PORT OF OAKLAND

14 November 2014

Mr. Keith Nowell
Alameda County Health Care Services Agency
Department of Environmental Health
1131 Harbor Bay Parkway, Suite 250
Alameda, CA 94502-6577

**Subject: Transmittal of Technical Memorandum Requested by the Alameda
County Health Care Services Agency, Department of Environmental
Health on the Oakland Maintenance Center Site,
1100 Airport Drive Oakland, California
(Site#: RO00000414 – MOIA, United Airlines)**

Dear Keith:

Please find attached the above-referenced technical memorandum on Tier 2 screening of
groundwater data, prepared by BASELINE Environmental Consulting, providing
evaluations as requested by the Alameda County Environmental Health Care Services
Agency, Department of Environmental Health in an email dated 15 October 2014.

I declare, under penalty of perjury, that the information and/or recommendations
contained in the attached document or report is true and correct to the best of my
knowledge.

Please feel free to contact me at the Port of Oakland at (510) 627-1184 if you have any
questions.

Sincerely,

Douglas Herman
Environmental Scientist
Port of Oakland

s/epp/Oakland Maintenance Hangar MF-25-26

TECHNICAL MEMORANDUM

Date: 14 November 2014   **Job No.:** 12315-20.02282

To: Keith Nowell and Dilan Roe, Alameda County Health Care Agency, Department of Environmental Health

From: Lydia Huang, P.E. No. 43995

Subject: **Exceedance of Tier 2 Screening Values for Total Petroleum Hydrocarbons as Diesel and Metals in Groundwater, Oakland Maintenance Center Site, Oakland, California (Toxic Leaks Case RO0000414)**

The Port of Oakland ("Port") submitted a request for No Further Action for the Oakland Maintenance Center ("OMC") Site, located at 1100 Airport Drive at the Oakland International Airport, in October 2012 to Alameda County Environmental Health ("ACEH").[1] In response to comments and requests from the ACEH, BASELINE submitted two technical memoranda, dated 7 February 2014 and 9 May 2014, on behalf of the Port to support the request for No Further Action. This current memorandum was prepared in response to ACEH's 15 October 2014 email to the Port, which directed the Port to evaluate the instances where the Tier 2 screening values for groundwater for the protection of potential ecological receptors were exceeded, as presented in the BASELINE's May 2014 technical memorandum.

The base Tier 2 screening values for groundwater used in BASELINE's May 2014 technical memorandum were for the protection of potential ecological receptors in an estuarine environment found in Table F-4a, Summary of Selected Aquatic Habitat Goals, in the document *Screening for Environmental Concerns at Sites With Contaminated Soil and Groundwater*, issued by the San Francisco Bay Regional Water Quality Control Board ("RWQCB"), updated December 2013. The base screening values were then multiplied by dilution attenuation factors ("DAF") which were a function of the distance between the different Areas of Concern ("AOCs") across the OMC Site and the nearest possible aquatic receptor location.

The data presented in the May 2014 technical memorandum showed that there were instances where total petroleum hydrocarbons ("TPH") as diesel concentrations in groundwater exceeded the AOC-specific Tier 2 screening values in AOCs 1, 2, and 3, and certain metal concentrations exceeded AOC-specific screening values in AOCs 1, 2, 3, 5, 7, 8, 9, 14, and 17. This memorandum further evaluates these exceedances of the Tier 2 screening values. A figure from

---

[1] No Further Action was requested in the report titled, *Final Report, Closure Documentation for the Former Oakland Maintenance Center (OMC), Oakland International Airport, 1100 Airport Drive, Oakland, California*, prepared by URS Corporation and dated 31 October, 2012.

the June 2004 investigation report prepared by ERM showing the location of the AOCs and sample locations is provided in Attachment A for reference.[2]

TIER 2 SCREENING FOR TPH AS DIESEL IN GROUNDWATER

A discussion of TPH as diesel in groundwater samples collected from AOCs 1, 2, and 3 is presented below. The Tier 2 screening table for TPH from BASELINE's May 2014 technical memorandum is provided in Attachment B for reference.

TPH as Diesel in Groundwater in AOC 1

AOC 1 was identified in the 2004 investigation by ERM as a small parts wash rack and cleaning room at the northwest side of the hangar building.[3] Five grab groundwater samples collected from AOC 1 were analyzed for TPH as gasoline and as diesel. None of the five grab groundwater samples collected from AOC 1 had TPH as gasoline concentrations that exceeded the DAF-adjusted Tier 2 screening value.

TPH as diesel was quantified with and without silica gel cleanup. The sample collected from boring ERM-B-2 in 2003 analyzed without silica gel cleanup was quantified to contain TPH as diesel at 5,500 micrograms per liter ("µg/l"), above the DAF-adjusted Tier 2 screening value for ecological receptors of 4,224 µg/l. The TPH as diesel concentration in this same sample analyzed after silica gel cleanup was less than the laboratory reporting limit of 560 µg/l. These results indicate that the majority of the TPH as diesel quantified without silica gel cleanup was polar and may not have been of petroleum origin. And as often is the case with grab groundwater samples, the sample may have entrained soil particles and the reported concentrations may not represent dissolved concentrations. The TPH as diesel concentrations in the other four grab groundwater samples were below the DAF-adjusted Tier 2 screening value, including those results that were quantified without silica gel cleanup.

Groundwater monitoring wells ERM-MW-01 through ERM-MW-05 are located near AOC 1. None of the samples collected from these wells were analyzed for TPH, indicating that TPH was not considered a chemical of concern in the vicinity of AOC 1. In addition, groundwater samples collected from AOCs 4, 5, 9, and 17, which are located between AOC 1 and possible ecological receptors in the storm water ditches northwest of the hangar building, did not contain TPH as diesel above the respective DAF-adjusted Tier 2 screening values for ecological receptors.

---

[2] *Former United Airlines Oakland Maintenance Center, Site Investigation and Risk Assessment Report, Oakland International Airport,* prepared by ERM and dated June 2004.
[3] Ibid.

Considering the lines of evidence presented above, the one exceedance of the DAF-adjusted Tier 2 screening value for TPH as diesel quantified without silica gel cleanup in AOC 1 does not represent a risk to potential ecological receptors.

TPH as Diesel in Groundwater in AOCs 2 and 3

AOC 2 was identified in the 2004 investigation by ERM as the aircraft wash rack.[4] A concrete paved area was used for aircraft storage and washing. Wash water was collected into a wastewater vault which was connected to the sanitary sewer; AOC 3 was defined as the wastewater vault into which the wash water drained.

In AOCs 2 and 3, four grab groundwater samples from borings ERM-B-4, ERM-B-5, ERM-B-6, and W-B-12 and one groundwater sample from well ERM-MW-09 exceeded the DAF-adjusted Tier 2 screening value for TPH as diesel.

There are five groundwater monitoring wells in the AOCs 2 and 3 area with TPH as diesel data, namely ERM-MW-06, ERM-MW-07, ERM-MW-08, ERM-MW-09, and ERM-MW-10. As grab groundwater samples from borings often entrain soil particles and the reported TPH concentrations may not represent dissolved concentrations, samples collected from wells are generally considered more representative. Some of the borings where these grab groundwater samples were collected are immediately adjacent to wells (e.g., boring ERM-B-4 is next to well ERM-MW-08, borings ERM-B-5 and ERM-B-6 are next to well ERM-MW-09, and boring W-B-12 is next to well ERM-MW-10). As there are groundwater samples collected from wells in the area, assessment of TPH as diesel impacts to groundwater is better accomplished by considering sample results from wells rather than grab groundwater samples.

Wells ERM-MW-06, ERM-MW-07, ERM-MW-08, ERM-MW-09, and ERM-MW-10 were sampled on three occasions, in May 2003, November 2003, and June 2006 and the samples were analyzed for TPH as diesel in a total of 14 samples. Only one of these groundwater samples was reported to contain TPH as diesel above the DAF-adjusted Tier 2 screening value. The sample collected from ERM-MW-09 from November 2003 was quantified without silica gel cleanup to contain TPH as diesel at 2,600 µg/l, slightly above the DAF-adjusted Tier 2 screening value of 2,240 µg/l; this sample was also quantified after silica gel cleanup and was reported to contain TPH as diesel at 760 µg/l, below the screening value. Samples collected from ERM-MW-09 in May 2003 and June 2006 did not contain TPH as diesel concentrations without silica gel cleanup above the DAF-adjusted Tier 2 screening value.

---

[4] ERM op. cit., p.2.

Considering the available data for TPH as diesel in groundwater collected from AOCs 2 and 3, it does not appear that the instances when the DAF-adjusted Tier 2 screening value for TPH as diesel were exceeded represent a risk to ecological receptors.

TIER 2 SCREENING FOR METALS IN GROUNDWATER

The concentrations of certain metals in groundwater samples collected from the OMC Site exceeded the Tier 2 screening values presented in BASELINE's May 2014 technical memorandum for the protection of potential aquatic receptors in the storm water drainage ditches along the edges of the site. The Tier 2 screening values used in the May 2014 memorandum were conservatively chosen to be those protective of an estuarine environment, which are the lower of the values protective of freshwater and saltwater environments. In actuality, the habitat in the storm water drainage ditches near the OMC Site appears to resemble a freshwater habitat.

To evaluate whether the storm water ditches more resembles a fresh- or salt-water habitat, BASELINE reviewed available electrical conductivity data for groundwater at the OMC Site. Table 1 summarizes the electrical conductivities recorded on groundwater sampling forms from the June 2006 monitoring event.[5] The data indicate that there is a wide variability of electrical conductivities between the wells, even among wells that are near each other. For example, consider the electrical conductivities measured in seven wells located at the northwestern corner of the OMC Site, nearest the northwestern drainage ditches (ERM-MW-06, ERM-MW-08, ERM-MW-09, ERM-MW-10, ERM-MW-15, ERM-MW-16, and ERM-MW-17); the electrical conductivities in these wells ranged from 430 to 9,310 micro-Siemen/centimeter ("μS/cm"), with five of the values less than 2,500 μS/cm (Table 1).[6] Across the OMC Site, about half of the all the electrical conductivities recorded from the wells at the end of purging were less than 3,000 μS/cm, and the overall average electrical conductivity among the wells was about 4,300 μS/cm.[7] The pockets of more saline water detected in some of the wells may be indicative of isolated and random influence of Bay water intrusion. But perhaps more influential, the habitat is expected to be more similar to a freshwater environment because the ditches periodically receive large volumes of storm water during and following rain events.

Table 2 presents a revised Tier 2 screening of metal concentrations in groundwater using base Tier 2 screening values based on the protection of aquatic receptors in a freshwater

---

[5] Electrical conductivity values were summarized from groundwater sampling forms provided in Appendix A of *Groundwater Sampling and Analysis Report, Former United Airlines Hangar, Oakland International Airport, Port of Oakland, Oakland, California*, prepared by SCA Environmental Inc. and dated August 2006.

[6] For reference, the electrical conductivity of sea water is typically in the range of 55,000 μS/cm, and the electrical conductivity of drinking water is typically in the range between 50 and 800 μS/cm.

[7] Values cited in this paragraph exclude suspect or possibly erroneous values recorded on the sampling forms.

habitat[8] (in contrast to the estuarine screening values presented in the May 2014 technical memorandum). The base screening values for a freshwater habitat is higher than the saltwater values for arsenic, beryllium, copper, nickel, silver, thallium, and zinc.

The primary metal of concern appears to be nickel in AOCs 1, 2, and 3 (Table 2). The other metals where at least one reported groundwater concentration exceeded the DAF-adjusted Tier 2 screening value were arsenic (in AOC 17), beryllium (in AOC 14), cadmium (in AOCs 2 and 3), cobalt (in AOC 1), copper (in AOCs 2 and 3), lead (in AOCs 2, 9, and 14), silver (in AOC 9), and zinc (in AOC 2). The available data set prevented a thorough evaluation of each metal. One problem was that many reporting limits were above the DAF-adjusted Tier 2 screening values (e.g., cadmium, cobalt, lead, and silver). Other metals with more appropriate laboratory reporting limits had large percentages of non-detect results which prevented the calculation of meaningful upper confidence limits ("UCLs") (e.g., copper, lead, and zinc). Also some elevated concentrations in grab groundwater samples were markedly higher than samples collected from nearby wells, which raise doubts about the grab groundwater results.[9]

Nickel was the only available data set suitable for statistical evaluation. Therefore, we propose to use nickel as the indicator metal to represent all metals.

Nickel in Groundwater in AOCs 1, 2 and 3

The 95 percent UCLs for nickel concentrations in groundwater were calculated for AOCs 1, 2, and 3 for comparison against the AOC-specific Tier 2 screening value for protection of a freshwater aquatic habitat. The statistical software ProUCL (version 5.0) was used to calculate UCLs using parametric and nonparametric methods for data sets with non-detect results and the estimated 95 percent UCLs are summarized below. The output form ProUCL is provided in Attachment C.

---

[8] Values are from Table F-4a Summary of Selected Aquatic Habitat Goals in the document *Screening for Environmental Concerns at Sites with Contaminated Soil and Groundwater*, issued by the San Francisco Bay RWQCB as updated December 2013.

[9] Examples: (1) in AOC 2, copper and lead concentrations reported for grab groundwater samples collected from W-B-8 were markedly higher than samples collected from adjacent well ERM-MW-06; and (2) in AOC 3, cadmium and copper concentrations reported for grab groundwater samples collected from W-B-12 were markedly higher than samples collected from adjacent well ERM-MW-10.

AOC	Number of Data Points	Number of Detected	ProUCL Suggested 95 Percent UCL(s) (µg/l)	AOC-Specific Tier 2 Screening Value (µg/l)
1	28	24	155 to 200	343
2	24	21	148 to 150	182
3	6	4	91	120

The estimates of the 95 percent UCL for nickel concentrations in groundwater were below the AOC-specific Tier 2 freshwater screening values in all three AOCs, suggesting that nickel concentrations in groundwater do not represent an ecological risk.

Based on the detailed evaluation presented above, we conclude that the instances where TPH as diesel and metal concentrations in groundwater samples exceed the Tier 2 screening values for the protection of aquatic habitat do not represent a significant ecological risk at the OMC Site.

ENCLOSURES:
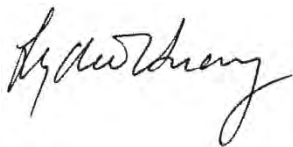
Table 1: Electrical Conductivity in Groundwater, June 2006

Table 2: Post-2002 Data Set – Groundwater Results – Metals – Revised Tier 2

Attachment A: ERM 2004 Figure showing AOCs and Sample Locations

Attachment B: Revised Table E-4b from May 2014 Technical Memorandum

Attachment C: ProUCL Output for Nickel in Groundwater for AOCs 1, 2, and 3

_____

Lydia Huang

TABLE 1: ELECTRICAL CONDUCTIVITY IN GROUNDWATER MONITORING WELLS

Oakland Maintenance Center Site, Oakland, California (microSiemen/centimeter)

Well	June 2006 Groundwater Sampling Event	
	Measured at Beginning of Purging	Measured at End of Purging
ERM-MW01	2,180	3,740
ERM-MW02	4,240	2,300
ERM-MW03	4,030	4,080
ERM-MW04	41 a	5,380
ERM-MW05	37 a	11,700
ERM-MW06	1,240	430
ERM-MW07	15 a	13 a
ERM-MW08	22 a	2,440
ERM-MW09	870	1,430
ERM-MW10	725	875
ERM-MW11	5,140	5,080
ERM-MW12	9,290	9,580
ERM-MW13	6,150	12,200
ERM-MW14	7,360	6,920
ERM-MW15	1,010	990
ERM-MW16	22,400	9,310
ERM-MW17	2,790	5,000
UAL-MW1	4,290	4,410
UAL-MW2	1,320	1,300
UAL-MW3	49 a	4,800
UAL-MW4	9,290	9,200
UAL-MW5	36 a	7,513
MW-1	720	730
MW-2	1,530	1,570
MW-3	735	730
MW-4	730	740
MW-5	no data on sampling form	
MW-6	1,600	1,620
MW-7	no data on sampling form	
MW-8	1,635	1,635

Notes:

Electrical conductivity values were recorded on groundwater sampling forms in Appendix A of *Groundwater Sampling and Analysis Report, Former United Airlines Hangar, Oakland International Airport, Port of Oakland, Oakland, California,* prepared by SCA Environmental Inc. and dated August 2006.

For reference, the electrical conductivity of sea water is typically in the range of 55,000 µS/cm, and the electrical conductivity of drinking water is typically in the range between 50 and 800 µS/cm.

[a] Value is suspect and possibly erroneous.

Table 2: Post-2002 Data Set – Groundwater Results – Metals – Revised Tier 2 Screening
Oakland Maintenance Center Site, Oakland, California (μg/L)

Sample Location	AOC	Date Sampled	Antimony	Arsenic	Beryllium	Cadmium	Cobalt	Copper	Lead	Nickel	Silver	Thallium	Zinc
Base Tier 2 ESLs - Ecological Receptor (a)			30	150	2.7	0.25	3.0	9.0	2.5	52	0.34	20	120
Area of Concern 1													
DAF-Adjusted Tier-2 ESLs (DAF = 6.6)			198	990	18	1.7	20	59	17	343	2.2	132	792
ERM-B-1	1	4/15/2003	<50	<50	<5	<5	20	<5	<50	190	<5	<50	6.5
ERM-B-2	1	4/15/2003	<50	<50	<5	<5	<20	<5	<50	130	<5	--	<5
ERM-B-2	1	4/15/2003	--	--	--	--	--	--	--	--	--	<5	--
ERM-MW-01	1	5/9/2003	--	--	--	--	--	--	--	90	--	--	--
ERM-MW-01	1	11/6/2003	--	--	--	--	--	--	--	190	--	--	--
ERM-MW-01	1	6/27/2006	--	--	--	--	--	--	--	71	--	--	--
ERM-MW-02	1	5/9/2003	--	--	--	--	--	--	--	36	--	--	--
ERM-MW-02	1	11/6/2003	--	--	--	--	--	--	--	15	--	--	--
ERM-MW-02	1	6/27/2006	--	--	--	--	--	--	--	24	--	--	--
ERM-MW-03	1	5/9/2003	--	--	--	--	--	--	--	<30	--	--	--
ERM-MW-03	1	11/6/2003	--	--	--	--	--	--	--	49	--	--	--
ERM-MW-03	1	6/27/2006	--	--	--	--	--	--	--	39	--	--	--
ERM-MW-04	1	5/9/2003	--	--	--	--	--	--	--	62	--	--	--
ERM-MW-04	1	11/7/2003	--	--	--	--	--	--	--	200	--	--	--
ERM-MW-04	1	6/27/2006	--	--	--	--	--	--	--	51	--	--	--
ERM-MW-05	1	5/9/2003	--	--	--	--	--	--	--	<30	--	--	--
ERM-MW-05	1	11/7/2003	--	--	--	--	--	--	--	45	--	--	--
ERM-MW-05	1	6/27/2006	--	--	--	--	--	--	--	<20	--	--	--
ERM-MW-11	1	12/30/2003	--	--	--	--	--	--	--	14	--	--	--
ERM-MW-11	1	6/27/2006	--	--	--	--	--	--	--	97	--	--	--
ERM-MW-12	1	12/29/2003	--	--	--	--	--	--	--	10	--	--	--
ERM-MW-12	1	6/27/2006	--	--	--	--	--	--	--	22	--	--	--
ERM-MW-13	1	12/29/2003	--	--	--	--	--	--	--	160	--	--	--
ERM-MW-13	1	6/27/2006	--	--	--	--	--	--	--	370	--	--	--
ERM-MW-14	1	12/29/2003	--	--	--	--	--	--	--	590	--	--	--
ERM-MW-14	1	6/27/2006	--	--	--	--	--	--	--	68	--	--	--
W-B-4	1	4/15/2003	<50	<50	<5	<5	<20	<5	<50	<20	<5	--	<20
W-B-5	1	4/15/2003	<50	<50	<5	<5	<20	<5	<50	64	<5	<50	<20
W-B-6	1	4/15/2003	<50	<50	<5	<5	<20	<5	<50	31	<5	<50	<20
Area of Concern 2													
DAF-Adjusted Tier 2 ESLs (DAF = 3.5)			105	525	9.5	0.88	11	32	8.8	182	1.2	70	420
ERM-B-3	2	4/15/2003	<50	<50	<5	<5	<20	<5	<50	120	<5	<50	<5
ERM-B-4	2	4/15/2003	<50	<50	<5	<5	<20	<5	<50	160	<5	<50	<5
ERM-B-5	2	4/15/2003	<50	<50	<5	<5	<20	<5	<50	230	<5	--	6.6
ERM-B-6	2	4/15/2003	<50	<50	<5	<5	<20	<5	<50	260	<5	--	<5
ERM-B-7	2	4/15/2003	<50	<50	<5	5.6	<20	5.4	<50	92	<5	<50	14
ERM-MW-06	2	5/9/2003	--	--	--	<5	--	--	<50	<30	--	--	--
ERM-MW-06	2	12/30/2003	--	--	--	--	--	17	--	--	--	--	--
ERM-MW-06 (b)	2	11/6/2003	--	--	--	<5	--	--	21	10	--	--	--
ERM-MW-06	2	6/27/2006	--	--	--	<5	--	<10	<3	<20	--	--	--
ERM-MW-07	2	5/9/2003	--	--	--	<5	--	--	<50	84	--	--	--
ERM-MW-07 (b)	2	11/6/2003	--	--	--	<5	--	--	33	70	--	--	--
ERM-MW-07	2	6/26/2006	--	--	--	<5	--	--	<3	23	--	--	--
ERM-MW-08	2	5/9/2003	--	--	--	<5	--	--	<50	110	--	--	--
ERM-MW-08 (b)	2	11/6/2003	--	--	--	<5	--	--	33	240	--	--	--
ERM-MW-08	2	6/26/2006	--	--	--	<5	--	--	<3	250	--	--	--

Table 2: Post-2002 Data Set – Groundwater Results – Metals – Revised Tier 2 Screening
Oakland Maintenance Center Site, Oakland, California (μg/L)

Sample Location	AOC	Date Sampled	Antimony	Arsenic	Beryllium	Cadmium	Cobalt	Copper	Lead	Nickel	Silver	Thallium	Zinc
Base Tier 2 ESLs - Ecological Receptor (a)			30	150	2.7	0.25	3.0	9.0	2.5	52	0.34	20	120
ERM-MW-09	2	5/9/2003	--	--	--	<5	--	--	<50	230	--	--	--
ERM-MW-09 (b)	2	11/6/2003	--	--	--	<5	--	--	20	370	--	--	--
ERM-MW-09	2	6/26/2006	--	--	--	<5	--	--	<3	140	--	--	--
ERM-MW-15	2	12/30/2003	--	--	--	--	--	--	--	6	--	--	--
ERM-MW-15	2	6/26/2006	--	--	--	--	--	--	--	110	--	--	--
ERM-MW-16	2	12/30/2003	--	--	--	--	--	--	--	13	--	--	--
ERM-MW-16	2	6/26/2006	--	--	--	--	--	--	--	48	--	--	--
W-B-7	2	4/17/2003	<50	<50	<5	<5	<20	<5	<50	<20	<5	<50	<20
W-B-8	2	4/14/2003	<50	<50	<5	<5	<20	48	1900	52	<5	--	790
W-B-8 (c)	2	4/14/2003	<60	<500	<4	<5	<50	94	960	100	<10	<50	140
Area of Concern 3													
DAF-Adjusted Tier 2 ESLs (DAF = 2.3)			69	345	6.2	0.58	6.9	21	5.8	120	0.78	46	276
ERM-MW-10	3	5/9/2003	--	--	--	<5	--	--	<50	82	--	--	--
ERM-MW-10	3	12/30/2003	--	--	--	--	--	<5	--	--	--	--	--
ERM-MW-10 (b)	3	11/6/2003	--	--	--	<5	--	--	<15	120	--	--	--
ERM-MW-10	3	6/26/2006	--	--	--	<5	--	<10	<3	26	--	--	--
W-B-10	3	4/15/2003	<50	<50	<5	<5	<20	<5	<50	<20	<5	<50	<20
W-B-11	3	4/15/2003	<50	<50	<5	<5	<20	<5	<50	<20	<5	<50	<20
W-B-12	3	4/15/2003	<50	<50	<5	38	<20	220	<50	63	<5	<50	36
Area of Concern 5													
DAF-Adjusted Tier 2 ESLs (DAF = 6)			180	900	16	1.5	18	54	15	312	2.0	120	720
ERM-B-10	5	4/17/2003	74	<50	8.6	<5	<20	<5	<50	<20	<5	<50	<20
ERM-B-11	5	4/17/2003	<50	<50	<5	<5	<20	<5	<50	<20	<5	--	<20
W-B-1	5	4/14/2003	<60	<5	<4	<5	<50	<50	<50	<50	<10	<50	<50
W-B-2	5	4/14/2003	<50	<50	<5	<5	<20	<5	<50	<20	<5	<50	<20
W-B-2 (c)	5	4/14/2003	<60	<5	<4	<5	<50	<50	<50	<50	<10	<50	<50
W-B-3	5	4/15/2003	55	<50	6.1	<5	<20	<5	<50	<20	<5	<50	6.3
W-B-3 (c)	5	4/15/2003	<60	<5	<4	<5	<50	<50	<50	60	<10	<50	<50
Area of Concern 7													
DAF-Adjusted Tier 2 ESLs (DAF = 4.2)			126	630	11	1.1	13	38	11	218	1.4	84	504
ERM-MW-17	7	12/30/2003	--	<5	--	--	--	--	--	--	--	--	--
ERM-MW-17	7	6/26/2006	--	8	--	--	--	--	--	--	--	--	--
ERM-MW-17D	7	12/30/2003	--	<5	--	--	--	--	--	--	--	--	--
W-B-16	7	4/17/2003	<50	<50	<5	<5	<20	<5	<50	54	<5	<50	<20
W-B-16 (c)	7	4/17/2003	<60	5.5	<4	<5	<50	<50	<50	54	<10	<50	<50
W-B-17	7	4/17/2003	<50	<50	<5	<5	<20	<5	<50	<20	<5	<50	<20
W-B-17 (c)	7	4/17/2003	<6	12	<4	<5	<50	<50	<50	<50	<10	<5	<50
Area of Concern 8													
DAF-Adjusted Tier 2 ESLs (DAF = 2.7)			81	405	7.3	0.68	8.1	24	6.8	140	0.92	54	324
ERM-B-12	8	4/17/2003	<50	<50	<5	<5	<20	<5	<50	63	<5	<50	<20
Area of Concern 9													
DAF-Adjusted Tier 2 ESLs (DAF = 5.5)			165	825	15	1.4	17	50	14	286	1.9	110	660
ERM-B-13	9	4/16/2003	<50	<50	5.9	<5	<20	<5	57	<20	5.8	<50	17
ERM-B-14	9	4/17/2003	<50	<50	<5	<5	<20	<5	<50	<20	<5	65	<20
P-2/UAL-MW-5	9	4/22/2003	<60	<500	<4	<5	<50	<50	<50	<50	<10	<50	<50
P-2/UAL-MW-5	9	11/6/2003	--	--	--	--	--	--	--	<5	--	--	--
P-2/UAL-MW-5	9	6/27/2006	--	--	--	--	--	--	--	<20	--	--	--
W-B-22	9	4/18/2003	<50	<50	<5	<5	<20	<5	<50	<20	<5	<50	9.9

Table 2: Post-2002 Data Set – Groundwater Results – Metals – Revised Tier 2 Screening
Oakland Maintenance Center Site, Oakland, California (μg/L)

Sample Location	AOC	Date Sampled	Antimony	Arsenic	Beryllium	Cadmium	Cobalt	Copper	Lead	Nickel	Silver	Thallium	Zinc
Base Tier 2 ESLs - Ecological Receptor (a)			30	150	2.7	0.25	3.0	9.0	2.5	52	0.34	20	120
Area of Concern 14													
DAF-Adjusted Tier 2 ESLs (DAF = 1)			30	150	2.7	0.25	3.0	9.0	2.5	52	0.34	20	120
ERM-B-23	14	4/17/2003	<50	<50	<5	<5	<20	<5	<50	<20	<5	<50	<20
W-B-32	14	4/16/2003	<50	<50	5.8	<5	<20	5.6	50	<20	<5	--	21
W-B-38	14	4/15/2003	<50	<50	<5	<5	<20	<5	<50	<20	<5	<50	<20
Area of Concern 17													
DAF-Adjusted Tier 2 ESLs (DAF = 5.5)			165	825	15	1.4	17	50	14	286	1.9	110	660
UAL-MW-1	17	4/15/2003	<60	8	<4	<5	<50	<50	<50	<50	<10	<50	<50
UAL-MW-1	17	6/27/2006	<60	42	<2	--	--	--	--	--	--	--	--
UAL-MW-2	17	4/15/2003	<60	<5	<4	<5	<50	<50	<50	<50	<10	<50	<50
UAL-MW-2	17	6/27/2006	<60	<5	<2	--	--	--	--	--	--	--	--
UAL-MW-3	17	4/15/2003	<60	<5	<4	<5	<50	<50	<50	100	<10	<50	<50
UAL-MW-3	17	6/27/2006	<60	12	<2	--	--	--	--	--	--	--	--
P-1/UAL-MW-4	17	4/22/2003	<60	847	<4	<5	<50	<50	<50	<50	<10	<50	<50
Area of Concern 18													
DAF-Adjusted Tier 2 ESLs (DAF = 7)			210	1050	19	1.8	21	63	18	364	2.4	140	840
W-B-18	18	4/18/2003	<60	<50	<4	<5	<50	<50	<50	<50	<10	<50	<50
W-B-19	18	4/18/2003	<60	<50	<0.4	<0.5	<5	<5	<50	<5	<1	<50	<5
W-B-20	18	4/18/2003	<60	<50	<0.4	<0.5	<5	<5	<50	<5	<1	<50	<5
W-B-20D	18	4/18/2003	<600	<500	<0.4	<0.5	<5	<5	<5	<5	<1	<500	<5
W-B-9	18	4/18/2003	<60	<50	<0.4	<0.5	<5	<5	<50	<5	<1	<50	<5
Area of Concern 19													
DAF-Adjusted Tier 2 ESLs (DAF = 1)			30	150	2.7	0.25	3.0	9.0	2.5	52	0.34	20	120
W-B-25	19	4/16/2003	<50	<50	<5	<5	<20	<5	<50	<20	<5	<50	8.1
W-B-29	19	4/16/2003	<50	<50	<5	<5	<20	<5	<50	<20	<5	<50	5

Yellow highlighting indicates an exceedance of the AOC-specific Tier screening value.
Bolding indicates detected concentrations.
All units are in micrograms per liter (μg/L).

Only analytes that have at least one detection and have exceeded the Tier-1 screening level are shown.
DAF = dilution attenuation factor
ESL = environmental screening level
-- = not analyzed
< = analyte was not detected at or above the laboratory method detection limit

(a) Base Tier 2 ESLs from Table F-4a, Summary of Selected Aquatic Habitat Goals, Freshwater Habitat, in the document *Screening for Environmental Concerns at Sites with Contaminated Soil and Groundwater,* Updated December 2013 by the San Francisco Bay RWQCB.
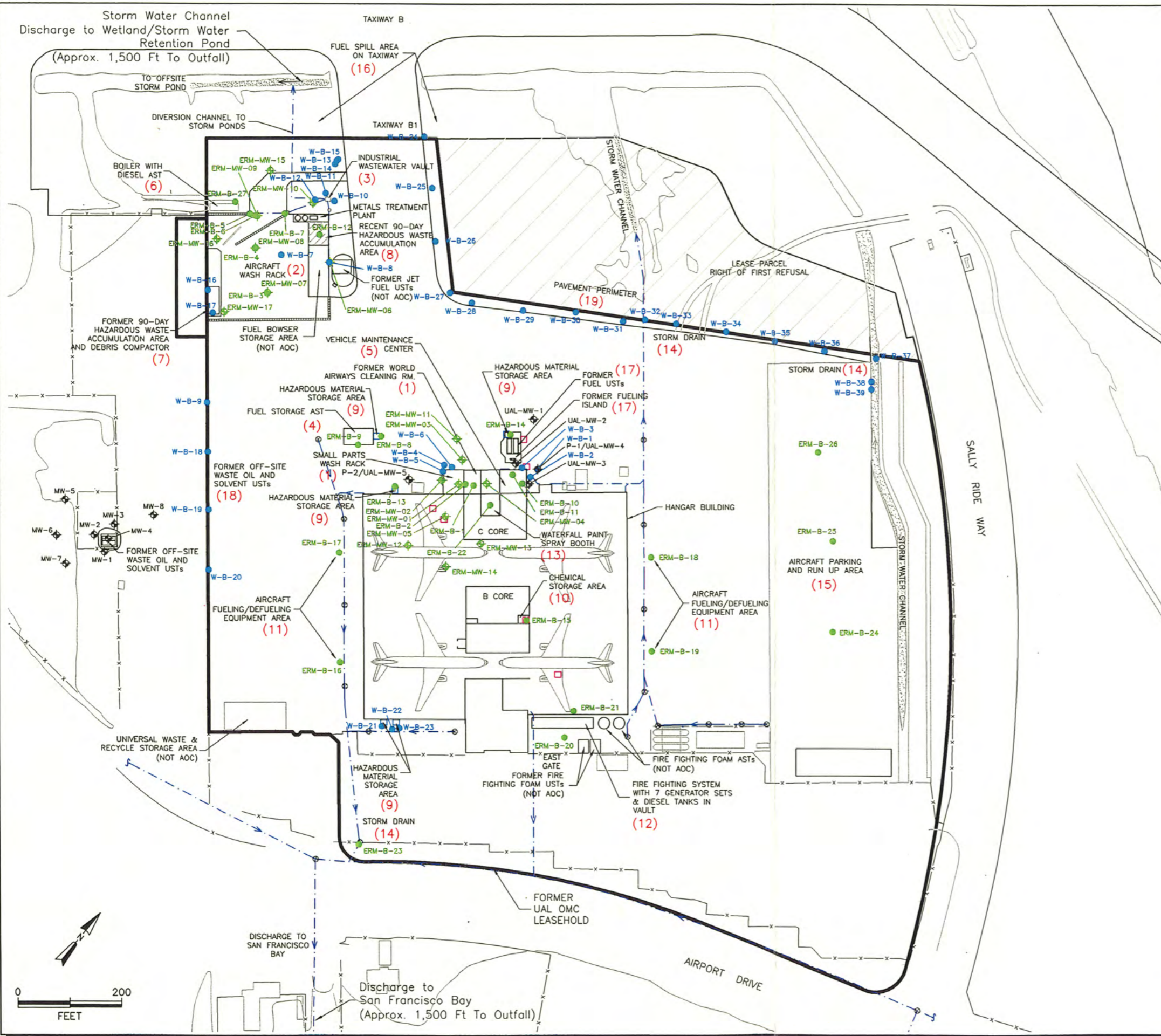
(b) The 11/6/2003 data for samples collected from wells ERM-MW-06, ERM-MW-07, ERM-MW-08, ERM-MW-09, and ERM-MW-10 were discovered to be missing from previous tabulations.

(c) Analyzed by second laboratory.

Attachment A

ERM 2004 Figure showing AOCs and Sample Locations

Storm Water Channel
Discharge to Wetland/Storm Water Retention Pond
(Approx. 1,500 Ft To Outfall)

TAXIWAY B

TO OFFSITE STORM POND

FUEL SPILL AREA ON TAXIWAY
(16)

DIVERSION CHANNEL TO STORM PONDS

TAXIWAY B1

BOILER WITH DIESEL AST
(6)

INDUSTRIAL WASTEWATER VAULT
(3)

METALS TREATMENT PLANT

RECENT 90-DAY HAZARDOUS WASTE ACCUMULATION AREA
(8)

AIRCRAFT WASH RACK
(2)

FORMER JET FUEL USTs (NOT AOC)

FORMER 90-DAY HAZARDOUS WASTE ACCUMULATION AREA AND DEBRIS COMPACTOR
(7)

FUEL BOWSER STORAGE AREA (NOT AOC)

VEHICLE MAINTENANCE CENTER
(5)

PAVEMENT PERIMETER
(19)

STORM WATER CHANNEL

LEASE PARCEL RIGHT OF FIRST REFUSAL

STORM DRAIN
(14)

STORM DRAIN (14)

FORMER WORLD AIRWAYS CLEANING RM.
(1)

HAZARDOUS MATERIAL STORAGE AREA
(9)

FUEL STORAGE AST
(4)

HAZARDOUS MATERIAL STORAGE AREA
(9)

FORMER FUEL USTs (17)

FORMER FUELING ISLAND (17)

SMALL PARTS WASH RACK
(1)

FORMER OFF-SITE WASTE OIL AND SOLVENT USTs
(18)

HAZARDOUS MATERIAL STORAGE AREA
(9)

FORMER OFF-SITE WASTE OIL AND SOLVENT USTs

HANGAR BUILDING

C CORE

WATERFALL PAINT SPRAY BOOTH
(13)

AIRCRAFT PARKING AND RUN UP AREA
(15)

AIRCRAFT FUELING/DEFUELING EQUIPMENT AREA
(11)

B CORE

CHEMICAL STORAGE AREA
(10)

AIRCRAFT FUELING/DEFUELING EQUIPMENT AREA
(11)

UNIVERSAL WASTE & RECYCLE STORAGE AREA (NOT AOC)

HAZARDOUS MATERIAL STORAGE AREA
(9)

EAST GATE

FORMER FIRE FIGHTING FOAM USTs (NOT AOC)

FIRE FIGHTING FOAM ASTs (NOT AOC)

FIRE FIGHTING SYSTEM WITH 7 GENERATOR SETS & DIESEL TANKS IN VAULT
(12)

STORM DRAIN
(14)

SALLY RIDE WAY

STORM WATER CHANNEL

DISCHARGE TO SAN FRANCISCO BAY

FORMER UAL OMC LEASEHOLD

AIRPORT DRIVE

Discharge to San Francisco Bay (Approx. 1,500 Ft To Outfall)

FEET
0   200

LEGEND

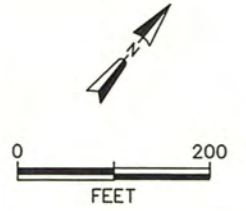| (5) | AREA of CONCERN (AOC) FOR INVESTIGATION |
ERM-MW-01	ERM MONITORING WELL
UAL-MW-3	OTHER MONITORING WELL
ERM-B-10	ERM BORING
W-B-2	WEISS BORING
□	SATELLITE HAZARDOUS WASTE ACCUMULATION POINTS (NOT AOC)
□	HAZARDOUS MATERIAL STORAGE AREA (9)
⊗	STORM WATER DRAIN CATCH BASIN (14)
—··—	STORM WATER SEWER LINE (14)
▭	TRENCH DRAIN (14)
▭	STORM WATER CHANNEL (14)

Figure 4
Soil Boring and Monitoring Well Locations
Former United Airlines Oakland Maintenance Center
Oakland International Airport, Oakland, California

ERM   01/04

Attachment B

Revised Table E-4b from May 2014 Technical Memorandum

Revised Table E-4b
Post-2002 Data Set - Groundwater Results - TPH - Tier-2

Sample Location	AOC	Date Sampled	TPH-d	TPH-d (sg)	TPH-g	TPH-ho	TPH-jf	TPH-mo
Airport Worker Tier-2 (a)			NS	NS	NS	NS	NS	NS
Construction Worker Tier-2 (a)			NS	NS	NS	NS	NS	NS
Ecological Receptor Tier-2 (a) (DAF = 1)			640	640	500	640	640	640
Area of Concern 1								
Ecological Receptor Tier-2 (a) (DAF = 6.6)			4224	4224	3300	4224	4224	4224
ERM-B-1	1	4/15/2003	2300 J	340 J	110 Y	NA	NA	NA
ERM-B-2	1	4/15/2003	5500 JY	<560 UJ	71 Y	NA	NA	NA
W-B-4	1	4/15/2003	140 JY	97 JY	<50	NA	NA	NA
W-B-5	1	4/15/2003	<500 UJY	NA	<50	NA	NA	NA
W-B-6	1	4/15/2003	520 JY	260 JY	<50	NA	NA	NA
Area of Concern 2								
Ecological Receptor Tier-2 (a) (DAF = 3.5)			2240	2240	1750	2240	2240	2240
ERM-B-3	2	4/15/2003	930 Y	200 Y	<50	NA	NA	NA
ERM-B-4	2	4/15/2003	4500 J	840 J	<50	NA	NA	NA
ERM-B-5	2	4/15/2003	12000 J	4700 J	<500	NA	NA	NA
ERM-B-6	2	4/15/2003	7700 J	990 J	1700	NA	NA	NA
ERM-B-7	2	4/15/2003	1900 J	150 J	<50 J	NA	NA	NA
ERM-MW-06	2	5/9/2003	<50	NA	<50	<100	<100	<100
ERM-MW-06	2	11/6/2003	390	110	NA	<250	<50	<250
ERM-MW-06	2	6/27/2006	NA	NA	<50 UJ	NA	NA	NA
ERM-MW-06 (b)	2	5/9/2003	NA	NA	<50	NA	NA	NA
ERM-MW-07	2	5/9/2003	89 Y	NA	<50	<100	<100	110 Y
ERM-MW-07	2	11/6/2003	<50	NA	NA	<250	<50	<250
ERM-MW-07	2	6/26/2006	<50	NA	<50	<300	<50	<300
ERM-MW-07 (b)	2	5/9/2003	NA	NA	<50	NA	NA	NA
ERM-MW-08	2	5/9/2003	170 Y	NA	<50	<100	<100	150 Y
ERM-MW-08	2	11/6/2003	1100	250 J	NA	1900	<50	<250
ERM-MW-08	2	6/26/2006	450 Y	NA	77 Y	330 Y	400 Y	<300
ERM-MW-08 (b)	2	5/9/2003	NA	NA	<50	NA	NA	NA
ERM-MW-09	2	5/9/2003	540 Y	NA	220 J	<100	<100	270 Y
ERM-MW-09	2	11/6/2003	2600	760	NA	1300	<250	<250
ERM-MW-09	2	6/26/2006	920 Y	NA	460 Y	580 Y	820 Y	<300
ERM-MW-09 (b)	2	5/9/2003	NA	NA	<50	NA	NA	NA
W-B-7	2	4/17/2003	83 J	79 J	<50	NA	NA	NA
W-B-8	2	4/14/2003	91 J	100 J	<50	NA	210	1100
W-B-8 (b)	2	4/14/2003	NA	210	NA	NA	NA	NA
Area of Concern 3								
Ecological Receptor Tier-2 (a) (DAF = 2.3)			1472	1472	1150	1472	1472	1472
ERM-MW-10	3	5/9/2003	75 Y	NA	<50	<100	<100	110 Y
ERM-MW-10	3	11/6/2003	140	180	NA	620	<50	<250
ERM-MW-10	3	6/26/2006	<50	NA	<50	<300	<50	<300
ERM-MW-10 (b)	3	5/9/2003	NA	NA	<50	NA	NA	NA
W-B-10	3	4/15/2003	160 JY	93 JY	<50	NA	NA	NA
W-B-11	3	4/15/2003	140 J	120 J	<50	NA	NA	NA
W-B-12	3	4/15/2003	4100 J	5100 J	<50	NA	NA	NA

Revised Table E-4b
Post-2002 Data Set - Groundwater Results - TPH - Tier-2

Sample Location	AOC	Date Sampled	TPH-d		TPH-d (sg)		TPH-g		TPH-ho	TPH-jf		TPH-mo	
Airport Worker Tier-2 (a)			NS		NS		NS		NS	NS		NS	
Construction Worker Tier-2 (a)			NS		NS		NS		NS	NS		NS	
Ecological Receptor Tier-2 (a) (DAF = 1)			640		640		500		640	640		640	
Area of Concern 4													
Ecological Receptor Tier-2 (a) (DAF = 6.2)			3968		3968		3100		3968	3968		3968	
ERM-B-8	4	4/16/2003	52	Y	72	Y	<50	UJ	NA	NA		NA	
ERM-B-9	4	4/16/2003	120	Y	150	Y	<50	UJ	NA	NA		NA	
Area of Concern 5													
Ecological Receptor Tier-2 (a) (DAF = 6)			3840		3840		3000		3840	3840		3840	
ERM-B-10	5	4/17/2003	96	Y	<73.1	U	59	Y	NA	NA		NA	
ERM-B-11	5	4/17/2003	110	J	<73.1	U	<50		NA	NA		NA	
W-B-1	5	4/14/2003	110	Q	NA		<50	Q	NA	<50	Q	540	Q
W-B-2	5	4/14/2003	200	J Y	88	J Y	90		NA	<50		<250	
W-B-2 (b)	5	4/14/2003	<50		NA		<50	Y	NA	NA		NA	
W-B-3	5	4/15/2003	120		<78.9	U	85	Y	NA	<50		650	
W-B-3 (b)	5	4/15/2003	98		NA		<50		NA	NA		NA	
Area of Concern 6													
Ecological Receptor Tier-2 (a) (DAF = 2.4)			1536		1536		1200		1536	1536		1536	
ERM-B-27	6	4/17/2003	550	J	180		NA		NA	NA		NA	
Area of Concern 7													
Ecological Receptor Tier-2 (a) (DAF = 4.2)			2688		2688		2100		2688	2688		2688	
W-B-16	7	4/17/2003	69	Y	<73.1	U	<50		NA	<50		<250	
W-B-16 (b)	7	4/17/2003	57		NA		<50		NA	NA		NA	
W-B-17	7	4/17/2003	660	J	220	Y	<50		NA	<50		<250	
W-B-17 (b)	7	4/17/2003	<50		NA		<50		NA	NA		NA	
Area of Concern 8													
Ecological Receptor Tier-2 (a) (DAF = 2.7)			1728		1728		1350		1728	1728		1728	
ERM-B-12	8	4/17/2003	<50		NA		<50		NA	NA		NA	
Area of Concern 9													
Ecological Receptor Tier-2 (a) (DAF = 5.5)			3520		3520		2750		3520	3520		3520	
ERM-B-13	9	4/16/2003	86	Y	77	Y	<50		NA	NA		NA	
ERM-B-14	9	4/17/2003	110	J	170	Y	<50		NA	NA		NA	
P-2/UAL-MW-05	9	6/27/2006	NA		NA		<50		NA	NA		NA	
P-2/UAL-MW-5	9	4/18/2003	<50	Y	NA		<50		NA	NA		NA	
P-2/UAL-MW-5	9	4/22/2003	<50	Q	NA		<50	Q	NA	<50	Q	<250	Q
W-B-22	9	4/18/2003	<50	UJ	NA		<50	UJ	NA	NA		NA	
Area of Concern 11													
Ecological Receptor Tier-2 (a) (DAF = 4.8)			3072		3072		2400		3072	3072		3072	
ERM-B-16	11	4/16/2003	59	Y	82	Y	NA		NA	NA		NA	
ERM-B-17	11	4/16/2003	51	Y	80	Y	NA		NA	NA		NA	
ERM-B-18	11	4/16/2003	96	J	100	J	NA		NA	NA		NA	
ERM-B-19	11	4/16/2003	80	J	100	J	NA		NA	NA		NA	
Area of Concern 12													
Ecological Receptor Tier-2 (a) (DAF = 6.4)			4096		4096		3200		4096	4096		4096	
ERM-B-20	12	4/17/2003	61	Y	83	J	NA		NA	NA		NA	
ERM-B-21	12	4/17/2003	130	J	130	Y	NA		NA	NA		NA	

Revised Table E-4b
Post-2002 Data Set - Groundwater Results - TPH - Tier-2

Sample Location	AOC	Date Sampled	TPH-d		TPH-d (sg)		TPH-g		TPH-ho	TPH-jf		TPH-mo	
Airport Worker Tier-2 (a)			NS		NS		NS		NS	NS		NS	
Construction Worker Tier-2 (a)			NS		NS		NS		NS	NS		NS	
Ecological Receptor Tier-2 (a)	(DAF = 1)		640		640		500		640	640		640	
Area of Concern 14													
Ecological Receptor Tier-2 (a)	(DAF = 1)		640		640		500		640	640		640	
ERM-B-23	14	4/17/2003	<50		NA		<50		NA	NA		NA	
W-B-32	14	4/16/2003	**250**	Y	**160**	Y	<50		NA	NA		NA	
W-B-38	14	4/15/2003	**230**	J	**120**	J	<50		NA	NA		NA	
Area of Concern 15													
Ecological Receptor Tier-2 (a)	(DAF = 1)		640		640		500		640	640		640	
ERM-B-24	15	4/15/2003	**620**	J	**160**		NA		NA	NA		NA	
ERM-B-25	15	4/15/2003	**370**	J	**140**	J	NA		NA	NA		NA	
ERM-B-26	15	4/16/2003	**360**		**140**		NA		NA	NA		NA	
Area of Concern 16													
Ecological Receptor Tier-2 (a)	(DAF = 1)		640		640		500		640	640		640	
W-B-14	16	4/15/2003	**67**	J	**69**	J	NA		NA	NA		NA	
Area of Concern 17													
Ecological Receptor Tier-2 (a)	(DAF = 5.5)		3520		3520		2750		3520	3520		3520	
P-1/UAL-MW-04	17	6/27/2006	NA		NA		<50	UJ	NA	NA		NA	
P-1/UAL-MW-4	17	4/18/2003	**82**	Y	**100**	J	<50		NA	NA		NA	
P-1/UAL-MW-4	17	4/22/2003	<50	Q	NA		<50	Q	NA	<50	Q	<250	Q
UAL-MW-01	17	6/27/2006	NA		NA		<50	UJ	NA	NA		NA	
UAL-MW-02	17	6/27/2006	NA		NA		<50	UJ	NA	NA		NA	
UAL-MW-03	17	6/27/2006	NA		NA		<50	UJ	NA	NA		NA	
UAL-MW-1	17	4/15/2003	<50		NA		<50		NA	<50		<250	
UAL-MW-1	17	4/18/2003	<50		NA		<50		NA	NA		NA	
UAL-MW-1	17	11/6/2003	<50		NA		<50		<250	<50		<250	
UAL-MW-2	17	4/15/2003	<50	Q	NA		<50	Q	NA	<50	Q	<250	Q
UAL-MW-2	17	4/18/2003	**280**	J	**120**	J	<50		NA	NA		NA	
UAL-MW-2	17	11/6/2003	<50		NA		<50		<250	<50		<250	
UAL-MW-3	17	4/15/2003	<50		NA		<50		NA	<50		<250	
UAL-MW-3	17	4/18/2003	**86**	Y	**78**	J	<50		NA	NA		NA	
Area of Concern 18													
Ecological Receptor Tier-2 (a)	(DAF = 7)		4480		4480		3500		4480	4480		4480	
W-B-18	18	4/18/2003	<50	Q	NA		<50	Q	NA	<50	Q	<250	Q
W-B-19	18	4/18/2003	<50	Q	NA		<50	Q	NA	<50	Q	<250	Q
W-B-20	18	4/18/2003	<50	Q	NA		<50	Q	NA	<50	Q	<250	Q
W-B-20D	18	4/18/2003	<50	Q	NA		<50	Q	NA	<50	Q	<250	Q
W-B-9	18	4/18/2003	<50	Q	NA		<50	Q	NA	<50	Q	<250	Q
Area of Concern 19													
Ecological Receptor Tier-2 (a)	(DAF = 1)		640		640		500		640	640		640	
W-B-25	19	4/16/2003	<50		NA		<50		NA	NA		NA	
W-B-29	19	4/16/2003	<50		NA		<50		NA	NA		NA	

Notes

Yellow highlighting indicates an exceedance of the selected ESL.

Bolding indicates detected concentrations.

All units are in micrograms per liter (ug/L).

Only analytes that have at least one detection and have exceeded the Tier-1 screening level are shown.

< = analyte was not detected at or above the laboratory method detection limit

DAF = dilution attenuation factor

ESL = environmental screening level

NA = not analyzed

NS = no ESL standard

sg = silica gel clean up

TPH-d = total petroleum hydrocarbon as diesel range organics

TPH-g = total petroleum hydrocarbon as gasoline range organics

TPH-ho = total petroleum hydrocarbon as hydraulic oil

TPH-jf = total petroleum hydrocarbon as jet fuel

TPH-mo = total petroleum hydrocarbon as motor oil range organics

Qualifiers

J = The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample.

Q = Data not validated and there is a high uncertainty associated with the quality adequacy of the data.

UJ = The analyte was not detected above the reported sample quantitation limit. However, the reported quantitation limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample.

Y = Sample exhibits chromatographic pattern which does not resemble standard.

Footnotes

(a) Tier-2 airport and construction worker screening level value is based on commercial values in Table E-1 Environmental Screening Levels (ESLs) Groundwater Screening Levels (RWQCB, December 2013). Tier-2 Ecological receptor screening level value is based on estuarine values in Table F-4a Summary of Selected Aquatic Habitat Goals (RWQCB, December 2013) multiplied by a DAF specific to the approximate location of the AOC as listed in Table 1.

(b) Analyte analyzed by a second method.

References

RWQCB (San Francisco Bay Regional Water Quality Control Board), 2013. Screening For Environmental Concerns at Sites With Contaminated Soil and Groundwater November 2007, Updated December 2013. California EPA, http://www.waterboards.ca.gov/sanfranciscobay/esl.htm.

Attachment C

ProUCL Output for Nickel in Groundwater for AOCs 1, 2, and 3

UCL Statistics for Data Sets with Non-Detects

User Selected Options	
Date/Time of Computation	11/12/2014 10:46:07 AM
From File	Nickel in GW_c.xls (AOC 1)
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

Nickel in Groundwater from AOC 1

General Statistics

Total Number of Observations	28	Number of Distinct Observations	25
Number of Detects	24	Number of Non-Detects	4
Number of Distinct Detects	23	Number of Distinct Non-Detects	2
Minimum Detect	10	Minimum Non-Detect	20
Maximum Detect	590	Maximum Non-Detect	30
Variance Detects	17462	Percent Non-Detects	14.29%
Mean Detects	109.1	SD Detects	132.1
Median Detects	63	CV Detects	1.211
Skewness Detects	2.565	Kurtosis Detects	7.453
Mean of Logged Detects	4.171	SD of Logged Detects	1.035

Normal GOF Test on Detects Only

Shapiro Wilk Test Statistic	0.69	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.916	Detected Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.245	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.181	Detected Data Not Normal at 5% Significance Level
Detected Data Not Normal at 5% Significance Level		

Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs

Mean	95.56	Standard Error of Mean	23.99
SD	124.3	95% KM (BCA) UCL	140.6
95% KM (t) UCL	136.4	95% KM (Percentile Bootstrap) UCL	136.6
95% KM (z) UCL	135	95% KM Bootstrap t UCL	170.5
90% KM Chebyshev UCL	167.5	95% KM Chebyshev UCL	200.1
97.5% KM Chebyshev UCL	245.4	99% KM Chebyshev UCL	334.3

Gamma GOF Tests on Detected Observations Only

A-D Test Statistic	0.537	**Anderson-Darling GOF Test**
5% A-D Critical Value	0.77	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.16	**Kolmogrov-Smirnoff GOF**
5% K-S Critical Value	0.183	Detected data appear Gamma Distributed at 5% Significance Level
Detected data appear Gamma Distributed at 5% Significance Level		

Gamma Statistics on Detected Data Only

k hat (MLE)	1.096	k star (bias corrected MLE)	0.987
Theta hat (MLE)	99.54	Theta star (bias corrected MLE)	110.6
nu hat (MLE)	52.6	nu star (bias corrected)	47.36
MLE Mean (bias corrected)	109.1	MLE Sd (bias corrected)	109.8

Gamma Kaplan-Meier (KM) Statistics			
k hat (KM)	0.591	nu hat (KM)	33.11
Approximate Chi Square Value (33.11, α)	20.96	Adjusted Chi Square Value (33.11, β)	20.36
95% Gamma Approximate KM-UCL (use when n>=50)	151	95% Gamma Adjusted KM-UCL (use when n<50)	155.4

Gamma ROS Statistics using Imputed Non-Detects			
GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs			
GROS may not be used when kstar of detected data is small such as < 0.1			
For such situations, GROS method tends to yield inflated values of UCLs and BTVs			
For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates			
Minimum	0.01	Mean	93.5
Maximum	590	Median	50
SD	128	CV	1.369
k hat (MLE)	0.405	k star (bias corrected MLE)	0.386
Theta hat (MLE)	230.8	Theta star (bias corrected MLE)	242.5
nu hat (MLE)	22.69	nu star (bias corrected)	21.59
MLE Mean (bias corrected)	93.5	MLE Sd (bias corrected)	150.6
		Adjusted Level of Significance (β)	0.0404
Approximate Chi Square Value (21.59, α)	12.03	Adjusted Chi Square Value (21.59, β)	11.59
95% Gamma Approximate UCL (use when n>=50)	167.8	95% Gamma Adjusted UCL (use when n<50)	174.2

Lognormal GOF Test on Detected Observations Only		
Shapiro Wilk Test Statistic	0.985	Shapiro Wilk GOF Test
5% Shapiro Wilk Critical Value	0.916	Detected Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.0897	Lilliefors GOF Test
5% Lilliefors Critical Value	0.181	Detected Data appear Lognormal at 5% Significance Level
Detected Data appear Lognormal at 5% Significance Level		

Lognormal ROS Statistics Using Imputed Non-Detects			
Mean in Original Scale	95.45	Mean in Log Scale	3.943
SD in Original Scale	126.6	SD in Log Scale	1.117
95% t UCL (assumes normality of ROS data)	136.2	95% Percentile Bootstrap UCL	136
95% BCA Bootstrap UCL	156	95% Bootstrap t UCL	168.7
95% H-UCL (Log ROS)	168.5		

UCLs using Lognormal Distribution and KM Estimates when Detected data are Lognormally Distributed			
KM Mean (logged)	3.951	95% H-UCL (KM -Log)	160.2
KM SD (logged)	1.086	95% Critical H Value (KM-Log)	2.563
KM Standard Error of Mean (logged)	0.211		

DL/2 Statistics			
DL/2 Normal		DL/2 Log-Transformed	
Mean in Original Scale	95.29	Mean in Log Scale	3.933
SD in Original Scale	126.7	SD in Log Scale	1.127
95% t UCL (Assumes normality)	136.1	95% H-Stat UCL	170
DL/2 is not a recommended method, provided for comparisons and historical reasons			

Nonparametric Distribution Free UCL Statistics			
Detected Data appear Gamma Distributed at 5% Significance Level			

Suggested UCL to Use			
95% KM (Chebyshev) UCL	200.1	95% GROS Adjusted Gamma UCL	174.2
95% Adjusted Gamma KM-UCL	155.4		

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

UCL Statistics for Data Sets with Non-Detects

User Selected Options	
Date/Time of Computation	11/12/2014 10:48:18 AM
From File	Nickel in GW_d.xls (AOC 2)
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

Nickel in Groundwater in AOC 2

General Statistics

Total Number of Observations	24	Number of Distinct Observations	21
Number of Detects	21	Number of Non-Detects	3
Number of Distinct Detects	19	Number of Distinct Non-Detects	2
Minimum Detect	6	Minimum Non-Detect	20
Maximum Detect	370	Maximum Non-Detect	30
Variance Detects	9934	Percent Non-Detects	12.5%
Mean Detects	129.4	SD Detects	99.67
Median Detects	110	CV Detects	0.77
Skewness Detects	0.756	Kurtosis Detects	-0.0496
Mean of Logged Detects	4.428	SD of Logged Detects	1.14

Normal GOF Test on Detects Only

Shapiro Wilk Test Statistic	0.923	**Shapiro Wilk GOF Test**	
5% Shapiro Wilk Critical Value	0.908	Detected Data appear Normal at 5% Significance Level	
Lilliefors Test Statistic	0.157	**Lilliefors GOF Test**	
5% Lilliefors Critical Value	0.193	Detected Data appear Normal at 5% Significance Level	
Detected Data appear Normal at 5% Significance Level			

Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs

Mean	114.6	Standard Error of Mean	20.74
SD	99.14	95% KM (BCA) UCL	152.3
95% KM (t) UCL	150.1	95% KM (Percentile Bootstrap) UCL	148.4
95% KM (z) UCL	148.7	95% KM Bootstrap t UCL	156.1
90% KM Chebyshev UCL	176.8	95% KM Chebyshev UCL	205
97.5% KM Chebyshev UCL	244.1	99% KM Chebyshev UCL	320.9

Gamma GOF Tests on Detected Observations Only

A-D Test Statistic	0.376	**Anderson-Darling GOF Test**	
5% A-D Critical Value	0.763	Detected data appear Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.128	**Kolmogrov-Smirnoff GOF**	
5% K-S Critical Value	0.194	Detected data appear Gamma Distributed at 5% Significance Level	
Detected data appear Gamma Distributed at 5% Significance Level			

Gamma Statistics on Detected Data Only

k hat (MLE)	1.289	k star (bias corrected MLE)	1.137
Theta hat (MLE)	100.4	Theta star (bias corrected MLE)	113.8
nu hat (MLE)	54.16	nu star (bias corrected)	47.75
MLE Mean (bias corrected)	129.4	MLE Sd (bias corrected)	121.4

Gamma Kaplan-Meier (KM) Statistics			
k hat (KM)	1.335	nu hat (KM)	64.08
Approximate Chi Square Value (64.08, α)	46.66	Adjusted Chi Square Value (64.08, β)	45.62
95% Gamma Approximate KM-UCL (use when n>=50)	157.3	95% Gamma Adjusted KM-UCL (use when n<50)	160.9

Gamma ROS Statistics using Imputed Non-Detects			
GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs			
GROS may not be used when kstar of detected data is small such as < 0.1			
For such situations, GROS method tends to yield inflated values of UCLs and BTVs			
For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates			
Minimum	6	Mean	115.2
Maximum	370	Median	96
SD	100.6	CV	0.873
k hat (MLE)	1.062	k star (bias corrected MLE)	0.957
Theta hat (MLE)	108.5	Theta star (bias corrected MLE)	120.4
nu hat (MLE)	50.96	nu star (bias corrected)	45.92
MLE Mean (bias corrected)	115.2	MLE Sd (bias corrected)	117.8
		Adjusted Level of Significance (β)	0.0392
Approximate Chi Square Value (45.92, α)	31.38	Adjusted Chi Square Value (45.92, β)	30.53
95% Gamma Approximate UCL (use when n>=50)	168.7	95% Gamma Adjusted UCL (use when n<50)	173.3

Lognormal GOF Test on Detected Observations Only		
Shapiro Wilk Test Statistic	0.9	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.908	Detected Data Not Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.168	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.193	Detected Data appear Lognormal at 5% Significance Level
Detected Data appear Approximate Lognormal at 5% Significance Level		

Lognormal ROS Statistics Using Imputed Non-Detects			
Mean in Original Scale	115.2	Mean in Log Scale	4.215
SD in Original Scale	100.6	SD in Log Scale	1.211
95% t UCL (assumes normality of ROS data)	150.4	95% Percentile Bootstrap UCL	149
95% BCA Bootstrap UCL	152	95% Bootstrap t UCL	155.6
95% H-UCL (Log ROS)	288.8		

UCLs using Lognormal Distribution and KM Estimates when Detected data are Lognormally Distributed			
KM Mean (logged)	4.158	95% H-UCL (KM -Log)	310
KM SD (logged)	1.269	95% Critical H Value (KM-Log)	2.922
KM Standard Error of Mean (logged)	0.268		

DL/2 Statistics			
DL/2 Normal		**DL/2 Log-Transformed**	
Mean in Original Scale	114.7	Mean in Log Scale	4.179
SD in Original Scale	101.1	SD in Log Scale	1.26
95% t UCL (Assumes normality)	150.1	95% H-Stat UCL	310.2
DL/2 is not a recommended method, provided for comparisons and historical reasons			

Nonparametric Distribution Free UCL Statistics
Detected Data appear Normal Distributed at 5% Significance Level

Suggested UCL to Use			
95% KM (t) UCL	150.1	95% KM (Percentile Bootstrap) UCL	148.4

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

UCL Statistics for Data Sets with Non-Detects		

User Selected Options	
Date/Time of Computation	11/12/2014 11:31:21 AM
From File	Nickel in GW_g.xls (AOC 3)
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

Nickel in Groundwater in AOC 3

General Statistics			
Total Number of Observations	6	Number of Distinct Observations	5
Number of Detects	4	Number of Non-Detects	2
Number of Distinct Detects	4	Number of Distinct Non-Detects	1
Minimum Detect	26	Minimum Non-Detect	20
Maximum Detect	120	Maximum Non-Detect	20
Variance Detects	1533	Percent Non-Detects	33.33%
Mean Detects	72.75	SD Detects	39.15
Median Detects	72.5	CV Detects	0.538
Skewness Detects	0.0353	Kurtosis Detects	0.37
Mean of Logged Detects	4.149	SD of Logged Detects	0.65

<p style="color:red; text-align:center">Note: Sample size is small (e.g., <10), if data are collected using ISM approach, you should use
guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest.
For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012).
Chebyshev UCL can be computed using the Nonparametric and All UCL Options of ProUCL 5.0</p>

Normal GOF Test on Detects Only		
Shapiro Wilk Test Statistic	0.999	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.748	Detected Data appear Normal at 5% Significance Level
Lilliefors Test Statistic	0.157	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.443	Detected Data appear Normal at 5% Significance Level
Detected Data appear Normal at 5% Significance Level		

Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs			
Mean	55.17	Standard Error of Mean	17.54
SD	37.21	95% KM (BCA) UCL	N/A
95% KM (t) UCL	90.52	95% KM (Percentile Bootstrap) UCL	N/A
95% KM (z) UCL	84.02	95% KM Bootstrap t UCL	N/A
90% KM Chebyshev UCL	107.8	95% KM Chebyshev UCL	131.6
97.5% KM Chebyshev UCL	164.7	99% KM Chebyshev UCL	229.7

Gamma GOF Tests on Detected Observations Only		
A-D Test Statistic	0.24	**Anderson-Darling GOF Test**
5% A-D Critical Value	0.659	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.211	**Kolmogrov-Smirnoff GOF**
5% K-S Critical Value	0.396	Detected data appear Gamma Distributed at 5% Significance Level
Detected data appear Gamma Distributed at 5% Significance Level		

Gamma Statistics on Detected Data Only			
k hat (MLE)	3.777	k star (bias corrected MLE)	1.111
Theta hat (MLE)	19.26	Theta star (bias corrected MLE)	65.48
nu hat (MLE)	30.22	nu star (bias corrected)	8.888
MLE Mean (bias corrected)	72.75	MLE Sd (bias corrected)	69.02

Gamma Kaplan-Meier (KM) Statistics

k hat (KM)	2.198	nu hat (KM)	26.37
Approximate Chi Square Value (26.37, α)	15.67	Adjusted Chi Square Value (26.37, β)	12.79
95% Gamma Approximate KM-UCL (use when n>=50)	92.87	95% Gamma Adjusted KM-UCL (use when n<50)	113.8

Gamma ROS Statistics using Imputed Non-Detects

GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs
GROS may not be used when kstar of detected data is small such as < 0.1
For such situations, GROS method tends to yield inflated values of UCLs and BTVs
For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates

Minimum	0.01	Mean	48.5
Maximum	120	Median	44.5
SD	48.28	CV	0.995
k hat (MLE)	0.265	k star (bias corrected MLE)	0.244
Theta hat (MLE)	182.8	Theta star (bias corrected MLE)	198.9
nu hat (MLE)	3.185	nu star (bias corrected)	2.926
MLE Mean (bias corrected)	48.5	MLE Sd (bias corrected)	98.23
		Adjusted Level of Significance (β)	0.0122
Approximate Chi Square Value (2.93, α)	0.351	Adjusted Chi Square Value (2.93, β)	0.157
95% Gamma Approximate UCL (use when n>=50)	404.6	95% Gamma Adjusted UCL (use when n<50)	N/A

Lognormal GOF Test on Detected Observations Only

Shapiro Wilk Test Statistic	0.946	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.748	Detected Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.246	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.443	Detected Data appear Lognormal at 5% Significance Level
Detected Data appear Lognormal at 5% Significance Level		

Lognormal ROS Statistics Using Imputed Non-Detects

Mean in Original Scale	52.27	Mean in Log Scale	3.563
SD in Original Scale	43.93	SD in Log Scale	1.053
95% t UCL (assumes normality of ROS data)	88.41	95% Percentile Bootstrap UCL	79.22
95% BCA Bootstrap UCL	83.77	95% Bootstrap t UCL	92.37
95% H-UCL (Log ROS)	467.6		

UCLs using Lognormal Distribution and KM Estimates when Detected data are Lognormally Distributed

KM Mean (logged)	3.764	95% H-UCL (KM -Log)	154.3
KM SD (logged)	0.712	95% Critical H Value (KM-Log)	3.207
KM Standard Error of Mean (logged)	0.336		

DL/2 Statistics

DL/2 Normal		DL/2 Log-Transformed	
Mean in Original Scale	51.83	Mean in Log Scale	3.533
SD in Original Scale	44.38	SD in Log Scale	1.078
95% t UCL (Assumes normality)	88.34	95% H-Stat UCL	511.5
DL/2 is not a recommended method, provided for comparisons and historical reasons			

Nonparametric Distribution Free UCL Statistics

Detected Data appear Normal Distributed at 5% Significance Level

Suggested UCL to Use

95% KM (t) UCL	90.52	95% KM (Percentile Bootstrap) UCL	N/A
Warning: One or more Recommended UCL(s) not available!			

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.