FMC MIDDLEPORT
ECOLOGICAL RISK ASSESSMENT FOR THE CORRECTIVE MEASURES STUDY

Suspected Air Deposition and Culvert 105 Study Areas

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ACRONYMS AND ABBREVIATIONS

COC	constituent of concern
CMA	corrective measure alternative
CMS	corrective measure study
Eco-SSL	ecological soil screening level
EPA	U.S. Environmental Protection Agency
ERA	ecological risk assessment
ESB	ecological screening benchmark
HHRA	human health risk assessment
NYCRR	New York Codes, Rules and Regulations
NYNHP	New York Natural Heritage Program
NYSDEC	New York State Department of Environmental Conservation
RFI	RCRA facility investigation
total DDx	sum of DDT, DDD, and DDE

1 INTRODUCTION

FMC Corporation (FMC) owns and operates a pesticide formulating facility (Facility or Site) located in the Village of Middleport and the Town of Royalton, Niagara County, New York. FMC is implementing a Resource Conservation and Recovery Act (RCRA) Corrective Measures Study (CMS) for the suspected air deposition and Culvert 105 study areas. The CMS includes the identification, evaluation, and justification/recommendation of corrective measures, including the performance of human health and ecological risk assessments, as specified in the Agencies-approved August 2009 *Corrective Measures Study Work Plan for Suspected Air Deposition and Culvert 105 Study Areas* (AMEC Geomatrix 2009). This Appendix presents the results of FMC's evaluation of residual (i.e., following implementation of corrective measure(s)) ecological risks associated with the suite of corrective measure alternatives being evaluated.

This report has been revised in response to the comments provided to FMC by the New York State Department of Environmental Conservation (NYSDEC) and the United States Environmental Protection Agency (USEPA) (jointly, the "Agencies"), in consultation with the New York State Department of Health (NYSDOH), on the *Draft Corrective Measures (CMS) Report for the Suspected Air Deposition and Culvert 105 Study Areas, Middleport, NY* (Preliminary Draft June/July 2010). The Agencies' comments addressed were those outlined in a December 2, 2010 from the Agencies, which summarized agreements reached among the Agencies, NYSDOH, and FMC and set forth directives regarding the revision of the June/July 2010 draft report and Appendix G, the Ecological Risk Assessment, included as part of that report.

Purpose of Report

The purpose of this ecological risk assessment (ERA) report is to assess the potential residual ecological risks associated with the various corrective measures alternatives (CMAs, also referred to as alternatives). As directed by the Agencies in comments provided by letter dated March 23, 2010, the ecological evaluation focuses on the Culvert 105 study area north of Sleeper Street.

This assessment was based on relevant components from the first two steps of the ERA process under the Ecological Risk Assessment Guidance for Superfund (USEPA 1997). This report relies on the results of the sampling and analyses conducted as part of the RCRA facility investigation (RFI) field investigations (ARCADIS and AMEC Geomatrix 2009; ARCADIS 2009a). The RFI data are summarized in Volume IV of the RFI report (ARCADIS 2009a).

1.1 SITE BACKGROUND

Culvert 105 is a municipal stormwater drainage way (total length of approximately 6,600 feet or 1.3 miles) that consists of a series of open swales/ditches and buried sewer pipes that collect stormwater runoff from areas in the eastern part of the Village of Middleport. Historically, stormwater runoff from portions of the FMC facility was collected in Culvert 105. The culvert includes portions that are located south and north of the Erie Canal. The Culvert 105 study area considered in the ecological evaluation is located north of the Erie Canal and is bounded by Sleeper Street to the south and Pearson Road to the north (Figure 1-1). This northern portion of Culvert 105 variously consists of open drainage ditches and buried storm sewer pipe. It receives stormwater runoff from residential and business properties, vacant land, a park, public streets, and farm fields. In the past, there were orchards and green houses north of the canal from which stormwater runoff drained into Culvert 105.

The open ditch sections of Culvert 105 are approximately 2 to 4 feet in width and 2 to 4 feet deep. The buried sections of Culvert 105 consist of 24-in.-diameter (with some 36-in.-diameter) sewer pipe sections of various constructions, including tile, metal, plastic, stone, or concrete.

1.2 REPORT ORGANIZATION

The organization of the remainder of this ERA report is as follows:

- Section 2, Preliminary Problem Formulation and Ecological Effects Evaluation, presents a summary of the ecological setting, potential fate and transport mechanisms, potentially complete exposure pathways, and the conceptual site model.
- Section 3, Exposure Assessment and Screening Risk Evaluation, presents the results of the ecological assessment, which includes a summary of the data collected to date, the comparison of the results for each CMS alternative to ecological screening values, and the uncertainty discussion.
- Section 4, Summary and Conclusions, summarizes and interprets the results of this ERA.
- Section 5, References, includes the literature and guidance cited in the development of this ERA.

2 PRELIMINARY PROBLEM FORMULATION AND FMC'S ECOLOGICAL EFFECTS EVALUATION

This section provides information concerning the regional and site-specific ecological conditions that are relevant to this ERA.

2.1 REGIONAL AND SITE-SPECIFIC ECOLOGICAL SUMMARY

The FMC facility is located in the Great Lakes Ecoregion of New York, which is characterized by gently rolling, low-level landscapes and flat lake plains. The region's climate is influenced by the Great Lakes. The site-specific ecological features were summarized in ICF (1993) and CRA (1993) and are presented below.

2.1.1 Regional Climate

The climate of the Middleport area is classified as humid continental, consisting of cool-wet winters and hot-wet summers. Table 5.1 in Volume IV of the RFI report (ARCADIS 2009a) summarized the regional climate (based on information generated at the Lockport meteorological station approximately 10 miles west of the FMC facility) as follows:

- The mean annual temperature is 47.8°F, with the coldest average temperature occurring in January (23.6°F) and the warmest in July (70.9°F). Mean daily temperatures below 32°F occur from mid-November through mid-April. It is estimated that the ground is frozen approximately 85 days/year from mid-December through early March.
- The mean monthly precipitation ranges from 2.2 to 3.9 in. The annual total mean precipitation is approximately 37 in. Days with precipitation greater than 0.01 in. (rainfall equivalent) occur on average 10 to 16 days/month (153 days/year). Approximately 41 of the 153 days/year with precipitation are estimated to occur on days when the ground is frozen.
- The prevailing wind direction in the Middleport area is southwest to northeast.

2.1.2 Surface Water Hydrology

Surface water flow is intermittently present in the open ditch sections of Culvert 105, which receive runoff during and immediately after major rain events and during thaws. The open ditch beds are dry during most of the year.

2.1.3 **Local Land Use**

The Agencies directed that ecological risks be evaluated for Culvert 105 study area north of Sleeper Street. Two reaches have been identified in this area (see Figure 1-1):

- *Reach C2*: Three properties are traversed in this reach—AD1, AE1, and AF1. The below ground portions of the culvert are located predominantly in the northern and southern portions of Reach C2, and traverse land used for residential purposes. Culvert 105 is an open ditch between these areas traversing wooded areas and areas occupied by residences. The total length of open ditch in Reach C2 is approximately 650 feet out of a total length of approximately 1,550 feet.

- *Reach C3*: Seven properties are traversed in this reach—AG1, AH1, AH2, AI1, AJ1, AJ2, and AK1. This reach includes approximately 1,870 feet of open ditch. The upper portion of Reach C3 traverses wooded areas of vacant land and land occupied by the Middleport sewage treatment plant. The lower portion of Reach C3 traverses wooded or landscaped areas of residential properties and agricultural properties.

A third reach of Culvert 105, Reach C1, is located south of Sleeper Street and was not evaluated in this ecological assessment principally because 1) Reach C1 had undergone soil removal as part of the 2007 early action remedial work, and 2) the culvert is underground in this area, and thus not accessible to ecological receptors.

Reach C2 and the lower portion of Reach C3 are both bounded by developed residential properties with well maintained open areas (i.e., lawns) or small wooded areas. The land area in the upper portion of Reach C3 is undeveloped and wooded. A few agricultural properties are located in the vicinity of the upper portions of Reach C3. The Village of Middleport wastewater treatment plant is also located in the upper portion of Reach C3. The substrate of the open ditch portion of the culvert in this area includes both engineered materials (e.g., rip-rap) and settled solids. The latter, when present, is a sandy-silt to sandy-gravel.

2.1.4 **Terrestrial Vegetation**

The terrestrial vegetation in Reach C2 of the culvert area is characterized by maintained lawns and associated properties. Consequently, the ecological community of Reach C2 is likely very limited because maintained lawn areas do not support diverse or robust ecological communities. Portions of Reach C3 are undeveloped and wooded, and therefore have more natural ecological communities and could support native wildlife. However, the relatively small size of these areas likely limits their overall value to the larger community.

CRA (1999) reported that vegetation associated with the open ditches in Reaches C2 and C3 likely include grasses, sedges, and cattails, including the invasive purple loosestrife (*Lythrum salicaria*), reed grasses (*Pharagmites australis*), reed canary grass (*Phalaris arundinacea*), sedges

(*Carex* spp.), and cattails (*Typha* spp.). A tree inventory of adjoining areas to the evaluated portion of the Culvert 105 study area showed that the dominant trees along the road right-of-ways were silver maple, Norway maple, and sugar maples (CETSC 2007). Some of these species may also be present on the developed properties in Reach C2.

2.1.5 Wildlife

Avian species (e.g., swallows, robins), small mammals (e.g., gray squirrels), and large mammals (e.g., deer) that would typically be expected in this portion of New York State are also expected to occur in this area.

2.1.6 Rare, Threatened, or Endangered Species

The New York Natural Heritage Program (NYNHP), under authority of NYSDEC, provides information on the locations and identities of rare species to enable fully informed decision-making while protecting these sensitive resources. NYNHP was contacted on behalf of FMC by ARCADIS on August 27, 2008, concerning the presence of any rare, threatened, or endangered species in the area of the FMC CMS. NYNHP replied by letter dated September 13, 2008, and reported no records of known occurrences of rare or state-listed animals or plants, significant natural communities, or other significant habitats near the site. These correspondences are provided as part of Appendix A in Volume V of the RFI report (ARCADIS 2009b).

The U.S. Fish and Wildlife Service list the bald eagle (*Haliaeetus leucocephalus*) and Eastern prairie fringed orchid (*Platanthera leucophea*) as federally listed endangered or threatened species in Niagara County.[1] On August 8, 2007, the bald eagle was delisted as an endangered species, but still receives protection under the Bald and Golden Eagle Protection Act of 1940 (last amended in 1978). The Eastern prairie fringed orchid is listed as a threatened species. This species prefers moist to wet prairies and wet sedge meadows, which are not present in Culvert 105 Reaches C2 and C3. These two areas also lack the large open-water habitat preferred for foraging by bald eagles (Snyder 1993).

2.2 POTENTIAL FATE AND TRANSPORT MECHANISMS

Arsenic was the only constituent of concern (COC) that was carried forward in the HHRA risk analyses, and this constituent is considered the primary COC in the ecological evaluation. Lead and chlorinated pesticides also were detected in some samples collected from the study area and are additionally considered in the ecological evaluation. The analytical results for these constituents are discussed in Section 3. The key fate and transport pathways relevant to the ecological receptors and these constituents in the Culvert 105 Reaches C2 and C3 include the following:

[1] This information was obtained from http://www.fws.gov/northeast/nyfo/es/CountyLists/NiagaraDec2006.htm.

- Site-related materials that are present in Culvert 105 may have been transported to the Culvert 105 Reaches C2 and C3 via surface water flow in the culvert.

- Some of the chemicals reported in the soil samples may be derived in the Culvert 105 Reaches C2 and C3 areas, at least in part, from the use of inorganic and organic pesticides when these areas were historically used for orchards or other agricultural applications.

- Historical Culvert 105 flooding events, and other intermittent flows, may have transported water or other materials containing Site-related chemicals to soil in the flood zone of Reaches C2 and C3.

- The distribution of arsenic in the soils may not be due exclusively to these flooding or other flow events (see Volume IV of the RFI report for detailed analysis of this information; ARCADIS 2009a). The path of the open ditch through some of the properties has changed over time. Materials removed from ditch inverts may have been placed elsewhere on the adjoining properties as fill material. In addition, soils on some of the adjoining properties may have been disturbed or regraded in the past, which could affect the distribution of chemicals in these areas.

- Table 2-1 summarizes the biota uptake factors and other relevant physical-chemical parameters for lead, arsenic, and the DDT series (ORNL 2010; USEPA 1999). There is low potential for bioaccumulation of these chemicals by plant receptors in the Culvert 105 Reaches C2 and C3 areas because the values are all well below one (i.e., greater relative concentrations will be retained in the soils than will be accumulated by the plants) . Similarly, there is low potential for bioaccumulation of arsenic and lead by soil invertebrates, although some accumulation of DDT compounds may occur for the soil invertebrates. The soil-water partition coefficients (for arsenic and lead) and the organic carbon-partition coefficient (for the DDT series) both suggest that these chemicals are readily absorbed by the soils/sediments in this area. The extent of the adsorption for the DDT series is dependent upon the total organic carbon content of the soils.

This information was used to refine the prior conceptual site model.

2.2.1 Refined Conceptual Site Model

A site-wide conceptual site model was developed that summarizes the sources, transport mechanisms, exposure media, and exposure routes for human and ecological receptors (see Figure 4.1 of CRA [1999]). The principal exposure routes for ecological receptors were via direct pathways (ingestion and direct contact of soils) and indirect pathways (ingestion of prey that may bioaccumulate chemicals from soils).

Only complete pathways provide a route of exposure, and therefore a potential risk. Complete pathways are defined by the following four components:

1. A source and mechanism of chemical release (e.g., spills);
2. A receptor;
3. A point of potential contact with the impacted medium, referred to as the exposure point (e.g., exposed soils); and
4. An exposure route (e.g., potential for direct contact with soils).

If any one of the components is missing, the pathway is not considered complete and, therefore, no risk will be associated with that pathway. The prior site-wide conceptual site model was updated to reflect the environmental setting of Reaches C2 and C3 (Figure 2-1). The refinements are summarized below:

- Large portions of the Culvert 105 Reaches C2 and C3 were previously orchards or used for other agricultural purposes. Some of the arsenic, lead, and other chemical residues detected in the soils may be attributable to these former land uses.

- Although water flow is intermittent in buried and exposed ditch portions of Culvert 105 in this area, there is the potential for solid phase transport of the FMC-related and agricultural-related chemicals via the culvert.

- The absence of standing water in the open ditches precludes the development of stable benthic or fish populations in this area. Therefore, the potential for uptake of FMC-related chemicals by aquatic biota (and their subsequent use as prey by higher trophic level organisms) was not considered to be a significant transport pathway.

Terrestrial receptors have potential for direct exposure based on the refined conceptual site model. Therefore, screening benchmarks that are based on exposures for these types of receptors will be the most relevant for this ecological assessment.

3 EXPOSURE ASSESSMENT AND SCREENING RISK EVALUATION

While arsenic is the principal COC evaluated in the ERA, lead and chlorinated pesticides related to historic operations at the FMC facility were also detected in some samples collected from the Culvert 105 study area and are considered in the ERA. A two-step process was used to assess potential ecological risks for this area. First, the observed results were compared to relevant ecological screening benchmarks (ESBs) under the various CMAs. Samples that would be removed (i.e., excavated) under each of the CMAs were replaced with concentrations reflective of background or unimpacted soils prior to recalculating the average concentrations. Second, the ecological significance of these results under each of the CMAs was evaluated.

3.1 EMPIRICAL DATA COLLECTION

Volume IV of the RFI report (ARCADIS 2009a) summarized the analytical results of sediment and soil samples collected from previous field investigations performed in 1986, 1990, 2002, and 2005. Consistent with that document, the soil and sediment results were combined together for this assessment. As discussed in the RFI report, the settled material present within the open ditch sections did not meet the regulatory definition of sediment provided in the NYSDEC guidance (NYSDEC 1999) for evaluation of potential ecological impacts, and therefore was evaluated as soil, not sediment. The intermittent flow conditions in the open ditch in these reaches will preclude the establishment of benthic communities typically anticipated with aquatic systems, and therefore, consideration of these habitats as terrestrial (soil) is appropriate.

A total of 969 soil results for arsenic were available for this evaluation. The arsenic data reflects the combined FMC and Agencies results. When the Agencies collected split samples of the FMC samples, the average of these two datasets were used as the sample result. This included samples collected from 15 different depth intervals, as summarized in Table 3-1a.

Of these 969 arsenic results, there were 413 results that fell within the 0–6-in. depth interval representing surface soils. Some of the sample locations had results from multiple depths that fell within this interval (e.g., 0–3 and 3–6 in.). These were depths averaged for the calculation of average chemical concentrations for the surface soils. This depth interval was selected because it is ecologically relevant for herbaceous plants (with shallow roots) that may be consumed by herbivores, soil invertebrates that may be consumed by higher tropic level receptors, and depths where incidental contact may occur by these receptors. An evaluation of alternate depth intervals is presented in the Uncertainty Assessment (Section 3.4).

For the non-arsenic results for samples collected from Reach C2 and Reach C3, there were a total of 69 results representing 5 different depth intervals (Table 3-1b). Eighteen of these results were considered surface soils (i.e., depths of 0–6 in.). Seventeen of these samples were collected from Reach C2.

Figures 3.2, 3.4, and 3.5 in Volume IV of the RFI report (ARCADIS 2009a) show the sampling locations for the Culvert 105 study area. Figure 3.2 includes the sampling locations for Reach C1, which, as discussed earlier, is not part of this evaluation. The sampling locations for Reach C2 and Reach C3 are shown in the RFI report, Volume IV, Figures 3.4 and 3.5, respectively.

The analytical results were compiled into a Microsoft Excel® or Microsoft Access® database to facilitate data evaluation. Sample-specific analytical results are tabulated in the RFI report, Volume IV, Appendix C (arsenic data only) and Appendix D (other analytical results), and are not repeated herein. Table 3-2 summarizes the summary statistics for the surface (0–6 in.) chemical results. In this case, the individual sample results were depth-averaged, which reduced the 413 individual arsenic results to 210 results.

The average media concentrations were calculated for each of the CMAs, and these values were used to compare against the screening benchmarks. The average values were used for these comparisons in lieu of individual sample results, because the average concentrations are more representative of potential exposures by ecological receptors.

3.2 ECOLOGICAL SCREENING BENCHMARKS

This section summarizes the ecological screening used to determine whether the average chemical concentrations in the soils/sediments under the various CMAs exceed ESBs and suggest the potential for an ecological impact from these residual levels. The soil ecological benchmarks were used for evaluating the results.

3.2.1 Arsenic Ecological Benchmark Values

A value of 13 mg/kg (from 6 NYCRR Part 375) was used as the arsenic ESB in the RFI report. This value was derived by NYSDEC and represents the background concentration of arsenic in rural soils of New York State. An arsenic concentration of 20 mg/kg was used for screening purposes as a reasonable estimate of the upper range of background for soils in Middleport area based upon prior field studies. As requested by the Agencies, both the state-wide and site-specific arsenic background soil concentrations are used in this ecological assessment. , Additionally, toxicity-based Ecological Soil Screening Levels (Eco-SSLs) developed by the USEPA are used in the assessment. For arsenic in soils, the following Eco-SSL values (USEPA 2005) are available:

- Plants: 18 mg/kg
- Avian wildlife: 43 mg/kg

- Mammalian wildlife: 46 mg/kg

Plants are the most sensitive receptor, although arsenic tolerance in plants is species-specific, and also related to arsenic speciation.

3.2.2 Lead Ecological Benchmark Values

A value of 63 mg/kg from 6 NYCRR Part 375 (Part 375) was used as the NYSDEC ESB. Part 375 acknowledges that this value is below statewide rural background, but it is within the range for the site-specific background (range: 22 to 114 mg/kg, average: 54.5 mg/kg; see Table 6.1 in ARCADIS 2009a). The lead Eco-SSLs are also used to assess these results. For lead in soils, the following Eco-SSL values (USEPA 2005b) are available and are considered in the ecological evaluation:

- Plants: 120 mg/kg
- Soil Invertebrates: 1,700 mg/kg
- Avian wildlife: 11 mg/kg
- Mammalian wildlife: 56 mg/kg.

3.2.3 Total DDT Ecological Benchmark Values

The chlorinated pesticides that were detected with the greatest frequency were the DDT series (DDx). NYSDEC has established a total DDx ESB of 0.002 mg/kg, and identifies the woodcock as the sensitive receptor. The NYSDEC value is below the detection limit reported for the soil samples from this investigation (approximately 0.004 mg/kg)[2]. As with the arsenic evaluation, the ecological assessment also includes comparison to the Eco-SSLs. USEPA (2007) developed Eco-SSL values for total DDx for avian and mammalian wildlife only (the data were insufficient to derive Eco-SSLs for plants or soil invertebrates). These values are shown below:

- Avian wildlife: 0.093 mg/kg
- Mammalian wildlife: 0.021 mg/kg.

Table 3-2 shows that the remaining pesticides were detected at far lower frequency than the total DDx series (e.g., most were detected in only one sample). Given this sporadic occurrence, these other pesticides are not likely to pose ecological risks given that the overall frequency of exposures to members of the ecological community will be rare. The uncertainty section, however, summarizes whether the samples with detected chlorinated pesticides are addressed by the arsenic actions.

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[2] The NYSDEC ESB is also below the average Total DDx concentration (0.03 mg/kg) of the borrow material from a local source unaffected by FMC operations and used for the 2007 Early Action.

3.3 FMC'S ECOLOGICAL ASSESSMENT OF CMS ALTERNATIVES

The CMAs are based on removal of residual arsenic levels in soils/sediments. The following alternatives are under consideration:

- *CMS Alternative 1 (CMA 1):* No Further Action.
- *CMS Alternative 2 (CMA 2):* Remediation of soil with arsenic concentrations above 20 mg/kg.
- *CMS Alternative 3 (CMA 3):* Remediation of soil to post-remediation soil arsenic concentrations based on land usages, as summarized below:
    - Residential – average of 20 mg/kg, with a maximum of 40 mg/kg;
    - Public – average of 30 mg/kg, with a maximum of 60 mg/kg;
    - Recreational – average of 40 mg/kg, with a maximum of 80 mg/kg.
- *CMS Alternative 4 (CMA 4):* Remediation to a post-remediation average arsenic concentration of 30 mg/kg on each property, with a maximum allowable concentration of 60 mg/kg.
- *CMS Alternative 5 (CMA 5):* Remediation to a post-remediation average arsenic concentration of 40 mg/kg on each property, with a maximum allowable concentration of 80 mg/kg.
- *CMS Alternative 6A/B (CMA 6A/B):* Remediation of soil to post-remediation soil arsenic concentrations based on land usages, as summarized below:
    - Residential – average of 20 mg/kg, with a maximum of 35 mg/kg;
    - Recreational – average of 30 mg/kg, with a maximum of 50 mg/kg;
    - Industrial – average of 40 mg/kg, with a maximum of 80 mg/kg.
- *CMS Alternative 7A/B (CMA 7A/B):* Same as CMA 6A, except that post-remediation maximum arsenic concentration for residential land use is 30 mg/kg.
- *CMS Alternative 8 (CMA 8):* Remediation to a post-remediation average arsenic concentration of 20 mg/kg,, with a maximum allowable concentration of 30 mg/kg.

For both CMA 6A/6B and 7A/7B, the suffix "A" does not include the Roy-Hart School property in the dataset compilation, while the suffix "B" includes the school property in the dataset compilation.

The FMC Middleport Soil Arsenic Data Analysis memorandum (and associated documentation), provided as an attachment to the Human Health Risk Assessment (HHRA) appendix, outlines the approach taken to identify those samples that were removed as part of each CMS alternative. The samples that are removed under each of these alternatives are replaced with the following values for the calculation of the average soil concentrations:

- *Arsenic*: Replaced with 5 mg/kg. This is the average concentration in backfill that has been used in previous interim corrective and remedial actions relative to the FMC facility.
- *Lead*: Replaced with 50 mg/kg. This is the average value (rounded down) of the site-specific background samples reported in Volume IV of the RFI report (see Table 6.1 of ARCADIS 2009a)
- *Total DDx*: Replaced with 2 μg/kg. This is half the reported detection limit for DDx in these samples (i.e., it assumes that there are no detectable DDx in the backfill materials.

Table 3-3 lists the sample results that were removed for each CMS alternative that was evaluated as part of this ecological assessment.

3.3.1 Evaluation of Soil Arsenic Results

The average arsenic concentrations for Reaches C2 and C3 under the CMAs are summarized in the table below.

Residual Average Arsenic Concentrations (mg/kg) in Surface Soils (0–6 in.) for Each CMS Alternative

Reach	CMA 1 (No action)	CMA 2	CMA 3	CMA 4	CMA 5	CMA 6A/B	CMA 7A/B	CMA 8
C2 and C3	68.1	5.5	10.6	16.2	18.7	9.3	8.5	7.6
C2 only	83.9	5.5	10.2	14.2	15.2	8.6	7.7	7.7
C3 only	41.5	5.4	11.2	19.6	24.6	10.6	10.6	9.8

Under CMA 1 (No Further Action), the average arsenic surface soil concentration is greater than the site-specific background (20 mg/kg) and New York State's SCO (13 mg/kg) or plant Eco-SSL (18 mg/kg). This would imply that there would be impacts to the vegetation in this area; however, no impacts (e.g., weak plant growth) have been observed during any of the prior field investigations. For example, the open ditch portion of the culvert on Property AD1 was well vegetated (see RFI report. Volume IV, Appendix A, photograph number 15) even though the surface arsenic concentrations were above the conservative plant ecological benchmark (see RFI report, Volume IV, Figure 3.5). The site-specific bioavailability assessment performed using site soils to support the HHRA showed that the arsenic can readily bind to iron oxides and iron sulfate. Therefore, the absence of any obvious stress on the native vegetation may be attributable to a reduction in the bioavailability of arsenic in these soils.

The average surface soil concentration under CMA 1 is also above the conservative screening level benchmarks for other ecological receptors (except for Reach C3 alone). The properties in Reach C2 have been observed to be well-maintained residential properties that would not support diverse or robust ecological communities; therefore, the application of the avian or mammalian screening benchmarks may not be fully relevant for this reach. The average arsenic surface soil concentration in Reach C3, which is undeveloped and wooded (and therefore represents better habitat for ecological receptors), is 41.5 mg/kg. This value is below the screening benchmarks for the avian and mammalian receptors (43 and 46 mg/kg, respectively). Therefore, based on FMC's ecological analysis, these receptors are not at risk under the No Further Action alternative in Reach C3. Collectively, the results of the FMC's ecological risk evaluation for the No Further Action alternative suggest in the opinion of FMC and its experts that there would be (and are) negligible ecological risks for Reaches C2 and C3.

The average residual surface arsenic concentrations are estimated to reduce to 6, 11, 16, 19, 9, 9, and 8 mg/kg under CMA 2 through 8, respectively, for the properties within the flood zone of Culvert 105 in Reaches C2 and C3. Such actions reduce the average soil concentrations to near or below the screening ecological benchmarks. In the opinion of FMC and its experts, the overall impact on ecological risks is considered negligible, particularly given that, based on FMC's analysis, the risks under the No Further Action alternative are also considered negligible. Based on FMC's ecological s evaluation, no removal actions for arsenic in soils are needed to address potential ecological risks.

3.3.2 Evaluation of Soil Lead Results

For lead, the corresponding samples that were removed due to residual arsenic concentrations under each CMS alternative were also removed from the lead dataset and replaced with the background lead concentration (50 mg/kg). The average lead concentrations for Reaches C2 and C3 under the CMAs are summarized in the table below.

Residual Average Lead Concentrations (mg/kg) in Surface Soils (0–6 in.) for Each CMS Alternative

Reach	CMA 1 (No action)	CMA 2	CMA 3	CMA 4	CMA 5	CMA 6A/B	CMA 7A/B	CMA 8
C2 and C3	137	58.6	74.6	74.1	74.7	70.6	70.6	70.6
C2 only	141.2	59.1	76	75.5	75.5	72	72	72
C3 only	61.9	50	50	50	61.9	50	50	50

Under CMA 1 (No Further Action), with the exception of Reach C3 only, the lead surface soil concentration is greater than the NYSDEC benchmark (63 mg/kg), avian Eco-SSL (11 mg/kg), and mammalian Eco-SSL (56 mg/kg), but less than the soil invertebrate Eco-SSL (1,700 mg/kg). Like arsenic, lead can also bind to iron oxides and iron sulfate, reducing its potential bioavailability (e.g., Suedel et al., 2006). Therefore, based on FMC's ecological evaluation, it is not likely that there would be any potential ecological impact under the No Further Action alternative.

Several of the soil lead results would also be removed as part of the arsenic action. Nearly all of the samples (14 of 19) would be removed under CMA 2. The number of samples that are removed under the remaining CMAs is summarized in the table below.

Number of Lead Samples Replaced with Surrogate Values Based on Arsenic Removal

CMA 1 (No Action)	CMA 2	CMA 3	CMA 4	CMA 5	CMA 6A/6B	CMA 7A/7B	CMA 8
0/19	14/19	7/19	6/19	5/19	10/19	10/19	10/19

Consequently, the average lead concentrations in the soils are reduced under CMAs 2 through 8, and would fall within the observed range of site-specific background soils (range: 22 to 114 mg/kg).

3.3.3 Evaluation of Soil Total DDx Results

For total DDx, the corresponding samples that were removed due to residual arsenic concentrations under each CMS alternative were also removed from the total DDx dataset and replaced with half the reported detection limit (2 μg/kg). The average total DDx concentrations for Reaches C2 and C3 under the CMAs are summarized in the table below.

Residual Average Total DDx Concentrations (µg/kg) in Surface Soils (0–6 in.) for Each CMS Alternative

Reach	CMA 1 (No action)	CMA 2	CMA 3	CMA 4	CMA 5	CMA 6A/B	CMA 7A/B	CMA 8
C2 and C3	204.2	13.1	18.5	19.2	29.8	14.1	14.1	14.1
C2 only	204	14	19.4	20	20	15	15	15
C3 only	204	2	2	2	204	2	2	2

Under CMA 1 (No Further Action), the total DDx surface soil concentration is greater than the NYSDEC benchmark (2 µg/kg), avian Eco-SSL (93 µg/kg), and mammalian Eco-SSLs (21 µg/kg). Nearly all of the soil total DDx samples (14 of 19) would be removed under CMA 2. The number of samples that are removed declines with the remaining CMAs, as summarized in the table below.

Number of Total DDx Samples Replaced with Surrogate Values Based on Arsenic Removal

CMA 1	CMA 2	CMA 3	CMA 4	CMA 5	CMA 6A/6B	CMA 7A/7B	CMA 8
0/19	14/19	7/19	6/19	5/19	10/19	10/19	10/19

Consequently, the average total DDx concentrations in the soils are reduced under each of CMAs relative to the No Further Action alternative. The average total DDx concentrations for Reaches C2 and C3 combined fall below the avian and mammalian Eco-SSL values for CMA 2 through 4, were slightly above the mammalian Eco-SSL value under CMA 5, and were below the avian and mammalian EcoSSLs for the remaining CMAs. The calculated average total DDx concentrations for all of the CMAs are above the NYSDEC benchmark when C2 and C3 were combined. However, this is observed predominantly in Reach C2, which does not include ideal habitat for ecological receptors. The average total DDx concentration in the undeveloped portion of Reach C3 is near or below all of the evaluated ecological benchmarks except for CMA 1 and CMA 5. The total DDX in single soil sample from this area (C7) will not be removed under CMA 5.

It has been shown that the bioavailability of total DDx is significantly reduced in "aged" soils based on uptake studies using earthworms (Morrison et al., 2000). Although these authors did not evaluate the potential mechanism(s) of this sequestration process, they were able to clearly show that across different soil types the uptake of DDx by earthworms was dramatically reduced (upward of 85%) from aged soils with known historical (30 and 49 years old, in that study) applications of total DDx. This could be the case for DDx in Middleport-area, though site-specific data on bioavailability are lacking. Therefore, it is likely that the detected levels of total DDx are not readily bioavailable under current site conditions. Based on FMC's ecological evaluation, total DDx is unlikely to cause any ecological impacts under current conditions and at the low projected average concentrations under CMAs 2 - 8.

3.4 UNCERTAINTY EVALUATION

Uncertainty is inherent in all aspects of the risk assessment process, and such uncertainties can result in overestimations or underestimations of the true ecological risk present at the site. For this assessment, the key areas of uncertainty include: 1) the representativeness of the screening benchmarks, and 2) the selection of evaluated sampling depths.

3.4.1 Representativeness of the Ecological Screening Benchmarks

The ESBs used for this comparison included both NYSDEC and EPA values. These were selected for this assessment because they are conservative and also have been applied to other sites when screening chemicals for inclusion in quantitative risk assessments. Their application in this assessment of the CMAs serves to reduce the potential to underestimate the possible ecological risks under each alternative.

The NYSDEC values are “generic” values that do not reflect chemical speciation, local geochemistry, or other factors that may reduce the bioavailability of the soils for ecological receptors. As noted earlier, although the average arsenic concentrations exceeded the conservative NYSDEC ecological screening benchmark for plants, there was no apparent impact on the local vegetation in the Culvert 105 Reach C2 or Reach C3 areas. Therefore, there is some uncertainty in the relevance of using a generic plant-based ESB for this dataset.

The Eco-SSLs were also included in this evaluation because they were developed for multiple receptor types. An advantage to using the Eco-SSLs is that they include a rigorous review process for determining the suitability of the literature used as data sources. But, like the NYSDEC values, the Eco-SSLs do not fully address factors that may reduce the bioavailability of the chemicals on a site-specific basis.

3.4.2 Selection of Evaluated Sampling Depths

Surface soils, representing the depth interval of 0–6 in., were used for the comparison to ecological benchmarks. This interval was selected because it represents the most ecologically relevant depth interval. As part of this uncertainty evaluation, the average arsenic results were also calculated for the 0–12-in.depth interval. The analytical results were depth weighted, and are compared to the surface depth interval in the table below.

Residual Depth-Weighted Average Arsenic Concentrations (mg/kg) for Two Depth Intervals for Each CMS Alternative for Reaches C2 and C3

Depth Interval	CMA 1 (No action)	CMA 2	CMA 3	CMA 4	CMA 5	CMA 6A/6B	CMA 7A/7B	CMA 8
0–6 in.	68.2	5.5	10.6	16.2	18.7	9.3	8.5	7.6
0–12 in.	53.8	5.7	9.7	14.0	17.3	9.0	8.3	7.7

Although the mean values differ slightly between the two depth intervals, the overall conclusions based on the 0–6 in. interval would be the same if the alternate depth interval of 0–12 in. were used. Therefore, there is little uncertainty for the ecological risk evaluation in the selection of the 0–6-in. depth interval as the representation of surface soils.

3.4.3 Use of Depth-Averaging for Calculating Average Chemical Concentrations

The results for the individual surface soil samples were first depth-averaged prior to calculating the average soil concentrations for the evaluated areas. This was done principally because the surface soil interval (0–6 in.) included samples from multiple depths (i.e., 0–3 and 3–6 in.) in some cases, or was samples that represented this entire depth interval (i.e., 0–6 in. only). To determine whether there is uncertainty introduced into the average chemical concentrations using the depth-averaging approach, the surface soil arsenic results were also calculated without depth weighing. These are compared to the depth-weighted results for the combined Reach C2 and Reach C3 areas in the table below.

Residual Average Surface (0–6 in.) Arsenic Concentrations (mg/kg) with and without Depth-Averaging for Each CMS Alternative for Reaches C2 and C3

	CMA 1 (No action)	CMA 2	CMA 3	CMA 4	CMA 5	CMA 6A/6B	CMA 7A/7B	CMA 8
Depth-averaged	68.2	5.5	10.6	16.2	18.7	9.3	8.5	7.6
As reported	67.7	5.5	10.7	16.2	18.7	9.4	8.6	7.7

There were only slight differences in the calculated averages whether depth-averaging was used or not. Therefore, it can be concluded that there is little uncertainty when the depth-averaged results were used for comparisons to ecological benchmarks.

4 SUMMARY AND CONCLUSIONS

FMC's ecological risk evaluation of the CMAs for Culvert 105 Reaches C2 and C3 was based on a comparison of the average arsenic concentrations to conservative screening benchmarks, and also an assessment of the potential ecological resources in this area. The ecological community of the culvert area is very limited. The maintained lawn areas in Reach C2 and the lower portion of Reach C3 do not support diverse or robust ecological communities. The northern wooded sections of Reach C3 have natural ecological communities that could support native wildlife, but the relatively small size of these areas limits their overall value to the larger ecological community.

The average arsenic concentrations under the No Further Action (CMA 1) exceed the state soil ESB values for arsenic and the Eco-SSL developed for plants. However, the most sensitive ecological receptor is plants, and there is no evidence that the vegetative community has been adversely affected. In Reach C3, where the comparison of the arsenic concentrations in soil to the avian and mammalian screening benchmarks is relevant, the average arsenic concentrations were below these benchmark values. Soil concentrations of other chemicals, such as lead and total DDx, are also not expected to impact the evaluated receptors because of the likely reduced bioavailability of these chemicals in the soils.

Consequently, based on FMC's ecological risk evaluation, corrective action in the Culvert 105 study area is not warranted or appropriate on the basis of ecological risk.

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FIGURES

CITY:SYRACISE, NY GROUP: ENVCAD DB: P. LISTER LD: P. LISTER PM: D. WRIGHT LYR: ON=*;OFF=REF, (FRZ)
G:\ENVCAD\SYRACUSE\ACT\B0037736\0000\00021\DWG\37736B04.DWG LAYOUT: 1-1 SAVED: 6/18/2010 9:11 AM ACADVER: 17.0S (LMS TECH) PAGESETUP: ---- PLOTSTYLETABLE: PLTFULL.CTB PLOTTED: 6/18/2010 9:11 AM BY: LISTER, PAUL
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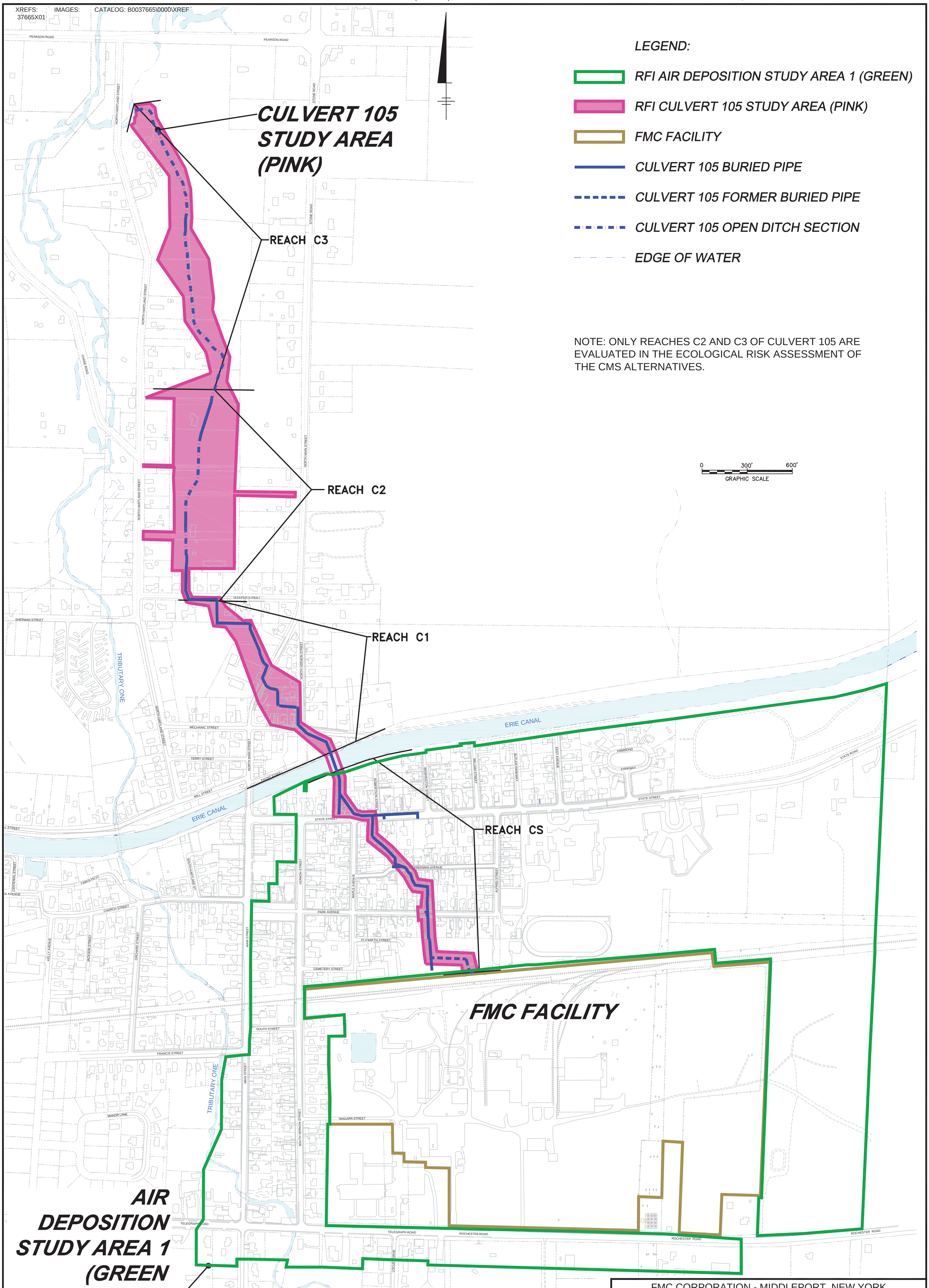

FMC CORPORATION - MIDDLEPORT, NEW YORK
ECOLOGICAL RISK ASSESSMENT FOR THE CMS - SUSPECTED AIR DEPOSITION AND CULVERT 105 STUDY AREAS

Site Location Map for Culvert 105 Reaches C2 and C3

ARCADIS

FIGURE
1-1

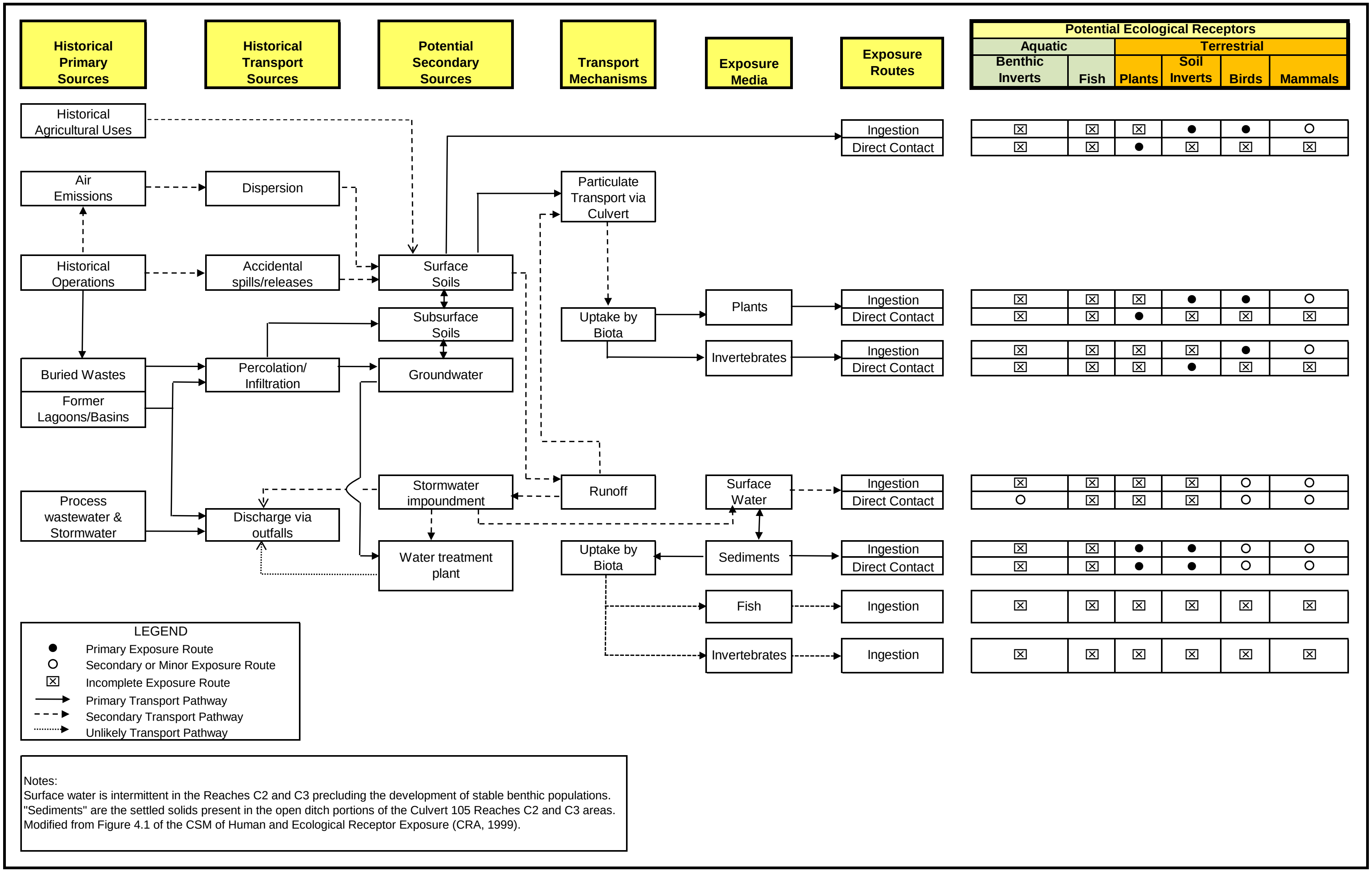

Figure 2-1. Refined Conceptual Site Model for Culvert 105 Reaches C2 and C3
FMC Facility, Middleport, NY

TABLES

Table 2-1. Summary of Biota Uptake Factors and Other Relevant Physical-Chemical Parameters for Selected Chemicals Reported in Site Soils

Chemical	Soil-to-Dry Plant Uptake	Soil-to-Wet Plant Uptake	Soil-to-Invertebrate Uptake[a]	Soil-Water Partition Coefficient (cm^3/g)	Organic Carbon Partition Coefficient (L/kg)	Log of Octanol-Water Partition Coefficient	Water Solubility (mg/L)	Comment
Arsenic	4.00E-02	1.00E-02	0.11	2.90E+01	--	--	--	As inorganic arsenic
Lead	9.00E-02	7.60E-04	0.03	9.00E+02	--	--	--	
4,4'-DDD	1.24E-02	2.48E-03	1.26	--	1.18E+05	6.02E+00	9.00E-02	Assumed same as for 4,4'-DDT
4,4'-DDE	6.45E-03	1.29E-03	1.26	--	1.18E+05	6.51E+00	4.00E-02	Assumed same as for 4,4'-DDT
4,4'-DDT	3.78E-03	7.56E-04	1.26	--	1.69E+05	6.91E+00	5.50E-03	

Notes:

-- = no data available

Additional pesticides were detected in the soil/sediment samples collected from Reaches C2 and C3, but the detection frequencies for those pesticides were far lower than the chemicals shown in this table.

Data from ORNL Risk Assessment Information System (ORNL 2010), unless noted.

[a] Data from USEPA (1999). Data are on a wet weight tissue and dry weight soils basis.

Table 3-1a. Number of Arsenic Soil Results by Depth Interval from Culvert 105 Reaches C2 and C3

Depth Interval (in)	Reach C2	Reach C3	Sum
0–3	130	77	207
0–4	0	2	2
0–6	2	1	3
3–6	128	75	203
6–12	131	77	208
12–17	0	1	1
12–18	112	57	169
18–24	109	53	162
24–30	3	1	4
24–36	1	0	1
30–36	3	1	4
36–38	1	0	1
36–39	1	1	2
36–42	1	0	1
42–45	1	0	1
Sum	623	346	969

Table 3-1b. Number of Non-Arsenic Soil Results by Depth Interval from Culvert 105 Reaches C2 and C3

Depth Interval (in)	Reach C2	Reach C3	Sum
0–3	15	0	15
0–6	2	1	3
6–12	17	5	22
12–18	15	0	15
18–24	13	1	14
Sum	62	7	69

Note:

The non-arsenic samples included lead and pesticides.

Table 3-2. Summary of Surface Soil Analytical Results for Soil Samples Collected from Reaches C2 and C3

Parameter	Frequency of Detection	Average	Range of Positives	Range of Nondetects	Units
Arsenic	210/210	68.2	2.4 - 479.5	--	mg/kg
Lead	19/19	68.4	19.3-492	--	mg/kg
4,4'-DDD	10/19	83.5	0.93-1300	4-21	µg/kg
4,4'-DDE	18/19	48.6	0.78-200	4.8-4.8	µg/kg
4,4'-DDT	16/19	51.8	0.9-190	4.4-4.7	µg/kg
Total DDx	19/19	204	1.9 - 1610	--	µg/kg
alpha -Chlordane	1/18	12.8	27-27	2.1-200	µg/kg
beta -BHC	1/18	3	7-7	2.1-11	µg/kg
delta -BHC	1/19	3.4	10-10	2.1-20	µg/kg
Dieldrin	3/19	13.6	48-290	4-22	µg/kg
Endosulfan II	4/18	6.2 [a]	0.85-1.2	4-41	µg/kg
Endrin	1/18	6.5 [a]	0.99-0.99	4-41	µg/kg
Endrin aldehyde	6/18	6.2 [a]	1-1.6	4.3-41	µg/kg
gamma -BHC (Lindane)	1/19	5.3	80-80	2.1-20	µg/kg
gamma -Chlordane	1/18	11.4	15-15	2.1-200	µg/kg
Isodrin	1/18	5.6 [a]	0.81-0.81	4-21	µg/kg
Total Chlordane	1/1	750	750-750	--	µg/kg

Notes:

-- = no data available

Only those analytes detected in at least one surface soil sample are shown in this table.

This summary reflects the depth-weighted results from the sample depths 0–6 in. and combines the results from Reaches C2 and C3.

Total DDx is calculated is by summing DDT, DDD, and DDE results. Nondetect sample results were set to zero values for the calculation of the total DDx concentrations for a given sample.

Average concentrations were calculated by setting nondetect sample results to one-half the reported detection limits.

[a] Calculated mean exceeds maximum positive detected result.

Table 3-3. Summary of Samples Replaced with Surrogate Values for Each CMS Alternative

Sample Location ID	Sample Depth (in)			Arsenic Data							Non-Arsenic Data						
	Start	End	Reach	CMA 2	CMA 3	CMA 4	CMA 5	CMA 6A/B	CMA 7A/B	CMA 8	CMA 2	CMA 3	CMA 4	CMA 5	CMA 6A/B	CMA 7A/B	CMA 8
AD1-A5	0	3	C2	◆	☐	☐	☐	☐	☐	☐	◆	☐	☐	☐	☐	☐	☐
AD1-A5	3	6	C2	◆	☐	☐	☐	☐	☐	☐							
AD1-A6	0	3	C2	◆	☐	☐	☐	☐	☐	☐							
AD1-A6	3	6	C2	◆	☐	☐	☐	☐	☐	☐							
AD1-A7	0	3	C2	◆	☐	☐	☐	☐	☐	☐							
AD1-A7	3	6	C2	◆	☐	☐	☐	☐	☐	☐							
AD1-A8	0	3	C2	◆	◆	☐	☐	◆	◆	◆							
AD1-A8	3	6	C2	◆	◆	☐	☐	◆	◆	◆							
AD1-A9	0	3	C2	◆	☐	☐	☐	☐	☐	☐	◆	☐	☐	☐	☐	☐	☐
AD1-A9	3	6	C2	◆	☐	☐	☐	☐	☐	☐							
AD1-AA8	0	3	C2	◆	◆	☐	☐	◆	◆	◆							
AD1-AA8	3	6	C2	◆	◆	☐	☐	◆	◆	◆							
AD1-B5	0	3	C2	◆	☐	☐	☐	☐	☐	☐							
AD1-B6	0	3	C2	◆	☐	☐	☐	☐	☐	☐							
AD1-B7	0	3	C2	◆	☐	☐	☐	☐	☐	☐							
AD1-B7	3	6	C2	◆	☐	☐	☐	☐	☐	☐							
AD1-B8	0	3	C2	◆	◆	◆	☐	◆	◆	◆							
AD1-B8	3	6	C2	◆	◆	◆	☐	◆	◆	◆							
AD1-B9	0	3	C2	◆	☐	☐	☐	☐	☐	☐	◆	☐	☐	☐	☐	☐	☐
AD1-B9	3	6	C2	◆	☐	☐	☐	☐	☐	☐							
AD1-C5	0	3	C2	◆	☐	☐	☐	☐	☐	☐							
AD1-C5	3	6	C2	◆	☐	☐	☐	☐	☐	☐							
AD1-C6	0	3	C2	◆	☐	☐	☐	☐	☐	☐							
AD1-C6	3	6	C2	◆	☐	☐	☐	☐	☐	☐							
AD1-C7	0	3	C2	◆	☐	☐	☐	☐	☐	☐							
AD1-C7	3	6	C2	◆	☐	☐	☐	☐	☐	☐							
AD1-C8	0	3	C2	◆	◆	◆	◆	◆	◆	◆							
AD1-C8	3	6	C2	◆	◆	◆	◆	◆	◆	◆							
AD1-C9	0	3	C2	◆	☐	☐	☐	◆	◆	◆							
AD1-C9	3	6	C2	◆	☐	☐	☐	☐	☐	☐							
AD1-D5	0	3	C2	◆	☐	☐	☐	◆	◆	◆							
AD1-D5	3	6	C2	◆	☐	☐	☐	◆	◆	◆							
AD1-D6	0	3	C2	◆	☐	☐	☐	☐	☐	☐							
AD1-D6	3	6	C2	◆	☐	☐	☐	☐	☐	☐							
AD1-E5	0	3	C2	◆	☐	☐	☐	☐	☐	☐							
AD1-E5	3	6	C2	◆	☐	☐	☐	☐	☐	☐							
AD1-E6	0	3	C2	◆	☐	☐	☐	☐	☐	☐							
AD1-E6	3	6	C2	◆	☐	☐	☐	☐	☐	☐							
AD1-E7	0	3	C2	◆	☐	☐	☐	☐	☐	☐	◆	☐	☐	☐	☐	☐	☐
AD1-E7	3	6	C2	◆	☐	☐	☐	☐	☐	☐							
AD1-E8	0	3	C2	◆	◆	◆	◆	◆	◆	◆							
AD1-E8	3	6	C2	◆	◆	◆	◆	◆	◆	◆							
AD1-E9	0	3	C2	◆	◆	☐	☐	◆	◆	◆							

Table 3-3. Summary of Samples Replaced with Surrogate Values for Each CMS Alternative

Sample Location ID	Sample Depth (in) Start	End	Reach	Arsenic Data CMA 2	CMA 3	CMA 4	CMA 5	CMA 6A/B	CMA 7A/B	CMA 8	Non-Arsenic Data CMA 2	CMA 3	CMA 4	CMA 5	CMA 6A/B	CMA 7A/B	CMA 8
AD1-E9	3	6	C2	◆	◆	□	□	◆	◆	◆							
AD1-F5	0	3	C2	◆	□	□	□	◆	◆	◆	◆	□	□	□	◆	◆	◆
AD1-F5	3	6	C2	◆	□	□	□	□	◆	◆							
AD1-F6	0	3	C2	◆	□	□	□	□	□	□							
AD1-F6	3	6	C2	◆	□	□	□	□	□	□							
AD1-G5	0	3	C2	◆	□	□	□	◆	◆	◆	◆	□	□	□	◆	◆	◆
AD1-G5	3	6	C2	◆	□	□	□	□	◆	◆							
AD1-G6	0	3	C2	◆	□	□	□	□	□	□							
AD1-G6	3	6	C2	◆	□	□	□	□	□	□							
AD1-G7	0	3	C2	◆	◆	□	□	◆	◆	◆							
AD1-G7	3	6	C2	◆	◆	□	□	◆	◆	◆							
AD1-G8	0	3	C2	◆	◆	□	□	◆	◆	◆							
AD1-G8	3	6	C2	◆	□	□	□	◆	◆	◆							
AD1-G9	0	3	C2	◆	□	□	□	□	□	□							
AD1-G9	3	6	C2	◆	□	□	□	□	□	□							
C5.5E1	0	3	C2	◆	◆	◆	◆	◆	◆	◆							
C5.5E1	3	6	C2	◆	◆	◆	◆	◆	◆	◆							
C5.5E2	0	3	C2	◆	◆	□	□	◆	◆	◆							
C5.5E2	3	6	C2	◆	◆	□	□	◆	◆	◆							
C5.5E3	0	3	C2	◆	□	□	□	□	◆	◆							
C5.5E3	3	6	C2	◆	□	□	□	□	◆	◆							
C5.5E4	0	3	C2	◆	□	□	□	◆	◆	◆							
C5.5E4	3	6	C2	◆	□	□	□	◆	◆	◆							
C5.5E5	0	3	C2	◆	□	□	□	◆	◆	◆							
C5.5E5	3	6	C2	◆	□	□	□	□	◆	◆							
C5.5E6	0	3	C2	◆	□	□	□	□	□	□							
C5.5E6	3	6	C2	◆	□	□	□	□	□	□							
C5.5E7	0	3	C2	◆	□	□	□	□	◆	◆							
C5.5E7	3	6	C2	◆	□	□	□	□	◆	◆							
C5.5S	0	3	C2	◆	◆	◆	◆	◆	◆	◆							
C5.5S	3	6	C2	◆	◆	◆	◆	◆	◆	◆							
C5.5W1	0	3	C2	◆	◆	◆	◆	◆	◆	◆							
C5.5W1	3	6	C2	◆	◆	◆	◆	◆	◆	◆							
C5.5W2	0	3	C2	◆	◆	□	□	◆	◆	◆							
C5.5W2	3	6	C2	◆	◆	□	□	◆	◆	◆							
C5.5W3	0	3	C2	◆	◆	□	□	◆	◆	◆							
C5.5W3	3	6	C2	◆	□	□	□	◆	◆	◆							
C5.5W4	0	3	C2	◆	◆	□	□	◆	◆	◆							
C5.5W4	3	6	C2	◆	□	□	□	□	□	□							
C5E1	0	3	C2	◆	◆	◆	◆	◆	◆	◆							
C5E1	3	6	C2	◆	◆	◆	◆	◆	◆	◆							
C5E2	0	3	C2	◆	◆	◆	◆	◆	◆	◆							
C5E2	3	6	C2	◆	◆	◆	◆	◆	◆	◆							

Table 3-3. Summary of Samples Replaced with Surrogate Values for Each CMS Alternative

Sample Location ID	Sample Depth (in)		Reach	Arsenic Data							Non-Arsenic Data						
	Start	End		CMA 2	CMA 3	CMA 4	CMA 5	CMA 6A/B	CMA 7A/B	CMA 8	CMA 2	CMA 3	CMA 4	CMA 5	CMA 6A/B	CMA 7A/B	CMA 8
C5E3	0	3	C2	◆	◆	◆	◆	◆	◆	◆							
C5E3	3	6	C2	◆	◆	◆	◆	◆	◆	◆							
C5E4	0	3	C2	◆	◆	◆	◆	◆	◆	◆							
C5E4	3	6	C2	◆	◆	◆	◆	◆	◆	◆							
C5E5	0	3	C2	◆	□	□	□	□	□	□							
C5E5	3	6	C2	◆	□	□	□	□	□	□							
C5E6	0	3	C2	◆	□	□	□	□	□	□							
C5E6	3	6	C2	◆	□	□	□	□	□	□							
C5E7	0	3	C2	◆	□	□	□	□	□	□							
C5E7	3	6	C2	◆	□	□	□	□	□	□							
C5S	0	3	C2	◆	◆	◆	◆	◆	◆	◆							
C5S	3	6	C2	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆
C5W1	0	3	C2	◆	◆	◆	◆	◆	◆	◆							
C5W1	3	6	C2	◆	◆	◆	◆	◆	◆	◆							
C5W2	0	3	C2	◆	◆	◆	◆	◆	◆	◆							
C5W2	3	6	C2	◆	◆	◆	◆	◆	◆	◆							
C5W3	0	3	C2	◆	◆	□	◆	◆	◆	◆							
C5W3	3	6	C2	◆	◆	□	◆	◆	◆	◆							
C5W4	0	3	C2	◆	◆	□	□	◆	◆	◆							
C5W4	3	6	C2	◆	◆	□	□	◆	◆	◆							
C5W5	0	3	C2	◆	◆	□	□	◆	◆	◆							
C5W5	3	6	C2	◆	◆	□	□	◆	◆	◆							
C5W6	0	3	C2	◆	◆	□	□	◆	◆	◆							
C5W6	3	6	C2	◆	□	□	□	◆	◆	◆							
C6	0	6	C2	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆
29-Dec	0	6	C2	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆
AD2-C10	0	3	C2	□	□	□	□	□	□	□							
AD2-C10	3	6	C2	□	□	□	□	□	□	□							
AD2-C11	0	3	C2	□	□	□	□	□	□	□							
AD2-C11	3	6	C2	□	□	□	□	□	□	□							
AD3-F1	0	3	C2	□	□	□	□	□	□	□							
AD3-F1	3	6	C2	□	□	□	□	□	□	□							
AD3-F2	0	3	C2	□	□	□	□	□	□	□							
AD3-F2	3	6	C2	□	□	□	□	□	□	□							
AD3-F3	0	3	C2	□	□	□	□	□	□	□							
AD3-F3	3	6	C2	□	□	□	□	□	□	□							
AD3-F4	0	3	C2	□	□	□	□	□	□	□							
AD3-F4	3	6	C2	□	□	□	□	□	□	□							
AE1-H10	0	3	C2	□	□	□	□	□	□	□							
AE1-H10	3	6	C2	□	□	□	□	□	□	□							
AE1-H5	0	3	C2	◆	◆	◆	◆	◆	◆	◆							
AE1-H5	3	6	C2	◆	◆	◆	◆	◆	◆	◆							
AE1-H6	0	3	C2	◆	◆	◆	◆	◆	◆	◆							

Table 3-3. Summary of Samples Replaced with Surrogate Values for Each CMS Alternative

Sample Location ID	Sample Depth (in)			Arsenic Data							Non-Arsenic Data						
	Start	End	Reach	CMA 2	CMA 3	CMA 4	CMA 5	CMA 6A/B	CMA 7A/B	CMA 8	CMA 2	CMA 3	CMA 4	CMA 5	CMA 6A/B	CMA 7A/B	CMA 8
AE1-H6	3	6	C2	◆	◆	◆	◆	◆	◆	◆							
AE1-H9	0	3	C2	□	□	□	□	□	□	□	□	□	□	□	□	□	□
AE1-H9	3	6	C2	□	□	□	□	□	□	□							
AE1-I5	0	3	C2	◆	◆	◆	◆	◆	◆	◆							
AE1-I5	3	6	C2	◆	◆	◆	◆	◆	◆	◆							
AE1-I6	0	3	C2	◆	◆	◆	◆	◆	◆	◆							
AE1-I6	3	6	C2	◆	◆	◆	◆	◆	◆	◆							
AE1-I7	0	3	C2	◆	◆	◆	◆	◆	◆	◆							
AE1-I7	3	6	C2	◆	◆	◆	◆	◆	◆	◆							
AE1-I8	0	3	C2	□	□	□	□	□	□	□							
AE1-I8	3	6	C2	□	□	□	□	□	□	□							
AE1-I9	0	3	C2	□	□	□	□	□	□	□	□	□	□	□	□	□	□
AE1-I9	3	6	C2	□	□	□	□	□	□	□							
AE1-J5	0	3	C2	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆
AE1-J5	3	6	C2	◆	◆	◆	◆	◆	◆	◆							
AE1-J9	0	3	C2	□	□	□	□	□	□	□	□	□	□	□	□	□	□
AE1-J9	3	6	C2	□	□	□	□	□	□	□							
C6.5E1	0	3	C2	◆	◆	◆	◆	◆	◆	◆							
C6.5E1	3	6	C2	◆	◆	◆	◆	◆	◆	◆							
C6.5E2	0	3	C2	◆	◆	◆	◆	◆	◆	◆							
C6.5E2	3	6	C2	◆	◆	◆	◆	◆	◆	◆							
C6.5E3	0	3	C2	◆	◆	◆	◆	◆	◆	◆							
C6.5E3	3	6	C2	◆	◆	◆	◆	◆	◆	◆							
C6.5E4	0	3	C2	◆	◆	◆	◆	◆	◆	◆							
C6.5E4	3	6	C2	◆	◆	◆	◆	◆	◆	◆							
C6.5E5	0	3	C2	◆	◆	◆	◆	◆	◆	◆							
C6.5E5	3	6	C2	◆	◆	◆	◆	◆	◆	◆							
C6.5E6	0	3	C2	◆	◆	◆	◆	◆	◆	◆							
C6.5E6	3	6	C2	◆	◆	◆	◆	◆	◆	◆							
C6.5E7	0	3	C2	◆	◆	◆	◆	◆	◆	◆							
C6.5E7	3	6	C2	◆	◆	◆	◆	◆	◆	◆							
C6.5S	0	3	C2	◆	◆	◆	◆	◆	◆	◆							
C6.5S	3	6	C2	◆	□	□	□	□	□	□							
C6.5W1	0	3	C2	□	□	□	□	◆	◆	◆							
C6.5W1	3	6	C2	□	□	□	□	◆	◆	◆							
C6.5W2	0	3	C2	□	□	□	□	□	□	□							
C6.5W2	3	6	C2	□	□	□	□	□	□	□							
C6.5W3	0	3	C2	□	□	□	□	□	□	□							
C6.5W3	3	6	C2	□	□	□	□	□	□	□							
C6E1	0	3	C2	◆	◆	□	□	◆	◆	◆							
C6E1	3	6	C2	◆	◆	□	□	◆	◆	◆							
C6E2	0	3	C2	◆	◆	◆	◆	◆	◆	◆							
C6E2	3	6	C2	◆	◆	◆	◆	◆	◆	◆							

Table 3-3. Summary of Samples Replaced with Surrogate Values for Each CMS Alternative

Sample Location ID	Sample Depth (in)			Arsenic Data							Non-Arsenic Data						
	Start	End	Reach	CMA 2	CMA 3	CMA 4	CMA 5	CMA 6A/B	CMA 7A/B	CMA 8	CMA 2	CMA 3	CMA 4	CMA 5	CMA 6A/B	CMA 7A/B	CMA 8
C6E3	0	3	C2	◆	◆	◆	◆	◆	◆	◆							
C6E3	3	6	C2	◆	◆	◆	◆	◆	◆	◆							
C6E4	0	3	C2	◆	◆	◆	□	◆	◆	◆							
C6E4	3	6	C2	◆	◆	◆	□	◆	◆	◆							
C6E5	0	3	C2	◆	◆	◆	◆	◆	◆	◆							
C6E5	3	6	C2	◆	◆	◆	◆	◆	◆	◆							
C6E6	0	3	C2	◆	◆	◆	◆	◆	◆	◆							
C6E6	3	6	C2	◆	◆	◆	◆	◆	◆	◆							
C6E7	0	3	C2	◆	◆	◆	◆	◆	◆	◆							
C6E7	3	6	C2	◆	◆	◆	◆	◆	◆	◆							
C6E8	0	3	C2	◆	◆	◆	◆	◆	◆	◆							
C6E8	3	6	C2	◆	◆	◆	◆	◆	◆	◆							
C6E9	0	3	C2	◆	◆	◆	◆	◆	◆	◆							
C6E9	3	6	C2	◆	◆	◆	□	◆	◆	◆							
C6S	0	3	C2	◆	◆	◆	◆	◆	◆	◆							
C6S	3	6	C2	◆	□	□	□	□	◆	◆							
C6W1	0	3	C2	◆	◆	◆	◆	◆	◆	◆							
C6W1	3	6	C2	◆	□	□	□	□	□	□							
C6W2	0	3	C2	◆	◆	◆	◆	◆	◆	◆							
C6W2	3	6	C2	◆	◆	□	□	◆	◆	◆							
C6W3	0	3	C2	◆	◆	□	□	◆	◆	◆							
C6W3	3	6	C2	◆	◆	□	□	◆	◆	◆							
C6W4	0	3	C2	◆	□	□	□	□	□	□							
C6W4	3	6	C2	◆	□	□	□	□	□	□							
AE3-H11	0	3	C2	□	□	□	□	□	□	□	□	□	□	□	□	□	□
AE3-H11	3	6	C2	□	□	□	□	□	□	□							
AF1-K5	0	3	C2	◆	◆	◆	◆	◆	◆	◆							
AF1-K5	3	6	C2	◆	◆	◆	◆	◆	◆	◆							
AF1-K6	0	3	C2	◆	◆	◆	◆	◆	◆	◆							
AF1-K6	3	6	C2	◆	◆	◆	◆	◆	◆	◆							
AF1-K7	0	3	C2	◆	□	□	□	◆	◆	◆							
AF1-K7	3	6	C2	◆	□	□	□	◆	◆	◆							
AF1-K8	0	3	C2	◆	□	□	□	◆	◆	◆	◆	□	□	□	◆	◆	◆
AF1-K8	3	6	C2	◆	□	□	□	◆	◆	◆							
AF1-K9	0	3	C2	□	□	□	□	□	□	□							
AF1-K9	3	6	C2	□	□	□	□	□	□	□							
AF1-L10	0	3	C2	◆	◆	□	□	◆	◆	◆							
AF1-L10	3	6	C2	◆	◆	□	□	◆	◆	◆							
AF1-L11	0	3	C2	◆	◆	□	□	◆	◆	◆	◆	◆	□	□	◆	◆	◆
AF1-L11	3	6	C2	◆	◆	□	□	◆	◆	◆							
AF1-L9	0	3	C2	◆	◆	□	□	◆	◆	◆							
AF1-L9	3	6	C2	◆	◆	□	□	◆	◆	◆							
C7E1	0	3	C2	◆	◆	◆	◆	◆	◆	◆							

Table 3-3. Summary of Samples Replaced with Surrogate Values for Each CMS Alternative

Sample Location ID	Sample Depth (in)			Arsenic Data							Non-Arsenic Data						
	Start	End	Reach	CMA 2	CMA 3	CMA 4	CMA 5	CMA 6A/B	CMA 7A/B	CMA 8	CMA 2	CMA 3	CMA 4	CMA 5	CMA 6A/B	CMA 7A/B	CMA 8
C7E1	3	6	C2	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆
C7E10	0	3	C2	◆	◆	◆	◆	◆	◆	◆							
C7E10	3	6	C2	◆	◆	◆	◆	◆	◆	◆							
C7E11	0	3	C2	◆	◆	◆	◆	◆	◆	◆							
C7E11	3	6	C2	◆	◆	◆	◆	◆	◆	◆							
C7E2	0	3	C2	◆	◆	◆	◆	◆	◆	◆							
C7E2	3	6	C2	◆	◆	◆	◆	◆	◆	◆							
C7E3	0	3	C2	◆	◆	◆	◆	◆	◆	◆							
C7E3	3	6	C2	◆	◆	◆	◆	◆	◆	◆							
C7E4	0	3	C2	◆	◆	◆	◆	◆	◆	◆							
C7E4	3	6	C2	◆	◆	◆	◆	◆	◆	◆							
C7E5	0	3	C2	◆	◆	◆	◆	◆	◆	◆							
C7E5	3	6	C2	◆	◆	◆	◆	◆	◆	◆							
C7E6	0	3	C2	◆	◆	◆	◆	◆	◆	◆							
C7E6	3	6	C2	◆	◆	◆	□	◆	◆	◆							
C7E7	0	3	C2	◆	◆	◆	◆	◆	◆	◆							
C7E7	3	6	C2	◆	◆	◆	□	◆	◆	◆							
C7E8	0	3	C2	◆	◆	◆	◆	◆	◆	◆							
C7E8	3	6	C2	◆	◆	◆	◆	◆	◆	◆							
C7E9	0	3	C2	◆	◆	◆	◆	◆	◆	◆							
C7E9	3	6	C2	◆	◆	◆	◆	◆	◆	◆							
C7S	0	3	C2	◆	◆	◆	◆	◆	◆	◆							
C7S	3	6	C2	◆	◆	◆	◆	◆	◆	◆							
C7W1	0	3	C2	◆	◆	◆	◆	◆	◆	◆							
C7W1	3	6	C2	◆	◆	◆	◆	◆	◆	◆							
C7W10	0	3	C2	◆	◆	◆	◆	◆	◆	◆							
C7W10	3	6	C2	◆	◆	◆	◆	◆	◆	◆							
C7W11	0	3	C2	◆	◆	◆	◆	◆	◆	◆							
C7W11	3	6	C2	◆	◆	◆	◆	◆	◆	◆							
C7W2	0	3	C2	◆	◆	◆	◆	◆	◆	◆							
C7W2	3	6	C2	◆	◆	◆	◆	◆	◆	◆							
C7W3	0	3	C2	◆	◆	◆	◆	◆	◆	◆							
C7W3	3	6	C2	◆	◆	◆	◆	◆	◆	◆							
C7W4	0	3	C2	◆	◆	◆	◆	◆	◆	◆							
C7W4	3	6	C2	◆	◆	◆	◆	◆	◆	◆							
C7W5	0	3	C2	◆	◆	◆	◆	◆	◆	◆							
C7W5	3	6	C2	◆	◆	◆	◆	◆	◆	◆							
C7W6	0	3	C2	◆	◆	◆	◆	◆	◆	◆							
C7W6	3	6	C2	◆	◆	◆	◆	◆	◆	◆							
C7W7	0	3	C2	◆	◆	◆	◆	◆	◆	◆							
C7W7	3	6	C2	◆	◆	◆	◆	◆	◆	◆							
C7W8	0	3	C2	◆	◆	◆	◆	◆	◆	◆							
C7W8	3	6	C2	◆	◆	◆	◆	◆	◆	◆							

Table 3-3. Summary of Samples Replaced with Surrogate Values for Each CMS Alternative

Sample Location ID	Sample Depth (in)			Arsenic Data							Non-Arsenic Data						
	Start	End	Reach	CMA 2	CMA 3	CMA 4	CMA 5	CMA 6A/B	CMA 7A/B	CMA 8	CMA 2	CMA 3	CMA 4	CMA 5	CMA 6A/B	CMA 7A/B	CMA 8
C7W9	0	3	C2	◆	◆	◆	◆	◆	◆	◆							
C7W9	3	6	C2	◆	◆	◆	◆	◆	◆	◆							
C7.3E1	0	3	C3	◆	◆	◆	◆	◆	◆	◆							
C7.3E1	3	6	C3	◆	◆	◆	◆	◆	◆	◆							
C7.3E2	0	3	C3	◆	◆	◆	□	◆	◆	◆							
C7.3E2	3	6	C3	◆	◆	□	□	◆	◆	◆							
C7.3E3	0	3	C3	□	□	□	□	□	□	□							
C7.3E3	3	6	C3	□	□	□	□	□	□	□							
C7.3S	0	3	C3	◆	◆	□	□	◆	◆	◆							
C7.3W1	0	3	C3	□	◆	□	□	◆	◆	◆							
C7.3W1	3	6	C3	□	◆	□	□	◆	◆	◆							
C7.3W2	0	3	C3	□	□	□	□	□	□	□							
C7.3W2	3	6	C3	□	□	□	□	□	□	□							
C7.3W3	0	3	C3	□	□	□	□	□	□	□							
C7.3W3	3	6	C3	□	□	□	□	□	□	□							
C8W4	0	3	C3	□	□	□	□	□	□	□							
C8W4	3	6	C3	□	□	□	□	□	□	□							
C8W5	0	3	C3	□	□	□	□	□	□	□							
C8W5	3	6	C3	□	□	□	□	□	□	□							
C8E1	0	3	C3	◆	◆	◆	□	◆	◆	◆							
C8E1	3	6	C3	◆	◆	◆	□	◆	◆	◆							
C8E2	0	3	C3	◆	◆	◆	◆	◆	◆	◆							
C8E2	3	6	C3	◆	◆	◆	□	◆	◆	◆							
C8E3	0	3	C3	◆	◆	◆	◆	◆	◆	◆							
C8E3	3	6	C3	◆	◆	□	□	◆	◆	◆							
C8S	0	3	C3	◆	◆	□	□	◆	◆	◆							
C8S	3	6	C3	◆	◆	□	□	◆	◆	◆							
C8W1	0	3	C3	◆	◆	□	□	◆	◆	◆							
C8W1	3	6	C3	◆	◆	□	□	◆	◆	◆							
C8W2	0	3	C3	◆	◆	□	□	◆	◆	◆							
C8W2	3	6	C3	◆	◆	□	□	◆	◆	◆							
C8W3	0	3	C3	◆	□	□	□	□	□	□							
C8W3	3	6	C3	◆	□	□	□	□	□	□							
C7.5E1	0	3	C3	◆	◆	◆	◆	◆	◆	◆							
C7.5E1	3	6	C3	◆	◆	◆	◆	◆	◆	◆							
C7.5E2	0	3	C3	◆	◆	◆	□	◆	◆	◆							
C7.5E2	3	6	C3	◆	◆	□	□	◆	◆	◆							
C7.5E3	0	3	C3	◆	◆	◆	□	◆	◆	◆							
C7.5E3	3	6	C3	◆	□	□	□	□	□	□							
C7.5E4	0	3	C3	□	□	□	□	□	□	□							
C7.5E4	3	6	C3	□	□	□	□	□	□	□							
C7.5S	0	3	C3	◆	◆	□	□	◆	◆	◆							
C7.5S	3	6	C3	◆	◆	□	□	◆	◆	◆							

Table 3-3. Summary of Samples Replaced with Surrogate Values for Each CMS Alternative

Sample Location ID	Sample Depth (in)			Arsenic Data							Non-Arsenic Data						
	Start	End	Reach	CMA 2	CMA 3	CMA 4	CMA 5	CMA 6A/B	CMA 7A/B	CMA 8	CMA 2	CMA 3	CMA 4	CMA 5	CMA 6A/B	CMA 7A/B	CMA 8
C7.5W1	0	3	C3	◆	◆	□	□	◆	◆	◆							
C7.5W1	3	6	C3	◆	◆	□	□	◆	◆	◆							
C7.5W2	0	3	C3	□	□	□	□	□	□	□							
C7.5W2	3	6	C3	□	□	□	□	□	□	□							
C7.5W3	0	3	C3	□	□	□	□	□	□	□							
C7.5W3	3	6	C3	□	□	□	□	□	□	□							
C8.2E1	0	3	C3	◆	◆	□	□	◆	◆	◆							
C8.2E1	3	6	C3	◆	◆	□	□	◆	◆	◆							
C8.2E2	0	3	C3	◆	◆	□	□	◆	◆	◆							
C8.2E2	3	6	C3	◆	◆	□	□	◆	◆	◆							
C8.2E3	0	3	C3	◆	◆	□	□	◆	◆	◆							
C8.2E3	3	6	C3	◆	◆	□	□	◆	◆	◆							
C8.2E4	0	3	C3	◆	◆	◆	□	◆	◆	◆							
C8.2E4	3	6	C3	◆	◆	□	□	◆	◆	◆							
C8.2E5	0	3	C3	◆	◆	□	□	◆	◆	◆							
C8.2E5	3	6	C3	◆	□	□	□	◆	◆	◆							
C8.2E6	0	3	C3	◆	□	□	□	□	◆	◆							
C8.2E6	3	6	C3	◆	□	□	□	□	□	□							
C8.2E7	0	3	C3	◆	□	□	□	□	◆	◆							
C8.2E7	3	6	C3	◆	□	□	□	□	□	□							
C8.5E2	0	3	C3	◆	□	□	□	◆	◆	◆							
C8.5E2	3	6	C3	□	□	□	□	□	□	□							
C8.5E3	0	3	C3	◆	◆	□	□	◆	◆	◆							
C8.5E4	0	3	C3	◆	◆	□	□	◆	◆	◆							
C8.5E4	3	6	C3	◆	□	□	□	◆	◆	◆							
C8.5E5	0	3	C3	◆	◆	□	□	◆	◆	◆							
C8.5E5	3	6	C3	◆	□	□	□	□	◆	◆							
C8.5E6	0	3	C3	◆	◆	□	□	◆	◆	◆							
C8.5E6	3	6	C3	◆	□	□	□	□	□	□							
C8.5E7	0	3	C3	◆	◆	□	□	◆	◆	◆							
C8.5E7	3	6	C3	◆	□	□	□	□	□	□							
C8E4	0	3	C3	◆	◆	◆	□	◆	◆	◆							
C8E4	3	6	C3	◆	◆	□	□	◆	◆	◆							
C8E5	0	3	C3	◆	◆	◆	□	◆	◆	◆							
C8E5	3	6	C3	◆	◆	□	□	◆	◆	◆							
C8E6	0	3	C3	◆	◆	□	□	◆	◆	◆							
C8E6	3	6	C3	◆	◆	□	□	◆	◆	◆							
C8E7	0	3	C3	◆	◆	□	□	◆	◆	◆							
C8E7	3	6	C3	◆	◆	□	□	◆	◆	◆							
C8E8	0	3	C3	◆	◆	□	□	◆	◆	◆							
C8E8	3	6	C3	◆	◆	□	□	◆	◆	◆							
C8E9	0	3	C3	◆	□	□	□	□	◆	◆							
C8E9	3	6	C3	◆	□	□	□	□	□	□							

Table 3-3. Summary of Samples Replaced with Surrogate Values for Each CMS Alternative

Sample Location ID	Sample Depth (in)			Arsenic Data							Non-Arsenic Data						
	Start	End	Reach	CMA 2	CMA 3	CMA 4	CMA 5	CMA 6A/B	CMA 7A/B	CMA 8	CMA 2	CMA 3	CMA 4	CMA 5	CMA 6A/B	CMA 7A/B	CMA 8
C8.5E1	0	3	C3	◆	□	□	□	□	□	□							
C8.5E1	3	6	C3	◆	□	□	□	□	□	□							
C8.5S	0	3	C3	◆	◆	□	□	◆	◆	◆							
C8.5S	3	6	C3	◆	◆	□	□	◆	◆	◆							
C8.5W1	0	3	C3	◆	□	□	□	□	□	□							
C8.5W1	3	6	C3	◆	□	□	□	□	□	□							
C9E1	0	3	C3	◆	◆	□	□	◆	◆	◆							
C9E1	3	6	C3	◆	□	□	□	□	◆	◆							
C9E2	0	3	C3	◆	□	□	□	□	□	□							
C9E2	3	6	C3	□	□	□	□	□	□	□							
C9E3	0	3	C3	◆	□	□	□	□	□	□							
C9E3	3	6	C3	□	□	□	□	□	□	□							
C9S	0	3	C3	◆	◆	◆	◆	◆	◆	◆							
C9S	3	6	C3	◆	◆	◆	◆	◆	◆	◆							
C9W1	0	3	C3	◆	◆	◆	◆	◆	◆	◆							
C9W1	3	6	C3	◆	◆	◆	◆	◆	◆	◆							
C9W2	0	3	C3	◆	◆	◆	◆	◆	◆	◆							
C9W2	3	6	C3	◆	◆	◆	◆	◆	◆	◆							
C9W3	0	3	C3	◆	◆	◆	◆	◆	◆	◆							
C9W3	3	6	C3	◆	◆	◆	◆	◆	◆	◆							
C8.2W1	0	3	C3	◆	□	□	□	□	□	□							
C8.2W1	3	6	C3	◆	□	□	□	□	□	□							
C10S	0	3	C3	◆	◆	□	□	◆	◆	◆							
C10S	3	6	C3	◆	◆	□	□	◆	◆	◆							
C10W1	0	3	C3	◆	◆	◆	◆	◆	◆	◆							
C10W1	3	6	C3	◆	◆	◆	◆	◆	◆	◆							
C10W2	0	3	C3	◆	◆	◆	◆	◆	◆	◆							
C10W2	3	6	C3	◆	◆	◆	◆	◆	◆	◆							
C10W3	0	3	C3	□	□	□	□	□	□	□							
C10W3	3	6	C3	□	□	□	□	□	□	□							
C8.5W2	0	3	C3	◆	□	□	□	□	□	□							
C8.5W2	3	6	C3	◆	□	□	□	□	□	□							
C8.5W3	0	3	C3	◆	□	□	□	□	□	□							
C8.5W3	3	6	C3	◆	□	□	□	□	□	□							
C8.5W4	0	3	C3	◆	□	□	□	□	□	□							
C8.5W4	3	6	C3	◆	□	□	□	□	□	□							
C8.5W5	0	3	C3	◆	◆	◆	◆	◆	◆	◆							
C8.5W5	3	6	C3	◆	□	□	□	□	□	◆							
C8.5W6	0	3	C3	□	□	□	□	□	□	□							
C8.5W6	3	6	C3	□	□	□	□	□	□	□							
C8.5W7	0	3	C3	□	□	□	□	□	□	□							
C8.5W7	3	6	C3	□	□	□	□	□	□	□							
C9.5W1	0	3	C3	□	□	□	□	□	□	□							

Table 3-3. Summary of Samples Replaced with Surrogate Values for Each CMS Alternative

Sample Location ID	Sample Depth (in)			Arsenic Data							Non-Arsenic Data						
	Start	End	Reach	CMA 2	CMA 3	CMA 4	CMA 5	CMA 6A/B	CMA 7A/B	CMA 8	CMA 2	CMA 3	CMA 4	CMA 5	CMA 6A/B	CMA 7A/B	CMA 8
C9.5W1	3	6	C3	□	□	□	□	□	□	□							
C9.5W2	0	3	C3	□	□	□	□	□	□	□							
C9.5W2	3	6	C3	□	□	□	□	□	□	□							
C9.5W3	0	3	C3	□	□	□	□	□	□	□							
C9.5W3	3	6	C3	□	□	□	□	□	□	□							
C9W4	0	3	C3	◆	□	◆	□	□	□	◆							
C9W4	3	6	C3	◆	□	◆	□	□	□	◆							
C9W5	0	3	C3	◆	□	◆	□	□	□	◆							
C9W5	3	6	C3	◆	□	□	□	□	□	◆							
C9W6	0	3	C3	◆	□	◆	□	□	□	◆							
C9W6	3	6	C3	◆	□	□	□	□	□	◆							
C9W7	0	3	C3	□	□	□	□	□	□	□							
C9W7	3	6	C3	□	□	□	□	□	□	□							
C9W8	0	3	C3	□	□	□	□	□	□	□							
C9W8	3	6	C3	□	□	□	□	□	□	□							
C8.2W2	0	3	C3	◆	□	□	□	□	□	□							
C8.2W2	3	6	C3	◆	□	□	□	□	□	□							
C8.2W3	0	3	C3	□	□	□	□	□	□	□							
C8.2W3	3	6	C3	□	□	□	□	□	□	□							
C7	0	6	C3	◆	◆	◆	□	◆	◆	◆	◆	◆	◆	□	◆	◆	◆
C10E1	0	3	C3	◆	◆	◆	□	◆	◆	◆							
C10E1	3	6	C3	◆	◆	□	□	◆	◆	◆							
C10E2	0	3	C3	◆	◆	□	□	◆	◆	◆							
C10E2	3	6	C3	◆	◆	□	□	◆	◆	◆							
C10E3	0	3	C3	◆	◆	□	□	◆	◆	◆							
C10E3	3	6	C3	◆	◆	□	□	◆	◆	◆							

Notes:
◆ = Sample removed and replaced with surrogate value for CMS alternative.
□ = Sample retained for CMS alternative.
A blank entry under the non-arsenic columns indicates that no sample result was available from this location.