, aquifer zone, etc.

13. Table 4-4, Data Collection Requirements , Phase II Groundwater Data Gaps Investigation.

Comments (below) on Parcels C and D pertain only to exceedences of drinking water criteria (see FSP comment 3). It is recommended that the Navy screen Parcel C and D groundwater data against NAWQCs, and that any exceedences of NAWQCs be added to the Phase II chemical analytical program.

Comments for Parcel E pertain to exceedences of both drinking water criteria and NAWQCs, and are, hence, more complete.

Please note that DTSC does not agree with the Navy's decision rule that analytes can be excluded if succeeding measurements are below criteria, because of the very small data set for most wells at the site. In dynamic environments (like that at the site) two rounds of annual sampling is considered a minimum data set for assessing chemical analytical trends.

Parcel C

The analytes listed on this table were not cross checked against the analytes on Table 4-5. Comments are provided under Table 4-5.

Parcel D

The analytes listed on this table were not cross checked against the analytes on Table 4-6. Comments are provided under Table 4-5.

Parcel E

The proposed chemical analytical program is responsive to DTSC's requests with two minor exceptions. Analytes that exceeded screening criteria (MCLs, NAWQCs, HGALs) are included in the chemical analytical program, with some minor exceptions that have been agreed upon.

Please add the following analytes to this table and to Tables 4-5 through 4-7, as appropriate.

Parcel E: Aluminum to IR01MWI-8 and IR02MW298A.

14. Table 4-5, Parcel C Wells for Resampling, Target Analytes column. For the sake of consistency, please add the following analytes which are not included on this table but are included on Table 4-4:

IR25MW18A	TDS
IR25MW19A	TDS

Please add:

IR06MW11A	PCBs
IR06MW22A	PCBs
IR28MW128A	VOCs, MNA*
IR28MW340A	VOCs, MNA
IR28MW151A	

The plume is not well defined to the south, east and west. Nearest wells are 300 to 400 feet distant. More wells may be needed in these areas.

IR58MW31A	VOCs, MNA, PCBs, TPHe, TPHp, pesticides
IR58MW32B	VOCs, MNA
IR58MW33B	VOCs, MNA
PA28MW50A	VOCs, MNA
PA28MW51A	VOCs, MNA

* MNA recommended to be consistent with Navy's approach at other VOC sites.

MNA is proposed at IR58MW25F and IR8MW26A, but VOC sampling is not. Is this intentional? (This occurs at a few other wells, including Parcel D wells.)

What is the rationale for manganese sampling of groundwater? How many wells were sampled? Several detections are noted (in ug/L) at: IR06MW44A (2950), IR28MW125A (107), IR28MW127 (425), IR28MW155A (225), IR28MW311A (1750), and IR58MW25F (3.5). What is the significance of these results?

On Figures 9B-1 and 9B-2, IR28MW211F is mistakenly identified as IR28MW342F.

15. Table 4-6, Parcel D Wells for Resampling, Target Analytes column. For the sake of consistency, please add the following analytes which are not included on this table but are included on Table 4-4:

IR09MWPO43A	manganese (6080)*, nickel, thallium
IR33MW61A	aluminum, VOCs
IR33MW120B	lead
IR34MW01A	aluminum
IR34MW36B	thallium
IR34MW37A	thallium, manganese (10400)
IR34MW37B	thallium, manganese (5590)

* Manganese was detected in more wells Parcel D (compared to Parcel C). Repeat sampling is requested for the three highest values, which are shown (in ug/L).

16. Table 4-7, Parcel E Wells for Resampling, Target analytes column. For the sake of consistency, please add the following analytes which are not included on this table but are included on Table 4-4:

IR01MW05A	antimony, arsenic, cadmium, chromium, chromium VI, copper, lead, mercury, silver
IR01MW18A	chromium VI
IR01MW42A	lead
IR01MW44A	zinc
IR01MW62A	chromium VI
IR01MW367A	zinc
IR01MWI-2	chromium VI
IR01MWI-5	chromium VI
IR01MWI-9	chromium VI
IR02MW101A1	chromium VI
IR02MW114A2	chromium VI
IR02MW141A	chromium VI
IR02MW175A	aluminum
IR02MW183A	SVOCs
IR02MW298A	aluminum, chromium VI, nickel
IR02MW209A	TDS
IR02MWB-1	chromium VI
IR02MWB-2	chromium VI
IR02MWB-3	chromium VI
IR03MW224A	chromium VI
IR03MW226A	chromium VI
IR03MW342A	chromium, chromium VI, copper, lead,

	mercury, nickel, zinc
IR03MWO-1	chromium VI
IR04MW35A	nickel
IR04MW40A	cadmium, nickel
IR04MW85A	cadmium, mercury
IR12MW21A	SVOCs
IR14MW10A	cadmium
IR14MW13	SVOCs
IR15MW07	silver
IR36MW135A	cadmium
IR36MW03A	pesticides
IR36MW04A	pesticides
IR36MW06A	pesticides

17. Consider adding analytes to IR28MW393B and PA33MW37A, for "sulphurous" and "poopy" odors noted on well logs.

18. Appendix B. Rationale for Parcel E Well Sampling, Phase II GDGI (2 pages) is presented following the minutes of the December 5 meeting. This document was not previously seen or reviewed by DTSC. Inclusion of this document at this place in the FSP implies that it was part of meeting minutes or that is was distributed at a BCT meeting, which is not accurate. The rationale for Parcel E sampling should be included in the body of the document.

DTSC does not agree with the rationale in all cases. However, the chemical analytical program presented for Parcel E is adequate.

Quality Assurance Project Plan Addendum (QAPP)

1. As for previous QAPPs, DTSC defers to USEPA for detailed review of this QAPP.

Appendix 1

1. Chain of custody (COC) form. Please include a space for the laboratory to record temperature upon receipt of the sample coolers. The laboratory should also note any other problems with the samples received, especially bubbles in samples for volatile organic compounds (VOCs). Alternatively, an example laboratory log in sheet should be included in this appendix. And, laboratory log in sheets should be included in the field report (in addition to COC forms).

Appendix 2

1. Table 2-1, footnote 2. Silica gel cleanup. The footnote says: "...silica gel cleanup will not be used at locations with extensive historical analytical results without silica gel cleanup". How will samples with and without silica gel cleanup be distinguished in field reports or result summaries? What is meant by "extensive" historical results? If it is agreed that silica gel cleanup is preferred, why not use the method for all samples?

2. Table 2-1, Notes. Please include citations in the References section (or in the footnotes) for the manuals noted--i.e., MCAWW, RSK, SMEWW.

3. Table 2-1, Preservation column, Nitrite-N/Nitrate-N. Add "Cool to 4C."

4. Table 2-1, Analytical Method column, Methane/ethane/ethene. Please describe analytical method "RSK-175". Is this a modified 8015? Provide information from the manual cited.

5. Table 2-1. Ferrous iron and manganese (II). In the column Preservation, the phrases "Filter if turbid" and "Keep out of sunlight and analyze within one hour of collection" are appropriate. However, the superscripts for footnotes 1 and 2 which are attached to those phrases appear to be in error, since they result in contradictions. For example, footnote 1 says: "7 days to extraction, 40 days from extraction to analysis" and the column Analytical Holding Time says: "Analyze as soon as possible". Also, the reference to footnote 2, which concerns silica gel cleanup, seems to be in error.

Please change column Analytical Holding Time to say: "Analyze within one hour of collection".

Please delete superscripts 1 and 2.

6. Table 2-1, Sample Volume, Container column. For all VOC analyses, please specify "gray butyl/teflon lined caps" for volatile organic analyses (VOA) vials.

7. Table 2-1. Monitored natural attenuation (MNA) parameters. FSP Table 4-7 lists MNA parameters in footnote 1. The following compounds are listed in FSP Table 4-7 footnote 1 but are not listed in QAPP Table 2-1: Fe+3, calcium, magnesium, sodium, and potassium. Will these be included in dissolved metals analyses?

8. Table 2-2, footnote 5. PCBs. In the NAWQC (National Ambient Water Quality Criteria) column, the value given for Aroclor-1260 is .19 ug/L. Footnote 5 identifies that .19 ug/L is from the "Great Lakes Water Quality Initiative, Tier II criteria". Please replace this value with the NAWQC for polychlorinated biphenyls (total PCBs), which is .03 ug/L (saltwater aquatic life protection, continuous concentration, 4-day average). The value (.03 ug/L) for total PCBs also applies separately to Aroclor-1260. Note that .03 ug/L is below the laboratory reporting limit (LRL) of .1 ug/L for Aroclor-1260.

In general, California values, not Great Lakes' values, are appropriate and should be cited when federal values don't exist. A useful summary of California and federal criteria are provided in: A Compilation of Water Quality Goals, dated August 2000. This RWQCB report, prepared by Jon B. Marshak, is revised regularly, and is available at www.swrqb.ca.gov/rwqcb5.

9. Tables 2-2 and 3-1 to 3-6. All method analytes should be included on these tables (e.g., BTEX, SVOCs, PAHs, metals).

10. Table 2-2. In the maximum allowable contaminant level (MCL) column, please note whether the state or the federal MCL is cited. It is recommended that two columns be provided--one for state MCLs and one for federal MCLs. Alternatively, when the state MCL differs from the federal MCL, include the state MCL in the same column as the federal MCL, but enclose the state MCL in parentheses.

Information Package for Phase I Groundwater Data Gaps Investigation

1. The information package was well designed and provided the information requested by agencies in a format that was easily accessible which facilitated review.

2. Table (page 3): Well Condition Survey...Comparison with Data Quality Objectives, Develop Decision Rules Column, last bullet. DTSC disagrees with the decision rule: "If well sediment covers more than 50 percent (or 3 feet, whichever is greater) of the well screen interval, then the well will be abandoned. The well will be replaced if the location is deemed necessary for future monitoring." Instead, the well construction

details should be reviewed to determine if the design or construction was faulty, development should be attempted, and if development is not successful, well decommissioning and/or well replacement should be proposed to the agencies.

Fortunately, in the Response column, the Navy's proposed actions for three silted-in wells are acceptable because they are consistent with DTSC's position outlined above.

3. Table (page 3): Well Condition Survey...Comparison with Data Quality Objectives. Abandonment. As noted in FSP comment 10, "abandonment" of wells is not permissible under state law.

In the Response column, the Navy notes that no wells were "abandoned" during Phase I. And, "abandonment" is not proposed for the three silted-in wells.

4. Section 3.1.1, A-Aquifer Groundwater Flow Patterns, page 5

LNAPLs. Depression of the groundwater table due to light non-aqueous phase liquids (LNAPLs) is posed as a possible interpretation of groundwater elevation anomalies. The LNAPL should be sampled, the density of the LNAPL determined, and the elevation of the water table corrected accordingly. The extent of LNAPL should be indicated on ground water elevation maps, and a note provided indicating that the water level measurements were/were not corrected for LNAPL.

5. Table (page 7): Water Level Measurement Study...Comparison with Data Quality Objectives, Develop Decision Rules, last two bullets. Conditions for Re-surveying Wells. The Navy proposes that wells will be re-surveyed, as follows: "If the survey data at more than 30 percent of the re-surveyed wells varies by more than .05 feet when compared with historical elevation data, then an additional 20 wells will be resurveyed before the groundwater elevation measurements are taken (additional survey data will be evaluated using the same decision rules)." This rule is not sufficient. In particular, the decision to re-survey more wells depends on the population of first wells re-surveyed. However, it is not stated how that population of first wells is selected, or why the first population is an appropriate predictor of wells base-wide. Similarly, how is the second population of wells selected? Moreover, a rationale for selecting the size of the first population (24 wells) is not provided.

It is recommended that regular re-surveying of all base-wide wells be proposed, at a minimum on a five-year basis. In addition, if anomalous water elevations are measured at any well, re-surveying should be

considered as immediate corrective action. All new wells should be surveyed, as proposed by the Navy.

Fortunately, DTSC agrees with the Navy's actions noted in the Related Field Activity column. The Navy says that re-surveying was conducted: "at all wells included in the water-level measurement event for the Phase I GDGI, and existing wells proposed for addition to the Phase II GDGI. A total of 187 A-aquifer wells and 18 B-aquifer wells were surveyed."

6. Table (page 7): Water Level Measurement Study...Comparison with Data Quality Objectives, Response column, last paragraph. The Navy proposes, and DTSC agrees, that it is generally appropriate to postpone detailed analyses of the historic variation of water elevation measurements until after additional data is collected in the Phase II GDGI. It is also expected that the data will be re-analyzed following Phase III GDGI. However, some recommended changes to the existing program are provided in the comments above, in the hopes of answering some questions related to groundwater flow at this time.

To facilitate analysis of historic data, rainfall hydrographs for the historic and current periods should be provided.

7. Tables (pages 9, 12): B-Aquifer Study..., A-Aquifer and Bedrock Water Bearing Zone Study ..., Develop Decision Rules column. Plume Delineation. The Navy proposes that plume boundaries and remedial units (RUs) will be delineated based on exceedences of MCLs and NAWQCs. While RUs may be defined based on relevant criteria, plumes should be defined based on measurements above detection limits (DLs), and, if appropriate, Hunters Point Groundwater Ambient Levels (HGALs).

The Navy proposes, and DTSC agrees, that decisions regarding the revisions of plume boundaries should be postponed until after Phase II GDGI results are reviewed. Plume boundaries may be further revised after review of Phase III GDGI results.

8. Ground Water Elevations. Please provide a table of all groundwater level measurements, current and historical, for all wells sampled or measured for ground water elevations during these investigations.

9. Figure 6. Groundwater flow direction arrows should be perpendicular to contour lines. Please adjust the arrow near IR01MW07AS. Add a line indicating the 1935 shoreline, and any known

current or historic creeks or seeps.

10. Table 5: Summary of Groundwater Screening Criteria. The table (and data quality objectives) should include RWQCB's total petroleum hydrocarbon (TPH) screening criteria for Hunters Point. The table should include all analytes in exceedence at Hunters Point. That is, Parcel B analytes should also be included.

11. Table 5, Footnote a. The footnote should state that HGALs apply to the shallow A-aquifer only. No HGALs have been developed for deeper aquifers.

Please check that all NAWQCs are included. For example, NAWQCs for polychlorinated biphenyls are not included. The NAWQCs for total PCBs apply to individual congeners as well, as noted in a footnote in the reference cited (Marshak, 2000).

12. Table 3, IR06MW22A. Please bold pentachlorophenol.

Appendix A

1. Field protocols. MNA parameters. Samples for MNA parameters may be compromised if not collected using the exacting standards for micropurging described by USEPA in the fact sheet by Puls and Barcelona (previously provided). Review of the Micropurging Groundwater Sampling Data Sheets indicates that these protocols are generally not being followed. It is recommended that a careful review of field protocols is warranted if the Navy intends to propose natural attenuation.

The field report which evaluates results should contain a discussion on the field protocols. If the well construction and soil types are such that micropurging is not possible at some wells, the effect of using conventional methods on MNA sampling results should be discussed.

Since, in general, micropurging is not being performed, the sheet title should be changed, so as to not be misleading. That is, the word "micropurging" should be deleted.

What quality assurance/quality control (QA/QC) evaluations are needed for MNA parameters collected in the field to assess data validation and usability?

Field protocols are also discussed in some of the following comments.

2. Dissolved Oxygen. Dissolved oxygen (DO) is enriched in many wells during sampling due to conventional pumping and bailing methods. Concentrations up to 11 mg/L were recorded, which is greater than solubility of DO (10 mg/L). For the few samples where the recommended protocols were followed, DO levels at sampling were approximately equal to initial DO levels, which indicates that the sampling protocols were appropriate.

DO results which are artifacts of purging and sampling do not represent aquifer conditions and cannot be used to support MNA proposals.

What analytes are sensitive to DO?

How will initial DO readings (stratified readings in static well water, prior to purging) be used?

Please explain DO readings less than zero (e.g., IR34MW37B).

3. Purging rates for MNA parameters are specified as 100 mL/min in the references cited above. Sampling sheets should record that a purge rate of 100 mL/min was used. Alternatively, sampling sheets should indicate that the ground water elevations did not change appreciably during purging and sampling (say less than .1 ft).

4. DO and salinity. Notes were provided on some logs regarding the salinity assumed for DO readings. What is the standard procedure for salinity assumptions?

On the sampling sheet, a separate column should be provided for salinity.

5. Iron (Fe^{+2}). Fe^{+2} was analyzed in the field using a field test kit. Fe^{+2} results were almost all non-detect. The few exceptions are (in mg/L): IR06MW41A at 5, IR06MW44A at 2, IR25MW15A2 at 7.2, IR25MW17A at .02, PA28MW51A at .025. What do these results signify?

Field results were not always provided for Fe^{+2}, when Fe^{+2} analyses were indicated on the sampling sheet. Are Fe^{+2} field results recorded elsewhere? If so, these records should be provided.

Field kits require filtering for Fe^{+2} if "turbid". In order to record that appropriate protocols have been followed, sampling sheets should note that in-line field filtering has been performed for turbid samples. The

turbidity of the sample (or subsample) used for Fe^{+2} analysis should be recorded. For the test, how is "turbid" defined? How sensitive is the test to turbidity?

Please provide more information on the field test used. What is the sensitivity and concentration range of the test? Are there interferences? Is the test sensitive to DO or other field parameters? For example is the test sensitive to pH? Values of pH from less than 5 (IR37MW26B) to 11.6 (IR33MW61A) were measured during Phase I. Should field values be confirmed with laboratory values for a portion of the samples?

6. In-line filtering. In-line field filtering is strongly recommended for dissolved metals analyses, and has become the standard of field practice. The FSP text says that in-line filtering is to be used, but the sampling sheets did not clearly indicate that in-line filtering was performed. In fact, some sheets indicated "gravity" filtering. Please confirm that in-line filtering is performed. The sampling sheets should clearly indicate that in-line filtering is performed.

7. Turbidity. Please explain turbidity readings less than zero (IR28MW309B, -314B, IR58MW32B, -33B, etc.).

8. Volatile compounds. A low sampling rate (100 mL/min) is required for all volatile compounds (i.e., volatile organic compounds (VOCs), TPH-e, and volatile metals). In some cases, a notation was made (e.g., "100 mL/min for VOAs"). But in most cases, the sampling sheet does not indicate that the sampling rate was reduced for volatile compounds.

9. The sample sheet noted that the well name and the name marked on the well were different for IR28MW27F and R28MW272A. Was this well re-named/re-drilled? Which is the current name?

10. Well condition. For IR58MW25F, the sampling sheet noted that "no well monument-cover gone" and "cardboard covers well". For IR34MW36B, the sheet notes "not labeled" and "no lock box". Have these well problems been corrected?

11. For some wells, the sampling sheets say "see back of sheet". Please provide missing backs of sheets as appropriate (e.g., for IR28MW170A, -172F, -270A and PA50MW04A).

12. "No log" is noted for IR06MW22A and -32A. Does this mean that

there are no logs for those wells or that the well logs were not available?

Appendix B

1. APCL checked "other liquid" (not "groundwater") on log in sheets for several batches (e.g., 4150, 4162, 4207, 4332, 4387, 8250). Is this because of sample turbidity?

2. As requested by DTSC, additional information on chain of custody forms was provided. In most cases, chain of custody forms included: cooler temperature, a note "filtered in field" for metals, and preservation notes. In a few cases, these notes were not included.

3. As requested by DTSC, laboratory log in sheets were included, which facilitated DTSC's review.

4. Severn Trent Laboratories-VT (STL) noted that cooler temperatures were not met for airbill 812144055151 and says "all samples canceled except 0034J005 and 0034R002". Why were these samples not cancelled also?

Appendix C

1. Development records are not provided for some wells (e.g., IR25MW39A, -39B, -37A, -38B, -59A1, -42B). Please provide development records for all new and old wells redeveloped during this field event.

2. Water levels were not indicated on all well logs.

3. With the exception of serpentinite (and graywacke on one occasion), rock types were not identified--maybe due to the fine grained nature of the soil. When possible, please identify rock fragments. Manganese oxide stains (IR28MW393B, IR25MW41A) and "limonite (?)"were logged, as appropriate.

4. In the well development record for IR28MW393B, please clarify the last work in the comment "Bob thinks white particles are just _____".

If you have any questions, Please contact me at (510) 540-3822.

Sincerely,

Chein Ping Kao, P.E.
Senior Hazardous Substance Engineer
Office of Military Facilities

Enclosure

CC: Ms. Sheryl Lauth /Claire Trombadore
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Attachment 1

DTSC Project Manager Checklist for: Monitored Natural Attenuation (MoNA) of Chlorinated VOC's

Site Name:_____Site Address:_____
_____

Specify Site Operations/Process(es) that were origin of groundwater contamination: ____
_____
_____
_____
_____

Project Status: PA/SI____RI____ FS____ RD/RA____
Other_____

Do Multiple Sources Exist ? Yes _____No_____

Identify source type(s) and dates of release or beginning of release:
LUST _____ Surface Spill _____ Landfill _____ Impoundment _____ Unknown _____
Others
_____
_

1.0
SCREENING OF MoNA PROPOSAL

Exposure Pathways

1.
Does the Proposal present a pathways exposure analysis?
Yes ____ No ____

If No, reject proposal.

2.
Does the site (or specific plume) pose an immediate threat to human or environmental receptors?
Yes ____ No ____

If yes, MoNA should not be considered.

3.
If the site (or specific plume) does not pose an immediate threat identify receptors and completed exposure pathways now and potentially in the future?

Receptors	Completed Pathway-now	Completed Pathway-future
Human	_____	_____
Ecological	_____	_____
Wetlands	_____	_____
Public Wells	_____	_____
Private Wells	_____	_____
Ag Wells	_____	_____
Groundwater	_____	_____
Other	_____	_____

Groundwater Evaluation

4.Are the following remedial objectives clearly identified and discussed:

a. Clean-up levels

Yes ____ No ____

b. Performance-Monitoring-Points

Yes ____ No ____

c. Source control, when appropriate

Yes ____ No ____

5.Does the Proposal identify the extent of groundwater contamination all the Water Bearing Zones (WBZ), list the number of wells used to monitor each WBZ, and present their orientation relative to the plume?

Yes ____ No ____

6.
Does the Proposal identify Chemicals of Potential Concern (COPCs) and their extent (horizontal and vertical) for each groundwater plume and each WBZ of interest?

Yes ____ No ____

7.
Do the wells being used for evaluation of MoNA have at least six rounds of sampling results?

Yes ____ No ____

8.Does the Proposal reference an approved Quality Assurance Project Plan or provide adequate QA/QC descriptions of sampling protocols and analytical procedures?

Yes ____ No ____

9.
Does the Proposal provide maximum concentrations and graphical representation of concentration trends (minimum of six sampling events), in wells being proposed for evaluating MoNA, for the following compounds:

COPCs	Max. Concen	Well ID and Concentration Trend
Tetrachloroethylene	_____	_____
Trichloroethylene	_____	_____
1,1-Dichloroethylene	_____	_____
cis-1,2-Dichloroethylene	_____	_____
Vinyl Chloride	_____	_____
1,1,1-Trichloroethane	_____	_____
1,1,2,2-Tetrachloroethane	_____	_____
Dichloromethane	_____	_____
1,2-Dichloroethane	_____	_____
1,1-Dichloroethane	_____	_____
Chloromethane	_____	_____
Chloroethane	_____	_____
Chloroform	_____	_____

Carbon Tetrachloride	_____	_____
Others (list)	_____	_____

10.
Does the Proposal identify travel distance and time it will take for COPCs to reach the nearest receptor?

Yes ____ No ____

11.
Have all WBZs and specific wells used for evaluating MoNA (including background wells) been sampled on a regular basis for the following parameters:

Indicator Parameters (Water)	Yes	No	Proposed/Recom. TestMethods
Carbon Dioxide	___	___	_____/SM4500-CO2 A-D
Chloride	___	___	_____/US EPA 325.2, 300.0, 9021
Dissolved Oxygen	___	___	_____/calibrated flow cell
Ethane	___	___	_____/Mod. method 8015 using GC-FID/ASTM D2820?
Ethene (ethylene)	___	___	_____/Mod. method 8015 using GC-FID/ASTM D2421-95
Dihydrogen (H_2)	___	___	_____/cal. flow cell w/ bubl. chamber
Iron, Dis. or Fe^{+2}	___	___	_____/US EPA SM 236.2/SM 3500D
Methane	___	___	_____/Mod. method 8015 using GC-FID/ASTM D2820?
Nitrate/Nitrite	___	___	_____/US EPA 353.2, 300.0
pH(between 5 and 9)	___	___	_____/calibrated flow cell/US EPA 150.1
Propane	___	___	_____/Mod. method 8015 using GC-FID/ASTM D2820?

Redox Pot. (Eh or pE)	___	___	_____/calibrated flow cell
Sulfate	___	___	_____/US EPA 300.0, 375.2
Sulfide	___	___	_____/US EPA 376.1/SM 4500-S2
Temperature	___	___	_____/calibrated flow cell\US EPA 170.1

Note -These are the minimum parameters needed to initially evaluate MoNA processes on chlorinated compounds. Other parameters may be necessary to fully evaluate MoNA processes (see Proposed Monitoring Evaluation, Section 6.3).

12.
Are lithologic types for affected WBZs identified?

Yes ____ No ____

Unconsolidated Sediments _____ Fractured Bedrock _____
Consolidated Sediments _____ Unfractured Bedrock _____
Unknown _____ Other _____

13.Does the Proposal present maps showing well location and flow nets for each WBZ?

Yes ____ No ____

14.
Does the Proposal present cross-sections along and perpendicular to the groundwater plume axis, showing contaminant and other appropriate parameter data?

Yes ____ No ____

15.
For each WBZ, does the Proposal present measurements for:

- H & V WBZ velocities	Yes _____	No _____
- For all affected WBZs	Yes _____	No _____
- H & V gradient directions	Yes _____	No _____
- For all affected WBZs	Yes _____	No _____
- Total Porosity	Yes _____	No _____
- For all affected WBZs	Yes _____	No _____
- Effective Porosity	Yes _____	No _____
- For all affected WBZs	Yes _____	No _____
- Hydraulic Conductivity	Yes _____	No _____
- For all affected WBZs	Yes _____	No _____
- Bulk Density	Yes _____	No _____
- For all affected WBZs	Yes _____	No _____

Note: H & V -Horizontal and Vertical

Natural Attenuation Processes

16.
Does the Proposal identify each NA Process(es) proposed or occurring at the site?

a. **Physical**
   i. Dilution ____
   ii. Dispersion ____
   iii. Adsorption ____
   iv. Volatilization ____

b. **Biological**
   i. Reductive Dechlorination ____
   ii. Direct Mineralization ____
   iii. Cometabolic Degradation ____

c. **Chemical**
   i. Hydrolysis ____
   ii. Elimination ____
   iii. Reductive Dehalogenation ____

17.
Are site-specific data provided to support each active MoNA process?
Yes____ No____

18.
Does the Proposal present data to support the following lines of evidence for each COPC?

a. Documented loss of contaminant mass at a field scale.
Yes ____ No ____

b. Presence and distribution of geochemical and biochemical indicators.
Yes ____ No ____

c. Direct microbiological evidence.
Yes ____ No ____

19.
Has the Proposal defined a Monitoring Strategy for:

a.
Specific wells in all affected WBZs.
Yes ____ No ____

b.
Geochemical and chemical parameters to support biodegradation processes, daughter and byproduct identification and quantitation, electron donors and electron acceptors.
Yes ____ No ____

c.
Quantitation of biodegradation rates for each COPC.

Yes ____ No ____

d.
Compliance monitoring wells.

Yes ____ No ____

20.
Does the Proposal provide Contingency Plans, definitive schedules and financial assurances in the event that transport rates to receptors exceed biodegradation rates and receptors may be exposed?

Yes ____ No ____

21.
Does the Proposal include the estimated time-frame to reach remedial action objectives?

Yes ____ No ____

22.
Does the Proposal clearly describe how the estimated time-frame was calculated?

Yes ____ No ____

23.
Is the Proposal signed by a Registered Geologist or Professional Engineer licensed in the State of California?

Yes ____ No ____

Decision Point: If screening evaluation of MoNA Proposal is favorable move to **Detailed Proposal Evaluation**. If not favorable then reject proposal and use **Screening of Proposal** criteria for definitive rationale.

2.0 DETAILED PROPOSAL EVALUATION

General Site Information

Does the Proposal provide a release history, including the estimated year(s) of release, for each source area being considered?

Yes ____ No ____

Source Area _____

- Continuous release, now discontinued _____
- Intermittent Release, now discontinued _____
- One-time release/slug _____
- Active release continuous _____
- Active release intermittent _____
- Unknown _____

Source Area _____

- Continuous release, now discontinued _____
- Intermittent Release, now discontinued _____
- One-time release/slug _____
- Active release continuous _____
- Active release intermittent _____
- Unknown _____

Does the Proposal indicate what the Site is currently used for ?

Yes _____ No_____

Has the site been used for any MoNA process studies or experiments?

Yes _____ No_____

Have source controls been implemented?

Yes_____ No_____

Does the Proposal Analyze Future Site Use/Reuse?

Yes _____ No_____

Exposure Pathways

Have all the appropriate exposure pathways been considered?

Yes ____ No ____

Does the Proposal identify potential receptor types?

Yes _____ No _____

If the site (or specific plume) does not pose an immediate threat identify receptors and completed exposure pathways now and potentially in the future?

Receptors	Completed Pathway-now	Completed Pathway-future

Human _____ _____

_____

Ecological _____ _____

_____

Wetlands _____ _____

_____

Public Wells _____ _____

_____

Private Wells _____ _____

_____

Ag Wells _____ _____

_____

Groundwater _____ _____

_____

Surface water _____ _____

_____

Others

_____ _____

_____

_____ _____

_____

Hydrogeologic Information

Do affected WBZs have designated beneficial uses as defined in the RWQCB Basin Plan ?

Unknown ____ Yes ____ No ____

Does the Proposal present groundwater flow directions in 3 dimensions.

Yes ____ No ____

Do commingled plumes (two different solvent plumes or a hydrocarbon and solvent plumes) exist at the site?

Yes ____ No____

If "Yes", are the commingled plumes in different WBZs?

Yes ____ No ____

Do background wells exist for each plume being considered for MoNA?

Yes ____ No ____

Do nearby recharge or discharge sources exist for the contaminated WBZs?

Yes ____ No ____

If "Yes", does the Proposal describe their location(s) and impacts relative to the

extent of contamination?

Yes ____ No ____

Is the site covered with material that will prevent infiltration from rainfall?

Yes____ No____

If "Yes" does the Proposal discuss where surface water runoff collect?

Yes ____ No____

If "No", does the Proposal discuss what percent and magnitude of rainfall infiltrate the first encountered WBZ?

Yes ____ No ____

Does the Proposal discuss different COPCs associated with different source areas?

Yes ____ No ____

Does the Proposal identify different WBZs that are affected by COPCs ?

Yes ____ No ____

Does the Proposal discuss and present the vertical and lateral extent of each COPC defined in each affected WBZ?

Yes ____ No____

Are necessary Hydraulic Characteristics (including recharge and discharge sources) of each affected WBZ defined and quantified?

Yes ____ No ____

Does the Proposal discuss plume behavior?

Yes ____ No ____

Does the Proposal discuss any special conditions that limit the extent (man-made or natural) of the plume?

Yes ____ No ____

If there are seasonal variations in groundwater, does the Proposal discuss the impacts of seasonal variation on the GW plume and MoNA processes.

Yes ____ No ____

Does the Proposal present site-specific data that discusses fate and transport for each type of COPC ?

Yes ____ No ____

Does the Proposal identify preferred COPC transport pathways (high hydraulic conductivity) in each WBZ?

Yes ____ No ____

Does the Proposal present site-specific data for groundwater transport rates in each WBZ?

Yes ____ No ____

If "Yes", does the Proposal list vertical, lateral, and resultant components for each WBZ?

Yes ____ No ____

Does the Proposal present site-specific data exist regarding WBZ soil adsorption potentials?

Yes ____ No ____

If "Yes", does the Proposal describe and estimate, by WBZ, retardation due to adsorption (e.g. COPC transport rates compared to groundwater flow rates?

Yes ____ No ____

Does the Proposal provide site-specific values for Intrinsic Permeability, pH, Temperature, Alkalinity, Dissolved Oxygen, Total Organic Carbon, Redox Potential, Nutrients (C:N:P) ratios, salts, for each WBZ?

Yes ____ No ____

Does the Proposal provide a tabulated listing of site-specific K_{oc} and K_d values exist for each COPC?

Yes ____ No ____

If "No", does the Proposal identify the source of K_{oc} and K_d values.

Yes ____ No ____

Does the Proposal list solubility in water for each COPC ?

Yes ____ No ____

Does the Proposal provide a tabular listing of vapor pressures, Henry's Law Constants, and boiling points for each COPC?

Yes ____ No ____

Is groundwater pH in each WBZ between 5 and 9?

Yes ____ No ____

Does the Proposal discuss vertical and lateral distributions in each WBZ?

Yes ____ No ____

Does each WBZ have high (> 0.1%) or low (< 0.1%) Total Organic Carbon (TOC)?

Yes ____ No ____

How were TOCs determined ?
measured _____ table lookup _____ unknown _____ notdefined_____

Does groundwater in each WBZ have a dissolved oxygen content $\geq$ 1 to 2 mg/L ?
Yes ____ No ____
If "Yes", does the Proposal present and discuss vertical and lateral distributions of oxygen in each WBZ?
Yes ____ No ____

3.0 PROPOSED MONITORING EVALUATION

Does the Proposal identify the location of a background monitoring well and does trend data on: pH, Temperature, Alkalinity, Dissolved Oxygen, Redox Potential, Nutrients (C:N:P) ratios, Chloride, for wells in each WBZ?
Yes ____ No ____
Does the Proposal identify discrete monitoring points to provide representative samples from each geochemical shell in each WBZ?
Yes ____ No ____

Do monitoring points exist outside the area of contamination that provide comparison points for data collected from each geochemical shell in each WBZ?
Yes ____ No ____
If "No", does the Proposal describe how mass balances will be calculated?
Yes ____ No ____

Is the sampling frequency for each monitoring point in each WBZ identified?
monthly____ quarterly ____ yearly____ other _____

Is the rational for the sampling frequency provided?
Yes ____ No ____

Does the list of proposed monitoring constituents for each sampling point, in each WBZ, address the type(s) of NA processes?
Yes ____ No ____
If "No", does the Proposal describe how the NA process type(s) will be determined?

Yes ____ No ____

Do quantitative remedial objectives exist for each COPC in each WBZ?
Yes ____ No ____

Are reasonable time frames for evaluating the effectiveness of each type of NA process presented?

Yes ____ No ____

If "Yes", is the rational and basis for establishing the time frames presented in the Proposal?

Yes ____ No ____

Does the Proposal contain analytical methods for monitoring the following in-situ biodegradation indicator parameters, carbon-sources, COPCs and Daughter Products? (*Note: Recommended test method include various choices depending on magnitude of reporting limit, matrix interferences, and other factors. Select appropriate test methods for ground water conditions at your site.*)

Indicator Parameters	Yes	No	Proposed/Recom. Test Methods
Alkalinity 310.2,	___	___	_____/US EPA 310.1, 310.1_M
Ammonia nitrogen 350.2/SM 4500-NH_3 A-H	___	___	_____/US EPA
Bicarbonate 310.1/SM 4500-CO_2 A-D	___	___	_____/US EPA
BOD 405.1/SM5210 B-C	___	___	_____/US EPA
Boron 200.7/SM4500 B-D	___	___	_____/US EPA
Calcium US EPA	___	___	_____/US EPA 200.7, 215.1
Carbonate 310.1/SM 4500-CO_2 A-D	___	___	_____/US EPA
Carbon Dioxide A-D	___	___	_____/SM 4500-CO2
Chloride 300.0, 9021	___	___	_____/US EPA 325.2,
COD 410.4/SM	___	___	_____/US EPA 410.1, 5220A-D
Conductivity cell/ US EPA 120.1/ASTM D1125	___	___	_____/calibrated flow
Dis. Organic Carbon with filtering/	___	___	_____/US EPA 415.1 SM 5310 B-D

with filtering
Dissolved Oxygen ___ ___ _____/calibrated flow cell/ ASTM D5462
Ethane ___ ___ _____/Mod. method 8015 using GC-FID/ASTM D2820?
Ethene (ethylene) ___ ___ _____/Mod. method 8015 using GC-FID/ASTM D2421-95
Fatty Acids ___ ___ _____/ SM 5560B, see literature for speciation methods
Hydrogen (H_2) ___ ___ _____/cal. flow cell with bubble chamber
Iron, Dis. or Fe^{+2} ___ ___ _____/US EPA SM 236.2/ SM 3500D
Magnesium ___ ___ _____/ US EPA 200.7, 242.1
Manganese ___ ___ _____/US EPA 243.1, 243.2
Methane ___ ___ _____/Mod. method 8015 using GC-FID/ASTM D2820?
Nitrate Nitrite ___ ___ _____/US EPA 353.2, 300.0
pH ___ ___ _____/calibrated flow cell/ US EPA 150.1
Phosphate ___ ___ _____/US EPA 300.0/ SM 4110B
Phosphorous ___ ___ _____/ US EPA 365.3, 365.4
Potassium ___ ___ _____/ US EPA 200.7/258.1
Propane ___ ___ _____/Mod. method 8015 using GC-FID/ASTM D2820?
Propene ___ ___ _____/Mod. method 8015 using GC-FID/ASTM D2820?
Redox Pot. (Eh or pE) ___ ___ _____/calibrated flow cell/ SM 2580 A or B-proposed
SAR ___ ___ _____/calculated

Sodium	___	___	_____/US EPA 200.7, 273.1
Sulfate	___	___	_____/US EPA 300.0, 375.2
Sulfide	___	___	_____/US EPA 376.1/ SM 4500-S2
TDS	___	___	_____/US EPA 160.1, 160.1_M, 160.2, 160.3
TOC	___	___	_____/US EPA 415.1/ SM5310B-D
Temperature	___	___	_____/calibrated flow cell/ US EPA 170.1

Anthropogenic Carbon Sources	Yes	No	Proposed/Rec. Test Methods
Total Petrol. Hydro's.	___	___	_____/8015-M (gas & diesel)
BTEX	___	___	_____/US EPA 8020
PAHs	___	___	_____/US EPA 8310
Other _____	___	___	_____/_____
_____	___	___	_____/_____
_____	___	___	_____/_____
_____	___	___	_____/_____
_____	___	___	_____/_____

Indicator Parameters and Priority Pollutants

COPCs and Daughter Products	Yes	No	Proposed/Rec. Test Methods
VOCs	___	___	_____/US EPA 8260
Semi-VOCs	___	___	_____/US EPA 8270
Metals	___	___	_____/US EPA 6010 with AA confirm.

Indicator Parameters Points of Interest for Evaluation Purposes

Alkalinity
= strond acids -strong bases, helps buffer ground water system against acids produced by biodegrad. processes

Ammonia	NH_3 maybe due to presence of fertilizers
BOD	measure of rate at which oxygen consumed by bacteria
Carbon Dioxide	biodegradation yields gas byproduct

Chloride	concentrations greater than background if liberated
Biological DCE	is at least 80% cis-1,2 DCE
DOC	differentiate background from anthropogenic sources
Dissolved Oxygen	Always below 10 mg/l-solubility limit
Ethene (ethylene)	presence indicates biodegradation is occurring
Fatty Acids	Produces by biodeg. and bacteri identification technique
Hydrogen (H_2)	Anaerobic Respiration-Denitrification <0.1 nm/l Anaerobic Respiration-Iron Reduct. 0.2-0.8nm/l Anaerobic Respiration-Sulfate Red. 1.0-4.0 nm/l Anaerobic Respiration-Methanogenesis 5-10 nm/l
Dissolved Iron (Fe^{+2})	Fe^{+3} < 1 mg/l, Fe^{+2} > 5 mg/L implies Fe reduction
Manganese	Electron Acceptor, but less abundant than Fe
Methane	Always Below 40 gm/l-solubility limit
Nitrate/Nitrite	Solubility almost unlimited, Electron Acceptor
pH	typical range is 5 -9
Phosphate	Nutrient with variable impacts on metabolic activity
Propane	Is not naturally occurring-presence implies new source
Redox Pot. (Eh)	Aerobic Respiration +820 mv Anaerobic Respiration-Denitrification + 740 mv Anaerobic Respiration-Iron Reduction -50 mv Anaerobic Respiration-Sulfate Reduction -222 mv Anaerobic Respiration-Methanogenesis -240 mv
Sodium	>1% salts excludes many bacteria and minimizes biodeg.
Sulfate	Solubility almost unlimited, natural > 5 mg/l
Sulphide	> background if sulfate reduction occuring
TOC	Aquifer matrix content important for solute-retardation calculations, Dis. fraction is food source for bacteria
Temperature	Affects solubility of oxygen and metabolic activity, "Q_{10}" rule, deg rates double for every 10C over range

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:natattck.wpd