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TECHNICAL MEMORANDUM

TO: Katrina Higgins-Coltrain, EPA Region 6

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SUBJECT: Development of Human Health Risk Based Preliminary Remediation Goals for the Wilcox Oil Company Superfund Site, Bristow, Creek County, Oklahoma

This technical memorandum discusses the derivation of Preliminary Remediation Goals (PRGs) based on the human health risk assessment (HHRA) for the Wilcox Oil Company Superfund Site.

1. HUMAN HEALTH RISK MANAGEMENT DECISIONS

As noted in the HHRA and RI report, a number of potential source areas were present within the Site. These potential source areas include the skimming and cracking plant, re-distillation battery, stills, cooling ponds, Lead Additive Area, approximately 10 buildings housing refinery operations, storage tanks, and other related refinery structures historically located on the Lorraine and Wilcox Process Areas. Other potential source areas include approximately 80 bulk storage tanks of various sizes historically located at the Lorraine and Wilcox Process Areas, as well as the East and North Tank Farms. Surficial waste material was also identified in the Loading Dock Area.

Crude oil, fuel oil, gas oil, distillate, kerosene, naphtha, and benzene (petroleum ether), acids, and other refined products were reportedly stored on the property (EA 2016c). Site data suggest that periodic releases of crude oil, sludge, and refined product occurred in these areas during operations. These releases may have been discharged to surface and subsurface soil, and subsequently migrated to groundwater, surface water, and sediment. VOCs may have also migrated into the vadose zone as soil gas.

As a result of the varied sources and source areas, the HHRA evaluated a wide range of contaminants of potential concern (COPCs) in site media for each of the five exposure areas. Risk results for most of the COPCs fall within EPA's risk management range. Many of these additional COPCs are suspected to be ubiquitous regional contaminants related to historical activities and/or background concentrations rather than site-specific contaminants. This section provides: (1) a basis of understanding regarding carcinogenic and non-carcinogenic risks and EPA's risk management range, (2) a discussion of chemicals that fall above EPA's acceptable risk range, and (3) an evaluation of chemicals within EPA's risk management range based on spatial extent, magnitude of exceedance, and fate and transport considerations in order to determine an appropriate path forward within the context of risk management.

1.1 BASIS OF UNDERSTANDING

Human health risks are evaluated by carcinogenic and non-carcinogenic risks as discussed in the subsections below. Additionally, potential human health concerns associated with lead in soil were evaluated using blood-lead modeling.

1.1.1 Carcinogenic Risk

For carcinogens, risks are expressed as the incremental probability of an individual developing cancer over a lifetime as a result of exposure to the level of the carcinogen at the site. A carcinogenic risk of 10^{-6} indicates that an individual experiencing the reasonable maximum exposure estimate for the site has a 1 in 1,000,000 chance of developing cancer as a result of site-related exposure. This is referred to as an excess incremental lifetime cancer risk because it would be in addition to the risks of cancer individuals face from other causes. The chance of an individual developing cancer from all other causes has been estimated to be as high as 40 percent (Howlader et al., 2015).

Because the cancer slope factor (used to calculate excess lifetime carcinogenic risk) is the statistical 95th percent upper-bound confidence limit on the dose-response slope, this method provides a conservative, upper-bound estimate of risk. It should be noted that the interpretation of the significance of the cancer risk estimate is based on the appropriate public policy. EPA in the NCP (40 Code of Federal Regulation Part 300) (1990a) states that:

> *"...For known or suspected carcinogens, acceptable exposure levels are generally concentration levels that represent an excess upper bound lifetime cancer risk to an individual of between 10^{-4} and 10^{-6}."*

This risk range represents EPA's generally acceptable risk range for site-related exposures, or a 1 in 10,000 to 1 in 1,000,000 chance, respectively, of an individual developing cancer. Carcinogenic risks that are below the lower end of the acceptable risk range (i.e., 10^{-6}) are considered *de minimis* and require no action. Carcinogenic risks within the risk management range (i.e., between 10^{-4} and 10^{-6}) are subject to a risk management decision. Generally, only carcinogenic risks above the upper end of the acceptable risk range (i.e., 10^{-4}) warrant additional consideration. However, the upper end of the cancer risk range is not a discrete line and "specific risk estimate around 10(-4) may be considered acceptable if justified based on site-specific conditions, including any remaining uncertainties on the nature and extent of contamination and associated risks (EPA 1991c)". Additionally, the EPA notes, "A risk manager may also decide that a lower level of risk to human health is unacceptable and that remedial action is warranted where, for example, there are uncertainties in the risk assessment results (EPA 1991c)."

1.1.2 Non-carcinogenic Risk

For non-carcinogens (systemic toxicants), potential effects are evaluated by comparing an exposure level over a specified time period (e.g., exposure duration) with a reference dose or reference concentration derived for a similar exposure period. A reference dose or reference concentration represents a level to which an individual may be exposed and not expected to cause any harmful effect. A HQ (ratio of average daily intake level to acceptable daily intake level) of less than 1.0 indicates that a receptor's dose of a single contaminant is less than the reference dose. As a result, there will be no concern that potential adverse systemic health

DRAFT

effects will be observed in the exposed populations. However, if the sum of several HQs exceeds 1.0, and the COPC affect the same target organ, there may be concern that potential adverse systemic health effects will be observed in the exposed populations. In general, the greater the value of the HQ above 1.0, the greater the level of concern. However, the HQ does not represent a statistical probability that an adverse health effect will occur.

For the consideration of exposures to more than one chemical causing systemic toxicity via several different pathways, the individual HQs are summed to provide an overall HI. If the HI is less than 1.0, then no adverse health effects are likely to be associated with exposures at the site. However, if the total HI is greater than 1.0, separate endpoint-specific HIs may be calculated based on toxic endpoint of concern or target organ (e.g., HQs for neurotoxins are summed separately from HQs for renal toxins). If an endpoint-specific HI is greater than 1.0, there is reason for concern about potential health effects for that endpoint. Similar to carcinogenic risks, uncertainties associated with the risk assessment may not warrant action for noncancer hazards that are greater than 1.0.

1.1.3 Lead Modeling

Potential health concerns associated with lead exposure relates the effect in terms of the amount of lead in blood associated with an observed effect. For this HHRA, the amount of lead in blood associated with an observed effect was set to a reference value based on the 97.5th percentile of the NHANES-generated blood-lead level in children 1-5 years old (CDC 2012) which equates to 5 µg/dL. Therefore, this blood-lead level is used to identify potential concerns for children with elevated blood-lead levels. Additionally, blood-lead levels of 8 µg/dL and 10 µg/dL were evaluated. To achieve a specific level of protectiveness, the EPA has established a limit that a typical (or hypothetical) child would have an estimated risk of no more than 5 percent exceeding the reference blood-lead level.

1.1.4 Media and Chemicals With Carcinogenic Risks Above 10^{-4} , Non-carcinogenic Hazards Above a Hazard Index of 1.0, or Blood-Lead Level Exceedance

The HHRA revealed carcinogenic risks above 10^{-4}, noncarcinogenic hazards above 1.0, and/or blood-lead levels above a level of concern for soil within the Loading Dock Area, Wilcox Process Area, and Lorraine Process Area and shallow groundwater within the Wilcox Process Area. Media and chemicals that resulted in potential risk concerns are discussed below.

1.1.4.1 Soil

<u>Lead</u>

Surface soil within the Lorraine Process Area and Wilcox Process revealed greater than 5% of the child population exceeded all reference blood-lead levels evaluated in the IEUBK. A range of reference blood-lead levels were evaluated: 5 µg /dL, 8 µg /dL, and 10 µg /dL. This reveals lead is a potential concern for resident children in surface soil within the Lorraine Process Area and the Wilcox Process Area. For the adult lead model, only the 5 µg/dL reference blood-lead level had greater than 5% of the population exceeding in the Lorraine and Wilcox Process Areas. Additionally, the Lead Additive Area within the Wilcox Process Area has surface soil that contains high levels of leachable lead down to a depth of approximately 2 ft bgs. This source area is being addressed under the site's Source Control ROD (EPA 2018b) and was not evaluated

in this HHRA. This reveals lead is a potential concern across these areas and is identified as a COPC for further consideration.

Metals (Cobalt, Copper, Iron)

The HHRA revealed cobalt, copper, and iron, with noncarcinogenic hazards greater than 1 for the Loading Dock Area (cobalt) and the Wilcox Process Area (cobalt, copper, iron) under the resident scenario. The exceedance of the noncarcinogenic hazard of 1 was due to the ingestion of homegrown produce and ingestion of beef exposure pathways. As noted, these pathways are modeled from surface soil concentrations. The models used to estimate the concentration of these metals in produce and beef have a high degree of uncertainty and are likely to overestimate potential concentrations. For cobalt, the background UPL is 11.1 mg/kg. The 95UCL within the Loading Dock Area (15.2 mg/kg) is only slightly higher than the background UPL, and the Wilcox Process Area 95UCL (3.87 mg/kg) is lower than the background UPL. This reveals that cobalt is not a site concern. For copper within the Wilcox Process Area, the 95UCL is highly influenced by the maximum detected concentration of 7,490 mg/kg at WPA-SB-28-0.5. The sample collected at 2 ft bgs at WPA-SB-28 revealed a copper concentration of 8.8 mg/kg. Also, this maximum detected concentration is 60 times higher than the next highest detection of 124 mg/kg at WPA-SB-48. For iron within the Wilcox Process Area, the maximum detected concentration of 47,500 mg/kg at WPA-SB-27-0.5 slightly exceeds the background UPL of 14,700 mg/kg. Additionally, the maximum detected concentration does not exceed the full residential soil RSL of 55,000 mg/kg. As a result of the uncertainty associated with the homegrown produce and beef ingestion exposure routes and overall chemical concentrations, cobalt, copper, and iron are not considered COPCs for the site.

Residential Yards

The assessment of the residential yards found potential concerns for exposure to surface soil. Carcinogenic risks were equal to the upper end of the EPA's acceptable cancer risk range, and non-carcinogenic hazards were above 1. Cadmium and cobalt were the COPCs with non-carcinogenic hazards above 1, and benzo(a)pyrene and arsenic are the primary contributors to carcinogenic risks. It is noted that the assessment of the residential yards used the maximum detected concentration. Additionally, risk concerns identified for soil also include the ingestion of homegrown produce and beef. As noted previously, these exposure routes are modeled on conservative parameters and likely overestimate risks.

The maximum detected concentration of cobalt in surface soil was 61.2 mg/kg (sample location WO-021-005-06-51) and a 95%UCLM of 3.69 mg/kg (Table 3.16). The 95%UCLM of cobalt is below the background UTL of 11.1 mg/kg (Table 2.16). This reveals the overall distribution of cobalt concentrations across the residential yards is consistent with background concentrations. Additionally, the maximum detected concentration of cobalt at residential location WO-021 is six times higher than the next detect of 10.9 mg/kg. The 95UCL for cobalt at location WO-021 15.0 mg/kg, which would result in a noncarcinogenic hazard less than 1 for cobalt. Therefore, cobalt is not retained as a COPC for the residential yards.

The background cadmium (average or 95UCL) could not be calculated because it was detected in only one background sample while all others were non-detect. The non-carcinogenic hazard of 2 is a result of direct contact with soil and ingestion of homegrown produce. The ingestion of homegrown produce is a modeled exposure pathway with high uncertainty. Additionally, these

DRAFT

risk results are based upon the maximum detected concentration of 80.2 at WO-008-001. The next highest detection of cadmium at WO-008 was 2.2 mg/kg. Additionally, the overall 95%UCLM of cadmium was 0.23 mg/kg and the arithmetic mean was 6.07 mg/kg of all residential yards combined (Table 3.16). Both of these are below the EPA RSL of 71 mg/kg. This reveals that cadmium concentrations are not a concern across the residential yards and is not retained as a COPC.

Arsenic and benzo(a)pyrene were the primary contributors to carcinogenic risks of $1x10^{-4}$ within the residential yards. Similar to cadmium, the 95UCL for arsenic (3.29 mg/kg) and benzo(a)pyrene (0.148 mg/kg) are an order of magnitude lower than the maximum detected concentration used in the risk calculations (Table 3.16). This reveals the overall distribution of arsenic and benzo(a)pyrene in the residential yards is not a concern.

1.1.5 Media and Chemicals Subject to a Risk Management Decision: Carcinogenic Risks Between 10^{-6} and 10^{-4}

Potential exposures to surface water and sediment at the site were within the EPA acceptable cancer risk range and noncarcinogenic hazards were below the level of concern. Therefore, these media are not expected to pose human health concerns. Carcinogenic risks for all receptors exposure to soil were also within the EPA acceptable risk range.

It is noted that the HHRA evaluated potential human health concerns based the entire exposure area. However, the exposure areas are larger than area that are typically evaluated for residential yards. To further evaluate the surface soil medium of concern and evaluate potential concerns for smaller exposure areas (i.e., potential residential yards), sample results were reviewed to determine if areas of high concentration are present within the five soil exposure areas. Areas of high concentration were determined as concentrations that exceed the residential soil RSL by two orders of magnitude (i.e., 100 times). The only chemical that exceeded this criterion was benzo(a)pyrene within the Wilcox Process Area, the Lorraine Process Area, and East Tank Farm. The maximum detected concentrations of benzo(a)pyrene in surface soil (WPA-SB-20-2.0 at 31 mg/kg; LOR-TP-09-0.5 at 38.9 mg/kg; and ETF-SB-02-0.5 at 12 mg/kg) and subsurface soil (WPA-SB-20-6.0 at 24 mg/kg) exceeded the residential soil RSL by greater than two orders of magnitude. Additionally, benzo(a)pyrene was detected within WPA-SB-18-2.0 at 23 mg/kg. The highest detections of benzo(a)pyrene were primarily within the Wilcox Process Area, except for the one detection within the Lorraine Process Area and one location in the East Tank Farm. The maximum detected concentration of benzo(a)pyrene in surface soil (ETF-SB-02-0.5 at 12 mg/kg) within the East Tank Farm exceeded the residential soil RSL by two orders of magnitude; however, this location was cleaned up as a result of a removal action completed in 2017. Therefore, benzo(a)pyrene should be retained as a COPC for the site.

DRAFT

2. DEVELOPMENT OF PRGS

Risk results from the HHRA were reviewed to determine PRGs for the site. The site-specific PRGs are chemical limits calculated upon toxicity values and site-specific exposure conditions evaluated in the HHRA (EA 2020). As presented in the HHRA, the site was divided into five exposure areas for evaluation due to the sites overall size and configuration. The HHRA determined potential health concerns for receptors with exposures to lead in soil (Lorraine Process Area and Wilcox Process Area) and exposures to shallow groundwater (Wilcox Process Area). For shallow groundwater, potential unacceptable risks were determined for the resident, construction worker, and commercial worker exposure.

Additionally, soil sample results were reviewed to determine if areas of high concentration are present within the five soil exposure areas. Areas of high concentration were determined as concentrations that exceed the residential soil Regional Screening Level (RSL) by two orders of magnitude (i.e., 100 times). The only chemical that exceeded this criterion was benzo(a)pyrene. Therefore, benzo(a)pyrene was also identified as a COPC.

PRGs were determined for each of the chemicals identified as COPCs. PRGs were developed for chemicals with cancer risks greater than 10^{-6} and target organ specific Hazard Index (HI) greater than 1. Tables 1 through 2 present a summary of the PRGs calculated for the site COPCs. Calculations for the determination of PRGs are provided in Attachment 1. The PRGs are for cancer risk levels of 10^{-6}, 10^{-5}, and 10^{-4} or a noncancer hazard of 0.1 and 1. The following equation was used to calculate site-specific PRGs:

For carcinogens:

$$Site\ Specific\ PRG\ = \frac{EPC}{Risk} \times TR$$

Where,

PRG	=	Preliminary remediation goal
TR	=	Target carcinogenic risk level (i.e., 10^{-6}, 10^{-5}, 10^{-4})
Risk	=	Chemical-specific cumulative carcinogenic risk calculated in HHRA
EPC	=	Chemical-specific exposure point concentration presented in HHRA

For non-carcinogens:

$$Site\ Specific\ PRG\ = \frac{EPC}{HQ} \times THQ$$

Where,

PRG	=	Preliminary remediation goal
THQ	=	Target hazard quotient (i.e., 1, 0.1)
HQ	=	Chemical-specific total hazard quotient shown in HHRA
EPC	=	Chemical-specific exposure point concentration presented in HHRA.

3. SELECTION OF SOIL PRGS

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A brief discussion of the risk-based PRGs is presented below.

Lead is classified a probable human carcinogen. However, EPA has not published a slope factor (SF) or inhalation unit risk (IUR) for quantifying carcinogenic risks. Blood lead levels are the indicator of excess lead exposure in humans. In the HHRA, modeled blood level results are compared to the established threshold of no more than 5 percent of the population having a blood-lead of 5, 8, and 10 micrograms (µg) lead per deciliter (dL) or greater. Blood-lead levels were evaluated for residents using the EPA's Integrated Exposure Uptake Biokinetic Model (IEUBK) Lead Model and for workers using the EPA's Recommendations of the Technical Review Workgroup (TRW) for Lead, An Interim Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil. Land use within the five exposure areas at the site vary from residential to commercial/industrial. Zoning does not exist for the area the site is located. As a result, acceptable lead concentrations in soil may vary within an exposure area. To simply this difference in land use across the exposure area, lead PRGs were determined based upon the blood-lead levels of 5, 8, and 10 µg lead/dL of blood. The IEUBK model was used to determine the appropriate PRGs for the various blood-lead levels. It is noted that the IEUBK model does not provide a printout of the PRG determination. For the worker, the EPA Adult Lead Model was used to determine the appropriate PRGs for the various blood-lead levels. Outputs from this model are provided in Attachment 1. The final selection of the appropriate PRG will depend upon identified land use and remedial feasibility.

Benzo(a)pyrene was identified as a site COPC in the HHRA even though carcinogenic risks were within the EPA acceptable cancer risk range. The HHRA evaluated potential human health concerns based the entire exposure area. However, the exposure areas are larger than typical areas that are evaluated as residential yards. To further evaluate the surface soil medium of concern and evaluate potential concerns for smaller exposure areas (i.e., potential residential yards), sample results were reviewed to determine if areas of high concentration are present within the five soil exposure areas. Based upon this review, it was determined that localized levels of benzo(a)pyrene within the Wilcox Process Area and East Tank Farm may present carcinogenic risks greater than the EPA acceptable cancer risk range. For benzo(a)pyrene, the highest concentrations in soil were found just north of the lead additive area in the Wilcox Process Area (sample locations WPA-SB-09, WPA-SB-18 and WPA-SB-20).

Tables 1 and 2 present the summary of soil COPC PRGs for the resident and commercial/industrial worker in soil.

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4. REFERENCES

EA Engineering, Science, and Technology, Inc. PBC. 2020. *Final Human Health Risk Assessment, Revision 02, Remedial Investigation / Feasibility Study, Wilcox Oil Company Superfund Site, Bristow, Creek County, Oklahoma*. April

Oklahoma Department of Environmental Quality (ODEQ). 2020. *Letter to Katrina Higgins-Coltrain, EPA, From: Todd Downham, ODEQ, Re: Groundwater Use, Wilcox Oil Company Superfund Site, Bristow, Creek County, Oklahoma*. 19 May 2020.

Tables

1 Risk-Based Site-Specific Preliminary Remediation Goals for Carcinogenic and Non-Carcinogenic Risks in Soil, Resident, Child and Adult

2 Risk-Based Site-Specific Preliminary Remediation Goals for Carcinogenic and Non-Carcinogenic Risks in Soil, Commercial/Industrial Worker

DRAFT