MOTIVA
ENTERPRISES LLC

October 22, 2010

Federal Express Tracking Number: 7940 3916 5470

Ms. Nancy Marker
State of Delaware
Department of Natural Resources & Environmental Control
Solid & Hazardous Waste Management Branch
89 Kings Highway
Dover, DE 19901

Re: Addendum to the Revised Baseline Ecological Risk Assessment
Delaware City Refinery

Dear Ms. Marker:

Please find enclosed two (2) paper copies and one (1) electronic version of the Addendum to the Revised Baseline Ecological Risk Assessment. The BERA Addendum presents an ecological risk evaluation of the remaining on-site surface water feature, the Cooling Water Influent Channel.

If you have any questions or need additional information, please call Mr. Stephen Zahniser of URS at (215) 367-2649 or me at (410) 392-0533.

Sincerely,

Glenn Hardcastle
Motiva Enterprises LLC

Attachments

cc: Barbara Smith, USEPA (w/o enclosure)
Glenn Hardcastle, Motiva Enterprises
Aaron Vahid, PBF Energy
Chad Smith, MWH
Steve Nichols, Valero
Rob Balcells, URS

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ADDENDUM

BASELINE ECOLOGICAL RISK ASSESSMENT

DELAWARE CITY REFINERY
DELAWARE CITY, DELAWARE

Prepared for

Motiva Enterprises LLC

October 2010

URS

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ADDENDUM

BASELINE ECOLOGICAL RISK ASSESSMENT

DELAWARE CITY REFINERY
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Prepared for

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October 2010

URS

URS Corporation
335 Commerce Drive
Suite 300
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215.367.2500

19998564.00000

URS

October 25, 2010

Ms. Nancy Marker:

Please find enclosed the Transmittal Letter for the Addendum to the Revised Baseline Ecological Risk Assessment, a revised Cover Sheet, and a CD of the report including the revised cover sheet.

Please replace the current cover sheet with the enclosed sheet as the original does not include the word Addendum. I apologize for any inconvenience this caused.

Regards,

Stephen J Zahniser

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Glossary of Acronyms

BERA	Baseline Ecological Risk Assessment
BTAG	Biological Technical Assistance Group
CSM	conceptual site model
COPC	constituent of potential concern
CWEC	Cooling Water Effluent Channel
CWIC	Cooling Water Influent Channel
DNREC	Department of Natural Resources and Environmental Control
DURBRS	Delaware Uniform Risk-Based Remediation Standard
MTBE	methyl tert-butyl ether
RCRA	Resource Conservation and Recovery Act
SERA	Screening Ecological Risk Assessment
SQuiRT	Screening Quick Reference Tables
SWMU	Solid Waste Management Unit
TAME	tert-amyl methyl ether
µg/L	micrograms per liter
USEPA	United States Environmental Protection Agency
VOC	volatile organic compound

Executive Summary

URS Corporation, on behalf of Motiva Enterprises LLC, has prepared this Addendum to the *Revised Baseline Ecological Risk Assessment* Report (BERA, URS, 2009) for the Delaware City Refinery (Facility), located in Delaware City, Delaware. The *Tier I Screening Ecological Risk Assessment* Report (SERA, URS, 2000) addressed potential ecological risk associated with on-site Solid Waste Management Units (SWMUs). Six SWMUs were not screened from further ecological evaluation in the SERA and were addressed by the BERA. These included:

- SWMU 20B1 & 20B2 (Stormwater Channel and Guard Basin 4);
- SWMU 21 (Guard Basins Nos. 5 & 6 and Effluent Channel);
- SWMU 24A (Dredge Material Storage Area 1);
- SWMU 24B (Dredge Material Storage Area 2);
- SWMU 26 (Tetraethyl Lead Pit); and
- SWMU 33 (Piers).

Potential ecological risks associated with Dragon Run (south of the refinery operating area, but adjacent to Facility property) were addressed in a prior report (*Interim Report, Dissolved Phase Plume Delineation - Phase II*, URS, 2008). The potential for off-site migration of operations-related constituents northward was presented in the September 2010 *Phase II RCRA Facility Investigation – Groundwater* (URS, 2010). Potential ecological risks associated with the Cooling Water Effluent Channel (CWEC) were addressed in the BERA, as part of SWMU 21 (URS, 2009). This addendum to the BERA presents an ecological risk evaluation of the remaining on-site surface water feature, the Cooling Water Influent Channel (CWIC).

Together these reports complete the ecological evaluation of potentially affected areas under Corrective Action Permit HW09A13. This BERA Addendum was performed to fulfill, in part, the requirements of the Delaware Department of Natural Resources and Environmental Control (DNREC) remediation standards and was completed in accordance with DNREC's *Remediation Standards Guidance under the Delaware Hazardous Substance Cleanup Act* (DNREC, 1999).

The objectives of the ecological risk evaluation for the CWIC are: 1) to evaluate whether groundwater concentrations of operations-related constituents pose a threat to the environment in the CWIC under site-specific exposure conditions, and 2) to support decisions concerning the need for further ecological evaluation or action based upon current analytical site data.

Based on current and potential future uses of the Facility and the vicinity and hydrogeology of the site, the following receptors were considered:

- Benthic invertebrate community;
- Fish community;
- Semi-aquatic birds; and
- Semi-aquatic mammals.

This risk evaluation was performed in accordance with the requirements and technical guidance of the DNREC *Hazardous Substance Cleanup Act Guidance Manual* (1994) and *Remediation Standards Guidance under the Delaware Hazardous Substance Cleanup Act* (1999). In addition, technical guidance related to risk assessment from the United States Environmental Protection Agency (USEPA) was applied, as appropriate.

Approach

The approach to investigate potential risk to the environment included focused evaluations of current site conditions and screening assessments of constituent concentrations in groundwater in on-site wells in proximity to the CWIC. This is an extremely conservative screening approach because it does not take into account attenuation as chemicals migrate in groundwater, it does not take into account the mixing of the groundwater as it enters the waterbody, and it does not take into account the active attenuation and degradation processes that occur in the biologically active zone in the top several inches of soil/sediment beneath the soil/water interface. In this zone, chemicals in groundwater are exposed to aggressive and biologically active media, which can provide significant additional degradation to that which occurs in the lower groundwater zones, due to the abundance of oxygen, nutrients, sulfates, microorganisms, and other related factors. Consequently, using groundwater concentrations to conservatively represent potential surface water concentrations greatly overstates potential risks. Further, use of groundwater concentrations to evaluate potential ecological risk in the CWIC is inherently conservative, because the CWIC is an engineered structure that is part of the Facility's water management system, and typically draws in hundreds of millions of gallons of water per day during operations.

Results

Recent and historical constituent concentrations in groundwater from monitoring wells near the CWIC were compared to ecological surface water screening benchmarks. Six operations-related constituents of potential concern (COPCs)[1] were identified for evaluation in this report. The identification of COPCs serves to focus the risk characterization to those chemicals that could potentially affect ecological receptors. Chemicals eliminated by the initial, conservative screening do not pose a risk to ecological receptors.

[1] Chemicals potentially associated with operations whose concentrations exceed conservative, screening-level benchmarks.

A weight-of-evidence approach was then used to characterize risk. This evaluation indicated that the aquatic and semi-aquatic ecological receptors potentially using the channel are not affected by the COPCs. This conclusion is based upon the low number of detections and exceedances of the COPCs, especially in samples collected from the well nearest to the CWIC. Concentrations in this well (D33) in 2009 and 2010 have been either below laboratory detection limits or at very low levels.

Additionally, the large volume of water that is drawn into the CWIC as part of the once-through cooling process under operational conditions significantly dilutes potential groundwater contribution to the channel. Even under conditions when the refinery is not operating, the potential groundwater contribution to the CWIC is minor compared to the volume of surface water in the channel.

Conclusions

The results of the ecological risk assessment performed for the CWIC indicate that, based upon the COPC concentrations in the groundwater, there are no significant ecological risks to potential receptors. Furthermore, as demonstrated in the *Phase II RCRA Facility Investigation – Groundwater* report (URS, 2010), COPC concentrations in groundwater are generally stable or declining, resulting in an additional decrease in potential ecological risks over time.

No additional ecological risk assessments are recommended for the Facility at this time.

1.0 Introduction

URS Corporation, on behalf of Motiva Enterprises LLC, has prepared this Addendum to the *Revised Baseline Ecological Risk Assessment* Report (BERA, URS, 2009) for the Delaware City Refinery, Delaware City, Delaware. The BERA was submitted to the Delaware Department of Natural Resources and Environmental Control (DNREC) on September 2, 2009. The *Tier I Screening Ecological Risk Assessment* Report (SERA, URS, 2000) addressed potential ecological risk associated with on-site Solid Waste Management Units (SWMUs). Six SWMUs were not screened from further ecological evaluation in SERA, and were addressed by the BERA. These included:

- SWMU 20B1 & 20B2 (Stormwater Channel and Guard Basin 4);
- SWMU 21 (Guard Basins Nos. 5 & 6 and Effluent Channel);
- SWMU 24A (Dredge Material Storage Area 1);
- SWMU 24B (Dredge Material Storage Area 2);
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- SWMU 33 (Piers).

Ecological risks associated with Dragon Run (south of the refinery operating area, but adjacent to Facility property) were addressed in a prior report (*Interim Report, Dissolved Phase Plume Delineation - Phase II*, URS, 2008). The potential for off-site migration of operations-related constituents northward was presented in the September 2010 *Phase II RCRA Facility Investigation – Groundwater* (URS, 2010). Potential ecological risks associated with the Cooling Water Effluent Channel (CWEC) were addressed in the BERA, as part of SWMU 21 (URS, 2009). This addendum to the BERA presents an ecological risk evaluation of the remaining on-site surface water feature, the Cooling Water Influent Channel (CWIC).

Together these reports complete the ecological evaluation of potentially affected areas under Corrective Action Permit HW09A13. This BERA Addendum was performed to fulfill, in part, the requirements of the Delaware DNREC remediation standards and was completed in accordance with DNREC's *Remediation Standards Guidance under the Delaware Hazardous Substance Cleanup Act* (DNREC, 1999).

1.1 Background

The Facility includes a 5,050-acre tract of land approximately one mile northwest of Delaware City, Delaware (**Figure 1**). The main operating areas (areas within the property, which are actively in use and include the SWMUs) occupy approximately 1,000 of the 5,050 acres of the

Facility property and historically produced mainly gasoline and heating oil. Several existing and former industrial and light industrial facilities are located north and west of the operating areas, including the Metachem (Superfund) site and the Occidental Chemical Corporation facility to the north, and AKZO, Formosa Plastics, and INEOS Films facilities to the west (**Figure 2**).

Environmental investigations and remediation activities have been ongoing at the Facility since 1983. Since 1988, this work has been performed under the modified Resource Conservation and Recovery Act (RCRA) Corrective Action Permit No. DED 00 202 9738, which was issued by the USEPA to Texaco Refining and Marketing, Inc., the owner of the Facility at that time. Corrective Action Permit DED 00 202 9738 expired in December 1998 and was superseded by Corrective Action Permit HW09A13, which was issued on September 30, 2003 by DNREC. Prior to that time, DNREC had been authorized by the USEPA to be the lead agency overseeing the work. Previous submissions to USEPA and DNREC include the *Background Information Survey Report* (Dames & Moore, 1991a), the *Identification of the Potential for an Occurring or Past Release Study Report* (Dames & Moore, 1991b), and the *Verification of Release Study Report* (Dames & Moore, 1995).

In September 2003, DNREC reissued the site-wide corrective action permit, which included a requirement to conduct interim measures that address SWMUs 20B1 & 20B2 (Guard Basin 4), and the Oily Sediment Area in SWMU 24B. In view of the interim measures, USEPA and DNREC agreed that no further ecological risk assessment would be necessary for these areas provided the interim measures are sufficiently comprehensive.

In 2003, USEPA approved the BERA Work Plan and Ecological Phase II Sampling Plan to fill data gaps needed to perform the BERA, and the majority of the field work was performed in Fall 2003.

In January 2005, USEPA approved an outline for the BERA Report and authorized continuation of the risk assessment process. The BERA was performed in accordance with the USEPA eight-step process outlined in *Ecological Risk Assessment Guidance for Superfund* (USEPA, 1997). The first two steps of this process comprise the *Tier I Screening Ecological Risk Assessment* Report (SERA, URS, 2000).

Pursuant to recommendations made by USEPA following review of the SERA, a work plan was prepared and approved to perform additional media sampling and analysis for six SWMUs in order to further characterize the nature and extent of contamination. Sample collection and analysis were performed consistent with the Data Quality Objectives process and Steps 3 – 6 of the USEPA guidance document. Analytical results provided by this additional sampling were

combined with ecological information obtained during the SERA in order to evaluate the potential risk to on-site ecological receptors.

The BERA involved completion of Steps 3 – 8 of the USEPA risk assessment process and the results were reported in the July 2005 Draft BERA Report. DNREC and USEPA provided comments on the Draft BERA in February 2008. These comments were addressed by Motiva in a June 24, 2008 letter. DNREC and USEPA approved the comment resolution in a letter dated August 5, 2008, which also requested that the BERA be finalized accordingly. The agency comments were incorporated into the *Revised Baseline Ecological Risk Assessment* Report (URS, 2009), submitted in September 2009.

The final Phase I RCRA Facility Investigation (RFI) Report was approved by DNREC on May 19, 2005. The recently-completed Phase II RCRA Facility Investigation addressed data gaps identified during the Phase I RFI and completed assessment of groundwater conditions. The results of the groundwater investigations were submitted in the *Phase II RCRA Facility Investigation – Groundwater* Report (URS, 2010).

URS Corporation has prepared this BERA Addendum to assess the potential risks to ecological receptors in the CWIC that may come in contact, either directly or indirectly, with media impacted by operations-related constituents.

1.2 Objectives and Approach

The objectives of this ecological risk evaluation are as follows:

- To evaluate whether groundwater concentrations of operations-related constituents pose a threat to the environment in the CWIC under site-specific exposure conditions; and
- To support decisions concerning the need for further evaluation or action based upon current analytical site data.

Pathways that are incomplete (i.e., no potential for exposure of a receptor to an operations-related constituent) do not contribute to ecological risks and thus are not assessed for potential impacts in this BERA Addendum.

1.3 Report Organization

The risk evaluation is designed to: 1) characterize the CWIC from an exposure/risk perspective and 2) conservatively estimate threats to potentially exposed aquatic and semi-aquatic biota.

The ecological risk evaluation for the CWIC includes a characterization of the physical and ecological features of the channel, and analytical results from groundwater sampling events to provide supporting data for evaluating risk. Constituents of potential concern (COPCs) were identified for the groundwater-to-surface water pathway in order to determine the potential impact on the CWIC. Specific goals of the risk evaluation include the following:

- Characterize the aquatic ecological habitats and communities in the CWIC;
- Determine if concentrations of COPCs in Facility groundwater potentially pose a risk to ecological receptors in the CWIC; and
- Identify uncertainties and/or data gaps in the assessment of risk for the CWIC.

An ecological conceptual site model (CSM) for the CWIC is presented in Section 2, Conceptual Site Model. The CSM describes the potential linkages between ecological receptors in the channel and operations-related chemical stressors in groundwater. Use of the groundwater data and identification of the COPCs are discussed in Section 3, Data Analysis. Determination of potentially complete ecological pathways is described in Section 4, Exposure Assessment. Section 5, Risk Characterization discusses COPC concentrations in groundwater and evaluates associated risk in terms of potentially complete ecological pathways. Conclusions resulting from this assessment are presented in Section 6, Summary and Conclusions.

2.0 Conceptual Site Model

The CSM identifies potential sources of constituents, types of constituents, affected media, current and potential future receptors, and potential exposure pathways (**Figure 3**). The CSM is used as the foundation on which risk assessment exposure and risk assessments are based.

Current and probable future land use plays a significant role in the development of the CSM. The Facility is an industrial site and is assumed to remain industrial in perpetuity. Although the refinery is not currently operating, PBF Energy Company, the current owner, has indicated that the Facility will be operational as a refinery again in 2011. Accordingly, future land use assumes that the CWIC will remain to support future operations at the Facility. East of the Facility is the Delaware River, which supplies water to the CWIC. The CWIC is essential to facility operations, providing a conduit for the non-contact cooling water supply, and when in operation, approximately 400 million gallons of water per day are typically continuously withdrawn from the Delaware River through the CWIC. The CWIC may receive groundwater from the Facility; however, the available data suggest that dissolved phase constituents are at low or undetectable concentrations at the well closest to the CWIC. Additionally, the proportion of groundwater influx, if any, would be minimal compared to the significant inflow from the Delaware River.

The portion of the Delaware River in the vicinity of the Facility supports a variety of resident fish and invertebrate species, and is a migration route for anadromous fishes such as American shad (*Alosa sapidissima*), blueback herring (*A. aestivalis*), and striped bass (*Morone saxatilis*).

2.1 Groundwater Migration Pathways

Groundwater on the west side of the Facility generally flows to the east before intersecting a north/south trending paleochannel. The geometry of the paleochannel, and its higher transmissivity as compared to surrounding areas, dominates local groundwater flow (URS, 2010). Once groundwater enters the paleochannel, the majority of the water volume moves in either a northerly or a southerly direction, depending on where it enters the channel. The majority of the Columbia Formation groundwater flowing beneath the eastern portion of the Facility flows to the south with a smaller component flowing to the north. The divide between northerly and southerly groundwater flow within the paleochannel appears to occur beneath the northern portion of the Bulk Storage Tank Farm. However, results of the groundwater investigations performed as part of the Phase II RFI indicate that the impact to groundwater from Facility operations is contained within the Facility property (URS, 2010). Additionally, concentrations are largely stable or declining, which indicates that the plumes are not migrating off-site (URS, 2010).

The closest surface waterbodies that could potentially receive groundwater underlying the operations area are Dragon Run approximately 3,600 feet to the south of the operations area and the Delaware River to the northeast.

Red Lion Creek, north of the Facility (Figure 2), was not retained for evaluation of potential groundwater impacts, given that this is an incomplete pathway. The majority of Columbia Formation groundwater flowing beneath the eastern portion of the Facility flows to the south; only a small component flows to the north. COPC concentrations in site plumes are largely stable or declining and wells along the northern property boundary are either not impacted (i.e., no detected concentrations) or contain COPCs below regulatory limits (URS, 2010). Further, groundwater flowing northward would have to travel beneath the Metachem Superfund site and Occidental Chemical before approaching Red Lion Creek. Therefore, there is no potential for groundwater discharge of operations-related constituents to surface water features to the north.

Potential ecological risks associated with operations-related constituents in groundwater migrating southward toward Dragon Run were addressed in *Interim Report, Dissolved Phase Plume Delineation - Phase II* (URS, 2008), which was approved by DNREC in a letter dated October 3, 2008. Surface water and sediment samples collected from Dragon Run in 2005-2007 were analyzed for key operations-related constituents. Based on the 2005, 2006, and 2007 analytical data collected from Dragon Run, neither surface water nor sediments contained sufficient concentrations of methyl tert-butyl ether (MTBE), tert-amyl methyl ether (TAME), benzene, toluene, ethylbenzene, or xylenes to pose a threat to ecological resources. The analytical results of the 2007 surface water program were similar to results from the 2005 and 2006 sampling events, and revealed only low levels of MTBE, TAME, benzene, and toluene. None of the reported constituent concentrations in the surface water samples collected in 2005, 2006, and 2007 exceeded the USEPA Region 5 Environmental Screening Limits, or the USEPA EcoSAR limits. Based on these DNREC-accepted results, no further evaluation of ecological risks was warranted for Dragon Run.

Overall, groundwater flow in the water table aquifer appears to be limited along the eastern boundary of the Facility (east of the paleochannel) by the presence of the lower permeability Cretaceous sediments, Quaternary silts and clays, and the apparent absence of the more permeable Columbia Formation sediments. Furthermore, the Guard Basins create a local zone of perched water, resulting in radial flow away from these features. This, in turn, further inhibits eastward groundwater flow in this area. Migration of groundwater from the operations area of the Facility to locations east of the paleochannel and to the Delaware River is likely limited. However, a connection potentially exists between the CWIC and the CWEC to the Delaware

River. Potential ecological risks associated with the CWEC were addressed in the BERA, as part of SWMU 21 (URS, 2009). An evaluation of potential ecological impacts from the Facility groundwater on the CWIC is incorporated into this BERA Addendum.

Given the land use assumptions and hydrogeology described above, the following receptors were evaluated:

- Benthic invertebrate community;
- Fish community;
- Semi-aquatic birds; and
- Semi-aquatic mammals.

A description of the CWIC and associated receptors are provided in the following sections. The CSM developed for the channel describes the potential linkages between chemical stressors in groundwater underlying the Facility and the receptors selected for evaluation. The ecological CSM is presented in **Figure 3**.

2.2 Surface Water Features

The CWIC is a 10-acre man-made tidal channel that receives water from the Delaware River. Through large pumps and controls located at the on-site wastewater treatment plant, the river water is conveyed from the CWIC to the Facility process units for non-contact cooling of equipment. The narrow banks of the CWIC are dominated by the invasive common reed (*Phragmites australis*); thus, channel banks provide poor foraging and shelter habitat for wildlife. Wildlife (primarily piscivorous birds) have been observed in the CWIC during reconnaissance-level surveys of the Facility surface water features. No herptiles or mammals have been observed in the CWIC during the aforementioned surveys. Direct contact with surface water, ingestion of surface water, and food chain ingestion by semi-aquatic birds and mammals represent potential ecological exposure pathways for the CWIC.

2.3 Receptors

Descriptions of the aquatic and semi-aquatic receptors that potentially inhabit and/or forage in the CWIC are provided below.

2.3.1 Benthic Macroinvertebrates

Although no known community data are available for the CWIC, benthic macroinvertebrates are likely present in this waterbody. Macroinvertebrates living within or on sediments are in direct

contact with surface water, and are a typical food source for wildlife of other trophic levels such as wading birds, amphibians, and small fish.

2.3.2 Fish

Fish communities present in the CWIC could potentially be exposed to operations-related constituents in groundwater, if present, through: 1) direct contact exposure to potentially impacted surface water, and 2) ingestion of prey (e.g., invertebrates) that have bioaccumulated operations-related constituents, if present, from discharging groundwater. Where present, fish provide a food resource to piscivorous wildlife (i.e., birds and mammals) that may visit these surface water features during foraging events.

2.3.3 Semi-aquatic Birds

Semi-aquatic avian groups such as dabbling waterfowl (e.g., ducks) and wading birds (e.g., herons, egrets) may utilize portions of the CWIC. The primary exposure pathway for semi-aquatic birds is food chain exposure (consumption of benthic invertebrates and/or fish); direct ingestion of surface water typically contributes only a very small portion of the overall exposure to this receptor group, and thus was considered a minor exposure pathway. Additionally, inhalation and dermal absorption are not considered significant pathways for ecological exposure because they typically have a negligible contribution to the overall exposure for wildlife receptors (Sample et al., 1997; USEPA, 2005).

2.3.4 Semi-aquatic Mammals

Semi-aquatic mammals that may utilize the CWIC include the raccoon (*Procyon lotor*), an omnivorous species common in both terrestrial and aquatic habitats, and the muskrat (*Ondatra zibethicus*), an herbivore that constructs dens in wetlands or in stream or river banks. Consumption of prey containing operations-related COPCs is the primary potential route of exposure for the semi-aquatic mammal guild.

3.0 Data Analysis

3.1 Groundwater Data Summary

Groundwater monitoring at the Facility has been performed quarterly for a subset of wells and yearly site-wide in addition to other permit-related monitoring. The most recent, validated, complete groundwater data collected during quarterly or annual sampling events (i.e., up through February 2010) were used in this risk assessment, when available, for consistency with the *Phase II RCRA Facility Investigation – Groundwater* report (URS, 2010). If a well was not sampled during the February 2010 sampling event, the latest complete dataset from that well collected during a quarterly or annual sampling event was used. The use of the most recent round of groundwater data is appropriate based on an evaluation of the plume-wide concentration trends, which appear to be generally stable or declining. Although concentrations of constituents in individual wells may vary, the concentrations in the plumes overall have remained relatively stable over the past two to three years of available data. Therefore, conclusions drawn from this risk assessment will remain valid as long as there are no changes in observed concentration trends. The data used in the risk assessment, including sample collection dates, are provided in **Appendix A**.

Groundwater data used to assess the potential for ecological impacts to the CWIC were taken from the wells positioned closest to the channel (**Figure 4**). Wells F1 through F7, D12, 24b-MW-15, and D33 were considered as representative of the local groundwater plume in the vicinity of the CWIC. Well D33 is directly adjacent to the CWIC. For two wells, Wells 24b-MW15 and D33, data were available from the February 2010 sampling event. However, for Wells F7 and D12, August 2009 data were used because these were the most recent data for those wells. Additionally, August 2008 data were used for Wells F1 through F6 in order to assess risk from metals. Therefore, not all constituents were analyzed in samples from every well during each sampling event.

During these sampling events, groundwater was analyzed for dissolved and total metals and organic compounds. As documented in the *Interim Report, Dissolved Phase Plume Delineation – Phase II* (URS, 2008), not all of the constituents originate from the Facility. Chlorinated volatile organic compounds are from up-gradient, offsite sources, and thus are not quantitatively evaluated further in this risk assessment.

Due to the absence of analytical surface water data for the channel, chemical concentrations in groundwater were used to screen against chronic ecological surface water benchmarks, without accounting for attenuation or mixing, resulting in a highly conservative assessment of potential

risk. Under normal refinery operations, when approximately 400 million gallons of water per day are being continuously withdrawn from the CWIC, groundwater potentially migrating into the CWIC would be thoroughly mixed with surface water and drawn into the refinery; therefore, surface water in the Delaware River itself would likely not be affected by potential groundwater discharge to the CWIC.

3.2 Identification of COPCs

For the ecological surface water screening evaluation, analytes were identified as COPCs if the maximum groundwater concentration exceeded the respective ecological surface water screening benchmark. Comparisons of groundwater concentrations to surface water benchmarks represent a highly conservative assessment of potential risk given that neither attenuation as the COPCs migrate in groundwater, nor mixing in the receiving surface water feature, are considered. Consequently, an individual groundwater well exceedance of an ecological surface water benchmark does not imply that adverse effects will occur in the waterbody since the benchmarks are applicable to the surface water medium (not groundwater), are highly conservative, and are purposefully set at low levels to minimize the risk of failing to identify a COPC. The screening benchmarks/criteria do not consider site-specific bioavailability or receptor sensitivity and are not intended to quantify actual risk. However, exceedance of a benchmark or criterion is an indicator that the concentration of a COPC observed in the environment is at a level that warrants additional evaluation.

In order to identify ecological surface water COPCs, a data screening analysis was performed using the following surface water screening benchmarks:

- DNREC uniform-risk based standard (URS) for the Protection of the Environment (DNREC, 1999);
- USEPA Region III Biological Technical Assistance Group (BTAG) Surface Water Benchmarks[2] (USEPA, 2006a; 2006b); and
- National Oceanographic and Atmospheric Administration (NOAA) Screening Quick Reference Tables (SQuiRT) (Buchman, 2008).

The data collected from the wells near the CWIC indicate that 11 organic compounds, two dissolved metals, and five total metals were detected in at least one sample (**Table 1**). Of these, two metals, cadmium (total and dissolved) and iron (dissolved), exceeded their respective

[2] Given that the Delaware River near DCR is an estuarine system, USEPA Region III BTAG saltwater benchmarks were applied in the influent channel screening evaluation. If no saltwater screening value was available, the freshwater benchmark was applied (if available).

ecological surface water screening benchmarks. Four organic compounds also exceeded their respective ecological surface water screening benchmarks, including benzene, isopropylbenzene, dimethylbenzene (total xylenes), and naphthalene. These six constituents were identified as COPCs.

4.0 Exposure Assessment

An exposure pathway is the course a chemical takes from its source to the exposed receptor. In order for an exposure pathway to be complete, it must contain a source, a transport medium (e.g., soil, air), a point of contact (receptor), and an exposure route (e.g., ingestion, dermal, or inhalation). If any of these elements is missing, an exposure pathway is deemed incomplete and can be excluded from the quantitative evaluation of risk (USEPA, 1989).

For the CWIC ecological evaluation, benthic invertebrates, fish, semi-aquatic birds, and semi-aquatic mammals represent potential receptors exposed to channel surface water, into which groundwater underlying the Facility may infiltrate.

Constituents that may be present in the surface water or sediment may remain in those media, or be taken up by biota through ingestion or direct contact. Potential exposure media for this evaluation includes sediment, surface water, and aquatic prey. Based on the ecological CSM and data screening for the CWIC, the following potentially complete aquatic exposure pathways exist:

- Exposure to sediment and surface water; and
- Exposure to benthic and pelagic prey (benthic invertebrates, fish).

Potential ecological receptors may be exposed to COPCs through the following exposure routes:

- Direct contact with COPCs in sediment and/or surface water;
- Incidental ingestion of potentially impacted sediment; and
- Ingestion of potentially impacted aquatic biota.

5.0 Risk Characterization

The objective of the risk characterization is to determine potential risk to receptors based on the concentrations of operations-related constituents in groundwater, and receptor exposures to these constituents. In this BERA Addendum, risk characterization was based on a qualitative evaluation of each COPC using a weight-of-evidence approach. Eight lines of evidence were used, where appropriate:

1) The number of detected concentrations;

2) The number of concentrations exceeding the benchmark;

3) Whether the constituent was detected in the well closest to the CWIC (i.e., Well D33);

4) Whether the detected concentration in Well D33 (or reporting limit for a non-detect) exceeded the benchmark;

5) Magnitude of exceedances;

6) The appropriateness of the screening benchmark for ecological risk assessment;

7) Comparison of detected concentrations and/or reporting limits to other applicable ecological benchmarks; and

8) Site-specific geology and hydrogeology information.

If the weight-of-evidence suggests that COPCs do not negatively impact the CWIC, a complete pathway does not exist and therefore, there is no unacceptable risk and no additional ecological risk assessments are warranted.

The ecological risk evaluation presented herein compares shallow groundwater concentrations to ecological screening benchmarks for surface water, and then applies a weight-of-evidence assessment of the potential ecological risk. This is an extremely conservative approach because the use of groundwater concentrations does not take into account attenuation as chemicals migrate in groundwater, or mixing of groundwater as it enters the waterbody, or the active attenuation and degradation processes that occur in the biologically active zone in the top several inches of soil/sediment beneath the soil/water interface. In this zone, COPCs are exposed to aggressive, biologically active media which can provide significant, additional degradation to that which occurs in the lower groundwater zones due to an abundance of oxygen, nutrients,

sulfates, microorganisms, and other related factors. Further, use of groundwater concentrations to evaluate potential ecological risk in the CWIC is inherently conservative, because the CWIC is an engineered structure that is part of the Facility's water management system, and typically draws in hundreds of millions of gallons of water per day during operations.

5.1 Risks

Six compounds were identified as COPCs because maximum concentrations in groundwater samples collected in the vicinity of the CWIC exceeded ecological surface water screening benchmarks. Most maximum concentrations were detected in samples collected from Well F7, which is located approximately 1,000 feet up-gradient of the CWIC compared to the other wells. These six compounds, cadmium, iron, benzene, isopropylbenzene, dimethylbenzene (total xylenes), and naphthalene, are discussed below in relation to concentrations in other wells, location of these concentrations, background concentrations, and applicability of the surface water screening benchmarks that were used as surrogates for groundwater evaluation. These discussions are important to put the potential for risk to aquatic receptors in context. Note that the discussions for cadmium and iron are focused on the dissolved fractions, given that the dissolved phases of these metals represent the bioavailable fractions and are most relevant to assessing the potential for ecological risk.

Cadmium: Detected concentrations of dissolved cadmium (1.2 µg/L and 1.5 µg/L) marginally exceeded the DURBRS for the Protection of the Environment (1 µg/L) in two of six samples. The detected concentration of dissolved cadmium does not exceed the NOAA SQuirT chronic, marine benchmark of 8.8 µg/L (Buchman, 2008). The detected concentrations of dissolved cadmium in groundwater are only slightly higher than the conservative surface water benchmark, and residual cadmium concentrations that receptors could potentially be exposed to are likely greatly reduced due to natural attenuation and mixing in the CWIC. Therefore, risks due to cadmium are considered negligible.

Iron: The maximum dissolved iron concentration from wells near the CWIC exceeded the DNREC (1999) DURBRS for the Protection of the Environment. However, iron is a naturally-occurring metal not associated with historic refinery-related processes. In the Columbia Formation, Woodruff (1970), writing for the Delaware Geological Survey, found that iron is "moderately high," with average concentrations of dissolved iron equal to 110 µg/L. While the maximum concentration from the CWIC wells is greater than this value by two orders of magnitude, Marine and Rasmussen (1955) found that the distribution of iron in Delaware aquifers is sporadic and ranges widely. Marine and Rasmussen (1955) report that "Excessive iron in water from the Pleistocene sediments is one of the most serious water-quality problems in

Delaware," and Woodruff (1970) calls the "pattern of iron occurrence in Delaware's ground waters, particularly in the Columbia Formation," a "puzzling hydrologic problem." These studies indicate that although iron concentrations exceed the DURBRS, this constituent is a naturally-occurring element found in the Columbia Formation and not related to refinery operations. In addition to the naturally occurring dissolved iron, anaerobic biodegradation processes documented at the site have resulted in ferric iron reduction and a corresponding increase in ferrous (dissolved) iron concentrations in areas where the hydrocarbon plumes are present. The elevated levels of dissolved iron do not extend beyond the plume areas (URS, 2010).

Additionally, the DNREC (1999) DURBRS for the Protection of the Environment for iron of 1,000 µg/L is the USEPA EcoTox Threshold Benchmark Value (USEPA, 1996). This value was selected from the USEPA chronic ambient water quality criteria (AWQC) (USEPA, 1996). The reference for the USEPA AWQC is the USEPA (1976) "Red Book." According to USEPA (1976), the criterion was derived based on freshwater toxicity information because marine species were not adequately investigated. The area of the Delaware River near the Facility is estuarine and therefore, freshwater benchmarks may not be appropriate.

Because iron is dissolved from the soils and sediments in this area of Delaware and groundwater concentrations are usually greater than surface water concentrations (Rasmussen et al., 1957), the exceedance of the freshwater-based DURBRS for iron does not indicate that risks are posed to aquatic receptors in the CWIC or the Delaware River.

Benzene: Two of the 10 groundwater samples analyzed for benzene had concentrations exceeding the surface water screening benchmark of 1 µg/L. These samples were collected from Well F7 and Well 24b-MW15. DNREC (1999) states that the DURBRS for the Protection of the Environment for benzene, 1 µg/L, was derived from the USEPA National Recommended Water Quality Criteria, December 1998 (see Federal Register Vol. 63, No. 237). The only values provided for benzene in the 1998 version or the current National Recommended Water Quality Criteria (USEPA, 2009) are for the protection of human health, which are not appropriate for use in ecological screening. Other ecological screening benchmarks, which are more appropriate for protection of aquatic receptors, include the USEPA (2006b) Region 3 BTAG Marine Screening Value and the NOAA SQuiRT chronic, marine value, both of which are 100 µg/L.

The only detected concentration or reporting limit that significantly exceeds this more appropriate benchmark is the maximum concentration, found in a sample collected from Well F7, located approximately 1,000 feet upgradient of the CWIC (the benzene concentration in Well

24b-MW15 was 101 µg/L). Well F7 is one of the furthest up-gradient of those evaluated. Well D33 is located adjacent to the CWIC and is likely most representative of the groundwater potentially discharging to the channel. Benzene sampled from this well was detected at a laboratory-estimated ("J"-qualified) concentration of 0.59 µg/L, which is below both the DNREC (1999) DURBRS and the other ecological screening benchmarks. Seven of the 10 wells evaluated had benzene concentrations < 1 µg/L. Therefore, concentrations of benzene in groundwater near the CWIC are highly unlikely to pose a threat to receptors in the CWIC due to the low concentrations near the channel. Additionally, if groundwater were to discharge to the channel, benzene concentrations would be subject to considerable mixing in the CWIC.

Isopropylbenzene (cumene): Isopropylbenzene was detected in one of the two samples it was analyzed for at a concentration above the screening benchmark (13.4 µg/L from Well F7, located approximately 1,000 feet upgradient of the CWIC). The reporting limit of the other analyzed sample (1 µg/L) is below the surface water benchmark of 2.6 µg/L. The second sample was collected from Well D12, which is located in close proximity to Well F7, again suggesting that the groundwater impact is highly localized. Natural attenuation as the groundwater migrates towards the channel, along with mixing in the surface water, suggests that concentrations of isopropylbenzene in groundwater near the CWIC are not likely to pose a threat to aquatic receptors that may be in the CWIC.

Dimethylbenzene (total xylenes): This constituent was detected in groundwater from Well F7, located approximately 1,000 feet upgradient of the CWIC, at a concentration (33.1 µg/L) exceeding the surface water benchmark (2 µg/L). The other seven samples for which dimethylbenzene data are available were non-detect at either 3 µg/L (six wells) or at 4 µg/L (one well). These reporting limits are slightly greater than the surface water benchmark; therefore, some uncertainty exists regarding this constituent in groundwater at these wells. However, the generally low reporting limits at nearby and downgradient wells, along with the distance to the channel and the significant mixing in the CWIC, suggest that dimethylbenzene in groundwater near the CWIC is unlikely to pose a risk to aquatic receptors in the channel.

Naphthalene: Naphthalene was detected in groundwater samples at concentrations exceeding surface water benchmarks in two of four well samples. The constituent was not detected (at 4 µg/L) in a sample collected from Well D12, which is located in close proximity to Well F7, where the maximum concentration was detected (54.4 µg/L), suggesting that groundwater impacts are highly localized. Additionally, naphthalene was detected at the estimated concentration of 1.45 µg/L in a sample from Well D33, which is below the screening benchmark of 12 µg/L. Since Well D33 is located adjacent to the CWIC, it is likely most representative of

the groundwater that could discharge to the channel. The low detections in this well adjacent to the CWIC, in addition to the localized nature of the contamination and the mixing capacity of the channel, indicates that naphthalene concentrations in groundwater are unlikely to pose a risk to receptors in the CWIC.

5.2 Risk Evaluation Summary

Based on these results, no adverse effects are posed to ecological receptors in the CWIC from groundwater infiltration. The ecological community in the CWIC is limited due to the structure and function of the channel. The intake channel is a cooling water structure that has narrow banks dominated by invasive species. When operational, surface water is continually drawn into the Facility, which likely limits fish populations within the channel. Additionally, the engineered nature of the CWIC structure does not support conditions necessary for establishment of a high quality community of aquatic organisms.

5.3 Uncertainty

Assumptions and other factors that influence the findings of the risk assessment are addressed below as a discussion of uncertainties in the evaluation of ecological risks.

- **Site data sets:** The collection of groundwater data over many years at the Facility provides widespread sample coverage, creating data sets sufficient for use in both risk assessment and remedial decision making. Groundwater data from perimeter monitoring wells therefore provide sufficient information for determining if further study is necessary to address ecological exposures in the surface water features that potentially receive site groundwater.
- **Absence of Screening Benchmarks:** Surface water screening benchmarks, used as a conservative surrogate for groundwater evaluation, were available for the majority of the constituents analyzed in the CWIC risk evaluation. However, no appropriate ecological screening benchmarks were available for the following detected constituents from CWIC wells: the total fractions of iron, lead, and nickel, m,p-xylenes, methylcyclohexane, tert-amyl methyl ether, and tert-butyl alcohol. Risk from m,p-xylenes was addressed in the screening of dimethylbenzene (total xylenes) which is the total concentration of m,p-xylenes plus o-xylene. The lack of screening benchmarks for the other constituents contributes uncertainty to the risk assessment for the CWIC. The potential effects posed by detected chemicals in groundwater lacking screening benchmarks are uncertain.

- **Uncertainties of the Conceptual Site Model:** The uncertainties associated with the CSM are due to the nature of what exposure scenarios actually occur as opposed to may occur. An ecological inventory for the CWIC was not undertaken for this BERA Addendum; therefore, it is not possible to ascertain what particular organisms are potentially exposed to operations-related constituents with a high degree of confidence. However, the consideration of fish, benthic macroinvertebrates, and semi-aquatic wildlife in the risk evaluation is considered to provide ample coverage of biotic groups that may be influenced by potential groundwater discharge from the Facility. Therefore, the uncertainty associated with failing to identify a potentially exposed ecological resource is considered minimal.

6.0 Summary and Conclusions

Under the provisions of DNREC (1999) Remediation Guidance, a risk evaluation was conducted for the CWIC, as presented in this Addendum to the BERA. The previously submitted BERA addressed ecological risks associated with on-site SWMUs, including the CWEC, at the Facility. Ecological risks in Dragon Run were addressed in the *Interim Report, Dissolved Phase Plume Delineation - Phase II* (URS, 2008), which was approved by DNREC in a letter dated October 3, 2008. Together, these reports complete the ecological risk evaluation of potentially affected areas under Corrective Action Permit HW09A13.

The CWIC is an engineered structure that likely does not support viable communities of aquatic biota. Additionally, under normal refinery operating conditions, a significant volume of water from CWIC is drawn into the facility and used as cooling water. Although these limitations are likely to preclude exposure by aquatic and semi-aquatic organisms, benthic invertebrate communities, fish communities, semi-aquatic birds, and semi-aquatic mammals were considered as potential ecological receptors in the CWIC.

The BERA Addendum supports the following conclusion:

> *The weight-of-evidence suggests that there are no significant risks to aquatic and semi-aquatic ecological receptors using the CWIC. This conclusion is based on the low number of detections and exceedances of Facility-related COPCs in groundwater samples, particularly in samples collected from the well nearest to the CWIC (Well D33). As previously stated, using groundwater concentrations to compare to ecological surface water screening benchmarks is an extremely conservative screening approach because it does not take into account groundwater attenuation, nor does it take into account mixing in the channel. Additionally, the large volume of water that is drawn into the CWIC as part of the once-through cooling process significantly dilutes potential groundwater contribution to the channel.*

In summary, the results of the ecological risk assessments performed for the CWIC indicate that, based on the current Facility-related constituent concentrations in the water-bearing zone, there are no significant ecological risks to potential receptors. Furthermore, as presented in the *Phase II RCRA Facility Investigation – Groundwater* report (URS, 2010), COPC concentrations in groundwater are generally stable or declining, resulting in additional decrease in ecological risks over time.

No additional ecological risk assessments are recommended for the Facility at this time.

7.0 References

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TABLES

TABLE 1
DETECTED CONSTITUENTS IN GROUNDWATER - COOLING WATER INFLUENT CHANNEL
DELAWARE CITY REFINERY
DELAWARE CITY, DELAWARE

Constituent	CAS Number	Number of Samples	Number of Detections	Detection Frequency	Minimum Detected Concentration	Maximum Detected Concentration	Location of Maximum	Minimum Detection Limit	Maximum Detection Limit	Screening Benchmark	Screening Benchmark Source	Exceeds Benchmark?
Organic Compounds (ug/L)												
Benzene	71-43-2	10	3	30	**0.59**	**504**	F7	1	1	1	1	**Y**
Dimethylbenzene (Total Xylenes)[a]	1330-20-7	8	1	12.5	**33.1**	**33.1**	F7	3	4	2	1	**Y**
Ethylbenzene	100-41-4	8	1	12.5	3.46	3.46	F7	1	1	7	1	N
Isopropylbenzene (Cumene)	98-82-8	2	1	50	**13.4**	**13.4**	F7	1	1	2.6	3	**Y**
m,p-Xylenes	179601-23-1	2	1	50	23.1	23.1	F7	2	2	NS	---	N
Methylcyclohexane	108-87-2	2	1	50	14	14	F7	2	2	NS	---	N
Naphthalene	91-20-3	4	3	75	**1.45**	**54.4**	F7	4	4	12	1	**Y**
tert-Amyl methyl ether	994-05-8	4	1	25	33.9	33.9	F7	5	8	NS	---	N
tert-Butyl Alcohol	75-65-0	4	1	25	75.3	75.3	F7	4	50	NS	---	N
tert-Butyl Methyl Ether	1634-04-4	10	5	50	4.64	80	F7	1	6	11,070	3	N
Toluene	108-88-3	8	1	12.5	5.55	5.55	F7	1	1	10	1	N
Dissolved Metals (ug/L)												
Cadmium	7440-43-9	6	3	50	**1**	**1.5**	F3	1	1	1	1	**Y**
Iron	7439-89-6	2	1	50	**20,900**	**20,900**	F7	200	200	1,000	1	**Y**
Total Metals (ug/L)												
Cadmium	7440-43-9	6	2	33.3	**1**	**1.2**	F3	1	10	0.12	2	**Y**
Chromium, Total	7440-47-3	6	2	33.3	5.9	8.9	F1	5	5	56	5	N
Iron	7439-89-6	2	1	50	21,200	21,200	F7	200	200	NS	---	N
Lead	7439-92-1	6	1	16.7	8.29	8.29	F2	5	5	NS	---	N
Nickel	7440-02-0	6	1	16.7	10.7	10.7	F4	10	10	NS	---	N
Other												
Alkalinity, Total (as $CaCO_3$) (mg/L)	ALK	1	1	100	308	308	F7			NA	---	---
Chloride (As Cl) (mg/L)	16887-00-6	2	2	100	64.2	466	F7			NA	---	---
Methane (ug/L)	74-82-8	2	1	50	1,280	1,280	F7	10.8	10.8	NA	---	---
Nitrogen, Nitrate (As N) (mg/L)	7727-37-9	2	1	50	5.4	5.4	D12	0.1	0.1	NA	---	---
Nitrogen, Ammonia (As N) (mg/L)	14797-55-8	1	1	100	22.4	22.4	F7			NA	---	---
Sulfate (as SO_4) (mg/L)	14808-79-8	2	1	50	46.7	46.7	D12	1	1	NA	---	---
Total Carbon (mg/L)	7440-44-0	1	1	100	3.26	3.26	D12			NA	---	---

Notes:

NS=No screening value available

NA = not applicable. These constituents are analyzed to determine if degradation of Facility-related constituents is occurring. Screening of these analytes is not appropriate.

Screening Value Source:

1. DNREC (1999) URS for Protection of the Environment, which are based on the dissolved fraction.
2. USEPA (2006b) Region 3 BTAG Marine Screening Values
3. USEPA (2006a) Region 3 BTAG Freshwater Screening Values. Marine Screening Value not available.
4. DNREC (1999) URS for Protection of the Environment for chromium(III) used.
5. USEPA (2006b) Region 3 BTAG Marine Screening Value for chromium(III) used.
6. NOAA Screening Quick Reference Tables (SQuiRTs) (Buchman, 2008)

a) Total xylenes concentration was calculated as the sum of m,p-Xylenes plus o-Xylene (1,2-Dimethylbenzene) where applicable

b) ug/L = micrograms per liter

c) mg/l = milligrams per liter

FIGURES

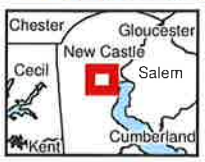
Legend

DCR Property Boundary

0 1,750 3,500 7,000 Feet

1 inch = 3,500 feet

Reference:
USGS 7.5 Min Topographical Maps
Newark East, Saint Georges, 1993
Wilmington South, 2000
Delaware City, 2001
NAD 1983 State Plane Delaware
Projection: Transverse Mercator
Linear Unit: Foot US



URS
335 Commerce Drive, Suite 300
Fort Washington, PA 19034
Phone: (215) 367-2500 Fax: (215) 367-1000

Job: 19998564.00000

Prepared by: VP

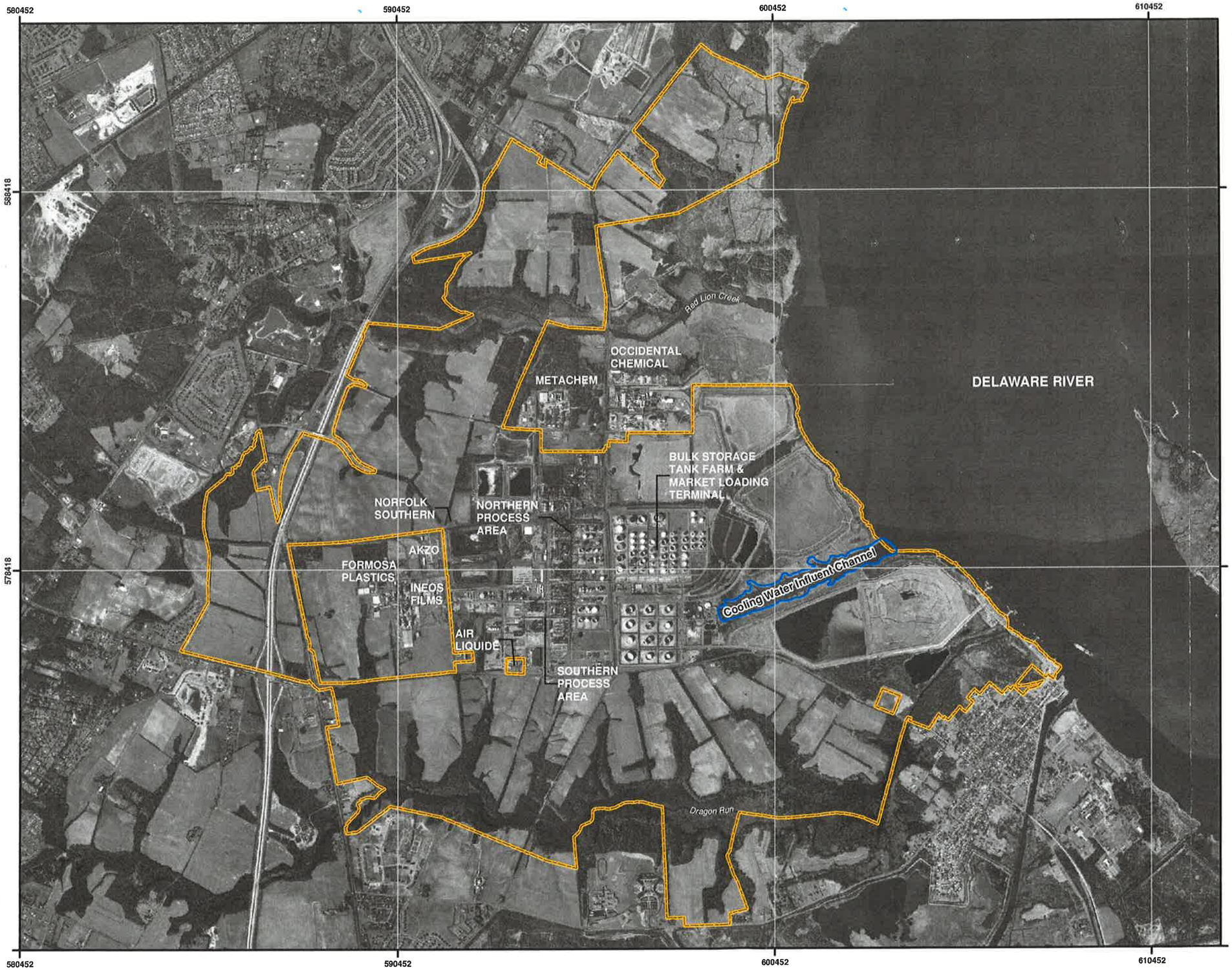
Checked by: MR

Date: 10/05/2010

Figure 1
Site Vicinity Map

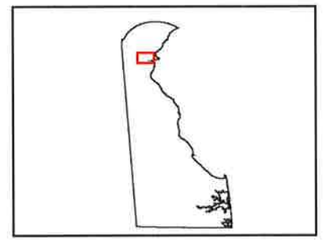
Delaware City Refinery
Delaware City, Delaware

Q:\GIS_Data\MOTIVA\Projects\BERAAddendum\Figure 1 - Site Vicinity Map.mxd



Explanation

- Cooling Water Influent Channel
- DCR Property Boundary



Key Map
Not to Scale

Reference:
2002 DE State Imagery

N

NAD1983 StatePlane Delaware
FIPS 0700 Feet
Projection: Transverse Mercator
False Easting: 656166.666667
False Northing: 0.000000
Central Meridian: -75.416667
Scale Factor: 0.999995
Latitude Of Origin: 38.000000

0 1,300 2,600 5,200 Feet

URS

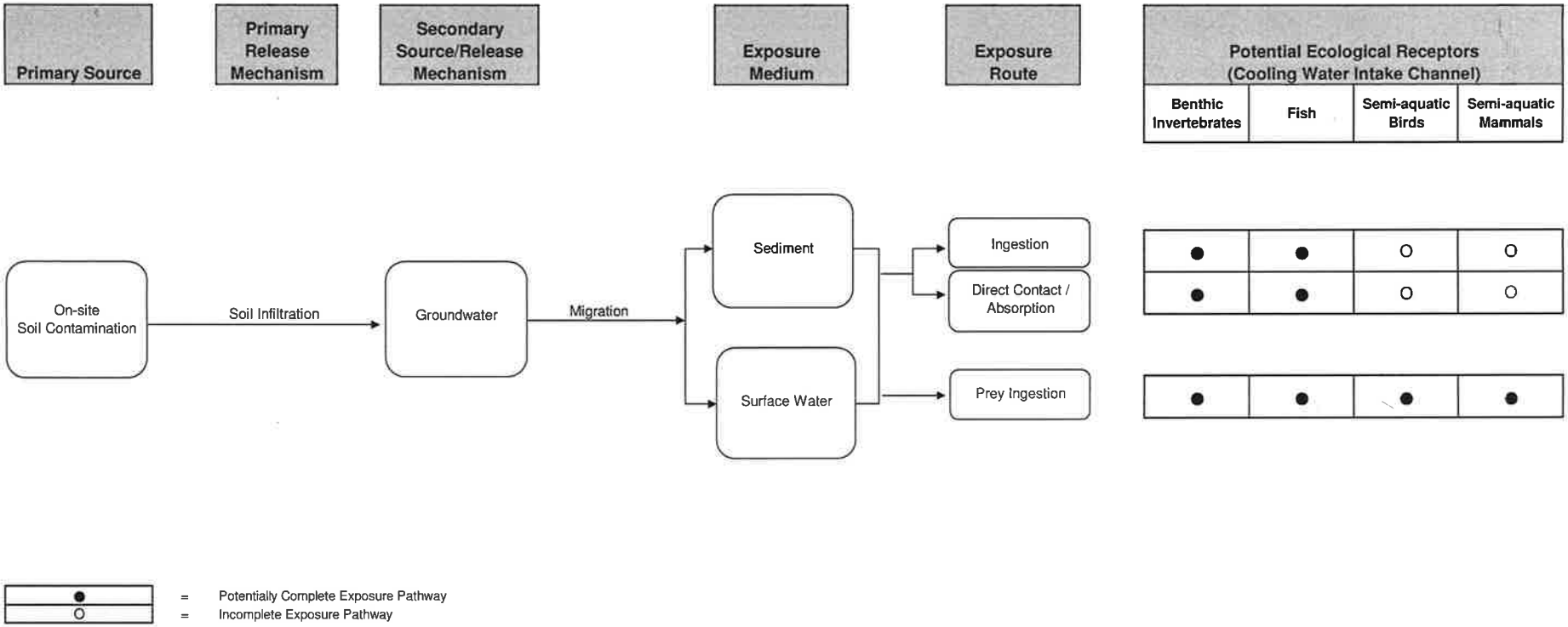
Figure 2
Cooling Water Influent Channel Site Map

Delaware City Refinery
Delaware City, Delaware

Prepared By: VP	Checked By: MR
Job: 19998564.00000	Date: 10/05/2010

Q:\GIS_Data\MOTIVA\Projects\BERAAddendum\Figure 2 - Site Map.mxd

FIGURE 3
CWIC ECOLOGICAL CONCEPTUAL SITE MODEL
DELAWARE CITY REFINERY
DELAWARE CITY, DELAWARE



598000
599000
600000
601000
579000
578000
577000

24b-MW15
F1
F5
F6
F7
F4
F3
F2
D12
D33
Cooling Water Influent Channel

Legend

- Monitoring Well - Columbia
- Monitoring Well - Riverine
- DCR Property Boundary

Key Map
Not to Scale

N

NAD1983 StatePlane Delaware
FIPS 0700 Feet
Projection: Transverse Mercator
False Easting: 656166.666667
False Northing: 0.000000
Central Meridian: -75.416667
Scale Factor: 0.999995
Latitude Of Origin: 38.000000

GCS North American 1983

0 150 300 600
Feet

1 inch = 300 feet

URS

Figure 4
Map of Sampling Locations

Delaware City Refinery
Delaware City, Delaware 19805

Prepared By: VP	Checked By: DR
Job: 19998564.00000	Date: 10/04/2010

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A

APPENDIX A
GROUNDWATER DATA

APPENDIX A-1

GROUNDWATER DATA - COOLING WATER INFLUENT CHANNEL
DELAWARE CITY REFINERY
DELAWARE CITY, DELAWARE

Constituent	CAS Number	Sampling Well									
		24b-MW15	D12	D33	F1	F2	F3	F4	F5	F6	F7
		2/18/10	8/20/09	2/17/10	8/26/08	8/26/08	8/26/08	8/26/08	8/26/08	8/26/08	8/20/09
Organic Compounds (ug/L)											
1,1,1-Trichloroethane	71-55-6		1 U								5 U
1,1,2,2-Tetrachloroethane	79-34-5		1 U								5 U
1,1,2-Trichloro-1,2,2-Trifluoroethane	76-13-1		8 U								40 U
1,1,2-Trichloroethane	79-00-5		2 U								10 U
1,1-Dichloroethane	75-34-3		2 U								10 U
1,1-Dichloroethene	75-35-4		2 U								10 U
1,2,4-Trichlorobenzene	120-82-1		5 U								25 U
1,2-Dibromo-3-Chloropropane	96-12-8		4 U								20 U
1,2-Dibromoethane (Ethylene Dibromide)	106-93-4		2 U								10 U
1,2-Dichlorobenzene	95-50-1		2 U								10 U
1,2-Dichloroethane	107-06-2		2 U								10 U
1,2-Dichloropropane	78-87-5		2 U								10 U
1,3-Dichlorobenzene	541-73-1		1 U								5 U
1,4-Dichlorobenzene	106-46-7		1 U								5 U
2-Hexanone	591-78-6		15 U								75 U
Acetone	67-64-1		15 U								75 U
Benzene	71-43-2	101	1 U	0.59 J	1 U	1 U	1 U	1 U	1 U	1 U	504
Bromodichloromethane	75-27-4		1 U								5 U
Bromoform	75-25-2		2 U								10 U
Bromomethane	74-83-9		3 U								15 U
Carbon Disulfide	75-15-0		8 U								40 U
Carbon Tetrachloride	56-23-5		1 U								5 U
Chlorobenzene	108-90-7		1 U								5 U
Chloroethane	75-00-3		2 U								10 U
Chloroform	67-66-3		16.1 B								10 U
Chloromethane	74-87-3		2 U								10 U
cis-1,2-Dichloroethylene	156-59-2		2 U								10 U
cis-1,3-Dichloropropene	10061-01-5		1 U								5 U
Cyclohexane	110-82-7		2 U								10 U
Dibromochloromethane	124-48-1		2 U								10 U
Dichlorodifluoromethane	75-71-8		2 U								10 U
Dimethylbenzene (Total Xylenes)	1330-20-7		4 U		3 U	3 U	3 U	3 U	3 U	3 U	33.1
Ethylbenzene	100-41-4		1 U		1 U	1 U	1 U	1 U	1 U	1 U	3.46 J
Isopropylbenzene (Cumene)	98-82-8		1 U								13.4

APPENDIX A-1
GROUNDWATER DATA - COOLING WATER INFLUENT CHANNEL
DELAWARE CITY REFINERY
DELAWARE CITY, DELAWARE

Constituent	CAS Number	Sampling Well									
		24b-MW15	D12	D33	F1	F2	F3	F4	F5	F6	F7
		2/18/10	8/20/09	2/17/10	8/26/08	8/26/08	8/26/08	8/26/08	8/26/08	8/26/08	8/20/09
m,p-Xylenes	179601-23-1		2 U								23.1
Methyl Acetate	79-20-9		2 U								10 U
Methyl Ethyl Ketone (2-Butanone)	78-93-3		20 U								100 U
Methyl Isobutyl Ketone (4-Methyl-2-Pentanone)	108-10-1		40 U								200 U
Methylcyclohexane	108-87-2		2 U								14
Methylene Chloride	75-09-2		5 U								25 U
Naphthalene	91-20-3	29.8	4 U	1.45 J							54.4
o-Xylene (1,2-Dimethylbenzene)	95-47-6		2 U								10 U
Styrene	100-42-5		1 U								5 U
tert-Amyl methyl ether	994-05-8	8 U	8 U	5 U							33.9 J
tert-Butyl Alcohol	75-65-0	50 U	4 U	10 U							75.3
tert-Butyl Methyl Ether	1634-04-4	2 U	2 U	6 U	1 U	58.1	51.5	68.9	1 U	4.64	80
Tetrachloroethylene (PCE)	127-18-4		2 U								10 U
Toluene	108-88-3		1 U		1 U	1 U	1 U	1 U	1 U	1 U	5.55
trans-1,2-Dichloroethene	156-60-5		2 U								10 U
trans-1,3-Dichloropropene	10061-02-6		2 U								10 U
Trichloroethylene (TCE)	79-01-6		2 U								10 U
Trichlorofluoromethane	75-69-4		2 U								10 U
Vinyl Chloride	75-01-4		1 U								5 U
Dissolved Metals (ug/L)											
Antimony	7440-36-0				10 U	10 U	10 U	10 U	10 U	10 U	
Cadmium	7440-43-9				1 U	1.2	1.5	1 U	1	1 U	
Chromium, Total	7440-47-3				5 U	5 U	5 U	5 U	5 U	5 U	
Iron	7439-89-6		200 U								20,900
Lead	7439-92-1				5 U	5 U	5 U	5 U	5 U	5 U	
Nickel	7440-02-0				10 U	10 U	10 U	10 U	10 U	10 U	
Selenium	7782-49-2				10 U	10 U	10 U	10 U	10 U	10 U	
Total Metals (ug/L)											
Antimony	7440-36-0				10 U	10 U	10 U	10 U	10 U	10 U	
Cadmium	7440-43-9				10 U	1	1.2	1 U	1 U	1 U	
Chromium, Total	7440-47-3				8.9	5.9	5 U	5 U	5 U	5 U	
Iron	7439-89-6		200 U								21,200
Lead	7439-92-1				5 U	8.29	5 U	5 U	5 U	5 U	
Nickel	7440-02-0				10 U	10 U	10 U	10.7	10 U	10 U	
Selenium	7782-49-2				10 U	10 U	10 U	10 U	10 U	10 U	

APPENDIX A-1
GROUNDWATER DATA - COOLING WATER INFLUENT CHANNEL
DELAWARE CITY REFINERY
DELAWARE CITY, DELAWARE

Constituent	CAS Number	Sampling Well									
		24b-MW15	D12	D33	F1	F2	F3	F4	F5	F6	F7
		2/18/10	8/20/09	2/17/10	8/26/08	8/26/08	8/26/08	8/26/08	8/26/08	8/26/08	8/20/09
Other											
Alkalinity, Total (as $CaCO_3$) (mg/L)	ALK										308
Chloride (As Cl) (mg/L)	16887-00-6		64.2								466
Ethane (ug/L)	74-84-0		21.7 U								21.7 U
Ethene (ug/L)	74-85-1		28.7 U								28.7 U
Methane (ug/L)	74-82-8		10.8 U								1280 B
Nitrogen, Nitrate (As N) (mg/L)	7727-37-9		5.4								0.1 U
Nitrogen, Ammonia (As N) (mg/L)	14797-55-8										22.4 L
Sulfate (as SO_4) (mg/L)	14808-79-8		46.7 K								1 U
Sulfide, Total (mg/L)	105-05-2		5 U								5 U
Total Carbon (mg/L)	7440-44-0		3.26								

Notes:
B = Result is potentially biased high due to blank contamination
K = An associated QC sample had an outlier; the sample result may be biased high.
J = Reported result is between the method detection limit and the reporting limit. Value is estimated
L = Result is estimated and potentially biased low due to a minor quality control anomal
U = Analyte not detected above the method detection limit
ug/l = micrograms per liter
mg/l = milligrams per liter