A STUDY OF FATE AND BEHAVIOR OF DILUTED BITUMEN OILS ON MARINE WATERS

Dilbit Experiments – Gainford, Alberta

Abstract

This document is a final report for a series of physical and chemical tests that were conducted on the fate and behavior of diluted bitumen oils at a test facility in Gainford, Alberta. Additionally, as part of this study, a series of tests were conducted to determine the efficiency of various types of oil spill response equipment under similar conditions.

Witt O'Brien's, Polaris Applied Sciences, and
Western Canada Marine Response Corporation

About Witt O'Brien's

Witt O'Brien's is a global leader in preparedness, crisis management, and disaster response and recovery with the depth of experience and capability to provide services across the crisis and disaster life cycle. Witt O'Brien's is uniquely positioned to bring together policy architects and technical experts in public safety with leaders from all levels of government and private sector partners to forge solutions to emergency management challenges.

Witt O'Brien's brings a new approach to the crisis and disaster industry by combining extensive real world experience with innovative planning, training, exercise, and technology solutions.

About Polaris Applied Sciences

Polaris Applied Sciences has been involved with oil spill response and related research for more than 30 years. They have provided assessments, made recommendations, and have assisted with the implementation of marine and onshore spill response programs worldwide for major industry response capabilities as well as national response programs. Their key industry clients have included BP, Chevron, Conoco-Philips, ExxonMobil, Pemex, Qatar Petroleum, Shell, and Total. In addition they have completed many projects for the P&I Clubs, as well as for the International Maritime Organization (IMO), the World Bank, the International Monetary Fund (IMF), and the European Bank for Reconstruction and Development (EBRD). The Polaris team provides companies worldwide with scientific support to spill response, natural resource damage assessment (NRDA) and resource reinstatement, environmental restoration services, and spill planning and training.

About Western Canada Marine Response Corporation

As a Transport Canada certified response organization, Western Canada Marine Response Corporation's mandate is to ensure there is a state of preparedness in place and to mitigate the impact when an oil spill occurs. This includes the protection of wildlife, economic and environmental sensitivities, and the safety of both the responders and the public.

Western Canada Marine Response Corporation's customer base (2,000+ members) includes oil handling facilities, barging companies, freighters visiting our ports, ferries, cruise ships, US-bound vessels traveling through Western Canada waters, and others including, but not limited to, forest industry facilities, fish camps, and float plane companies.

Disclaimer

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Acronyms and Abbreviations

Acronym	Meaning
a.k.a.	also known as
ANS	Alaska North Slope (crude)
API	American Petroleum Institute (standards, protocols)
ASTM	American Society for Testing and Materials (standards)
AWB	Access Western Blend
bbl/hr	barrels per hour (recovery rate)
BTEX	benzene, toluene, ethylbenzene, xylene
^oC	degrees Celsius
C1-C7	HC molecules containing between 1 to 7 carbons
C1-C29	HC molecules containing between 1 to 29 carbons
CLB	Cold Lake Blend
CLWB	Cold Lake Winter Blend
cm	centimeters
cSt	centistokes
D	day(s)
dilbit	diluted bitumen
dyn/cm	dyne per centimeter
EBRD	European Bank for Reconstruction and Development
EPA	US Environmental Protection Agency (& their test protocols)
^oF	degrees Fahrenheit
FAQs	Frequently Asked Questions
FERC	Federal Energy Regulatory Commission
g	grams
GC/MS	gas chromatography / mass spectrometry (combo test)
HC	hydrocarbon(s)
hr(s)	hour(s)
I.D.	identification (number)
IMF	International Monetary Fund
IMO	International Maritime Organization
in	inches
ISB	in-situ burning
kg/m^3	kilogram per meter cubed
KMC	Kinder Morgan Canada, Inc.
L	liters
LEL	lower explosive limit
m	meters
m^3/hr	meters cubed per hour (recovery rate)
mL	milliliter
mm	millimeters
MPa	megapascal
mph	miles per hour
m/s	meters per second
n/a	not applicable
NRDA	natural resource damage assessment
OSR	oil spill response
PAH	poly aromatic hydrocarbon
ppm	parts per million

Acronym	Meaning
ppt	parts per thousand
psi	pounds per square inch
SCAT	Shoreline Cleanup Assessment Technique
SOCSEX	subsurface oil in coarse sediments experiment(s)
SOP	standard operating procedure
SVOCs	semi-volatile organic compounds
synbit	synthetic (crude) bitumen
syncrude	synthetic crude oil
TMPL	Trans Mountain Pipeline ULC
TMX	Trans Mountain Pipeline Expansion Project
tPAH	total poly aromatic hydrocarbons
TPH	total petroleum hydrocarbons
µg/L	micrograms per liter
USG	US gallons (versus gallons – UK)
UV	ultraviolet (light/radiation)
WEC	World Energy Council
WCMRC	Western Canada Marine Response Corporation

Table of Contents

1 Executive Summary

In June 2012, Trans Mountain Pipeline ULC (TMPL) asked O'Brien's Response Management (now Witt O'Brien's) to organize a study on diluted bitumen (dilbit) products that are being transported out of the oil fields of Northern Alberta to support a pending application for their system expansion (Trans Mountain Pipeline Expansion Project: TMX). The purpose of the requested study was to further the knowledge of dilbit in general and, more specifically, to investigate the behavior of dilbit when spilled into a marine environment. Some of the basic questions to be answered were:

Will diluted bitumens sink or float in marine waters?

Will diluted bitumens behave any differently than other heavy crude oils as they weather?

Is the performance of the equipment currently stockpiled by North American oil spill recovery organizations adequate to mechanically remove diluted bitumens off the surface of the water?

The study's multi-disciplinary Project Team consisted of Witt O'Brien's (acting in a management role); Polaris Applied Sciences (undertaking the project science); and Western Canada Marine Response Corporation (supporting the equipment test). This team was tasked with designing and executing a controlled test to evaluate the fate and behavior of dilbit discharged into a simulated marine environment similar to that of Burrard Inlet (Vancouver, BC, Canada) where the Westridge Terminal is located.

The resulting study consisted of the following steps:

1. Literature Review;
2. Gap Analysis and Research Plan Development;
3. Execution of Test and Experiments to Support the Research;
4. Final Reporting

The literature review was conducted in the fall of 2012. World-wide, dilbit have occupied a small share of the commercial energy market with few instances of their involvement in significant spill events. As a result, limited empirical observations have been recorded about how these products reacted when spilled into the environment. The literature review was forced to rely largely on available information on other heavy crude oils.

Following the literature review, data gaps were identified and a research plan was developed. Research was conducted from May 13 through May 26 in Gainford, Alberta, and consisted of three main focus areas:

- Scientific sampling of oil and its impact on water quality as the dilbit oils weathered under varied physical conditions;
- The testing of mechanical equipment to recover these products weathering on the surface of the water over a 10-day period;
- Testing the efficacy of non-mechanical countermeasures, such as in-situ burning, chemical dispersants, and shoreline cleaning agents.

To execute the scientific portion of the study, the team employed a series of dedicated tanks where they could observe the 10 day behavior of two types of dilbit on brackish water: Cold Lake Blend (CLB) and Access Western Blend (AWB). Wind and wave generating devices were used to simulate environmental conditions for the study. Neither of the two weathered dilbits sank under the conditions tested. In the end, the behavior of both products proved to be no different than what might be expected of so-called conventional heavy crude oils when exposed to similar conditions.

For the equipment portion of the study, the operational team employed only CLB dilbit carefully discharged into a series of large rectangular tanks. The tanks were staged outdoors where they would be subject to ambient atmospheric conditions. Each recovery device was uniformly tested and analyzed for both its ability to recover spilled oil and the efficiency with which that task was accomplished. All skimming devices were able to recover the spilled dilbits at all stages of the 10-day weathering cycle.

Three non-mechanical countermeasures were investigated for their ability to mitigate spilled CLB dilbit under specific conditions. In-situ burning was found to be effective on oil that had only weathered for 24 hours or less. Chemical dispersants were marginally effective for up to a 6 hour weathering window. Corexit 9580, a shoreline cleaning agent, proved effective up to a 4 day weathering cycle.

2 Introduction

Although several detailed studies have been completed that characterize the fate and behavior of heavy crude oils made from Alberta oil sands, most are laboratory and bench-scale tests. Kinder Morgan Canada, Inc. (KMC) undertook an initiative to expand upon this knowledge through larger, meso-scale tests of diluted Alberta oil sands bitumen (dilbit) crude oil. Larger tank tests allow for simulated wave and current conditions that may be more typical of the marine setting of Burrard Inlet, the export point for dilbit from the Trans Mountain Pipeline (TMPL) (Figures 2-1 and 2-2).

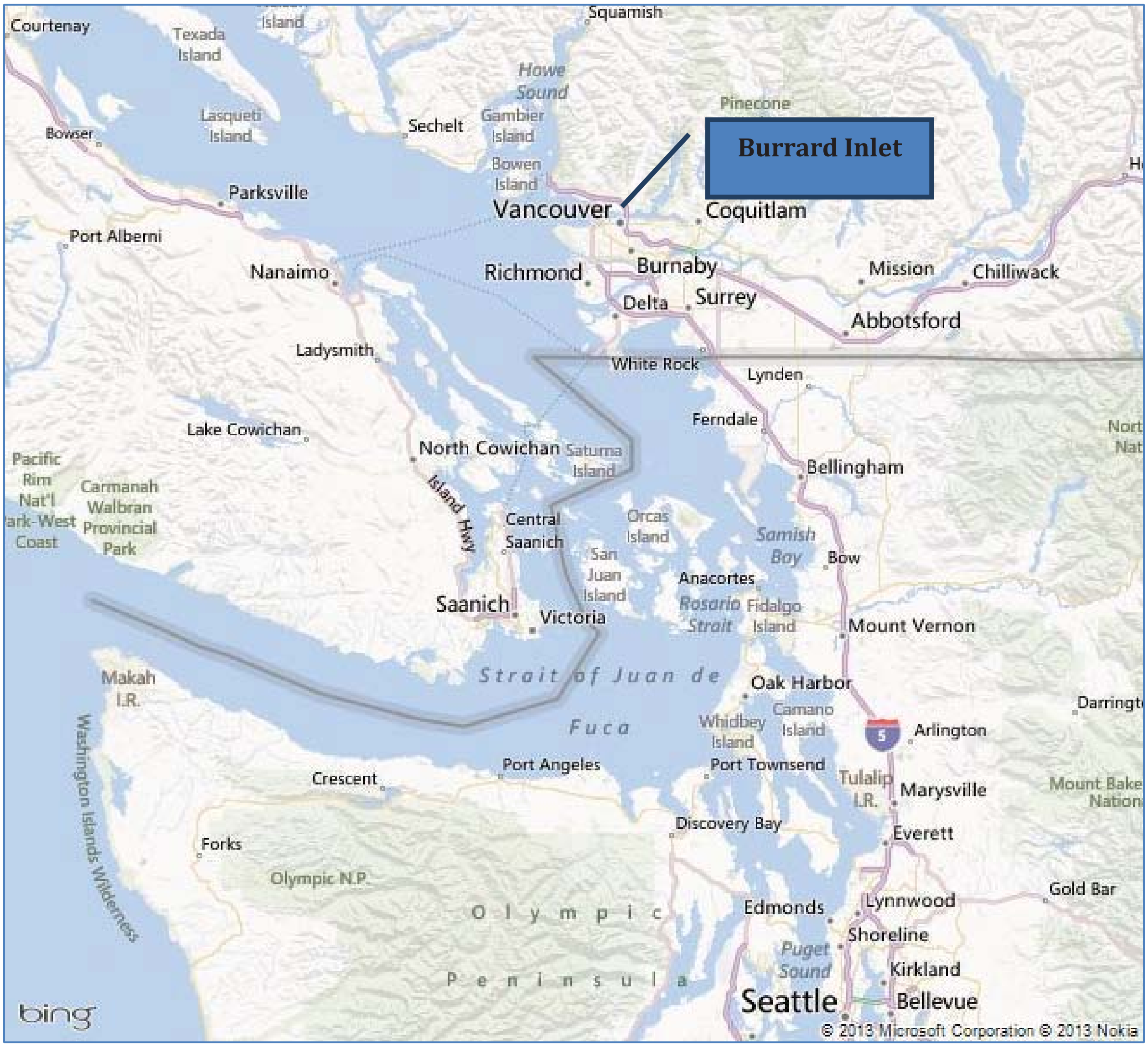


Figure 2-1: Overview of the Oil Export Area

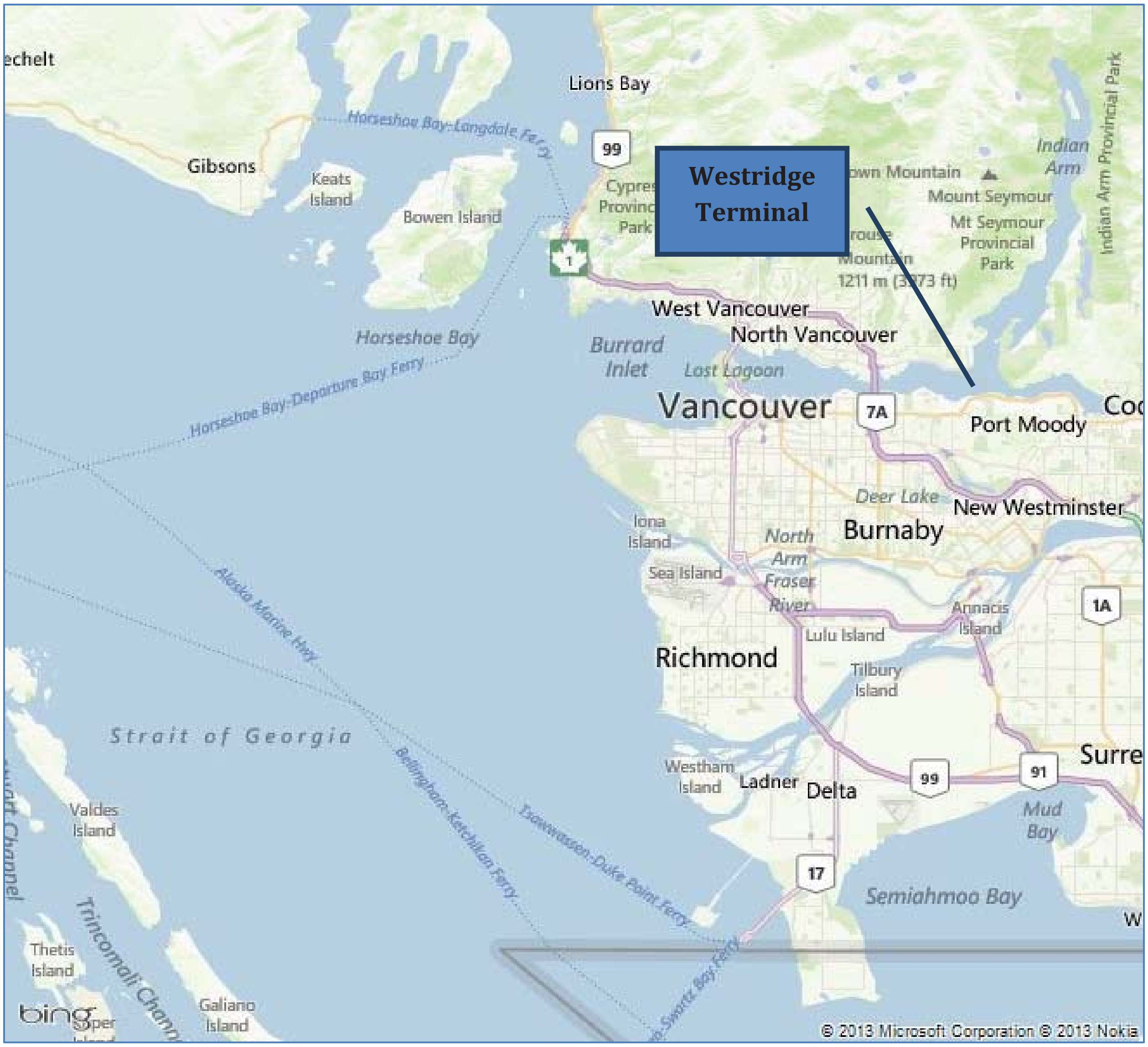


Figure 2-2: Detailed View of the Oil Export Area near Vancouver

2.1 Background

The crude bitumen contained in the Canadian oil sands can be described as a naturally occurring petroleum that exists in the semi-solid or solid phase in natural deposits. The extracted bitumen is extremely viscous, and it will not flow unless heated or diluted with lighter hydrocarbons (HC). At room temperature, it is much like cold molasses. The World Energy Council (WEC) defines natural bitumen as "oil having a viscosity greater than 10,000 centipoise under reservoir conditions and an American Petroleum Institute (API) gravity of less than 10° API." In order to transport it through pipelines, a diluent is added to the bitumen. The diluent used could be lighter crude oils, synthetic crude oils, or natural gas condensates. Diluted bitumen (diluted with naphtha to make it flow in pipelines) is known as dilbit in the Canadian petroleum industry, while bitumen upgraded to synthetic crude oil is known as syncrude, and syncrude blended with bitumen as synbit. Putting the bitumen in solution with the diluent produces a homogeneous blend that has considerably lower density and viscosity with good pumping and flow properties. The product has to meet quality specifications that are posted with the National Energy Board in Canada and the Federal Energy Regulatory Commission (FERC) in the US.

The oil properties and behavior of dilbit are of interest to spill modelers, transportation and handling operators, environmental scientists, and spill responders as proposed pipeline expansion programs are underway for delivery of diluted Alberta oil sands crude oils to export destinations. Although dilbits have been transported via pipeline for the past 30 years and their general properties are akin to other heavy oils, the specific characteristics and behaviors of these oils as they weather have been the subject of a limited number of published studies. As a precursor to this study, the Project Team undertook a literature search and review that focused on the behavior of, and response to, spilled dilbits. Although there are numerous reports and studies that have been conducted on heavy oils (crudes and refined), the literature review resulted in only six reported studies focused specifically on dilbits in available on-line searches. Two documented spills of dilbit into an aquatic setting are the 2010 Marshall Spill (Kalamazoo, MI) from the Enbridge Pipeline (NTSB 2012; see also Enbridge Line 6B Response) and the 2007 Burnaby Spill (Burrard Inlet) from an excavator puncture of the TMPL. The Marshall Spill involved both Cold Lake and MacKay River dilbits on land and into a freshwater setting whereas the Burrard Inlet incident was an Albian Heavy blend that reached the estuarine waters and shoreline near the TMPL Westridge Terminal (Stantec, 2012; also see TMPL Westridge 2007 Spill).

Tests conducted by Brown et al. (1992) documented the evaporative loss of CLB from four types of shoreline material, ranging from approximately 1 percent to 9 percent of 24 hour weathered oil. SLRoss (2010) evaluated the physical properties of two dilbit products to generate the necessary parameters for marine oil spill modeling. The products tested were MacKay River Heavy Bitumen diluted with synthetic crude (Suncor Synthetic Light) and CLB bitumen diluted with condensate. The 2010 report notes that test oils were placed in a wind tunnel to generate evaporated oil products under controlled conditions and measure the changes in physical properties. The tests showed that all oils, with the exception of the MacKay River blend, had densities less than one when evaporated. The MacKay River blend densities remained lighter than standard seawater throughout the evaporation tests. Subsequently, SLRoss (2011) undertook a series of meso-scale tests using a circulating loop (flume) to assess the behavior of CLB dilbit under more natural weathering conditions in freshwater where, once again, weathered dilbit continued to float on the freshwater surface in the flume during the full 13 days of testing.

Two workshops specifically focused on dilbits and the current state of knowledge, including implications for spill response, have been held in Canada (Halifax 2011 and Devon 2012). Recommendations made during both workshops included the continued need to expand knowledge of dilbit characterization, behavior when spilled into a number of distinct receiving environments, and spill countermeasures.

2.2 Study Objectives

The overall study goal was to better understand and assess oil behavior, weathering, and oil spill response (OSR) countermeasures for spilled dilbit crude in a controlled simulated condition similar to the potential receiving environment of Burrard Inlet (Figure 2-1 and Figure 2-2). The objectives of the applied research were multifaceted. One objective was to better understand and characterize the changes in physical and chemical properties of dilbit in an estuarine simulated condition over a 10-day period. Another objective of the meso-scale trials was to determine efficiency and effectiveness of dispersant, in-situ burning, and shoreline cleaning agents as potential countermeasures for various stages of weathered oil. The third part of the study was to test various types of oil spill response equipment under similar weathering conditions and to assess their efficiencies over time. Air sampling and monitoring also was included with the objective of providing measured emission rates that could be used to ground-truth numerical estimates modeled for accidental release/hazard assessment (reported separately).

2.3 Burrard Inlet Setting

A brief summary of the range of conditions found in Burrard Inlet is provided in consideration of variables for meso-scale tests, based largely on Thompson (1991).

2.3.1 Oceanography

Most of Burrard Inlet is characterized by an upper surface layer of brackish water subject to runoff and river inputs, predominantly the Fraser River for the outer harbor and the Indian, Seymour, and Capilano rivers for the inner harbor. The surface water layer temperatures are dependent on local weather conditions and precipitation, generally ranging from a mean near 7 ˚Celsius (˚C) in February to approximately 17 ˚C in July. On average, salinities decrease from approximately 20-25 ppt (parts per thousand) at First Narrows to approximately 15 ppt near the south end of Indian Arm.

2.3.2 Weather

Winds typically are east-west, controlled by local topography, with monthly mean wind speeds ranging from 2.5 meters per second (m/s) to 3 m/s for Vancouver Harbor. Average high and low temperatures (Coal Harbor) range from 7 ˚C and 1 ˚C (December) to 23 ˚C and 14 ˚C (July-August) (World Weather Online).

2.3.3 Shoreline Types

Burrard Inlet has a large range of shoreline types. Primary natural shorelines include mud flats, mixed sediment, cobble beaches, boulder beaches, and bedrock. Much of the shoreline is man-made rip-rap. Fine mud occurs in deposition areas such as Port Moody Arm, with coarse cobble and pebble at First and Second Narrows, and on river deltas such as the mouth of the Capilano River (Vancouver Harbor Shoreline Atlas).

2.3.4 Oil Types

A Cold Lake Winter Blend (CLWB) dilbit was selected to provide a "standard" dilbit, with the winter blend representing more diluent initially. The slightly higher diluent is expected to result in higher hydrocarbon flux to atmosphere and to the water column (dissolution of acutely toxic low molecular weight hydrocarbons). More research has been completed with

CLB dilbit than other blends; thus, it was expected that results from these tests would provide a basis for comparison with a broader range of prior research.

Access Western Blend (AWB) was the second oil tested for physical and chemical properties under similar weathering scenarios as the tests on CLWB. AWB is a dilbit from the Athabasca region south of Fort McMurray, Alberta.

Oil sands bitumens are blended with diluents to meet pipeline export specifications. These blends meet specific oil export tariffs and must fall within a defined range of density (not to exceed 940 kg/m^3 and viscosity (not to exceed 350 centistokes (cSt)) at reference temperatures (see range of oil properties for AWB and Cold Lake dilbits in Appendix A, from Crude Oil Monitor). The blend is a single-phase liquid with its own unique properties. Dilbit is not a bitumen in suspension, in emulsion, or a two-phase liquid.

3 Methodology

3.1 Tanks / Facility Description

The CLWB and AWB studies were conducted from May 13 through May 26, 2013 at the TMPL pump station in Gainford, Alberta (Figure 3-1). The Gainford site was divided into several distinct research areas:

- Scientific study for CLWB, located outside the shed (Figure 3-1 and Figure 3-2);
- Scientific study for AWB, located inside the facility's shed;
- Equipment testing for CLWB, located outside and adjacent to the shed (Figure 3-1 and Figure 3-2); and
- In-situ burning test site located in a close but safe distance from the rest of the research areas.

The scientific study tanks were filled with water at a prepared salinity, using SolarSalt, of 20 ppt. Water temperature, pH, and salinity were monitored twice daily in all of the science tanks.

Figure 3-1: Gainford, Alberta (site of study)

3.2 CLWB and AWB Research Tanks

The scientific study area for AWB was located inside an open shed while the CLWB dilbit study area was located outside the shed (Figure 3-2). During the first two days of weathering, all CLWB tanks were directly exposed to wind (carrying visible amounts of dust) and direct sunlight. The night of May 17 (after approximately 48 hours of weathering without cover), these tanks were covered with a tent (Figure 3-3) in preparation for forecasted windy and rainy weather.

Two types of air monitoring were carried out, for occupational safety purposes, during field testing operations:

1. At least one worker wore a four-gas detector in all potentially vaporous areas. Air monitoring for benzene, lower explosive limit (LEL), oxygen, and carbon monoxide was done throughout the test period. These gas detectors were calibrated before the field tests and were bump tested daily.

2. A field safety person carried out benzene levels monitoring whenever testing activities warranted it. For example, benzene levels were monitored during the oil pours, during skimming and pumping activities in the equipment testing area, and during sample collections in the science shed. When levels rose above 0.05 ppm, all personnel in that area donned half-face respirators. *Note: All those personnel were fit-tested before being allowed to wear respirators.*

Benzene levels were within tolerances for half-face (cartridge) respirators and were required for all personnel working with oil inside the shed or working directly with the oil in tanks. The only alarm that activated was when a worker stepped immediately downwind of the exhaust from a skimmer power pack.

Tanks S1 through S3 were used for AWB weathering. The CLWB weathering was conducted in an industrial tank, shown on the left picture in Figure 3-2, divided into three rectangular areas: S9A, S9B, and S9C. Tanks S9A and S9C were rectangular surface tanks (2.97 m^2) inside S9B (18.58 m^2). Tank S4, measuring 1 m by 1 m, was located outside, uncovered, and was used to weather CLWB for countermeasures testing. Table 3-1 summarizes the dimensions of these tanks and includes the volume of spilled oil and estimated initial oil thickness.

Tank I.D.	Tank dimensions (shape)	Water depth	Type of Dilbit	Oil spill quantity (Liters)	Initial Oil Thickness (mm)	Imposed weathering conditions
S1	2.38 m^2 x 2.13 m (Cylinder)	1.9 m	AWB	25	10.68	Static
S2	2.35 m^2 x 2.13 m (Cylinder)	1.9 m	AWB	25	10.80	Mild
S3	2.38 m^2 x 2.13 m (Cylinder)	1.9 m	AWB	25	10.68	Moderate
S4	1.49 m^2 x 1.22 m (Cube)	1 m	CLWB	20	13.46	Mild (outside)
S9A	2.97 m^2 x 1.4 m (Rectangular)	1.2 m	CLWB	30	10.09	Moderate
S9B	55.02 m^2 x 1.4 m (Rectangular)	1.2 m	CLWB	148	11.71	Static
S9C	2.97 m^2 x 1.4 m (Rectangular)	1.2 m	CLWB	30	10.09	Mild

Table 3-1: Tanks and oil characteristics

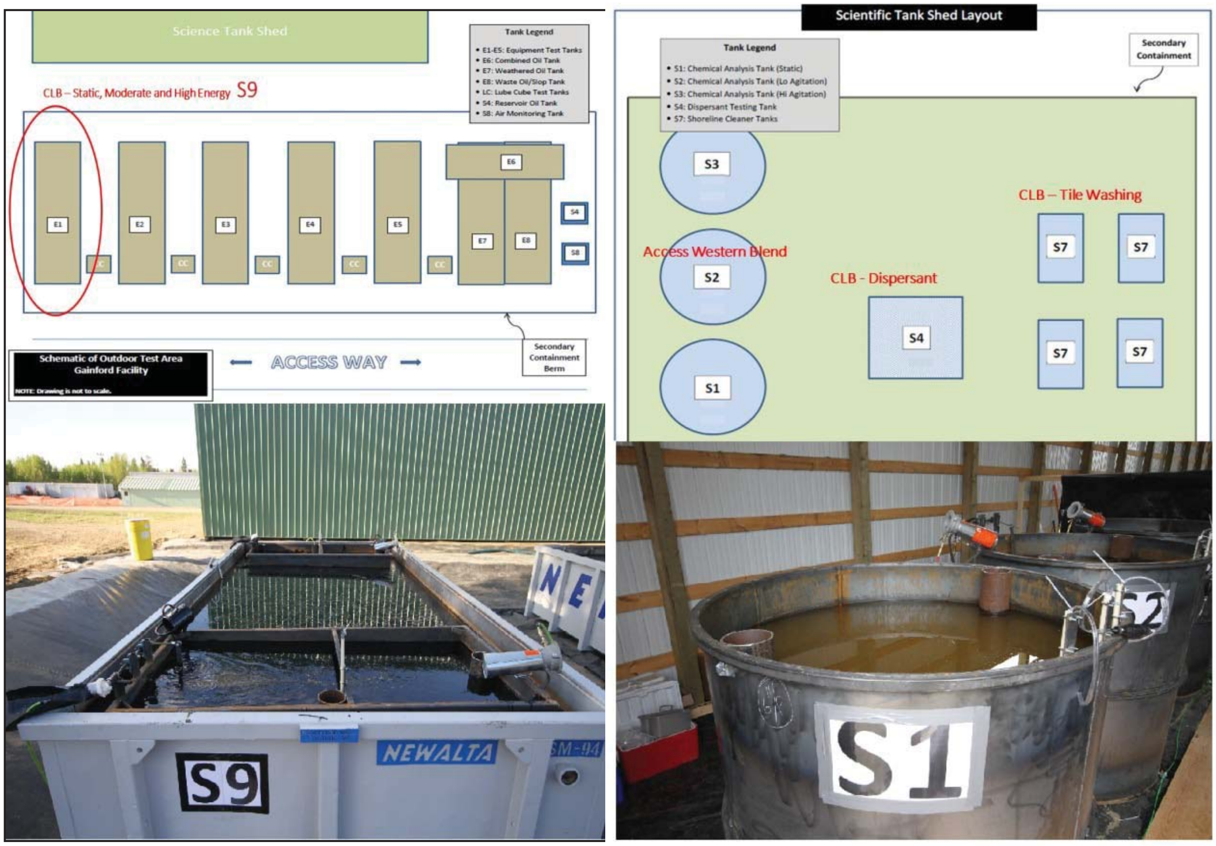


Figure 3-2: Tanks S9A, S9B, and S9C (left) and AWB tanks S1, S2, and S3 (right)

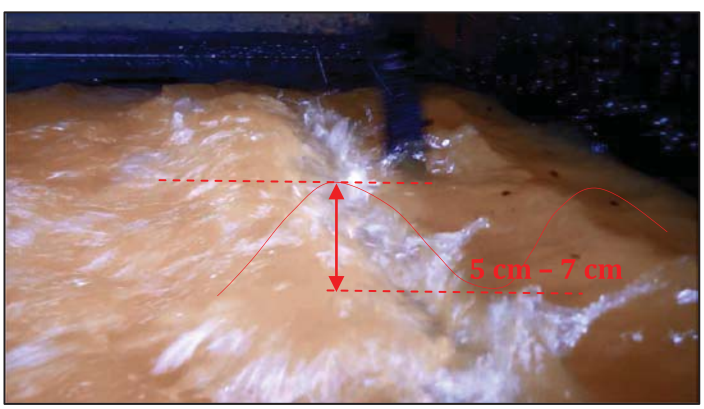
Figure 3-3: Tanks S9A, S9B, and S9C covered with tent

Each type of oil (CLWB and AWB) was exposed to three similar types of weathering conditions. Table 3-2 and Figures 3-4, 3-5, and 3-6 summarize the agitation conditions imposed on each tank:

- Static Conditions: No agitation induced. Wind exposure was minimized as far as was practical.
- Mild Agitation: Low imposed wind and wave conditions; induced by simple mechanical means through intrinsically safe fans and a paddle mechanism.
- Moderate Agitation: Greater induced wind and wave agitation.

Tank #	Dilbit Type	Agitation	Average T (Max and Min)	Average Salinity (Max and Min)	Average pH (Max and Min)
S1	AWB	Static – no agitation	15.9 (19 – 14)	20.6 (22 – 20)	7.5 (8.0 – 7.0)
S2	AWB	Mild – avg. wavelets height approx. 2 cm – 4 cm; avg. wind 5 mph (2.23 m/s)	14.3 (16 – 13)	21 (22 – 20)	7.5 (8.0 – 7.0)
S3	AWB	Moderate – avg. wavelets height approx. 5 cm – 7 cm; avg. wind 10 mph (4.5 m/s)	11.7 (16 – 10)	21.6 (23 – 20)	7.7 (9.0 – 7.0)
S4	CLWB	Mild – avg. wavelets height approx. 2 cm – 4 cm; avg. wind 5 mph (2.2 m/s)	16.1 (19 – 13)	22.5 (24 – 20)	7.6 (9.0 – 7.0)
S9A	CLWB	Moderate – avg. wavelets height approx. 5 cm – 7 cm; avg. wind 10 mph (4.5 m/s)	15.2 (23 – 9.3)	22.3 (24 – 20)	7.6 (8.5 – 7.0)
S9B	CLWB	Static – no agitation	14.9 (22 – 9)	21.2 (22 – 20)	7.5 (8.0 – 7.0)
S9C	CLWB	Mild – avg. wavelets height approx. 2 cm – 4 cm; avg. wind 5 mph (2.2 m/s)	15.1 (22 – 9.6)	21.7 (23 – 20)	7.5 (8.0 – 7.0)

Table 3-2: Summary of water conditions during weathering experiments



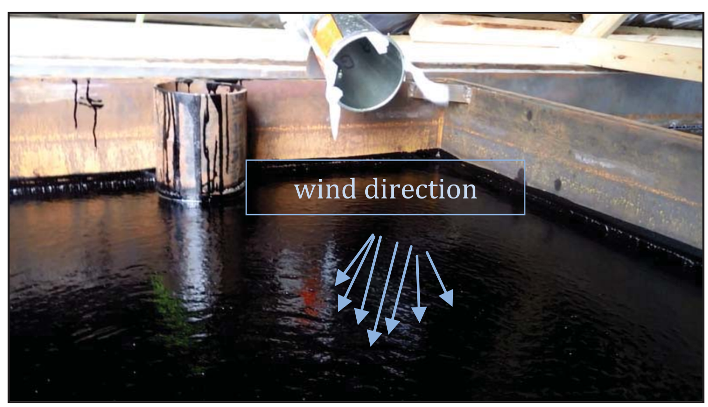


Figure 3-4: (Left) Moderate wave (5 cm – 7 cm) and (right) moderate wind (10 – 18 mph) generated in S9A

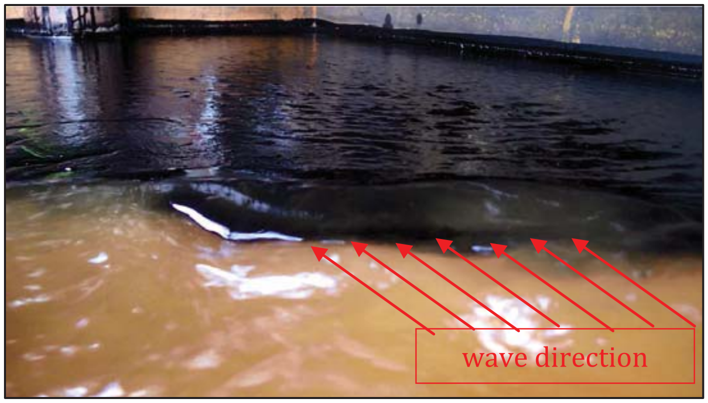


Figure 3-5: CLWB oil pushed by moderate waves and moderate wind in S9A

Figure 3-6: Panoramic view (180°) of AWB oil pushed by moderate waves and moderate wind in S3

3.3 Flux Chamber Sampling Program

A flux chamber sampling program was conducted outside the shed (Tank S8) to analyze the emission rate of chemical groupings (e.g., total petroleum hydrocarbon (TPH), volatile organic compounds, reduced sulphur compounds, and light hydrocarbons (C1 to C5)) from CLWB over a nine day sampling period by RWDI AIR Inc.

Tank 8 was a freshwater cube tank (1.49 m^2 by 1.22 m) exposed to ambient conditions with no agitation imposed. Using a floating flux chamber placed onto the surface of Tank S8, CLWB emission fluxes were sampled over a 2 minute period every 8 hours for the first day, every 12 hours from day 2 to day 7, and once per day on days 8 and 9.

A report of the flux chamber sampling program, including decay times in emission rates, is included in Appendix H.

3.4 Oil Fate and Weathering

Oil was applied to achieve approximately 1 cm slick thickness at the moment released (prior to evaporation or weathering processes; see Table 3-1). Containment by the tank configuration limited what would be the natural spreading of oil in an unconfined condition, creating an artificially thick slick, and limited hydrocarbon dilution in the water column thus representing a "worst-case" of natural dispersion and dissolution.

Sampling was conducted throughout the 10-day weathering period for both whole oil (surface layer oil sample) and the water column of each tank at frequencies indicated in Table 3-3. Water column samples were drawn from 0.5, 1, and 1.5 m depths from each of the AWB test tanks (S1 to S3) and at 0.5 for the CLWB tanks. Physical tests for whole oil and chemical tests for water column samples were conducted by Maxxam Analytics Inc. (Maxxam) in Edmonton and Calgary, with test protocols as defined in Tables 3-4 and 3-5. During the 10-day experimental period, several probes using a weighted sorbent drop and an oil snare on the end of a hand tool were employed to ascertain if any oil had sunken to the bottom of the tanks. No evidence of sunken oil was found from these probes nor was oil observed on the bottom of the tanks at the conclusion of testing when tanks were emptied.

Note: Source oil extracted from the reservoir tank (S4) was taken to small tanks for dispersant, shoreline cleaner tests, and to an outdoor tank for in-situ burning (ISB). While sampling for physical and chemical properties of oil and water was collected in both CLWB and AWB, countermeasure tests were conducted only on CLWB oil.

Elapsed Time	Oil Properties	Water Column HC	CLWB - Field Dispersant Effectiveness	CLWB - ISB	CLWB Shore Cleaner
0 hr	√	√			
2 hrs	√	√			
4 hrs	√	√			
6 hrs	√	√	√	√	
12 hrs	√	√			
1 day	√	√	√	√	√
2 days	√	√			
3 days				√	√
4 days	√	√			
5 days					√
6 days	√	√			
8 days	√	√			
9 days	√	√			
10 days	√	√			

Table 3-3: Sampling frequency and testing protocols used for oil and water column studies

Property	Test Temperature °C	Technique/Instrumentation	Procedure (Lab SOP)
Density	15	Anton Paar Densitometer (DMA 4500)	ASTM D5002 (PTC SOP-00100)
Viscosity	Variable: 5 to 80 °C	Anton Paar Viscometer (SVM 3000 Stabinger)	ASTM D341, D7042 (PTC SOP-00267)
Interfacial Tension	15	CSC DuNouy Ring Tensiometer	ASTM D971-99a
Pour Point	N/A	ASTM Test Jars and Thermometers	ASTM D97/ASTM D5853 (PTC SOP-00068)
Flash Point	N/A	Closed Cup Flash Tester	ASTM D93 (PTC SOP-00082)
Water Content	N/A	Karl-Fischer Titration	ASTM D1123/ASTM D4377 (PTC SOP-000167)
Dispersant Effectiveness	20	Swirling Flask	ASTM F2059

Table 3-4: Test procedures used to measure physical properties of oil and/or oil-water emulsion

Analysis	Procedure (Lab SOP)	Medium	Samples
BTEX (benzene, toluene, ethylbenzene, and xylenes)	EPA 8260 -HS GC/MS (AB SOP-00039)	Water	3 each 40 mL
Alkylated PAH/SVOCs	ESTD-OR-20/EPA 8270D – GC/MS (AB SOP-000037; CAL SOP-00250)	Water	2 each 250 mL
HC Light Ends (C1-C7)	ASTM D5580	Water	2 each 250 mL
Total petroleum hydrocarbons (TPH)	EPA 3550C SM 5520CF - IR (CAL SOP-00096)	Water	1 each 500 mL
HC (C1 thru C29) + BTEX	Modified ASTM D2887	Oil	1 L

Table 3-5: Chemical analyses

Notes regarding several of the test methods and limitations due to incorporated water include:

Density- Approximately 0.7 mL of crude oil is introduced into an oscillating sample tube and the change in oscillating frequency caused by the mass in the tube is used in conjunction with internal calibration data to determine the density of the sample. Water incorporated into the oil matrix, noted in several cases, may affect the oil density, but is likely representative of the emulsion.

Viscosity- The sample is introduced into the measuring cells, which are at a closely controlled and known temperature. The measuring cells consist of a pair of rotating concentric cylinders. The dynamic viscosity is determined from the equilibrium rotational speed of the inner cylinder under the influence of the sheer stress of the sample and an eddy current brake in conjunction with adjustment data. Tests are run at increasing temperatures to achieve measurable values within the equipment range. All dynamic viscosities were measured at least at three temperatures. Viscosity values reported at temperatures other than the test temperatures were calculated by extrapolation following internal lab and the American Society for Testing and Materials (ASTM) procedures. High water content, as found in an oil-water emulsion, may affect the results.

Flash Point- A sample is heated at a slow constant rate with continuous stirring. An ignition source is directed into the test cup at regular intervals with simultaneous interruptions to stirring. The flash point is the lowest temperature at which application of the ignition source causes vapor above the sample to ignite. Presence of water in the sample may prohibit the ascension of vapor during the test which can result in a non-flammable vapor.

Pour Point- After preliminary heating, the sample is cooled at a specified rate and examined at intervals of 3 °C for flow characteristics. Water in the sample, such as from an emulsion, may interfere with test results.

3.5 Chemical Dispersant Application

Tank S4 served as the CLWB weathering reservoir tank. The weathered oil collected from S4 was used for burning, dispersant, and shore cleaning tests. Tank SD, built to the same dimensions as S4, was located inside the shed, filled with water, and prepared to a salinity of 35 ppt to simulate more oceanic conditions for the dispersant tests. Salt water was chosen to represent the most likely location for dispersant application approval as opposed to a brackish (Burrard Inlet) condition. A measured volume of weathered CLWB oil previously collected from Tank S4 was applied to the water surface and allowed to spread on the static water surface. A water sample was drawn from 1 m below the surface before and at approximately 20 minutes following oil application for hydrocarbon analysis. Dispersant (Corexit EC 9500A) was then applied directly to the oil on water at a 1:20 ratio from a handheld spray bottle. The tank was then provided with mild agitation (3 cm - 5 cm chop) to aid in dispersant mixing and penetration into the oil.

Visual and photographic documentation were obtained of the dispersant application. A third water sample was collected from 1 m below the surface at approximately 20 minutes following dispersant application for hydrocarbon analysis. Sorbent pads were used to collect all oil remaining on the water surface and clinging to tank walls following the dispersant application. Sorbents were weighed to gauge how much oil remained after dispersant application (see Appendix B). Tank S9 was then drained and cleaned immediately after each test in preparation for the next test.

Swirling flask tests (ASTM 2059) were also conducted on bulk weathered CLWB samples collected from tanks S9 and S4 (Table 3-4). Tests were run at 20 °C and with water at 33 ppt salinity.

3.6 Controlled Burning

Two liters of oil were collected from Tank S4 at each of the following weathering intervals: 6 hours, 1 day, 3 days, and 5 days. Burns were conducted under a specific Safety Plan, with a waiver for the burn ban in place at the time, and with local fire department personnel and a fire engine on site. The outdoor burn basin consisted of an open top tank, 3 m in diameter, filled with freshwater and in which a 50 cm diameter steel ring was positioned on blocks such that the ring provided approximately 5 cm of freeboard above the water line. The 2 L weathered oil sample jars were weighed, then oil was slowly poured into the ring, and the empty containers with "clingage" were re-weighed.

Burn ignition was aided with diesel and a hand-held propane torch. More weathered oils (Day 1 and Day 3) required re-starts, for which additional diesel starter was added. Data recorded during the burns included air temperature, water temperature, average wind speed and peak gusts, and time of burn. Following the burn test, oil was collected using sorbents and weighed to provide an indication of the amount of oil remaining (see Appendix C). A small quantity of small (generally less than 3 mm) oil particulates and droplets were not recovered with sorbent pads.

3.7 Substrate Washing

A series of surface washing tests using shoreline cleaning agents were conducted on granite tiles using CLWB dilbit from three stages of on-water weathering in Tank S4 and with variable drying times on tiles (Table 3-6). Shoreline cleaners, also known as surface washing agents or beach cleaners, are chemical agents applied to oil that are stranded on shoreline substrates, with the intent to lift oil off the substrate for subsequent containment and recovery. Untreated granite tiles were oiled by hand with CLWB collected after 1 day, 3 days, and 5 days of weathering in Tank S4 (Figure 3-7, Tank S4). Weathered CLWB dilbit from Tank S4 was poured onto each of six 12 in by 6 in (30.5 by 15.2 cm), light colored, porous (not polished) granite tiles by hand such that the oil covered an entire side of the tile evenly with an oil coat (0.01 to 0.1 cm) as defined by Shoreline Cleanup Assessment Technique (SCAT) standard terminology. Once oiled, tiles were allowed to stand in shade and/or sun, tilted at approximately 45 degrees, from 24 to 144 hours before treatment (Table 3-6; Figure 3-7). Oil thickness was estimated by running a thin piece of rigid waterproof paper through the oil and examining the oiled band on the paper against a graduated scale (Figure 3-7). This process was repeated with oil weathered on water for 72 hours (3 days) and 96 hours (5 days; Table 3-6). Air temperatures throughout the experiment ranged from 10^{o}C at night to a maximum of 23^{o}C during the day.

Tiles were treated with two agents: an off-the-shelf degreaser containing D-limonene, and Corexit 9580, a shoreline cleaning agent. Commercial D-Limonene was unavailable and the results should not be compared to other surface washing tests using commercial D-Limonene. The application rates used are those recommended by the US Environmental Protection Agency (EPA) for shoreline treatment for Corexit 9580. The application ratio tested was the recommended dosage of approximately 1 US gallon per 100 square feet (0.41 L/m^2) or 1.3 ounces (approximately 37 mL) per tile. The application volume was tested with the spray bottle to estimate the number of hand sprays that equals 1.3 ounces (≅37 mL).

A photograph of each tile was taken before and after treatment and compared to untreated wet tiles. For each test condition there was a reference tile with no shoreline cleaning agent and a tile each with cleaning agents.

The treatment consisted of ambient temperature freshwater run through a power washer adjusted to the lowest pressure available, and fitted with a fan tip to distribute the water to approximately 25 cm wide, or the width of the tile being cleaned. The tip was maintained by a governor at 22.5 cm from the tile surface (Figure 3-7). The pressure from the tip was consistent with a garden hose (0.21 – 0.31 megapascal (MPa); 30-45 pounds per square inch (psi)) and was safe for contact with human skin at 22.5 cm with no adverse effects. The treatment proceeded for 30 seconds (approximately 11 passes with the wand) and used approximately 3 L of water.

Observations included standard SCAT terminology for oil remaining on tile, oil removed in water, nature of oil removed in water (sinking, floating, color, character, adherence to sorbent materials), whether the cleaned tile produces sheen, and ease with which additional oil wipes off with casual contact and sorbent.

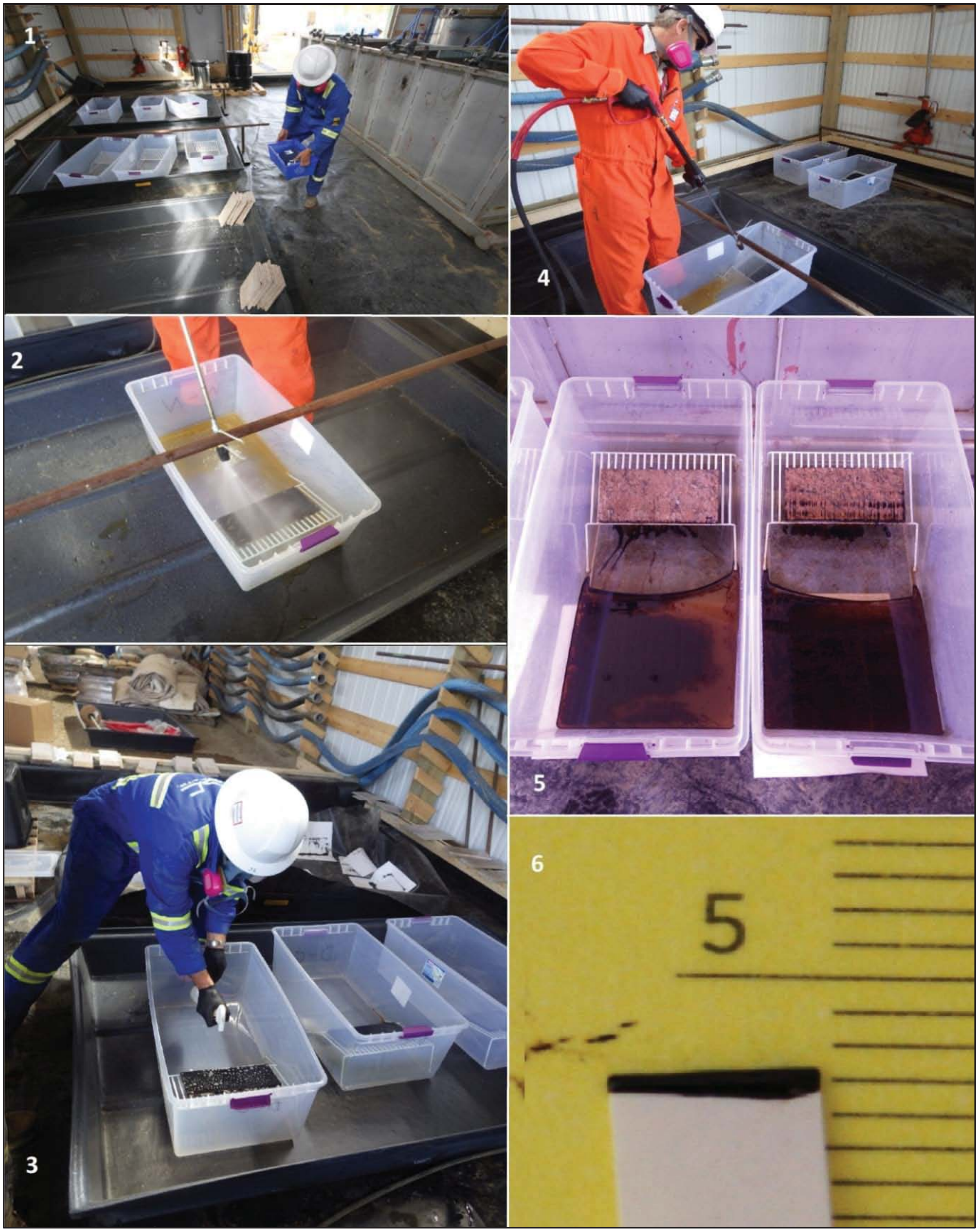


Figure 3-7: 1) Surface washing test area; 2) Apparatus for consistent wash distance and pressure; 3) Applying Corexit 9580; 4) Washing; 5) Post-wash results on side by side pre-wet and pre-dry tiles; 6) Example measure of oil thickness on tile (lines are 1 mm apart)

Tile ID	Tile Condition When Oiled	Oil on water (Days)	Agent Applied	Time Oil on Tiles Prior to Treatment (hrs.)	Total Time before Treatment (hrs.)
1D-W-C-24	Wet	1D	Corexit 9580	24	48
1D-W-L-24	Wet	1D	D-Limonene	24	48
1D-W-N-24	Wet	1D	None	24	48
1D-W-C-48	Wet	1D	Corexit 9580	48	72
1D-W-L-48	Wet	1D	D-Limonene	48	72
1D-W-N-48	Wet	1D	None	48	72
1D-D-C-24	Dry	1D	Corexit 9580	24	48
1D-D-L-24	Dry	1D	D-Limonene	24	48
1D-D-N-24	Dry	1D	None	24	48
1D-D-C-48	Dry	1D	Corexit 9580	48	72
1D-D-L-48	Dry	1D	D-Limonene	48	72
1D-D-N-48	Dry	1D	None	48	72
3D-W-C-24	Wet	3D	Corexit 9580	24	94.5
3D-W-L -24	Wet	3D	None	24	95
3D-W-C-48	Wet	3D	Corexit 9580	48	119
3D-W-N-48	Wet	3D	None	48	119
3D-W-C-72	Wet	3D	Corexit 9580	72	143
3D-W-C-96	Wet	3D	Corexit 9580	96	167
3D-D-C-24	Dry	3D	Corexit 9580	24	95
3D-D-N-24	Dry	3D	None	24	95
3D-D-C-48	Dry	3D	Corexit 9580	48	119
3D-D-N-48	Dry	3D	None	48	119
3D-D-C-72	Dry	3D	Corexit 9580	72	143
3D-D-C-96	Dry	3D	Corexit 9580	96	167
3D-W-C-120	Wet	3D	Corexit 9580	120	191
3D-D-C-120	Dry	3D	Corexit 9580	120	191
5D-W-C-24	Wet	5D	Corexit 9580	24	144
5D-W-N-24	Wet	5D	None	24	144
5D-W-C-48	Wet	5D	Corexit 9580	48	168
5D-W-N-48	Wet	5D	None	48	168
5D-W-c-72	Wet	5D	Corexit 9580	72	192
5D-W-C-96	Wet	5D	Corexit 9580	96	216
5D-D-C-24	Dry	5D	Corexit 9580	24	144
5D-D-N-24	Dry	5D	None	24	144
5D-D-C-48	Dry	5D	Corexit 9580	48	168
5D-D-N-48	Dry	5D	None	48	168
5D-D-C-72	Dry	5D	Corexit 9580	72	192
5D-D-C-96	Dry	5D	Corexit 9580	96	216
5D-W-C-120	Wet	5D	Corexit 9580	120	240
5D-D-C-120	Dry	5D	Corexit 9580	120	240

Table 3-6: Surface washing tests

Note: Some high pressure and hot water was tested following ineffective results with flushing alone.

An additional treatment included several tests of high pressure and hot water flushing following ineffective treatment using low pressure on several tiles. A pressure wand set to the lowest setting (low pressure) was used to flush a number of tiles for approximately three passes of 3-5 seconds each with the wand roughly 25 cm from the tiles. When completed, the tiles were allowed to sit for several minutes and then a photograph of each tile was taken with a label in each photograph listing date, time, post-spill day, cleaning agent applied, and indicating that high pressure flushing had occurred.

4 Results

4.1 Physical Properties of Weathered AWB Dilbit

Summaries of the measured oil physical properties for AWB during weathering are provided below in Table 4-1 through Table 4-3. Density increases during weathering were more pronounced with moderate agitation, whereas oil under static conditions and mild agitation had comparable change (Figure 4-1). In all cases absolute densities (at 15 °C) reached or slightly exceeded 1000 kg/m³ (freshwater equivalent). The increase in AWB pour point and in viscosity as it weathered was pronounced in the first 48 hours, with the latter ranging 108 to over 60,000 cSt within that timeframe Figure 4-3).

Sample ID	Hours post-spill	Absolute Density @ 15 °C (kg/m³)	Viscosity @ 15 °C (cSt)	Water Content (mass %)	Pour Point (°C)	Closed Cup Flash Point (°C)	Interfacial Tension (dyn/cm)
S1-PS-01	0	920.1	270.5*	3.4	-21	<-35	27
S1-2H-01	2	943.4	1,026*	6.7	-18	<-35	30
S1-4H-01	4	946.2	1,210	5.0	-12	<-35	22
S1-6H-01	6	959.0	2,844	5.1	-12	-12	22
S1-12H-01	12	967.4	6,296*	0.8	-6	<-35	51
S1-1D-01	24	980.7	--	8.3	--	<-35	22
S1-2D-01	48	979.1	20,269*	1.0	6	-10	27
S1-4D-01	96	987.3	59,126*	1.2	6	20	48
S1-6D-01	144	994.0	116,477*	1.6	12	22	55
S1-8D-01	192	997.9	228,350*	1.7	12	52	130
S1-10D-01	240	1000.0	265,263*	4.5	9	58	150

*Table 4-1: AWB in tank S1 weathered under static conditions. Note: * denotes calculated values*

Sample ID	Hours post-spill	Absolute Density @ 15 °C (kg/m³)	Viscosity @ 15 °C (cSt)	Water Content (mass %)	Pour Point (°C)	Closed Cup Flash Point (°C)	Interfacial Tension (dyn/cm)
S2-PS-01	0	920.1	270.5*	3.4	-21	<-35	27
S2-2H-01	2	936.5	749.0*	0.2	-24	<-35	31
S2-4H-01	4	942.9	1,097	0.9	-27	<-35	34
S2-6H-01	6	949.7	1,658	0.2	-18	<-35	35
S2-12H-01	12	958.4	3,128*	4.2	-15	<-35	41
S2-1D-01	24	971.2	9,027*	0.5	3	<-35	43
S2-2D-01	48	983.0	31,539*	0.9	12	-13	49
S2-4D-01	96	995.7	151,596*	3.7	9	5	76
S2-6D-01	144	978.0	241,152*	5.8	9	24	250
S2-8D-01	192	1002.0	435,942*	6.3	15	24	130
S2-10D-01	240	1010.0	763,943*	18.2	12	75	190

*Table 4-2: AWB in tank S2 weathered under mild agitation conditions. Note: * denotes calculated values*

Sample ID	Hours post-spill	Absolute Density @ 15 °C (kg/m³)	Viscosity @ 15 °C (cSt)	Water Content (mass %)	Pour Point (°C)	Closed Cup Flash Point (°C)	Interfacial Tension (dyn/cm)
S3-PS-01	0	920.1	270.5*	3.4	-21	<-35	27
S3-2H-01	2	956.3	2,665	8.6	-6	<-35	36
S3-4H-01	4	969.1	6,994*	25.3**	-6	<-35	44
S3-6H-01	6	979.2	13,766	24.1**	0	-3	50
S3-12H-01	12	982.4	26,746*	--	3	-3	52
S3-1D-01	24	984.2	35,607*	42.4**	3	4	83
S3-2D-01	48	995.8	117,267*	42.5**	15	3	96
S3-4D-01	96	997.2	371,916*	45.3**	6	25	71
S3-6D-01	144	993.7	117,493*	3.4	15	25	200
S3-8D-01	192	991.2	47,117*	52.0**	12	26	55
S3-10D-01	240	1007.0	135,014*	43.4**	12	20	190

Table 4-3: AWB in tank S3 weathered under moderate agitation conditions

*(Note: * denotes calculated values based on three measures at other temperatures; Note: ** denotes anomalies due to high level of free water content that could have affected physical properties results analyzed during lab-tests)*

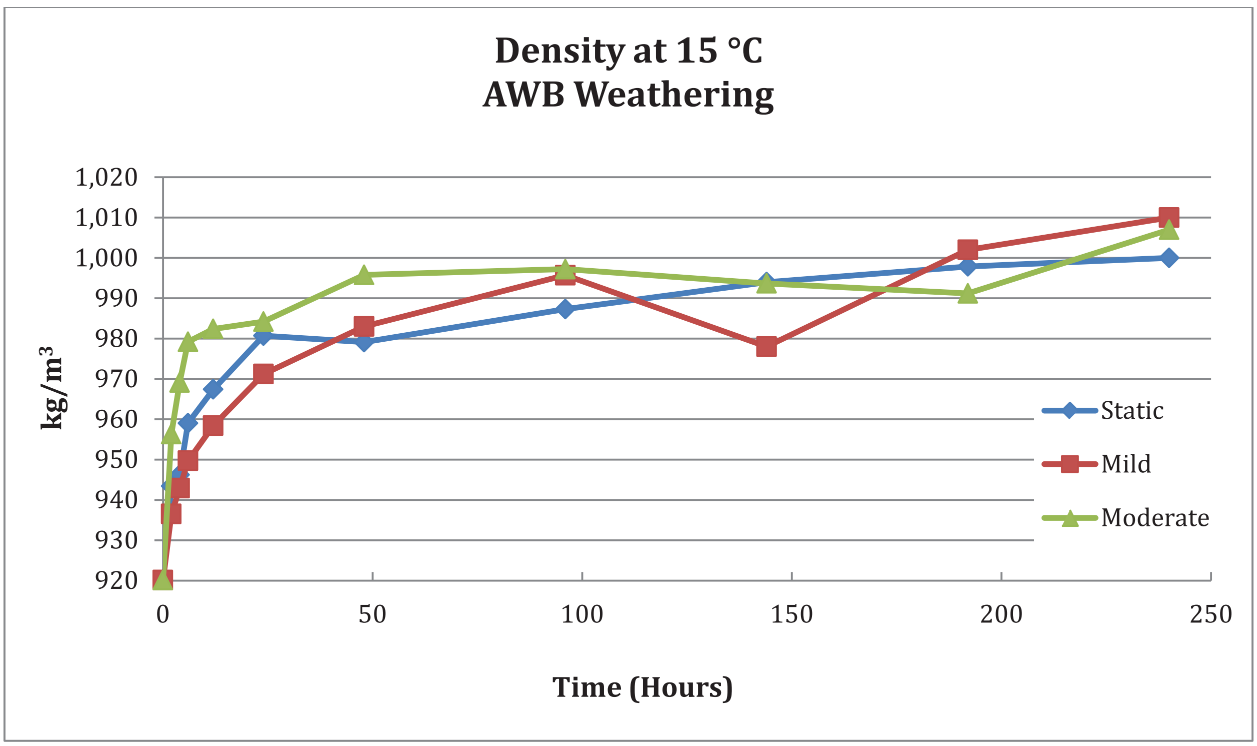


Figure 4-1: AWB - Absolute Density

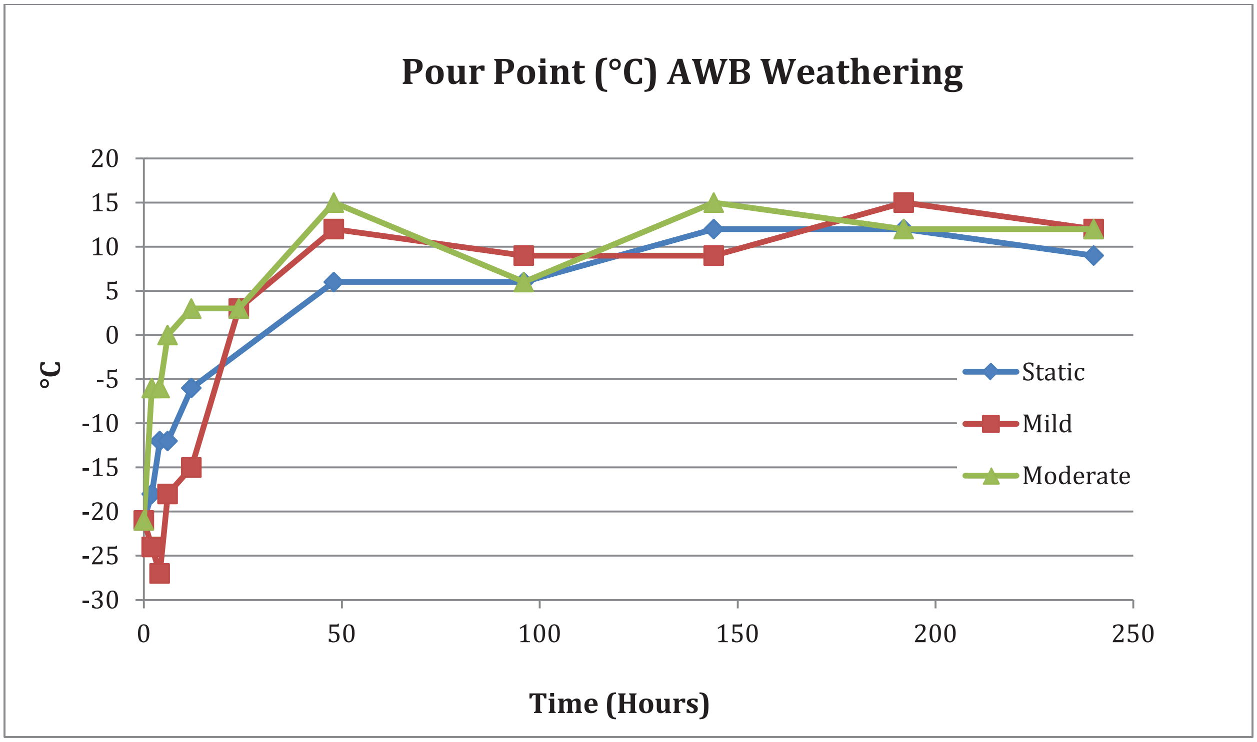


Figure 4-2: AWB - Pour Point

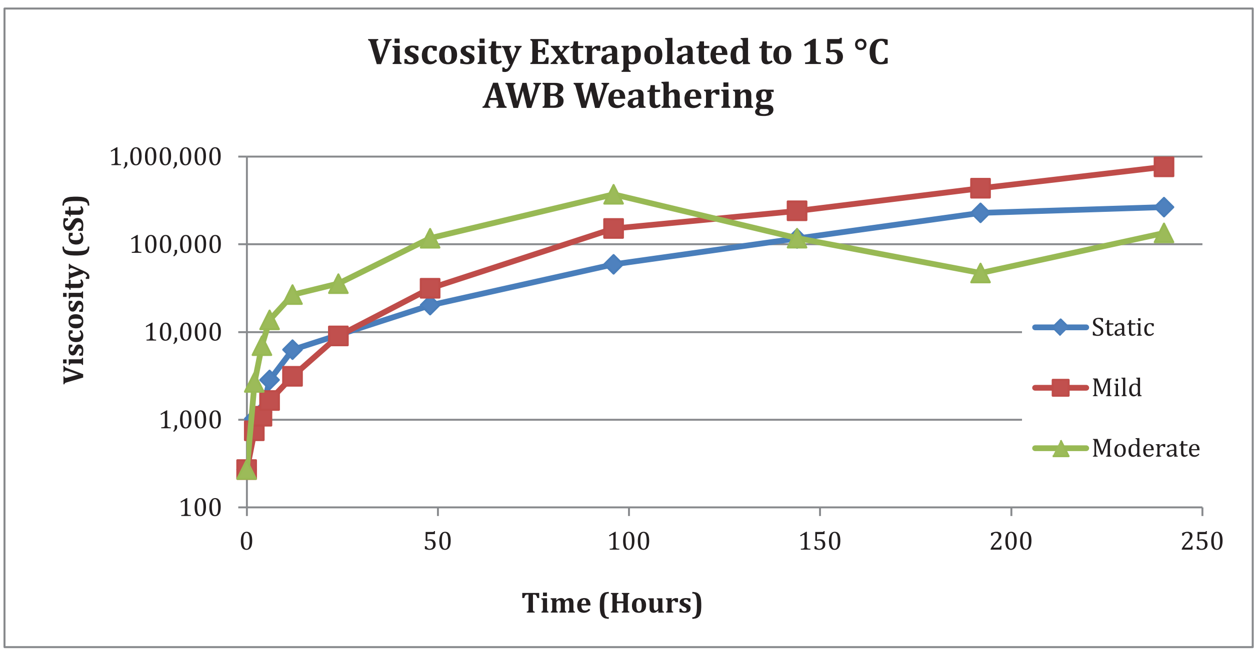


Figure 4-3: AWB Viscosities

4.2 Physical Properties of Weathered CLWB Dilbit

Summaries of the measured oil physical properties for CLWB dilbit during weathering are provided below in Tables 4-4 through 4-6. Density increases were more pronounced in the first 24 hours of weathering for the moderate agitation (Figure 4-4) but oils in both agitation tanks achieved similar densities after that time. In all cases, absolute densities (at 15 °C) never exceeded 1000 kg/m^3 (freshwater equivalent) with the exception of a single measurement at 8 days for the CLWB oil under moderate agitation. The increase in pour point was continual in all tanks with pour points in excess of 10 °C noted within 4-5 days (Figure 4-5). Viscosities increased to over 10,000 cSt within the first 48 hours, although increases in viscosity were much less pronounced in the static tank (Figure 4-6).

Sample ID	Hours post-spill	Absolute Density @ 15 °C (g/L)	Viscosity @ 15 °C (cSt)	Water Content (mass %)	Pour Point (°C)	Closed Cup Flash Point (°C)	Interfacial Tension (dyn/cm)
S9-OH-OIL	0	924.8	--	0.9	-21	<-35	31
S9A-2H-01	2	954.9	1661*	1.6	-15	<-35	36
S9A-4H-01	4	959.7	2706*	1.4	-9	<-35	39
S9A-6H-01	6	965.8	4521*	2.5	-21	<-22	39
S9A-12H-01	12	973.3	8933*	5.1	-6	-3	37
S9A-1D-01	24	980.4	14,133*	8.5	-3	15	40
S9A-2D-01	48	989.7	35,626*	11.4	-6	32	52
S9A-4D-01	96	995.9	154,077*	39.6**	0	70	150
S9A-6D-01	144	999.7	411,114*	40.2**	12	26	140
S9A-8D-01	192	1002.0	159,600*	36.1**	9	73	160
S9A-9D-01	216	996.5	417,801*	24.6**	24	71	190
S9A 10D 01	240	996.5	14,634*	35.9**	21	>100	170

Table 4-4: S9-A: CLWB in tank S9A weathered under moderate agitation conditions

*(Note: * denotes calculated values based on three measures at other temperatures; Note: ** denotes anomalies due to high level of free water content that could have affected physical properties results analyzed during lab-tests)*

Sample ID	Hours post-spill	Absolute Density @ 15 °C (kg/m^3)	Viscosity @ 15 °C (cSt)	Water Content (mass %)	Pour Point (°C)	Closed Cup Flash Point (°C)	Interfacial Tension (dyn/cm)
S9-OH-OIL	0	924.8	--	0.9	-21	<-35	31
S9B-2H-01	2	939.4	568*	1.4	-30	<-35	30
S9B -4H-01	4	946.1	915*	1.2	-21	<-35	34
S9B -6H-01	6	954.8	1586*	2.0	-15	<-20	38
S9B -12H-01	12	958.7	2255*	0.8	-9	<-15	36
S9B -1D-01	24	961.8	3985*	0.6	-6	-27	29
S9B-2D-01	48	969.7	5862*	1.6	-9	24	34
S9B-4D-01	96	975.6	12,179*	1.4	-6	25	34
S9B-6D-01	144	979.2	17,687*	1.1	6	5	46
S9B-8D-01	192	980.3	19,454*	0.8	9	34	40
S9B-9D-01	216	982.0	29,440*	2.2	15	34	45
S9B 10D 01	240	975.2	27,968*	1.9	12	35	51

Table 4-5: S9-B: CLWB in tank S9B weathered under static conditions

Sample ID	Hours post-spill	Absolute Density @ 15 °C (kg/m³)	Viscosity @ 15 °C (cSt)	Water Content (mass %)	Pour Point (°C)	Closed Cup Flash Point (°C)	Interfacial Tension (dyn/cm)
S9-OH-OIL	0	924.8	--	0.9	-21	<-35	31
S9C-2H-01	2	941.5	632.7	1.2	-21	<-35	39
S9C-4H-01	4	946.2	935.8	1.0	-18	<-35	36
S9C-6H-O1	6	952.4	1443	1.8	-18	<-35	33
S9C-12H-01	12	963.2	4744	1.5	--	-10	34
S9C-1D-01	24	984.4	5653	1.7	-3	-10	33
S9C-2D-01	48	983.4	26,479	2.3	3	31	45
S9C-4D-01	96	992.5	75,896	7.3	0	23	77
S9C-6D-01	144	996.3	117,498	9.7	9	73	88
S9C-8D-01	192	998.9	743,871	19.4	12	75	150
S9C-9D-01	216	997.7	195,792	--**	21	70	--
S9C 10D 01	240	996.8	302,527	22.3**	21	>100	170

Table 4-6: S9-C: CLWB in tank S9C weathered under mild agitation conditions

*(Note: * denotes calculated values based on three measures at other temperatures; Note: ** denotes anomalies due to high level of free water content that could have affected physical properties results analyzed during lab-tests)*

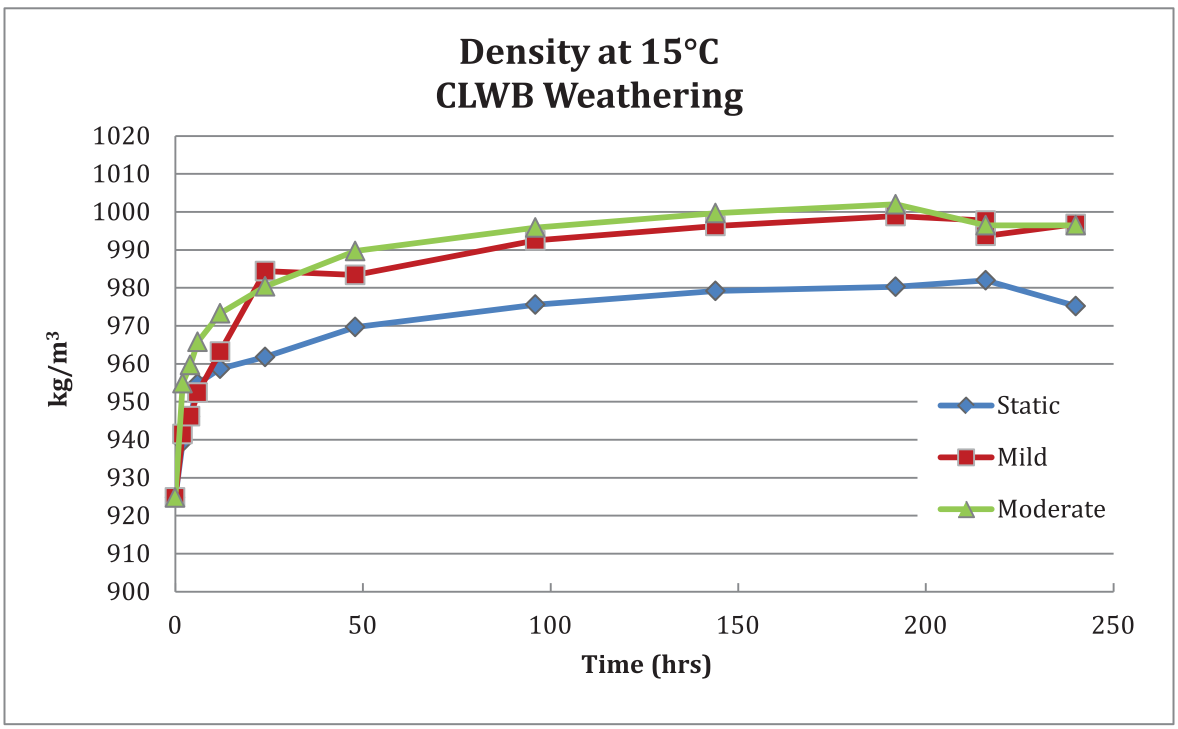


Figure 4-4: CLWB - Absolute Density

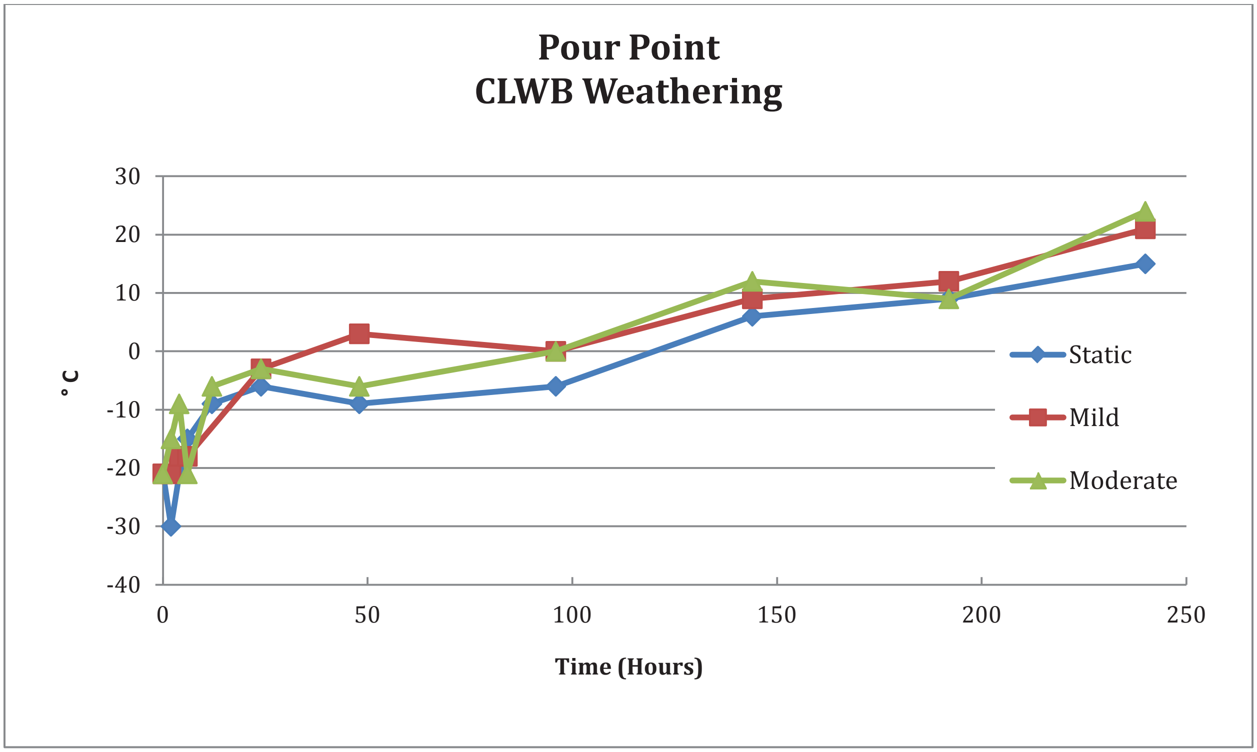


Figure 4-5: CLWB Pour Point

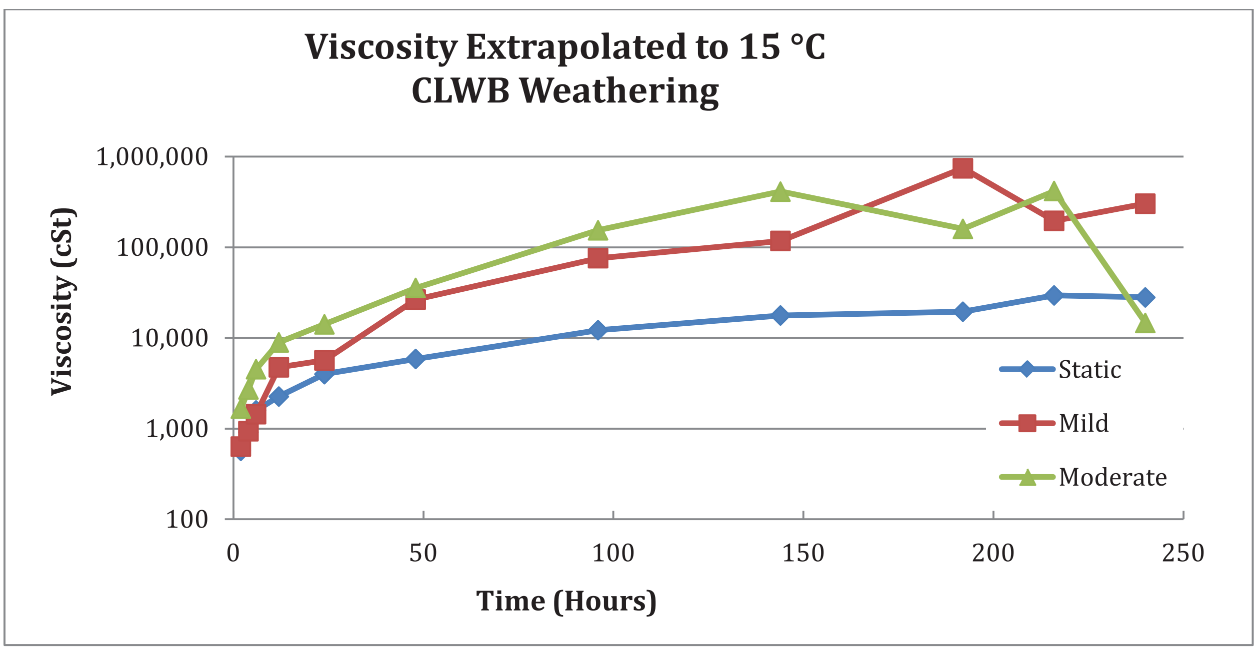


Figure 4-6: CLWB Viscosities

Tank S4 was used as a source of weathered oil for dispersant application, burning, and shore cleaning agent tests. With agitation conditions similar to Tank S2, the major difference between S2 and S4 was the location of S4 (exposed to sunlight and ambient atmospheric conditions). Absolute densities (at 15 °C) exceeded 1000 kg/m³ (freshwater) after weathering nine days, similar to Day 8 for the moderate agitation Tank S9A (Table 4-7).

Sample ID	Hours post-spill	Absolute Density @ 15 °C (kg/m³)	Viscosity @ 15 °C (cSt)	Water Content (mass %)	Pour Point (°C)	Closed Cup Flash Point (°C)	Interfacial Tension (dyn/cm)
S9-OH-OIL	0	924.8	--	0.9	-21	<-35	31
S4-6H-01	6	969.9	5703*	4.1	3	-12	38
S4-1D-01	24	984.2	24762*	3.5	15	4	48
S4-3D-04	72	997.7	201284*	33.4**	9	56	170
S4-5D-04	120	997.3	179587*	42.9**	9	>100	130
S4-9D-01	216	1008.0	254489*	36.8**	12	72	220

Table 4-7: CLWB in tank S4 (oil reservoir tank) – weathered under mild agitation conditions, sun light, and local weather conditions (wind and rain)

*(Note: * denotes calculated values based on three measures at other temperatures; Note: ** denotes anomalies due to high level of free water content that could have affected physical properties results analyzed during lab-tests)*

4.3 Chemistry of Weathered Oil

Oil chemistry, including C1-C30 and poly aromatic hydrocarbon (PAH) analyses, were to characterize the originating (fresh oil) dilbit and to assess hydrocarbon content and degradation patterns. Figures 4-7 and 4-8 show PAH data for weathered and fresh AWB oil samples. Figures 4-9 and 4-10 show relative weight concentrations of C1 through C30 compounds in fresh and weathered AWB and CLWB dilbits, respectively, and compare changes in these compounds with different levels of induced agitation. Also see Appendix E (Oil Chemistry Data) tables for additional details data on specific compounds.

PAH includes compounds that have some of the more serious environmental effects of the compounds in crude oil. PAHs in the environment are derived largely from combustion of oil and coal, but are also produced by the burning of wood, forest fires, and a variety of other combustion sources. In general, PAH content is low in both oils compared to many other crude oils. A typical crude oil may contain 0.2 percent to more than 7 percent total PAH. The National Research Council (2003) reports an average PAH content of 1.39 for 25 crude oils (heavy and light) using data from numerous sources. Heavy distillates and light distillates averaged 2.42 and 3.44 percent, respectively. Fresh oil samples of CLWB and AWB dilbits contained 1.1 and 0.45 percent PAH by weight, respectively.

PAH chromatograms over time show similar relative abundance of analytes in the oil with little noticeable depletion of PAH under static conditions and slightly more PAH loss in the mild and moderate weathering tanks after 10 days. Concentrations of total poly aromatic hydrocarbons (tPAH) increased in the oil over time in some instances as other lighter constituents in the oil are lost to volatilization. This is evident in the static tanks and not the weathering tanks, which had lower tPAH at the end of the experiment than in other conditions. C1-C30 analysis shows rapid depletion of lower molecular weight compounds in all instances and maximum depletion in the tanks with moderate weathering conditions (Figures 4-9 and 4-10). The percent of compounds present by weight decreases rapidly in the lighter compounds and can consequently increase in heavier molecular weight compounds in light or low weathering conditions. Moderate agitation resulted in reduction in percent by weight among all compounds.

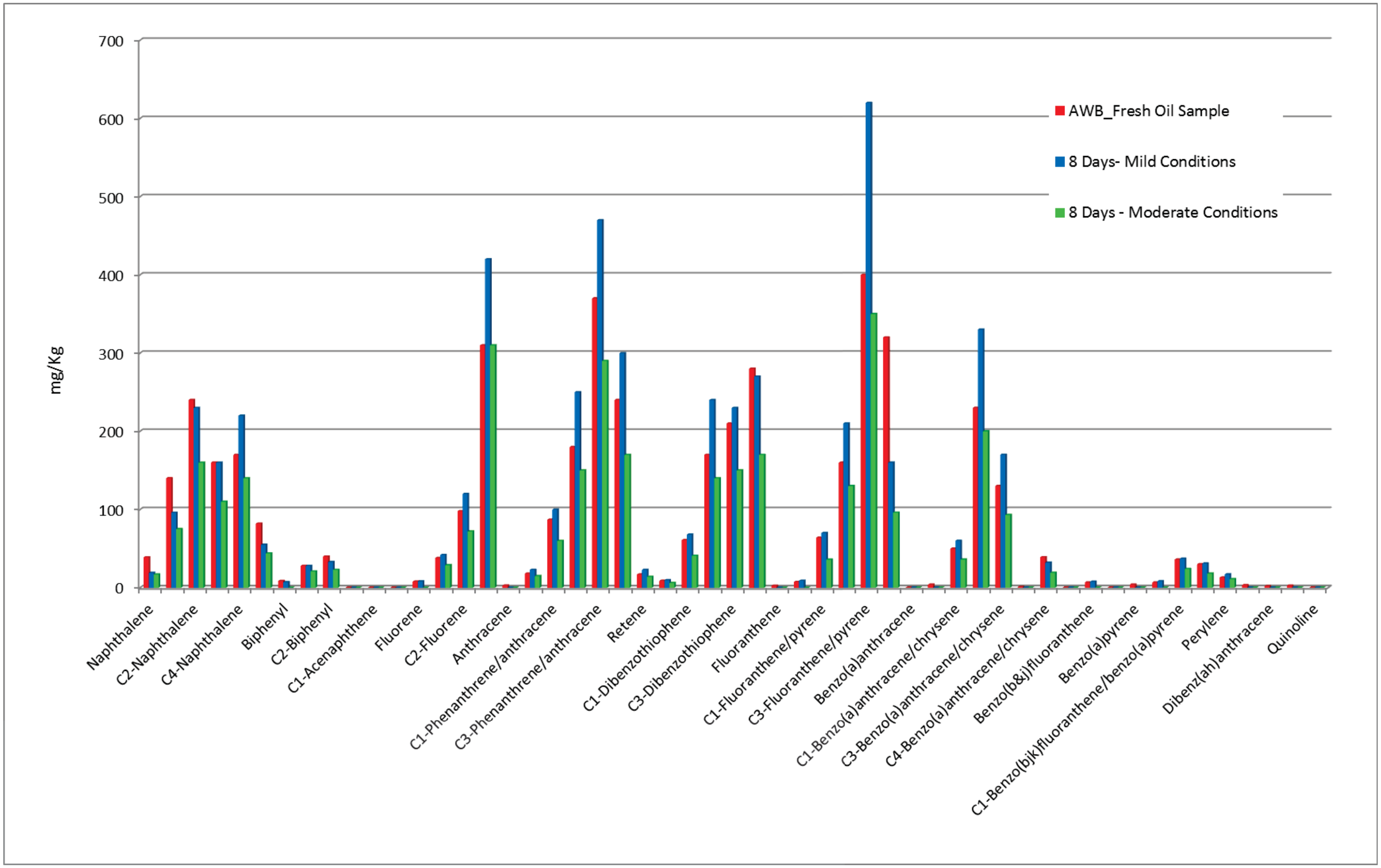


Figure 4-7: Oil chemistry data - AWB

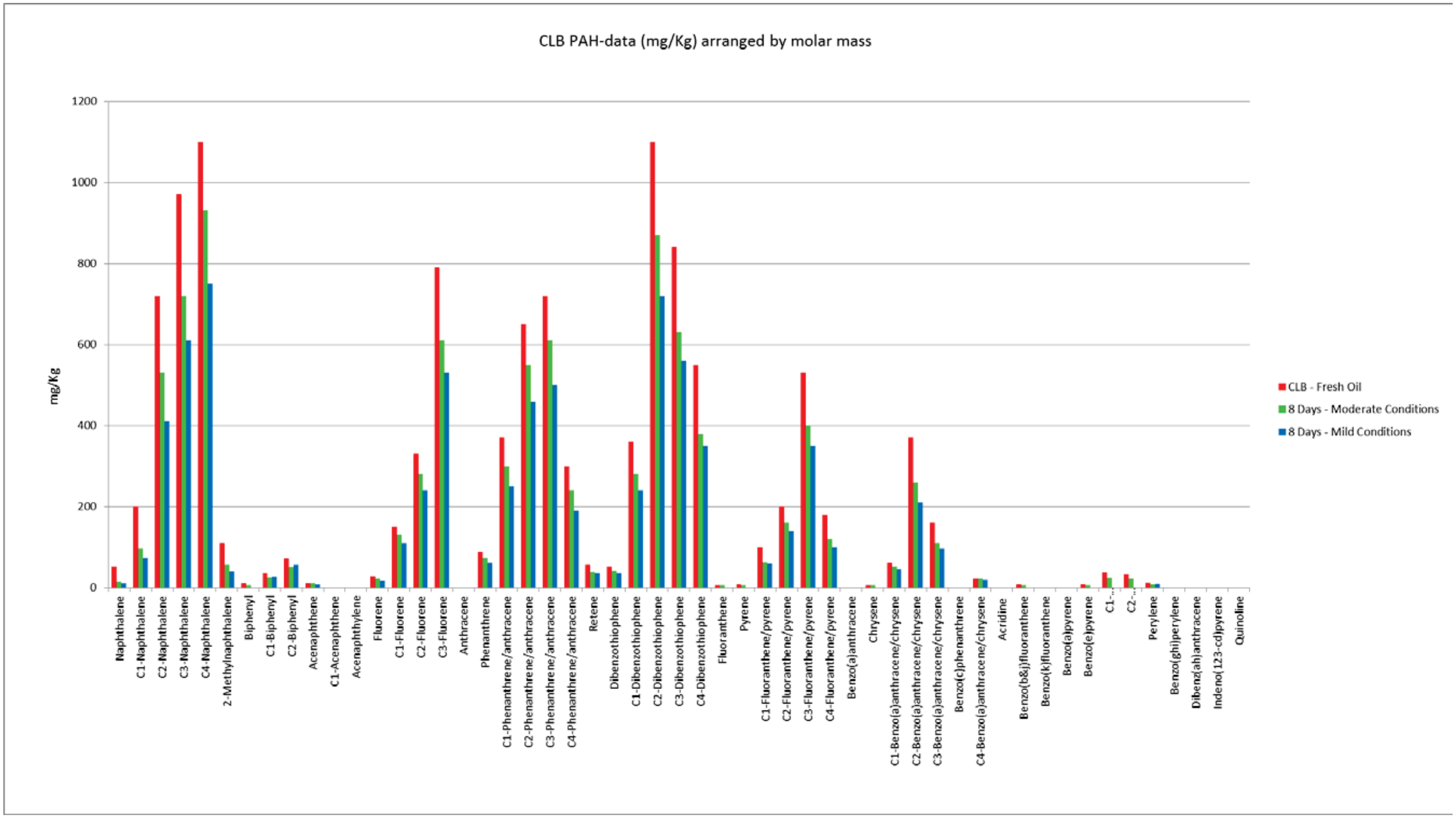


Figure 4-8: Oil chemistry data – CLWB dilbit

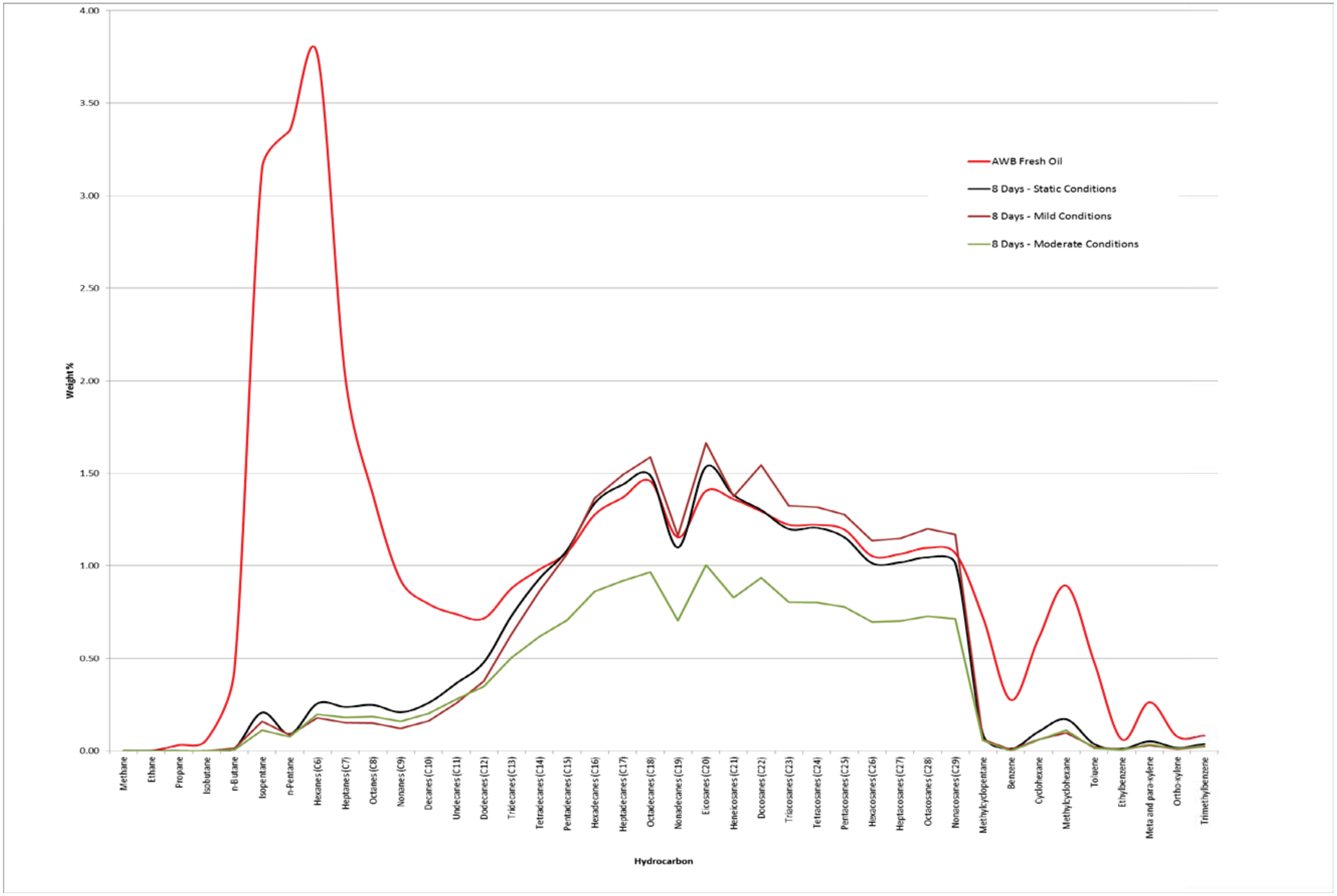


Figure 4-9: Light ends (C1 – C30) AWB

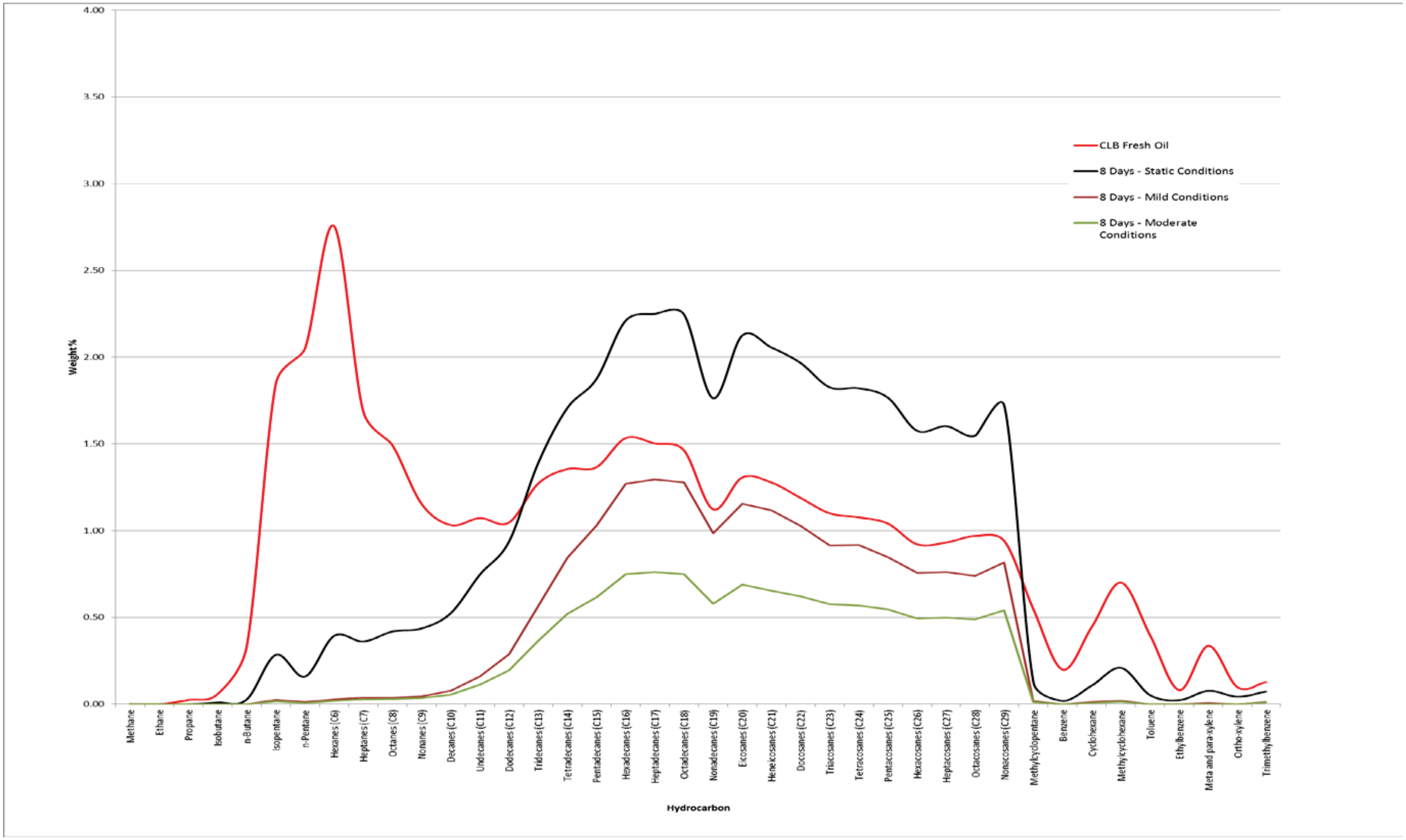


Figure 4-10: Light ends (C1-C30) CLWB dilbit

4.4 Oil Distribution in the Water Column

Oil distribution and partitioning into the water column are provided through TPH and BTEX analyses of water samples at specific depths below the water surface (also see Appendix F (Water Chemistry Data) tables and graphs for additional details). Note that the limited volume of water within each tank and the lack of any possible dilution provides for very conservative measures of oil constituents in the water column relative to what may happen in open water conditions such as in Burrard Inlet.

4.4.1 TPH in the Water Column

Total petroleum hydrocarbon (TPH) measured in the water columns of the AWB and CLWB dilbit tanks were in nearly all cases below detection thresholds (<2 mg/L) with the exception of tanks with moderate agitation (S3- AWB and S9A- CLWB). The highest TPH values measured were 120 mg/L at 1 m below the water surface from the CLWB dilbit and 60 mg/L at 50 cm below the water surface for AWB (Figure 4-11). By approximately 12 hours, all TPH values, regardless of depth in the water column or oil type, were near 10 mg/L in the tanks with moderate agitation. This pattern demonstrates that the lower molecular weight fractions of TPH tend to be more soluble in water and weather (e.g., volatilize) faster.

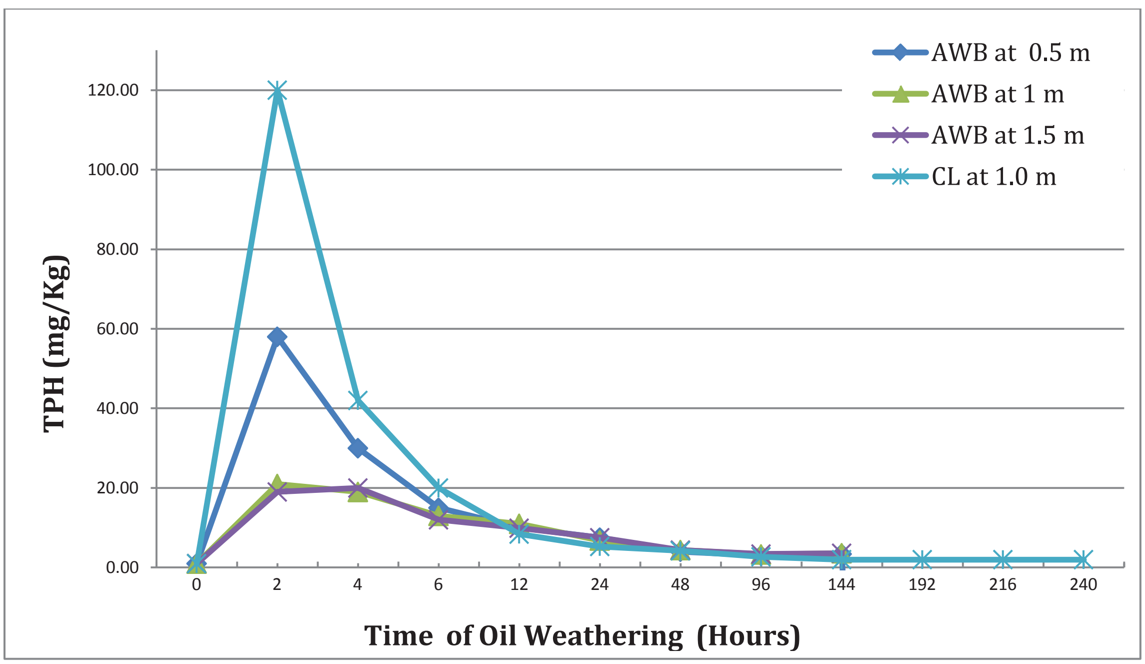


Figure 4-11: TPH in water column samples - AWB and CLWB weathering under moderate conditions

4.4.2 BTEX in the Water Column

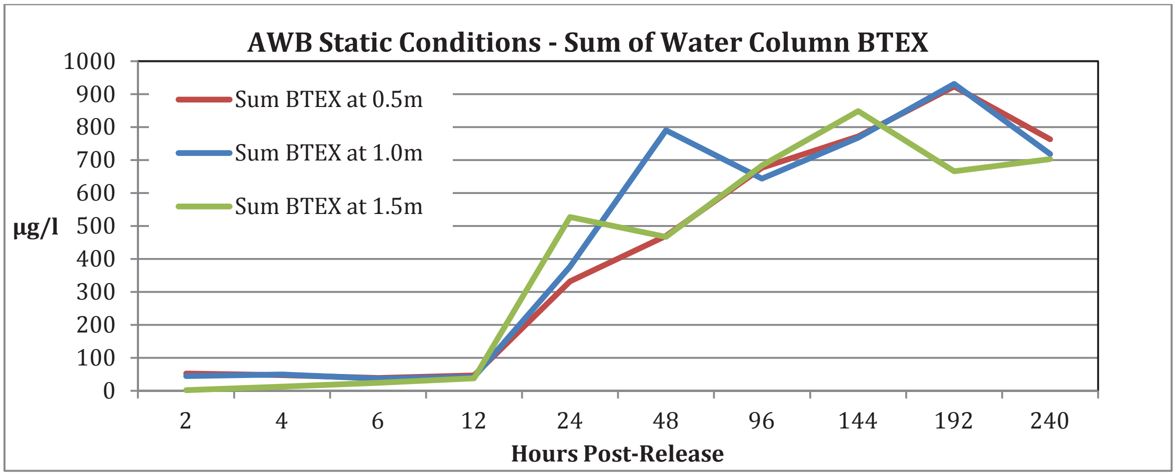
BTEX is the collective name for benzene, toluene, ethylbenzene, and xylenes, the volatile single-ringed aromatic compounds found in crude oils. The behavior of the four compounds is somewhat similar when released to the environment and thus they are usually considered as a group. Most crude oils contain BTEX usually from about 0.5 up to 5 percent or more. The CLWB and AWB contain approximately 1 percent BTEX in the fresh oil samples, consistent with other crude oils. Gasoline can contain up to 40 percent BTEX. BTEX compounds are volatile and, if discharged into the sea, rapidly volatilize producing a net loss of BTEX compounds.

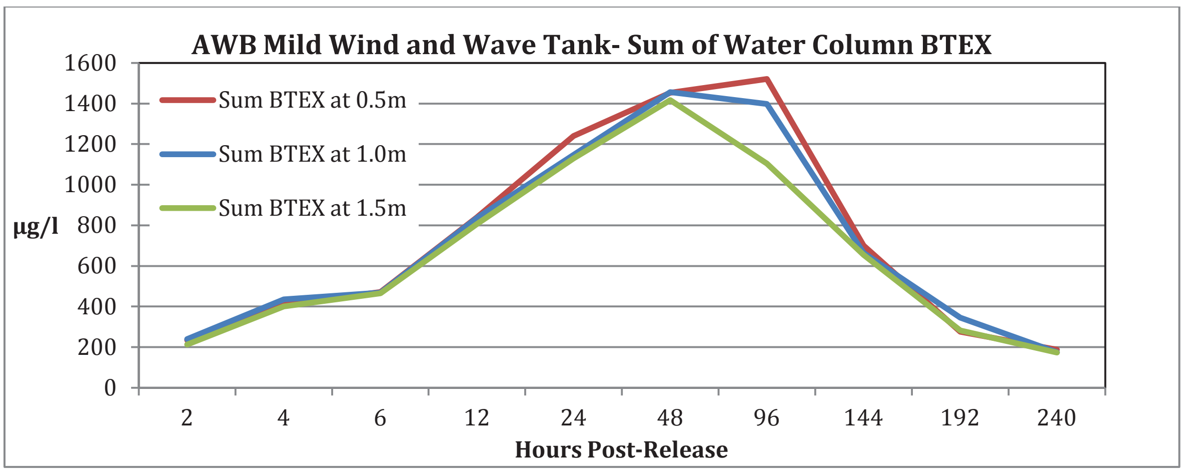
Single-ringed aromatics are also soluble in water at low parts per million (ppm) levels and readily partition out of the heavy crude. In the study of both CLWB and AWB, the BTEX compounds partitioned into the water column evenly at all depths examined (Figure 4-12) but behaved somewhat differently overall under different wind and wave conditions. BTEX in both oils behaved very similarly. In the static tests, dissolution of BTEX in the water column increased at 12 to 24 hours with maximum concentrations reaching approximately 900 micrograms per liter (µg/L) (∑ BTEX) at approximately 6 days (Figure 4-12). There was little evidence of a net loss of BTEX in the static water leading up to 10 days.

In mild wind and wave conditions, BTEX began to partition into the water column immediately reaching maximum ∑ BTEX concentrations of 1,200 µg/L (CLWB) to 1,500 µg/L (AWB) in 48 hours (Figure 4-12; also see Appendix F). Net loss of BTEX to volatilization was apparent at 48 hours with water concentrations dropping to less than 200 µg/L by 8 days.

In moderate wind and wave conditions, CLWB ∑BTEX reached 3,000 µg/L almost immediately followed by a net loss to <100 µg/L in 4 days (Figure 4-12). The AWB ∑BTEX reached maximum concentrations of approximately 1,700 µg/L after four hours followed by a slightly slower net loss to <200 µg/L after 4 days. It is possible that the CLWB tanks located outdoors resulted in more rapid net loss of BTEX compounds.

In general, the results are expected, following the trend of more rapid and complete dissolution with mixing, as well as more rapid net loss of these constituents.





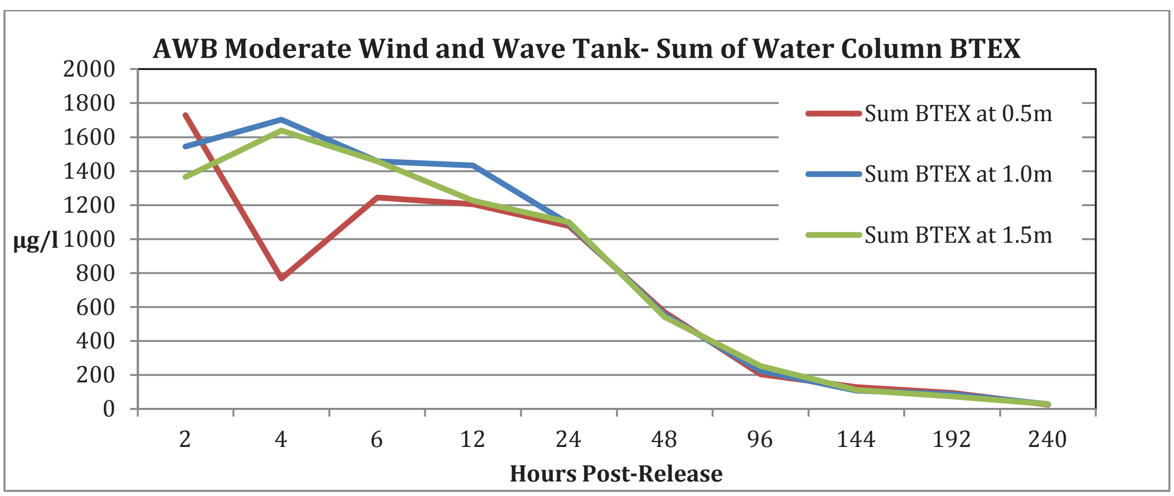


Figure 4-12: BTEX in water column samples – AWB Tanks

4.5 Dispersant Application

Visual observations suggested that the dispersant was marginally effective on the relatively fresh oil (six hours weathered CLWB) but not effective on the one day weathered CLWB. The one day weathered CLWB was affected by the dispersant as application produced oil globules/droplets in the cm-scale size range; however, substantially more oil remained on or returned to the surface following the test than the six hour weathered oil sample. Comparisons of the weights of applied oil and oil recovered on sorbent pads corroborate the visual assessment of dispersant action (Table 4-8; Figure 4-13; also see Appendix B for dispersant datasheets). Measures of the TPH content in the water column prior to oil placement, following oil placement and prior to dispersing, and post-dispersant application (Table 4-9) corroborate the visual observations.

Oil Sample (Weathering Time)	Weight Applied (g)	Weight Recovered (g)	% Dispersed (Not Recovered on Sorbent)
SD-6HR	871	422	52
SD-1 Day	895	929	-4

Table 4-8: Calculated weights of CLWB tested and recovered during dispersant trials

Oil Sample ID	Description (Weathering Time)	TPH / Alkanes (mg/L)
SD-0H-W500	Water sample taken prior to spill (6 hours weathered CLWB)	<2.0
SD-6H-W500-1	Water sample taken 20 min after spill (6 hours weathered CLWB)	<2.0
SD-6H-W500-2	Water sample taken 20 min after using Corexit 9500 on oil (6 hours weathered CLWB)	360 (1)
SD-1D-W500	Water sample taken prior to spill (1 day weathered CLWB)	<2.0
SD-1D-W500-1	Water sample taken 20 min after spill (1 day weathered CLWB)	<2.0
SD-1D-W500-2	Water sample taken 20 min after using Corexit 9500 on oil (1 day weathered CLWB)	80 (1)

Table 4-9: TPH / Alkanes (mg/L) measured in water samples during dispersant trials

Sample	Agitation	Density	% Effectiveness
S9B-6H-01	Static	0.9557	7.8
S9B-1D-01	Static	0.9627	4.6
S9B-4D-01	Static	0.9765	0
S9C-6H-01	Mild	0.9471	5.5
S9C-1D-01	Mild	0.9853	5.4
S9C-4D-01	Mild	0.9934	0
S4-6H-01	Mild	0.9708	5
S4-1D-01	Mild	0.9851	3.3
S9A-6H-01	Moderate	0.9667	6
S9A-1D-01	Moderate	0.9813	5
S9A-4D-01	Moderate	0.9968	0

Table 4-10: Laboratory measured dispersibility of weathered CLWB determined by Swirling Flask testing

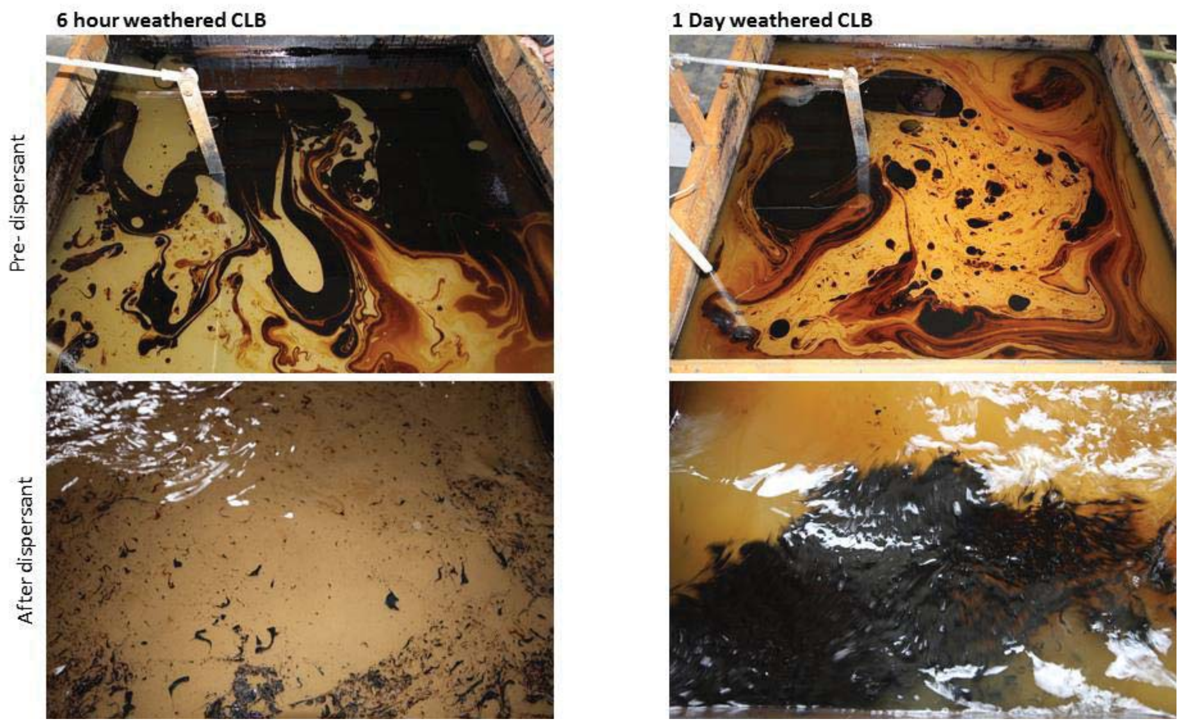


Figure 4-13: Photos of dispersant application on weathered CLWB dilbit

Although visual observations and the measured floating oil weight recovered during the meso-scale field tests indicated that Corexit 9500 is not effective on the one day weathered CLWB, additional research is required to further characterize this and other types of dispersants' effectiveness on CLWB.

Laboratory tests conducted of Corexit 9500 dispersant on weathered CLWB samples showed minimum dispersant effectiveness with values ranging between 0 to 7.8 percent (Table 4-10). All samples weathered for four days showed no dispersibility. The maximum dispersibility corresponded to six hour weathered CLWB oil that had remained in the static tank.

4.6 Controlled Burning

Tests revealed that CLWB can be successfully ignited and burned provided weathering is limited to less than 3 days (with equivalent density of less than 997.7 kg/m^3 and viscosity less than 8018 at 40 °C). The first burn test (Six hour weathered CLWB) ignited relatively easily and burned well for a period of approximately two minutes and extinguished on its own. The second test (24 hour weathered CLWB) was difficult to ignite and took two attempts. The second attempt, using more accelerant than 6 hour weathered CLWB (200 mL more diesel) and higher torch-temperature, burned for approximately 2 minutes once started. A sustained burn was not achieved for the 72 hour weathered oil sample, despite added diesel as an accelerant and repeated direct attempts with the propane torch. Comparisons of the weights of applied oil and oil recovered on sorbent pads provide approximate oil removal efficiency from the test burns (Table 4-11; Figure 4-14; also Appendix C for ISB datasheets). Burned residue on the steel ring was only partially removed between burns two and three and likely contributed to the higher amount of oil recovered on sorbents following the S4-3 day post-burn attempt.

Oil Sample (Weathering Time)	Weight Applied (g)	Weight Recovered^ (g)	% Burned (Not Recovered on Sorbent)
S4-6HR	1735	447	74
S4-1 Day	1803	856	53
S4-3 Day	1657	1912	0

Table 4-11: Calculated weights of CLWB dilbit tested and recovered during burn trials

Figure 4-14: Photos of CLWB dilbit burns

4.7 Substrate Surface Washing

Flushing alone was ineffective at removing the majority of bulk oil and black stain in all instances. Increasing pressure removed bulk oil throughout the experiment but black stain persisted. Only increasing the pressure and temperature to >60 psi (0.41 MPa) and >60°C, a point known to be more harmful to biota than the benefit of the treatment (Mauseth et al. 1997), removed all but a black stain during the test period without the use of a shoreline cleaning agent (see additional photos in Appendix D).

The duration of effectiveness of Corexit 9580 in combination with ambient temperature, low pressure flushing was determined mainly by the time oil spent weathering on land. Effectiveness diminished at approximately 4 days (96 hours) on dry land in sunlight with no immersion in water (tide exchange) (Figure 4-15). This is assumed to represent a worst case scenario of oil stranded at extreme high tide and with no further submersion. As expected, oil exposure to sunlight made a difference in cleaner effectiveness. Oiled tiles that remained in shade were effectively cleaned with Corexit 9580 after up to 5 days (120 hours) of exposure to air. The time oil spent weathering on water had little noticeable effect given that Corexit 9580 effectively removed oil from the tiles for all three on-water weathering scenarios – 1 day (24 hours), 3 days (72 hours), and 5 days (120 hours) –when oil was allowed to sit on the tiles for 96 hours (sunlight) to 120 hours (shade). The thickness of the oil on tiles after 24 hours, however, varied from 0.5 mm (24 hours in water) to up to 2 mm (5 days in water)(Figure 4-15). Despite slightly thicker oil on tiles after the oil weathered for three and five days in the water, the Corexit 9580 appeared to be similarly effective on these tiles after equivalent drying times. Oil thickness may also be affected by slope and temperature, although there was no observed difference in oil thickness on several tiles that were laid flat. Colder temperatures or prolonged weathering may result in greater oil thickness, which could lead to variations in shoreline cleaning agent effectiveness.

A portion of the removed oil in the Corexit tests floated and was recoverable in both snare and sorbent pads while a portion appeared to have been dispersed rendering the water “muddy” in appearance. Once the agent was ineffective, the oil had weathered to a point where it could only be scraped off, or removed with high pressure and temperature. Little sheen was observed in the water after flushing, even with freshly coated tiles after 24 hours.

Flushing in combination with an off-the-shelf degreaser containing D-Limonene was ineffective at removing the majority of bulk oil and black stain in all instances. Commercial D-Limonene was not available and would likely have been more effective than off-the-shelf degreaser containing D-Limonene. Given the results of Corexit 9580, there is no reason to believe commercial D-Limonene would not be similarly effective on this oil. These results are not comparable to other studies using commercial grade D-Limonene.

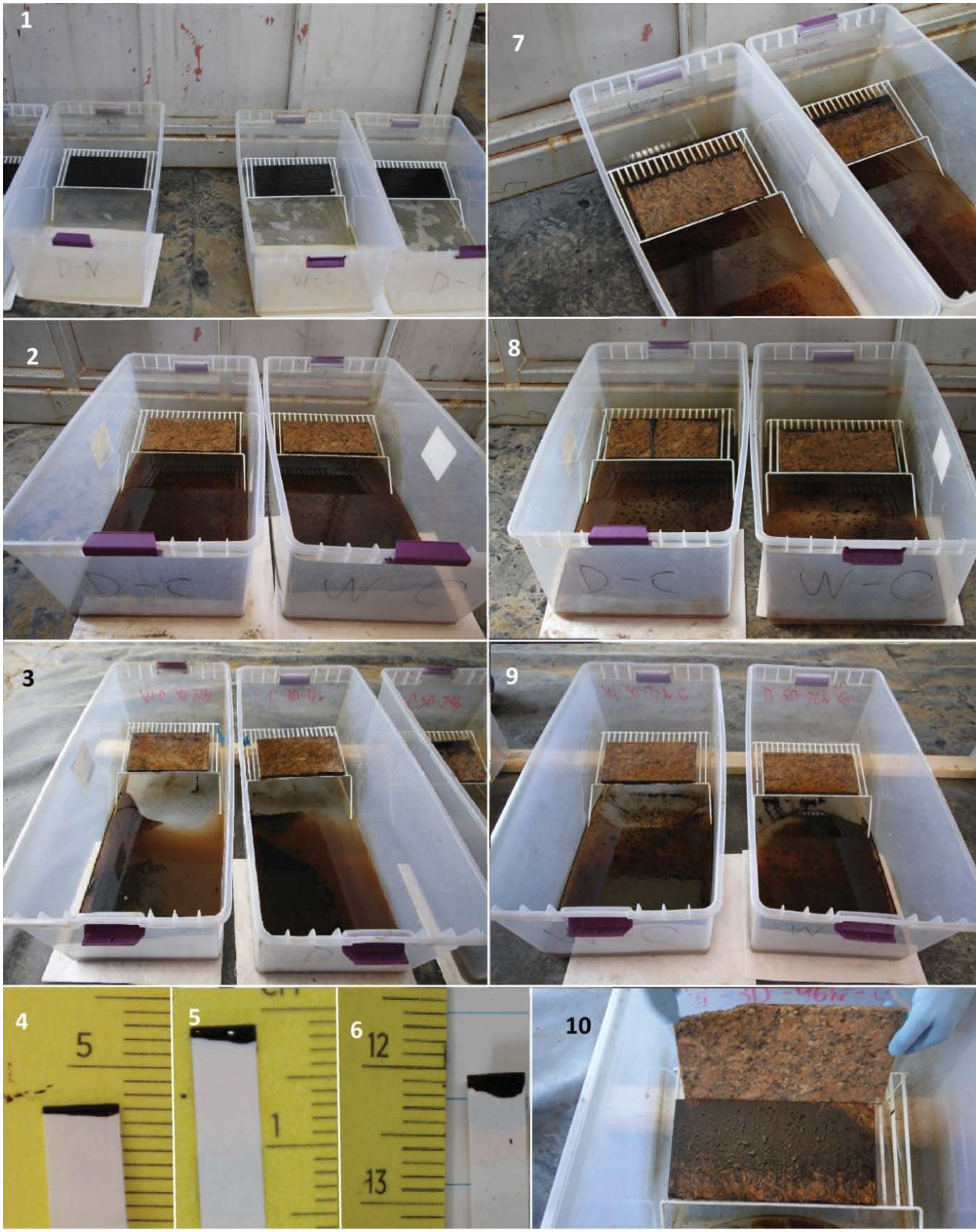


Figure 4-15: 1) Oil on water 24 hours, in air 24 hours, flushing, and D-limonene alone (ineffective); 2) Oil on water 24 hours, in air 24 hours, Corexit 9580; 3) Oil on water 3 days, 72 hours in air, Corexit 9580; 4) Oil thickness of oil on water 24 hours, in air 24 hours; 5) Oil thickness of oil on water 3 days, in air 24 hours; 6) Oil thickness of oil on water 5 days, in air 24 hours; 7) Oil on water 24 hours, in air 48 hours, Corexit 9580; 8) Oil on water 3 days, in air 48 hours, Corexit 9580; 9) Oil on water 5 days, in air 72 hours, Corexit 9580; 10) Oil on water 3 days, in air 96 hours, Corexit 9580

5 Discussion

5.1 Oil Fate and Behavior

Changes in the physical properties of AWB and CLWB dilbits were similar throughout the 10-day trials. Increased agitation (wave paddle and wind) yielded slightly faster weathering rates as revealed in oil densities (Figure 5-1). Initial oil densities of 921 kg/m^3 and 925 kg/m^3 of the AWB and CLWB dilbits, respectively, increased to greater than 980 kg/m^3 within approximately 24-48 hours of weathering in all cases in which agitation was applied. Relative densities continued to increase with further weathering albeit at a slower rate. Like many other heavy crude oils with only slightly positive buoyancy after weathering, these oils could become submerged with the addition of sediment and negatively buoyant particulates, or after contact with the shoreline where they may attach to particulate matter.

Oil and emulsion viscosities increased for both AWB and CLWB dilbits within the first 24 to 48 hours, factors that influence oil behavior on water and potentially affect oil skimming and pumping systems. AWB dilbit under moderate agitation showed the most pronounced initial increase in viscosity (Figure 5-2), increasing from an initial value of less than 1000 cSt to over 10,000 cSt within a 4 to 6 hour window. CLWB dilbit under moderate agitation reached 10,000 cSt at approximately 12 hours, whereas both dilbits, under mild agitation, required approximately 24 hours of weathering to achieve the same viscosity. Depending on the type of dilbit and agitation conditions, the viscosities of the emulsions continue to increase over time to the next order of magnitude, 100,000 cSt, after 4 to 8 days of weathering.

Exposure to ultraviolet (UV) and ambient air conditions (S4 and initial 48 hrs for S9) may account for a slight increase in weathering rates.

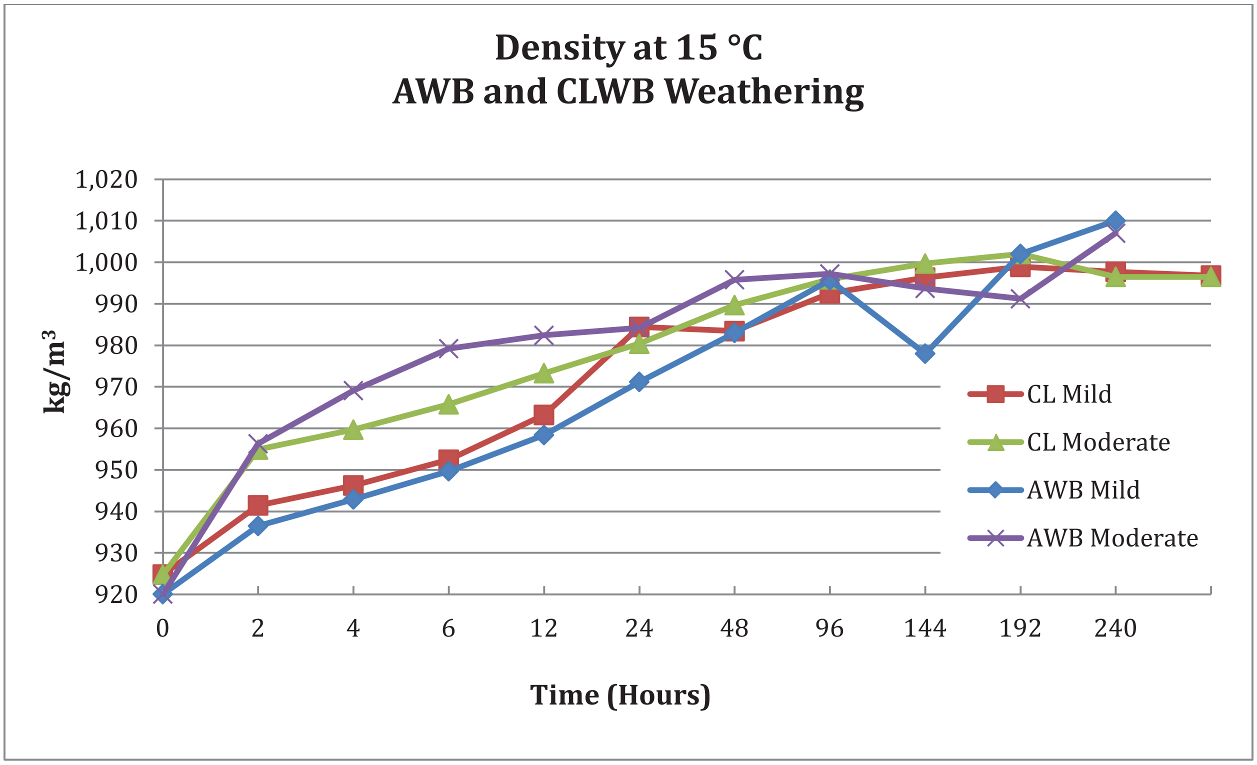


Figure 5-1: AWB and CLWB dilbit densities relative to degree of weathering

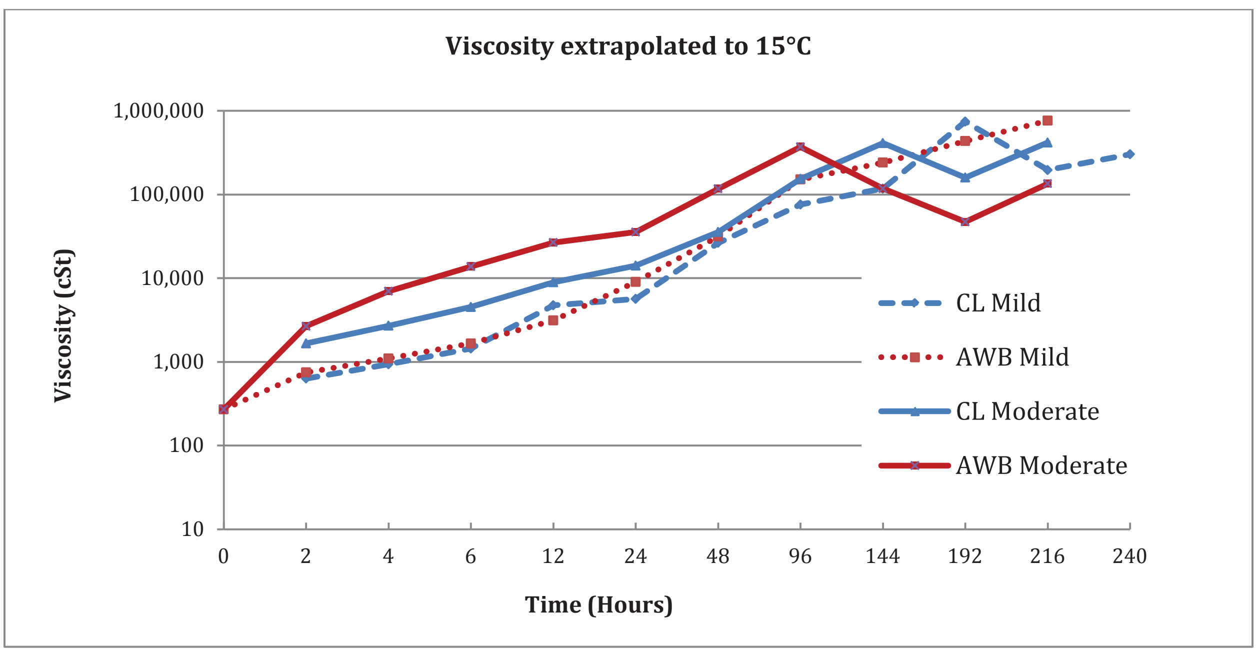


Figure 5-2: Viscosity of weathered AWB and CLWB dilbits under mild to moderate agitation

Both AWB and CLWB dilbits exhibit water uptake within the weathered oil matrix, although not as a stable, uniform emulsion but rather as a mechanically mixed and unstable oil-water combination. Water content analyses, conducted following procedures for whole oil, showed no systematic uptake or pattern for either oil during the weathering process. Given the unstable character of water in oil, sampling and sample processing may result in very different oil-water mixtures at the time of analyses; hence, no conclusions are drawn for those tests other than to note that the maximum water contents measured, above 40 percent, were noted on samples from three tanks (S3, S9A, and S4) with moderate and mild agitation, respectively, and after 1 to 3 days of weathering.

5.2 Spill Countermeasures

The meso-scale tests provided an opportunity to test various spill countermeasures and to ascertain to what extent these may be viable options for response in marine waters.

5.2.1 Dispersants' Effectiveness

Dispersants can be effective as a spill countermeasure provided appropriate environmental and operating conditions are met and that the dispersant is effective on the oil as it weathers. The meso-scale tests with weathered CLWB dilbit showed that some dispersion can be achieved using the recommended dose of 1:20 with Corexit 9500 on CLWB dilbit within the first day of response, depending on extent and degree of weathering. With viscosities approaching 10,000 cSt within the first 12 hours, the potential window for dispersant use is limited. Dispersants are very unlikely to be applicable within Burrard Inlet but may be an appropriate response option in open marine settings to complement mechanical systems. Although dispersant use has not been approved for use on actual spills in Canada, they have been conceptually approved on spill exercises and are part of the response options in the State of Washington waters of the Strait of Juan de Fuca.

5.2.2 Controlled In-Situ Burning

Like dispersants, controlled in-situ burning (ISB) can be effective as a spill countermeasure provided appropriate environmental and operating conditions are met and that ignition can be started and sustained on the oil as it weathers. The meso-scale tests conducted with weathered CLWB dilbit showed that ISB is viable on oil weathered up to one day. Agitation led to water uptake within the oil matrix and could impede initiation of a burn. Burns would not be expected to be a countermeasure used within Burrard Inlet but could be an effective countermeasure to complement mechanical response options particularly in remote areas.

5.2.3 Shoreline Cleaner

Options for shoreline cleaning depend on the degree of oiling, type of substrate oiled, and character of oil. The Gainford test provided an opportunity to consider a shore cleaning agent, Corexit 9580, for its effectiveness as a possible aid in shore cleanup operations for weathered, stranded CLWB dilbit. Prior experience during response to the Burnaby spill had shown that Corexit 9580 worked effectively to enhance shoreline cleanup. Quick assessment field tests conducted during that spill response were used to gain approval for use of the agent during cleanup of the dilbit on cobble shorelines in Burrard Inlet.

The meso-scale tests showed that removal of oil that had weathered for five days on water and then remained on tiles and exposed to air for four days was still effective when using washing substrate treated with Corexit 9580. Low pressure washing (up to approximately 50 psi) of oiled substrate alone is unlikely to be effective for a shoreline oiled with dilbit. Over-the-counter degreaser with D-Limonene proved to be ineffective, although these tests are not comparable to others using commercial formulations intended for spill response. Approval for use of Corexit 9580 should be sought immediately following a spill and prior to shoreline contact to ensure there is sufficient time to use it effectively if needed.

5.3 Oil and Water Chemistry

A comparison of the polycyclic aromatic chemical components in fresh oils (AWB, CLWB, and Alaska North Slope (ANS)) is shown in Figure 5-3. Generally, the naphthalene content is higher in the ANS crude relative to CLWB or AWB, whereas the latter crudes have slightly higher heavier PAH contents.

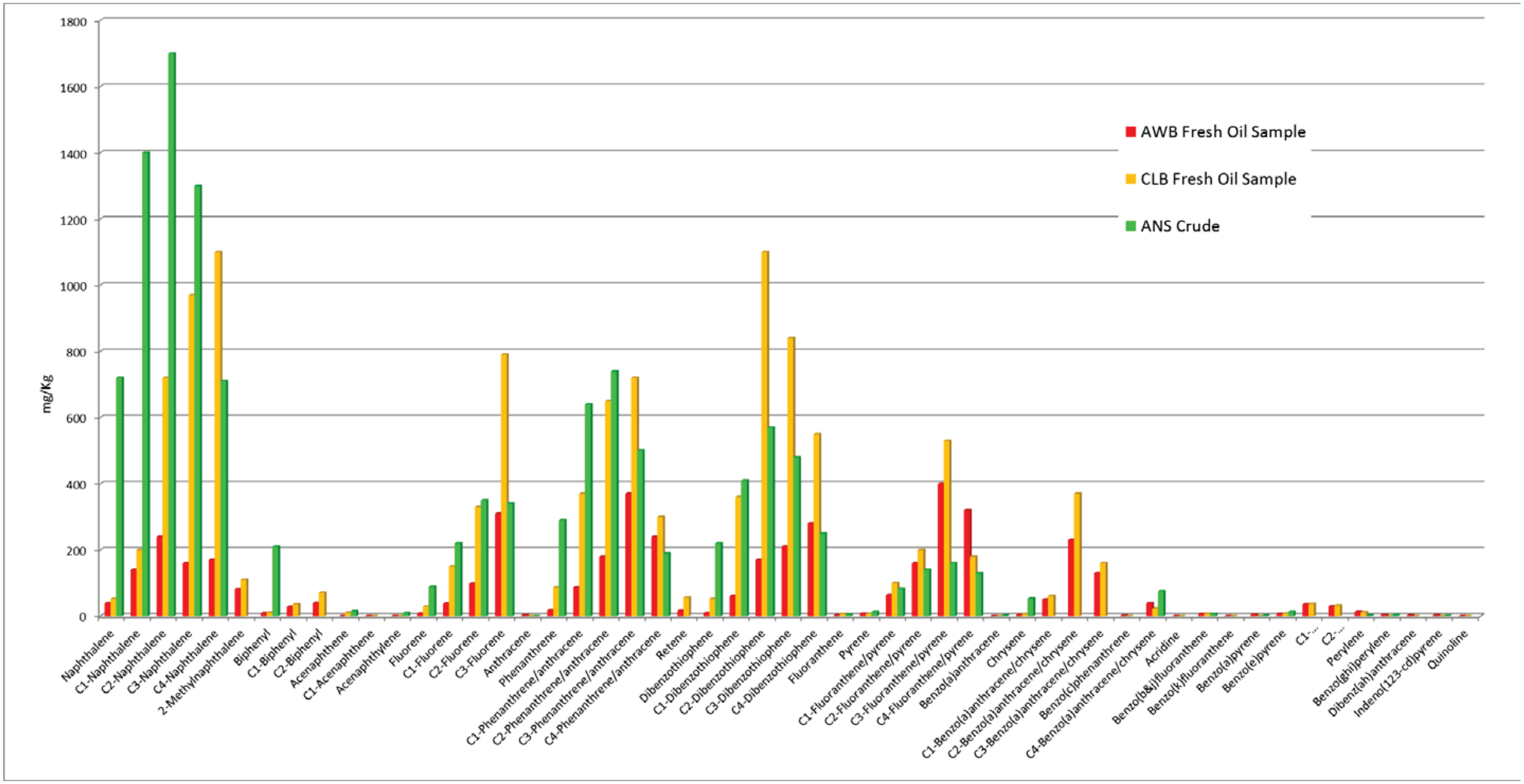


Figure 5-3: Comparison of PAH concentrations between CLWB and AWB dilbits and ANS crude

BTEX in the water column dissolves faster and is depleted in the water column with increased agitation (Figure 5-4 and Figure 5-5). These BTEX concentrations and the depletion rates shown are from the confined water in the tank below an artificially thick slick. Unconfined oil, mixing, and dilution would result in much faster depletion rates and lower concentrations.

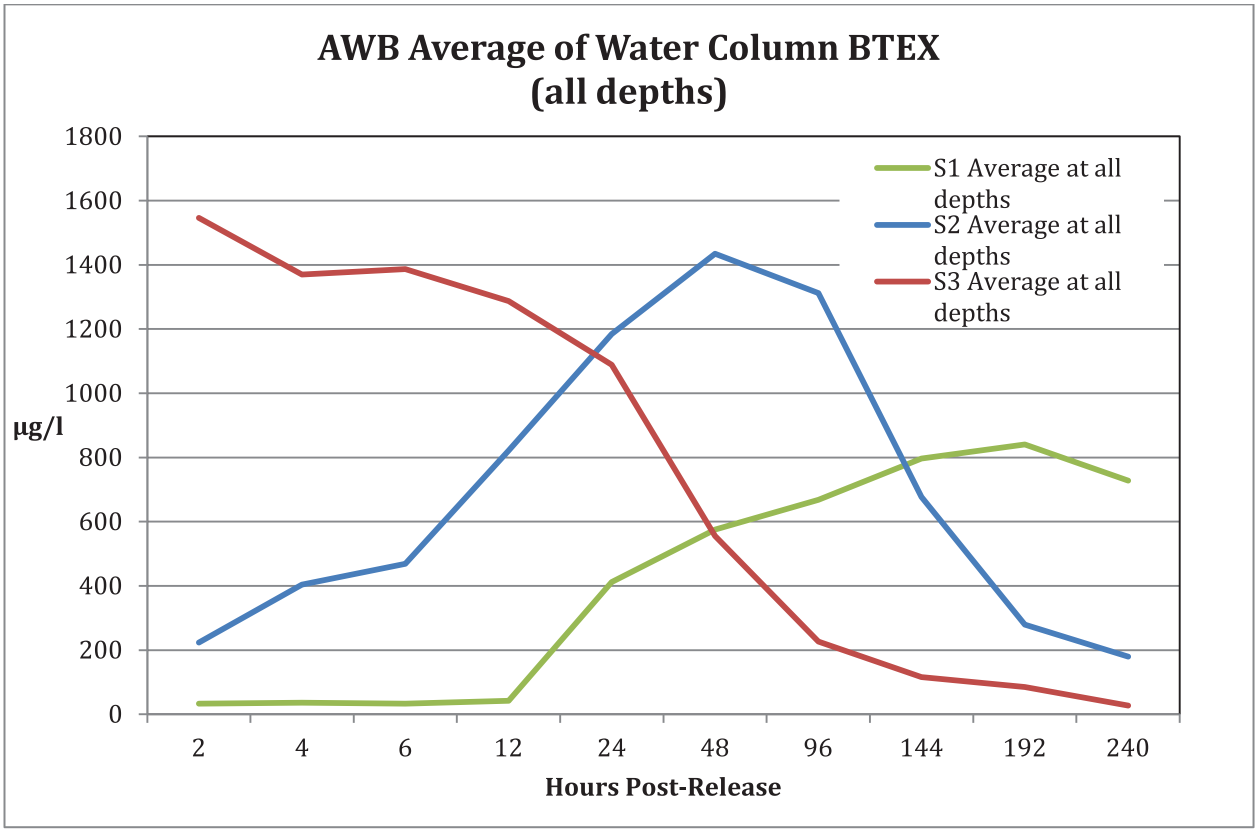


Figure 5-4: Average BTEX concentrations in water from 0.5, 1, and 1.5 m below AWB dilbit

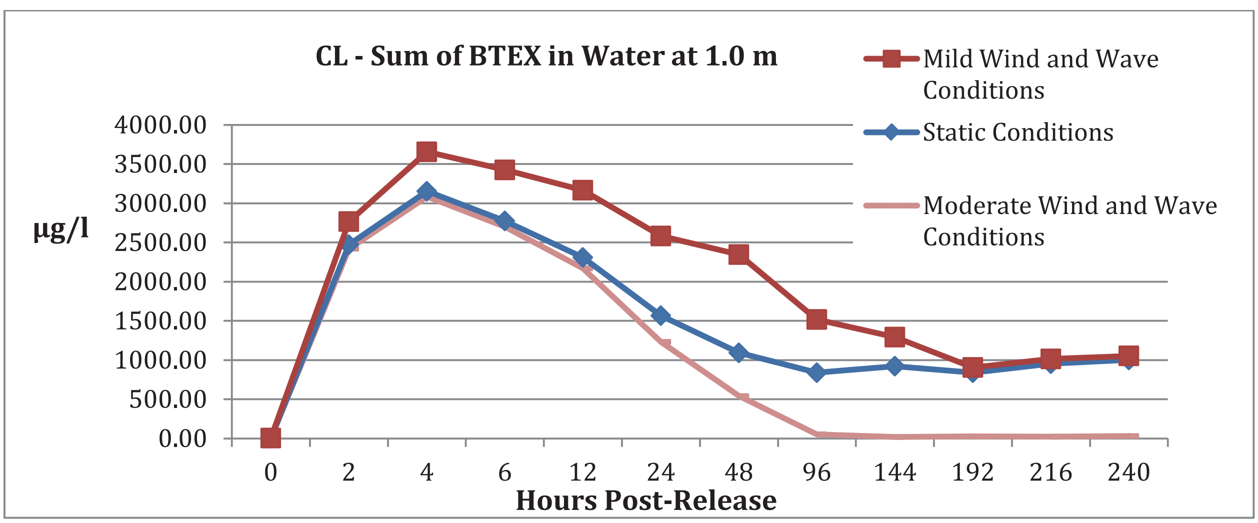


Figure 5-5: BTEX concentrations in water at 1 m depth below CLWB dilbit

6 Equipment Testing

The oil spill recovery equipment testing was conducted concurrently with the scientific study as a way to investigate the efficacy of mechanical skimmers on oil sands products, specifically dilbit. The parallel testing of skimming equipment with the scientific study offered attractive efficiencies for the project including: 1) maximum use of personnel and supporting material; 2) complete site utilization; 3) execution under similar conditions; and 4) availability of common source oil. Additionally, conducting the studies at the same time and location enabled test site visitors to simultaneously observe both studies.

Skimming equipment for the Gainford field test was provided by interested vendors who volunteered to exercise their equipment in an effort to better evaluate unit performance on oils produced from bitumen extracted from oil sands in Alberta, Canada. Western Canada Marine Response Corporation (WCMRC) personnel worked closely with the equipment vendors to enhance the overall test experience.

Figure 6-1: Vendor providing a briefing prior to equipment testing

6.1 Methodology

6.1.1 Facility Design and Tank Layout

The equipment test was conducted adjacent to the scientific study area at the same pump station located in Gainford, Alberta (Figure 6-1). Heavy equipment was used to construct a below grade containment pad which was then lined with an impermeable membrane.

Inserted into the test pit were a series of open-top welded steel bins, also known as “roll-off boxes.” These 26.5 m^3 (7,000 gallon) capacity rectangular tanks measured 6.4 m by 3.0 m by 1.4 m. Each skimmer was assigned a dedicated test tank. The equipment test tanks were given the following designations:

Tank Designation	Purpose	Note
E1-E5	Skimmer Testing	The test site was initially designed for five skimmer tests; three vendors participated in the Gainford test. Those vendors were assigned tanks E-3, E-4 & E-5. E-1 was later consigned to additional science testing and re-designated S-9. E-2 was a surplus tank.
E6	Common Discharge Tank	Described in the methodology section below.
E7	Weathered Oil Tank	Contained oil that was left to weather for ten days, then used for the last day of skimmer testing (May 22).
E8	Waste Oil Tank	a.k.a. the "Slop Tank."
CC	Calibration Cube	Used for measuring oil recovered during the timed portion of the skimmer tests.

Table 6-1: Tank designations

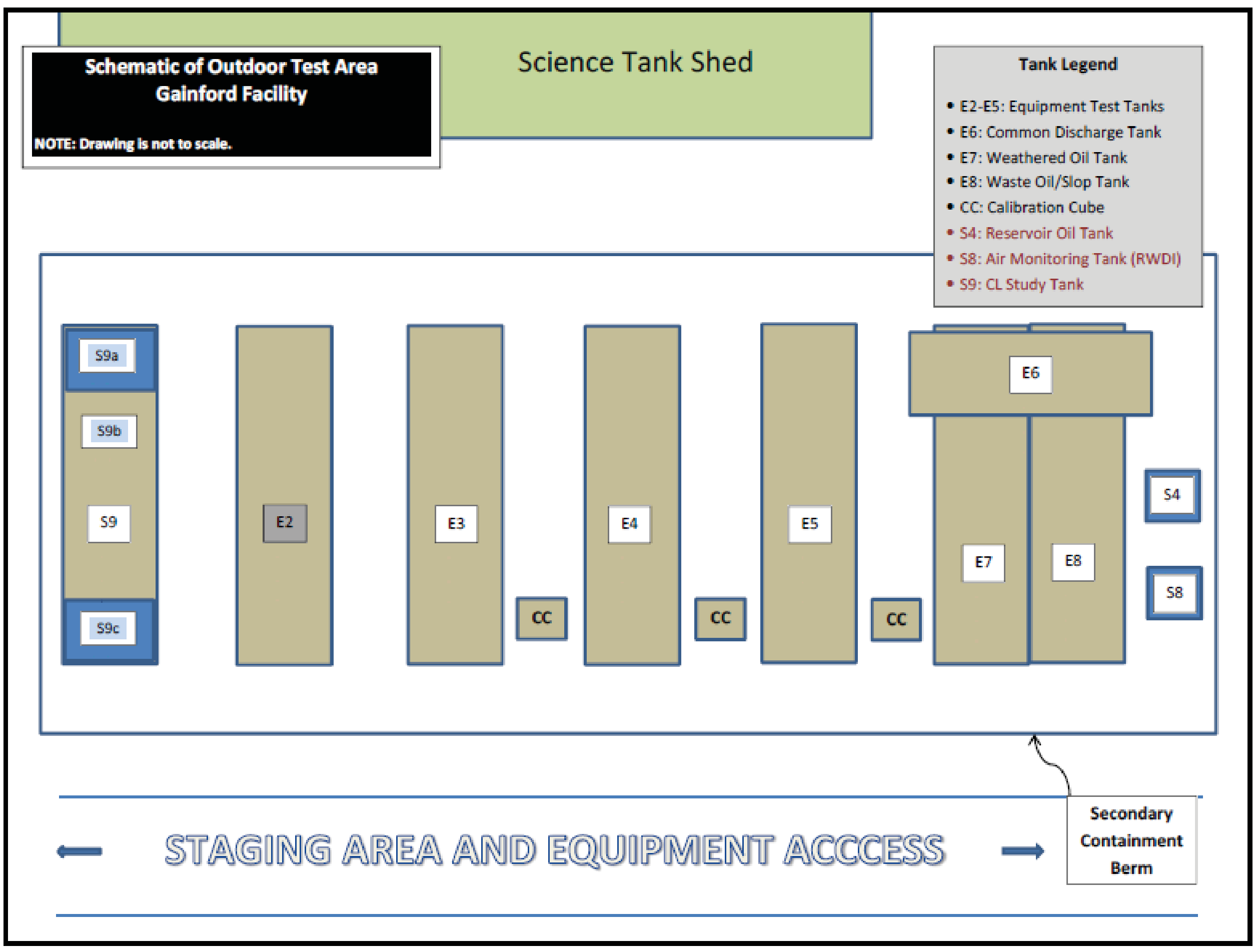


Figure 6-2: Equipment test tank schematic

6.1.2 Testing Protocols/ASTM Standards

The objective of the Gainford equipment test was to evaluate whether the current inventory of oil skimmers is suitable for recovering a common dilbit product. Each skimmer manufacturer was offered the opportunity to perform under consistent operating conditions and measurement procedures that were guided by the following ASTM standards:

F-631: Standard Guide for Collecting Skimmer Performance Data in Controlled Environments
F-2008: Standard Guide for Qualitative Observations of Skimmer Performance
F2709-08: Standard Test Method for Determining Nameplate Recovery Rate of Stationary Oil Skimmer Systems

It should be noted that each of the respective manufacturers of the devices exercised at Gainford had previously tested their units under strict adherence to ASTM standards as part of the nameplate recovery certification process. As such, it was not the intent of the Gainford study to replicate any of those prior tests. Rather, the ASTM standards referenced at Gainford were used only as guidance for the following parameters:

- Quantitative measurement of ambient conditions
- Appropriate laboratory analysis of virgin and recovered product
- Test facility design
- Test methodology
- Skimmer performance calculations

To allow vendors to correctly configure power units, check hose connections, and ensure operability prior to test commencement, vendors were given the opportunity to calibrate their equipment with the water of their respective tanks prior to the discharge of any oil.

Oil was discharged into the test tanks on May 13, and the subsequent tests followed the protocol as detailed below:

1. Allow the oil to stand for four hours prior to skimmer testing to reduce the combustible gas and benzene levels.
2. Skimmer discharge lines were plumbed so that the recovered liquids could be diverted to either a calibration cube or to the common waste tank (E6). After achieving steady state operation in the discharged oil, the subject skimmer effluent was diverted from the common waste tank (E6) to the calibration cube for a specified time (initially 30 seconds but modified in later test periods to a full 4 minutes; see modification 1 below).
3. The product in the calibration cube was allowed to settle for approximately one day after which the total liquid volume was measured. The cube was then decanted of free water. Once the water was removed the volume of the cube was again measured. An oil sample was then taken from the calibration cube sample tap and analyzed offsite for

water content according to Karl-Fischer Titration procedures (ASTM D1123). The volumetric measurements were then used to determine the skimmer's recovery capacity and efficiency.

4. The fluids accumulated in the common waste tank (E6) were allowed to settle for approximately one day. Thereafter, the water was decanted, and the remaining emulsion was gravity fed in equal amounts back to the test tanks. This procedure provided each of the skimmers with a common starting point for the next test in the sequence (see modification 2 below).

In accordance with the plan, these procedures were repeated on Day 3 (~48 hours after the initial oil release); Day 5 (~96 hours); Day 7 (~144 hours); and Day 9 (~192 hours).

On the last test day, Day 10 (~240 hours), a final test was conducted with skimmers exercised in tank E7, the weathered oil tank. The weathered oil tank (E7) was charged with 625 L (165 US gallons) of CLWB that had been poured in it on Day 1 (May 13) and left undisturbed for ten days. Originally, this last day test with 10 day weathered oil was to be a "Best in Show" exercise; however, this test was also modified (see modification 3 below) to better reflect evolving conditions.

Figure 6-3: Day 10 testing

6.1.3 Discussion of Test Modifications Made During the Test Period:

Modification 1 - Discharge Time to the Calibration Cube: The initial plan called for the tests to be conducted for a uniform 30 seconds. This duration was based on ASTM guidance and the concern that the 1 m^3 calibration cube capacity would be exceeded. After the first day of testing concluded, it was determined that the calibration cubes had sufficient capacity and that the tests could be run for longer durations. As of the second round of equipment tests (Day 3; ~48 hours), it was mutually agreed that the skimmers would run for four minutes after achieving steady state operation. This modification to the testing procedure remained consistent for the subsequent five tests.

Modification 2 - Common Waste Tank: After the first day of testing it was determined that diverting oil to the common waste tank, settling the liquids, and then redistributing that oil back to the test tanks was laborious and offered no benefit to the test. Therefore, a second protocol modification was made such that skimmer discharge – prior to diversion to the calibration cube – would no longer be directed to E6, but would now simply be recirculated back to the source tank.

Modification 3 - Last Test Day: The last test day was modified such that any vendor who wished to test their skimmer in tank E7 (10 day weathered CLWB) would be given that opportunity. Two of the vendors agreed to do so.

6.2 Oil Type and Properties

The same CLWB (winter blend) as was issued for the fate and behavior science study was chosen to be used for the equipment test. The CLWB was drawn from the pipeline in March and stored until the time of the test in closed-top drums in Edmonton, Alberta. The CLWB possessed the following properties at the beginning of the test period at Gainford:

Absolute Density (kg/m^3)	925.2
Viscosity cSt @ 10 °C	309.6
Water Content (%)	0.43

Table 6-2: Properties of CLWB at the start of the equipment tests

Each test tank was given a measured, initial charge of three full 55 gallon drums (625 L or 165 US gallons) at the start of the test. To avoid emulsifying the oil from a plunging discharge stream, hand pumps were used to deliver the product onto a horizontal spillway resting on the surface of water. Releasing the oil into the E-series tanks took place between 1000 and 1100 on May 13.

The average thickness of the oil at the start of the test was measured to be ± 30 mm. This dimension was derived from calculations using vertical height measurements. In the interest of safety, skimmers had been pre-positioned in each tank after water depth measurements were taken but prior to discharge of the oil. This caused a perceived variation in slick thickness as a result of the different displacements of the skimming systems.

In accordance with the work plan, testing began on the first day of the release, approximately four hours after the nominal start of the spill, roughly between 1530 and 1600 on May 13.

6.3 Water Properties

Comparable to the science test tanks, the water properties of the equipment test tanks were representative of Burrard Inlet in British Columbia. The following target water conditions were determined to replicate Burrard Inlet water conditions for the purposes of this exercise:

Water Temperature	10 °C (50 °F)
Salinity	20 ppt (estuarine/brackish)
pH	7 (neutral)

Table 6-3: Water properties (target)

Site personnel were able to meet the target values for salinity and pH; however, higher than expected ambient air temperatures caused the tank water temperature to rise above the target value (see Table 6-4). Elevated water temperature was not deemed to be a significant factor in skimmer performance and realistically constituted conditions that could be experienced on Burrard Inlet surface waters during a summer day.

6.4 Equipment Tested

Under uniform conditions, the following skimming systems were tested in succession on the same days:

6.4.1 Aquaguard RBS Triton 60 DI3 Oil Skimming System

The Aquaguard system tested at Gainford was a brush skimmer driven by a diesel/hydraulic power pack. The skimmer's recovery technology uses oleophilic adhesion of the oil to the bristles of a brush rotating through the oil/water interface. A scraper removes the recovered product which is then collected in a common sump and pumped to a remote storage container.

Figure 6-4: Aquaguard RBS Triton Skimmer

Below are RBS Triton features summarized from the Aquaguard brochure:

- Stated recovery rates based on tests "witnessed by ABS Marine Services and Det Norske Veritas –tested to the ASTM-F631-93/99 standard;"
- Up to 98 percent efficiency;
- Versatile; brushes can be interchanged with either drums or discs for various oil types;
- When outfitted with the brush attachment, the recovery rate is 63 m^3/hr (396 bbl/hr).

6.4.2 Desmi DBD-5 Skimmer

The Desmi DBD-5 system was a diesel/hydraulic powered skimmer fitted with an oleophilic brush-drum assembly. The drum rotates through the oily water where oil is attracted and adheres to the brush surfaces. A scraper transfers the recovered oil into a central collection sump.

Below are DBD-5 features summarized from the Desmi brochure:

- Stated recovery rate with brushes is 7 m^3/hr (44 bbl/hr);
- This small unit has a 0.12 m or 5 inch draft suitable for use in shallow water environments

Figure 6-5: Desmi DBD-5 Skimmer

6.4.3 Lamor MultiMax LAM 50/3C Brush Skimmer

The Lamor system tested at Gainford was a stiff-brush conveyor belt type oil skimmer. The conveyor belt consists of three stiff-brush-chains. The oleophilic brush conveyor belt uses a patented brush cleaner to separate the oil from the water and lift the recovered product to the oil transfer pump.

Below are LAM 50/3C features summarized from the Lamor brochure:

- Bureau Veritas-certified recovery rate of 53.1 m^3/hr (334 bbl/hr);
- Designed to recover all types of oil with particular effectiveness in weathered oils, crude, high viscosity bunker oil, and emulsions.

Figure 6-6: Lamor MultiMax Skimmer

6.5 Results

6.5.1 Qualitative Observations and Comments

The Gainford equipment test sought to investigate the following questions:

- Does Cold Lake bitumen behave differently from other heavy crude oils commonly handled by this industry?
- Is the current inventory of skimmers, available to Trans Mountain Pipeline ULC and its contractors, capable of mechanically recovering dilbit under conditions that can be reasonably expected in the subject marine environment?
- From a recovery equipment operator's perspective, does dilbit behave differently from other crude oils you have recovered?
- Also from the operator's perspective, does the equipment get compromised in any way as a result of recovering dilbit?
- How does weathered dilbit affect equipment operation, performance, and ultimately the recovery rate?
- Can adjustments be identified to improve skimming operations of dilbit spilled on marine waters?

<u>Observations associated with the primary equipment test objective:</u>

- Throughout the allotted time period, all of the skimmers proved effective in recovering the product, whether it was fresh, emulsified, or naturally weathered after a 10 day exposure to ambient element conditions.
- There were no conditions during the testing period under which any of the three skimmers failed to operate.

<u>Peripheral observations:</u>

- At discharge the oil was less viscous than anticipated, prompting the vendors to state they would have preferred to have used oleophilic discs at the outset of the test and then switched to brushes later as the oil became more viscous.
- The oil floated throughout the 10 day period. No instances were observed of the oil's buoyancy being compromised either neutrally downward in the water column or sunken to the bottom of the tank. Visual observations of the tanks during final decontamination further affirmed the absence of sunken oil.
- Vendors and contractors both agreed that under the test conditions this dilbit behaved no differently than other crude oils and proved to be mechanically recoverable by the skimming units tested. As mentioned previously, owing to the light viscosity, recovery of the early discharged product would have been improved by the use of drum and disc skimming attachments. It was not until after a few days of weathering that the vendors would have opted to use the brush/belt attachments.

Figure 6-7: Equipment testing (Calibration Cube is to the right of Tank E5)

6.6 Weathered Oil Properties

- The data presented in Table 6-4: Summary data from equipment testing (also see Appendix G) documents the average density of the oil in the equipment test tanks starting at a value of 925.2 (absolute density at 15 °C/API 21.3) on May 13 and steadily increasing to 988.8/11.5 by May 21. These density numbers represent an average value for the oil contained in each of the three equipment test tanks over that time period. It should also be noted that this oil was not only weathering but was also being agitated and emulsified by the skimmers.
- The following density numbers for the same time period were for the undisturbed oil in tank E7 (the static tank): 925.2 kg/m^3 (API 21.3) to 975.1 kg/m^3 (API 13.5).

Figure 6-8: Timed equipment test

6.7 Quantitative Data Results

Table 6-4 summarizes the conditions under which the equipment test was performed and displays a range of performance results measured during the test.

Table 6-4: Summary data from equipment testing (shown on the next two pages)

			Prior to Skimmer Testing									
Date of Test	Duration of Peak Test	Number of Skimmers Tested	Air Temp (Avg./°C)	Water Temp (Avg./°C)	Salinity (Avg./ppt)	pH (Avg.)	Water Content in Oil Sample (lab result; %)		Density of Oil Sample (lab result; Absolute; kg/m³ @ 15 °C)		Viscosity of Oil Sample (lab result: cSt @ 10 °C)	
							High	Low	High	Low	High	Low
13-May	2 min	3	23.0	13.6	21.0	7.0	0.4		925.2		309.6	
15-May	4 min	3	17.0	15.5	22.6	7.0	4.1		952.4		1963.0	
17-May	4 min	3	14.5	17.1	20.3	7.7	35.5	8.8	985.1	970.1	303.4	113.9
19-May	4 min	3	11.8	18.9	20.0	7.6	41.2	27.7	989.9	982.5	446.2	235.9
21-May	4 min	3	14.8	19.5	21.3	8.0	45.1	22.5	993.0	986.2	611.3	299.7
22-May	4 min	2	15.1	18.4	18.0	7.5	1.2		975.1		153.8	

These values were for the oil at the beginning of the test and the oil from the common discharge tank. After the modification of the test, such that skimmers were discharging into their own tanks, there was a high and low value from those three tanks.

Values are from one tank (E7) which had been left for 10 days undisturbed.

These values were measured at 70 °C.

Date of Test	Approx. Elapsed Time from Oil Release that Test was Conducted (Hrs.)	Cal. Cube Avg. Settling Time (hh:mm)	Water Content in Oil Sample from Cal. Cube (lab result; %)		Total Fluid Recovered in Calibration Cube (measuring 113 cm x 92 cm; values below in cm)		Total Rate of Oil Recovery (liters/sec.)		% of Oil Content in Cal. Cube		% of Water Content in Cal. Cube	
			High	Low	High	Low	High	Low	High	Low	High	Low
13-May	4	24:00	22.0	5.7	34.0	7.5	0.86	0.21	33	19	81	66
15-May	46	19:56	91.1	8.2	16.5	14.5	0.59	0.58	95	81	18	5
17-May	96	21:03	50.4	24.1	17.7	8.1	0.70	0.31	98	79	21	2
19-May	144	21:38	47.5	20.0	39.8	10.6	0.71	0.40	94	28	72	6
21-May	192	23:40	49.0	26.2	20.0	6.1	0.82	0.25	95	79	21	5
22-May	216	22:34	17.0	13.2	8.2	2.9	0.26	0.12	97	73	27	3

This particular sample jar was almost all water and this number is an anomaly. The comparative numbers should be 11.8 (high) and 8.2 (low).

7 Recommended Future Research

7.1 Science

The experiments conducted at Gainford, combined with previous and other recent tests, have advanced the general knowledge of dilbit weathering, fate, and behavior. Recent meso-scale tank tests have encompassed different imposed energy conditions as well as freshwater to brackish water conditions. Areas for potential future investigation include:

- Sediment interaction and sinking – a series of tests to help understand the sediment/oil interaction (degree of binding or adhesion, and resulting densities). Experience from the Enbridge spill at Marshall (2010, Kalamazoo, Michigan) noted oil bound to sediment had sunk but, in many cases, was easily released back into the water column with agitation. This indirectly suggests that the weathered dilbit was not tightly bound to sediment particles.
- Effects of different diluents and bitumens – more oil weathering testing has been completed with CLB dilbit, as this is one of the predominant commodities transported; however, different diluents and source bitumens in dilbit and synthetic crude (syncrude) blends may behave differently when spilled, as well as have very different chemical characteristics and potential effects. Laboratory and meso-scale testing with additional blends would augment and broaden the knowledge base for these oils.
- Sediment penetration and flushing – a series of previous experiments were conducted by Environment Canada to determine penetration and retention of different crude oils in different sediments and under different hydraulic and environmental conditions (Harper et al., 1995; Humphrey et al., 1993). Using similar protocols, subsequent testing was conducted by Environment Canada using bitumen (Harper et al., 2002b). Additional testing, following test protocols used for the subsurface oil in coarse sediments experiment(s) (SOCSEX; Humphrey et al., 1993; Harper et al., 1995), can provide improved details on oil penetration and retention for a broader range of sediment/soil types and under different hydraulic conditions (i.e., simulated riverbed on water level drops and rises, tidal flushing). Other variables to investigate would include sediment grain size, hydraulic conditions such as water level change/ tidal flushing, and temperature and weathering state. These results could be used in conjunction with data from previous similar experiments and spill observations to describe a more accurate projection of dilbit penetration, retention, persistence, effects, and removal.
- Shoreline cleaning agents – additional testing for cleaner effectiveness using a variety of available cleaning agents is recommended. Only two cleaning agents were tested during these trials, and one proved to be effective. A more robust complement of potential cleaning agents would assist with pre-approvals should they be needed.
- Dispersant effectiveness – additional testing of dispersants using fluorometers and for different dilbit blends under variable conditions of Day 0 to Day 1 weathering will provide valuable feedback as an early countermeasure option. Additional testing using a range of dispersant to oil ratios is also suggested.

- Controlled burning – additional tests of controlled burning on various dilbit blends and a range of initial oil thicknesses will provide important information to operational feasibility and constraints as an early countermeasure.
- Biodegradation – tests to determine the effectiveness of natural and enhanced biodegradation on dilbits will provide important information on guidelines for cleanup and remediation. An understanding of biodegradation rates under different environmental conditions and using varying combinations of nutrient enrichments will assist in guiding net benefits analyses for spill cleanup.

7.2 Equipment

When the opportunity for future testing presents itself, the following situations would benefit from further investigation:

- Interchanging oleophilic discs/drums with brushes at the outset or low viscosity portion of the test period.
- Providing equipment manufacturers with oil samples for use in their respective test facilities.
- While the dilbit used at Gainford did *not* sink, certain circumstances (notably those involving fresh water and robust sediment loads) may cause heavy oils to become submerged. This phenomenon would benefit from further experimentation and study.

8 Conclusions

The overall study objective was to obtain an expanded understanding and assessment of dilbit behavior, weathering, and OSR countermeasures performance under controlled simulated conditions similar to the potential receiving environment of Burrard Inlet. This objective was achieved through the Gainford meso-scale tests. Answers to some of the fundamental questions posed regarding potential dilbit spills into a setting such as Burrard Inlet were obtained, as summarized in Table 8-1.

8.1 Scientific Testing

Specific goals were to better understand and characterize the changes in physical and chemical properties and oil distribution of dilbit in an estuarine simulated condition over a 10 day period and to determine efficiency and effectiveness of dispersant, in-situ burning, and shoreline cleaning agents as potential countermeasures for various stages of weathered oil. The Gainford tests successfully met these goals.

Both AWB and CLB dilbits exhibited properties typical of a heavy, "conventional" crude oil. In no instance was any oil observed to have sunk. Visual observations of the surface of the oil in the various tanks showed that a crust, or armoring, formed as the oil weathered. In some instances, especially noted under static conditions, the lighter components of the oil came out of solution and bubbles formed within the slick. These bubbles rose to the surface and, in places, became trapped under the crusted layer. Weathered oil densities approached, and in several instances, exceeded that of freshwater but not that used to represent Burrard Inlet brackish water. Visual observations were made of weathered oil overwashing within tanks with agitation; however, the weathered oil did not submerge or sink in the tanks.

Chemical analyses of the weathered oils and of the water column showed that concentrations of BTEX diminished rapidly within 48 hours and that TPH in the water column only exceeded the detection limit (2 mg/L) during the first 48 hours in tanks with moderate surface agitation, despite the artificial confinement imposed by tanks relative to what may be expected in an open, natural setting.

Countermeasures tested included dispersant application, burning, and shoreline cleaners. The visual observations of the dispersant test revealed that Corexit 9500 was marginally effective on 6 hour weathered oil and not particularly effective for more weathered CLWB dilbit. The early test burn (6 hour weathered CLWB dilbit) was effective with a sustained burn of 2 L of oil lasting for more than 2 minutes with approximately 70 percent of oil removed through burning. Additional burn testing showed approximately 50 percent of 24 hour weathered oil was removed, but only after sustained effort to ignite. The 72 hour weathered oil was not successfully ignited. Tests with Corexit 9580 found the cleaning agent to be effective on oils weathered up to five days. Test observations noted that the time oil weathers on water before being placed on the tile was less important than the time the weathered oil was exposed to air.

Comments regarding frequently asked questions (FAQs; see Table 8-1) and key points are:

- There was no two-phase separation into bitumen and diluent;

- Off-gassing of light-ends has safety implications for responders and the public during the initial hours of exposure to a release, as is the case for most oil spills;
- Both AWB and CLWB dilbits remained floating on brackish water during the 10 days of weathering;
- Both AWB and CLWB weathered dilbits surpassed viscosities of 10,000 cSt within 48 hours and exhibited strong tendencies to form a more continuous thick mat rather than a thin sheen on water which, with continued weathering and agitation, can be expected to produce tar balls.

8.2 Equipment Testing

It should be recognized that any time operators, contractors, and scientists have the opportunity to work with crude oils in an environmentally-sound field exercise, all stakeholders will benefit. As such, the Gainford equipment test delivered positive results, as summarized below:

- No performance shortcomings were observed in the current inventory of recovery equipment available to TMPL and its contractors;
- The more viscous oil encountered on test days 7, 9, and 10 caused no skimmer malfunctions including stalls, seizures, or poor recovery;
- Operational adjustments to compensate for increased dilbit viscosity were no different than field adjustments made to equipment during actual spill events for most oils;
- This particular dilbit behaved similarly to any other crude oil that the Gainford spill response professionals had experienced in the past.

Does dilbit sink in water when spilled? Both Cold Lake Blend (CLB) and Access Western Blend (AWB) dilbits are lighter than freshwater. Dilbit spilled into fresh, brackish, or saltwater will stay on the water surface unless another mechanism mixes it into the water column, as would be the case for any oil. Only after extensive weathering may some portion become submerged or sink in freshwater, without invoking additional parameters that can modify the density of the spilled product.
Can dilbit be recovered from water using conventional spill response skimmers? Fresh dilbit oil is much like most medium to heavy crude oils and can be recovered using a variety of skimmer systems, ranging from weirs to oleophilic units. As dilbit weathers, the oil viscosity increases significantly but skimmers designed for more viscous oils, including brush, belt, and mechanical systems, can continue to effectively recover weathered oil (demonstrated in up to 10 days of weathering in tank tests).
Can chemical dispersants be effectively used on dilbit spills? Given appropriate safety, environmental, and operating conditions, dispersants may be effective within the first day of a spill before weathering results in oil that is too viscous to effectively disperse.
Is controlled burning a possible countermeasure for use on dilbit spills? Given appropriate safety, environmental, and operating conditions, burning may be effective but likely for a short time period (approximately 12-24 hours) before weathering results in oil that is too viscous to effectively ignite an sustain combustion.
How toxic is dilbit relative to other crude oils? The BTEX (benzene, toluene, ethylbenzene, and xylene) components in crude oils are some of the key chemicals of concern for toxicity. The BTEX content in CLB and AWB dilbits is approximately 1 to 1.2 percent by volume, respectively, which is slightly less than that found in Alaska North Slope or Alberta Sweet crude oils.
How variable are the weathering patterns and oil properties between different dilbits and syncrudes? The Gainford tests showed that the weathering patterns between CLB and AWB are similar and that oil physical and chemical properties are consistent with other heavy crude oil. The full range of properties of dilbit blends are well known and published (see Crude Oil Monitor), although weathering characterization of the range of oils is the subject of ongoing research.
Can spilled dilbit be contained on water? Lab and meso-scale tests have consistently shown both AWB and CLB dilbits to float on freshwater and saltwater. Spill containment strategies and tactics for floating oils are quite applicable to dilbit. Changes in spilled oil behavior and movement on water can be influenced by numerous factors. Effective containment requires adjusting strategies and tactics to changing conditions for a spill of any oil type.
Can spilled dilbit be effectively cleaned off shorelines? The Gainford meso-scale tests showed that fresh to very weathered CLB can be effectively removed from a hard substrate through a combination of shoreline cleaner (Corexit 9580) and low to moderate water pressure flushing. These techniques may not be suited for all types of shorelines; however, they generally are appropriate for coarse-grained materials (gravel, cobbles, and boulders and including coarse sediment mixes).

Table 8-1: Frequently Asked Questions.

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- Greg Challenger, Polaris Applied Sciences
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- Michael Davies, KMC TMX
- Kevin Gardner, WCMRC
- Andy Graham, Polaris Applied Sciences
- Bikramjit Kanjilal, KMC TMX
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- Gary Sergy, S3 Environmental
- Gary Shigenaka, NOAA

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- Steven Bott, CEPA
- Martin Bundred, ESRD
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- John McKim and Vince Mitchel, Lamor
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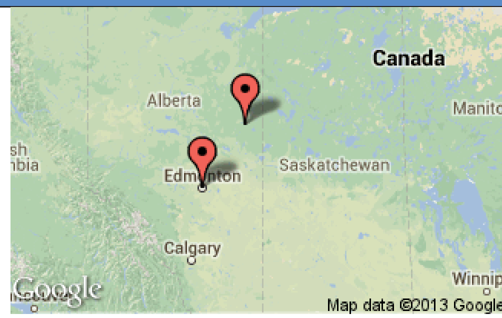
Appendix A: Crude Quality Inc. Data for Cold Lake and Access Western Blend

Witt O'Brien's, Polaris Applied Sciences, and
Western Canada Marine Response Corporation

crudemonitor.ca	Access Western Blend (AWB)
	Source: http://www.crudemonitor.ca/crude.php?acr=AWB

What is Access Western Blend crude?

Access Western Blend (AWB) is a heavy, high TAN dilbit produced by Devon Energy Canada and MEG Energy Corp. Production is from the Athabasca region south of Fort McMurray, Alberta. Production is generated by SAGD thermal methods. Diluent is supplied to the production sites from Edmonton and dilbit is pumped back to Edmonton on the Access Pipeline. AWB is available for upgrading in the Edmonton area, and for export on the Enbridge and Kinder Morgan systems.



Most Recent Sample Comments:
AWB-618, Jun 22, 2013

Access Western Blend contained marginally reduced BTEX, butanes, and C7 x C10 content for the month of June. This sample also showed a slight increase in pentanes.

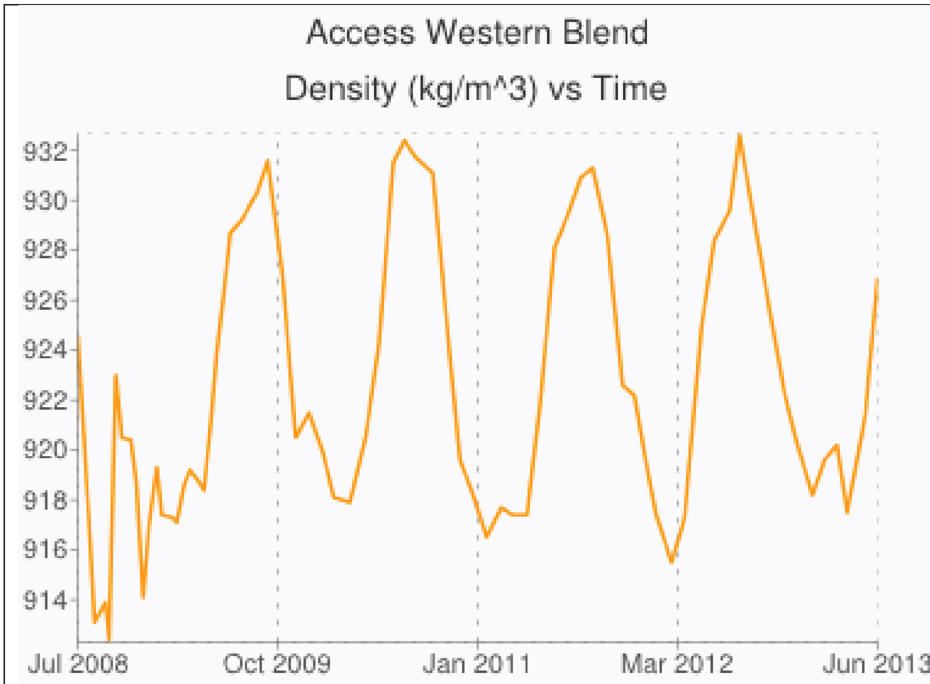
Basic Analysis

Property	Most Recent Sample	6 Month Average	1 Year Average	5 Year Average
Density *(kg/m³)*	926.9	920.6	923.1	922.2
Gravity *(°API)*	21.0	22.1	21.7	21.8
Sulphur *(wt%)*	3.98	3.90	3.90	3.94
MCR *(wt%)*	10.90	10.46	10.54	10.65
Sediment *(ppmw)*	-	90	92	201
TAN *(mgKOH/g)*	1.80	1.69	1.71	1.70
Salt *(ptb)*	-	7.6	6.7	6.8
Nickel *(mg/L)*	76.0	73.0	73.4	72.1
Vanadium *(mg/L)*	212.0	199.0	198.8	194.0
Olefins *(wt%)*	-	-	ND	ND

*ND indicates a tested value below the instrument threshold

Light Ends Summary

Property *(vol%)*	Most Recent Sample	6 Month Average	1 Year Average	5 Year Average
C3-	0.04	0.03	0.03	0.03
Butanes	0.50	0.55	0.60	0.68
Pentanes	10.04	8.34	8.45	8.42
Hexanes	6.52	6.83	6.78	6.81
Heptanes	3.29	4.32	4.16	4.35
Octanes	1.61	2.48	2.28	2.57
Nonanes	0.73	1.27	1.13	1.25
Decanes	0.37	0.59	0.54	0.54



BTEX

Property *(vol%)*	Most Recent Sample	6 Month Average	1 Year Average	5 Year Average
☐ Benzene	0.25	0.30	0.30	0.29
☐ Toluene	0.36	0.52	0.50	0.50
☐ Ethyl Benzene	0.04	0.06	0.05	0.06
☐ Xylenes	0.26	0.40	0.36	0.39

e-mail: Crude Quality Inc.
phone: +1 (780) 757-9909
#201, 17850 105 Avenue
Edmonton, Alberta Canada T5S 2H5

Adapted from: http://www.crudemonitor.ca/crude.php?acr=AWB

Website maintained by Crude Quality Inc.

Crude Quality Data Summary

#201, 17850 - 105 Avenue
Edmonton, Alberta, T5S2H5
Phone: (780) 991-9900

Crude: Access Western Blend **Location:** Edmonton
Batch: AWB-618 **Sample Date:** June 22, 2013

Summary Comments

Access Western Blend contained marginally reduced BTEX, butanes, and C7 x C10 content for the month of June. This sample also showed a slight increase in pentanes.

Basic Analysis Information

	June 22, 2013	5 Year Avg. +/- Std. Dev.	Avg. - Std. Dev.	Avg. + Std. Dev.
Relative Density	0.928	0.923 +/- 0.005	0.918	0.928
Gravity (degrees API)	21.0	21.8 +/- 0.9	20.9	22.7
Absolute Density (kg/m^3)	926.9	922.2 +/- 5.4	916.8	927.6
Sulphur (mass%)	3.98	3.94 +/- 0.10	3.84	4.04
MCR (mass%)	10.90	10.65 +/- 0.49	10.16	11.14
TAN (mgKOH/g)	1.80	1.70 +/- 0.11	1.59	1.81
Nickel (mg/L)	76.0	72.1 +/- 4.9	67.2	77.0
Vanadium (mg/L)	212.0	194.0 +/- 12.0	182.0	206.0

Light Ends (Vol%)

	June 22, 2013	5 Year Avg. +/- Std. Dev.	Avg. - Std. Dev.	Avg. + Std. Dev.
Propane	0.04	ND	-	-
Butanes	0.50	0.68 +/- 0.15	0.53	0.83
Pentanes	10.04	8.42 +/- 1.21	7.21	9.63
Hexanes	6.52	6.81 +/- 0.67	6.14	7.48
Heptanes	3.29	4.35 +/- 0.49	3.86	4.84
Octanes	1.61	2.57 +/- 0.44	2.13	3.01
Nonanes	0.73	1.25 +/- 0.24	1.01	1.49
Decanes	0.37	0.54 +/- 0.12	0.42	0.66

BTEX (Vol%)

	June 22, 2013	5 Year Avg. +/- Std. Dev.	Avg. - Std. Dev.	Avg. + Std. Dev.
Benzene	0.25	0.29 +/- 0.03	0.26	0.32
Toluene	0.36	0.50 +/- 0.08	0.42	0.58
Ethyl-Benzene	0.04	0.06 +/- 0.01	0.05	0.07
Xylenes	0.26	0.39 +/- 0.08	0.31	0.47

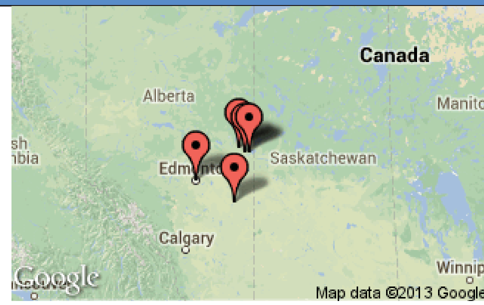
Source: http://www.crudemonitor.ca/crude.php?acr=AWB

crudemonitor.ca	Cold Lake (CL)

Source: http://www.crudemonitor.ca/crude.php?acr=CL

What is Cold Lake crude?

The main players in the Cold Lake oil sands deposit are Imperial Oil Resources, Cenovus Energy, Canadian Natural Resources Limited, and Shell Energy. Cold Lake production is bitumen based and requires the use of steam to release the bitumen from the underground reservoirs, and the use of diluents to meet pipeline viscosity and density specifications.



Most Recent Sample Comments:

CL(H)-780, Jun 25, 2013. Typical light ends and bulk properties were observed in Cold Lake at HardistyBasic Analysis.

Basic Analysis

Property	Most Recent Sample	6 Month Average	1 Year Average	5 Year Average
Density *(kg/m³)*	930.6	924.6	928.1	928.0
Gravity *(°API)*	20.4	21.4	20.8	20.9
Sulphur *(wt%)*	3.82	3.75	3.77	3.80
MCR *(wt%)*	10.50	10.25	10.40	10.46
Sediment *(ppmw)*	-	109	91	162
TAN *(mgKOH/g)*	1.04	0.98	0.99	0.98
Salt *(ptb)*	-	10.7	10.6	11.8
Nickel *(mg/L)*	69.0	65.2	66.0	65.4
Vanadium *(mg/L)*	177.0	173.3	173.4	170.5
Olefins *(wt%)*	-	ND	ND	ND

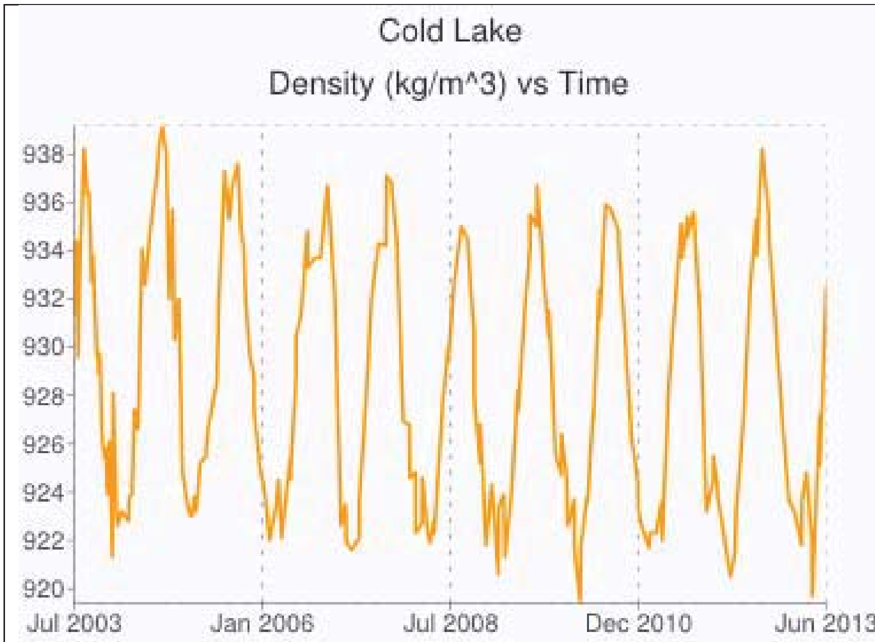
*ND indicates a tested value below the instrument threshold

Light Ends Summary

Property *(vol%)*	Most Recent Sample	6 Month Average	1 Year Average	5 Year Average
C3-	0.06	0.04	0.04	0.04
Butanes	1.06	0.83	0.85	1.02
Pentanes	7.03	6.24	6.06	6.18
Hexanes	5.18	5.62	5.43	5.31
Heptanes	3.14	3.67	3.46	3.36
Octanes	1.84	2.43	2.22	2.23
Nonanes	1.11	1.57	1.42	1.35
Decanes	0.60	0.77	0.72	0.63

BTEX

Property (vol%)	Most Recent Sample	6 Month Average	1 Year Average	5 Year Average
Benzene	**0.22**	**0.25**	0.25	0.23
Toluene	**0.38**	**0.47**	0.42	0.39
Ethyl Benzene	**0.04**	**0.07**	0.06	0.06
Xylenes	**0.30**	**0.40**	0.35	0.33



e-mail: Crude Quality Inc. phone: +1 (780) 757-9909 #201, 17850 105 Avenue Edmonton, Alberta Canada T5S 2H5	Adapted from: http://www.crudemonitor.ca/crude.php?acr=CL Website maintained by Crude Quality Inc.

Crude Quality Data Summary

#201, 17850 - 105 Avenue
Edmonton, Alberta, T5S2H5
Phone: (780) 991-9900

Crude: Cold Lake **Location:** Hardisty

Batch: CL(H)-780 **Sample Date:** June 25, 2013

Summary Comments

Typical light ends and bulk properties were observed in Cold Lake at Hardisty.

Basic Analysis Information

	June 25, 2013	5 Year Avg. +/- Std. Dev.	Avg. - Std. Dev.	Avg. + Std. Dev.
Relative Density	0.931	0.929 +/- 0.006	0.923	0.935
Gravity (degrees API)	20.4	20.9 +/- 0.8	20.1	21.7
Absolute Density (kg/m^3)	930.6	928.0 +/- 5.1	922.9	933.1
Sulphur (mass%)	3.82	3.80 +/- 0.08	3.72	3.88
MCR (mass%)	10.50	10.46 +/- 0.34	10.12	10.80
TAN (mgKOH/g)	1.04	0.98 +/- 0.08	0.90	1.06
Nickel (mg/L)	69.0	65.4 +/- 3.1	62.3	68.5
Vanadium (mg/L)	177.0	170.5 +/- 12.3	158.2	182.8

Light Ends (Vol%)

	June 25, 2013	5 Year Avg. +/- Std. Dev.	Avg. - Std. Dev.	Avg. + Std. Dev.
Propane	0.06	0.04 +/- 0.01	0.03	0.05
Butanes	1.06	1.02 +/- 0.25	0.77	1.27
Pentanes	7.03	6.18 +/- 0.99	5.19	7.17
Hexanes	5.18	5.31 +/- 0.64	4.67	5.95
Heptanes	3.14	3.36 +/- 0.47	2.89	3.83
Octanes	1.84	2.23 +/- 0.43	1.80	2.66
Nonanes	1.11	1.35 +/- 0.31	1.04	1.66
Decanes	0.60	0.63 +/- 0.18	0.45	0.81

BTEX (Vol%)

	June 25, 2013	5 Year Avg. +/- Std. Dev.	Avg. - Std. Dev.	Avg. + Std. Dev.
Benzene	0.22	0.23 +/- 0.03	0.20	0.26
Toluene	0.38	0.39 +/- 0.07	0.32	0.46
Ethyl-Benzene	0.04	0.06 +/- 0.01	0.05	0.07
Xylenes	0.30	0.33 +/- 0.07	0.26	0.40

Source: http://www.crudemonitor.ca/crude.php?acr=CL

Appendix B: Analysis Data for Tank Dispersant Tests

Witt O'Brien's, Polaris Applied Sciences, and
Western Canada Marine Response Corporation

Oil Used for Dispersant Test		DISP_1	DATE:	22-May-13	
	SD-6HR		Air Temp:		
Full	980.12		Winds:	5 mph	(Low flow)
Empty	109.02	Total Oil Used	Water Temp.	18 C	
Oil	871.1	871.1	Salinity	35 ppt	
			Waves (cm)	5-10cm	chop

	Approx Intervals (min)		
Oil on Water	0	*Comments:*	Even oil distribution
Water Sample 1	20		1m below surface
Disp Applied	23		1:20; Wave & wind applied after dispersant
Water Sample 2	43		1m below surface
Surface oil collected	50		

Oil Recovered after Dispersant Application (grams)			
4Pads +1Dry	643	*Observations:*	Small, mm-size droplets visible; entrained

Tare weights		
4 wet sorbent pads*	180	
1 dry pad	41	Total Oil Recovered
		422
		Not on Sorbents 52%

*Single sorbent pad (wet) average wt = 45g
*Single sorbent pad (dry) average wt = 41g
*Single Ziplock average weight = 12.1 g

Oil Used for Dispersant Test		DISP_2	DATE:	22-May-13	
	SD-1D		Air Temp:		
Full	1029.12		Winds:	5 mph	(Low flow)
Empty	134.35	Total Oil Used	Water Temp.	18 C	
Oil	894.77	894.77	Salinity	35 ppt	
			Waves (cm)	5-10cm	chop

	Approx Intervals (min)		
Oil on Water	0	*Comments:*	Even oil distribution
Water Sample 1	20		1m below surface
Disp Applied	23		1:20; Wave & wind applied after dispersant
Water Sample 2	43		1m below surface
Surface oil collected	50		

Oil Recovered after Dispersant Application (grams)

6Pads +1Wet	1243.68	*Observations:*	cm-size oil drops formed, re-surfacing
			not efficient
			disperant tank testing of more weathered oil cancelled

Tare weights

7 wet sorbent pads*	315	
		Total Oil Recovered
		928.68

Not on Sorbents	-4%

*Single sorbent pad (wet) average wt = 45g
*Single sorbent pad (dry) average wt = 41g
*Single Ziplock average weight = 12.1 g

Appendix C: Analysis Data for Tank ISB Test

Witt O'Brien's, Polaris Applied Sciences, and
Western Canada Marine Response Corporation

ISB 1

Oil Used for Burn	S4-6H-02	S4-6H-03	
Full	980.48	993.6	
Empty	124.91	114.25	Total Oil Used
Oil	855.57	879.35	1734.92

DATE: 23-May-13
Air Temp: 17 C
Winds: 1-3 mph (Occasional gusts to 7 mph)
Water Temp. 16 C
Freshwater Tank

	TIME	Comments:
Oil on Water	0750	Even oil distribution
Diesel Starter Added	0753	100ml diesel
Begin Diesel Burn	0755	
Begin Dilbit Burn	0757	Black smoke
End Burn	0759	Sudden extinguished; gust?

Oil Recovered after Burn (grams)		Observations:
Liter Bottle & Burn Residue	149.21	Sticky and cohesive residue; some almost brittle
Bag 1 + oiled sorbents	320.56	mm-size residue particulates entrained in freshwater
Bag 2 + oiled sorbents	331.14	

Tare weights		
6 sorbent pads*	270	
1 L empty	60	Total Oil Recovered
2 Ziplock bags*	24.4	446.51

Estimated % Burned 74%

*Single sorbent pad (wet) average wt = 45g
*Single sorbent pad (dry) average wt = 41g
*Single Ziplock average weight = 12.1 g

ISB 2

Oil Used for Burn (grams)	S4-1D-02	S4-1D-03	
Full	1070.78	1042.22	
Empty	163.54	146.67	Total Oil Used
Oil	907.24	895.55	1802.79

DATE: 23-May-13
Air Temp: 17 C
Winds: 0-3 mph (Occasional gusts to 5 mph)
Water Temp. 16 C
Freshwater Tank

	TIME	Comments:
Oil on Water	0851	
Diesel Starter Added	0852	100ml diesel
Begin Diesel Burn 1	0854	
Begin Diesel Burn 2	0856	
Propane to Dilbit Burn	0857	Limited black smoke, not sustained
Diesel Starter Added	0904	200ml diesel
Begin Diesel Burn 3	0905	
Begin Dilbit Burn		
End Burn	0907	

Oil Recovered after Burn (grams)		Observations:
Bag 1 + oiled sorbents	546.17	Difficult to start ignition
Bag 2 + oiled sorbents	462.54	Thick (approx. 3mm) residue on burn ring wall
Bag 3 + oiled sorbents	198.53	Residue very slightly positively bouyant on freshwater

Tare weights		
7 sorbent pads*	315	
3 Ziplock bags*	36.3	Total Oil Recovered
		855.94

Estimated % Burned 53%

*Single sorbent pad (wet) average wt = 45g
*Single sorbent pad (dry) average wt = 41g
*Single Ziplock average weight = 12.1 g

Oil Used for Burn (grams)			ISB 3	DATE:	23-May-13	
	S4-3D-02	S4-3D-03		Air Temp:	18 C	
Full	1016.81	1025.54		Winds:	3-4 mph	(Occasional gusts to 8 mph)
Empty	170	214.9	Total Oil Used	Water Temp.	16 C	
Oil	846.81	810.64	1657.45	Freshwater Tank		

	TIME		
Oil on Water	1036	*Comments:*	
Diesel Starter Added	1037		100ml diesel used to rinse each bottle (for total 200ml as starter)
Begin Diesel Burn 1	1038		Limited black smoke, not sustained
Propane to Dilbit Burn	1040		Limited black smoke, not sustained
Diesel Starter Added	1046		100 or 200ml added???
Begin Diesel	1046		
End Burn	1047		Diesel burned out; dilbit did not start with diesel restart or direct torch

Oil Recovered after Burn (grams)			
Bag 1 + oiled sorbents	539.54	*Observations:*	Two waterbugs survived in tank ---all burns
Bag 2 + oiled sorbents	878.67		No burn
Bag 3 + oiled sorbents	378.49		
Bag 4+1L bottle+sorbent	493.73		

Tare weights		
5 sorbent pads*	270	
4 Ziplock bags*	48.4	Total Oil Recovered
1 L empty	60	1912.03

Estimated % Burned -15%

*Single sorbent pad (wet) average wt = 45g
*Single sorbent pad (dry) average wt = 41g
*Single Ziplock average weight = 12.1 g

Appendix D: Substrate Washing Tests

Witt O'Brien's, Polaris Applied Sciences, and
Western Canada Marine Response Corporation

Tile ID	W/D	Days Oil on water	Date Oiled	Hours post-spill	Oiled observations	Thickness Measured (mm)	Agent Applied	Setup Hours	Total Time	Clean observations^	Comments	Conclusion
1D-W-C-24	Wet	1D	14/May/13	24	"100%, CT"	0.5 - 1.0	Corexit 9580	24	48	"<1%, FL/ST"	Oil floating in water	Effective
1D-W-L-24	Wet	1D	14/May/13	24	"100%, CT"	0.5 - 1.0	D-Limonene	24	48	"100%, CT"	No oil in water	Ineffective
1D-W-N-24	Wet	1D	14/May/13	24	"100%, CT"	0.5 - 1.0	None	24	48	"100%, CT"	No oil in water	Ineffective
1D-W-C-48	Wet	1D	14/May/13	24	"100%, CT"	0.5 - 1.0	Corexit 9580	48	72	"<1%, FL/ST"	Oil floating on water	Effective
1D-W-L-48	Wet	1D	14/May/13	24	"100%, CT"	0.5 - 1.0	D-Limonene	48	72	"100%, CT"	No oil in water	Ineffective
1D-W-N-48	Wet	1D	14/May/13	24	"100%, CT"	0.5 - 1.0	None	48	72	"100%, CT"	No oil in water	Ineffective
1D-D-C-24	Dry	1D	14/May/13	24	"100%, CT"	0.5 - 1.0	Corexit 9580	24	48	"3-5%, FL/ST"	Oil floating in water	Effective
1D-D-L-24	Dry	1D	14/May/13	24	"100%, CT"	0.5 - 1.0	D-Limonene	24	48	"100%, CT"	No oil in water	Ineffective
1D-D-N-24	Dry	1D	14/May/13	24	"100%, CT"	0.5 - 1.0	None	24	48	"100%, CT"	No oil in water	Ineffective
1D-D-C-48	Dry	1D	14/May/13	24	"100%, CT"	0.5 - 1.0	Corexit 9580	48	72	"2%, FL/ST"	Oil floating in water	Effective
1D-D-L-48	Dry	1D	14/May/13	24	"100%, CT"	0.5 - 1.0	D-Limonene	48	72	"100%, CT"	No oil in water	Ineffective
1D-D-N-48	Dry	1D	14/May/13	24	"100%, CT"	0.5 - 1.0	None	48	72	"100%, CT"	No oil in water	Ineffective
3D-W-C-24	Wet	3D	16/May/13	71	"100%, CT/CV"	1.0 - 1.1	Corexit 9580	24	94.5	"1%,FL/ST"	Oil on water	Effective
3D-W-L -24	Wet	3D	16/May/13	71	"100%, CT/CV"	1.0 - 1.1	None	24	95	"100%, CT/CV"	No oil in water	Ineffective
3D-W-C-48	Wet	3D	16/May/13	71	"100%, CT/CV"	1.0 - 1.1	Corexit 9580	48	119	1-3% CT FL/ST	Oil on water	Effective
3D-W-N-48	Wet	3D	16/May/13	71	"100%, CT/CV"	1.0 - 1.1	None	48	119	"100%, CT/CV"		Ineffective
3D-W-C-72	Wet	3D	16/May/13	71	"100%, CT/CV"	1.0 - 1.1	Corexit 9580	72	143	"5% CT, 95% ST/FL"	Oil in water	Mostly Effective
3D-W-C-96	Wet	3D	16/May/13	71	"100%, CT/CV"	1.0 - 1.1	Corexit 9580	96	167	"80% ST/CT, 20% ST/FL, "	Oil in water	Marginally effective
3D-D-C-24	Dry	3D	16/May/13	71	"100%, CT/CV"	1.0 - 1.1	Corexit 9580	24	95	"1-3% CT, FL/ST"	Oil on water	Effective
3D-D-N-24	Dry	3D	16/May/13	71	"100%, CT/CV"	1.0 - 1.1	None	24	95	"100%, CT/CV"	No oil on water	Ineffective
3D-D-C-48	Dry	3D	16/May/13	71	"100%, CT/CV"	1.0 - 1.1	Corexit 9580	48	119	"1-3%, FL/ST"	Oil on water	Effective
3D-D-N-48	Dry	3D	16/May/13	71	"100%, CT/CV"	1.0 - 1.1	None	48	119	"100%, CT/CV"	No oil on water	Ineffective
3D-D-C-72	Dry	3D	16/May/13	71	"100%, CT/CV"	1.0 - 1.1	Corexit 9580	72	143	"1-3% CT, 97% ST/FL"	Oil in water"	Mostly effective
3D-D-C-96	Dry	3D	16/May/13	71	"100%, CT/CV"	1.0 - 1.1	Corexit 9580	96	167	"65% CT/ST (black), 35% ST/FL"	Oil in water	"Marginally effective, possibly needs full 30 min soak time"
3D-W-C-120	Wet	3D	16/May/13	71	"100%, CT/CV"	1.0 - 1.1	Corexit 9580	120	191	"85% CT/ST (black), 15% ST (transparent)"	"Previously washed in water only (24h), oil in water, black oil thickness < 0.5 mm"	Removed oil but left black stain

Tile ID	W/D	Days Oil on water	Date Oiled	Hours post-spill	Oiled observations	Thickness Measured (mm)	Agent Applied	Setup Hours	Total Time	Clean observations^	Comments	Conclusion
3D-D-C-120	Dry	3D	16/May/13	71	"100%, CT/CV"	1.0 - 1.1	Corexit 9580	120	191	"70% CT/ST, 30% ST"	"Previously washed in water only (24h), oil in water, black oil thickness < 0.5 mm"	Removed oil but left black stain
5D-W-C-24	Wet	5D	18/May/13	120	"100%, CV"	1.0 - 2.0	Corexit 9580	24	144	"20% CT, 80% ST/FL"	"Oil on water, lower part of tile likely had thicker oil"	Mostly effective
5D-W-N-24	Wet	5D	18/May/13	120	"100%, CV"	1.0 - 2.0	None	24	144	100% CT/CV	"Ineffective, no oil on water"	Ineffective
5D-W-C-48	Wet	5D	18/May/13	120	"100%, CV"	1.0 - 2.0	Corexit 9580	48	168	"90% ST/FL, 5-10% ST/CT"	Oil in water	Effective
5D-W-N-48	Wet	5D	18/May/13	120	"100%, CV"	1.0 - 2.0	None	48	168	100% CT/CV	No oil in water	Ineffective
5D-W-c-72	Wet	5D	18/May/13	120	"100%, CV"	1.0 - 2.0	Corexit 9580	72	192	100% ST/FL	Oil in water	effective
5D-W-C-96	Wet	5D	18/May/13	120	"100%, CV"	1.0 - 2.0	Corexit 9580	96	216			
5D-D-C-24	Dry	5D	18/May/13	120	"100%, CV"	1.0 - 2.0	Corexit 9580	24	144	"15% CT, 85% ST/FL"	"Oil on water, lower part of tile likely had thicker oil"	Mostly Effective
5D-D-N-24	Dry	5D	18/May/13	120	"100%, CV"	1.0 - 2.0	None	24	144	100% CT/CV	No oil on water	Ineffective
5D-D-C-48	Dry	5D	18/May/13	120	"100%, CV"	1.0 - 2.0	Corexit 9580	48	168	"90% ST/FL, 10% CT"	Oil in water	Effective
5D-D-N-48	Dry	5D	18/May/13	120	"100%, CV"	1.0 - 2.0	None	48	168	100% CT/CV	"Ineffective, no oil on water"	Ineffective
5D-D-C-72	Dry	5D	18/May/13	120	"100%, CV"	1.0 - 2.0	Corexit 9580	72	192	100% ST/FL	Oil in water	Effective
5D-D-C-96	Dry	5D	18/May/13	120	"100%, CV"	1.0 - 2.0	Corexit 9580	96	216			
5D-W-C-120	Wet	5D	18/May/13	120	"100%, CV"	1.0 - 2.0	Corexit 9580	120	240		Previously washed in water only (24h)	
5D-D-C-120	Dry	5D	18/May/13	120	"100%, CV"	1.0 - 2.0	Corexit 9580	120	240		Previously washed in water only (24h)	

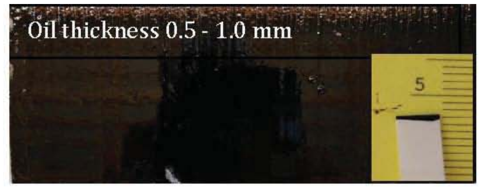
^ Notes: % denotes percent covered with oil: Oil thicknesses are CV>0.1cm but ≤1cm, CT ≤ 0.1cm and >0.01 cm (can be scratched off tile with fingernail, ST is visible oil but ≤0.01cm (not easily scratched off), and FL is film (usually as a translucent sheen)

Table D-1: Substrate Washing Test Results

Tiles coated with CLWB in 20 ppt seawater weathering under mild conditions (2 cm – 3 cm waves and 5 mph (2.2 m/s) winds).

May 15, 2013
Granite tiles pre and post oiling.

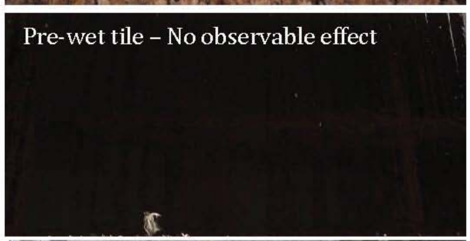
Oil on water 24 hours, oil on tile 24 hours.



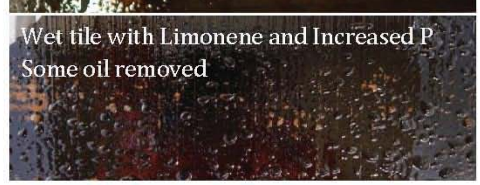
Tiles after 24 hours on land, treated for 20 mins with commercial D-Limonene and washed for 30 sec.

Tiles after 24 hours, treated with Corexit 9580 (20 min) and washed with low pressure for 30 sec.

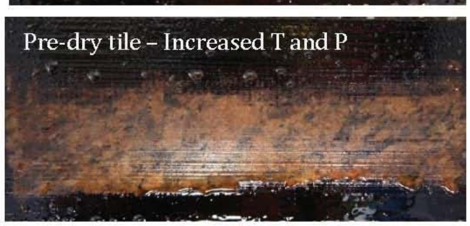
Control with no treatment and washed with low pressure for 30 sec. No observable difference.



Increased pressure by applying wand at 5 cm.

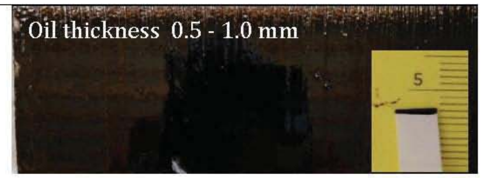


Increased temp from ambient to 190C.

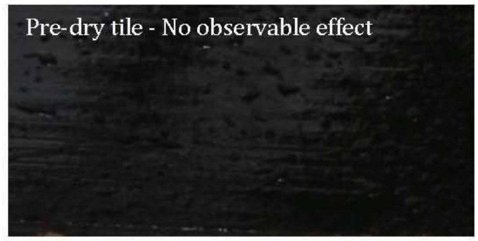


Granite tiles pre and post oiling.

Oil on tiles 48 hours.

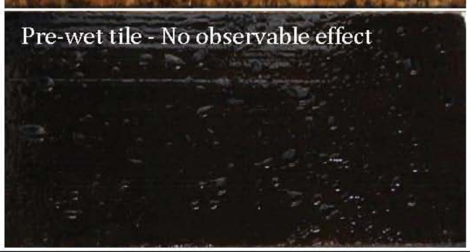


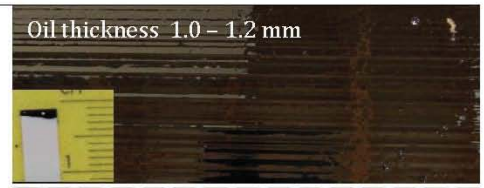
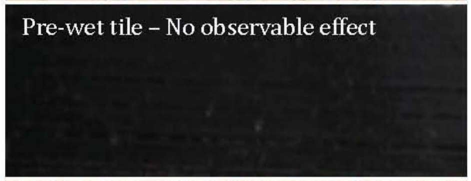
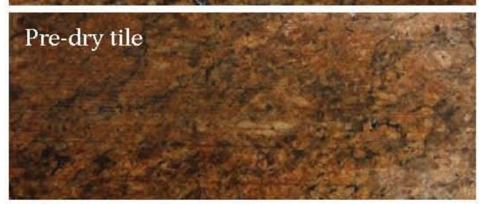
Tiles after 48 hours, treated for 20 mins with Commercial D-Limonene and washed with low pressure for 30 sec.

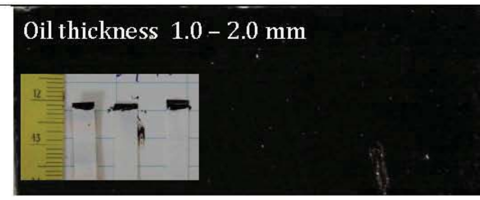
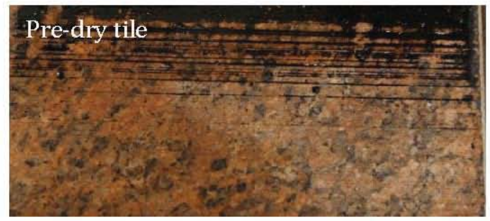


Pre-wetted and dry tiles after 48 hours, treated with Corexit 9580 (20 min) and washed with low pressure for 30 sec.

Control with no treatment and washed with low pressure for 30 sec. No observable difference.



Granite tiles pre and post oiling. Oil on water 72 hours.		
Oil 24 hours on tile. Not treated and washed for 30 sec.		
Oil on tiles 24 hours, treated with Corexit 9580 (20 min) and washed for 30 sec.		
Oil on tiles 48 hours, treated with Corexit 9580 (20 min) and washed for 30 sec.		
Oil on tiles 72 hours, treated with Corexit 9580 (20 min) and washed for 30 sec.		
Oil on tiles 96 hours, treated with Corexit 9580 (20 min) and washed for 30 sec.		
Oil on tiles 120 hours, treated with Corexit 9580 (20 min) and washed for 30 sec.		
Oil on tiles 144 hours, treated with Corexit 9580 (20 min) and washed for 30 sec.		

Granite tiles pre and post oiling. Oil on water 96 hours.		
Oil 24 hours on tile. Not treated and washed for 30 sec.		
Oil on tiles 24 hours, treated with Corexit 9580 (20 min) and washed for 30 sec.		
Oil on tiles 48 hours, treated with Corexit 9580 (20 min) and washed for 30 sec.		
Oil on tiles 72 hours (shade), treated with Corexit 9580 (20 min) and washed for 30 sec.		
Oil on tiles 96 hours, treated with Corexit 9580 (20 min) and washed for 30 sec.		
Oil on tiles 96 hours (partial sun), treated with Corexit 9580 (20 min) and washed for 30 sec.		

Oil on tiles 96 hours (partial sun), treated with Corexit 9580 (20 min) and washed for 30 sec.		
96 hours full sun, treated with Corexit 9580, washed after 20 mins.		

Appendix E: Oil Chemistry Data

Witt O'Brien's, Polaris Applied Sciences, and
Western Canada Marine Response Corporation

Introduction

This appendix section presents the chemistry data (light ends in weight % according to ASTM D5580) and poly aromatic hydrocarbons (PAHs) of Access Western Blend (AWB) and Cold Lake Winter Blend (CLWB) as they weather under three turbulence conditions:

- Static Conditions: One tank with no agitation induced. Wind exposure was minimized as far as was practical.
- Mild Agitation: One tank with low wind and wave conditions (e.g. 2 cm – 4 cm waves and 5 mph (2.2 m/s) winds, which were induced by simple mechanical means (intrinsically safe fans and paddles mechanism)).
- Moderate Agitation: One tank with conditions similar to Tank 2 but with a larger induced wind and wave agitation (e.g. 5-7 cm waves and 10 mph (4.5 m/s) winds).

COMPONENT	0 Hours (WT%)	12 Hours (WT%)	I Day (WT%)	2 Days (WT%)	2 Days (WT%)	8 Days (WT%)	10 Days (WT%)	10 Days (WT%)	10 Days (WT%)
Methane	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Ethane	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Propane	0.03	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Isobutane	0.06	0.02	0.01	0.01	0.01	<0.01	0.01	<0.01	<0.01
n-Butane	0.43	0.10	0.03	0.05	0.06	0.01	0.02	0.02	0.01
Isopentane	3.15	1.13	0.31	0.59	0.65	0.21	0.19	0.09	0.07
n-Pentane	3.35	0.90	0.23	0.41	0.45	0.09	0.08	0.05	0.05
Hexanes (C6)	3.76	1.46	0.40	0.76	0.75	0.26	0.22	0.09	0.13
Heptanes (C7)	2.02	1.03	0.31	0.59	0.51	0.24	0.21	0.09	0.14
Octanes (C8)	1.38	0.88	0.27	0.53	0.44	0.25	0.22	0.09	0.14
Nonanes (C9)	0.92	0.71	0.21	0.41	0.34	0.21	0.20	0.07	0.12
Decanes (C10)	0.79	0.72	0.22	0.45	0.38	0.26	0.24	0.09	0.16
Undecanes (C11)	0.74	0.75	0.24	0.52	0.46	0.36	0.35	0.16	0.22
Dodecanes (C12)	0.72	0.78	0.25	0.55	0.53	0.48	0.48	0.26	0.29
Tridecanes (C13)	0.88	1.00	0.32	0.71	0.72	0.73	0.77	0.49	0.43
Tetradecanes (C14)	0.98	1.13	0.36	0.81	0.86	0.93	1.02	0.74	0.53
Pentadecanes (C15)	1.07	1.25	0.38	0.90	0.96	1.08	1.23	0.98	0.61
Hexadecanes (C16)	1.28	1.49	0.45	1.06	1.18	1.34	1.54	1.30	0.75
Heptadecanes (C17)	1.37	1.60	0.45	1.11	1.21	1.44	1.68	1.48	0.81
Octadecanes (C18)	1.46	1.71	0.50	1.16	1.37	1.49	1.79	1.59	0.83
Nonadecanes (C19)	1.15	1.36	0.37	0.93	1.06	1.10	1.40	1.25	0.66
Eicosanes (C20)	1.40	1.67	0.45	1.11	1.28	1.53	1.57	1.40	0.72
Heneicosanes (C21)	1.36	1.63	0.42	1.07	1.24	1.38	1.76	1.53	0.77
Docosanes (C22)	1.29	1.56	0.41	1.02	1.17	1.30	1.46	1.33	0.66
Triacosanes (C23)	1.22	1.45	0.38	0.96	1.08	1.20	1.41	1.30	0.65
Tetracosanes (C24)	1.22	1.49	0.37	0.95	1.07	1.21	1.39	1.27	0.64
Pentacosanes (C25)	1.20	1.45	0.35	0.93	1.03	1.15	1.30	1.24	0.60
Hexacosanes (C26)	1.05	1.28	0.30	0.81	0.90	1.01	1.13	1.06	0.51
Heptacosanes (C27)	1.06	1.33	0.29	0.84	0.91	1.02	1.09	1.01	0.47
Octacosanes (C28)	1.10	1.37	0.29	0.87	0.93	1.05	1.03	0.93	0.42
Nonacosanes (C29)	1.07	1.35	0.27	0.84	0.91	1.01	1.12	1.00	0.43
Methylcyclopentane	0.72	0.35	0.11	0.20	0.18	0.09	0.09	0.05	0.05
Benzene	0.27	0.11	0.03	0.05	0.04	0.01	0.01	<0.01	<0.01
Cyclohexane	0.61	0.33	0.11	0.21	0.19	0.10	0.09	0.03	0.04
Methylcyclohexane	0.89	0.54	0.17	0.34	0.30	0.17	0.15	0.05	0.08
Toluene	0.48	0.25	0.08	0.14	0.06	0.04	0.02	0.01	0.01
Ethylbenzene	0.06	0.04	0.01	0.03	0.02	0.01	0.01	<0.01	<0.01
Meta and para-xylene	0.26	0.19	0.07	0.14	0.11	0.05	0.03	0.01	0.02
Ortho-xylene	0.08	0.06	0.02	0.04	0.03	0.02	0.01	<0.01	0.01
Trimethylbenzene	0.08	0.08	0.03	0.07	0.06	0.04	0.03	0.01	0.02

Table E-1: Light ends (C1-C30) of AWB weathering under static conditions

COMPONENT	0 Hours (WT%)	12 Hours (WT%)	I Day (WT%)	8 Days (WT%)
Methane	<0.01	<0.01	<0.01	<0.01
Ethane	<0.01	<0.01	<0.01	<0.01
Propane	0.03	0.01	<0.01	<0.01
Isobutane	0.06	0.02	0.01	<0.01
n-Butane	0.43	0.12	0.03	0.01
Isopentane	3.15	1.07	0.31	0.16
n-Pentane	3.35	0.95	0.23	0.08
Hexanes (C6)	3.76	1.29	0.72	0.18
Heptanes (C7)	2.02	0.81	0.47	0.15
Octanes (C8)	1.38	0.63	0.38	0.15
Nonanes (C9)	0.92	0.47	0.29	0.12
Decanes (C10)	0.79	0.45	0.30	0.16
Undecanes (C11)	0.74	0.46	0.34	0.26
Dodecanes (C12)	0.72	0.46	0.36	0.38
Tridecanes (C13)	0.88	0.57	0.46	0.63
Tetradecanes (C14)	0.98	0.63	0.52	0.86
Pentadecanes (C15)	1.07	0.69	0.57	1.06
Hexadecanes (C16)	1.28	0.81	0.68	1.36
Heptadecanes (C17)	1.37	0.85	0.71	1.49
Octadecanes (C18)	1.46	0.89	0.74	1.59
Nonadecanes (C19)	1.15	0.70	0.57	1.16
Eicosanes (C20)	1.40	0.85	0.69	1.66
Heneicosanes (C21)	1.36	0.82	0.66	1.37
Docosanes (C22)	1.29	0.77	0.65	1.54
Triacosanes (C23)	1.22	0.72	0.61	1.32
Tetracosanes (C24)	1.22	0.72	0.61	1.32
Pentacosanes (C25)	1.20	0.70	0.59	1.28
Hexacosanes (C26)	1.05	0.62	0.53	1.14
Heptacosanes (C27)	1.06	0.62	0.53	1.15
Octacosanes (C28)	1.10	0.64	0.54	1.20
Nonacosanes (C29)	1.07	0.62	0.53	1.17
Methylcyclopentane	0.72	0.29	0.16	0.06
Benzene	0.27	0.09	0.04	0.01
Cyclohexane	0.61	0.26	0.17	0.06
Methylcyclohexane	0.89	0.41	0.25	0.10
Toluene	0.48	0.20	0.11	0.02
Ethylbenzene	0.06	0.03	0.02	0.01
Meta and para-xylene	0.26	0.14	0.10	0.03
Ortho-xylene	0.08	0.04	0.03	0.01
Trimethylbenzene	0.08	0.05	0.04	0.02

Table E-2: Light ends (C1-C30) of AWB weathering under mild agitation conditions

COMPONENT	0 Hours (WT%)	12 Hours (WT%)	I Day (WT%)	2 Days (WT%)	8 Days (WT%)
Methane	<0.01	<0.01	<0.01	<0.01	<0.01
Ethane	<0.01	<0.01	<0.01	<0.01	<0.01
Propane	0.03	<0.01	<0.01	<0.01	<0.01
Isobutane	0.06	0.01	<0.01	0.01	<0.01
n-Butane	0.43	0.03	0.02	0.03	0.01
Isopentane	3.15	0.39	0.21	0.33	0.11
n-Pentane	3.35	0.29	0.15	0.23	0.08
Hexanes (C6)	3.76	0.50	0.25	0.41	0.20
Heptanes (C7)	2.02	0.38	0.19	0.30	0.18
Octanes (C8)	1.38	0.35	0.17	0.27	0.18
Nonanes (C9)	0.92	0.30	0.14	0.21	0.16
Decanes (C10)	0.79	0.33	0.16	0.23	0.20
Undecanes (C11)	0.74	0.38	0.19	0.28	0.28
Dodecanes (C12)	0.72	0.43	0.21	0.32	0.35
Tridecanes (C13)	0.88	0.56	0.28	0.46	0.50
Tetradecanes (C14)	0.98	0.65	0.32	0.55	0.62
Pentadecanes (C15)	1.07	0.72	0.35	0.63	0.70
Hexadecanes (C16)	1.28	0.87	0.42	0.79	0.86
Heptadecanes (C17)	1.37	0.93	0.44	0.83	0.92
Octadecanes (C18)	1.46	0.99	0.46	0.96	0.97
Nonadecanes (C19)	1.15	0.80	0.35	0.77	0.70
Eicosanes (C20)	1.40	0.96	0.42	0.93	1.00
Heneicosanes (C21)	1.36	0.96	0.41	0.92	0.83
Docosanes (C22)	1.29	0.90	0.40	0.91	0.94
Triacosanes (C23)	1.22	0.84	0.38	0.82	0.80
Tetracosanes (C24)	1.22	0.86	0.38	0.82	0.80
Pentacosanes (C25)	1.20	0.84	0.37	0.80	0.78
Hexacosanes (C26)	1.05	0.74	0.33	0.72	0.70
Heptacosanes (C27)	1.06	0.77	0.33	0.73	0.70
Octacosanes (C28)	1.10	0.80	0.35	0.76	0.73
Nonacosanes (C29)	1.07	0.79	0.34	0.75	0.71
Methylcyclopentane	0.72	0.14	0.06	0.11	0.06
Benzene	0.27	0.03	0.01	0.01	<0.01
Cyclohexane	0.61	0.13	0.07	0.11	0.06
Methylcyclohexane	0.89	0.21	0.11	0.18	0.11
Toluene	0.48	0.08	0.04	0.05	0.01
Ethylbenzene	0.06	0.02	0.01	0.01	0.01
Meta and para-xylene	0.26	0.07	0.05	0.07	0.04
Ortho-xylene	0.08	0.02	0.01	0.02	0.01
Trimethylbenzene	0.08	0.04	0.02	0.04	0.03

Table E-3: Light ends (C1-C30) of AWB weathering under moderate agitation conditions

COMPONENT	0 Hours (WT%)	12 Hours (WT%)	I Day (WT%)	2 Days (WT%)	4 Days (WT%)	8 Days (WT%)	10 Days (WT%)
Methane	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Ethane	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Propane	0.02	0.01	0.01	<0.01	<0.01	<0.01	<0.01
Isobutane	0.06	0.02	0.03	0.02	0.01	0.01	0.01
n-Butane	0.33	0.10	0.10	0.06	0.04	0.03	0.02
Isopentane	1.85	0.81	0.81	0.49	0.39	0.28	0.21
n-Pentane	2.05	0.70	0.67	0.37	0.25	0.16	0.11
Hexanes (C6)	2.76	1.26	1.18	0.73	0.58	0.39	0.29
Heptanes (C7)	1.69	0.97	0.88	0.59	0.50	0.36	0.29
Octanes (C8)	1.49	1.04	0.94	0.67	0.61	0.42	0.34
Nonanes (C9)	1.15	0.93	0.84	0.63	0.70	0.44	0.36
Decanes (C10)	1.03	0.94	0.86	0.69	0.69	0.52	0.44
Undecanes (C11)	1.07	1.11	1.02	0.85	0.93	0.75	0.65
Dodecanes (C12)	1.05	1.18	1.10	0.95	1.10	0.94	0.83
Tridecanes (C13)	1.27	1.53	1.43	1.25	1.54	1.39	1.26
Tetradecanes (C14)	1.35	1.71	1.60	1.41	1.80	1.71	1.57
Pentadecanes (C15)	1.37	1.77	1.67	1.46	1.91	1.87	1.74
Hexadecanes (C16)	1.53	2.02	1.90	1.65	2.19	2.21	2.04
Heptadecanes (C17)	1.50	2.02	1.90	1.63	2.18	2.25	2.07
Octadecanes (C18)	1.46	1.99	1.89	1.60	2.12	2.25	2.05
Nonadecanes (C19)	1.12	1.55	1.48	1.25	1.49	1.76	1.60
Eicosanes (C20)	1.31	1.70	1.63	1.43	2.03	2.12	1.91
Heneicosanes (C21)	1.28	1.94	1.88	1.41	1.64	2.06	1.83
Docosanes (C22)	1.19	1.71	1.65	1.27	1.88	1.97	1.75
Triacosanes (C23)	1.10	1.58	1.52	1.13	1.59	1.83	1.64
Tetracosanes (C24)	1.08	1.57	1.55	1.14	1.57	1.82	1.62
Pentacosanes (C25)	1.04	1.53	1.50	1.05	1.48	1.77	1.57
Hexacosanes (C26)	0.92	1.38	1.36	0.94	1.30	1.58	1.40
Heptacosanes (C27)	0.93	1.44	1.43	0.94	1.28	1.60	1.41
Octacosanes (C28)	0.97	1.41	1.42	0.97	1.28	1.55	1.37
Nonacosanes (C29)	0.94	1.60	1.62	0.94	1.18	1.72	1.51
Methylcyclopentane	0.54	0.31	0.29	0.19	0.17	0.12	0.10
Benzene	0.20	0.09	0.07	0.05	0.03	0.02	0.01
Cyclohexane	0.45	0.27	0.25	0.02	0.17	0.11	0.09
Methylcyclohexane	0.70	0.47	0.43	0.31	0.28	0.21	0.17
Toluene	0.40	0.22	0.29	0.13	0.06	0.05	0.04
Ethylbenzene	0.08	0.06	0.05	0.04	0.03	0.02	0.02
Meta and para-xylene	0.34	0.24	0.21	0.15	0.11	0.08	0.06
Ortho-xylene	0.10	0.07	0.07	0.05	0.04	0.04	0.04
Trimethylbenzene	0.13	0.12	0.11	0.09	0.08	0.07	0.06

Table E-4: Light ends (C1-C30) of CLWB weathering under static conditions

COMPONENT	0 Hours (WT%)	12 Hours (WT%)	I Day (WT%)	2 Days (WT%)	4 Days (WT%)	8 Days (WT%)	10 Days (WT%)
Methane	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Ethane	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Propane	0.02	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Isobutane	0.06	0.02	0.02	0.01	<0.01	<0.01	<0.01
n-Butane	0.33	0.09	0.06	0.02	0.01	<0.01	0.01
Isopentane	1.85	0.71	0.54	0.19	0.08	0.02	0.02
n-Pentane	2.05	0.61	0.43	0.12	0.04	0.01	0.01
Hexanes (C6)	2.76	1.06	0.80	0.26	0.10	0.03	0.02
Heptanes (C7)	1.69	0.79	0.63	0.23	0.10	0.04	0.04
Octanes (C8)	1.49	0.86	0.73	0.28	0.13	0.04	0.04
Nonanes (C9)	1.15	0.80	0.71	0.30	0.18	0.05	0.04
Decanes (C10)	1.03	0.85	0.80	0.38	0.22	0.08	0.07
Undecanes (C11)	1.07	1.03	1.02	0.57	0.41	0.16	0.16
Dodecanes (C12)	1.05	1.12	1.16	0.73	0.63	0.29	0.30
Tridecanes (C13)	1.27	1.46	1.55	1.07	1.07	0.56	0.64
Tetradecanes (C14)	1.35	1.62	1.76	1.27	1.42	0.84	1.03
Pentadecanes (C15)	1.37	1.68	1.84	1.36	1.61	1.03	1.34
Hexadecanes (C16)	1.53	1.92	2.12	1.57	1.91	1.27	1.68
Heptadecanes (C17)	1.50	1.89	2.12	1.55	1.93	1.29	1.78
Octadecanes (C18)	1.46	1.88	2.09	1.52	1.89	1.28	1.81
Nonadecanes (C19)	1.12	1.47	1.67	1.18	1.34	0.99	1.41
Eicosanes (C20)	1.31	1.61	1.82	1.37	1.82	1.15	1.69
Heneicosanes (C21)	1.28	1.81	2.07	1.36	1.47	1.12	1.63
Docosanes (C22)	1.19	1.61	1.82	1.23	1.66	1.03	1.55
Triacosanes (C23)	1.10	1.50	1.66	1.07	1.38	0.91	1.44
Tetracosanes (C24)	1.08	1.48	1.70	1.07	1.34	0.92	1.45
Pentacosanes (C25)	1.04	1.45	1.61	0.99	1.28	0.85	1.39
Hexacosanes (C26)	0.92	1.31	1.49	0.89	1.11	0.76	1.26
Heptacosanes (C27)	0.93	1.36	1.53	0.89	1.12	0.76	1.29
Octacosanes (C28)	0.97	1.33	1.52	0.92	1.13	0.74	1.25
Nonacosanes (C29)	0.94	1.51	1.74	0.88	1.07	0.82	1.41
Methylcyclopentane	0.54	0.26	0.21	0.08	0.04	0.02	0.02
Benzene	0.20	0.07	0.05	0.01	0.01	<0.01	<0.01
Cyclohexane	0.45	0.23	0.19	0.07	0.04	0.01	0.01
Methylcyclohexane	0.70	0.39	0.33	0.13	0.06	0.02	0.02
Toluene	0.40	0.18	0.23	0.04	<0.01	<0.01	<0.01
Ethylbenzene	0.08	0.05	0.04	0.02	0.01	<0.01	<0.01
Meta and para-xylene	0.34	0.21	0.17	0.07	0.02	0.01	0.01
Ortho-xylene	0.10	0.07	0.06	0.02	0.01	<0.01	<0.01
Trimethylbenzene	0.13	0.11	0.10	0.05	0.03	0.01	0.01

Table E-5: Light ends (C1-C30) of CLWB weathering under mild agitation conditions

COMPONENT	0 Hours (WT%)	12 Hours (WT%)	I Day (WT%)	2 Days (WT%)	4 Days (WT%)	8 Days (WT%)	10 Days (WT%)
Methane	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Ethane	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Propane	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Isobutane	0.06	0.01	0.01	<0.01	<0.01	<0.01	<0.01
n-Butane	0.33	0.05	0.04	0.01	0.01	<0.01	0.01
Isopentane	1.85	0.43	0.32	0.09	0.04	0.02	0.02
n-Pentane	2.05	0.35	0.25	0.06	0.03	0.01	0.01
Hexanes (C6)	2.76	0.65	0.47	0.13	0.06	0.02	0.02
Heptanes (C7)	1.69	0.53	0.38	0.12	0.06	0.03	0.03
Octanes (C8)	1.49	0.61	0.45	0.15	0.08	0.03	0.03
Nonanes (C9)	1.15	0.62	0.47	0.16	0.09	0.03	0.03
Decanes (C10)	1.03	0.72	0.57	0.22	0.14	0.05	0.05
Undecanes (C11)	1.07	0.96	0.81	0.35	0.25	0.11	0.09
Dodecanes (C12)	1.05	1.12	1.00	0.47	0.39	0.20	0.14
Tridecanes (C13)	1.27	1.51	1.40	0.71	0.68	0.37	0.26
Tetradecanes (C14)	1.35	1.72	1.63	0.87	0.91	0.52	0.37
Pentadecanes (C15)	1.37	1.80	1.71	0.94	1.04	0.62	0.43
Hexadecanes (C16)	1.53	2.06	1.97	1.08	1.24	0.75	0.51
Heptadecanes (C17)	1.50	2.06	1.96	1.06	1.26	0.76	0.51
Octadecanes (C18)	1.46	2.02	1.93	1.03	1.24	0.75	0.49
Nonadecanes (C19)	1.12	1.59	1.50	0.79	0.89	0.58	0.37
Eicosanes (C20)	1.31	1.72	1.65	0.91	1.22	0.69	0.43
Heneicosanes (C21)	1.28	1.97	1.83	0.87	1.00	0.65	0.40
Docosanes (C22)	1.19	1.72	1.66	0.79	1.14	0.62	0.38
Triacosanes (C23)	1.10	1.57	1.53	0.69	0.96	0.58	0.34
Tetracosanes (C24)	1.08	1.58	1.51	0.68	0.94	0.57	0.34
Pentacosanes (C25)	1.04	1.52	1.48	0.62	0.91	0.55	0.32
Hexacosanes (C26)	0.92	1.36	1.32	0.54	0.81	0.49	0.28
Heptacosanes (C27)	0.93	1.41	1.36	0.53	0.83	0.50	0.28
Octacosanes (C28)	0.97	1.38	1.33	0.54	0.87	0.49	0.27
Nonacosanes (C29)	0.94	1.56	1.50	0.50	0.82	0.54	0.30
Methylcyclopentane	0.54	0.17	0.12	0.04	0.03	0.01	0.01
Benzene	0.20	0.04	0.03	0.01	<0.01	<0.01	<0.01
Cyclohexane	0.45	0.15	0.12	0.04	0.02	0.01	0.01
Methylcyclohexane	0.70	0.27	0.20	0.07	0.03	0.01	0.01
Toluene	0.40	0.12	0.16	0.02	0.01	<0.01	<0.01
Ethylbenzene	0.08	0.04	0.03	0.01	<0.01	<0.01	<0.01
Meta and para-xylene	0.34	0.16	0.12	0.04	0.02	<0.01	<0.01
Ortho-xylene	0.10	0.05	0.04	0.01	0.01	<0.01	<0.01
Trimethylbenzene	0.13	0.09	0.08	0.03	0.02	0.01	0.01

Table E-6: Light ends (C1-C30) of CLWB weathering under moderate agitation conditions

COMPONENT	0 Hours (WT%)	6 Hours (WT%)	I Day (WT%)	5 Days (WT%)
Methane	<0.01	<0.01	<0.01	<0.01
Ethane	<0.01	<0.01	<0.01	<0.01
Propane	0.02	<0.01	<0.01	<0.01
Isobutane	0.06	0.01	<0.01	<0.01
n-Butane	0.33	0.05	0.01	<0.01
Isopentane	1.85	0.38	0.11	0.01
n-Pentane	2.05	0.33	0.08	<0.01
Hexanes (C6)	2.76	0.25	0.18	0.01
Heptanes (C7)	1.69	0.19	0.17	0.02
Octanes (C8)	1.49	0.17	0.22	0.02
Nonanes (C9)	1.15	0.14	0.25	0.02
Decanes (C10)	1.03	0.16	0.33	0.04
Undecanes (C11)	1.07	0.19	0.49	0.10
Dodecanes (C12)	1.05	0.21	0.63	0.19
Tridecanes (C13)	1.27	0.28	0.87	0.38
Tetradecanes (C14)	1.35	0.32	1.00	0.58
Pentadecanes (C15)	1.37	0.35	1.04	0.71
Hexadecanes (C16)	1.53	0.42	1.17	0.88
Heptadecanes (C17)	1.50	0.44	1.16	0.91
Octadecanes (C18)	1.46	0.46	1.12	0.90
Nonadecanes (C19)	1.12	0.35	0.86	0.70
Eicosanes (C20)	1.31	0.42	1.00	0.82
Heneicosanes (C21)	1.28	0.41	0.97	0.81
Docosanes (C22)	1.19	0.40	0.89	0.73
Triacosanes (C23)	1.10	0.38	0.80	0.65
Tetracosanes (C24)	1.08	0.38	0.79	0.65
Pentacosanes (C25)	1.04	0.37	0.75	0.60
Hexacosanes (C26)	0.92	0.33	0.66	0.55
Heptacosanes (C27)	0.93	0.33	0.67	0.55
Octacosanes (C28)	0.97	0.35	0.69	0.57
Nonacosanes (C29)	0.94	0.34	0.67	0.55
Methylcyclopentane	0.54	0.15	0.06	0.01
Benzene	0.20	0.04	0.01	<0.01
Cyclohexane	0.45	0.14	0.05	<0.01
Methylcyclohexane	0.70	0.25	0.10	0.01
Toluene	0.40	0.13	0.04	<0.01
Ethylbenzene	0.08	0.04	0.01	<0.01
Meta and para-xylene	0.34	0.16	0.06	<0.01
Ortho-xylene	0.10	0.05	0.02	<0.01
Trimethylbenzene	0.13	0.09	0.05	0.01

Table E-7: Light ends (C1-C30) of CLWB used for dispersant effectiveness tests (weathering under mild agitation conditions)

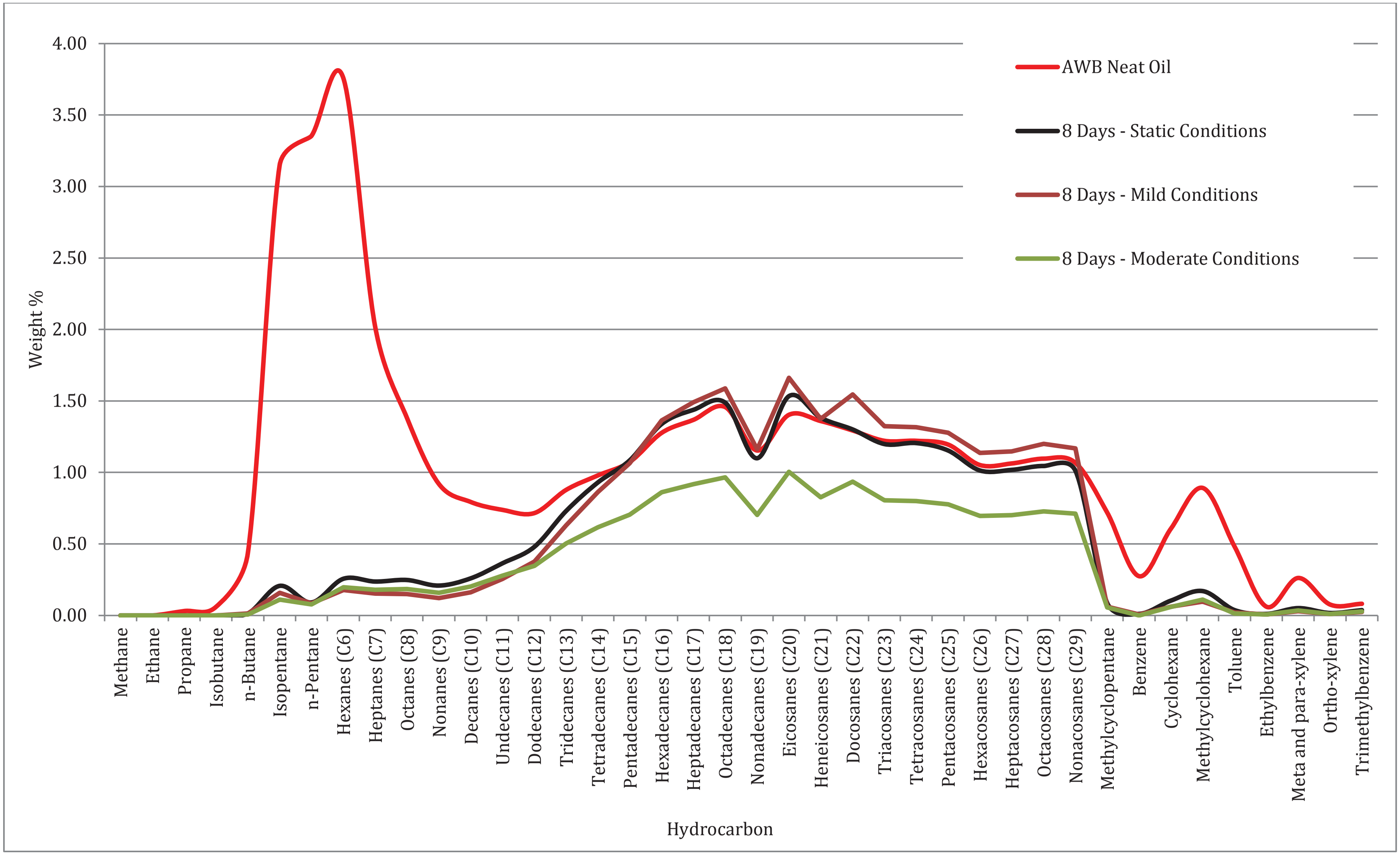


Figure E-1: AWB Light ends (C1 - C30)

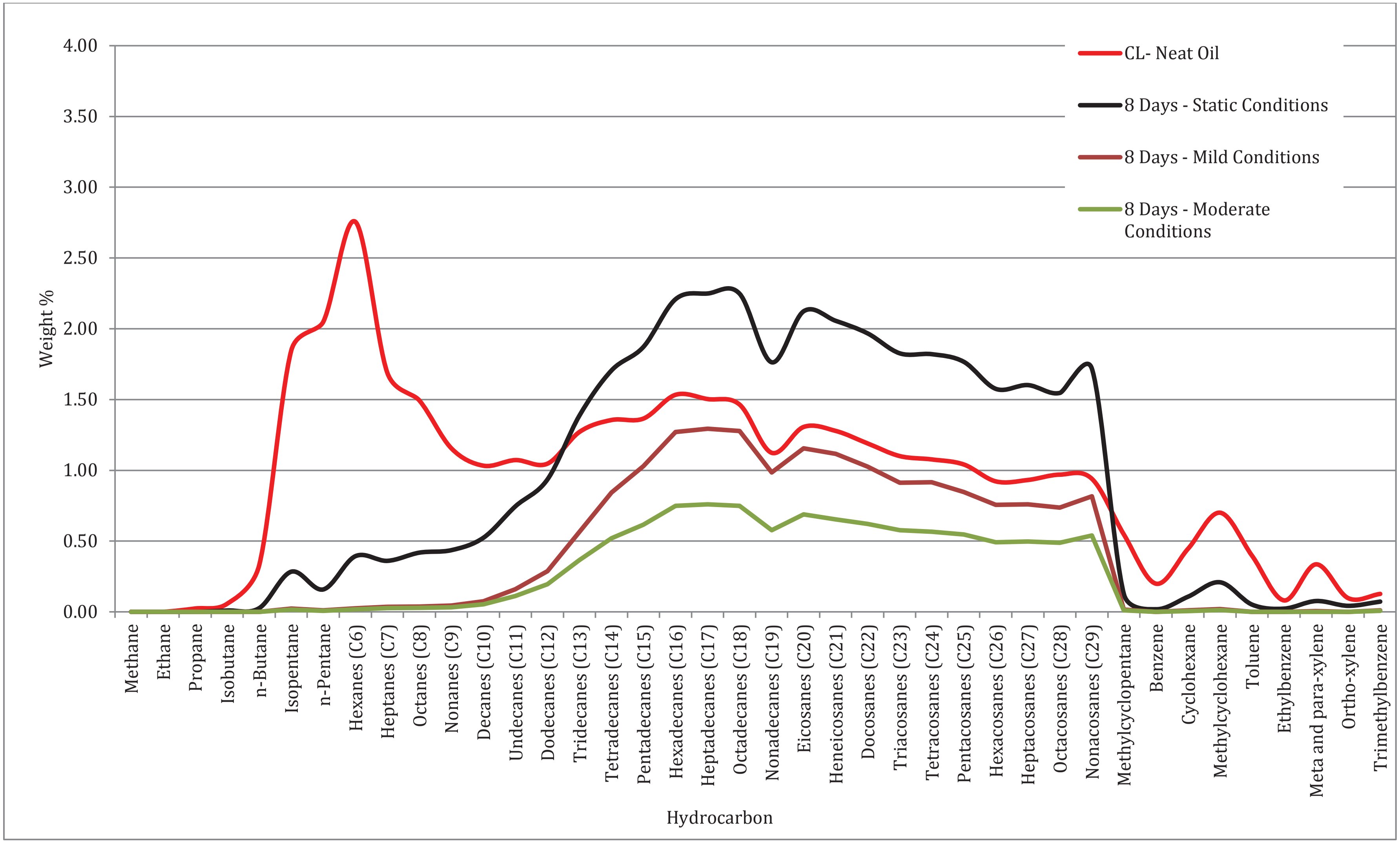


Figure E-2: CLWB Light ends (C1 - C30)

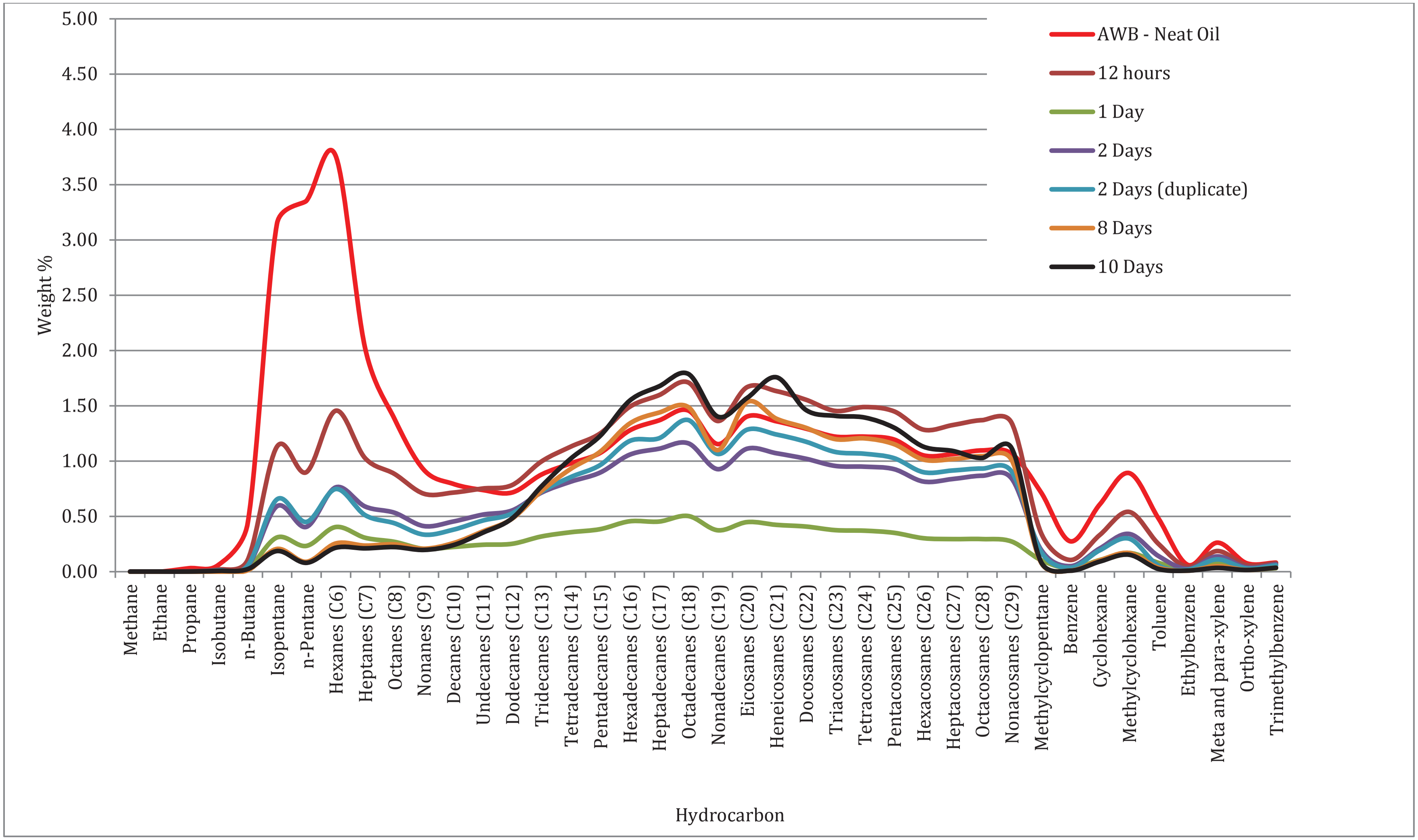


Figure E-3: AWB Light ends (C1 - C30) - Static conditions

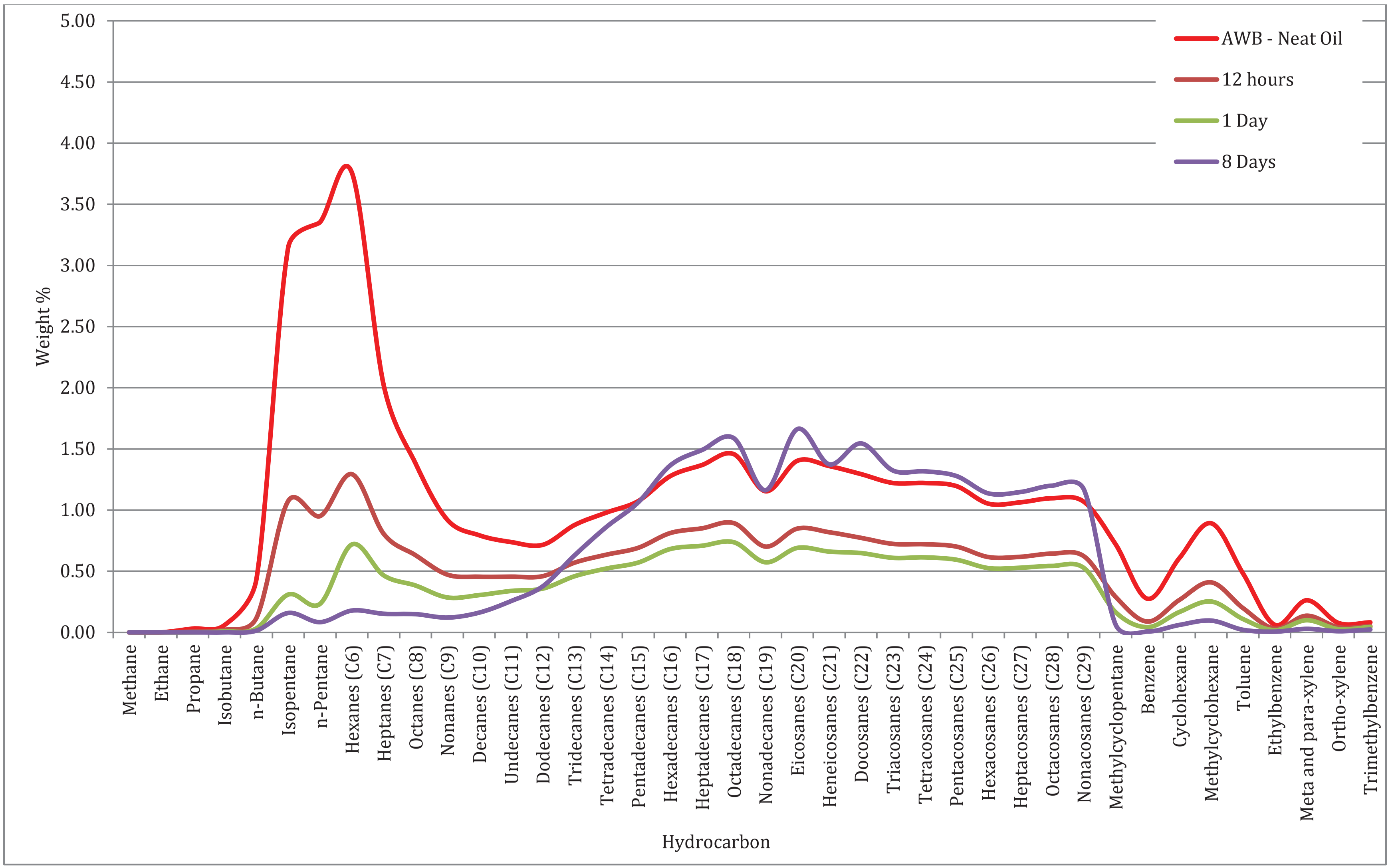


Figure E-4: AWB Light ends (C1 - C30) - Mild conditions

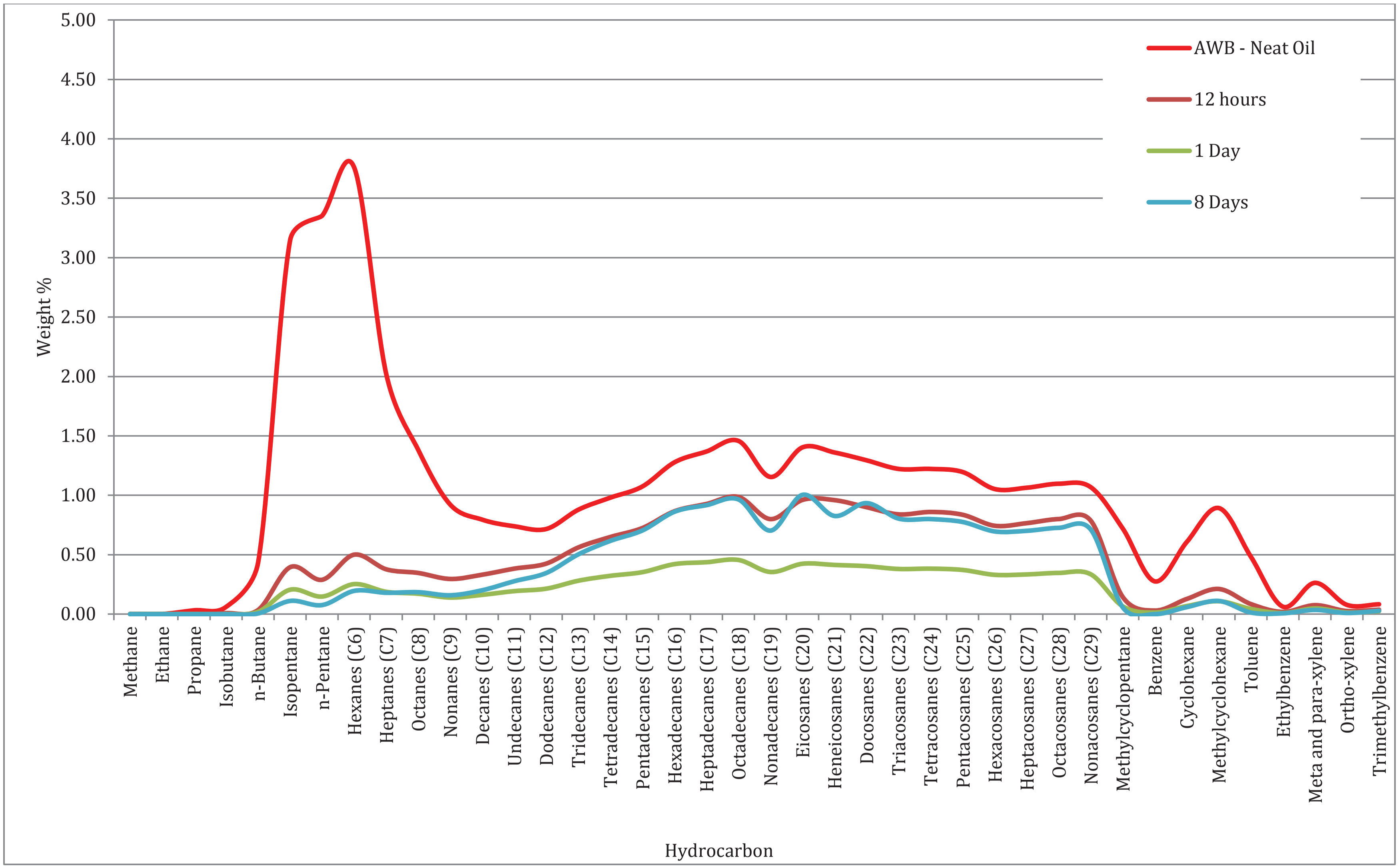


Figure E-5: AWB Light ends (C1 - C30) - Moderate condition

Appendix F: Water Chemistry Data (PAH, BTEX & C6-C10, and TPH)

Witt O'Brien's, Polaris Applied Sciences, and
Western Canada Marine Response Corporation

Introduction

This appendix section presents the chemistry data (PAH, BTEX, and TPH) of water samples collected from AWB and CLWB fate and behavior tests as the oils weathered under three agitation conditions:

- Static Conditions: One tank with no agitation induced. Wind exposure was minimized as far as was practical.
- Mild Agitation: One tank with low wind and wave conditions (e.g. 2 cm – 4 cm waves and 5 mph (2.2 m/s) winds, which were induced by simple mechanical means (intrinsically safe fans and paddles mechanism)).
- Moderate Agitation: One tank with conditions similar to Tank 2 but with a larger induced wind and wave agitation (e.g. 5-7 cm waves and 10 mph (4.5 m/s) winds).

mple Point	Acenaphthene	Acenaphthylene	Acridine	Anthracene	Benzo(a)anthracene	Benzo(b&j)fluoranthene	Benzo(k)fluoranthene	Benzo(ghi)perylene	Benzo(c)phenanthrene	Benzo(a)pyrene	Benzo(e)pyrene	Chrysene	Dibenz(ah)anthracene	Fluoranthene	Fluorene	Indeno(123-cd)pyrene	2-Methylnaphthalene	Naphthalene	Phenanthrene	Perylene	Pyrene	Quinoline	Retene	C1-Naphthalene	C2-Naphthalene	C3-Naphthalene	C4-Naphthalene
S1-PS-L2-W250-1	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.040	<0.050	<0.0085	0.14	0.12	0.056	<0.050	<0.020	<0.20	<0.050	0.34	0.3	0.12	<0.10
S1-PS-L2-W250-2	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.040	<0.050	<0.0085	0.15	0.13	0.061	<0.050	<0.020	<0.20	<0.050	0.35	0.31	0.11	<0.10
S1-2H-L1-W250-1	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.040	<0.050	<0.0085	0.18	0.16	0.069	<0.050	<0.020	0.21	<0.050	0.41	0.36	0.14	0.11
S1-2H-L1-W250-2	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0085	<0.0085	0.0093	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.040	<0.050	<0.0085	0.17	0.15	0.067	<0.050	<0.020	<0.20	<0.050	0.38	0.36	0.13	0.11
S1-4H-L1-W250-1																											
S1-4H-L1-W250-2																											
S1-6H-L1-W250-1	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.040	<0.050	<0.0085	0.15	0.16	<0.050	<0.050	<0.020	<0.20	<0.050	0.28	0.33	<0.10	0.13
S1-6H-L1-W250-2	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.040	<0.050	<0.0085	0.21	0.23	0.06	<0.050	<0.020	<0.20	<0.050	0.41	0.47	0.15	0.16
S1-12H-L1-W250-1	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.040	<0.050	<0.0085	0.16	0.18	0.064	<0.050	<0.020	0.2	<0.050	0.3	0.35	0.13	0.1
S1-12H-L1-W250-2	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.040	<0.050	<0.0085	0.16	0.16	0.061	<0.050	<0.020	0.21	<0.050	0.29	0.31	0.13	<0.10
S1-1D-L1-W250-1	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.040	<0.050	<0.0085	0.32	0.43	0.054	<0.050	<0.020	0.25	<0.050	0.66	0.4	0.13	0.11
S1-1D-L1-W250-2	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.040	<0.050	<0.0085	0.31	0.43	0.053	<0.050	<0.020	0.22	<0.050	0.62	0.42	0.13	<0.10
S1-2D-L1-W250-1	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	0.027	<0.040	<0.050	<0.0085	0.43	0.61	0.056	<0.050	<0.020	0.22	<0.050	0.88	0.55	0.16	0.13
S1-2D-L1-W250-2	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.020	<0.040	<0.050	<0.0085	0.44	0.62	0.058	<0.050	<0.020	0.24	<0.050	0.9	0.55	0.15	0.14
S1-4D-L1	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.040	<0.050	<0.0085	0.77	1.1	0.069	<0.050	<0.020	<0.85	<0.050	1.4	0.82	0.23	0.16
S1-6D-L1	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.040	0.055	<0.0085	0.83	1.1	0.074	<0.050	<0.020	<0.65	<0.050	1.5	1.1	0.21	0.13
S1-8D-L1	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.040	0.083	<0.0085	1.2	1.7	0.097	<0.050	<0.020	0.83	<0.050	2.1	1.2	0.33	0.26
S1-10D-L1	<0.10	<0.10	<0.20	0.014	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.040	0.077	<0.0085	1.4	1.9	0.097	<0.050	<0.020	0.9	<0.050	2.6	1.6	0.46	0.28

mple Point	Biphenyl	C1-Biphenyl	C2-Biphenyl	C1-Fluorene	C2-Fluorene	C3-Fluorene	Dibenzothiophene	C1-Dibenzothiophene	C2-Dibenzothiophene	C3-Dibenzothiophene	C4-Dibenzothiophene	C1-Phenanthrene/anthracene	C2-Phenanthrene/anthracene	C3-Phenanthrene/anthracene	C4-Phenanthrene/anthracene	C1-Fluoranthene/pyrene	C2-Fluoranthene/pyrene	C3-Fluoranthene/pyrene	C4-Fluoranthene/pyrene	C1-Benzo(a)anthracene/chrysene	C2-Benzo(a)anthracene/chrysene	C3-Benzo(a)anthracene/chrysene	C4-Benzo(a)anthracene/chrysene	C1-Benzo(bjk)fluoranthene/benzo(a)py	C2-Benzo(bjk)fluoranthene/benzo(a)py	C1-Acenaphthene
S1-PS-L2-W250-1	0.028	0.15	0.071	0.089	0.13	0.2	0.035	0.037	0.082	0.046	<0.020	0.055	<0.050	0.06	<0.050	<0.020	<0.020	<0.020	<0.020	<0.0085	<0.0085	<0.0085	<0.0085	<0.0075	<0.0075	<0.10
S1-PS-L2-W250-2	0.032	0.16	0.075	0.09	0.12	0.23	0.035	0.039	0.073	0.037	<0.020	0.059	<0.050	0.054	<0.050	<0.020	<0.020	<0.020	<0.020	<0.0085	<0.0085	<0.0085	<0.0085	<0.0075	<0.0075	<0.10
S1-2H-L1-W250-1	0.032	0.14	0.071	0.098	0.15	0.18	0.038	0.052	0.1	0.091	<0.020	0.075	0.088	0.16	0.072	<0.020	0.05	0.068	<0.020	<0.0085	<0.0085	<0.0085	<0.0085	<0.0075	<0.0075	<0.10
S1-2H-L1-W250-2	0.034	0.17	0.087	0.1	0.13	0.2	0.036	0.044	0.091	0.076	<0.020	0.075	0.074	0.14	0.051	<0.020	0.046	0.049	<0.020	0.015	0.046	<0.0085	<0.0085	<0.0075	<0.0075	<0.10
S1-4H-L1-W250-1																										
S1-4H-L1-W250-2																										
S1-6H-L1-W250-1	0.03	0.14	0.079	0.083	0.095	<0.10	0.028	0.04	0.07	0.079	<0.020	0.054	0.055	0.059	<0.050	<0.020	0.043	0.064	<0.020	0.0094	0.069	<0.0085	<0.0085	<0.0075	<0.0075	<0.10
S1-6H-L1-W250-2	0.039	0.18	0.11	0.1	0.15	<0.10	0.039	0.047	0.084	0.053	<0.020	0.071	0.076	0.11	0.06	0.028	0.06	0.089	0.043	0.017	0.12	<0.0085	<0.0085	<0.0075	<0.0075	<0.10
S1-12H-L1-W250-1	0.032	0.18	0.099	0.14	0.16	0.13	0.036	0.045	0.075	0.052	<0.020	0.074	0.068	0.067	<0.050	<0.020	0.034	<0.020	<0.020	0.011	0.043	<0.0085	<0.0085	<0.0075	<0.0075	<0.10
S1-12H-L1-W250-2	0.031	0.18	0.091	0.14	0.15	0.14	0.035	0.041	0.079	0.052	<0.020	0.069	0.071	0.072	<0.050	<0.020	0.033	<0.020	<0.020	<0.0085	0.049	<0.0085	<0.0085	<0.0075	<0.0075	<0.10
S1-1D-L1-W250-1	0.047	0.15	0.081	0.084	0.11	0.24	0.032	0.036	0.059	0.049	<0.020	0.074	<0.050	0.055	<0.050	<0.020	<0.020	<0.020	<0.020	<0.0085	0.03	<0.0085	<0.0085	<0.0075	<0.0075	<0.10
S1-1D-L1-W250-2	0.045	0.14	0.14	0.089	0.12	0.19	0.032	0.042	0.059	0.044	<0.020	0.067	<0.050	<0.050	<0.050	<0.020	0.027	<0.020	<0.020	<0.0085	0.025	<0.0085	<0.0085	<0.0075	<0.0075	<0.10
S1-2D-L1-W250-1	0.052	0.16	0.079	0.092	0.13	<0.050	0.035	0.043	0.076	0.074	<0.020	0.071	0.069	0.061	<0.050	<0.020	0.03	<0.020	<0.020	<0.0085	<0.0085	<0.0085	<0.0085	<0.0075	<0.0075	<0.10
S1-2D-L1-W250-2	0.053	0.15	0.079	0.1	0.14	<0.050	0.037	0.043	0.083	0.071	<0.020	0.077	0.058	0.06	<0.050	<0.020	0.026	<0.020	<0.020	<0.0085	<0.0085	<0.0085	<0.0085	<0.0075	<0.0075	<0.10
S1-4D-L1	0.1	0.17	0.17	0.1	0.11	<1.4	0.04	<0.020	0.072	0.054	<0.020	0.11	0.058	0.054	<0.050	<0.020	<0.020	<0.020	<0.020	<0.0085	<0.0085	<0.060	<0.33	<0.14	<0.22	<0.10
S1-6D-L1	0.094	0.27	0.2	0.11	0.11	0.19	0.035	0.047	0.092	0.055	0.53	0.083	0.068	0.053	<0.050	<0.020	<0.020	<0.020	<0.020	<0.0085	<0.0085	<0.0085	<0.0085	<0.0075	<0.0075	<0.10
S1-8D-L1	0.13	0.27	0.24	0.17	0.2	0.42	0.051	0.087	0.11	0.07	<0.020	0.11	0.1	0.07	<0.050	0.021	<0.020	<0.020	<0.020	<0.0085	<0.0085	<0.0085	<0.0085	<0.0075	<0.0075	<0.10
S1-10D-L1	0.18	0.27	0.21	0.16	0.16	<1.4	0.055	0.084	0.1	0.07	<0.020	0.14	0.15	0.13	<0.050	<0.020	<0.020	<0.020	<0.020	<0.0085	<0.0085	<0.060	<0.33	<0.14	<0.22	<0.10

Table F-1: AWB Static - PAH water data at 0.5 m

nple Point	Acenaphthene	Acenaphthylene	Acridine	Anthracene	Benzo(a)anthracene	Benzo(b&j)fluoranthene	Benzo(k)fluoranthene	Benzo(ghi)perylene	Benzo(c)phenanthrene	Benzo(a)pyrene	Benzo(e)pyrene	Chrysene	Dibenz(ah)anthracene	Fluoranthene	Fluorene	Indeno(123-cd)pyrene	2-Methylnaphthalene	Naphthalene	Phenanthrene	Perylene	Pyrene	Quinoline	Retene	C1-Naphthalene	C2-Naphthalene	C3-Naphthalene	C4-Naphthalene
S1 2H L2 W250-1	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.040	<0.050	<0.0085	0.16	0.15	0.06	<0.050	<0.020	<0.20	<0.050	0.36	0.34	0.12	0.1
S1 2H L2 W250-2	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.040	<0.050	<0.0085	0.18	0.16	0.071	<0.050	<0.020	<0.20	<0.050	0.41	0.37	0.14	0.14
S1-4H-L2-W250-1																											
S1-4H-L2-W250-2																											
S1-6H-L2-W250-1	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.040	<0.050	<0.0085	0.16	0.17	<0.050	<0.050	<0.020	<0.22	<0.050	0.29	0.36	0.13	0.11
S1-6H-L2-W250-2	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.040	<0.050	<0.0085	0.18	0.22	0.051	<0.050	<0.020	<0.20	<0.050	0.32	0.38	0.12	0.12
S1-12H-L2-W250-1	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.040	0.052	<0.0085	0.16	0.17	0.061	<0.050	<0.020	0.24	<0.050	0.27	0.32	0.1	0.11
S1-12H-L2-W250-2	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.040	<0.050	<0.0085	0.15	0.16	0.056	<0.050	<0.020	0.21	<0.050	0.27	0.3	<0.10	<0.10
S1-1D-L2-W250-1	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.040	<0.050	<0.0085	0.37	0.51	0.061	<0.050	<0.020	0.23	<0.050	0.73	0.52	0.16	0.11
S1-1D-L2-W250-2	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.040	<0.050	<0.0085	0.35	0.48	0.054	<0.050	<0.020	0.21	<0.050	0.69	0.46	0.15	0.1
S1-2D-L2-W250-1	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	0.028	<0.040	<0.050	<0.0085	0.46	0.66	0.062	<0.050	<0.020	0.24	<0.050	0.95	0.6	0.19	0.15
S1-2D-L2-W250-2	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.020	<0.040	<0.050	<0.0085	0.42	0.6	0.058	<0.050	<0.020	0.22	<0.050	0.86	0.57	0.16	0.13
S1-4D-L2	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.040	<0.050	<0.0085	0.75	1.1	0.066	<0.050	<0.020	<0.85	<0.050	1.4	0.81	0.22	0.19
S1-6D-L2	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.040	0.052	<0.0085	0.86	1.2	0.072	<0.050	<0.020	<0.52	<0.050	1.6	0.9	0.23	0.12
S1-8D-L2	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.040	0.082	<0.0085	1.2	1.7	0.088	<0.050	<0.020	0.74	<0.050	2.1	1.2	0.31	0.2
S1-10D-L2	<0.10	<0.10	<0.20	0.013	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.040	0.078	<0.0085	1.4	1.8	0.095	<0.050	<0.020	0.87	<0.050	2.4	1.5	0.46	0.29

nple Point	Biphenyl	C1-Biphenyl	C2-Biphenyl	C1-Fluorene	C2-Fluorene	C3-Fluorene	Dibenzothiophene	C1-Dibenzothiophene	C2-Dibenzothiophene	C3-Dibenzothiophene	C4-Dibenzothiophene	C1-Phenanthrene/anthracene	C2-Phenanthrene/anthracene	C3-Phenanthrene/anthracene	C4-Phenanthrene/anthracene	C1-Fluoranthene/pyrene	C2-Fluoranthene/pyrene	C3-Fluoranthene/pyrene	C4-Fluoranthene/pyrene	C1-Benzo(a)anthracene/chrysene	C2-Benzo(a)anthracene/chrysene	C3-Benzo(a)anthracene/chrysene	C4-Benzo(a)anthracene/chrysene	C1-Benzo(b|k)fluoranthene/benzo(a)p	C2-Benzo(b|k)fluoranthene/benzo(a)p	C1-Acenaphthene	1-Methylnaphthalene
S1 2H L2 W250-1	0.032	0.15	0.077	0.093	0.14	0.18	0.034	0.047	0.089	0.078	<0.020	0.075	0.073	0.13	0.056	<0.020	0.042	<0.020	<0.020	0.012	0.079	0.017	<0.0085	<0.0075	<0.0075	<0.10	0.13
S1 2H L2 W250-2	0.034	0.16	0.079	0.1	0.18	0.26	0.038	0.047	0.095	0.077	<0.020	0.085	0.081	0.15	0.057	<0.020	0.039	0.04	0.021	0.012	0.068	<0.0085	<0.0085	<0.0075	<0.0075	<0.10	0.15
S1-4H-L2-W250-1																											
S1-4H-L2-W250-2																											
S1-6H-L2-W250-1	0.029	0.15	0.1	0.097	0.13	<0.10	0.03	0.039	<0.020	0.084	<0.020	0.071	0.078	0.065	0.05	0.021	0.046	0.074	<0.020	0.015	0.11	<0.0085	<0.0085	<0.0075	<0.0075	<0.10	0.14
S1-6H-L2-W250-2	0.03	0.17	0.077	0.082	0.15	<0.10	0.033	0.037	0.073	0.097	<0.020	0.071	0.1	0.094	0.067	<0.020	0.06	0.036	<0.020	0.014	0.12	<0.0085	<0.0085	<0.0075	<0.0075	<0.10	0.14
S1-12H-L2-W250-1	0.033	0.2	0.097	0.15	0.17	0.15	0.035	0.046	0.07	0.067	<0.020	0.076	0.074	0.074	<0.050	<0.020	0.04	<0.020	<0.020	0.01	0.047	<0.0085	<0.0085	<0.0075	<0.0075	<0.10	0.12
S1-12H-L2-W250-2	0.029	0.16	0.09	0.14	0.16	0.16	0.033	0.04	0.076	0.056	<0.020	0.071	0.065	0.068	<0.050	<0.020	0.031	<0.020	<0.020	<0.0085	0.034	<0.0085	<0.0085	<0.0075	<0.0075	<0.10	0.12
S1-1D-L2-W250-1	0.05	0.15	0.084	0.1	0.14	0.23	0.036	0.041	0.07	0.052	<0.020	0.079	0.066	0.061	<0.050	<0.020	0.027	<0.020	<0.020	0.0095	0.037	<0.0085	<0.0085	<0.0075	<0.0075	<0.10	0.28
S1-1D-L2-W250-2	0.046	0.13	0.065	0.087	0.13	0.19	0.033	0.037	0.065	0.047	<0.020	0.073	0.061	0.057	<0.050	<0.020	0.025	<0.020	<0.020	<0.0085	0.029	<0.0085	<0.0085	<0.0075	<0.0075	<0.10	0.26
S1-2D-L2-W250-1	0.056	0.17	0.086	0.12	0.16	<0.050	0.04	0.053	0.084	0.077	<0.020	0.083	0.071	0.068	<0.050	<0.020	0.028	<0.020	<0.020	<0.0085	<0.0085	<0.0085	<0.0085	<0.0075	<0.0075	<0.10	0.38
S1-2D-L2-W250-2	0.051	0.16	0.082	0.1	0.14	<0.050	0.035	0.039	0.075	0.074	<0.020	0.077	0.067	0.067	<0.050	<0.020	0.025	<0.020	<0.020	<0.0085	0.036	<0.0085	<0.0085	<0.0075	<0.0075	<0.10	0.34
S1-4D-L2	0.091	0.18	0.16	0.097	0.11	<1.4	0.035	0.068	0.065	0.052	<0.020	0.14	0.15	0.12	<0.050	<0.020	<0.020	<0.020	<0.020	<0.0085	0.034	<0.060	<0.33	<0.14	<0.22	<0.10	
S1-6D-L2	0.097	0.24	0.18	0.11	0.11	0.26	0.037	0.071	0.072	0.052	0.5	0.079	0.058	<0.050	<0.050	<0.020	<0.020	<0.020	<0.020	<0.0085	<0.0085	<0.0085	<0.0085	<0.0075	<0.0075	<0.10	
S1-8D-L2	0.14	0.25	0.23	0.17	0.17	0.38	0.051	0.061	0.1	0.065	<0.020	0.094	0.098	0.081	<0.050	<0.020	0.033	<0.020	<0.020	0.013	0.012	0.0099	0.017	<0.0075	<0.0075	<0.10	
S1-10D-L2	0.16	0.25	0.19	0.15	0.14	<1.4	0.054	0.074	0.12	0.073	<0.020	0.16	0.18	0.12	<0.050	<0.020	<0.020	<0.020	<0.020	<0.0085	<0.0085	<0.060	<0.33	<0.14	<0.22	<0.10	

Table F-2: AWB Static - PAH water data at 1.0 m

mple Point	Acenaphthene	Acenaphthylene	Acridine	Anthracene	Benzo(a)anthracene	Benzo(b&j)fluoranthene	Benzo(k)fluoranthene	Benzo(ghi)perylene	Benzo(c)phenanthrene	Benzo(a)pyrene	Benzo(e)pyrene	Chrysene	Dibenz(ah)anthracene	Fluoranthene	Fluorene	Indeno(123-cd)pyrene	2-Methylnaphthalene	Naphthalene	Phenanthrene	Perylene	Pyrene	Quinoline	Retene	C1-Naphthalene	C2-Naphthalene	C3-Naphthalene	C4-Naphthalene
S1-2H-L3 W250-1	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.040	<0.050	<0.0085	0.14	0.13	0.055	<0.050	<0.020	<0.20	<0.050	0.32	0.29	0.1	<0.10
S1 2H L3 W250-2	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.040	<0.050	<0.0085	0.14	0.12	0.053	<0.050	<0.020	<0.20	<0.050	0.32	0.28	<0.10	<0.10
S1-4H-L3-W250-1																											
S1-4H-L3-W250-2																											
S1-6H-L3-W250-1																											
S1-6H-L3-W250-2	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.040	<0.050	<0.0085	0.16	0.21	<0.050	<0.050	<0.020	<0.20	<0.050	0.31	0.35	0.11	<0.10
S1-12H-L3-W250-1	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.040	<0.050	<0.0085	0.15	0.19	0.059	<0.050	<0.020	0.24	<0.050	0.29	0.31	0.12	0.11
S1-12H-L3-W250-2	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.040	<0.050	<0.0085	0.15	0.17	0.053	<0.050	<0.020	0.23	<0.050	0.3	0.33	0.11	0.1
S1-1D-L3-W250-1	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.040	<0.050	<0.0085	0.42	0.6	0.057	<0.050	<0.020	0.27	<0.050	0.83	0.52	0.18	0.12
S1-1D-L3-W250-2	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.040	<0.050	<0.0085	0.44	0.63	0.062	<0.050	<0.020	0.25	<0.050	0.88	0.57	0.17	0.11
S1-2D-L3-W250-1	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	0.028	<0.040	<0.050	<0.0085	0.5	0.75	0.061	<0.050	<0.020	0.24	<0.050	1	0.63	0.17	0.13
S1-2D-L3-W250-2	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.020	<0.040	<0.050	<0.0085	0.51	0.75	0.063	<0.050	<0.020	0.23	<0.050	1	0.66	0.15	0.15
S1-4D-L3	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.040	<0.050	<0.0085	0.72	1	0.064	<0.050	<0.020	<0.85	<0.050	1.4	0.78	0.22	0.17
S1-6D-L3	<0.10	<0.10	<0.20	0.014	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.040	0.062	<0.0085	0.97	1.3	0.092	<0.050	<0.020	<0.54	<0.050	1.9	0.97	0.27	0.16
S1-8D-L3	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.040	0.082	<0.0085	1.1	1.6	0.097	<0.050	<0.020	0.75	<0.050	1.9	1.2	0.31	0.2
S1-10D-L3	<0.10	<0.10	<0.20	0.012	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.040	0.073	<0.0085	1.3	1.8	0.091	<0.050	<0.020	1.2	<0.050	2.3	1.4	0.43	0.27

mple Point	Biphenyl	C1-Biphenyl	C2-Biphenyl	C1-Fluorene	C2-Fluorene	C3-Fluorene	Dibenzothiophene	C1-Dibenzothiophene	C2-Dibenzothiophene	C3-Dibenzothiophene	C4-Dibenzothiophene	C1-Phenanthrene/anthracene	C2-Phenanthrene/anthracene	C3-Phenanthrene/anthracene	C4-Phenanthrene/anthracene	C1-Fluoranthene/pyrene	C2-Fluoranthene/pyrene	C3-Fluoranthene/pyrene	C4-Fluoranthene/pyrene	C1-Benzo(a)anthracene/chrysene	C2-Benzo(a)anthracene/chrysene	C3-Benzo(a)anthracene/chrysene	C4-Benzo(a)anthracene/chrysene	C1-Benzo(bjk)fluoranthene/benzo(a)py	C2-Benzo(bjk)fluoranthene/benzo(a)py	C1-Acenaphthene	1-Methylnaphthalene
S1-2H-L3 W250-1	0.028	0.14	0.067	0.087	0.13	0.17	0.033	0.03	0.055	0.044	<0.020	0.057	<0.050	0.078	<0.050	<0.020	<0.020	<0.020	<0.020	<0.0085	<0.0085	<0.0085	<0.0085	<0.0075	<0.0075	<0.10	0.12
S1 2H L3 W250-2	0.027	0.14	0.071	0.085	0.14	0.16	0.033	0.039	0.065	0.043	<0.020	0.057	<0.050	0.077	<0.050	<0.020	<0.020	<0.020	<0.020	<0.0085	<0.0085	<0.0085	<0.0085	<0.0075	<0.0075	<0.10	0.12
S1-4H-L3-W250-1																											
S1-4H-L3-W250-2																											
S1-6H-L3-W250-1																											
S1-6H-L3-W250-2	0.028	0.11	0.086	0.086	<0.050	<0.10	0.031	<0.020	0.079	0.079	<0.020	<0.050	0.082	0.11	<0.050	<0.020	0.048	0.063	0.049	0.013	0.091	<0.0085	<0.0085	<0.0075	<0.0075	<0.10	0.13
S1-12H-L3-W250-1	0.032	0.18	0.097	0.15	0.17	<0.050	0.033	0.044	0.067	0.073	<0.020	0.08	0.084	0.096	<0.050	<0.020	0.041	<0.020	0.048	0.015	0.071	0.028	<0.0085	<0.0075	<0.0075	<0.10	0.12
S1-12H-L3-W250-2	0.03	0.17	0.094	0.14	0.17	0.15	0.035	0.043	0.084	0.076	<0.020	0.068	0.076	0.078	<0.050	<0.020	0.043	0.059	0.034	0.012	0.061	0.019	<0.0085	<0.0075	<0.0075	<0.10	0.12
S1-1D-L3-W250-1	0.053	0.16	0.089	0.097	0.11	0.24	0.032	0.038	0.072	0.056	<0.020	0.074	0.073	0.077	<0.050	<0.020	0.032	<0.020	<0.020	0.011	0.041	<0.0085	<0.0085	<0.0075	<0.0075	<0.10	0.31
S1-1D-L3-W250-2	0.056	0.15	0.15	0.1	0.12	0.23	0.034	0.043	0.072	0.058	<0.020	0.064	0.072	0.072	<0.050	<0.020	0.044	0.051	0.025	0.013	0.06	0.022	<0.0085	<0.0075	<0.0075	<0.10	0.33
S1-2D-L3-W250-1	0.059	0.17	0.087	0.12	0.15	<0.050	0.039	0.049	0.082	0.072	<0.020	0.077	0.062	0.066	<0.050	<0.020	0.034	<0.020	<0.020	<0.0085	<0.0085	<0.0085	<0.0085	<0.0075	<0.0075	<0.10	0.41
S1-2D-L3-W250-2	0.06	0.17	0.072	0.11	0.12	<0.050	0.041	0.05	0.081	0.075	<0.020	0.086	0.081	0.077	<0.050	<0.020	0.031	<0.020	<0.020	<0.0085	<0.0085	<0.0085	<0.0085	<0.0075	<0.0075	<0.10	0.4
S1-4D-L3	0.098	0.18	0.17	0.089	0.092	<1.4	0.035	0.052	0.067	0.047	<0.020	0.11	0.061	0.1	<0.050	<0.020	<0.020	<0.020	<0.020	0.009	<0.0085	<0.060	<0.33	<0.14	<0.22	<0.10	
S1-6D-L3	0.11	0.27	0.12	0.13	0.15	0.26	0.045	7.9	0.11	<0.020	0.54	0.1	0.076	0.07	<0.050	<0.020	<0.020	<0.020	<0.020	<0.0085	<0.0085	<0.0085	<0.0085	<0.0075	<0.0075	<0.10	
S1-8D-L3	0.13	0.26	0.26	0.19	0.18	0.37	0.051	0.021	0.09	0.083	<0.020	0.11	0.11	0.079	<0.050	0.02	0.053	<0.020	<0.020	<0.0085	<0.0085	<0.0085	<0.0085	<0.0075	<0.0075	<0.10	
S1-10D-L3	0.17	0.25	0.2	0.15	0.16	<1.4	0.053	0.081	0.14	0.094	<0.020	0.13	0.15	0.11	<0.050	<0.020	0.028	<0.020	<0.020	<0.0085	0.029	<0.060	<0.33	<0.14	<0.22	<0.10	

Table F-3: AWB Static - PAH water data at 1.5 m

mple Point	Acenaphthene	Acenaphthylene	Acridine	Anthracene	Benzo(a)anthracene	Benzo(b&j)fluoranthene	Benzo(k)fluoranthene	Benzo(ghi)perylene	Benzo(c)phenanthrene	Benzo(a)pyrene	Benzo(e)pyrene	Chrysene	Dibenz(ah)anthracene	Fluoranthene	Fluorene	Indeno(123-cd)pyrene	2-Methylnaphthalene	Naphthalene	Phenanthrene	Perylene	Pyrene	Quinoline	Retene	C1-Naphthalene	C2-Naphthalene	C3-Naphthalene	C4-Naphthalene
S2-2H-L1-W40	<0.19	<0.19	<0.37	<0.019	<0.016	<0.016	<0.016	<0.016	<0.093	<0.014	<0.093	<0.016	<0.014	<0.074	<0.093	<0.016	<0.19	<0.19	<0.093	<0.093	<0.037	<0.37	<0.093	0.23	0.28	<0.19	<0.19
S2-4H-L1-W250-1																											
S2-4H-L1-W250-2																											
S2-6H-L1-W250-1	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.040	<0.050	<0.0085	0.31	0.43	0.07	<0.050	<0.020	0.21	<0.050	0.65	0.48	0.16	0.13
S2-6H-L1-W250-2	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.040	0.052	<0.0085	0.33	0.46	0.084	<0.050	<0.020	0.22	<0.050	0.73	0.48	0.18	0.14
S2-12H-L1-W250-1	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.040	0.052	<0.0085	0.42	0.67	0.057	<0.050	<0.020	0.32	<0.050	0.84	0.54	0.16	0.12
S2-12H-L1-W250-2	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.040	0.052	<0.0085	0.42	0.66	0.059	<0.050	<0.020	0.28	<0.050	0.85	0.53	0.15	0.1
S2-1D-L1-W250-1	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.040	<0.050	<0.0085	0.65	1	0.059	<0.050	<0.020	0.28	<0.050	1.3	0.7	0.2	0.12
S2-1D-L1-W250-2	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.040	<0.050	<0.0085	0.72	1.1	0.064	<0.050	<0.020	0.3	<0.050	1.4	0.74	0.2	0.12
S2-2D-L1-W250-1	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.020	<0.040	0.069	<0.0085	1.2	1.9	0.081	<0.050	<0.020	0.34	<0.050	2.3	1.3	0.34	0.18
S2-2D-L1-W250-2	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.020	<0.040	0.067	<0.0085	1.2	1.9	0.079	<0.050	<0.020	0.33	<0.050	2.3	1.3	0.34	0.18
S2-4D-L1	<0.10	<0.10	<0.20	0.011	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	0.0088	<0.050	<0.0085	<0.0075	<0.040	0.093	<0.0085	2	2.6	0.1	<0.050	<0.020	1.4	<0.050	3.5	2	0.55	0.3
S2-6D-L1	<0.10	<0.10	<0.20	0.012	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.040	0.097	<0.0085	1.5	1.6	0.11	<0.050	<0.020	<0.75	<0.050	2.8	1.8	0.49	0.24
S2-8D-L1	<0.10	<0.10	<0.20	0.016	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.040	0.14	<0.0085	1.4	1.5	0.16	<0.050	<0.020	1.2	<0.050	2.5	1.8	0.65	0.35
S2-10D-L1	<0.10	<0.10	<0.20	0.021	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.040	0.13	<0.0085	1.5	1.3	0.14	<0.050	<0.020	1.3	<0.050	2.6	2.2	0.71	0.45

mple Point	Biphenyl	C1-Biphenyl	C2-Biphenyl	C1-Fluorene	C2-Fluorene	C3-Fluorene	Dibenzothiophene	C1-Dibenzothiophene	C2-Dibenzothiophene	C3-Dibenzothiophene	C4-Dibenzothiophene	C1-Phenanthrene/anthracene	C2-Phenanthrene/anthracene	C3-Phenanthrene/anthracene	C4-Phenanthrene/anthracene	C1-Fluoranthene/pyrene	C2-Fluoranthene/pyrene	C3-Fluoranthene/pyrene	C4-Fluoranthene/pyrene	C1-Benzo(a)anthracene/chrysene	C2-Benzo(a)anthracene/chrysene	C3-Benzo(a)anthracene/chrysene	C4-Benzo(a)anthracene/chrysene	C1-Benzo(b|k)fluoranthene/benzo(a)py	C2-Benzo(b|k)fluoranthene/benzo(a)py	C1-Acenaphthene	1-Methylnaphthalene
S2-2H-L1-W40	0.045 (1)	0.30 (1)	0.42 (1)	0.19 (1)	0.13 (1)	0.51 (1)	<0.037	<0.037	0.050	0.045	0.073	<0.093	<0.093	<0.093	<0.093	<0.037	<0.037	<0.037	<0.037	<0.016	<0.016	<0.016	<0.016	<0.014	<0.014	<0.19	<0.19
S2-4H-L1-W250-1																											
S2-4H-L1-W250-2																											
S2-6H-L1-W250-1	0.046	0.18	0.09	0.11	0.15	0.18	0.037	0.05	0.098	0.07	<0.020	0.088	0.077	0.13	<0.050	<0.020	0.049	0.048	<0.020	0.014	0.073	<0.0085	<0.0085	<0.0075	<0.0075	<0.10	0.24
S2-6H-L1-W250-2	0.055	0.2	0.095	0.11	0.2	0.26	0.041	0.056	0.092	0.074	<0.020	0.087	0.086	0.16	0.057	<0.020	0.042	0.036	<0.020	0.013	0.057	<0.0085	<0.0085	<0.0075	<0.0075	<0.10	0.25
S2-12H-L1-W250-1	0.051	0.18	0.089	0.15	0.17	0.14	0.037	0.042	0.086	0.062	<0.020	0.074	0.082	0.087	<0.050	<0.020	0.039	0.051	0.047	0.014	0.059	<0.0085	<0.0085	<0.0075	<0.0075	<0.10	0.31
S2-12H-L1-W250-2	0.05	0.18	0.099	0.15	0.18	0.11	0.036	0.044	0.08	0.063	<0.020	0.074	0.084	0.081	<0.050	<0.020	0.038	0.051	0.043	0.012	0.063	0.018	<0.0085	<0.0075	<0.0075	<0.10	0.32
S2-1D-L1-W250-1	0.073	0.15	0.067	0.1	0.15	0.21	0.034	0.04	0.052	0.047	<0.020	0.081	0.065	0.057	<0.050	<0.020	0.034	<0.020	0.022	<0.0085	0.04	0.018	<0.0085	<0.0075	<0.0075	<0.10	0.47
S2-1D-L1-W250-2	0.079	0.16	0.066	0.1	0.13	0.2	0.036	0.042	0.065	0.048	<0.020	0.08	0.063	0.06	<0.050	<0.020	0.036	<0.020	<0.020	<0.0085	0.037	0.013	<0.0085	<0.0075	<0.0075	<0.10	0.52
S2-2D-L1-W250-1	0.13	0.23	0.1	0.14	0.21	<0.050	0.046	0.049	0.075	0.059	<0.020	0.1	0.079	0.059	<0.050	<0.020	0.037	<0.020	<0.020	0.0091	0.024	<0.0085	<0.0085	<0.0075	<0.0075	<0.10	0.91
S2-2D-L1-W250-2	0.13	0.22	0.099	0.12	0.18	<0.050	0.044	0.05	0.071	0.056	<0.020	0.1	0.072	0.06	<0.050	<0.020	0.026	<0.020	<0.020	<0.0085	0.03	<0.0085	<0.0085	<0.0075	<0.0075	<0.10	0.89
S2-4D-L1	0.24	0.32	0.19	0.15	0.13	<1.4	0.049	0.072	0.08	0.066	<0.020	0.15	0.085	0.061	<0.050	<0.020	<0.020	<0.020	<0.020	0.01	0.017	<0.060	<0.33	<0.14	<0.22	<0.10	
S2-6D-L1	0.17	0.34	0.16	0.16	0.16	<0.050	0.044	0.06	0.076	0.062	<0.020	0.12	0.098	0.081	<0.050	<0.020	<0.020	<0.020	<0.020	<0.0085	<0.0085	<0.0085	<0.0085	<0.0075	<0.0075	<0.10	
S2-8D-L1	0.21	0.39	0.29	0.24	0.21	0.42	0.064	0.096	0.11	0.095	<0.020	0.17	0.16	0.11	<0.050	0.029	0.041	<0.020	<0.020	<0.0085	0.014	<0.0085	<0.0085	<0.0075	<0.0075	<0.10	
S2-10D-L1	0.23	0.34	0.25	0.21	0.18	<1.4	0.068	0.084	0.11	0.071	<0.020	0.21	0.24	0.18	<0.050	0.025	<0.020	<0.020	<0.020	<0.0085	<0.0085	<0.060	<0.33	<0.14	<0.22	<0.10	

Table F-4: AWB Mild Conditions - PAH water data at 0.5 m

mple Point	Acenaphthene	Acenaphthylene	Acridine	Anthracene	Benzo(a)anthracene	Benzo(b&j)fluoranthene	Benzo(k)fluoranthene	Benzo(ghi)perylene	Benzo(c)phenanthrene	Benzo(a)pyrene	Benzo(e)pyrene	Chrysene	Dibenz(ah)anthracene	Fluoranthene	Fluorene	Indeno(123-cd)pyrene	2-Methylnaphthalene	Naphthalene	Phenanthrene	Perylene	Pyrene	Quinoline	Retene	C1-Naphthalene	C2-Naphthalene	C3-Naphthalene	C4-Naphthalene
S2-2H-L2-W250-1	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.040	<0.050	<0.0085	0.19	0.19	<0.050	<0.050	<0.020	<0.20	<0.050	0.36	0.33	0.13	0.11
S2-2H-L2-W250-2	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.040	<0.050	<0.0085	0.19	0.2	0.051	<0.050	<0.020	<0.20	<0.050	0.37	0.35	0.12	0.11
S2-4H-L2-W250-1																											
S2-4H-L2-W250-2																											
S2-6H-L2-W250-1	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.040	0.051	<0.0085	0.31	0.43	0.082	<0.050	<0.020	0.25	<0.050	0.64	0.5	0.18	0.12
S2-6H-L2-W250-2	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.040	<0.050	<0.0085	0.29	0.4	0.072	<0.050	<0.020	0.24	<0.050	0.64	0.46	0.17	0.15
S2-12H-L2-W250-1	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.040	0.052	<0.0085	0.42	0.67	0.065	<0.050	<0.020	0.28	<0.050	0.82	0.5	0.18	0.13
S2-12H-L2-W250-2	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.040	0.051	<0.0085	0.42	0.66	0.065	<0.050	<0.020	0.29	<0.050	0.84	0.56	0.21	0.13
S2-1D-L2-W250-1	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.040	<0.050	<0.0085	0.67	1	0.063	<0.050	<0.020	0.29	<0.050	1.3	0.72	0.2	0.11
S2-1D-L2-W250-2	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.040	<0.050	<0.0085	0.67	1.1	0.064	<0.050	<0.020	0.32	<0.050	0.49	0.74	0.2	0.12
S2-2D-L2-W250-1	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.020	<0.040	0.069	<0.0085	1.3	1.9	0.081	<0.050	<0.020	0.33	<0.050	2.4	1.3	0.36	0.2
S2-2D-L2-W250-2	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.020	<0.040	0.067	<0.0085	1.3	2	0.081	<0.050	<0.020	0.3	<0.050	2.5	1.3	0.36	0.2
S2-4D-L2	<0.10	<0.10	<0.20	0.012	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.040	0.11	<0.0085	2.3	3	0.12	<0.050	<0.020	1.2	<0.050	4.1	2.4	0.56	0.3
S2-6D-L2	<0.10	<0.10	<0.20	0.012	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.040	0.1	<0.0085	1.6	1.7	0.11	<0.050	<0.020	<0.61	<0.050	2.9	1.8	0.48	0.25
S2-8D-L2	<0.10	<0.10	<0.20	0.017	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.040	0.12	<0.0085	1.3	1.3	0.14	<0.050	<0.020	1.2	<0.050	2.2	1.8	0.59	0.35
S2-10D-L2	<0.10	<0.10	<0.20	0.021	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.040	0.12	<0.0085	1.4	1.3	0.14	<0.050	<0.020	1.1	<0.050	2.5	2	0.7	0.42

mple Point	Biphenyl	C1-Biphenyl	C2-Biphenyl	C1-Fluorene	C2-Fluorene	C3-Fluorene	Dibenzothiophene	C1-Dibenzothiophene	C2-Dibenzothiophene	C3-Dibenzothiophene	C4-Dibenzothiophene	C1-Phenanthrene/anthracene	C2-Phenanthrene/anthracene	C3-Phenanthrene/anthracene	C4-Phenanthrene/anthracene	C1-Fluoranthene/pyrene	C2-Fluoranthene/pyrene	C3-Fluoranthene/pyrene	C4-Fluoranthene/pyrene	C1-Benzo(a)anthracene/chrysene	C2-Benzo(a)anthracene/chrysene	C3-Benzo(a)anthracene/chrysene	C4-Benzo(a)anthracene/chrysene	C1-Benzo(bjk)fluoranthene/benzo(a)p	C2-Benzo(bjk)fluoranthene/benzo(a)p	C1-Acenaphthene	1-Methylnaphthalene
S2-2H-L2-W250-1	0.046	0.14	0.14	0.072	0.12	0.48	0.033	0.051	0.099	0.093	<0.020	0.062	0.083	0.1	0.056	<0.020	0.059	0.089	<0.020	0.015	0.063	0.049	<0.0085	<0.0075	0.016	<0.10	
S2-2H-L2-W250-2	0.047	0.15	0.095	0.074	0.11	0.43	0.032	0.052	0.091	0.083	<0.020	0.062	0.073	0.088	0.053	<0.020	0.051	0.098	<0.020	0.013	0.044	0.033	0.057	0.021	0.032	<0.10	
S2-4H-L2-W250-1																											
S2-4H-L2-W250-2																											
S2-6H-L2-W250-1	0.05	0.2	0.099	0.12	0.14	0.21	0.039	0.05	0.099	0.079	<0.020	0.09	0.077	0.2	0.053	<0.020	0.047	0.046	<0.020	0.015	0.091	<0.0085	<0.0085	<0.0075	<0.0075	<0.10	0.24
S2-6H-L2-W250-2	0.046	0.19	0.089	0.11	0.13	0.21	0.037	0.045	0.084	0.069	<0.020	0.081	0.08	0.16	<0.050	<0.020	0.043	<0.020	<0.020	0.012	0.046	<0.0085	<0.0085	<0.0075	<0.0075	<0.10	0.23
S2-12H-L2-W250-1	0.051	0.16	0.091	0.14	0.18	0.16	0.036	0.041	0.087	0.07	<0.020	0.077	0.083	0.096	<0.050	<0.020	0.036	<0.020	0.056	0.012	0.067	0.014	<0.0085	<0.0075	<0.0075	<0.10	0.31
S2-12H-L2-W250-2	0.052	0.18	0.098	0.15	0.18	0.18	0.038	0.042	0.093	0.065	<0.020	0.079	0.081	0.1	<0.050	<0.020	0.049	0.089	0.049	0.014	0.061	0.017	<0.0085	<0.0075	<0.0075	<0.10	0.31
S2-1D-L2-W250-1	0.076	0.17	0.072	0.1	0.14	0.17	0.034	0.035	0.064	0.046	<0.020	0.078	0.061	0.054	<0.050	<0.020	0.027	0.035	0.022	<0.0085	0.05	<0.0085	<0.0085	<0.0075	<0.0075	<0.10	0.49
S2-1D-L2-W250-2	0.076	0.17	0.066	0.1	0.14	0.24	0.033	0.041	0.06	0.049	<0.020	0.075	0.06	0.059	<0.050	<0.020	0.03	<0.020	<0.020	<0.0085	0.044	<0.0085	<0.0085	<0.0075	<0.0075	<0.10	0.49
S2-2D-L2-W250-1	0.14	0.23	0.11	0.14	0.21	<0.050	0.046	0.054	0.082	0.06	<0.020	0.097	0.077	0.067	<0.050	<0.020	0.035	<0.020	<0.020	0.011	0.041	<0.0085	<0.0085	<0.0075	<0.0075	<0.10	0.94
S2-2D-L2-W250-2	0.13	0.22	0.097	0.13	0.17	<0.050	0.047	0.054	0.087	0.064	<0.020	0.098	0.074	0.065	<0.050	<0.020	0.033	<0.020	<0.020	<0.0085	<0.0085	<0.0085	<0.0085	<0.0075	<0.0075	<0.10	0.94
S2-4D-L2	0.27	0.35	0.25	0.16	0.16	<1.4	0.053	0.071	0.081	0.07	<0.020	0.16	0.18	0.14	<0.050	<0.020	0.028	<0.020	<0.020	<0.0085	0.025	<0.060	<0.33	<0.14	<0.22	<0.10	
S2-6D-L2	0.19	0.35	0.22	0.17	0.16	0.22	0.045	0.072	0.089	0.054	<0.020	0.13	0.093	0.078	<0.050	0.022	<0.020	<0.020	<0.020	<0.0085	<0.0085	<0.0085	<0.0085	<0.0075	<0.0075	<0.10	
S2-8D-L2	0.19	0.35	0.29	0.24	0.19	0.33	0.058	0.078	0.093	0.073	<0.020	0.14	0.12	0.084	<0.050	<0.020	<0.020	<0.020	<0.020	<0.0085	<0.0085	<0.0085	<0.0085	<0.0075	<0.0075	<0.10	
S2-10D-L2	0.21	0.34	0.27	0.19	0.14	<1.4	0.061	0.073	0.1	0.065	<0.020	0.18	0.17	0.13	<0.050	0.025	<0.020	<0.020	<0.020	<0.0085	<0.0085	<0.060	<0.33	<0.14	<0.22	<0.10	

Table F-5: AWB Mild Conditions - PAH water data at 1.0 m

mple Point	Acenaphthene	Acenaphthylene	Acridine	Anthracene	Benzo(a)anthracene	Benzo(b&j)fluoranthene	Benzo(k)fluoranthene	Benzo(ghi)perylene	Benzo(c)phenanthrene	Benzo(a)pyrene	Benzo(e)pyrene	Chrysene	Dibenz(ah)anthracene	Fluoranthene	Fluorene	Indeno(123-cd)pyrene	2-Methylnaphthalene	Naphthalene	Phenanthrene	Perylene	Pyrene	Quinoline	Retene	C1-Naphthalene	C2-Naphthalene	C3-Naphthalene	C4-Naphthalene
S2-2H-L3-W250-1	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.040	<0.050	<0.0085	0.18	0.2	<0.050	<0.050	<0.020	<0.20	<0.050	0.33	0.32	0.11	<0.10
S2-2H-L3-W250-2	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.040	<0.050	0.0088	0.18	0.2	<0.050	<0.050	<0.020	<0.20	<0.050	0.35	0.32	0.12	0.12
S2-4H-L3-W250-1																											
S2-4H-L3-W250-2																											
S2-6H-L3-W250-1	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.040	<0.050	<0.0085	0.31	0.42	0.074	<0.050	<0.020	0.23	<0.050	0.61	0.43	0.17	0.13
S2-6H-L3-W250-2	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.040	0.053	<0.0085	0.32	0.44	0.087	<0.050	<0.020	0.22	<0.050	0.66	0.46	0.19	0.13
S2-12H-L3-W250-1	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.040	0.056	<0.0085	0.41	0.64	0.071	<0.050	<0.020	0.26	<0.050	0.74	0.52	0.2	0.13
S2-12H-L3-W250-2	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	0.0095	<0.050	<0.0085	<0.0075	<0.040	0.054	<0.0085	0.39	0.61	0.069	<0.050	<0.020	0.25	<0.050	0.79	0.48	0.17	0.11
S2-1D-L3-W250-1	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.040	<0.050	<0.0085	0.72	1.1	0.069	<0.050	<0.020	0.33	<0.050	1.4	0.73	0.21	0.14
S2-1D-L3-W250-2	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.040	<0.050	<0.0085	0.68	1.1	0.063	<0.050	<0.020	0.26	<0.050	1.3	0.72	0.22	0.12
S2-2D-L3-W250-1	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.020	<0.040	0.07	<0.0085	1.3	2	0.081	<0.050	<0.020	0.29	<0.050	2.5	1.4	0.35	0.21
S2-2D-L3-W250-2	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.020	<0.040	0.069	<0.0085	1.3	1.9	0.082	<0.050	<0.020	0.33	<0.050	2.4	1.4	0.36	0.17
S2-4D-L3	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.040	0.11	<0.0085	2.2	2.9	0.11	<0.050	<0.020	1.2	<0.050	3.9	2.2	0.59	0.33
S2-6D-L3	<0.10	<0.10	<0.20	0.015	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.040	0.11	<0.0085	1.6	1.7	0.12	<0.050	<0.020	<0.48	<0.050	2.9	2	0.48	0.26
S2-8D-L3	<0.10	<0.10	<0.20	0.019	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.040	0.13	<0.0085	1.4	1.5	0.14	<0.050	<0.020	0.99	<0.050	2.6	1.9	0.65	0.4
S2-10D-L3	<0.10	<0.10	<0.20	0.017	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.040	0.12	<0.0085	1.4	1.3	0.14	<0.050	<0.020	1.5	<0.050	2.6	2	0.7	0.42

mple Point	Biphenyl	C1-Biphenyl	C2-Biphenyl	C1-Fluorene	C2-Fluorene	C3-Fluorene	Dibenzothiophene	C1-Dibenzothiophene	C2-Dibenzothiophene	C3-Dibenzothiophene	C4-Dibenzothiophene	C1-Phenanthrene/anthracene	C2-Phenanthrene/anthracene	C3-Phenanthrene/anthracene	C4-Phenanthrene/anthracene	C1-Fluoranthene/pyrene	C2-Fluoranthene/pyrene	C3-Fluoranthene/pyrene	C4-Fluoranthene/pyrene	C1-Benzo(a)anthracene/chrysene	C2-Benzo(a)anthracene/chrysene	C3-Benzo(a)anthracene/chrysene	C4-Benzo(a)anthracene/chrysene	C1-Benzo(b|k)fluoranthene/benzo(a)p	C2-Benzo(b|k)fluoranthene/benzo(a)p	C1-Acenaphthene	1-Methylnaphthalene
S2-2H-L3-W250-1	0.047	0.14	0.14	0.069	0.1	0.52	0.03	0.044	0.087	0.09	<0.020	0.061	0.069	0.096	<0.050	<0.020	0.043	<0.020	<0.020	0.012	0.067	<0.0085	<0.0085	<0.0075	<0.0075	<0.10	
S2-2H-L3-W250-2	0.05	0.13	0.063	0.068	0.11	0.42	0.031	0.051	0.084	0.092	0.033	0.064	0.072	0.091	<0.050	<0.020	0.043	<0.020	<0.020	0.013	0.045	0.033	<0.0085	<0.0075	0.011	<0.10	
S2-4H-L3-W250-1																											
S2-4H-L3-W250-2																											
S2-6H-L3-W250-1	0.047	0.2	0.092	0.12	0.18	0.2	0.036	0.048	0.099	0.077	<0.020	0.08	0.07	0.12	0.059	<0.020	0.043	0.021	<0.020	0.012	0.046	<0.0085	<0.0085	<0.0075	<0.0075	<0.10	0.23
S2-6H-L3-W250-2	0.054	0.22	0.095	0.13	0.16	0.23	0.041	0.048	0.11	0.084	<0.020	0.088	0.089	0.17	0.06	<0.020	0.063	0.031	<0.020	0.015	0.043	<0.0085	<0.0085	<0.0075	<0.0075	<0.10	0.25
S2-12H-L3-W250-1	0.055	0.2	0.11	0.15	0.18	<0.050	0.036	0.047	0.088	0.07	<0.020	0.081	0.076	0.1	<0.050	<0.020	0.045	<0.020	<0.020	0.013	0.053	0.016	<0.0085	<0.0075	<0.0075	<0.10	0.3
S2-12H-L3-W250-2	0.053	0.19	0.095	0.14	0.15	0.14	0.035	0.04	0.083	0.065	<0.020	0.074	0.076	0.092	<0.050	<0.020	0.038	0.061	0.044	0.013	0.063	0.012	<0.0085	<0.0075	<0.0075	<0.10	0.29
S2-1D-L3-W250-1	0.083	0.18	0.18	0.11	0.15	0.26	0.037	0.051	0.068	0.063	<0.020	0.084	0.065	0.074	<0.050	<0.020	0.041	0.049	<0.020	<0.0085	0.048	0.0099	<0.0085	<0.0075	<0.0075	<0.10	0.53
S2-1D-L3-W250-2	0.077	0.16	0.066	0.098	0.12	0.17	0.034	0.041	0.062	0.044	<0.020	0.073	<0.050	0.053	<0.050	<0.020	0.023	<0.020	<0.020	<0.0085	0.03	<0.0085	<0.0085	<0.0075	<0.0075	<0.10	0.49
S2-2D-L3-W250-1	0.14	0.23	0.098	0.12	0.2	<0.050	0.047	0.057	0.093	0.068	<0.020	0.098	0.087	0.07	<0.050	<0.020	0.026	<0.020	<0.020	<0.0085	0.035	<0.0085	<0.0085	<0.0075	<0.0075	<0.10	0.94
S2-2D-L3-W250-2	0.13	0.23	0.1	0.13	0.16	<0.050	0.046	0.055	0.081	0.074	<0.020	0.1	0.091	0.058	<0.050	<0.020	0.039	<0.020	<0.020	<0.0085	0.054	<0.0085	<0.0085	<0.0075	<0.0075	<0.10	0.93
S2-4D-L3	0.25	0.33	0.23	0.16	0.14	<1.4	0.055	0.059	0.086	0.081	<0.020	0.18	0.11	0.17	<0.050	0.02	<0.020	<0.020	<0.020	<0.0085	0.03	<0.060	<0.33	<0.14	<0.22	<0.10	
S2-6D-L3	0.19	0.37	0.24	0.17	0.16	0.22	0.048	0.069	0.094	0.07	<0.020	0.13	0.11	0.092	<0.050	0.022	<0.020	<0.020	<0.020	<0.0085	<0.0085	<0.0085	<0.0085	<0.0075	<0.0075	<0.10	
S2-8D-L3	0.21	0.34	0.28	0.23	0.21	0.3	0.067	0.081	0.12	0.072	<0.020	0.15	0.14	0.092	<0.050	0.026	0.043	<0.020	<0.020	<0.0085	<0.0085	<0.0085	<0.0085	<0.0075	<0.0075	<0.10	
S2-10D-L3	0.21	0.33	0.21	0.2	0.15	<1.4	0.066	0.07	0.1	0.068	<0.020	0.2	0.21	0.14	<0.050	<0.020	<0.020	<0.020	<0.020	<0.0085	<0.0085	<0.060	<0.33	<0.14	<0.22	<0.10	

Table F-6: AWB Mild Conditions - PAH water data at 1.5 m

mple Point	Acenaphthene	Acenaphthylene	Acridine	Anthracene	Benzo(a)anthracene	Benzo(b&j)fluoranthene	Benzo(k)fluoranthene	Benzo(ghi)perylene	Benzo(c)phenanthrene	Benzo(a)pyrene	Benzo(e)pyrene	Chrysene	Dibenz(ah)anthracene	Fluoranthene	Fluorene	Indeno(123-cd)pyrene	2-Methylnaphthalene	Naphthalene	Phenanthrene	Perylene	Pyrene	Quinoline	Retene	C1-Naphthalene	C2-Naphthalene	C3-Naphthalene	C4-Naphthalene
S3-2H-L1-W250-1	<0.10	<0.10	<0.20	<0.010	<0.0085	0.033	<0.0085	0.046	<0.050	0.02	<0.050	<0.0085	<0.0075	<0.040	0.091	0.022	1.3	1.4	0.17	0.084	0.045	<0.20	0.075	2.1	2.9	1	1.1
S3-2H-L1-W250-2	<0.10	<0.10	<0.20	<0.010	0.021	0.057	<0.0085	0.055	<0.050	0.037	0.065	0.038	0.02	<0.040	0.12	0.037	1.4	1.5	0.23	0.15	0.068	0.23	0.12	1.4	2.6	1.5	1.7
S3-4H-L1-W250-1																											
S3-4H-L1-W250-2																											
S3-6H-L1-W250-1	<0.10	<0.10	<0.20	0.017	0.021	0.065	0.013	0.055	<0.050	0.049	0.065	0.036	<0.022	<0.040	0.16	<0.027	2	2.3	0.33	0.15	0.094	0.41	0.2	3.6	3.4	1.9	1.8
S3-6H-L1-W250-2	<0.10	<0.10	<0.20	0.035	0.04	0.13	0.032	0.081	<0.050	0.098	0.12	0.09	<0.046	0.062	0.23	<0.054	2.3	2.2	0.54	0.29	0.18	0.42	0.42	4.3	5.3	3.4	3.6
S3-12H-L1-W250-1	<0.10	<0.10	<0.20	0.013	0.012	0.045	<0.0085	0.03	<0.050	0.03	<0.050	0.021	<0.034	<0.040	0.15	<0.020	1.8	2.1	0.25	0.095	0.067	0.47	0.12	3.3	2.9	1.5	1.3
S3-12H-L1-W250-2	<0.10	<0.10	<0.20	0.011	<0.0085	0.031	<0.0085	0.022	<0.050	0.015	<0.050	0.016	<0.035	<0.040	0.14	<0.014	1.7	2.1	0.21	0.061	0.047	0.49	0.093	3.2	2.6	1.2	1
S3-1D-L1-W250-1	<0.10	<0.10	<0.20	0.018	0.026	0.066	0.011	0.044	<0.050	0.036	0.061	0.039	<0.021	<0.040	0.14	<0.040	1.7	2.1	0.3	0.15	0.097	0.47	0.21	3.2	3.1	1.9	1.9
S3-1D-L1-W250-2	<0.10	<0.10	<0.20	0.018	0.018	0.057	0.01	0.041	<0.050	0.047	0.057	0.025	<0.016	<0.040	0.15	<0.040	1.9	2.3	0.29	0.14	0.09	0.46	0.18	3.5	3.1	1.8	1.7
S3-2D-L1-W250-1	<0.10	<0.10	<0.20	0.016	0.016	0.049	0.0094	0.033	<0.050	0.037	<0.050	0.035	<0.020	<0.040	0.13	<0.024	1.6	2	0.25	0.11	0.077	0.42	0.14	3	2.5	1.4	1.4
S3-2D-L1-W250-2	<0.10	<0.10	<0.20	0.014	0.015	0.047	<0.0085	0.029	<0.050	0.024	<0.050	0.027	<0.020	<0.040	0.13	<0.019	1.6	2.1	0.24	0.1	0.072	0.4	0.14	3.1	2.5	1.3	1.3
S3-4D-L1	<0.10	<0.10	<0.20	0.017	<0.0085	0.034	<0.0085	0.023	<0.050	0.017	<0.050	0.015	0.0075	<0.040	0.1	0.017	1.2	1.5	0.17	0.064	0.047	1.9	0.084	2.1	1.6	0.83	1.1
S3-6D-L1	<0.10	<0.10	<0.20	0.028	<0.0085	0.027	<0.0085	0.019	<0.050	0.014	<0.050	<0.0085	<0.0075	<0.040	0.092	<0.0085	1	1.2	0.15	0.052	0.05	<0.90	0.065	1.9	1.3	0.55	0.59
S3-8D-L1	<0.10	<0.10	<0.20	0.026	<0.0085	0.019	<0.0085	0.0094	<0.050	0.0089	<0.050	<0.0085	<0.0075	<0.040	0.12	<0.0085	1.4	1.6	0.17	<0.050	0.04	1	<0.050	2.4	1.7	0.62	0.55
S3-10D-L1	<0.10	<0.10	<0.20	0.027	<0.0085	0.015	<0.0085	<0.0085	<0.050	0.0087	<0.050	<0.0085	<0.0075	<0.040	0.09	<0.0085	0.96	1	0.14	<0.050	0.044	1.9	<0.050	1.7	1.2	0.53	0.48

mple Point	Biphenyl	C1-Biphenyl	C2-Biphenyl	C1-Fluorene	C2-Fluorene	C3-Fluorene	Dibenzothiophene	C1-Dibenzothiophene	C2-Dibenzothiophene	C3-Dibenzothiophene	C4-Dibenzothiophene	C1-Phenanthrene/anthracene	C2-Phenanthrene/anthracene	C3-Phenanthrene/anthracene	C4-Phenanthrene/anthracene	C1-Fluoranthene/pyrene	C2-Fluoranthene/pyrene	C3-Fluoranthene/pyrene	C4-Fluoranthene/pyrene	C1-Benzo(a)anthracene/chrysene	C2-Benzo(a)anthracene/chrysene	C3-Benzo(a)anthracene/chrysene	C4-Benzo(a)anthracene/chrysene	C1-Benzo(bjk)fluoranthene/benzo(a)py	C2-Benzo(bjk)fluoranthene/benzo(a)py	C1-Acenaphthene	1-Methylnaphthalene
S3-2H-L1-W250-1	0.16	0.31	0.39	0.28	0.62	1.8	0.089	0.31	0.91	1.1	1.3	0.54	1.1	1.9	1.2	0.3	0.95	2	1.5	0.26	0.97	0.66	0.72	0.18	0.19	<0.10	
S3-2H-L1-W250-2	0.18	0.43	0.52	0.41	0.85	2.7	0.12	0.43	1.4	1.9	2.1	0.82	1.7	3.2	2.2	0.53	1.4	3.5	2.5	0.46	1.7	1.1	1.5	0.36	0.29	<0.10	
S3-4H-L1-W250-1																											
S3-4H-L1-W250-2																											
S3-6H-L1-W250-1	0.23	0.54	0.38	0.48	1.2	2.6	0.14	0.51	1.5	1.9	2.4	0.96	1.9	3.8	2.4	0.64	1.7	3.8	2	0.47	3.7	1.3	0.41	0.46	0.3	<0.10	1.4
S3-6H-L1-W250-2	0.29	0.78	0.7	0.87	2	4.8	0.22	0.95	3	4.2	5.3	1.6	3.7	7.4	4.8	1.3	3.1	7.5	5.3	0.92	7.7	2.4	0.63	0.84	0.62	0.16	1.6
S3-12H-L1-W250-1	0.21	0.47	0.31	0.44	0.99	0.89	0.11	0.32	1.2	1.3	1.7	0.64	1.3	2.6	1.6	0.44	1.1	2.4	1.4	0.3	2.3	1.1	0.16	0.63	0.83	<0.10	1.3
S3-12H-L1-W250-2	0.2	0.47	0.26	0.36	0.73	0.58	0.09	0.25	0.81	0.97	0.99	0.48	0.89	1.8	1.1	0.28	0.76	1.5	0.94	0.2	1.6	0.4	0.1	0.16	0.077	<0.10	1.2
S3-1D-L1-W250-1	0.21	0.49	0.3	0.47	0.99	2.8	0.13	0.5	1.5	1.9	2.3	0.98	1.9	3.7	2.4	0.62	1.8	3.9	2.8	0.49	3.9	1.3	0.35	0.43	0.37	<0.10	1.3
S3-1D-L1-W250-2	0.23	0.46	0.29	0.45	0.93	2.5	0.12	0.42	1.4	1.8	2	0.85	1.7	3.4	2.1	0.55	1.6	3.2	2.5	0.43	3.5	1.1	0.32	0.37	0.29	<0.10	1.4
S3-2D-L1-W250-1	0.2	0.41	0.27	0.39	0.88	2.3	0.11	0.36	1.2	1.6	1.9	0.7	1.4	2.9	1.9	0.48	1.3	2.8	1.7	0.36	3	1	0.21	0.43	0.27	<0.10	1.2
S3-2D-L1-W250-2	0.2	0.39	0.27	0.36	0.69	1.9	0.11	0.32	1.1	1.5	1.7	0.67	1.3	2.7	1.8	0.46	1.1	2.4	1.4	0.33	2.7	0.89	0.17	0.37	0.29	<0.10	1.2
S3-4D-L1	0.18	0.28	0.33	0.27	0.49	1.5	0.068	0.25	0.69	0.85	1.1	0.51	1	2	1.3	0.32	0.98	1.9	0.98	0.25	1.4	0.69	<0.33	0.28	0.26	<0.10	
S3-6D-L1	0.14	0.3	0.25	0.23	0.44	0.95	0.055	0.21	0.52	0.63	0.77	0.39	0.74	1.4	0.9	0.23	0.59	1.4	0.82	0.2	0.74	0.44	0.1	0.11	0.11	<0.10	
S3-8D-L1	0.18	0.32	0.32	0.28	0.36	0.94	0.079	0.17	0.39	0.44	0.5	0.3	0.5	0.86	0.48	0.16	0.36	0.72	0.4	0.11	0.54	0.25	0.051	0.095	0.055	<0.10	
S3-10D-L1	0.14	0.22	0.21	0.18	0.25	<1.4	0.061	0.13	0.33	0.46	0.58	0.32	0.54	0.94	0.54	0.16	0.39	0.85	0.43	0.12	0.61	0.3	<0.33	<0.14	<0.22	<0.10	

Table F-7: AWB Moderate Conditions - PAH water data at 0.5 m

mple Point	Acenaphthene	Acenaphthylene	Acridine	Anthracene	Benzo(a)anthracene	Benzo(b&j)fluoranthene	Benzo(k)fluoranthene	Benzo(ghi)perylene	Benzo(c)phenanthrene	Benzo(a)pyrene	Benzo(e)pyrene	Chrysene	Dibenz(ah)anthracene	Fluoranthene	Fluorene	Indeno(123-cd)pyrene	2-Methylnaphthalene	Naphthalene	Phenanthrene	Perylene	Pyrene	Quinoline	Retene	C1-Naphthalene	C2-Naphthalene	C3-Naphthalene	C4-Naphthalene
S3-2H-L2-W250-1	<0.10	<0.10	<0.20	<0.010	<0.0085	0.055	<0.0085	0.059	<0.050	0.035	0.062	0.026	0.021	<0.040	0.12	0.036	1.3	1.3	0.22	0.14	0.072	<0.20	0.12	2.3	2.6	1.5	1.8
S3-2H-L2-W250-2	<0.10	<0.10	<0.20	<0.010	<0.0085	0.06	<0.0085	0.053	<0.050	0.036	0.07	<0.0085	0.021	<0.040	0.11	0.042	1.4	1.3	0.24	0.15	0.071	<0.20	0.13	2.2	2.7	1.6	1.9
S3-4H-L2-W250-1																											
S3-4H-L2-W250-2																											
S3-6H-L2-W250-1	<0.10	<0.10	<0.20	0.03	0.035	0.12	0.019	0.074	<0.050	0.087	0.11	0.054	<0.032	0.057	0.2	<0.049	2.1	2.1	0.5	0.27	0.17	0.44	0.37	3.9	5	3	3
S3-6H-L2-W250-2	<0.10	<0.10	<0.20	<0.020	0.03	0.081	0.017	0.051	<0.050	0.062	0.077	0.042	<0.029	<0.040	0.16	<0.036	1.8	1.9	0.36	0.17	0.11	0.36	0.24	3.3	3.4	2	2.1
S3-12H-L2-W250-1	<0.10	<0.10	<0.20	0.012	0.0095	0.038	<0.0085	0.025	<0.050	0.017	<0.050	0.015	<0.013	<0.040	0.15	<0.018	1.9	2.2	0.23	0.078	0.057	0.48	0.1	3.5	3	1.3	1.2
S3-12H-L2-W250-2	<0.10	<0.10	<0.20	0.012	0.0097	0.04	<0.0085	0.027	<0.050	0.018	<0.050	0.017	<0.013	<0.040	0.14	<0.024	1.9	2.2	0.23	0.082	0.059	0.4	0.11	3.5	3	1.4	1.1
S3-1D-L2-W250-1	<0.10	<0.10	<0.20	0.021	0.021	0.076	0.0088	0.051	<0.050	0.042	0.07	0.031	<0.022	<0.040	0.17	<0.040	1.9	2.3	0.35	0.17	0.11	0.47	0.26	3.5	3.5	2.1	2.1
S3-1D-L2-W250-2	<0.10	<0.10	<0.20	0.017	0.016	0.058	0.014	0.039	<0.050	0.033	0.053	0.021	<0.015	<0.040	0.14	<0.040	1.8	2.1	0.27	0.13	0.085	0.47	0.17	3.3	2.8	1.6	1.6
S3-2D-L2-W250-1	<0.10	<0.10	<0.20	0.019	0.017	0.06	0.01	0.04	<0.050	0.034	0.058	0.035	0.027	<0.040	0.14	<0.027	1.7	2.1	0.29	0.13	0.091	0.44	0.19	3.1	2.6	1.6	1.7
S3-2D-L2-W250-2	<0.10	<0.10	<0.20	0.018	0.019	0.055	0.011	0.038	<0.050	0.032	0.054	0.028	<0.020	<0.040	0.15	<0.025	1.8	2.2	0.27	0.12	0.084	0.47	0.17	3.3	2.6	1.5	1.5
S3-4D-L2	<0.10	<0.10	<0.20	0.02	<0.0085	0.036	<0.0085	0.024	<0.050	0.018	<0.050	<0.0085	0.0083	<0.040	0.11	0.019	1.3	1.7	0.19	0.081	0.057	1.9	0.12	2.3	1.7	0.9	1.1
S3-6D-L2	<0.10	<0.10	<0.20	0.037	0.014	0.035	<0.0085	0.023	<0.050	0.019	<0.050	0.016	<0.0075	<0.040	0.12	0.013	1.4	1.6	0.19	0.069	0.048	<0.75	0.084	2.5	1.8	0.72	0.73
S3-8D-L2	<0.10	<0.10	<0.20	0.015	<0.0085	0.025	<0.0085	0.012	<0.050	0.012	<0.050	<0.0085	<0.0075	<0.040	0.13	0.01	1.4	1.5	0.16	<0.050	0.047	1.2	0.051	2.4	1.7	0.63	0.69
S3-10D-L2	<0.10	<0.10	<0.20	0.031	<0.0085	0.021	<0.0085	0.016	<0.050	0.011	<0.050	<0.0085	<0.0075	<0.040	0.1	0.011	1.1	1.1	0.16	<0.050	0.038	1.4	<0.050	2	1.5	0.61	0.62

mple Point	Biphenyl	C1-Biphenyl	C2-Biphenyl	C1-Fluorene	C2-Fluorene	C3-Fluorene	Dibenzothiophene	C1-Dibenzothiophene	C2-Dibenzothiophene	C3-Dibenzothiophene	C4-Dibenzothiophene	C1-Phenanthrene/anthracene	C2-Phenanthrene/anthracene	C3-Phenanthrene/anthracene	C4-Phenanthrene/anthracene	C1-Fluoranthene/pyrene	C2-Fluoranthene/pyrene	C3-Fluoranthene/pyrene	C4-Fluoranthene/pyrene	C1-Benzo(a)anthracene/chrysene	C2-Benzo(a)anthracene/chrysene	C3-Benzo(a)anthracene/chrysene	C4-Benzo(a)anthracene/chrysene	C1-Benzo(b|k)fluoranthene/benzo(a)p	C2-Benzo(b|k)fluoranthene/benzo(a)p	C1-Acenaphthene	1-Methylnaphthalene
S3-2H-L2-W250-1	0.17	0.44	0.49	0.4	0.97	3.1	0.11	0.45	1.5	1.9	2.4	0.83	1.7	3.5	2.1	0.55	1.5	3.6	2.5	0.44	1.8	1.1	1.1	0.32	0.31	<0.10	
S3-2H-L2-W250-2	0.17	0.39	0.49	0.42	1	2.9	0.12	0.5	1.6	2	2.4	0.9	1.8	3.6	2.2	0.58	1.6	3.7	2.8	0.45	1.8	1.3	1.2	0.31	0.29	<0.10	
S3-4H-L2-W250-1																											
S3-4H-L2-W250-2																											
S3-6H-L2-W250-1	0.26	0.68	0.58	0.85	2	3.8	0.21	0.8	3.1	3.9	4.3	1.6	3.5	7	4.4	1.1	2.9	7.2	3.8	0.85	7	2.3	0.58	0.75	0.66	0.14	1.5
S3-6H-L2-W250-2	0.21	0.55	0.43	0.56	1.2	3.1	0.14	0.58	1.9	2.5	2.8	1	2.4	4.5	2.8	0.73	1.9	4.2	2.6	0.55	4.6	1.5	0.35	0.48	0.23	0.11	1.3
S3-12H-L2-W250-1	0.22	0.49	0.32	0.4	0.67	1.6	0.1	0.27	0.93	1	1.3	0.56	1	2	1.3	0.34	0.89	2.3	1.3	0.25	2	0.73	0.27	0.22	0.17	<0.10	1.3
S3-12H-L2-W250-2	0.21	0.44	0.3	0.43	0.7	1.8	0.11	0.28	0.98	1.2	1.4	0.57	1.1	2.2	1.3	0.36	0.97	2.1	1.2	0.26	2.1	0.74	0.21	0.24	0.24	<0.10	1.3
S3-1D-L2-W250-1	0.24	0.51	0.44	0.56	1.1	3.2	0.15	0.54	1.8	2.5	2.8	1.1	2.1	4.3	2.8	0.74	1.8	4.4	3.7	0.54	4.4	1.3	0.4	0.46	0.4	0.1	1.4
S3-1D-L2-W250-2	0.22	0.41	0.26	0.43	0.92	2	0.12	0.43	1.4	1.6	2	0.84	1.6	3.2	2.1	0.56	1.5	3.1	1.9	0.41	3.3	1	0.34	0.34	0.33	<0.10	1.3
S3-2D-L2-W250-1	0.21	0.41	0.36	0.46	1.1	2.6	0.12	0.41	1.4	1.8	2.3	0.82	1.6	3.3	2.2	0.6	1.5	3.3	1.9	0.43	3.6	1.2	0.22	0.49	0.37	<0.10	1.2
S3-2D-L2-W250-2	0.22	0.43	0.32	0.42	0.95	2	0.12	0.41	1.4	2	2.2	0.77	1.6	3.2	2.2	0.54	1.4	3	1.8	0.4	3.2	1.2	0.24	0.44	0.4	<0.10	1.3
S3-4D-L2	0.18	0.28	0.33	0.27	0.63	2.3	0.076	0.25	0.77	1.1	1.4	0.59	1.2	2.3	1.4	0.38	1.1	2.1	1.2	0.3	1.6	0.72	<0.33	0.34	0.36	<0.10	
S3-6D-L2	0.18	0.4	0.24	0.29	0.54	1.3	0.084	0.26	0.67	0.89	1	0.5	0.96	1.9	1.1	0.31	0.85	1.8	1	0.27	0.98	0.68	0.13	0.14	0.14	<0.10	
S3-8D-L2	0.18	0.33	0.3	0.25	0.36	0.96	0.082	0.19	0.5	0.6	1.5	0.33	0.6	1	0.67	0.19	0.53	1.3	0.62	0.14	0.69	0.37	0.072	0.1	0.081	<0.10	
S3-10D-L2	0.16	0.25	0.25	0.2	0.34	<1.4	0.074	0.16	0.41	0.56	0.73	0.39	0.72	1.2	0.71	0.2	0.49	1.2	0.66	0.15	0.76	0.41	<0.33	0.18	<0.22	<0.10	

Table F-8: AWB Moderate Conditions - PAH water data at 1.0 m

mple Point	Acenaphthene	Acenaphthylene	Acridine	Anthracene	Benzo(a)anthracene	Benzo(b&j)fluoranthene	Benzo(k)fluoranthene	Benzo(ghi)perylene	Benzo(c)phenanthrene	Benzo(a)pyrene	Benzo(e)pyrene	Chrysene	Dibenz(ah)anthracene	Fluoranthene	Fluorene	Indeno(123-cd)pyrene	2-Methylnaphthalene	Naphthalene	Phenanthrene	Perylene	Pyrene	Quinoline	Retene	C1-Naphthalene	C2-Naphthalene	C3-Naphthalene	C4-Naphthalene
S3-2H-L3-W250-1	<0.10	<0.10	<0.20	<0.010	0.011	0.037	<0.0085	0.027	<0.050	0.019	<0.050	0.014	0.015	<0.040	0.08	0.021	1.1	1.3	0.16	0.083	0.037	<0.20	0.095	1.1	3	0.99	1.2
S3-2H-L3-W250-2	<0.10	<0.10	<0.20	<0.010	0.017	0.052	<0.0085	0.041	<0.050	0.032	0.057	0.017	0.011	<0.040	0.095	0.03	1.2	1.2	0.21	0.13	0.063	<0.20	0.16	1.2	3.3	1.4	1.6
S3-4H-L3-W250-1																											
S3-4H-L3-W250-2																											
S3-6H-L3-W250-1	<0.10	<0.10	<0.20	0.026	0.036	0.11	0.022	0.071	<0.050	0.052	0.11	0.056	<0.026	0.05	0.19	<0.045	2.1	2.1	0.45	0.24	0.15	0.46	0.33	3.8	4.4	2.9	2.9
S3-6H-L3-W250-2	<0.10	<0.10	<0.20	0.019	0.022	0.067	0.012	0.048	<0.050	0.054	0.069	0.03	<0.015	<0.040	0.16	<0.034	1.8	2.1	0.34	0.16	0.1	0.39	0.22	3.4	3.4	2	1.9
S3-12H-L3-W250-1	<0.10	<0.10	<0.20	0.015	0.013	0.045	<0.0085	0.031	<0.050	0.022	<0.050	0.02	0.011	<0.040	0.15	0.019	2	2.3	0.25	0.1	0.069	0.48	0.13	3.7	3.1	1.5	1.5
S3-12H-L3-W250-2	<0.10	<0.10	<0.20	0.018	0.017	0.058	0.01	0.038	<0.050	0.03	0.053	0.036	<0.019	<0.040	0.15	<0.027	1.9	2.2	0.28	0.12	0.081	0.47	0.18	3.6	3.3	1.8	1.7
S3-1D-L3-W250-1	<0.10	<0.10	<0.20	0.02	0.026	0.076	0.014	0.056	<0.050	0.037	0.074	0.041	0.023	<0.040	0.16	0.034	1.9	2.2	0.35	0.18	0.11	0.45	0.24	3.6	3.6	2.3	2.4
S3-1D-L3-W250-2	<0.10	<0.10	<0.20	0.018	0.018	0.064	0.011	0.043	<0.050	0.035	0.062	0.034	<0.019	<0.040	0.17	<0.040	2.2	2.6	0.32	0.14	0.097	0.6	0.18	4	3.5	1.9	1.9
S3-2D-L3-W250-1	<0.10	<0.10	<0.20	0.018	0.019	0.058	0.0098	0.036	<0.050	0.028	0.055	0.033	0.023	<0.040	0.14	<0.024	1.7	2.1	0.28	0.13	0.089	0.48	0.17	3.2	2.8	1.6	1.7
S3-2D-L3-W250-2	<0.10	<0.10	<0.20	0.016	0.017	0.051	0.01	0.034	<0.050	0.027	<0.050	0.029	<0.020	<0.040	0.13	<0.021	1.6	2.1	0.25	0.11	0.076	0.53	0.16	3.1	2.5	1.4	1.5
S3-4D-L3	<0.10	<0.10	<0.20	0.022	0.012	0.043	<0.0085	0.026	<0.050	0.02	<0.050	0.013	0.0089	<0.040	0.12	0.022	1.6	2	0.22	0.09	0.061	1.5	0.11	2.8	2.2	1.1	1.3
S3-6D-L3	<0.10	<0.10	<0.20	0.028	0.0089	0.027	<0.0085	0.021	<0.050	0.015	<0.050	0.017	<0.0075	<0.040	0.099	0.013	1.1	1.3	0.16	0.057	0.04	<0.62	0.063	2	1.4	0.6	0.71
S3-8D-L3																											
S3-10D-L3	<0.10	<0.10	<0.20	0.026	<0.0085	0.019	<0.0085	0.017	<0.050	0.0089	<0.050	<0.0085	<0.0075	<0.040	0.094	0.01	0.97	1	0.15	<0.050	0.034	1.3	0.056	1.8	1.3	0.58	0.61

mple Point	Biphenyl	C1-Biphenyl	C2-Biphenyl	C1-Fluorene	C2-Fluorene	C3-Fluorene	Dibenzothiophene	C1-Dibenzothiophene	C2-Dibenzothiophene	C3-Dibenzothiophene	C4-Dibenzothiophene	C1-Phenanthrene/anthracene	C2-Phenanthrene/anthracene	C3-Phenanthrene/anthracene	C4-Phenanthrene/anthracene	C1-Fluoranthene/pyrene	C2-Fluoranthene/pyrene	C3-Fluoranthene/pyrene	C4-Fluoranthene/pyrene	C1-Benzo(a)anthracene/chrysene	C2-Benzo(a)anthracene/chrysene	C3-Benzo(a)anthracene/chrysene	C4-Benzo(a)anthracene/chrysene	C1-Benzo(bjk)fluoranthene/benzo(a)py	C2-Benzo(bjk)fluoranthene/benzo(a)py	C1-Acenaphthene	1-Methylnaphthalene
S3-2H-L3-W250-1	0.15	0.081	0.28	0.27	0.56	2	0.08	0.31	0.89	1.1	1.1	0.48	0.98	1.8	1.1	0.29	0.86	2.1	0.8	0.25	0.92	0.64	0.21	0.15	0.14	<0.10	
S3-2H-L3-W250-2	0.16	0.085	0.42	0.35	0.87	2.9	0.1	0.48	1.3	1.6	1.7	0.69	1.5	2.8	1.7	0.46	1.4	3.1	1.1	0.38	1.4	1.1	0.26	0.22	0.19	<0.10	
S3-4H-L3-W250-1																											
S3-4H-L3-W250-2																											
S3-6H-L3-W250-1	0.25	0.69	0.58	0.72	1.8	4.2	0.19	0.71	2.6	3.5	4.1	1.4	3	6.4	4.1	1.1	2.8	6	3.8	0.8	6.3	2.2	0.51	0.72	0.5	0.15	1.5
S3-6H-L3-W250-2	0.22	0.53	0.38	0.53	1.1	2.7	0.14	0.5	1.6	2.5	2.7	1	2	4.1	2.6	0.66	1.8	4.2	2.5	0.51	4.2	1.5	0.31	0.45	0.39	0.1	1.3
S3-12H-L3-W250-1	0.22	0.48	0.34	0.43	0.81	2	0.11	0.33	1	1.5	1.7	0.68	1.3	2.5	1.6	0.46	1.1	2.4	1.4	0.32	2.5	0.85	0.24	0.29	0.3	<0.10	1.4
S3-12H-L3-W250-2	0.22	0.49	0.37	0.48	0.93	2.3	0.12	0.4	1.4	1.8	2.2	0.81	1.7	3.1	2.1	0.54	1.4	4	2	0.4	3.2	1	0.31	0.33	0.3	<0.10	1.4
S3-1D-L3-W250-1	0.24	0.53	0.63	0.59	1.3	3.3	0.15	0.54	1.8	2.5	2.8	1.1	2.2	4.3	2.9	0.81	2.2	4.6	3.2	0.56	4.5	1.4	0.33	0.48	0.41	<0.10	1.4
S3-1D-L3-W250-2	0.26	0.52	0.53	0.49	1.1	2.8	0.14	0.44	1.5	2	2.3	0.95	1.7	3.5	2.3	0.61	1.5	3.3	1.8	0.45	3.6	1.1	0.32	0.38	0.32	<0.10	1.6
S3-2D-L3-W250-1	0.21	0.45	0.34	0.43	1.1	2.6	0.12	0.42	1.4	1.9	2.3	0.81	1.7	3.3	2.1	0.55	1.4	3.4	2	0.41	3.3	1.1	0.23	0.5	0.37	<0.10	1.3
S3-2D-L3-W250-2	0.2	0.4	0.28	0.37	0.81	2	0.11	0.36	1.1	1.6	1.9	0.72	1.5	3	1.8	0.49	1.3	2.9	1.7	0.36	2.9	0.98	0.23	0.37	0.29	<0.10	1.2
S3-4D-L3	0.23	0.34	0.37	0.31	0.73	2.3	0.096	0.31	0.88	1.2	1.5	0.65	1.3	2.6	1.5	0.39	1.1	2.4	1.4	0.31	1.6	0.79	0.36	0.32	0.34	<0.10	
S3-6D-L3	0.15	0.34	0.31	0.23	0.43	1.3	0.065	0.22	0.53	0.76	0.79	0.41	0.78	1.6	0.91	0.26	0.7	1.4	0.79	0.21	0.86	0.49	0.16	0.12	0.097	<0.10	
S3-8D-L3																											
S3-10D-L3	0.15	0.26	0.3	0.2	0.28	<1.4	0.066	0.16	0.43	0.54	0.66	0.35	0.66	1.2	0.71	0.2	0.48	1	0.56	0.15	0.8	0.39	<0.33	<0.14	<0.22	<0.10	

Table F-9: AWB Moderate Conditions - PAH water data at 1.5 m

mple Point	Acenaphthene	Acenaphthylene	Acridine	Anthracene	Benzo(a)anthracene	Benzo(b&j)fluoranthene	Benzo(k)fluoranthene	Benzo(ghi)perylene	Benzo(c)phenanthrene	Benzo(a)pyrene	Benzo(e)pyrene	Chrysene	Dibenz(ah)anthracene	Fluoranthene	Fluorene	Indeno(123-cd)pyrene	2-Methylnaphthalene	Naphthalene	Phenanthrene	Perylene	Pyrene	Quinoline	Retene	C1-Naphthalene	C2-Naphthalene	C3-Naphthalene	C4-Naphthalene
S9B-2H-W250-1	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.040	<0.050	<0.0085	0.21	0.13	0.063	<0.050	<0.020	0.22	<0.050	0.43	0.48	0.15	0.13
S9B-2H-W250-2	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.040	<0.050	<0.0085	0.19	0.13	0.056	<0.050	<0.020	<0.20	<0.050	0.41	0.46	0.15	<0.10
S9B-4H-W250-1	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.040	<0.050	<0.0085	0.2	0.14	0.062	<0.050	<0.020	<0.20	<0.050	0.45	0.48	0.15	0.1
S9B-4H-W250-2	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.040	<0.050	<0.0085	0.21	0.15	0.068	<0.050	<0.020	0.22	<0.050	0.47	0.49	0.18	0.12
S9B-6H-W250-1	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.040	<0.050	<0.0085	0.23	0.15	0.094	<0.050	<0.020	<0.30	<0.050	0.48	0.68	0.27	0.25
S9B-6H-W250-2	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.040	<0.050	<0.0085	0.22	0.15	0.085	<0.050	<0.020	<0.35	<0.050	0.46	0.63	0.27	0.18
S9B-12H	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.040	0.073	<0.0085	0.26	0.24	0.13	<0.050	<0.020	0.93	<0.050	0.52	0.59	0.24	0.12
S9B-24H	0.11	<0.10	<0.20	0.023	0.013	0.024	<0.0085	0.02	<0.050	0.012	<0.050	0.027	<0.0075	0.042	0.27	0.017	1.8	1.9	0.54	<0.050	0.032	1.5	0.17	3.2	5.4	4.4	4.2
S9B-2D	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.040	0.11	<0.0085	0.63	0.76	0.16	<0.050	<0.020	1.2	<0.050	1.2	1.3	0.53	0.3
S9B-4D	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.040	0.15	<0.0085	1	1.3	0.23	<0.050	<0.020	1.6	<0.050	1.9	2.3	0.93	0.42
S9B-6D	0.1	<0.10	<0.20	<0.010	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.040	0.18	<0.0085	1.3	1.5	0.25	<0.050	0.036	1.2	<0.050	2.4	2.5	1.2	0.61
S9B-8D	0.12	<0.10	<0.20	0.017	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.040	0.21	<0.0085	1.3	1.6	0.27	<0.050	0.03	1.6	<0.050	2.5	2.7	1.4	0.62
S9B 9D	0.15	<0.10	<0.20	0.02	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.040	0.24	<0.0085	1.7	2.1	0.29	<0.050	0.035	1.4	<0.050	3.2	3.6	1.7	0.81
S9B 10D	0.16	<0.10	<0.20	0.027	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.040	0.24	<0.0085	1.9	2.3	0.31	<0.050	0.041	1.7	<0.050	3.6	4	1.9	0.89

mple Point	Biphenyl	C1-Biphenyl	C2-Biphenyl	C1-Fluorene	C2-Fluorene	C3-Fluorene	Dibenzothiophene	C1-Dibenzothiophene	C2-Dibenzothiophene	C3-Dibenzothiophene	C4-Dibenzothiophene	C1-Phenanthrene/anthracene	C2-Phenanthrene/anthracene	C3-Phenanthrene/anthracene	C4-Phenanthrene/anthracene	C1-Fluoranthene/pyrene	C2-Fluoranthene/pyrene	C3-Fluoranthene/pyrene	C4-Fluoranthene/pyrene	C1-Benzo(a)anthracene/chrysene	C2-Benzo(a)anthracene/chrysene	C3-Benzo(a)anthracene/chrysene	C4-Benzo(a)anthracene/chrysene	C1-Benzo(b|j|k)fluoranthene/benzo(a)py	C2-Benzo(b|j|k)fluoranthene/benzo(a)py	C1-Acenaphthene	1-Methylnaphthalene
S9B-2H-W250-1	0.024	<0.10	0.059	0.08	0.19	0.45	0.05	0.088	0.16	0.081	<0.020	0.13	0.092	0.063	<0.050	<0.020	<0.020	<0.020	<0.020	<0.0085	<0.0085	<0.0085	<0.0085	<0.0075	<0.0075	<0.10	0.17
S9B-2H-W250-2	<0.020	<0.10	0.044	0.071	0.17	0.31	0.043	0.078	0.14	0.076	<0.020	0.11	0.087	<0.050	<0.050	<0.020	<0.020	<0.020	<0.020	<0.0085	<0.0085	<0.0085	<0.0085	<0.0075	<0.0075	<0.10	0.15
S9B-4H-W250-1	0.024	<0.10	0.066	0.074	0.21	0.46	0.046	0.076	0.14	0.079	<0.020	0.12	0.081	<0.050	<0.050	<0.020	<0.020	<0.020	<0.020	<0.0085	<0.0085	<0.0085	<0.0085	<0.0075	<0.0075	<0.10	0.17
S9B-4H-W250-2	0.03	0.13	0.071	0.08	0.22	0.41	0.051	0.084	0.15	0.079	<0.020	0.13	0.083	0.072	<0.050	<0.020	<0.020	<0.020	<0.020	<0.0085	<0.0085	<0.0085	<0.0085	<0.0075	<0.0075	<0.10	0.17
S9B-6H-W250-1	0.044	0.23	0.11	0.13	0.12	0.84	0.051	0.16	0.26	0.16	<0.020	0.2	0.21	0.16	<0.050	0.028	<0.020	<0.020	<0.020	<0.0085	<0.0085	<0.0085	<0.0085	<0.0075	<0.0075	<0.10	
S9B-6H-W250-2	0.042	0.21	0.083	0.11	0.17	0.48	0.049	0.15	0.19	0.12	<0.020	0.15	0.13	0.091	<0.050	<0.020	<0.020	<0.020	<0.020	<0.0085	<0.0085	<0.0085	<0.0085	<0.0075	<0.0075	<0.10	
S9B-12H	0.049	0.27	0.22	0.19	0.25	0.77	0.058	0.14	0.17	0.097	<0.020	0.16	0.15	0.14	<0.050	<0.020	0.048	<0.020	<0.020	0.01	<0.0085	<0.0085	<0.0085	<0.0075	<0.0075	<0.10	
S9B-24H	0.17	0.48	0.63	0.88	1.4	2.6	0.32	1.3	3.2	2.3	1.5	1.5	2.2	2.4	1	0.35	0.63	1.2	0.72	0.2	0.93	0.44	0.076	0.12	0.079	0.14	
S9B-2D	0.078	0.21	0.1	0.21	0.24	0.77	0.098	0.16	0.19	0.093	0.043	0.21	0.17	0.076	<0.050	<0.020	<0.020	<0.020	<0.020	<0.0085	<0.0085	<0.0085	<0.0085	<0.0075	<0.0075	<0.10	
S9B-4D	0.12	0.24	0.13	0.3	0.31	1	0.14	0.26	0.3	0.11	0.043	0.27	0.2	0.11	<0.050	<0.020	<0.020	<0.020	<0.020	<0.0085	<0.0085	<0.0085	<0.0085	<0.0075	<0.0075	<0.10	
S9B-6D	0.14	0.28	0.29	0.36	0.5	1	0.18	0.21	0.35	0.18	<0.020	0.31	0.22	0.12	0.055	<0.020	0.035	<0.020	<0.020	<0.0085	<0.0085	<0.0085	<0.0085	<0.0075	<0.0075	<0.10	
S9B-8D	0.15	0.32	0.34	0.41	0.46	1.2	0.2	0.33	0.36	0.17	<0.020	0.33	0.25	0.11	0.057	<0.020	0.052	<0.020	<0.020	<0.0085	<0.0085	<0.0085	0.013	<0.0075	<0.0075	<0.10	
S9B 9D	0.18	0.33	0.3	0.42	0.49	1	0.23	0.41	0.4	0.19	0.074	0.39	0.25	0.15	0.077	0.039	0.071	<0.020	<0.020	<0.0085	<0.0085	<0.0085	0.018	0.011	0.016	<0.10	
S9B 10D	0.21	0.34	0.31	0.38	0.48	1.5	0.23	0.37	0.38	0.17	<0.020	0.44	0.29	0.19	0.061	0.034	<0.020	<0.020	<0.020	<0.0085	<0.0085	<0.060	<0.33	<0.14	<0.22	<0.10	

Table F-10: CLWB Static Conditions - PAH water data at 1.0 m

mple Point	Acenaphthene	Acenaphthylene	Acridine	Anthracene	Benzo(a)anthracene	Benzo(b&j)fluoranthene	Benzo(k)fluoranthene	Benzo(ghi)perylene	Benzo(c)phenanthrene	Benzo(a)pyrene	Benzo(e)pyrene	Chrysene	Dibenz(ah)anthracene	Fluoranthene	Fluorene	Indeno(123-cd)pyrene	2-Methylnaphthalene	Naphthalene	Phenanthrene	Perylene	Pyrene	Quinoline	Retene	C1-Naphthalene	C2-Naphthalene	C3-Naphthalene	C4-Naphthalene
S9C-2H-W250-1	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.040	<0.050	<0.0085	0.27	0.29	0.066	<0.050	<0.020	0.23	<0.050	0.56	0.59	0.25	0.17
S9C-2H-W250-2	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.040	<0.050	<0.0085	0.28	0.29	0.068	<0.050	<0.020	0.26	<0.050	0.57	0.58	0.27	0.16
S9C-4H-W250-1	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.040	<0.050	<0.0085	0.38	0.41	0.082	<0.050	<0.020	<0.48	<0.050	0.72	0.87	0.32	0.18
S9C-4H-W250-2	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.040	<0.050	<0.0085	0.37	0.39	0.086	<0.050	<0.020	<0.40	<0.050	0.7	0.75	0.3	0.17
S9C-6H-W250 1	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.040	0.057	<0.0085	0.48	0.54	0.097	<0.050	<0.020	<0.52	<0.050	0.93	1	0.4	0.19
S9C-6H-W250 2	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.040	0.058	<0.0085	0.48	0.55	0.099	<0.050	<0.020	<0.48	<0.050	0.89	0.89	0.39	0.18
S9C-12H	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.040	0.11	<0.0085	0.76	0.98	0.16	<0.050	<0.020	1	<0.050	1.4	1.5	0.64	0.38
S9C-24H	0.16	<0.10	<0.20	<0.040	0.018	0.031	<0.020	0.018	<0.050	0.015	<0.050	0.029	0.015	0.048	0.29	0.021	1.8	1.9	0.55	<0.050	0.035	1.9	0.17	3.3	5.5	4.6	4.5
S9C-2D	0.17	<0.10	<0.20	<0.020	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.040	0.31	<0.0085	2.1	2.4	0.41	<0.050	<0.020	1.9	<0.050	3.8	5	2.5	1.5
S9C-4D	0.27	<0.10	<0.20	0.031	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.040	0.46	<0.0085	2.8	2.6	0.55	<0.050	0.02	2.5	<0.050	5.2	7.1	3.5	1.7
S9C-6D	0.28	<0.10	<0.20	0.037	<0.0085	0.015	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.040	0.48	<0.0085	2.6	2.2	0.55	<0.050	0.022	2.1	<0.050	4.8	7.1	3.7	1.6
S9C-8D	0.19	<0.10	<0.20	0.034	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.040	0.4	<0.0085	1.2	0.79	0.51	<0.050	0.022	1.9	<0.050	2.2	4.1	3.2	1.6
S9C 9D	0.26	<0.10	<0.20	0.045	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.040	0.49	<0.0085	1.6	1	0.58	<0.050	<0.020	1.6	<0.050	3.1	6.9	3.6	1.8
S9C 10D	0.25	<0.10	<0.20	0.044	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.040	0.47	<0.0085	1.7	1.1	0.52	<0.050	<0.020	2	<0.050	3.2	6.7	3.5	1.8

mple Point	Biphenyl	C1-Biphenyl	C2-Biphenyl	C1-Fluorene	C2-Fluorene	C3-Fluorene	Dibenzothiophene	C1-Dibenzothiophene	C2-Dibenzothiophene	C3-Dibenzothiophene	C4-Dibenzothiophene	C1-Phenanthrene/anthracene	C2-Phenanthrene/anthracene	C3-Phenanthrene/anthracene	C4-Phenanthrene/anthracene	C1-Fluoranthene/pyrene	C2-Fluoranthene/pyrene	C3-Fluoranthene/pyrene	C4-Fluoranthene/pyrene	C1-Benzo(a)anthracene/chrysene	C2-Benzo(a)anthracene/chrysene	C3-Benzo(a)anthracene/chrysene	C4-Benzo(a)anthracene/chrysene	C1-Benzo(bjk)fluoranthene/benzo(a)py	C2-Benzo(bjk)fluoranthene/benzo(a)py	C1-Acenaphthene	1-Methylnaphthalene
S9C-2H-W250-1	0.03	0.1	0.064	0.086	0.17	0.29	0.049	0.08	0.17	0.11	<0.020	0.12	0.1	0.077	<0.050	<0.020	0.024	<0.020	<0.020	<0.0085	0.012	<0.0085	<0.0085	<0.0075	<0.0075	<0.10	0.22
S9C-2H-W250-2	0.031	0.1	0.063	0.088	0.18	0.3	0.048	0.079	0.17	0.1	<0.020	0.12	0.11	0.074	<0.050	<0.020	0.031	<0.020	<0.020	<0.0085	0.023	<0.0085	<0.0085	<0.0075	<0.0075	<0.10	0.22
S9C-4H-W250-1	0.052	0.22	0.086	0.1	0.081	0.5	0.04	0.07	0.12	0.066	<0.020	0.11	0.096	0.066	<0.050	<0.020	<0.020	<0.020	<0.020	<0.0085	<0.0085	<0.0085	<0.0085	<0.0075	<0.0075	<0.10	
S9C-4H-W250-2	0.049	0.21	0.089	0.1	0.16	0.53	0.046	0.079	0.14	0.082	<0.020	0.13	0.11	0.078	<0.050	<0.020	<0.020	<0.020	<0.020	<0.0085	<0.0085	<0.0085	<0.0085	<0.0075	<0.0075	<0.10	
S9C-6H-W250 1	0.061	0.22	0.099	0.12	0.13	0.46	0.052	0.11	0.14	0.08	<0.020	0.13	0.11	0.085	<0.050	<0.020	<0.020	<0.020	<0.020	<0.0085	<0.0085	<0.0085	<0.0085	<0.0075	<0.0075	<0.10	
S9C-6H-W250 2	0.063	0.24	0.097	0.13	0.18	0.39	0.055	0.11	0.15	0.084	<0.020	0.14	0.084	0.054	<0.050	<0.020	<0.020	<0.020	<0.020	<0.0085	<0.0085	<0.0085	<0.0085	<0.0075	<0.0075	<0.10	
S9C-12H	0.084	0.26	0.25	0.25	0.27	0.63	0.079	0.15	0.21	0.11	<0.020	0.19	0.17	0.11	<0.050	0.023	0.056	<0.020	<0.020	0.012	0.041	0.013	<0.0085	<0.0075	<0.0075	<0.10	
S9C-24H	0.18	0.48	0.63	0.9	1.5	2.6	0.33	1.4	3.3	2.4	1.4	1.5	2.3	2.5	1	0.37	0.72	1.3	0.81	0.23	1.1	0.44	0.11	0.11	0.1	0.18	
S9C-2D	0.21	0.36	0.25	0.55	0.46	0.6	0.25	0.46	0.81	0.49	0.24	0.56	0.58	0.47	0.16	0.064	0.15	0.19	<0.020	0.037	0.13	0.065	<0.0085	<0.0075	<0.0075	<0.10	
S9C-4D	0.3	0.46	0.34	0.76	0.57	<0.050	0.35	0.53	0.72	0.35	0.17	0.65	0.54	0.38	0.12	0.071	0.11	<0.020	<0.020	0.024	0.099	<0.0085	<0.0085	<0.0075	<0.0075	0.16	
S9C-6D	0.3	0.48	0.53	0.8	0.55	0.73	0.39	0.56	0.61	0.27	<0.020	0.6	0.41	0.25	0.082	0.052	0.055	<0.020	<0.020	<0.0085	<0.0085	<0.0085	<0.0085	<0.0075	<0.0075	0.15	
S9C-8D	0.18	0.35	0.45	0.74	0.54	0.71	0.37	0.58	0.71	0.33	<0.020	0.6	0.47	0.32	0.12	0.054	0.072	<0.020	<0.020	0.019	0.094	<0.0085	0.032	<0.0075	0.014	0.13	
S9C 9D	0.22	0.44	0.52	0.84	0.59	0.7	0.42	0.64	0.73	0.3	0.12	0.68	0.46	0.27	0.15	0.054	0.076	<0.020	0.022	<0.0085	<0.0085	<0.0085	<0.0085	0.008	0.013	0.16	
S9C 10D	0.24	0.45	0.51	0.84	0.57	0.65	0.38	0.6	0.69	0.31	<0.020	0.63	0.46	0.27	0.11	0.052	0.078	<0.020	<0.020	0.014	0.045	0.02	0.016	<0.0075	0.01	0.15	

Table F-11: CLWB Mild Conditions - PAH water data at 1.0 m

mple Point	Acenaphthene	Acenaphthylene	Acridine	Anthracene	Benzo(a)anthracene	Benzo(b&j)fluoranthene	Benzo(k)fluoranthene	Benzo(ghi)perylene	Benzo(c)phenanthrene	Benzo(a)pyrene	Benzo(e)pyrene	Chrysene	Dibenz(ah)anthracene	Fluoranthene	Fluorene	Indeno(123-cd)pyrene	2-Methylnaphthalene	Naphthalene	Phenanthrene	Perylene	Pyrene	Quinoline	Retene	C1-Naphthalene	C2-Naphthalene	C3-Naphthalene	C4-Naphthalene
S9A-2H-W250-1	1.7	<0.50	<1.0	0.35	0.61	0.6	0.12	0.34	<0.25	0.47	0.56	0.79	<0.15	0.58	2.8	<0.20	11	4.6	8.9	1.1	0.97	<30	5.1	20	68	92	94
S9A-2H-W250-2	0.94	<0.10	<0.20	0.18	0.22	0.31	0.06	0.19	<0.050	0.26	0.3	0.46	0.095	0.3	1.6	<0.13	6.4	3.8	4.9	0.58	0.49	<1.9	2.6	12	35	49	50
S9A-4H-W250-1	0.4	<0.10	<0.20	0.066	0.072	0.11	0.019	0.065	<0.050	0.066	0.099	0.16	<0.030	0.11	0.72	<0.043	3.7	3.3	1.9	0.19	0.17	<1.1	0.8	6.9	15	17	16
S9A-4H-W250-2	0.35	<0.10	<0.20	0.052	0.057	0.076	0.015	0.049	<0.050	0.059	0.076	0.11	<0.022	0.084	0.62	<0.032	3.6	3.6	1.5	0.14	0.13	0.94	0.66	6.8	13	14	13
S9A-6H-W250-1	0.25	<0.10	0.71	0.12	0.055	0.083	0.011	0.048	<0.050	0.049	0.083	0.11	0.027	0.09	0.61	0.031	3.4	3.1	1.4	0.14	0.1	<0.81	0.58	6.2	12	12	11
S9A-6H-W250-2	0.31	<0.10	0.51	0.084	0.032	0.056	<0.0085	0.04	<0.050	0.034	0.053	0.073	0.02	0.063	0.55	0.027	3.5	3.4	1.1	0.092	0.071	<1.3	0.4	6.4	12	9.6	8
S9A-12H	0.36	<0.10	<0.20	<0.10	0.035	0.061	<0.010	0.036	<0.050	0.038	0.06	0.066	0.025	0.08	0.66	0.024	4	4	1.3	0.094	0.071	3	0.4	7	12	11	11
S9A-24H	0.33	<0.10	<0.20	0.06	0.019	0.034	<0.0085	0.022	<0.050	0.021	<0.050	0.045	0.0094	0.061	0.57	0.016	3.4	3.3	0.99	0.062	0.046	3.2	0.26	5.9	10	7.9	6.5
S9A-2D	0.37	<0.10	<0.20	<0.080	0.027	0.044	<0.0085	0.03	<0.050	0.024	<0.050	0.055	<0.0075	0.064	0.71	0.022	3.3	2.8	1.2	0.063	0.054	2.6	0.31	5.9	11	8.6	7.8
S9A-4D	0.26	<0.10	<0.20	<0.050	0.011	0.025	<0.0085	0.017	<0.050	0.017	<0.050	0.031	<0.0075	0.048	0.54	0.014	1.5	1.2	0.94	<0.050	0.039	3.2	0.2	2.9	5.6	4.8	4.4
S9A-6D	<0.24	<0.24	<0.49	<0.024	<0.021	<0.021	<0.021	<0.021	<0.12	<0.018	<0.12	<0.021	<0.018	<0.098	0.29	<0.021	0.73	0.58	0.42	<0.12	<0.049	<0.49	<0.12	1.6	3.5	2	0.94
S9A-8D																											
S9A 9D	0.14	<0.10	<0.20	0.044	<0.0085	0.01	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.040	0.33	<0.0085	0.84	0.6	0.54	<0.050	0.034	2.1	<0.050	1.5	3.1	2.6	1.7
S9A 10D	0.17	<0.10	<0.20	0.052	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.040	0.36	<0.0085	1	0.7	0.59	<0.050	0.036	2.5	<0.050	2	3.5	2.8	1.8

mple Point	Biphenyl	C1-Biphenyl	C2-Biphenyl	C1-Fluorene	C2-Fluorene	C3-Fluorene	Dibenzothiophene	C1-Dibenzothiophene	C2-Dibenzothiophene	C3-Dibenzothiophene	C4-Dibenzothiophene	C1-Phenanthrene/anthracene	C2-Phenanthrene/anthracene	C3-Phenanthrene/anthracene	C4-Phenanthrene/anthracene	C1-Fluoranthene/pyrene	C2-Fluoranthene/pyrene	C3-Fluoranthene/pyrene	C4-Fluoranthene/pyrene	C1-Benzo(a)anthracene/chrysene	C2-Benzo(a)anthracene/chrysene	C3-Benzo(a)anthracene/chrysene	C4-Benzo(a)anthracene/chrysene	C1-Benzo(b|k)fluoranthene/benzo(a)py	C2-Benzo(b|k)fluoranthene/benzo(a)py	C1-Acenaphthene	1-Methylnaphthalene
S9A-2H-W250-1	1.1	4.1	6.5	15	29	65	5.2	30	94	70	46	33	56	63	28	8.8	18	36	19	5.5	40	13	3.3	3.7	3.2	3	7.6
S9A-2H-W250-2	0.66	2	3.7	8	16	30	2.8	12	49	35	24	16	29	25	14	4.7	9.2	17	10	2.9	21	6.9	1.6	2.1	1.7	1.5	4.7
S9A-4H-W250-1	0.35	0.93	1.3	2.9	5.1	10	1.1	4.4	16	12	8	5.5	9.6	11	4.1	1.6	3.1	6	3.5	1	7.1	2.2	0.53	0.71	0.54	0.56	2.7
S9A-4H-W250-2	0.33	0.77	1	2.4	4	7.4	0.91	3.4	12	8.8	6.4	4.4	7.3	8	3.2	1.2	2.3	4.4	2.5	0.72	5.3	1.4	0.38	0.51	0.37	0.42	2.7
S9A-6H-W250-1	0.29	0.76	1.3	2.3	3.9	8.7	0.82	4.1	12	8.2	5.7	4.6	7.3	6	2.9	1.2	2.2	4.6	2.5	0.78	2.8	1.7	0.36	0.36	0.28	0.42	
S9A-6H-W250-2	0.3	0.69	1.1	1.9	3	6.2	0.66	2.9	7.6	5.4	4.4	3.4	5	4.3	2.2	0.81	1.6	2.6	1.9	0.53	1.9	1.1	0.3	0.28	0.25	0.37	
S9A-12H	0.39	0.82	1.2	2.1	3.1	7.4	0.77	3.4	8.4	6.2	3.5	3.5	5.3	6	2.5	0.85	1.6	3.4	1.9	0.54	2.7	1.2	0.069	0.26	0.23	0.41	
S9A-24H	0.34	0.66	1	1.6	2	3.7	0.6	2.2	5	3.5	2.1	2.4	3.4	3.7	1.5	0.51	1	1.9	1.1	0.31	1.5	0.64	0.13	0.18	0.15	0.28	
S9A-2D	0.37	0.64	0.9	1.8	2.4	4.1	0.79	2.6	6.7	4.5	2.7	2.8	4.1	4.3	1.6	0.63	1.2	2.5	0.84	0.39	2	0.83	0.12	0.19	0.18	0.38	
S9A-4D	0.21	0.44	0.67	1.2	1.5	2.5	0.6	1.8	3.7	2.5	1.5	1.8	2.4	2.6	1	0.37	0.75	1.7	0.47	0.23	1.1	0.47	0.099	0.13	0.11	0.22	
S9A-6D	0.13 (1)	0.47 (1)	0.66 (1)	0.62 (1)	0.48 (1)	1.3 (1)	0.25	0.36	0.66	0.35	0.18	0.48	0.40	0.30	0.13	0.054	0.12	0.27	0.083	0.029	0.072	<0.021	<0.021	<0.018	<0.018	<0.24	0.64
S9A-8D																											
S9A 9D	0.12	0.31	0.42	0.71	0.66	1.2	0.37	0.78	1.2	0.79	0.5	0.8	0.81	0.69	0.29	0.12	0.21	0.3	0.2	0.051	0.25	0.11	0.031	0.031	0.018	0.1	
S9A 10D	0.15	0.29	0.39	0.73	0.67	<1.4	0.35	0.62	1	0.62	0.38	0.9	0.87	0.7	0.24	0.096	0.18	0.29	0.12	0.042	0.16	<0.060	<0.33	<0.14	<0.22	0.12	

Table F-12: CLWB Moderate Conditions - PAH water data at 1.0 m

mple Point	Benzene	Toluene	Ethylbenzene	m & p-Xylene	o-Xylene	Xylenes (Total)	F1 (C6-C10) BTEX	C6-C10
S1-2H-L1-W40-1	37	18	0.71	3.8	1.2	5	<100	<100
S1-2H-L1-W40-2	29	14	0.53	3	1	4	<100	<100
S1-2H-L1-W40-3	30	15	0.55	3.2	1.1	4.3	<100	<100
S1-4H-L1-W40-1	28	13	0.49	2.8	0.88	3.7		<100
S1-4H-L1-W40-2	30	14	0.5	2.9	0.99	3.9		<100
S1-4H-L1-W40-3	29	14	0.5	2.9	1	3.9		<100
S1-6H-L1-W40-1	21	11	0.4	2.3	0.76	3	<100	<100
S1-6H-L1-W40-2	25	13	0.49	2.7	0.89	3.6	<100	<100
S1-6H-L1-W40-3	23	11	0.43	2.4	0.81	3.2	<100	<100
S1-12H-L1-W40-1	27	13	0.59	3.1	1	4.2	<100	<100
S1-12H-L1-W40-2	28	14	0.61	3.3	1.1	4.4	<100	<100
S1-12H-L1-W40-3	28	14	0.58	3.2	1.1	4.3	<100	<100
S1-1D-L1-W40-1	180	110	3.3	21	7.1	28	<100	410
S1-1D-L1-W40-2	200	110	3.5	22	7.6	29	<100	410
S1-1D-L1-W40-3	190	110	3.4	21	7.4	29	<100	300
S1-2D-L1-W40-1	250	160	4.9	33	11	44	<100	490
S1-2D-L1-W40-2	260	170	5.2	35	11	46	<100	450
S1-2D-L1-W40-3	250	170	5.3	35	11	46	120	600
S1-4D-L1	350	250	8.7	50	17	68	120	790
S1-6D-L1	400	290	9.4	53	20	73	<100	750
S1-8D-L1	450	360	14	73	30	100	260	1200
S1-10D-L1	390	300	9.3	42	22	64	370	1100

Table F-13: AWB Static - BTEX and C6-C10 water data at 0.5 m

mple Point	Benzene	Toluene	Ethylbenzene	m & p-Xylene	o-Xylene	Xylenes (Total)	F1 (C6-C10) BTEX	C6-C10
S1 2H L2 W40-1	26	13	0.46	2.7	0.93	3.7	<100	120
S1 2H L2 W40-2	23	12	0.46	2.8	0.87	3.6	<100	<100
S1 2H L2 W40-3	31	15	0.61	3.3	1.1	4.4	<100	<100
S1-4H-L2-W40-1	31	14	0.53	2.9	0.93	3.8		<100
S1-4H-L2-W40-2	30	14	0.54	3.1	0.95	4		<100
S1-4H-L2-W40-3	31	15	0.56	3.1	1.1	4.2		<100
S1-6H-L2-W40-1	30	14	0.53	2.9	0.94	3.8	<100	<100
S1-6H-L2-W40-3	16	7.8	<0.40	1.6	0.63	2.2	<100	<100
S1-12H-L2-W40-1	25	11	0.42	2.4	0.86	3.2	<100	<100
S1-12H-L2-W40-2	27	13	0.61	3.3	1	4.3	<100	<100
S1-12H-L2-W40-3	25	12	0.54	3	1	4	<100	<100
S1-1D-L2-W40-1	210	120	3.9	24	8.4	33	<100	340
S1-1D-L2-W40-2	220	130	3.9	25	8.4	33	<100	450
S1-1D-L2-W40-3	210	130	3.9	25	8.4	33	<100	440
S1-2D-L2-W40-1	230	140	4.9	30	10	40	340	750
S1-2D-L2-W40-2	260	160	5.3	33	11	44	<100	440
S1-2D-L2-W40-3	830	500	16	110	33	140	340	1800
S1-4D-L2	330	240	8.3	49	17	66	<100	750
S1-6D-L2	390	290	9.9	57	21	78	470	1200
S1-8D-L2	460	360	13	70	28	98	240	1200
S1-10D-L2	370	280	8.4	38	22	60	<100	780

Table F-14: AWB Static - BTEX and C6-C10 water data at 1.0 m

mple Point	Benzene	Toluene	Ethylbenzene	m & p-Xylene	o-Xylene	Xylenes (Total)	F1 (C6-C10) BTEX	C6-C10
S1-2H L3 W40-1	0.6	0.72	<0.40	<0.80	<0.40	<0.80	<100	<100
S1-2H-L3-W40-2	0.62	0.8	<0.40	<0.80	<0.40	<0.80	<100	<100
S1-2H-L3-W40-3	0.61	0.76	<0.40	<0.80	<0.40	<0.80	<100	<100
S1-4H-L3-W40-1	6.7	3.3	<0.40	1.5	0.59	2.1	<100	<100
S1-4H-L3-W40-2	6.6	3.1	<0.40	1.1	0.44	1.5	<100	<100
S1-4H-L3-W40-3	8.2	4	<0.40	1.1	0.44	1.5	<100	<100
S1-6H-L3-W40-1	15	7	<0.40	1.7	0.58	2.3	<100	<100
S1-6H-L3-W40-2	15	6.9	<0.40	1.8	0.56	2.3	<100	<100
S1-6H-L3-W40-3	15	7	<0.40	1.8	0.58	2.4	<100	<100
S1-12H-L3-W40-1	23	11	0.46	2.5	0.89	3.3	<100	<100
S1-12H-L3-W40-2	23	11	0.48	2.5	0.87	3.4	<100	<100
S1-12H-L3-W40-3	23	10	<0.40	2.2	0.83	3.1	<100	<100
S1-1D-L3-W40-1	310	180	5.5	35	12	47	<100	600
S1-1D-L3-W40-2	300	170	5.2	34	11	45	<100	570
S1-1D-L3-W40-3	300	170	5.3	34	12	45	<100	550
S1-2D-L3-W40-1	270	170	5.8	35	12	46	220	700
S1-2D-L3-W40-2	240	160	5.2	32	11	43	230	680
S1-2D-L3-W40-3	250	160	5.6	34	11	45	280	740
S1-4D-L3	350	250	8.9	56	19	75	150	840
S1-6D-L3	430	320	11	64	24	88	360	1200
S1-8D-L3	320	260	10	54	22	76	390	1100
S1-10D-L3	370	270	7.8	35	20	55	<100	610

Table F-15: AWB Static - BTEX and C6-C10 water data at 1.5 m

mple Point	Benzene	Toluene	Ethylbenzene	m & p-Xylene	o-Xylene	Xylenes (Total)	F1 (C6-C10) BTEX	C6-C10
S2-2H-L1-W40-1	170	73	1.9	11	3.4	14		
S2-2H-L1-W40-2	140	62	1.9	11	3.2	14		
S2-2H-L1-W40-3	150	63	1.9	11	3.4	14		
S2-4H-L1-W40-2	270	130	3.3	20	6	26	<100	480
S2-4H-L1-W40-3	250	110	3	18	5.6	24	<100	380
S2-6H-L1-W40-1	310	140	3.7	23	7.5	31	120	600
S2-6H-L1-W40-2	300	140	3.7	23	7.2	30	<100	520
S2-6H-L1-W40-3	290	140	3.8	23	<0.40	23	<100	460
S2-12H-L1-W40-1	490	250	8.2	47	15	62	140	960
S2-12H-L1-W40-2	510	260	8.3	48	15	64	120	960
S2-12H-L1-W40-3	520	270	8.7	50	16	65	150	1000
S2-1D-L1-W40-1	660	360	10	61	22	83	210	1300
S2-1D-L1-W40-2	690	400	11	70	23	92	<100	1200
S2-1D-L1-W40-3	830	460	13	85	26	110	<100	880
S2-2D-L1-W40-1	790	480	16	110	34	140	360	1800
S2-2D-L1-W40-2	830	520	17	110	36	150	280	1800
S2-2D-L1-W40-3	780	480	16	100	34	140	290	1700
S2-4D-L1	800	540	20	120	40	160	480	2000
S2-6D-L1	350	260	9.7	60	21	81	480	1200
S2-8D-L1	120	110	4.7	30	11	41	180	460
S2-10D-L1	87	72	2.8	16	8.4	25	230	410

Table F-16: AWB Mild Conditions - BTEX and C6-C10 water data at 0.5 m

mple Point	Benzene	Toluene	Ethylbenzene	m & p-Xylene	o-Xylene	Xylenes (Total)	F1 (C6-C10) BTEX	C6-C10
S2-2H-L2-W40-1	150	73	1.9	12	3.6	15		
S2-2H-L2-W40-2	150	72	1.9	12	3.5	15		
S2-2H-L2-W40-3	150	73	1.9	12	3.6	16		
S2-4H-L2-W40-1	260	120	3	20	6	26		450
S2-4H-L2-W40-2	290	140	3.4	22	6.5	28		480
S2-6H-L2-W40-1	290	140	4.2	25	7.7	32	<100	430
S2-6H-L2-W40-2	300	140	3.7	24	7.5	32	<100	560
S2-6H-L2-W40-3	290	140	3.5	22	7.3	29	<100	470
S2-12H-L2-W40-1	510	260	8.4	49	16	65	300	1100
S2-12H-L2-W40-2	500	260	8.2	49	15	64	240	1100
S2-12H-L2-W40-3	500	260	8	48	15	63	190	1000
S2-1D-L2-W40-1	680	380	13	75	24	99	<100	1200
S2-1D-L2-W40-2	670	380	11	68	23	90	<100	1100
S2-1D-L2-W40-3	650	370	11	64	22	86	<100	1100
S2-2D-L2-W40-1	820	500	17	110	36	150	<100	1600
S2-2D-L2-W40-2	800	490	16	110	35	140	360	1800
S2-2D-L2-W40-3	790	490	16	110	35	140	420	1900
S2-4D-L2	720	510	18	110	38	150	<100	1300
S2-6D-L2	330	250	9.1	55	20	75	200	860
S2-8D-L2	160	130	5.7	37	13	50	120	470
S2-10D-L2	84	68	2.6	15	6.2	21	<100	190

Table F-17: AWB Mild Conditions - BTEX and C6-C10 water data at 1.0 m

mple Point	Benzene	Toluene	Ethylbenzene	m & p-Xylene	o-Xylene	Xylenes (Total)	F1 (C6-C10) BTEX	C6-C10
S2-2H-L3-W40-1	130	64	1.7	11	3.1	14		
S2-2H-L3-W40-2	140	65	1.6	11	3.2	14		
S2-2H-L3-W40-3	130	62	1.6	10	3	13		
S2-4H-L3-W40-1	250	120	2.7	18	5.6	24		360
S2-4H-L3-W40-2	250	120	2.9	18	5.8	24		490
S2-4H-L3-W40-3	260	120	3.1	19	5.8	25		470
S2-6H-L3-W40-1	290	140	4	23	7.6	31	<100	380
S2-6H-L3-W40-2	290	140	4.1	24	7.5	32	<100	410
S2-6H-L3-W40-3	290	140	4.1	23	7.6	31	<100	410
S2-12H-L3-W40-1	480	250	8	46	14	60	<100	860
S2-12H-L3-W40-2	490	250	7.9	47	15	61	<100	910
S2-12H-L3-W40-3	490	250	8.2	47	15	61	170	980
S2-1D-L3-W40-1	680	370	12	70	24	94	<100	1000
S2-1D-L3-W40-2	630	360	11	64	21	85	<100	1200
S2-1D-L3-W40-3	670	370	12	72	24	96	<100	950
S2-2D-L3-W40-1	780	480	16	110	33	140	190	1600
S2-2D-L3-W40-2	800	480	16	110	34	140	470	1900
S2-2D-L3-W40-3	770	470	16	110	33	140	390	1800
S2-4D-L3	560	410	14	89	31	120	<100	1100
S2-6D-L3	330	240	8.8	55	20	75	450	1100
S2-8D-L3	130	110	4.3	28	10	38	<100	240
S2-10D-L3	84	66	2.5	14	6	20	<100	210

Table F-18: AWB Mild Conditions - BTEX and C6-C10 water data at 1.5 m

mple Point	Benzene	Toluene	Ethylbenzene	m & p-Xylene	o-Xylene	Xylenes (Total)	F1 (C6-C10) BTEX	C6-C10
S3-2H-L1-W40-1	990	590	20	130	38	170		
S3-2H-L1-W40-2	970	570	20	130	37	170		
S3-2H-L1-W40-3	950	560	19	130	36	160		
S3-4H-L1-W40-1	210	130	4.3	27	9.5	37	<100	410
S3-4H-L1-W40-2	880	54	1.9	12	3.7	15	1800	2800
S3-4H-L1-W40-3	900	54	1.8	12	3.7	16	1600	2500
S3-6H-L1-W40-1	710	390	14	87	32	120	150	1400
S3-6H-L1-W40-2	540	300	10	69	24	93	<100	1000
S3-6H-L1-W40-3	870	510	19	120	39	160	310	1900
S3-12H-L1-W40-1	650	400	15	95	32	130	160	1300
S3-12H-L1-W40-2	680	410	15	98	33	130	280	1500
S3-12H-L1-W40-3	660	390	14	91	32	120	210	1400
S3-1D-L1-W40-1	500	400	16	110	33	140	160	1300
S3-1D-L1-W40-2	520	410	17	110	33	140	480	1600
S3-1D-L1-W40-3	520	410	17	110	34	140	480	1600
S3-2D-L1-W40-1	210	250	13	85	28	110	240	820
S3-2D-L1-W40-2	200	240	12	81	28	110	<100	650
S3-2D-L1-W40-3	200	240	12	81	27	110	220	780
S3-4D-L1	44	100	6.1	39	14	53	<100	260
S3-6D-L1	17	64	5	32	12	43	<100	180
S3-8D-L1	5	41	4.5	32	11	43	210	310
S3-10D-L1	1.8	9.9	1.4	8.1	2.8	11	<100	<100

Table F-19: AWB Moderate Conditions - BTEX and C6-C10 water data at 0.5 m

mple Point	Benzene	Toluene	Ethylbenzene	m & p-Xylene	o-Xylene	Xylenes (Total)	F1 (C6-C10) BTEX	C6-C10
S3-2H-L2-W40-1	880	520	17	110	33	140		
S3-2H-L2-W40-2	880	510	17	110	32	150		
S3-2H-L2-W40-3	850	500	17	110	32	150		
S3-4H-L2-W40-1	970	580	20	130	37	170	650	2400
S3-4H-L2-W40-2	960	570	19	130	36	160	550	2300
S3-4H-L2-W40-3	930	550	19	120	35	160	710	2400
S3-6H-L2-W40-1	790	500	18	110	34	140	100	1500
S3-6H-L2-W40-2	810	520	18	110	35	150	160	1700
S3-6H-L2-W40-3	780	490	17	100	33	140	140	1600
S3-12H-L2-W40-1	790	530	22	130	41	170	820	2300
S3-12H-L2-W40-2	770	510	21	120	39	160	740	2200
S3-12H-L2-W40-3	730	440	16	100	36	140	420	1700
S3-1D-L2-W40-1	500	400	16	110	33	140	200	1300
S3-1D-L2-W40-2	520	420	17	110	35	150	290	1400
S3-1D-L2-W40-3	530	420	17	110	34	140	390	1500
S3-2D-L2-W40-1	190	240	12	80	26	110	340	880
S3-2D-L2-W40-2	190	230	12	79	27	110	240	780
S3-2D-L2-W40-3	200	250	12	82	28	110	200	770
S3-4D-L2	48	110	6.7	45	15	59	120	340
S3-6D-L2	14	53	4.1	26	9.6	36	170	280
S3-8D-L2	4.9	37	4.3	31	9.7	40	<100	150
S3-10D-L2	2.1	12	1.5	9.4	3.5	13	<100	<100

Table F-20: AWB Moderate Conditions - BTEX and C6-C10 water data at 1.0 m

..mple Point	Benzene	Toluene	Ethylbenzene	m & p-Xylene	o-Xylene	Xylenes (Total)	F1 (C6-C10) BTEX	C6-C10
S3-2H-L3-W40-1	770	440	15	98	28	130		
S3-2H-L3-W40-2	800	460	15	100	29	130		
S3-2H-L3-W40-3	760	440	14	95	28	120		
S3-4H-L3-W40-1	920	540	18	120	35	150	790	2400
S3-4H-L3-W40-2	910	540	18	120	34	150	580	2200
S3-4H-L3-W40-3	930	560	19	120	36	160	720	2400
S3-6H-L3-W40-1	810	490	18	110	33	140	160	1600
S3-6H-L3-W40-2	780	480	17	100	34	140	130	1500
S3-6H-L3-W40-3	830	510	18	110	35	140	160	1700
S3-12H-L3-W40-1	750	500	21	130	39	170	770	2200
S3-12H-L3-W40-2	740	490	20	120	38	160	530	1900
S3-12H-L3-W40-3	500	260	<0.40	49	15	64	1200	2000
S3-1D-L3-W40-1	500	410	17	110	33	140	320	1400
S3-1D-L3-W40-2	530	430	17	110	35	150	150	1300
S3-1D-L3-W40-3	520	420	17	110	34	150	210	1300
S3-2D-L3-W40-1	190	240	12	82	26	110	150	690
S3-2D-L3-W40-2	180	230	12	79	25	100	190	720
S3-2D-L3-W40-3	190	240	12	81	27	110	340	880
S3-4D-L3	54	120	8.1	53	17	70	220	470
S3-6D-L3	15	55	4.2	27	10	37	120	230
S3-8D-L3	4.4	31	3.9	26	8.8	35	110	180
S3-10D-L3	2.6	12	1.4	9.2	3.3	12	<100	110

Table F-21: AWB Moderate Conditions - BTEX and C6-C10 water data at 1.5 m

mple Point	Benzene	Toluene	Ethylbenzene	m & p-Xylene	o-Xylene	Xylenes (Total)	F1 (C6-C10) BTEX	C6-C10
S9B-2H-W40-1	34	17	0.74	3.3	1.3	4.6		
S9B-2H-W40-2	27	13	0.58	2.6	1.1	3.7		
S9B-2H-W40-3	33	16	0.72	3.2	1.2	4.5		
S9B-4H-W40-1	42	21	0.87	4	1.6	5.6		
S9B-4H-W40-2	41	21	0.84	4	1.5	5.5		
S9B-4H-W40-3	41	21	0.84	3.9	1.5	5.4		
S9B-6H-W40 1	44	22	0.9	4.1	1.7	5.8		
S9B-6H-W40 2	45	22	0.92	4.3	1.7	6		
S9B-6H-W40 3	41	22	0.87	4.6	1.8	6.4		
S9B-12H	86	40	1.8	8	3.3	11	<100	150
S9B-24H	200	100	4.7	21	9	30	220	550
S9B-2D	300	190	8.7	38	17	54	<100	510
S9B-4D	430	280	13	37	27	63	220	1000
S9B-6D	500	340	13	21	28	49	140	1000
S9B-8D	430	310	17	22	34	56	430	1200
S9B 9D	490	360	19	22	41	63	<100	970
S9B 10D	520	370	20	20	41	61	<100	980

Table F-22: CLWB Static Conditions - BTEX and C6-C10 water data at 1.0 m

mple Point	Benzene	Toluene	Ethylbenzene	m & p-Xylene	o-Xylene	Xylenes (Total)	F1 (C6-C10) BTEX	C6-C10
S9C-2H-W40-1	180	93	3.9	18	6.6	24		
S9C-2H-W40-2	180	92	3.8	17	6.6	24		
S9C-2H-W40-3	170	86	3.5	16	6.3	23		
S9C-4H-W40-1	300	150	6.1	29	11	40		
S9C-4H-W40-2	310	160	6.2	30	12	41		
S9C-4H-W40-3	300	150	6	29	11	40		
S9C-6H-W40 1	370	210	8.4	43	16	59		
S9C-6H-W40 2	370	210	8.3	43	16	58		
S9C-6H-W40 3	380	210	8.5	43	16	59		
S9C-12H	510	260	12	54	22	76	<100	870
S9C-24H	570	320	16	75	30	110	180	1200
S9C-2D	610	460	23	120	47	160	<100	1100
S9C-4D	320	250	14	66	30	95	140	810
S9C-6D	190	130	6.5	27	17	44	190	570
S9C-8D	30	24	1.8	6.3	4.4	11	<100	<100
S9C 9D	25	23	1.7	6.6	4.7	11	220	280
S9C 10D	20	20	1.4	6.2	4.3	11	<100	<100

Table F-23: CLWB Mild Conditions - BTEX and C6-C10 water data at 1.0 m

Sample Point	Benzene	Toluene	Ethylbenzene	m & p-Xylene	o-Xylene	Xylenes (Total)	F1 (C6-C10) BTEX	C6-C10
S9A-2H-W40-1	1300	790	43	200	76	270		
S9A-2H-W40-2	1300	810	45	210	78	280		
S9A-2H-W40-3	1300	800	44	210	77	280		
S9A-4H-W40-1	1600	980	56	260	98	360		
S9A-4H-W40-2	1600	1100	58	270	100	370		
S9A-4H-W40-3	1600	1100	58	270	100	370		
S9A-6H-W40-1	1300	960	50	250	93	340		
S9A-6H-W40-2	1400	950	50	250	92	340		
S9A-6H-W40-3	1400	940	48	240	91	330		
S9A-12H	1100	750	40	200	77	280	1800	4000
S9A-24H	650	410	22	110	44	150	830	2100
S9A-2D	230	210	12	62	26	88	<100	550
S9A-4D	14	22	2.1	10	5	15	<100	<100
S9A-6D	5.9	8.6	0.71	3.7	1.8	5.5	<100	<100
S9A-8D	6.2	11	0.94	5.6	2.6	8.2	<100	<100
S9A 9D	5.6	9.5	1	4.1	2	6	<100	<100
S9A 10D	8.4	13	1.3	5.5	2.5	8	<100	<100

Table F-24: CLWB Moderate Conditions - BTEX and C6-C10 water data at 1.0 m

Sample Point	Total Petroleum Hydrocarbon
S1-2H-L1-W500	<2.0
S1-6H-L1-W500	<2.0
S1-12H-L1-W500	<2.0
S1-1D-L1-W500	<2.0
S1-2D-L1-W500	2.7
S1-4D-L1	<2.0
S1-6D-L1	<2.0
S1-8D-L1	<2.0
S1-2H L2 W500	<2.0
S1-6H-L2-W500	<2.0
S1-12H-L2-W500	<2.0
S1-1D-L2-W500	<2.0
S1-2D-L2-W500	<2.0
S1-4D-L2	<2.0
S1-6D-L2	<2.0
S1-8D-L2	<2.0
S1-2H L3-W500	<2.0
S1-6H-L3-W500	<2.0
S1-12H-L3-W500	<2.0
S1-1D-L3-W500	<2.0
S1-2D-L3-W500	<2.0
S1-4D-L3	<2.0
S1-6D-L3	<2.0
S1-8D-L3	<2.0

Table F-25: AWB Static Conditions – TPH at 0.5 m (L1 series), 1.0 m (L2 series), and 1.5 m (L3 series)

Sample Point	Total Petroleum Hydrocarbon
S2-4H-L1-W500	<2.0
S2-12H-L1-W500	<2.0
S2-1D-L1-W500	<2.0
S2-2D-L1-W500	2.9
S2-4D-L1	2.2
S2-6D-L1	<2.0
S2-8D-L1	<2.0
S2-2H-L2-W500	<2.0
S2-12H-L2-W500	2.8
S2-1D-L2-W500	<2.0
S2-2D-L2-W500	3.3
S2-4D-L2	<2.0
S2-6D-L2	<2.0
S2-8D-L2	<2.0
S2-2H-L3-W500	<2.0
S2-12H-L3-W500	<2.0
S2-1D-L3-W500	<2.0
S2-2D-L3-W500	3.7
S2-4D-L3	2
S2-6D-L3	<2.0
S2-8D-L3	<2.0

Table F-26: AWB Mild Conditions – TPH at 0.5 m (L1 series), 1.0 m (L2 series), and 1.5 m (L3 series)

Sample Point	Total Petroleum Hydrocarbon
S3-2H-L1-W500	58
S3-4H-L1-W500	30
S3-12H-L1-W500	15
S3-1D-L1-W500	10
S3-2D-L1-W500	7.5
S3-4D-L1	4
S3-6D-L1	3
S3-8D-L1	3.4
S3-2H-L2-W500	21
S3-4H-L2-W500	19
S3-12H-L2-W500	13
S3-1D-L2-W500	11
S3-2D-L2-W500	6.8
S3-4D-L2	4.4
S3-6D-L2	3.3
S3-8D-L2	3.6
S3-2H-L3-W500	19
S3-4H-L3-W500	20
S3-12H-L3-W500	12
S3-1D-L3-W500	9.9
S3-2D-L3-W500	7.5
S3-4D-L3	4.4
S3-6D-L3	3.4
S3-8D-L3	3.6

Table F-27: AWB Moderate Conditions – TPH at 0.5 m (L1 series), 1.0 m (L2 series), and 1.5 m (L3 series)

Sample Point	Total Petroleum Hydrocarbon
S9A-2H-W500	120
S9A-4H-W500	42
S9A-6H-W500	20
S9A-12H	8.4
S9A-24H	5.3
S9A-2D	4.2
S9A-4D	2.7
S9A-6D	<2.0
S9A-8D	<2.0
S9A 9D	<2.0
S9A 10D	<2.0
S9B-2H-W500	<2.0
S9B-4H-W500	<2.0
S9B-6H-W500	<2.0
S9B-12H	<2.0
S9B-24H	<2.0
S9B-2D	<2.0
S9B-4D	<2.0
S9B-6D	2.1
S9B-8D	<2.0
S9B 9D	2.1
S9B 10D	<2.0
S9C-2H-W500	<2.0
S9C-4H-W500	<2.0
S9C-6H-W500	<2.0
S9C-12H	<2.0
S9C-24H	4.6
S9C-2D	<2.0
S9C-4D	<2.0
S9C-6D	<2.0
S9C-8D	<2.0
S9C 9D	<2.0
S9C 10D	<2.0

Table F-28: TPH measured in water samples at 1.0 m - CLWB Static Conditions (S9B series), Mild Conditions (S9C series), and Moderate Conditions (S9A series)

Appendix G: Equipment Testing Oil Sample Analysis

Witt O'Brien's, Polaris Applied Sciences, and
Western Canada Marine Response Corporation

Date Sample Taken	Witt|O'Brien's No.	Maxxam ID No.	Results										
			Density @ 15°C			Viscosity							Water Content
			Rel. Dens.	API	Abs. Den.	@ 5°C	@ 10°C	@ 15°C	@ 60°C	@ 70°C	@ 80°C	@ 90°C	
May 13	E7-WC-13 May 2013	GJ4758											.43
May 13	E7-SG-13 May 2013	GJ4759	0.926	21.3	925.2								
May 13	E7-Vis-13 May 2013	GJ4760				447.4	309.6	220.3					
May 15	E6-WC-15 May 2013	GJ9950											4.1
May 15	E6-SG-15 May 2013	GJ9951	0.9533	16.9	952.4								
May 15	E6-Vis-15 May 2013	GJ9952				3224	1963	1252					
May 17	E3-SG-5-17 E3-Vis-5-17 E3-WC-5-17	GL0000	0.986	12	985.1					303.4	205	125.1	35.5
May 17	E4-SG-5-17 E4-Vis-5-17 E4-WC-5-17	GL0001	0.971	14.2	970.1					113.9	68.02		8.8
May 17	E5-SG-5-17 E5-Vis-5-17 E5-WC-5-17	GK9999	0.9756	13.5	974.7				203.2	124.8	73.95		17.7
May 19	E3-SG-5-19 E3-Vis-5-19 E3-WC-5-19	GL0066	0.9908	11.3	989.9					446.2	306.1	184.6	41.2
May 19	E4-SG-5-19 E4-Vis-5-19 E4-WC-5-19	GL0067	0.9834	12.4	982.5					235.9	143.3	95.71	27.7
May 19	E5-SG-5-19 E5-Vis-5-19 E5-WC-5-19	GL0068	0.9879	11.7	987.0					301.5	160.8		28.2
May 21	E3-SG-5-21 E3-Vis-5-21 E3-WC-5-21	GL0054	0.9939	10.9	993.0					611.3	391.2	213.7	45.1
May 21	E4-SG-5-21 E4-Vis-5-21 E4-WC-5-21	GL0055	0.9871	11.9	986.2					299.7	186.2	111.2	22.5
May 21	E5-SG-5-21 E5-Vis-5-21 E5-WC-5-22	GL0056	0.9881	11.7	987.2					362.1	215.3	110.7	33.0
May 22	E7-SG-5-22 E7-Vis-5-22 E7-WC-5-22	GL6308	0.976	13.5	975.1					153.8	95.6		1.2

Density, Viscosity and Water Content from E-Tanks Prior to Equipment Testing.

Date Sample Taken	Witt|O'Brien's No.	Maxxam ID No.	Results (% Water Content)
May 14	LC3-WC-14 May 2013	GJ9937	22
May 14	LC4-WC-14 May 2013	GJ9938	5.7
May 14	LC5-WC-14 May 2013	GJ9939	11
May 16	LC3-WC-16 May 2013	GK3580	11.8
May 16	LC4-WC-16 May 2013	GK3581	8.2
May 16	LC5-WC-16 May 2013	GK3582	91.1
May 18	WC-E3-5-18	GL0049	50.4
May 18	WC-E4-5-18	GL0050	24.1
May 18	WC-E5-5-18	GL0048	31.6
May 20	WC-E3-5-20	GL0060	47.5
May 20	WC-E4-5-20	GL0061	20.0
May 20	WC-E5-5-20	GL0062	36.3
May 22	WC-E3-5-22	GL8599	49
May 22	WC-E4-5-22	GL8600	26.2
May 22	WC-E5-5-22	GL8601	35.2
May 23	WC-E7-Lamor-23	GL8597	13.2
May 23	WC-E7-Aqua-23	GL8598	17.0

Water Content from Calibration Cubes: (samples taken directly from cube after manual, gross, decanting of water).

Appendix H: Flux Chamber Sampling Program in Support of Spill Modelling for the Trans Mountain Expansion Project Final Report

Witt O'Brien's, Polaris Applied Sciences, and
Western Canada Marine Response Corporation

Introduction

RWDI AIR Inc.'s final report, "Flux Chamber Sampling Program in Support of Spill Modelling for the Trans Mountain Expansion Project," dated September 6, 2013, is located on the following pages. Due to the size of the entire report, only the base report is included, and the appendices are excluded. The complete report and further information is available from the Fate and Behavior Final Report authors.

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CANADA'S BEST MANAGED COMPANIES

Flux Chamber Sampling Program in Support of Spill Modelling for the Trans Mountain Expansion Project

Gainford, Alberta

Final Report

RWDI # 1202006-7017
September 6, 2013

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EXECUTIVE SUMMARY

RWDI AIR Inc. (RWDI) completed flux chamber measurements in support of watercourse spill hazard modelling at the KMC facility in Gainford, Alberta over the period, May 13 to 22, 2013. RWDI directly measured emission flux rates off of a spill water holding tank. The objective of the study was to measure emission rates that could be used to ground-truth the numerical estimates modelled in the accidental release/hazard assessment for the watercourse and marine spill scenarios. The fresh water tank was loaded to a depth of 25 mm of Cold Lake Winter Blend Diluent Bitumen (dilbit) and left open to changing ambient conditions associated with solar load, wind, precipitation, temperature and so on.

The sampling protocols proposed for this study were based on reference testing methods as published by the Ontario Ministry of the Environment (OSTC ON-6) and the United States Environmental Protection Agency. Samples were collected into glass lined 1.4 L SUMMA canister and were analysed for Total Petroleum Hydrocarbons (aliphatic and aromatic fractionation: Aliphatics >C_5-C_6, Aliphatics >C_6-C_8, Aliphatics >C_8-C_{10}, Aliphatics >C_{10}-C_{12}, Aliphatics >C_{12}-C_{16}, Aromatics >C_7–C_8, Aromatics >C_8-C_{10}, Aromatics >C_{10}-C_{12}, Aromatics >C_{12}-C_{16}); volatile organic compounds, reduced sulphur compounds, and light hydrocarbons (C_1 to C_5). Over the nine day sampling period, emission fluxes were sampled over a two minute period every 8 hours for the first day, every 12 hours from day 2 to day 7, and once per day on days 8 and 9. Sample blanks were also submitted to the outside laboratory.

Decay curves were plotted for all of the chemical groupings noted above and several speciated hydrocarbons. The time duration for a decrease in the emission rate relative to the initial emission rate is summarized in the following table by chemical group.

Chemical Group	Time to Achieve Emission Rate Reduction by		
	> 80%	> 90%	> 95%
Light Hydrocarbons	6 h	12 h	175 h
Volatile Organic Compounds	12 h	66 h	82 h
Volatile Organic Hydrocarbons	12 h	82 h	175 h
Total Reduced Sulphurs	< 6 h	< 6 h	< 6 h
Total Hydrocarbons (Detected)	< 6 h	6 h	30 h
Total Volatile Organic Hydrocarbons (Detected)	12 h	30 h	37 h

The decay times in the emission rates varied by chemical group. For example, the light hydrocarbon emission rate was 80% lower after 6 hours which indicates the high volatility of this group. However, the light hydrocarbon group did not reach the 95% reduction in emission rate until 175 hours. The reduced sulphurs were the most volatile achieving a 95% reduction in less than six hours.

For all chemical groups and relative to the initial spill, the emission rates declined by 80% after 12 hours and by 90% after 3.4 days.

TABLE OF CONTENTS

Tables

Figures

Appendices

1. INTRODUCTION

RWDI AIR Inc. was retained by Tera Consulltants on behalf of Kinder Morgan Canada to conduct flux chamber sampling on a test oil spill at the Kinder Morgan facility located in Gainford, Alberta. RWDI was given a freshwater tank, Tank S8, in the field program which was part of a larger fate and behaviour study of heavy crude oil (Cold Lake Winter Blend dilbit) on marine waters. Tank S8 was left exposed to ambient conditions (i.e. solar load, precipitation, wind, etc.). Flux chamber samples were taken off of Tank S8 from May 13, 2013 to May 22, 2013. The objective of the survey was to take 'real-world' emission samples that would be used to ground-truth estimated emission rates used in the hazard and dispersion analysis of a spill to water.

The ambient parameters monitored during the flux chamber emission sampling included:

- Flux chamber temperature, pressure, and nitrogen gas flow rate;
- Tank S8 fresh water temperature below the dilbit; and,
- Ambient air temperature at time of sampling.

Collected samples were analyzed by Maxxam Analytics in Mississauga, Ontario for the following parameters:

- Benzene, toluene, ethyl benzene, and xylenes (BTEX);
- Total hydrocarbons (C_1 to C_5);
- Volatile organic hydrocarbons (VOHC, aliphatic and aromatic hydrocarbons C_5 to C_{16});
- Volatile organic compounds (VOCs, including chlorinated organics); and,
- Sulphur compounds (measured until all parameters dropped below detection limits).

Appendix A contains the pre-test work plan developed by RWDI for this study.

2. SOURCE DESCRIPTION

2.1 Tank Description

Tank S8 was designated for use by RWDI to conduct flux chamber measurements on site at the Gainford, Alberta facility. Tank S8 contained fresh water with a simulated oil spill to a depth of 25.4 mm (1 in.) on the surface. The tank was left outside exposed to ambient temperature, solar loading, wind conditions, and precipitation.

3. TEST PROGRAM

3.1 Sample Location

The floating flux chamber was placed directly onto Tank S8 as shown in Figure 1. When not in use, the flux chamber was cleaned and held suspended above the surface of the tank by about 250 mm as shown in Figure 2.

Figure 1: Floating flux chamber in sampling position on oil spill in Tank S8

Figure 2: Floating flux chamber suspended above oil spill after sampling event

3.2 Description of Testing Methodology

Flux sampling was performed in accordance with the Ontario Source Testing Code, version 3 Method ON-6, Part G, Section 7.0. A modification to the method allowed for the use of a floating flux chamber placed onto the surface of Tank S8. The flux chamber and floats were all stainless steel in construction to prevent cross contamination had plastic/rubber floats been used instead.

The flux chamber was purged with nitrogen at a rate of 0.00064 $m^3/s/m^2$ and allowed four air changes to occur before sample collection was initiated. Sampling was conducted using 1.4 L SUMMA canisters with a two minute fill time for the canisters (flow controller). The two minute fill time for the canister was to prevent air entrainment through a negative pressure condition on the flux chamber. The flux chamber pressure was monitored at all times to ensure that the chamber was maintained at a slight positive pressure. All sample lines and nitrogen lines were constructed of Teflon®, an inert material.

Upon completion of the sampling, the SUMMA canisters were sealed and packaged for transport to Maxxam Analytical Services in Mississauga, Ontario for analysis. Samples were collected on less frequently as the decrease in emission rates was observed using a handheld photo-ionization detector. Samples were taken according to the schedule in Table 1.

Table 1: Sampling Summary and Sample Log

RWDI Sample ID	Sampling Date	Start Time	End Time[1]
D01-H00	13-May-13	14:53	14:55
D01-H06	13-May-13	20:52	20:54
D01-H12	14-May-13	02:52	02:54
D01-H18	14-May-13	09:00	09:02
D01-H24	14-May-13	13:20	13:22
D02-H06	14-May-13	21:35	21:37
D02-H12	15-May-13	03:52	03:54
D02-H18	15-May-13	09:56	09:58
D02-H24	15-May-13	15:29	15:31
D03-H00	16-May-13	00:32	00:34
D03-H08	16-May-13	08:51	08:53
D03-H16	16-May-13	15:53	15:55
D04-H00	17-May-13	00:34	00:36
D04-H08	17-May-13	08:44	08:46
D04-H16	17-May-13	15:52	15:54
D05-H00	18-May-13	00:37	00:39
D05-H08	18-May-13	08:50	08:52
D05-H16	18-May-13	16:24	16:26
D06-H00	19-May-13	00:35	00:37
D06-H08	19-May-13	08:47	08:49
D06-H21	19-May-13	21:36	21:38
D07-H09	20-May-13	09:05	09:07
D07-H21	20-May-13	21:32	21:34
D08-H09	21-May-13	09:12	09:14
D08-H21	21-May-13	21:52	21:54
D09-H08	22-May-13	08:36	08:38

[1] All samples are identified by their end time

3.3 Process Data

Conditions during the sampling were monitored by RWDI personnel. The temperature of the air inside the flux chamber, fresh water temperature, ambient temperature, nitrogen flow rate into the flux chamber, and the pressure inside the flux chamber were all monitored at the time of sampling. Temperatures were measured with a chromel-alumel type-k thermocouple in conjunction with a digital temperature indicator. The flow rate of nitrogen was monitored using a positive displacement gas flow calibrator. Pressure within the flux chamber was monitored using a magnehelic gauge ranging from 0 to 0.5 in. w.g.

3.4 Quality Assurance/Quality control Activities

Applicable quality assurance measures were implemented during the sampling program to ensure the integrity of the results. These measures included detailed documentation of field data, equipment calibrations for all measured parameters, completion of Chain of Custody forms when submitting laboratory samples, and submission of field blank samples to the laboratory.

Leak checks were performed on the flux chamber by plugging exits to ensure that the pressure within the chamber would increase. This check was conducted before purging of the chamber during each test. Daily temperature sensor audits were completed by noting the ambient temperature, as measured by a mercury reference thermometer, and comparing these values to those obtained from the handheld sensor.

4. RESULTS

The average emission results for this study are presented in the 'Tables' section of this report. Table 1 presents a summary of test dates and times. Below is a summary of the applicable Tables (in Appendix D) and Figures(in Appendix E) numbers corresponding to each test parameter.

Parameter	Table	Figure
Light Hydrocarbons	D1	E1 to E6
Volatile Organic Compounds	D2	E7 to E17
Volatile Organic Hydrocarbons	D3	E18 to E23-
Total Reduced Sulphurs	D4	Not Plotted
Total Hydrocarbons (Detected)	D5	E24
Total Volatile Organic Hydrocarbons (Detected)	D6	E25

All sampling field notes are provided in Appendix B. In the same appendix, the diluted gas concentrations for several gases (i.e., H_2S, O_2, CO, total VOC's and benzene) and LEL (expressed as methane) are provided. All laboratory analytical results are included in Appendix C.

4.1 Discussion of Results

All reported concentrations and emission rates were corrected to reference conditions of 25ºC, and 101.3 kPa. When the laboratory reported values were less than their method detection limit for a specific component, the respective concentration and emission rates were calculated using this method detection limit. This method is a conservative approach when calculating the emission rates.

All compounds that were analyzed are listed in the 'Tables' section; however, figures are only presented for those compounds that had a representative number of samples above the method detection limit so that a decay curve could be plotted. No figures for total reduced sulphur compounds were created as these compounds volatilized quickly; a greater than 95% decrease to emission rate was observed in the first six hours (i.e., the first sampling interval).

For some canisters, the reduced sulphur compounds were analyzed after the maximum three day holding time; where sulphur compounds are considered to be stable. Samples that were analyzed within the three day holding time were re-analyzed several days later to try and calculate a decay trend for the different sulphur compounds. The objective was to apply this decay trend to those samples that were analyzed beyond the three day holding period. Due to the speed at which sulphur compounds volatilized, which was less than six hours to decrease below the detection limit, the application of an adjustment for the decay trend was not required.

To calculate the Total Hydrocarbons (Detected), or THC and the Total Volatile Organic Hydrocarbons (Detected), or TVOC; the sum, of all detectable compounds was taken and reported as methane equivalent (CH_4) for THC and ethyl benzene for TVOC. In order to determine the contribution of aliphatic compounds for THC and aromatic compounds for THC and TVOC, an average molecular mass was taken for the grouped compounds. As an example, to determine the molecular mass of aromatics in the grouping of eight to 10 carbon containing species, the molecular mass of ethyl benzene (106 g/mol) and cyclodecane (140 g/mol) were averaged to give the group of aromatics a molecular mass (123 g/mol). This averaging approach is expected to create minor errors in each group. Specifically, for the aromatics between eight and 10 carbons, the error is < 0.01% for the overall THC (expressed as methane) calculation.

Table 2 shows the time duration for specific compound groups, on average for those compounds that were measured, reached an 80%, 90%, and 95% decrease relative to the initial measured emission rate. For example, if the initial flux emission rate was 100 µg/s/m³, then an 80% decrease would be when the emission rate dropped below 20 µg/s/m³.

Table 2: Time Duration to Achieve Average Emission Rate Losses by Compound Group

Chemical Group	Time to Achieve Emission Rate Reduction by		
	> 80%	> 90%	> 95%
Light Hydrocarbons	6 h	12 h	175 h
Volatile Organic Compounds	12 h	66 h	82 h
Volatile Organic Hydrocarbons	12 h	82 h	175 h
Total Reduced Sulphurs	< 6 h	< 6 h	< 6 h
Total Hydrocarbons (Detected)	< 6 h	6 h	30 h
Total Volatile Organic Hydrocarbons (Detected)	12 h	30 h	37 h

5. CONCLUSIONS

A flux chamber sampling program was completed over the period, May 13 to 22, 2013 at the KMC Gainford, AB facility. This survey was used to directly measure flux rates from a spill of dilbit on fresh water to atmosphere for several chemicals and chemical groups. The results will be of interest for dispersion modeling of emissions related to an accidental spill as part of the hazard assessments for watercourse and marine releases. For all chemical groups and relative to the initial spill, the emission rates declined by 80% after 12 hours and by 90% after 3.4 days.