DREDGED MATERIAL MANAGEMENT PROGRAM

DIOXIN/FURAN/PCB SAMPLING IN PUGET SOUND
Work Plan

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Prepared for:

Seattle District Corps of Engineers
EPA Region 10
WA Dept. of Natural Resources
WA Dept. of Ecology

Prepared by:

Avocet Consulting
Olympia, WA USA

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1. Introduction and Background

The Dredged Material Program (DMMP) agencies (the "Agencies") are in the process of developing new procedures for evaluation of dredged material containing dioxins/furans to protect human health and the environment, support the Puget Sound Initiative's goals for Puget Sound, maintain the viability of the open-water disposal program, and ensure consistency with regulatory requirements. A number of alternatives are under consideration to determine the suitability of dredged material containing dioxin (and dioxin-like compounds such as PCBs) for unconfined, open-water disposal.[1]

While the Puget Sound Ambient Monitoring Program (PSAMP) has generated a geographically extensive, long-term sediment data set from sites throughout Puget Sound, they have not routinely analyzed for dioxins/furans and have limited their PCB congener analysis to a subset of the 209 possible congeners. There is little high resolution dioxin/furan or polychlorinated biphenyl (PCB) congener data available for Puget Sound outside of certain Superfund and Model Toxics Control Act (MTCA) cleanup sites and therefore, it is difficult to evaluate the practical, economic, environmental, and regulatory consequences of the alternatives.

As a result, the agencies have determined that additional data on concentrations of dioxins/furans and PCB congeners in Puget Sound is needed to inform the DMMP program deliberations. In addition, data collected will have utility for other programs such as cleanup programs (CERCLA/MTCA) and the Puget Sound Initiative.

The DMMP Agencies are committed to having a proposal for the evaluation procedures that is as clear as possible, and includes public input, by the 2009-2010 dredging season. Consequently, the DMMP intends to collect samples by September 2008 and have results available to the agencies mid-winter.

2. Study Objectives

The DMMP agencies have identified the following policy and technical questions that need to be answered to evaluate the alternatives under consideration:

Question 1. What are the concentrations of dioxins/furans and PCBs in the existing reference areas used by the DMMP? Currently, there is very limited number of high-resolution dioxin/furan and PCB data from DMMP reference sites in Puget Sound. Specifically, there are currently only 9 dioxin/furan samples from three reference locations, and these may not be representative of the organic carbon or grain size range in reference bays or for typical dredging projects. Similarly, there are currently only 5 detected PCB (Aroclor) values from two reference areas. There is no high-resolution PCB congener data (209 congeners) for these areas, and dioxin-like congener data may be needed along with dioxin/furan data to accurately evaluate risks.

[1] For more information on interpretive guideline revisions for dioxin see http://www.nws.usace.army.mil/PublicMenu/Doc_list.cfm?sitename=DMMO&pagename=Dioxin.

PCB Aroclor data does exist, but the detection limits are often higher than for PCB congeners and result in a large number of non-detects. Using PCB congener analysis increases the likelihood that concentrations will be measurable in cleaner areas.

Question 2. What are the concentrations of dioxins/furans and PCBs generally in Puget Sound, outside of the areas that have already been sampled (urban bays, cleanup sites)? Most of the existing high-resolution dioxin/furan/PCB data for Puget Sound are from Superfund and MTCA cleanup sites. In addition, some data are being collected by the Puget Sound Initiative in several urban bays in the Sound. Outside of these areas, almost no high-resolution data exist other than those collected recently by the DMMP agencies in the vicinity of the open-water disposal sites. This project is expected to generate much-needed dioxin and PCB congener information which could be an invaluable tool for Puget Sound mapping and characterization. The data will also help in determining the current environmental health of Puget Sound.

Question 3. Are the concentrations of dioxins/furans and PCBs in the existing reference areas different from those in Puget Sound that are also away from known sources? There has been an assumption that the existing reference areas, originally chosen to support bioassay testing, are cleaner than general concentrations in Puget Sound away from known sources such as outfalls and cleanup sites. However, there are insufficient data to test this assumption, and the results could affect how all of these areas are interpreted relative to the various definitions of background used in the Model Toxics Control Act (MTCA) and the Washington State Sediment Management Standards (SMS).

Question 4. Are these concentration distributions affected by TOC or grain size? The agencies are interested in whether there are consistent correlations between dioxins/furans/PCBs and TOC or grain size. Because the greater Puget Sound area has widely differing grain-size and TOC levels, this could affect the levels of dioxins/furans/PCBs found in these areas, even in the absence of localized sources.

Question 5. Are there reliable and less expensive methods for testing dioxins/furan and coplanar PCB toxicity that could be used to reduce the cost of testing for both agencies and applicants? Both of these chemical groups have dioxin-like toxicity, termed “2,3,7,8-tetrachlorodibenzo dioxin toxicity equivalents” or TEQs, and the two groups need to be considered together because of their common mode of action. The cost of testing for dioxins/furans is currently very high ($700-$900/sample), and costs for PCB congeners may be more than $1,000/sample. Several assays have recently been approved by EPA as standard methods with much lower costs, and it is possible that these less expensive assays could be useful in the DMMP suitability determination process. Samples collected for this project will be analyzed using two alternative techniques and standard fixed laboratory methods. It is hoped that through this project, the Agencies will be able to correlate results, and determine cost effectiveness, comparability and data quality for both methods.

Question 6. What are concentrations of the standard DMMP suite of contaminants of concern in these sediment samples? Because of the value of this information for dredging and clean-up programs in the Region, EPA took the opportunity to analyze these sediment samples for a broad suite of contaminants that are typically evaluated in dredging and clean-up programs.

Based on the questions above, the following six study objectives were developed for this field study:

- **Objective 1.** Identify the concentration distributions of dioxins/furans/PCB congeners in the existing DMMP reference areas.

- **Objective 2.** Identify the concentration distributions of dioxins/furans/PCB congeners in Puget Sound generally, away from known sources and cleanup sites.

- **Objective 3.** Compare the concentration distributions in the existing reference areas to general concentrations in Puget Sound away from known sources and cleanup sites to determine whether they are statistically different.

- **Objective 4.** Evaluate whether the concentration distributions appear to be correlated with grain size or TOC (if possible).

- **Objective 5.** Conduct corroborative testing of two dioxin/furan and PCB congener TEQ assays to determine whether they are well-correlated with standard methods, have low enough detection limits, and are cost-effective.

- **Objective 6.** Conduct simultaneous testing for the standard suite of DMMP Contaminants of Concern (COCs) in order to gain a better understanding of their concentrations throughout Puget Sound.

3. Sampling Design

The following sections describe how the sampling design meets the study objectives described in Section 2 and provide an overview of the samples that will be collected and the analyses that will be run. Details of the sampling and analysis protocols are provided in the appendices.

3.1 Overall Design

The study objectives described in Section 2 will be met through the following overall sampling approach:

- **Objective 1** – Five sampling stations will be located within each of four existing reference areas, for a total of 20 samples analyzed for 17 2,3,7,8-chlorine-

substituted dioxins/furans and 209 PCB congeners. The four reference areas that will be sampled include Carr Inlet, Holmes Harbor, Dabob Bay, and Samish Bay. Although Sequim Bay was originally included in the list of reference bays, the DMMP agencies have recently determined that it is not an appropriate reference area (details to be forthcoming in a SMARM '09 paper). However, Sequim Bay was included in the larger Puget Sound effort described in Objective 2.

- **Objective 2** – Five sampling stations will be located within each of ten strata representing geographic areas of the greater Puget Sound region (including portions of the Strait of Juan de Fuca and the San Juan Islands), for a total of 50 samples analyzed for dioxins/furans and PCB congeners. The ten strata were developed solely for the purpose of distributing the 50 samples throughout the greater Puget Sound area, and the strata boundaries will not be used for decision-making.

- **Objective 3** – The existing reference area distribution described above and the greater Puget Sound distribution described above will be compared to determine whether they are statistically different.

- **Objective 4** – Grain size and TOC will be analyzed at all stations and correlated with dioxin/furan/PCB TEQ and total PCB congener data to determine whether there is a correlation that could confound or explain geographic patterns in the data, if any.

- **Objective 5** – At each station, two assays recently approved by EPA as Standard Methods 4430 and 4435 will be conducted along with dioxin/furan and PCB congener analyses to determine whether these methods have a good correlation with the standard methods and can achieve low enough detection limits to detect concentrations in the areas sampled.

- **Objective 6** – Sediments at each station will be analyzed for the full suite of DMMP COCs, including metals, SVOCs, PAHs, pesticides, and PCB Aroclors.

3.2 Selection of Station Locations

Station locations were selected using a stratified random design. First, urbanized embayments were eliminated from consideration. These included Budd Inlet, Commencement Bay, Elliott Bay, Sinclair and Dyes Inlets, Eagle Harbor, Everett, and Bellingham Bay. The remaining areas were divided into strata. Each existing reference area was treated as one stratum. In addition, the greater Puget Sound area was divided into 10 strata to ensure that the 50 samples would be distributed throughout Puget Sound. The boundaries of these strata were located along obvious geographic features and basins where possible, but are not otherwise significant as their only purpose was to provide geographic coverage.

Within each of the 10 greater Puget Sound strata, Visual Sample Plan (Battelle, 2008) was used to generate 20 randomly located stations. Similarly, within each of the existing reference area strata, 8 randomly located stations were generated. In each stratum, starting with the lowest-numbered station, each station was reviewed for acceptability as follows:

- If the station was too shallow or too deep to be sampled by the EPA Ocean Survey Vessel *Bold* (< 35 ft or > 600 ft), the station was moved due west or due east until a depth of 35-600 ft was reached, whichever direction resulted in a shorter move. If the station could not be relocated without ending up on land, in Canadian waters, or within an urban bay, the station was rejected. Relocated stations were then re-evaluated according to the remaining exclusion criteria.

- If the station was located within 500 m of an outfall, cleanup site, or other known contaminant source (e.g., the Hood Canal floating bridge), the station was rejected. In the case of cleanup sites and other known contaminated areas, agency staff occasionally used collective best professional judgment to reject a station outside 500 m that was nevertheless near enough to contaminated areas or sources to potentially be influenced by them (e.g., two stations northeast of Rayonier and Port Angeles Harbor).

- If the station was located within 250 m of a detected DMMP screening level exceedance listed in Ecology's Environmental Information Management (EIM) database, the station was rejected. This radius is smaller than the above sites and sources, because this might be a single exceedance of a standard over a small area, and not all data in EIM are as rigorously verified as the source and site information above.

- In one case, a station was rejected because it was located in the Tacoma Narrows, in an area where agency staff believed it would not be feasible to maintain a station position and collect the sample.

- Any station meeting the above criteria, but which was located within 2500 m of a previously accepted station was not rejected, but was not selected as a primary or backup sampling location to avoid excessive station clustering and provide a representative sample set. It was not always possible to adhere to the 2500-meter rule in the reference areas (which were much smaller in area than the other strata), but stations were selected to provide the widest possible distribution of sampling points.

Stations that passed all of the above screening criteria were accepted as usable. In each of the Puget Sound strata, starting with the lowest-numbered station, the first 5 accepted stations were identified as the target sampling stations, and the second 5 accepted stations were identified as contingency sampling stations, in case any of the target 5 stations could not be sampled in the field. In all strata, there were sufficient accepted samples to provide 5 target and 5 contingency samples. In the existing

reference area strata, 5 target and 2-3 contingency samples were selected. Five sample splits will also be prepared in the field (locations to be selected at the Chief Scientist's discretion) as laboratory duplicates for QA/QC purposes.

In addition, the station locations were reviewed against Puget Sound-wide grain size data from EIM to determine whether it was likely that a complete grain size distribution would be sampled. In some areas, it appeared likely that most of the target and backup samples would be either coarse- or fine-grained, and in these strata, one or more contingency samples were identified that could be collected if the first four samples were all coarse- or all fine-grained. Field staff will perform wet sieving to roughly determine the grain size of sediments collected from target sampling stations. This information will be used to determine whether contingency grain size sampling stations will be substituted for target stations. The ability to collect a complete grain size distribution, even with the contingency samples, is somewhat uncertain. Many of the areas being sampled have never been sampled before, and therefore their grain size (and ability to collect a sample) is unknown. In addition, there will be some schedule constraints limiting the ability to pursue a large number of contingency samples.

Target and contingency samples are shown in Figure 1. A larger-format version of this figure with sample identifications shown is downloadable along with this Work Plan from the Corps of Engineers DMMP website, at http://www.nws.usace.army.mil/PublicMenu/Menu.cfm?sitename=DMMO&pagename=Dioxin_Work_Group. A complete list of the samples reviewed in each strata, their acceptance or rejection, and reasons for rejection along with other notes, is provided in Appendix A. The lat/longs for all stations are also provided in Appendix A.

3.3 Sampling and Analysis Methods

Samples will be collected during the period July 31 - August 8, 2008 from the EPA Ocean Survey Vessel *OSV Bold*, using a double van Veen and/or boxcore sampler. SOPs and a Quality Assurance Project Plan for the *OSV Bold* describing detailed sampling, decontamination, sample preparation, shipping, analytical, and quality assurance procedures are provided in Appendix B.

While it is intended that the *OSV Bold* will collect all the samples, the constrained schedule of the *OSV Bold*, along with the depths of many of the samples, their geographic distance from one another, and the degree to which contingency stations are needed, may prevent this. Should a second round of sampling be necessary to collect all the samples, SAIC will prepare a supplemental Sampling and Analysis Plan and complete the sampling under contract to DNR in late August or early September. This supplemental SAP would be consistent with the plan already developed for the *OSV Bold*.

In brief, surface samples will be collected from the top 10 cm of sediment and submitted for the following analyses:

- Method 6010/6020 metals
- Method 7471 mercury
- CLP 8270 FS/SIM PAHs
- Modified CLP 8270 FS semivolatiles
- CLP 8081 pesticides
- CLP 8182 PCB aroclors
- Method 1668 PCB congeners
- Method 1613 dioxins/furans
- ASTM D422-mod grain size
- PSEP 1997 TOC
- EPA 2450-G percent solids
- Chemical Activated Luciferase Gene Expression (CALUX) assay (EPA SW-846 method 4435)
- Aryl Hydrocarbon-Receptor PCR Assay (EPA SW-846 method 4430, trademarked as “Procept”)

All analyses other than the assays will be conducted under EPA’s CLP program, managed by Ginna Grepo-Grove, Project QA Manager, EPA Region 10. Details of the methods and reporting limits for the dioxins/furans/PCBs and all standard DMMP analytes can be found in the attached QAPP.

Samples for the assays will be split in the field and submitted to their respective laboratories (Xenobiotic Detection Systems for CALUX and APPL, Inc for the PCR Assay). Additional information on the screening assays is provided in Appendices B and C.

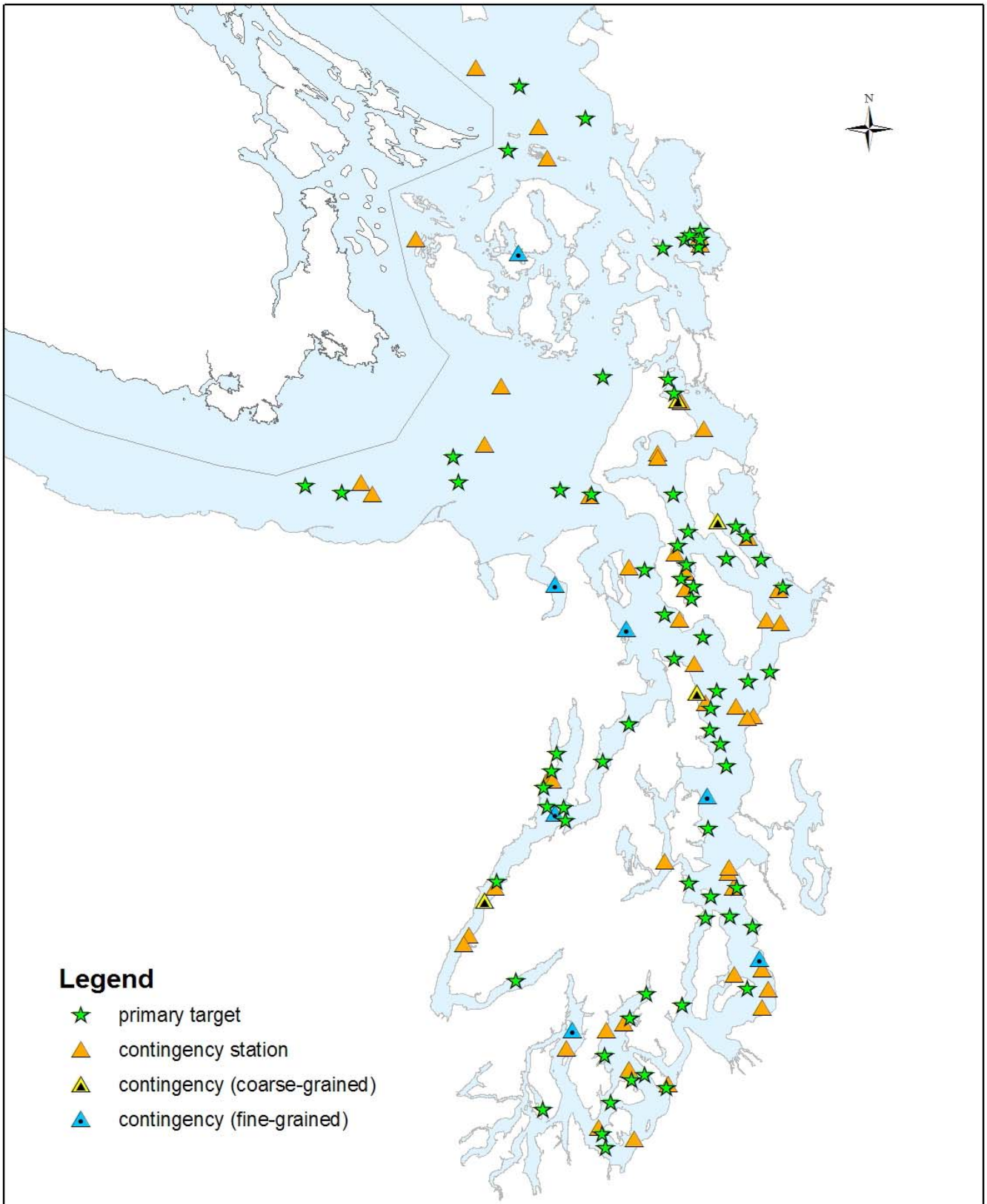

Figure 1. Proposed Sampling Locations

4. Data Interpretation

High Resolution Gas Chromatography/Mass Spectrometry (GC/MS) data will be subjected to independent quality assurance by EPA Region 10. Following a determination of its suitability for use, data will be assembled into an existing reference area data set and a greater Puget Sound data set. The two data sets will be compared to determine whether they are statistically different. If not different, the two data sets will be combined into a single Puget Sound data set. If the two distributions are different, they will be evaluated separately. Dioxin/furan and PCB congener data will be input into ArcGIS and mapped as point values.

Descriptive statistics will be developed for the data, including mean, median, percentiles and/or upper confidence intervals on the mean. Statistical outliers will be identified and removed from the distributions, if necessary.

Any geographic patterns apparent in the data will be further evaluated to determine possible relationships with sources and/or grain size and TOC data. Regression analyses will be run to evaluate the correlation between dioxin/furan/PCB congener concentrations and TOC or fines. If a strong correlation is found that appears to explain an apparent geographic trend in concentrations, consideration will be given to whether normalization of dioxin/furan/PCB data is needed.

Finally, the results of the CALUX and Procept assays will be evaluated with respect to a variety of performance metrics, including:

- Laboratory performance and timeliness of results
- QA/QC results
- Detection limits achieved
- Correlation with standard methods at low, medium, and high concentration ranges

This current investigation is likely to only provide samples with low or low-medium concentration ranges. However, existing data from EPA SITES studies (ongoing) include medium and high concentrations, although little to no data was from the Puget Sound region. In order to address this, archived sediments from Puget Sound projects with higher concentration ranges (as determined by high resolution GC/MS) are being submitted for assay by these methods. This will allow augmentation of the data set to achieve a representative range of concentrations for evaluation of the assays. If one or more of the assays performs well, achieves a low enough detection limit, and correlates well with the standard methods (particularly at low concentrations), it may be possible to develop a Tier 1 assay-based SL for a reason to believe approach in place of more expensive methods.

APPENDIX A

Table A-1. Sample Location Selection

ID	AREA NAME	STATUS	SAMPLE?	COMMENTS	SAMPLE ID	DEPTH (m)	LATITUDE	LONGITUDE
0	Admiralty Inlet	accepted	yes	meets all	AI_0	21	47.924110	-122.563920
1	Admiralty Inlet	accepted	yes	meets all	AI_1	85	47.959856	-122.492100
2	Admiralty Inlet	accepted	yes	meets all	AI_2	125	48.070659	-122.635635
3	Admiralty Inlet	accepted	yes	meets all	AI_3	46	47.997431	-122.587007
4	Admiralty Inlet	accepted	yes	meets all	AI_4	67	48.195790	-122.764289
5	Admiralty Inlet	accepted	contingency	meets all	AI_5_C	34	47.988730	-122.549094
6	Admiralty Inlet	rejected	no	within 250 meters of EIM hit			48.038535	-122.751972
7	Admiralty Inlet	rejected	no	shallow elevation - cannot be moved			48.029906	-122.752014
8	Admiralty Inlet	accepted	cont-fine	moved east to > 11 m depth	AI_8_C_GS	11	47.973011	-122.681740
9	Admiralty Inlet	accepted	contingency	meets all	AI_9_C	61	48.192895	-122.768338
10	Admiralty Inlet	rejected	no	within 500 m of marina			48.103876	-122.774997
11	Admiralty Inlet	accepted	contingency	meets all	AI_11_C	101	48.075672	-122.672890
12	Admiralty Inlet	rejected	no	between Port Townsend & Indian Island			48.059618	-122.754529
13	Admiralty Inlet	accepted	contingency	meets all	AI_13_C	98	47.916343	-122.513550
14	Admiralty Inlet	accepted	no	meets all			47.961572	-122.648417
15	Admiralty Inlet	accepted	no	meets all			48.013939	-122.659708
16	Admiralty Inlet	accepted	no	meets all			48.126454	-122.612860
17	Admiralty Inlet	rejected	no	within 500 m of Chevron bulk terminal			48.109322	-122.763495
18	Admiralty Inlet	accepted	no	meets all			48.129486	-122.672960
19	Admiralty Inlet	accepted	no	meets all			47.943421	-122.457039
0	Carr Inlet	accepted	yes	meets all	R_CAR_0	18	47.334214	-122.675090
1	Carr Inlet	accepted	yes	meets all	R_CAR_1	58	47.233204	-122.672441
2	Carr Inlet	accepted	yes	meets all	R_CAR_2	18	47.272381	-122.737715
3	Carr Inlet	accepted	contingency	meets all	R_CAR_3_C	98	47.250274	-122.678730
4	Carr Inlet	accepted	yes	meets all	R_CAR_4	11	47.374243	-122.636240
5	Carr Inlet	accepted	yes	meets all	R_CAR_5	113	47.241984	-122.640453
6	Carr Inlet	accepted	contingency	moved east to > 11 m depth	R_CAR_6_C	18	47.314357	-122.731719
7	Carr Inlet	accepted	contingency	moved west to > 11 m depth	R_CAR_7_C	18	47.325396	-122.689822
0	Central Puget Sound	accepted	yes	meets all	CPS_0	171	47.547542	-122.415114
1	Central Puget Sound	accepted	yes	meets all	CPS_1	43	47.554908	-122.531002

ID	AREA NAME	STATUS	SAMPLE?	COMMENTS	SAMPLE ID	DEPTH (m)	LATITUDE	LONGITUDE
2	Central Puget Sound	rejected	no	within 500 m of Kingston WWTP outfall			47.729386	-122.502757
3	Central Puget Sound	accepted	yes	moved west to < 200 m depth	CPS_3	162	47.645750	-122.483205
4	Central Puget Sound	accepted	yes	meets all	CPS_4	37	47.534222	-122.477740
5	Central Puget Sound	accepted	yes	moved west to < 200 m depth	CPS_5	94	47.748103	-122.438174
6	Central Puget Sound	rejected	no	within 500 meters of industrial outfall			47.663500	-122.499534
7	Central Puget Sound	accepted	contingency	moved east to < 200 m depth	CPS_7_C	180	47.548048	-122.422688
8	Central Puget Sound	accepted	contingency	meets all	CPS_8_C	34	47.591691	-122.590295
9	Central Puget Sound	accepted	contingency	meets all	CPS_9_C	113	47.572799	-122.434395
10	Central Puget Sound	accepted	contingency	moved east to < 200 m depth	CPS_10_C	171	47.580355	-122.432650
11	Central Puget Sound	accepted	no	moved west to < 200 m depth			47.532913	-122.447391
12	Central Puget Sound	accepted	no	meets all			47.675238	-122.586417
13	Central Puget Sound	rejected	no	moved east but now within urban bay			47.624741	-122.436032
14	Central Puget Sound	rejected	no	within 500 meters of King County CSO			47.539339	-122.404168
15	Central Puget Sound	accepted	no	meets all			47.520615	-122.487416
16	Central Puget Sound	accepted	no	moved west to < 200 m depth			47.663619	-122.490690
17	Central Puget Sound	accepted	no	moved east to > 11 m depth			47.579737	-122.545041
18	Central Puget Sound	accepted	cont-fine	meets all	CPS_18_C_GS	171	47.698344	-122.486853
19	Central Puget Sound	accepted	no	meets all			47.545452	-122.538658
0	Dabob Bay	accepted	yes	meets all	R_DAB_0	30	47.740752	-122.863135
1	Dabob Bay	accepted	yes	meets all	R_DAB_1	116	47.769133	-122.851855
2	Dabob Bay	accepted	yes	meets all	R_DAB_2	122	47.681601	-122.874953
3	Dabob Bay	accepted	yes	moved east to > 11 m depth	R_DAB_3	15	47.713740	-122.883457
4	Dabob Bay	accepted	contingency	meets all	R_DAB_4_C	40	47.729425	-122.871281
5	Dabob Bay	accepted	yes	meets all	R_DAB_5	98	47.680358	-122.834842
6	Dabob Bay	rejected	no	within 250 m of an EIM hit			47.786024	-122.864303
7	Dabob Bay	accepted	contingency	meets all	R_DAB_7_C	94	47.724925	-122.861720
0	Holmes Harbor	accepted	yes	meets all	R_HOL_0	11	48.055562	-122.544993
1	Holmes Harbor	accepted	yes	meets all	R_HOL_1	15	48.023633	-122.520458
2	Holmes Harbor	accepted	contingency	moved east to > 11 m depth	R_HOL_2_C	11	48.039516	-122.535434
3	Holmes Harbor	accepted	yes	meets all	R_HOL_3	27	48.110552	-122.553370
4	Holmes Harbor	accepted	yes	meets all	R_HOL_4	52	48.078638	-122.532449
5	Holmes Harbor	accepted	contingency	meets all	R_HOL_5_C	52	48.066487	-122.533583
6	Holmes Harbor	accepted	contingency	meets all	R_HOL_6_C	64	48.097494	-122.559938
7	Holmes Harbor	accepted	yes	meets all	R_HOL_7	30	48.043833	-122.516294

ID	AREA NAME	STATUS	SAMPLE?	COMMENTS	SAMPLE ID	DEPTH (m)	LATITUDE	LONGITUDE
0	Hood Canal	accepted	yes	meets all	HC_0	158	47.559638	-122.997660
1	Hood Canal	accepted	yes	meets all	HC_1	52	47.817637	-122.674166
2	Hood Canal	accepted	yes	meets all	HC_2	21	47.395863	-122.950929
3	Hood Canal	accepted	yes	meets all	HC_3	94	47.756145	-122.739541
4	Hood Canal	rejected	no	moved east but now within 2500 m of ID = 0			47.548331	-123.023939
5	Hood Canal	rejected	no	too close to Hood Canal Bridge			47.847211	-122.642034
6	Hood Canal	accepted	yes	meets all	HC_6	79	47.660054	-122.830690
7	Hood Canal	accepted	contingency	meets all	HC_7_C	143	47.549012	-123.002194
8	Hood Canal	accepted	contingency	meets all	HC_8_C	113	47.470629	-123.065274
9	Hood Canal	accepted	cont-coarse	meets all	HC_9_C_GS	165	47.527951	-123.029273
10	Hood Canal	accepted	cont-fine	meets all	HC_10_C_GS	119	47.670896	-122.856849
11	Hood Canal	accepted	contingency	meets all	HC_11_C	110	47.456785	-123.077453
12	Hood Canal	accepted	no	moved east to > 11 m depth			47.715238	-122.779759
13	Hood Canal	accepted	no	moved east to > 11 m depth			47.617393	-122.968718
14	Hood Canal	rejected	no	Port Ludlow, marina, wood waste			47.923611	-122.677740
15	Hood Canal	accepted	no	meets all			47.359716	-123.018251
16	Hood Canal	accepted	no	moved west to > 11 m depth			47.590000	-122.941443
17	Hood Canal	accepted	no	meets all			47.638646	-122.886663
18	Hood Canal	rejected	no	within 500 meters of industrial outfall			47.357916	-123.068775
19	Hood Canal	accepted	no	meets all			47.653145	-122.863036
0	North Central Puget Sound	accepted	yes	moved west to < 200 m depth	NCPS_0	177	47.784440	-122.453153
1	North Central Puget Sound	accepted	yes	meets all	NCPS_1	11	47.807343	-122.476675
2	North Central Puget Sound	accepted	yes	meets all	NCPS_2	125	47.886134	-122.382194
3	North Central Puget Sound	accepted	yes	moved west to < 200 m depth	NCPS_3	177	47.843304	-122.474905
4	North Central Puget Sound	accepted	yes	meets all	NCPS_4	155	47.870643	-122.458771
5	North Central Puget Sound	accepted	contingency	meets all	NCPS_5_C	122	47.850815	-122.488448
6	North Central Puget Sound	accepted	contingency	meets all	NCPS_6_C	11	47.829089	-122.371447
7	North Central Puget Sound	accepted	contingency	meets all	NCPS_7_C	52	47.826947	-122.384955
8	North Central Puget Sound	accepted	cont-coarse	moved east to > 11 m depth	NCPS_8_C_GS	11	47.868874	-122.510327
9	North Central Puget Sound	accepted	contingency	meets all	NCPS_9_C	168	47.845526	-122.412361
10	North Central Puget Sound	accepted	no	moved east to < 200 m depth			47.798709	-122.411629
11	North Central Puget Sound	accepted	no	meets all			47.890806	-122.408019
12	North Central Puget Sound	accepted	no	meets all			47.811589	-122.396578
13	North Central Puget Sound	accepted	no	meets all			47.830722	-122.402721

ID	AREA NAME	STATUS	SAMPLE?	COMMENTS	SAMPLE ID	DEPTH (m)	LATITUDE	LONGITUDE
14	North Central Puget Sound	accepted	no	meets all			47.862499	-122.443855
15	North Central Puget Sound	accepted	no	moved west to < 200 m depth			47.761884	-122.448894
16	North Central Puget Sound	accepted	no	moved east to > 11 m depth			47.899662	-122.380612
17	North Central Puget Sound	accepted	no	moved west to > 11 m depth			47.904343	-122.414296
18	North Central Puget Sound	accepted	no	moved west to > 11 m depth			47.752164	-122.385317
19	North Central Puget Sound	accepted	no	moved east to > 11 m depth			47.802614	-122.481826
0	Port Susan/Possession Sound	rejected	no	shallow elevation - cannot be moved			48.222533	-122.438960
1	Port Susan/Possession Sound	accepted	yes	meets all	PSPS_1	119	48.086850	-122.349191
2	Port Susan/Possession Sound	accepted	yes	meets all	PSPS_2	88	48.040256	-122.296362
3	Port Susan/Possession Sound	accepted	yes	meets all	PSPS_3	110	48.140775	-122.410020
4	Port Susan/Possession Sound	rejected	no	within 2500 meters of sample 3			48.136488	-122.382165
5	Port Susan/Possession Sound	rejected	no	shallow elevation - cannot be moved			48.209306	-122.442171
6	Port Susan/Possession Sound	rejected	no	shallow elevation - cannot be moved			48.234004	-122.369342
7	Port Susan/Possession Sound	rejected	no	Mukilteo			47.939926	-122.310970
8	Port Susan/Possession Sound	accepted	yes	moved west to > 11 m depth	PSPS_8	15	47.902704	-122.329394
9	Port Susan/Possession Sound	accepted	yes	meets all	PSPS_9	119	48.125836	-122.384334
10	Port Susan/Possession Sound	accepted	contingency	meets all	PSPS_10_C	165	47.986540	-122.338158
11	Port Susan/Possession Sound	accepted	contingency	meets all	PSPS_11_C	140	47.982623	-122.303402
12	Port Susan/Possession Sound	accepted	contingency	meets all	PSPS_12_C	101	48.035960	-122.307563
13	Port Susan/Possession Sound	accepted	contingency	meets all	PSPS_13_C	119	48.122467	-122.379460
14	Port Susan/Possession Sound	accepted	no	meets all			48.170421	-122.467291
15	Port Susan/Possession Sound	accepted	no	meets all			48.081888	-122.335006
16	Port Susan/Possession Sound	rejected	no	shallow elevation - cannot be moved			48.195822	-122.388079
17	Port Susan/Possession Sound	accepted	no	meets all			47.925663	-122.334314
18	Port Susan/Possession Sound	accepted	cont-coarse	moved east to > 11 m depth	PSPS_18_C_GS	11	48.150435	-122.456142
19	Port Susan/Possession Sound	accepted	no	meets all			48.052627	-122.347660
0	Samish Bay	accepted	yes	moved west to > 11 m depth	R_SAM_0	11	48.600899	-122.497630
1	Samish Bay	accepted	yes	moved west to > 11 m depth	R_SAM_1	11	48.627423	-122.492978
2	Samish Bay	accepted	contingency	moved west to > 11 m depth	R_SAM_2_C	11	48.604998	-122.492693
3	Samish Bay	accepted	yes	meets all	R_SAM_3	18	48.613228	-122.531947
4	Samish Bay	accepted	yes	meets all	R_SAM_4	15	48.620263	-122.519330
5	Samish Bay	accepted	yes	moved west to > 11 m depth	R_SAM_5	11	48.613246	-122.493851
6	Samish Bay	accepted	contingency	meets all	R_SAM_6_C	11	48.618640	-122.493980
7	Samish Bay	rejected	no	shallow water - cannot be moved			48.575470	-122.442946

ID	AREA NAME	STATUS	SAMPLE?	COMMENTS	SAMPLE ID	DEPTH (m)	LATITUDE	LONGITUDE
0	San Juan Islands	accepted	yes	meets all	SJI_0	24	48.599295	-122.585156
1	San Juan Islands	accepted	yes	meets all	SJI_1	55	48.812616	-122.776990
2	San Juan Islands	rejected	no	near refinery			48.502723	-122.705486
3	San Juan Islands	accepted	yes	meets all	SJI_3	152	48.866061	-122.940864
4	San Juan Islands	accepted	yes	meets all	SJI_4	34	48.388244	-122.736483
5	San Juan Islands	rejected	no	within 2500 meters of sample 4			48.381760	-122.749506
6	San Juan Islands	accepted	yes	meets all	SJI_6	110	48.760060	-122.970321
7	San Juan Islands	accepted	contingency	meets all	SJI_7_C	146	48.895844	-123.049165
8	San Juan Islands	accepted	contingency	meets all	SJI_8_C	177	48.799432	-122.893780
9	San Juan Islands	accepted	contingency	meets all	SJI_9_C	122	48.747298	-122.871798
10	San Juan Islands	accepted	contingency	moved east to < 200 m depth	SJI_10_C	165	48.614209	-123.198400
11	San Juan Islands	accepted	cont-fine	meets all	SJI_11_C_GS	40	48.592258	-122.945322
12	San Juan Islands	accepted	no	moved west to > 11 m depth			48.898215	-122.791047
13	San Juan Islands	accepted	no	moved east to < 200 m depth			48.480654	-123.090211
14	San Juan Islands	accepted	no	moved east to > 11 m depth			48.665649	-123.164782
15	San Juan Islands	accepted	no	meets all			48.534487	-122.732483
16	San Juan Islands	accepted	no	meets all			48.581321	-122.747634
17	San Juan Islands	accepted	no	meets all			48.421602	-122.981393
18	San Juan Islands	accepted	no	moved east to < 200 m depth			48.844995	-122.912477
19	San Juan Islands	accepted	no	moved east to < 200 m depth			48.576756	-123.192159
0	Saratoga Passage and Skagit Bay	accepted	yes	meets all	SPSB_0	116	48.088416	-122.433149
1	Saratoga Passage and Skagit Bay	accepted	yes	meets all	SPSB_1	79	48.195613	-122.563329
2	Saratoga Passage and Skagit Bay	accepted	yes	meets all	SPSB_2	88	48.133111	-122.527406
3	Saratoga Passage and Skagit Bay	accepted	yes	moved west to > 11 m depth	SPSB_3	15	48.383986	-122.573772
4	Saratoga Passage and Skagit Bay	rejected	no	within 500 meters of N.A.S. Whidbey Is Superfund site			48.280223	-122.616252
5	Saratoga Passage and Skagit Bay	rejected	no	within 2500 meters of ID = 0			48.090262	-122.446902
6	Saratoga Passage and Skagit Bay	accepted	yes	moved east to > 11 m depth	SPSB_6	11	48.360947	-122.559682
7	Saratoga Passage and Skagit Bay	accepted	cont-coarse	moved east to > 11 m depth	SPSB_7_C_GS	11	48.349920	-122.554089
8	Saratoga Passage and Skagit Bay	accepted	contingency	moved west to > 11 m depth	SPSB_8_C	24	48.301405	-122.488223
9	Saratoga Passage and Skagit Bay	accepted	contingency	meets all	SPSB_9_C	24	48.262497	-122.600549

ID	AREA NAME	STATUS	SAMPLE?	COMMENTS	SAMPLE ID	DEPTH (m)	LATITUDE	LONGITUDE
10	Saratoga Passage and Skagit Bay	accepted	contingency	moved west to > 11 m depth	SPSB_10_C	24	48.346449	-122.543734
11	Saratoga Passage and Skagit Bay	accepted	contingency	meets all	SPSB_11_C	27	48.255486	-122.600853
12	Saratoga Passage and Skagit Bay	accepted	no	meets all			48.112042	-122.540094
13	Saratoga Passage and Skagit Bay	accepted	no	meets all			48.065863	-122.408051
14	Saratoga Passage and Skagit Bay	accepted	no	moved west to > 11 m depth			48.412796	-122.660338
15	Saratoga Passage and Skagit Bay	accepted	no	moved west to > 11 m depth			48.369115	-122.560923
16	Saratoga Passage and Skagit Bay	accepted	no	moved west to > 11 m depth			48.275351	-122.504143
17	Saratoga Passage and Skagit Bay	accepted	no	moved west to > 11 m depth			48.269188	-122.507284
18	Saratoga Passage and Skagit Bay	accepted	no	meets all			48.403496	-122.593247
19	Saratoga Passage and Skagit Bay	accepted	no	meets all			48.274379	-122.509855
0	South Central Puget Sound	rejected	no	within 2500 meters of Central Puget Sound ID = 4			47.512476	-122.483853
1	South Central Puget Sound	accepted	yes	meets all	SCPS_1	177	47.501406	-122.431181
2	South Central Puget Sound	accepted	yes	meets all	SCPS_2	104	47.497574	-122.490001
3	South Central Puget Sound	accepted	yes	moved east to > 11 m depth	SCPS_3	15	47.381893	-122.390316
4	South Central Puget Sound	accepted	yes	meets all	SCPS_4	34	47.354724	-122.550134
5	South Central Puget Sound	accepted	yes	moved east to < 200 m depth	SCPS_5	180	47.482868	-122.377790
6	South Central Puget Sound	accepted	contingency	moved east to > 11 m depth	SCPS_6_C	11	47.404266	-122.422097
7	South Central Puget Sound	accepted	cont-fine	meets all	SCPS_7_C_GS	180	47.430825	-122.363980
8	South Central Puget Sound	rejected	no	too close to CB NS/Tideflats Superfund			47.313814	-122.493334
9	South Central Puget Sound	rejected	no	within 500 meters of industrial outfall			47.452911	-122.436710
10	South Central Puget Sound	accepted	contingency	meets all	SCPS_10_C	113	47.349586	-122.354801
11	South Central Puget Sound	rejected	no	within 500 m of haz waste gen/CU site, Quartermaster Harbor			47.371318	-122.466831
12	South Central Puget Sound	accepted	contingency	meets all	SCPS_12_C	149	47.380417	-122.340269
13	South Central Puget Sound	accepted	contingency	moved east to < 200 m depth	SCPS_13_C	177	47.413152	-122.354191
14	South Central Puget Sound	accepted	no	meets all			47.362140	-122.540292
15	South Central Puget Sound	accepted	no	meets all			47.357457	-122.408973
16	South Central Puget Sound	rejected	no	within 500 m of CB NS/Tideflats Superfund			47.318538	-122.509568
17	South Central Puget Sound	rejected	no	near CU site Quartermaster Harbor & 303d listed			47.382924	-122.454352

ID	AREA NAME	STATUS	SAMPLE?	COMMENTS	SAMPLE ID	DEPTH (m)	LATITUDE	LONGITUDE
18	South Central Puget Sound	accepted	no	moved east to < 200 m depth			47.516511	-122.405997
19	South Central Puget Sound	accepted	no	moved west to < 200 m depth			47.388336	-122.365915
0	South Sound	accepted	yes	moved west to > 11 m depth	SS_0	11	47.183985	-122.885831
1	South Sound	accepted	yes	meets all	SS_1	34	47.120918	-122.735566
2	South Sound	accepted	yes	meets all	SS_2	73	47.144589	-122.743990
3	South Sound	rejected	no	shallow elevation - cannot be moved			47.136121	-122.841601
4	South Sound	rejected	no	sample collection logistics - too swift			47.253016	-122.573009
5	South Sound	rejected	no	within 2500 meters of ID 1 and ID 2			47.129617	-122.759239
6	South Sound	accepted	yes	meets all	SS_6	70	47.219255	-122.588781
7	South Sound	accepted	yes	meets all	SS_7	49	47.195448	-122.722988
8	South Sound	accepted	contingency	meets all	SS_8_C	119	47.135336	-122.666505
9	South Sound	accepted	contingency	meets all	SS_9_C	43	47.284715	-122.830372
10	South Sound	accepted	cont-fine	meets all	SS_10_C_GS	27	47.314601	-122.817023
11	South Sound	accepted	contingency	meets all	SS_11_C	76	47.225275	-122.583501
12	South Sound	rejected	no	shallow elevation - cannot be moved			47.121301	-123.013119
13	South Sound	accepted	contingency	meets all	SS_13_C	64	47.154437	-122.751763
14	South Sound	rejected	no	shallow elevation - cannot be moved			47.377100	-122.824029
15	South Sound	accepted	no	meets all			47.347324	-122.818227
16	South Sound	accepted	no	meets all			47.128219	-122.757471
17	South Sound	accepted	no	meets all			47.169549	-122.753729
18	South Sound	accepted	no	meets all			47.302744	-122.805729
19	South Sound	accepted	no	moved east to > 11 m depth			47.144975	-122.785852
0	Strait of Juan de Fuca	accepted	yes	meets all	SJF_0	134	48.208629	-123.468376
1	Strait of Juan de Fuca	accepted	yes	meets all	SJF_1	67	48.202536	-122.841072
2	Strait of Juan de Fuca	accepted	yes	meets all	SJF_2	158	48.256914	-123.103888
3	Strait of Juan de Fuca	accepted	yes	meets all	SJF_3	125	48.197449	-123.379288
4	Strait of Juan de Fuca	rejected	no	too close to international boundary			48.262383	-123.872780
5	Strait of Juan de Fuca	rejected	no	near Rayonier			48.139919	-123.312744
6	Strait of Juan de Fuca	accepted	yes	meets all	SJF_6	85	48.215930	-123.091114
7	Strait of Juan de Fuca	rejected	no	near Rayonier			48.150315	-123.269537
8	Strait of Juan de Fuca	accepted	contingency	meets all	SJF_8_C	122	48.214024	-123.330270
9	Strait of Juan de Fuca	accepted	contingency	meets all	SJF_9_C	140	48.276670	-123.027870
10	Strait of Juan de Fuca	accepted	contingency	meets all	SJF_10_C	149	48.373441	-122.986706
11	Strait of Juan de Fuca	accepted	contingency	meets all	SJF_11_C	73	48.195738	-123.302630

ID	AREA NAME	STATUS	SAMPLE?	COMMENTS	SAMPLE ID	DEPTH (m)	LATITUDE	LONGITUDE
12	Strait of Juan de Fuca	accepted	cont-fine	meets all	SJF_12_C_GS	49	48.046926	-122.857203
13	Strait of Juan de Fuca	accepted	no	meets all			48.242093	-123.050897
14	Strait of Juan de Fuca	accepted	no	meets all			48.184364	-123.970641
15	Strait of Juan de Fuca	accepted	no	meets all			48.329407	-122.886090
16	Strait of Juan de Fuca	accepted	no	meets all			48.223472	-123.463522
17	Strait of Juan de Fuca	accepted	no	meets all			48.255686	-123.032020
18	Strait of Juan de Fuca	accepted	no	meets all			48.261091	-123.258570
19	Strait of Juan de Fuca	accepted	no	meets all			48.320384	-123.202481

APPENDIX B

CALUX CELL-BASED ASSAY PROTOCOL

The Chemical Activated LUciferase Gene Expression (CALUX) assay has been accepted by EPA as SW-846 method 4435. This recombinant cell bioassay system for the detection and relative quantification of dioxin-like chemicals was developed by Dr. George C. Clark of Xenobiotic Detection Systems (XDS) and Dr. Michael Denison at the University of California Davis, and is marketed by Xenobiotic Detection Systems (1601 East Geer Street, Suite S, Durham NC, 27704 USA). The XDS-CALUX method includes a proprietary method of separating PCBs and dioxin-like compounds to generate separate PCB-TEQs and dioxin-TEQs for samples. DR-CALUX is now offered by BioDetection Systems (Kruislaan 406, 1098 SM, Amsterdam, The Netherlands), but does not include the capability of separating PCB and dioxins.

The file "US EPA dioxin method 4435.pdf" provides the EPA 4435 documentation that overviews the method, and is available along with this document at http://www.nws.usace.army.mil/PublicMenu/Menu.cfm?sitename=DMMO&pagename=Dioxin_Work_Group.

APPENDIX C

HYBRIZYME qt-PCR ASSAY PROTOCOL

The Aryl Hydrocarbon-Receptor PCR Assay (Procept® Rapid Dioxin Assay) has recently been accepted by EPA as SW-846 method 4430. Originally developed by Hybrizyme Corporation (Suite G-70 2801 Blue Ridge Road Raleigh, NC 27607), it is being marketed through Eichrom Technologies, Inc (8205 S. Cass Ave Suite 106 Darien, IL 60561). Currently, the only commercial laboratory performing the assay is APPL, Inc. (4203 W. Swift Ave, Fresno, CA 93722). This assay is participating in a series of Superfund Innovative Technology Evaluation studies, details of which can be found at the following websites:
http://www.epa.gov/ORD/SITE/reports/540r05005/540r05005.pdf
http://www.epa.gov/esd/cmb/pdf/eichrom-web508.pdf

The EPA 4430 documentation that overviews the method can be found in the file "US EPA Method 4430.pdf", and the detailed methodology provided by Eichrom can be found in the file "DFS01-11_dioxin_soil_method.pdf", both available for download along with this document at
http://www.nws.usace.army.mil/PublicMenu/Menu.cfm?sitename=DMMO&pagename=Dioxin_Work_Group.