CDM

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Salford Quarry Site
Lower Salford Township

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Revised Final Remedial Investigation Report

Volume III of III

Appendix G - Revised Final SLERA

APPENDIX G

REVISED FINAL SCREENING LEVEL ECOLOGICAL RISK ASSESSMENT

Response Action Contract for Remedial Planning and Oversight Activities at Sites in EPA Region III

U.S. EPA Contract No. 68-S7-3003

Revised Final
Screening Level Ecological Risk Assessment
for
Salford Quarry Superfund Site
Lower Salford Township
Montgomery County, Pennsylvania

Work Assignment No.: 036-RICO-03Y3

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Contents

Contents (cont'd.)

Attachments

Tables

Figures

Section 1
Introduction

This Screening Level Ecological Risk Assessment (SLERA) has been completed for the Salford Quarry Superfund Site located in Lower Salford Township, Montgomery County, Pennsylvania to characterize the risk to ecological receptors on and near the site that may be exposed to contaminants in groundwater, surface water, soil, and sediment. The document has been prepared by CDM Federal Programs Corporation (CDM) for the United States Environmental Protection Agency (EPA) Region III, as authorized under Work Assignment No. 036-RICO-03Y3 of the Response Action Contract (RAC) 68-S7-3003. This SLERA represents Steps 1, 2, and portions of Step 3 of the EPA's Ecological Risk Assessment Process (EPA 1997).

This SLERA addresses risk to terrestrial receptors from contaminants in site groundwater, surface water, sediment, and soil. The West Branch of Skippack Creek, which contains numerous sensitive receptors, is a receiving waterbody of groundwater at the site, and is therefore impacted by the transport of contaminants from groundwater.

Data collected by CDM during the Fall 2002 and during the Remedial Investigation (RI) performed from June 2004 to November 2004 are used in this SLERA. Although several investigations were conducted at the site prior to the RI, no ecological risk assessment (ERA) was completed. This SLERA is intended to allow the risk assessment team and risk manager to rapidly determine if the site poses ecological risk and to identify which contaminants and exposure pathways require further evaluation. This information will then be used during remedy selection.

This document was prepared following the format, guidance, and methods described in EPA's *"Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments"* (EPA 1997) and the *Draft Technical Approach to Complete the Screening Level Ecological Risk Assessment* (CDM 2004). In addition, discussions with EPA personnel helped formulate the approach taken in the SLERA. Literature-based toxicity values were used to develop the food chain models. Both conservative and site specific exposure parameter assumptions were used to calculate exposure doses in the SLERA.

This SLERA is composed of the following components :

- Screening Level Problem Formulation—a qualitative evaluation of contaminant release, migration, and fate; identification of contaminants of concern, receptors, exposure pathways, and known ecological effects of the contaminants; and selection of endpoints for further study.

- Screening Level Exposure Assessment—a quantitative evaluation of contaminant release, migration, and fate; characterization of exposure pathways and receptors; and measurement or estimation of exposure point concentrations.

- Screening Level Ecological Effects Evaluation—literature reviews linking contaminant concentrations to effects on ecological receptors.
- Screening Level Risk Characterization—measurement or estimation of both current and future adverse effects.
- Screening Level Uncertainty Assessment—presentation of factors that provide uncertainty to this risk assessment.
- Preliminary Remediation Goals (PRGs)

Section 2
Screening Level Problem Formulation

This section provides a description of the environmental setting and nature and extent of contamination, presents the preliminary conceptual model of the site, and describes the process of selecting contaminants of potential concern.

2.1 Environmental Setting

This section presents the site conditions including a physical description of the site itself, local topography and drainage, and a description of local habitats and resident flora and fauna, including any endangered species.

2.1.1 Site Description

The Salford Quarry site is located at 610 Quarry Road in Lower Salford Township, Montgomery County, Pennsylvania (Figures 2-1 and 2-2). The site, which covers approximately three acres, is bounded on the north, south, and east by residential properties, and on the west by Quarry Road.

The site is situated on a parcel with an abandoned rock quarry that covers approximately 1.5 acres. The quarry was formed on the side of a hill by the mining of rock for crushed stone. Site mining operations and subsequent backfilling of the quarry have resulted in a roughly U-shaped outline of the quarry walls with the western side of the quarry backfilled to grade. The land in the vicinity of the site is primarily wooded, with an open meadow to the southwest. The West Branch of Skippack Creek flows through Lower Salford Township property to the west of the site (Figures 2-1 and 2-2).

2.1.2 Site Topography and Drainage

Topography around the site is characterized by moderately broad, gently rolling hills separated by moderately narrow to moderately broad valley bottoms. Perkiomenville, Telford, Collegeville, and Lansdale, PA U.S. Geological Survey (USGS) 7.5 Minute Quadrangles indicate that elevations within a ½-mile radius of the site range from approximately 200 to 320 feet above mean sea level (amsl). The elevation of the quarry cap is approximately 235 feet amsl, based on surveyed ground surface elevations for site monitoring wells MW-02 and MW-05, which are located onsite immediately adjacent to the western side of the quarry.

The West Branch of Skippack Creek receives the majority of surface water runoff from the site. Water drains off the site and across Quarry Road to the west via the ramp to the front gate. Water also drains off the site to the southwest and flows to a culvert near the south boundary of the site that runs to the west under Quarry Road. On the west side of the road, storm water flows from the culvert down a slope into a dry creek bed containing a ponded spring located at the bottom of the slope. The dry creek bed reaches to the southwest and intersects with the West Branch of the Skippack Creek.

2.1.3 Site History

Shale was quarried at the site in the early 1900's. After quarrying operations ceased in the 1930's, the quarry was used as a swimming hole. The quarry then began to be used by various parties as a waste depository. For example, in the 1950s, industrial, commercial and residential wastes were deposited in the landfill by a local hauler. The quarry was also used to dispose of fly ash cinders from a coal-fired plant. In 1963, the quarry was purchased by the American Olean Tile Company (AOT), a subsidiary of the National Gypsum Company, for waste disposal use. From 1963 until 1980, the quarry was used as a disposal area for fired and unfired tile waste and wash water slurry. These wastes originated from the manufacture of glazed ceramic tile and contained boron in the form of boron oxide and borosilicate. According to AOT, beginning in 1973, the site was utilized for the disposal of the majority of their lead-containing slurries. In 1981 two 10,000-gallon tanks containing mostly tile slurry buried by AOT were unearthed. Some fuel oil was in one compartment of one of the tanks. The fuel oil was removed and transported offsite for proper disposal. The Pennsylvania Department of Environmental Resources (PADER) allowed AOT to close the tanks in-place after the oil was removed. The site was officially closed in 1982 under PADER supervision. Closure of the site consisted of placing and compacting clayey soil on top of the waste, covering the fill soil with topsoil, and planting grass. Currently, the closed quarry exists as a relatively flat grassy field.

An investigation conducted in 1983 revealed high levels of boron in samples collected from onsite monitoring wells, surface water samples collected in the vicinity of the site, and nearby residential well samples. Low levels of trichloroethylene (TCE) contamination were also detected in one residential well sample. In January 1987, the Salford Quarry site was proposed for listing on the National Priorities List (NPL). When National Gypsum took title to the site in 1988, AOT assigned its obligation under the Consent Agreement to National Gypsum, the potentially responsible party (PRP).

The PRP began conducting a Remedial Investigation/Feasibility Study (RI/FS) of the site in the late 1980's. The majority of field work performed for the RI was conducted in 1991 and 1992. The site was removed from the NPL in 1992. The PRP discontinued RI/FS work when the site was removed from the NPL.

From July 1993 to January 1995, the EPA funded construction of a public water line for 113 residences in the area of the Salford Quarry site. Bottled water was supplied to affected residents by the PRP during the period when EPA was constructing the water line. The connections enabled all immediate threats to human health to be eliminated while EPA evaluated whether additional studies or cleanup activities would be necessary. After completion of the public water line, EPA re-scored the site and re-proposed it for inclusion on the NPL on April 1, 1997. The site remains in proposed status.

In the fall of 2002, CDM collected groundwater samples from site monitoring wells and a limited number of neighboring residential wells and surveyed a reach of the West Branch of the Skippack Creek. The results of the sampling and survey work are presented in the *Draft Data Evaluation Report Salford Quarry Site* (CDM 2003). Data collected during the event were used to aid in developing the scope of the field investigation for the subsequent RI/FS.

2.1.4 Habitat and Biota

An ecological reconnaissance is typically completed as part of the SLERA and is used to characterize the site ecology (i.e., to map habitats, identify ecological receptors, and identify potential contaminant exposure pathways). EPA requested that the characterization information reported in *"Natural Resources Inventory and Analysis Report, Vegetation and Natural Communities - Wildlife and Rare/Threatened/Endangered Species - Aquatic, Salford Quarry"* (NRI Report), by Eastern States Environmental Associates (ESEA), dated September 7, 1990, be used for the SLERA, and that a separate ecological reconnaissance not be performed. The NRI Report, with supplementary information added as needed, was used to describe the terrestrial and aquatic habitats, wildlife, and endangered species. A field inventory of the study area, inclusive of the quarry site and its immediate vicinity, determined that a variety of general habitat types are present in this area. These general habitat types include agriculture, low density residential development, early successional disturbed field, and stream corridor habitats consisting of open grove/meadow, forested woodlands, forested wetlands, and scrub/shrub wetlands.

2.1.4.1 Agriculture

This type of habitat includes a moderately sized area in the vicinity of the site. In areas to the southeast of the site is agricultural land maintained as hay and corn fields. Also, a local resident maintains a significant area where vegetables are grown. Along with low to moderate density residential development, agriculture land is the predominant habitat type associated with the West Branch of the Skippack Creek watershed upstream from the site. However, residential development is common in the area and the amount of available agricultural habitat has decreased since the NRI Report was prepared. For example, since the NRI Report was completed, a housing development was constructed directly to the east of the site in an area previously occupied by a hay field.

2.1.4.2 Residential Development

Resiential development includes a substantial area in the vicinity of the site. Single family residential homes on less than one acre to a few acres (two to four acres) are common around the site. This type of habitat has increased significantly since the NRI Report was prepared. This habitat type generally consists of single family residential homes with associated driveways and individual septic systems along with landscaped lawns and ornamental plantings. Residential development was found to exist north of the site and also west of the West Branch of the Skippack Creek. Such development is an increasingly occurring habitat type associated with the watershed upstream of the site.

2.1.4.3 Open Grove/Meadow

Open grove and meadow habitat includes a substantial area in the vicinity of the site and is primarily associated with the overall stream corridor habitat along the West Branch of Skippack Creek. This habitat type is characterized by its open, park like appearance, with scattered trees and patches of canopy vegetation. This open grove and meadow habitat generally has very little understory vegetation and a very lush groundcover. It includes both upland field and emergent wetland characteristics. With the exception of the forested upland and wetland areas and the scrub/shrub wetland area, a large portion of the stream corridor of the West Branch of the Skippack Creek in the vicinity of the site consists of open grove and meadow. Although abundant in the study area, this habitat type may not be in abundance in the general region of the site due to current land use practices. A significant portion of open grove and meadow in the vicinity of the site consists of a township park.

Canopy vegetation of open grove and meadow is generally scattered, with a low to moderate overall coverage density (10 - 50 percent) consisting primarily of black walnut (*Juglans nigra*), white ash (*Fraxinus americana*), red oak (*Quercus rubra*), white oak (*Quercus alba*), shagbark hickory (*Carya ovata*), mockernut hickory (*Carya tomentosa*), elm (*Ulmus americana*), black cherry (*Prunus serotina*), and eastern red cedar (*Juniperus virginiana*). Subcanopy vegetation is virtually nonexistent with the exception of scattered patches. Therefore, subcanopy vegetation generally has a low coverage density (0 - 30 percent coverage) consisting primarily of multiflora rose (*Rosa multiflora*), raspberry (*Rubus idaeus*), blackberry (*Rubus pensylvanicus*), black cherry, and elm. Ground cover throughout this habitat generally has a high coverage density (100 percent) and consists primarily of grasses, white clover (*Trifolium repens*), red clover (*Trifolium pratense*), plantain (*Plantago major*), cinquefoil (*Potentilla canadensis*), tall goldenrod (*Solidago altissima*), yarrow (*Achillea millefolium*), foxtail (*Alopecurus brachystachus*), Queen Anne's lace (*Daucus carota*), ragweed (*Ambrosia artemisiifolia*), daisy fleabane (*Erigeron annuus*), and numerous other herbaceous species.

2.1.4.4 Forested Broad-leaved Deciduous Woodlands

The forested deciduous woodlands habitat includes a rather small area in the vicinity of the site and is primarily associated with the overall stream corridor habitat along the West Branch of Skippack Creek. A small patch of this forested woodland habitat is located immediately adjacent to the disturbed portion of the quarry; this habitat is also associated with the rather steep slope existing between the creek and Quarry Road in the immediately vicinity of the site. The habitat type also is found in a relatively narrow strip to the west of the creek and also upstream from Morris Road. Forested deciduous woodlands are not unique to the overall region, but due to current land use practices, this habitat type is not in abundance at the site.

Canopy vegetation of the forested deciduous woodlands habitat generally has a high coverage density (80 - 100 percent) and consists primarily of black walnut, white ash, red oak, white oak, shagbark hickory, mockernut hickory, elm, black cherry, and eastern red cedar. Subcanopy vegetation generally has a moderate to high coverage density (60 - 90 percent) consisting primarily of multiflora rose, raspberry, blackberry, black cherry, and elm. Ground cover in this habitat generally has a moderate to high coverage density (50 - 90 percent) and consists primarily of poison ivy (*Toxicodendron radicans*), Japanese honeysuckle (*Lonicera japonica*), Virginia creeper (*Parthenocissus quinquefolia*), and false Solomon's seal (*Maianthemum stellatum*).

2.1.4.5 Forested Broad-leaved Deciduous Wetlands

The forested deciduous wetlands habitat includes a small area in the vicinity of the site and is primarily associated with the overall stream corridor habitat along the West Branch of Skippack Creek. It exists in certain areas directly associated with the creek and also with the small tributary that joins the creek to the southwest of the site. This habitat type is not unique to the overall region, but due to current land use practices, it is not in abundance in the vicinity of this site and appears to be limited primarily to stream corridors.

Canopy vegetation of the forested deciduous habitat generally has high coverage density (80 - 100 percent) and consists primarily of green ash (*Fraxinus pennsylvanica*), black walnut, white ash, elm, American sycamore (*Platanus occidentalis*), pin oak (*Quercus palustris*), and shagbark hickory. Subcanopy vegetation of this habitat generally has a moderate to high coverage density (60 - 90 percent) and consists primarily of multiflora rose, raspberry, blackberry, elm, green ash, American sycamore, and arrowwood (*Viburnum dentatum*). Ground cover throughout this habitat generally has a moderate to high coverage density (50 - 90 percent) and consists primarily of jewelweed (*Impatiens capensis*), poison ivy, Japanese honeysuckle, violets (*Viola spp.*), halberd-leaved tearthumb (*Polygonum arifolium*), and false Solomon's seal.

2.1.4.6 Scrub/Shrub Broad-leaved Deciduous Wetlands

The shrub deciduous wetland habitat includes a very small area in the vicinity of the subject property and is primarily associated with the overall stream corridor habitat associated with the West Bank of Skippack Creek. This particular habitat type appears to be limited to a small area along the creek to the southwest of the site. This habitat is not unique to the overall region, but due to current land use practices, it is not in abundance in the vicinity of the site and appears limited primarily to stream corridor areas.

Canopy vegetation of the shrub deciduous wetland habitat generally has a low coverage density (10 - 30 percent) and consists primarily of green ash, black walnut, elm, and American sycamore. Subcanopy vegetation of this habitat generally has high coverage density (90 percent) and consists primarily of multiflora rose, raspberry, blackberry, elm, green ash, and willow. Ground cover generally has a high coverage density (100 percent) and consists primarily of jewelweed, smartweed (*Polygonum spp.*), reed canary grass (*Phalaris arundinacea*), halberd-leaved tearthumb, sedges, rushes, and rough-leaf goldenrod.

2.1.4.7 Early Successional Field

The early successional field habitat is limited to the actual capped area of the quarry. This habitat type is typical of disturbed and/or waste areas. It is not unique to the overall region.

Canopy vegetation of this habitat is nonexistent. Likewise, subcanopy vegetation is generally nonexistent, with the exception of scattered multiflora rose and eastern red cedar. Ground cover throughout this habitat generally has a high coverage density (100 percent) and consists primarily of vetch (*Vicia spp.*), cinquefoil, tall goldenrod, lance-leaved goldenrod, yarrow, common mullein (*Verbascum thapsus*), foxtail, Queen

Anne's lace, ragweed, daisy fleabane, and numerous other herbaceous species typical of disturbed areas.

2.1.4.8 Aquatic Habitats

During the ecological reconnaissance completed from August 27 -29, 1990, a stream survey and inventories of the aquatic communities of the West Branch of Skippack Creek in the vicinity of the site were conducted to determine if the site is having a significant impact on the aquatic community of the stream. The locations of the sampling stations were designed to allow for comparison of the aquatic community upstream and not influenced from the site with the aquatic habitats downstream where potential impacts would be directed and likely observed (ESEA 1990).

The creek watershed in this area is dominated by agriculture and residential land use. Additionally, this stream is not free from impacts associated with roadway and development run-off waters. Run-off of fertilizers from agricultural land generally has an impact on associated streams by adding organic enrichment to the aquatic system. Leaching from septic systems has a similar effect on aquatic systems. Organic enrichment appears to be occurring in some portions of the creek included in the survey. Whereas some natural vegetation buffers exist, significant amounts of nutrient-rich run-off enter the stream from the adjacent agricultural fields in the watershed. The close proximity of septic systems associated with residential development to this stream likely adds to the organic enrichment.

The amount of algae and the types and abundance of invertebrates (caddisflies, mayflies, beetles, damselflies, and crayfish) collected in 1990 give an indication that a fair amount of nutrient enrichment of the stream occurs. However, whereas the types and abundance of invertebrate species collected in these stations gives an indication that organic enrichment is a problem, degradation of this stream was not at exceptionally high levels. The types and abundance of fishery species (several species of sunfish, and shiners) collected at these stations was generally representative of an aquatic ecosystem of at least moderately good quality. The creek upstream of the site was representative of a stream that has undergone organic enrichment, but the extent of this degradation was not at very high levels in 1990.

The amount of algae and the types and abundance of invertebrates collected 200 feet downstream from the site (Station 5 of NRI Report; see Attachment A) gave an indication that some amount of organic enrichment to the stream was occurring. Again, while some impact due to organic enrichment is indicated at these stations, high levels of stream degradation were not apparent in 1990. The types and abundance of fishery species collected, including several species of sunfish, white sucker, killifish, madtom, and smallmouth bass, is generally representative of an aquatic ecosystem with moderate to good water quality. The NRI station identifications do not correspond to the identifications of the CDM stream survey of 2002 (CDM 2003).

The amount of algae and types and abundance of invertebrates collected 350 feet downstream from the site (Station 6 of NRI Report) gave an indication that a substantial amount of organic enrichment to the stream was occurring. The last sample station is directly influenced by adjacent fields and is also located downstream from the confluence of a smaller stream with the creek. This smaller stream was determined to be significantly influenced by run-off from adjacent agriculture fields and septic system leaching. Due to the direct influences of the land character on the stream in the vicinity of this sampling station, along with the influx of nutrients associated with the smaller stream discharging into the creek, stream quality was more degraded at this location, with overall quality being classified as moderate in 1990. However, while the stream quality was degraded, aquatic species observed at this location did not indicate a high amount of degradation.

Additionally, during a site visit by CDM in August 2002, invertebrate species observed downstream of the site (near NRI Report Stations 5 and 6) included caddisfly larvae (*Trichoptera spp.*), dragonfly and damsel fly larvae (*Odonata spp.*), fly larvae (*Chironomid spp.*), and numerous crustaceans. Fish species observed at this time included bluegill sunfish (*Lepomis macrochirus*), white suckers (*Catostomus commersonii*), and smallmouth (*Micropterus dolomieu*) or largemouth bass (*Micropterus salmoides*). However, while a quantitative assessment of the stream involving the collection, identification, and analysis of species diversity was not completed for this site visit the extensive residential development that has occurred near the site since 1990 makes it probable that the stream quality has been degraded. At several times during flood events in August 2002 and June and July 2004, extensive siltation was noted in the stream.

In 1990, the spring west of the site was not sampled nor considered to be an aquatic habitat by ESAE due to its characteristics and size. ESAE did not find an aquatic community associated with this area at the time of field research and the only inundation of the area was a small puddle with a size of approximately 16 square feet and a depth of approximately one inch. Also, the spring was not included in the qualitative assessment of aquatic habitats by CDM in 2002. However, CDM collected surface water and sediment samples from the spring in 2004. In addition to the spring, two ponds are located north of the site (Figure 2-2). Like the spring, no surface water inlet was observed at these ponds, therefore, their hydrology is considered to be similar to a seep or spring. No sampling has been conducted at the two ponds. Surface water and sediment sampling should be conducted at the ponds to determine if the site contaminants are reaching and impacting the waterbodies.

2.1.5 Wildlife

The various types of habitats associated with the site were found to be of sufficient quality to support many of the wildlife species typically associated with those habitat types, however their small patch size appears to be a limiting factor. Additionally, the variety and distribution of habitats associated with the site allow for a good availability of transition areas. It is in these habitat transition areas that a majority of wildlife utilization actually occurs.

Each of the habitats present in the area was determined to provide sufficient structural components to allow the occurrence of wildlife species typically associated with that habitat type. Additionally, the distribution of the various habitats providing food, cover, and water for wildlife allow an excellent opportunity for wildlife utilization.

Mammals that were sighted in the vicinity of the site include the big brown bat (*Eptesicus Fuscus)*, eastern chipmunk *(Tamias straitus)*, white-tailed deer *(Odocoileus virginianus)*, red fox (*Vulpes vulpes*), eastern mole (*Scalopus aquaticus*), deer mouse (*Peromyscus maniculatus*), white-footed mouse (*Peromyscus leucopus*), muskrat (*Ondatra zibethicus*), Virginia opossum (*Didelphis virginiana*), eastern cottontail (*Sylvilagus floridanus*), raccoon (*Procyon lotor*), striped skunk (*Mephitis mephitis*), gray squirrel (*Sciurus carolinensis*), meadow vole (*Microtus pennsylvanicus*), and woodchuck (*Marmota momax*).

Birds that were sighted in the vicinity of the site include the red-winged blackbird (*Agelaius phoeniceus*), blue jay (*Cyanocitta cristata*), indigo bunting (*Passerina cyanea*), northern cardinal (*Cardinalis cardinalis*), catbird (*Dumetella corolinensis*), black-capped chickadee (*Parus atricapillus*), brown-headed cowbird (*Molothrus ater*), American crow (*Corvus brachyrhynchos*), mourning dove (*Zenaida macroura*), rock dove (*Columba livia*), common flicker (*Colaptes auratus*), American goldfinch (*Carduelis tristis*), common grackle (*Quiscalus quiscula*), red-tailed hawk (*Buteo platypterus*), sharp-shinned hawk (*Accipiter striatus*), green heron (*Butorides striatus*), American kestrel (*Falco sparverius*), belted kingfisher (*Megaceryle alcyon*), northern mockingbird (*Mimus polyglottos*), white-breasted nuthatch (*Sitta carolinensis*), Baltimore oriole (*Icterus galbula*), barred owl (*Strix varia*), ovenbird(*Seiurus aurocapillus*), eastern pewee (*Contopus virens*), eastern phoebe (*Sayornis phoebe*), American robin (*Turdus migratorius*), chipping sparrow (*Spizella passerina*), field sparrow (*Spizella pusilla*), house sparrow (*Passer domesticus*), song sparrow (*Melospiza melodia*), European starling (*Sturnus vulgaris*), wood thrush (*Hylocichla mustelina*), tufted titmouse (*Parus bicolor*), eastern towhee (*Pipilo erythrphthalmus*), veery (*Catharus fuscescens*), red-eyed vireo (*Vireo olivaceus*), turkey vulture (*Cathartes aura*), blue-winged warbler (*Vermivora pinus*), yellow warbler (*Dendroica petechia*), cedar waxwing (*Bombycilla cedrorum*), downy woodpecker (*Picoides pubescens*), hairy woodpecker (*Picoides villosus*), red-bellied woodpecker (*Melanerpes carolinus*), house wren (*Troglodytes aedon*), and common yellowthroat (*Geothypis trichas*).

Reptiles and amphibians that were sighted in the vicinity of the site include the bullfrog (*Rana catesbiana*), green frog (*Rana clamitans*), wood frog (*Rana sylvatica*), black racer (*Coluber constrictor*), black rat snake (*Elaphe obsoleta*), eastern garter snake (*Thamnophis sirtalis*), northern water snake (*Natrix sipedon*), American toad (*Bufo americanus*), and eastern box turtle (*Terrapene carolina*).

The NRI Report may be referenced for a complete species listing, including specific species which are associated with the individual habitats (ESEA 1990).

2.1.6 Endangered Species

In November 2002 a list of endangered or threatened species potentially present at the site was requested from state and federal agencies. The U.S. Fish and Wildlife Service (USFWS) responded that with the exception of transient species, no federally listed or proposed threatened or endangered species are known to occur in the project area (Densmore 2002). The Pennsylvania Fish and Boat Commission (PFBC) found that no endangered fish, amphibians, or reptiles listed as endangered or threatened in Pennsylvania are known to occur in the study area (Spotts 2002).

A Pennsylvania Natural Diversity Review completed by the Pennsylvania Bureau of Forestry found that no species of special concern are known to exist in the area (Newell 2002).

In March 2005 another request was made to state and federal agencies concerning the presence of endangered or threatened species near the site. This request was made because the status of threatened or endangered species for a given area should be updated annually. The USFWS responded that the project area is within the known range of the bog turtle (*Clemmys muhlenbergii*), a federally listed threatened species (Densmore 2005). The PFBC found that no endangered fish, amphibians, or reptiles listed as endangered or threatened in Pennsylvania are known to occur in the study area (Urban 2005). The Pennsylvania Bureau of Forestry had not responded to the request prior to the completion of this document. Copies of the response letters are presented in Attachment B.

During the ecological reconnaissance of the site in August 1990, no threatened or endangered species were observed, nor was there any indication as to their presence (ESEA 1990). Existing habitats associated with this study area were analyzed in accordance with the ranges and potential habitats of certain endangered species to determine if those species might be present in the vicinity of the site.

2.2 Nature and Extent of Contamination

An extensive amount of groundwater, surface water, sediment, soil, and residual waste data were collected during the RI investigation. Contaminant levels detected during the RI were compared to the EPA Region III Biological Technical Assistance Group (BTAG) screening levels (EPA 2004 and 2005). Contamination found during the RI is summarized in this section; a more detailed description of the extent of contamination can be found in the RI Report (CDM 2007).

2.2.1 Data Selection for Use in the SLERA

The SLERA will focus on assessing risk from groundwater, soil, surface water, sediment and residual waste. The PRP began conducting an RI/FS of the site in the late 1980's. The majority of field work performed for the RI was conducted in 1991 and 1992. In 1992, as the investigation progressed, the site was removed from the NPL and the PRP discontinued RI/FS work. The collection of groundwater, soil, surface water, sediment, and residual waste samples was completed for the RI, and therefore will be the primary data used in the SLERA. A summary of samples used to determine exposure point concentrations in the SLERA is provided in Table 2-1. Samples that were used to determine the impact of background conditions on the risk characterization are summarized in Table 2-2. However, background concentrations were not used to exclude contaminants from further consideration in the risk assessment process.

2.2.1.1 Groundwater Samples

In Fall 2002, CDM collected groundwater samples from five residential wells and the ten site monitoring wells. In Summer 2004, groundwater samples were collected from 14 residential wells and the ten monitoring wells. Another set of seven residential wells was sampled in November 2004. Therefore, the total number of residential groundwater samples was 26 (with one residential location being sampled twice).

All samples collected in Fall 2002 were analyzed for Target Analyte List (TAL) inorganics, Target Compound List (TCL) volatile organic compounds (VOCs), and boron. Monitoring well samples were also analyzed for lithium. All samples collected in Summer 2004 were analyzed for TCL VOCs, TAL inorganics, boron, and lithium. In addition, samples collected at MW-02 were analyzed for semi-volatile compounds (SVOCs). The seven residential well samples collected during the Fall 2004 sampling event were analyzed for TCL VOCs, boron and lithium. The groundwater sampling locations are shown in Figure 2-3.

2.2.1.2 Surface Water / Sediment Samples

Two rounds of surface water and sediment samples were collected at 11 locations along the West Branch of the Skippack Creek during the RI. One sample was collected from the spring located west of the site near the creek, for a total of 12 samples. The first round was collected in August 2004 (high-flow period); the second round was collected at the same locations in November 2004 (low-flow period). The first round of surface water samples was analyzed for TCL VOCs, TAL inorganics, boron, lithium, total suspended and dissolved solids, alkalinity, hardness, biological oxygen demand (BOD), and chemical oxygen demand (COD). The first round of sediment samples was analyzed for TCL VOCs, TAL inorganics, boron, lithium, total organic carbon (TOC), grain size, moisture, and solids. The surface water and sediment samples collected during the second round were analyzed for TCL VOCs, TAL inorganics, boron and lithium. Water quality, grain size, TOC, moisture, and solids were only analyzed during the first round. The surface water and sediment sampling locations are shown in Figure 2-4.

2.2.1.3 Soil Samples

During the RI, surface and subsurface soil samples were collected from eight locations to determine if the site has impacted the soil conditions in the area. Five sample locations were situated around the perimeter of the landfill and three sample locations were placed elsewhere (considered background locations). Surface soil samples were collected from a depth of zero to six inches below ground surface (bgs) and subsurface soil samples were collected from a depth of 6 to 24 inches bgs. Both surface and subsurface soil samples were collected at each sample location, for a total of 16 samples plus quality assurance/quality control (QA/QC) samples. The samples were analyzed for TCL VOCs, TAL inorganics, boron, lithium, TOC, and grain size. The soil sampling locations are shown in Figure 2-5.

2.2.1.4 Waste Samples

CDM collected waste samples from the quarry landfill in August 2004 to determine the characteristics of the waste. Three borings were advanced through the cap and waste to the bedrock surface (i.e., the base of the landfill). The borings were evenly spaced throughout the landfill. Three samples of the industrial waste and three samples of the underlying mixed waste were collected and analyzed for TAL inorganics and TCL VOCs (with and without the Toxic Characteristic Leaching Procedure [TCLP]), boron, lithium, Resource Conservation and Recovery Act (RCRA) hazardous waste characteristic parameters (reactivity, ignitability, and corrosivity), and water content. The samples were visually logged for evaluation of waste material present. The borings were advanced with standard hollow stem auger drilling tools and the samples were collected with three-inch diameter split spoons. A total of six samples plus QA/QC samples were collected. Figure 2-5 shows the waste boring locations.

2.2.2 Groundwater Contamination

Table 2-3 lists all detected analytes in groundwater, including detected analytes exceeding BTAG screening criteria and analytes for which no BTAG screening criteria exist. Table 2-4 lists all non-detected analytes.

Groundwater samples were collected when groundwater elevations were taken, in Fall (September/October 2002 and November 2004) and in summer (July/August 2004). Groundwater sampling locations are presented in Figure 2-3. No significant difference in contaminant concentrations was noted between the two periods based on simple qualitative comparisons.

2.2.2.1 Background Groundwater Samples

In the RI Report, three wells were considered background wells: one monitoring well (MW-06) and two residential wells (RES001 and RES004). However, no residential data are used in the SLERA. Therefore, only MW-06 is used as a background well for the SLERA. Monitoring well MW-06, located northwest of the site, was identified as the background location because it is upgradient from the site. Data from this well will be compared to onsite and downgradient samples.

Volatile Organic Analytical Results

Dichloromethane, 2-butanone, carbon disulfide, and acetone were detected at concentrations below BTAG screening criteria. The maximum detected concentrations of the compounds were qualified with a "B", indicating that the result was not detected substantially above the laboratory or field blank. The VOC concentrations ranged from 0.22 to 3.3 micrograms per liter (µg/L).

Inorganic Analytical Results

Six inorganics (barium, boron, copper, iron, manganese, and mercury) were detected at concentrations above BTAG screening criteria for groundwater in the background well.

Barium was detected at concentrations above the BTAG screening level of 4 µg/L. The measured concentrations were 194 µg/L (October 2002) and 156 µg/L (August 2004).

Boron was detected at concentrations above the BTAG screening level of 1.6 µg/L in July 2004 at MW-06 (140 µg/L). Boron was not detected in the October 2002 sampling event. The reporting limit for boron was 200 µg/L in 2002 and 50 µg/L in 2004. Therefore, boron was reportable in the 2004 data set because the detection limit was lower.

Copper was detected at a concentration of 13 L µg/L (October 2002) in the background well, exceeding the BTAG screening level of 10.84 µg/L.

Iron was detected at a concentration of 14,400 µg/L (October 2002), exceeding the BTAG screening level of 300 µg/L.

Manganese was detected at concentrations of 186 µg/L (October 2002) and 125 µg/L (July 2004), exceeding the BTAG screening level of 120 µg/L.

Mercury was detected at a concentration of 0.7 µg/L (October 2002), exceeding the BTAG screening level of 0.1 µg/L.

2.2.2.2 Onsite Groundwater Samples

Groundwater was sampled from a total of 25 residential well locations over three periods: October 2002, July/August 2004, and November 2004. Groundwater was sampled from a total of 10 monitoring well locations in September/October 2002 and July/August 2004. For the purposes of the SLERA, analytical results from groundwater samples collected at monitoring wells MW-07, MW-08, MW-09, and MW-10 were the only groundwater results compared to BTAG screening benchmarks. Sufficient hydrogeological evidence was collected during the Salford Quarry RI to suggest that groundwater at these four wells discharges to the surface water. Samples collected from wells (residential wells and the other six monitoring wells) that are open to groundwater and which may not migrate to surface water were not used in the screening process.

Volatile Organic Analytical Results

Twenty-three VOCs were detected in groundwater. Several chlorinated solvents including carbon disulfide, chloromethane, cis-1,2-dichloroethene (cis-1,2-DCE), and TCE have historically been detected in site wells.

Carbon disulfide was detected at a concentration of 8.7 B (qualified "B") µg/L in MW-07 (October 2002), above the BTAG screening value of 0.92 µg/L.

Chloromethane was detected in MW-07 at a concentration of 0.11 B µg/L (July 2004). There is no BTAG screening value available for this compound.

Cis-1,2-DCE was detected in MW-07, MW-08, and MW-10 at concentrations ranging from 0.18 J µg/L in MW-10 (July 2004) to 7 J µg/L in MW-08 (July 2004). There is no BTAG screening value for this compound.

TCE was detected above the BTAG screening value of 21 µg/L in all eight samples at concentrations ranging from 0.42 J to 28 µg/L, with the maximum concentration detected in MW-08 (July 2004).

Inorganic Analytical Results

Twenty-four inorganic analytes were detected in groundwater. A total of ten analytes (arsenic, barium, boron, cadmium, cyanide, iron, lithium, manganese, mercury, and selenium) had concentrations exceeding the BTAG screening criteria.

Arsenic was detected at concentrations above the BTAG screening value of 5 µg/L in MW-08. The measured concentrations of arsenic were 10.8 K µg/L (October 2002) and 9 µg/L (July 2004).

Barium was detected at concentrations above the BTAG screening value of 4 µg/L in 100 percent of the screening samples. Barium concentrations ranged from 66.8 µg/L in MW-07 (August 2004) to 324 µg/L in MW-09 (August 2004).

During the September/October 2002 sampling round, B-qualified beryllium detections were recorded in MW-07 and MW-09. Beryllium concentrations were 0.12 B µg/L in MW-09 and 0.36 B µg/L in MW-07. There is no BTAG screening value for this analyte.

Boron was detected at concentrations above the BTAG screening value of 1.6 µg/L in 100 percent of the samples used for the screen. Boron concentrations ranged from 11,800 µg/L in MW-08 (July 2004) to 237,000 µg/L in MW-08 (October 2002).

Cadmium was detected above the BTAG screening value of 0.28 µg/L in MW-07 (July 2004). Of the eight samples used in the screening comparison, cadmium exceeded the screening criterion in one sample. Cadmium was not detected in the other seven samples.

Cyanide was detected above the BTAG screening value of 5 µg/L in monitoring wells MW-08, MW-09, and MW-10. Concentrations ranged from 1.0 B µg/L in MW-08 (July 2004) to 6.2 B µg/L in MW-08 (October 2002).

Iron was detected above the BTAG screening value of 300 µg/L in monitoring wells MW-07 and MW-08. Concentrations ranged from 103 µg/L in MW-09 to 20,200 µg/L at MW-07 during the October 2002 sampling event.

Lithium was detected above the BTAG screening value of 14 µg/L in MW-09. Concentrations of lithium were 40 J µg/L (July 2004) and 41 J µg/L (October 2002). These exceedances account for the only lithium detections from samples used in the screening comparison.

Manganese was detected above the BTAG screening value of 120 µg/L in monitoring wells MW-07 and MW-08. Concentrations ranged from 6.3 K µg/L in MW-09 (October 2002) to 541 µg/L in MW-08 (October 2002).

Mercury was detected above the BTAG screening value of 0.1 µg/L in monitoring wells MW-07 and MW-09. Concentrations ranged from 0.1 J µg/L in MW-09 (July 2004) to 3.6 µg/L in MW-07 (October 2002). These exceedances account for the only mercury detections from samples used for the screen.

Selenium was detected above the BTAG screening value of 1.0 µg/L in monitoring wells MW-07, MW-08, MW-09 and MW-10. Concentrations ranged from 4.0 J µg/L in MW-10 (July 2004) to 8.1 J µg/L in MW-08 (July 2004).

2.2.3 Surface Water Contamination

Table 2-5 lists all detected analytes in surface water, including detected analytes exceeding BTAG screening criteria and analytes for which no BTAG screening criteria exists. Table 2-6 lists all non-detected analytes.

Surface water samples were collected at 11 locations along the West Branch of Skippack Creek and one location in the spring west of the site during a high flow event in July 2004 and during a low flow event in November 2004. These surface water sampling locations are identified in Figure 2-4. Inorganic concentrations presented in this section are reported as total rather than dissolved inorganics, since both total and dissolved concentrations were similar in magnitude. Total inorganic concentrations theoretically include both solid and dissolved analyte fractions; therefore, they are considered to be more conservative than dissolved concentrations. Also, the exposure of inorganic chemicals to ecological receptors is not limited to only dissolved chemicals. Where duplicate samples were collected, the higher concentration was reported.

2.2.3.1 Background Surface Water Samples

During each round of sampling, 12 surface water locations were sampled. One location is at a spring/seep. Two of the 11 surface water locations along the creek, SW11 and SW12, located the farthest upstream from the site, are considered background locations. Like the background soil samples, site-related contamination was not expected to influence these upstream locations. Samples collected at SW11 and SW12 serve as a basis of comparison for the surface water investigation samples.

Volatile Organic Analytical Results

Surface Water Samples
Dichloromethane was detected in one background surface water sample at SW12. The concentration of dichloromethane was 0.28 B µg/L. Acetone was also detected in 75 percent of the background samples.

Inorganic Analytical Results

Surface Water Samples
Seventeen analytes were detected in the surface water background samples. Barium, boron, calcium, copper, magnesium, manganese, potassium, sodium, vanadium, and zinc were detected in all background samples. The maximum detected concentrations of boron, cadmium, copper, vanadium, and zinc were qualified with a "B", indicating that the result was not detected substantially above the laboratory or field blank. Specifically, all four samples that had boron detections were B-qualified.

2.2.3.2 Downstream Surface Water Samples

Nine of the 11 surface water sampling locations along the creek, SW02 through SW10, spanned the area of West Branch of Skippack Creek from the Quarry Road bridge to approximately 250 feet upstream from the Morris Road bridge. One other sample, SW01, was collected from the spring west of the site.

Volatile Organic Analytical Results

Surface Water Samples
Surface water sampling at the spring location, SW01, confirmed the presence of dichloromethane and TCE at concentrations below BTAG screening levels. Cis-1,2 DCE was also detected but lacked screening criteria.

Acetone was detected at low concentrations of 2 J and 2.8 J µg/L in SW02 and SW04, respectively, but its presence is likely due to lab contamination. No other VOCs were detected in the surface water.

Inorganic Analytical Results

Surface Water Samples
At the spring location (SW01), boron was detected at a concentration of 70,400 µg/L, which exceeds the BTAG screening criteria of 1.6 µg/L. In addition, aluminum, barium, cadmium, iron, lithium, selenium, and thallium exceeded the ecological screening criteria at SW01.

Seven analytes (aluminum, barium, boron, cadmium, iron, selenium, and thallium) were detected in creek samples at levels above the ecological screening criteria.

In general, boron concentrations were consistently higher during the low-flow event in November 2004 than during the high-flow event in July 2004. In November 2004, boron was detected at concentrations above the BTAG screening level of 1.6 µg/L in all the surface water samples in the creek: SW02 (262 µg/L), SW03 (252 µg/L), SW04 (255 µg/L), SW05 (317 µg/L), SW06 (329 µg/L), SW07 (151 J µg/L), SW08 (110 J µg/L), SW09 (50.1 B µg/L), and SW10 (38.2 B µg/L). More rainfall events in July 2004 likely caused overall dilution of boron concentrations in the surface water. Boron concentrations were also seen to increase at locations downstream from the site. Boron concentrations in upstream samples, although qualified with a B (indicating blank contamination in the laboratory's continuing calibration blank), are still an order of magnitude less than the downstream samples.

Aluminum was detected in approximately 50 percent of the surface water samples. All aluminum detections exceeded the BTAG screening level of 87 µg/L. Aluminum concentrations ranged from 175 J to 1,680 µg/L. The maximum concentration was detected at SW05.

Cadmium was detected in 25 percent of the samples. All cadmium detections exceeded the BTAG screening level of 0.28 µg/L. Cadmium concentrations ranged from 0.31 B to 0.49 B µg/L. The average concentration detected was 1.97 µg/L, which was identical to the average background concentration.

Selenium was detected in 20 percent of the samples. All selenium detections exceeded the BTAG screening level of 1.0 µg/L. Selenium concentrations ranged from 4.9 J to 10.4 J µg/L. The maximum concentration was detected at SW01.

Iron was detected in approximately 75 percent of the samples. Iron detections exceeded the BTAG screening level of 300 µg/L in nine of the twenty samples. The maximum concentration of 1,220 µg/L was detected at SW05.

2.2.3.3 Biological and Chemical Oxygen Demand and Water Quality Parameter Results

All surface water samples were analyzed for BOD, COD, and groundwater/sediment quality parameters. BOD/COD analyses were performed by an EPA-approved laboratory while the water and sediment quality parameters were measured in the field by the sampler. Water quality parameters included pH, temperature, conductivity, turbidity, oxidation reduction potential (ORP), and dissolved oxygen. Sediment quality parameters included pH, temperature, conductivity, ORP, and color. BOD was not detected in any of the surface water samples, but COD was reported in all samples, except SW04, at concentrations between 13.5 milligrams per liter (mg/L) and 35.2 mg/L. The highest COD concentration was found in sample SW09, collected upstream of the site. The RI Report presents a complete list of BOD, COD, and water quality results.

2.2.4 Sediment Contamination

Table 2-7 lists all sediment detections, including detected analytes exceeding BTAG screening criteria and analytes for which no BTAG screening criteria exists. Table 2-8 lists all non-detected analytes.

Sediment samples were collected during a high flow event in July 2004 and during a low flow event in November 2004 at 11 locations along the West Branch of Skippack Creek and one location in the spring west of the site. All of the sediment sampling locations in 2004 are identified in Figure 2-4. Where duplicate samples were collected, the higher detection was reported.

2.2.4.1 Background Sediment Samples

Twelve sediment locations were sampled in each sampling round. One location is at a spring/seep. Two of the 11 sediment locations along the creek, SD11 and SD12, located the farthest upstream from the site, are considered background locations. Site-related contamination was not expected to influence these upstream locations. Samples collected at SD11 and SD12 serve as a basis of comparison to the sediment investigation samples.

Volatile Organic Analytical Results

Sediment Samples

Toluene, trichlorotrifluoromethane (CFC-11), dichloromethane, and cyclohexane were detected in samples collected during the low flow event in November 2004. The VOC concentrations ranged from 1-4 µg/L. Seventy-five percent of the maximum concentrations were detected at SD12.

Inorganic Analytical Results

Sediment Samples

All of the analytes except selenium were detected in background samples. Arsenic and cadmium were detected at maximum concentrations of 15.1 L and 1.5 milligrams per kilogram (mg/kg), respectively. Boron was detected in all four background samples with concentrations ranging from 7.2 B to 9.8 J mg/kg, with the maximum concentration being located at SD11.

2.2.4.2 Downstream Sediment Samples

Nine of the 11 sediment sampling locations along the creek, SD02 through SD10, spanned the area of the West Branch of Skippack Creek from the Quarry Road bridge to approximately 250 feet upstream from the Morris Road bridge. One other sample, SD01, was collected from the spring west of the site.

Volatile Organic Analytical Results

Sediment Samples

Five VOCs, including acetone, CFC-11, cyclohexane, dichloromethane, and toluene, were detected at very low concentrations in the sediment samples. All of the detected VOCs lacked ecological screening criteria. Acetone was detected at concentrations between 4 J and 9 J µg/kg, at SD01 and SD06, respectively. These detections are likely attributed to lab contamination. Toluene was detected at a concentration of 1 J µg/kg at SD08. Cyclohexane was detected at SD08 and SD10 at concentrations of 1 J and 4 J µg/kg, respectively. Toluene and cyclohexane are not considered site-related contaminants. Dichloromethane was detected in 50 percent of the samples, with the maximum concentration of 5 B µg/kg being detected at SW03.

Inorganic Analytical Results

Sediment Samples

Results for the sediment sample collected at the spring (SD01) indicated that eight analytes (antimony, arsenic, cadmium, cyanide, iron, lead, nickel, and manganese) were detected above the BTAG screening criteria.

Arsenic was detected at a concentration of 18.3 L mg/kg in the spring sediment (SD01), exceeding the BTAG screening level of 9.8 mg/kg.

Lead was detected at SD01 with a maximum concentration of 38.9 mg/kg exceeding the BTAG screening level of 35.8 mg/kg. The average concentration detected was 25.6 mg/kg, which was similar to the average background concentration of 24.5 mg/kg.

For the remaining sediment samples, eleven analytes, including antimony, arsenic, cadmium, chromium, copper, cyanide, iron, lead, manganese, nickel, and zinc were detected above the BTAG screening criteria.

Arsenic was detected above the BTAG screening value of 9.8 mg/kg in all twenty samples at concentrations ranging from 5.3 mg/kg to 25.9 L mg/kg, with the maximum concentration detected in SD07, located in the creek directly west of the spring location.

Cadmium was detected slightly above the BTAG screening value of 0.99 mg/kg in SD05, SD06, SD07, SD09, and SD10 at concentrations ranging from 1.2 mg/kg to 1.4

mg/kg, with the highest concentration found at both SD05 and SD09.

Lead was detected at SD07 with a concentration of 37.3 mg/kg, above the BTAG screening value of 35.8 mg/kg.

The two highest concentrations of boron (84.2 mg/kg and 50.3 mg/kg) were located at SD01. This concentration is approximately four times greater than the third highest concentration of 20.9 mg/kg located at SD07. An ecological screening criterion is not available for boron.

2.2.5 Soil Contamination

Table 2-9 lists all detected surface and subsurface soil analytes, including detections exceeding ecological screening criteria and all analytes for which no screening criteria exist. Table 2-10 lists all non-detected analytes.

One surface soil sample and one subsurface soil sample were collected from each of eight locations. Soil sampling locations can be seen in Figure 2-5. Three of the locations were considered background. Background soil samples were collected to provide a basis for comparison with onsite soil analytical results and help make a determination as to which contaminants, if any, are attributed to the landfill, to naturally-occurring conditions, or to contamination from an off-site source.

2.2.5.1 Background Soil Samples

VOC Analytical Results

Dichloromethane and tetrachlorethene (PCE) were detected in all of the background surface and subsurface samples. Dichloromethane concentrations ranged from 3-5 µg/kg. PCE concentrations ranged from 2-5 µg/kg. The maximum concentrations of both compounds were detected in the surface soil (0-6 inches bgs) location SL01.

Inorganic Analytical Results

Sixteen analytes (aluminum, barium, beryllium, calcium, chromium, cobalt, copper, iron, lead, lithium, magnesium, manganese, nickel, potassium, vanadium, and zinc) were detected in the surface and subsurface soil background samples. The majority of the highest concentrations were detected in the subsurface sample (6-24 inches bgs) located at SL02. Of these detected analytes, lithium was the only one not detected in all six soil samples.

2.2.5.2 Onsite Soil Samples

VOC Analytical Results

Surface Soil Samples

No VOCs, other than acetone (a common laboratory contaminant), were detected in the surface soil samples at concentrations exceeding ecological screening values. PCE was detected at low levels in all surface soils (SL04 through SL08) at concentrations between 2 J µg/kg and 11 J µg/kg.

Subsurface Soil Samples

No VOCs were detected in the subsurface soil samples at concentrations exceeding ecological screening values. However, three VOCs, including PCE, TCE, and cis-1,2 DCE, were detected in the subsurface soil at SL08 at concentrations of 11 J µg/kg, 160 J µg/kg, and 19 J µg/kg, respectively. In addition, like the surface soils, PCE was detected in subsurface soils from all other boring locations (SL04 through SL07) at concentrations between 3 J µg/kg and 7 J µg/kg. Since PCE was detected at all five site locations and the three background locations at similar concentrations, it is believed the detections are not attributed to the site. Furthermore, consistently detecting a VOC in near surface soils over a broad area is highly unlikely to be attributed to one source if no significant sources are known to exist in the area. The detections are also unlikely to be attributed to handling or analytical reporting of the soil samples, since the data is not blank-qualified (i.e., PCE was not identified in sample blanks).

Inorganic Analytical Results

A total of 17 analytes were detected in the surface and subsurface soil samples at levels exceeding screening criteria. Detections of site-related contaminants, including cadmium, lead, and lithium, are discussed in this section. All of the remaining metals identified in the onsite soils were detected at concentrations similar to those of background samples, with the exception of lead.

Surface Soil Samples

Fourteen analytes were detected in the surface soil samples (0-24 inches bgs) at levels exceeding the ecological screening criteria. Among site-related contaminants, cadmium, lead, and lithium were identified in the surface soils on site. Boron was not detected in any surface soil samples.

Cadmium was detected in surface soil above the ecological screening value of 0.38 mg/kg. The maximum concentration (0.6 mg/kg) was detected in SL08.

Lead was detected in all surface soil samples at concentrations above the ecological screening value of 16 mg/kg. Lead concentrations ranged from 38 mg/kg at SL04 to 338 mg/kg at SL07. The average concentration of lead in surface soils was 100.94 mg/kg. This average was approximately four times the highest concentration of the background samples (25.7 mg/kg).

Lithium, with an ecological screening value of 2 mg/kg, had exceedances in all surface soil samples. Lithium concentrations ranged from 23.3 mg/kg at SL07 to 33 mg/kg at SL05. The average concentration of lithium in the surface soils was 29.14 mg/kg. This average was similar to the background concentrations.

Subsurface Soil Samples

Seventeen analytes were detected in the subsurface soil samples at levels exceeding the ecological screening criteria. In the subsurface soil at SL08, located on the western boundary of the site, boron was detected at a concentration of 21.8 mg/kg, above the ecological screening value of 0.0005 mg/kg. Cadmium was also detected at SL08.

Boron and cadmium were not detected above the screening criteria in any other soil samples.

Lead was detected above the ecological screening value of 16 mg/kg in all subsurface soil samples, including SL04 through SL08, with the highest concentration of 1,940 mg/kg at SL08.

Lithium was detected above the ecological screening value of 2 mg/kg in four subsurface soil samples, including SL04, SL05, SL06, and SL07, with the highest concentration of 31.1 mg/kg at SL07, situated downslope from the site.

Sample location SL08 was collected from the area of stressed vegetation between the western boundary of the landfill and Quarry Road. The soil results indicate that the maximum concentrations of 12 analytes exceeding ecological screening criteria were found in the subsurface soil collected at SL08. The high concentrations of metals detected in SL08 is likely caused by landfill runoff.

2.2.6 Waste Characterization

Three borings (WT01, WT02, and WT03) were advanced through the clay cap and waste to the base of the landfill (the bedrock surface). The waste boring sampling locations can be seen on Figure 2-5. The topsoil and clay cap were observed to be 6 feet thick. Underlying the cap was industrial waste, a tile waste slurry zone from approximately 6 to 26 feet bgs, with a sharp contact with the mixed municipal waste that extends to the bedrock surface, encountered between 35.5 and 37.5 feet bgs. Groundwater was encountered between 14 and 19 feet bgs, indicating that both the tile waste and mixed waste are within the saturated zone.

At each boring, samples were collected from the industrial waste and from the underlying mixed municipal waste and analyzed for total TCL VOC and TAL inorganic analytes as well as TCLP analytes. There are no ecological screening criteria for waste material. Because groundwater provides the sole pathway for contact between the waste and biota, discussion of waste analyses will focus on chemicals that were detected in groundwater, with emphasis on chemicals that bioaccumulate. Municipal waste and industrial waste will be examined separately.

Total (not TCLP) municipal waste detections included VOCs, semivolatiles, pesticides, polychlorinated biphenyls (PCBs), and inorganics. None of the detected organic compounds bioaccumulate; however, cis-1,2 DCE and TCE were detected in municipal waste and in groundwater. A single cis-1,2-DCE detection occurred at WT01 at a concentration of 5 J micrograms per kilogram (µg/kg). TCE was detected at 31 µg/kg (WT01) and 11 J µg/kg (WT03). Inorganic constituents cadmium and copper were detected in all three waste borings. Cadmium and copper were also detected in groundwater and bioaccumulate. Cadmium concentrations in the municipal waste samples ranged from 17.0 to 19.2 mg/kg. Copper concentrations in the municipal waste samples ranged from 1,510 K to 3,420 K mg/kg. Boron was detected in all municipal waste borings at concentrations ranging from 831 mg/kg (WT03) to 1,260 mg/kg (WT02).

Municipal waste detections after TCLP included arsenic, barium, cadmium, lead mercury, selenium, and cyanide. Of these compounds, arsenic, cadmium, lead, and selenium bioaccumulate. Arsenic was detected at 81.4 J µg/L (WT02). Cadmium was detected at 509 µg/L (WT01) and 180 µg/L (WT03). Lead was detected in all waste borings at concentrations ranging from 449 to 2,500 µg/L. Selenium was detected at 98.0 B µg/L (WT02) and 97.7 B µg/L (WT03).

Total (not TCLP) industrial waste detections included one VOC, two SVOCs , and 20 inorganics. Cis-1,2 DCE was detected at 2 J µg/kg (WT02). Caprolactum and pentachlorophenol, semi-volatile compounds, were detected at 56 J µg/kg (WT01) and 81 J µg/L (WT01), respectively. Detected inorganics that bioaccumulate include cadmium, copper and lead. Cadmium was detected in all waste borings at concentrations ranging from 57.4 mg/kg (WT01) to 109 mg/kg (WT02). Copper was detected in all waste borings at concentrations ranging from 72.6 K mg/kg (WT01) to 128 K mg/kg (WT02). Lead was detected in all waste borings at concentrations ranging from 5,280 mg/kg (WT01) to 18,500 mg/kg (WT03). Boron does not bioaccumulate; however, it is a significant site contaminant that was detected in all waste borings at concentrations ranging from 1,120 mg/kg (WT01) to 3,150 mg/kg (WT02).

Industrial waste detections from TCLP analysis included barium, cadmium, lead, mercury, selenium, and cyanide. Of these compounds, cadmium, lead, and selenium bioaccumulate. Cadmium was detected in all waste borings at concentrations ranging from 1,100 µg/L to 2,140 µg/L. Lead was detected in all waste borings at concentrations ranging from 62,300 to 143,000 µg/L. Selenium was detected at 53.4 B µg/L (WT02) and 89.0 B µg/L (WT03).

Cadmium and lead exceeded the federal regulatory limit for TCLP analytes. The maximum regulatory concentrations for cadmium (1,000 µg/L) and lead (5,000 µg/L) were exceeded in the industrial waste from all locations . For a detailed list of TCLP results, please refer to the RI Report (CDM 2007).

2.3 Preliminary Conceptual Model

The following sections present a description of complete exposure pathways and the selection of endpoints and receptor species.

2.3.1 Complete Exposure Pathways

An environmental exposure pathway is the means by which contaminants are transported from a source to ecological receptors. As described previously, site-related chemicals have been detected in groundwater, with the potential for

discharge to surface water and sediment through run-off from the site or from direct groundwater discharge.

As opposed to most metals, boron tends to lightly sorb to soil and sediment particles and migrates through soil more easily than other metals. This is assisted by the mass transport on and off site by the physical forces of wind and water. As a result, it is assumed that the primary transport mechanism for boron is through groundwater movement and discharge. Data collected on the site indicated the presence of other metals, including lead and zinc, in the residual waste that are more likely to sorb to the soil. However, given that a cap is in place and in good condition over the residual waste, it seems unlikely that soil transport is a significant pathway.

Pathways that were evaluated in the SLERA include exposure to contaminants in onsite surface and shallow subsurface soil, groundwater, surface water, and sediment. The first complete exposure pathway involves exposure to contaminants in shallow soil near the quarry pit where waste was disposed. Surface and shallow subsurface soils at the site are classified as soils ranging in depth from zero to two feet below grade.

A second pathway involves exposure to contaminants to surface water and sediment via groundwater. At the site, groundwater discharges to a spring directly below the disposal pit. Water from this spring eventually flows into the creek. Groundwater may also discharge to the ground surface at other locations near the base of the disposal pit during high-flow conditions. It is also suspected that groundwater directly discharges to the creek downgradient of the site.

It should be noted that unusual patterns of dead vegetation were first noticed at the base (between cap toe and Quarry Road) of the disposal area on the site property in 2004 (Figure 2-6). The stressed vegetation can be seen in Attachment C, photograph no. 1. Boron is very toxic to vegetation and it has been theorized that groundwater seeps may be present here during high flow conditions. These conditions were accentuated from 2003-2005 when annual precipitation in Pennsylvania was approximately 10 inches above normal (NCDC 2005). Water levels measured at MW-06, MW-07, MW-08 during 2004 (summer) were approximately six feet higher than those measured in 2002 (summer). The raised water table may be responsible for discharging contaminated water to the ground surface at the spring. Numerous site visits during the past few years have revealed that the area surrounding the spring and dry creek bed have been devoid of vegetation, as can be seen in Attachment C, photographs no. 2 and 3. Because the water table is fairly shallow with respect to ground surface on the western side of the site, the elevated water may be within the root zone of many plants. Various contaminants that tend to bind to soil particles may still be present in the soil following an extended drought due to their physical properties. Therefore, these contaminants would also be available for plant assimilation.

Figure 2-7 represents the conceptual flow diagram for transport of contaminants of concern to ecological receptors. Based on this preliminary conceptual model, complete exposure pathways exist for receptor exposure to contaminants in groundwater, surface and subsurface soil, and sediment at the site. Plants found near the site will be directly exposed to contaminated groundwater that flows near or discharges to the surface. Terrestrial receptors that burrow, nest, or feed on the ground surface at the site will be directly exposed to contaminants in surface and shallow sub-surface soil.

Small mammals such as voles, mice, and shrews, that live and feed on the surface of the site and nest in shallow burrows, will be exposed to contaminated soil by direct contact during foraging and nesting activities. These mammals would be exposed to contaminants in soil through incidental ingestion of soil particles during feeding and through the ingestion of contaminated food items (food or prey that has bioconcentrated or bioaccumulated site contaminants). Small mammals will also be directly exposed to contaminants through ingestion of contaminated water from the seeps and springs near the site or from the creek.

Birds which nest and feed on or near the site will be exposed to contaminants in surface soil, sediment, and water by direct contact, ingestion, and inhalation of soil particles during preening or through the consumption of contaminated prey items. Birds may also accidentally ingest soil or sediment particles during feeding. Birds will be directly exposed to contaminants in seeps or pools contaminated by groundwater during drinking or bathing. Birds that feed or drink from the creek may also be exposed to contaminants transported by groundwater to the creek.

Higher order predators such as foxes or hawks that hunt on or near the site may be exposed to contaminants that have bioaccumulated in prey living on or near the site. These predators may also be exposed to contaminants through ingestion or inhalation of soil particles or direct contact with contaminated soil during grooming and preening activities. Predators that drink from the spring or from the creek may be directly exposed to contaminants. Other predators such as herons or kingfishers that hunt and feed along the creek could be exposed to contaminants in sediment and surface water or in prey items.

2.3.2 Selection of Endpoints and Receptor Species

Table 2-11 presents the endpoints and risk hypotheses that were used for the SLERA. Assessment endpoints for the SLERA include the following:

- Protection of the soil invertebrate community from the toxic effects (on survival, reproduction, and growth) of site-related chemicals present in the soil/sediment and to ensure that contaminant levels in soil invertebrate tissues are low enough to minimize the risk of contaminant bioaccumulation effects in higher trophic levels.

- Protection of the plant community on site and in West Branch of Skippack Creek from the toxic effects (on survival, reproduction, or growth) of site-related chemicals present in the soil/sediment and to ensure that contaminant levels in plant tissues are low enough to minimize the risk of contaminant bioaccumulation effects in higher trophic levels.

- Protection of mammals that live and feed on and near the site to ensure that direct contact with and ingestion of contaminants in soil and prey do not have an adverse impact on survival, reproduction, or growth.

- Protection of amphibians and reptiles that live and feed on and near the site to ensure that direct contact with and ingestion of contaminants in water, sediment, soil, and prey do not have an adverse impact on survival, reproduction, or growth.

- Protection of the avian community that feeds on and near the site to ensure that direct contact with and ingestion of contaminants in soil, water, and prey do not have an adverse impact on survival, reproduction, or growth.

- Protection of the benthic invertebrate community from the toxic effects (on survival, reproduction, or growth) of site-related chemicals present in the sediment and water and to ensure that contaminant levels in creek sediment invertebrate tissues are low enough to minimize the risk of contaminant bioaccumulation effects in higher trophic levels.

- Protection of fish that live in the creek near the site to ensure that direct contact with and ingestion of contaminants in sediment/water and prey do not have an adverse impact on survival, reproduction, or growth.

Measurement endpoints are chosen to link the existing conditions to the goals established by the assessment endpoints and are useful for assessment endpoint evaluation (e.g., effects are measured by comparing exposure dose estimates to literature-based toxicity endpoints). The SLERA measurement endpoints used to evaluate potential ecological impacts are the following:

- Survival and growth of plants are measured through comparison of contaminant exposure to contact ecotoxicity values for survival, reproduction, and growth and the protection of upper trophic organisms consuming plants.

- Survival and growth of soil invertebrates are measured through comparison of contaminant exposure to contact ecotoxicity values for survival, reproduction, and growth and the protection of upper trophic organisms consuming soil invertebrates.

- Exposure of amphibians and reptiles that feed on and near the site will be measured by a comparison of contaminant exposure to surface water and sediment ecotoxicity values for survival, reproduction, and growth and the protection of aquatic amphibians and reptiles.

- Exposure of mammals that feed on or near the site will be measured by a comparison of modeled dietary dose to a reference dietary Hazard Quotient (HQ) value of 1. Dietary HQ values are calculated for individual chemicals by dividing an estimated level of exposure by an ecotoxicity value that is equivalent to a chronic no observed adverse effects level (NOAEL). An HQ value greater than 1.0 represents a dietary dose causing potential risk to the receptor.

- Exposure of avian receptors that feed on and near the site will be measured by a comparison of modeled dietary dose to a reference value of 1. Dietary HQ values are calculated for individual chemicals by dividing an estimated level of exposure by an ecotoxicity value that is equivalent to a chronic NOAEL. An HQ value greater than 1.0 represents a dietary dose causing potential risk to the receptor.

- Survival and growth of benthic invertebrates are measured through comparison of contaminant exposure to contact ecotoxicity values for survival, reproduction, and growth of benthic invertebrates and the protection of organisms consuming them.

- Exposure of fish that live in the creek near the site will be measured by comparison of dietary HQs to an HQ of 1.0. Dietary HQs are calculated for individual chemicals by dividing an estimated level of exposure by an ecotoxicity value that is equivalent to a chronic NOAEL. An HQ of 1.0 represents a dietary dose that is equal to the ecotoxicity value.

It should be noted that amphibians and reptiles are important components of wetland and stream ecosystems, and may be exposed during different life stages to site chemicals through direct contact with contaminated surface water, sediment, soil, and ingested prey. These organisms were considered in the development of assessment endpoints; however, there is very little toxicological literature available to assess the potential for toxicity to reptiles and amphibians based on contaminant concentrations in media or prey items. These organisms represent both omnivorous and carnivorous feeding groups.

Selection of site receptors as a subset of all potential ecological receptors at the site is an important part of the SLERA. Since it is not feasible to evaluate every species which may be impacted, the selection of indicator species is an accepted step to focus the SLERA and allow for characterization of site risk. Receptor selection is guided by the results of the site habitat characterization, resident species information, and consideration of the criteria listed below:

- Rare, threatened, or endangered species.

- Receptors which represent site trophic levels (to assess food chain impact and potential concern for bioaccumulation).

- Habitat Suitability - Species chosen as receptors should inhabit habitats as found onsite and/or within the area of impact. Adequate habitat must be available for species consideration.

- Occurrence - Species chosen as receptors should have been observed (or expected to occur) with some frequency on site or within the area of site impact.

Receptor species selected for the SLERA were chosen to be representative of trophic levels and habitats that occur at the site. Receptor species selected to represent site biota are identified in Table 2-11. Mammalian receptor species include the herbivorous meadow vole (*Microtus pennsylvanicus)*, the insectivorous short-tailed shrew (*Blarina brevicauda)*, and the carnivorous red fox (*Vulpes vulpes*). Avian receptor species include the red-tailed hawk (*Buteo jamaicensis*) as a carnivore and the American robin (*Turdus migratorius*) as an insectivore. The reptile receptor species is the eastern garter snake (*Thamnophis sirtalis*). All receptors were observed at the site. Additionally, soil invertebrates and plants are included as receptor species as they form the base of the food chain. Evaluating the impact to plants in particular is important because boron is very toxic to vegetation.

2.4 Selection of Chemicals of Potential Concern

The following sections present contaminant screening values, a description of site contaminant fate and transport processes, and ecotoxicological information for site contaminants.

2.4.1 Screening Values

The selection of COPCs is used to narrow the focus of the ecological risk assessment. The selection process serves to identify dominant ecological site risk and to guide future remediation decisions.

Selection of COPCs was completed for all media evaluated in this SLERA (i.e., shallow soil (0-24 inches bgs), sediment, groundwater, and surface water). EPA Region III BTAG screening values (EPA 1995, EPA 2004 and EPA 2005) were used to screen maximum chemical concentrations detected in the soil, sediment, groundwater, and surface water. Alternate screening values were used to screen maximum chemical concentrations detected in the shallow soil. These alternate screening values were used in this order: (1) 2003 EPA Eco Soil Screening Levels, (2) EPA Region 5 Ecological Benchmarks, (3) Canadian environmental quality guidelines (4) Oak Ridge National Laboratory Screening Benchmarks (5) EPA Region IV Chronic Screening Values. These alternate sources were provided by the EPA BTAG and are documented in the *Response to EPA Comments on the Draft Work Plan and Cost Estimate (Modified Scope) dated November 14th, 2003 for Salford Quarry, Lower Salford Township, Montogmery County, Pennsylvania* (CDM 2003) and *Comments to the Draft Technical Approach to Complete the Screening Level Ecological Risk Assessment; Salford Quarry; Lower Salford Township, Montgomery County, Pennsylvania; December 2004* (Pluta 2005). Chemicals with detected concentrations greater than the ecological screening values were considered COPCs. Tables 2-3, 2-5, 2-7, and 2-9 provide a summary of the detected chemicals and identify COPCs. Non-detected chemicals were screened against ecological screening levels, however, these chemicals were not retained as COPCs. Tables 2-4, 2-6, 2-8, and 2-10 provide a summary of the non-detected chemicals. A summary of all identified COPCs for each medium is provided in Table 2-12.

2.4.2 Contaminant Fate and Transport

This subsection describes the environmental fate and transport of the chemicals identified in site groundwater, soil, surface water and sediment. An understanding of the fate and transport of contaminants as provided in this chapter is necessary to adequately evaluate potential exposure risks and remedial technologies for the FS. This section provides the following:

- a discussion of the contaminant groups of concern and potential sources
- a summary of potential contaminant transport pathways
- relevant physical-chemical properties of the contaminants
- a summary of the fate and transport characteristics of contaminants

Contaminant Transport Pathways

The various environmental media onsite present multiple potential pathways for contaminant migration. The fate and transport of these chemicals is determined by their physical and chemical properties in combination with the physical characteristics of the site and source area. Site and contaminant characteristics that bear upon contaminant transport pathways are discussed in the paragraphs that follow.

2.4.2.1 Site Media Influence on Contaminant Transport

The physical characteristics that affect the transport of contaminants are summarized below.

Topography/Surface Water Hydrology

Topography of the landfill cap is fairly flat with a slight downward slope toward the northwest. The site property is located within the watershed of the West Branch of the Skippack Creek. The creek flows south about 300 feet west of the site. The elevation of the creek is about 40 feet less than that of the quarry cap. The West Branch of Skippack Creek eventually flows into the Skippack Creek. The confluence of the two creeks is approximately 6,500 feet south of the site. The Skippack Creek flows into the Perkiomen Creek, a tributary of the Schuylkill River. A small spring is located west of the site between Quarry Road and the West Branch of Skippack Creek.

Groundwater Flow

In general, groundwater flow at the site is to the southwest toward the West Branch of Skippack Creek. Groundwater beneath the site occurs under unconfined conditions in the overburden, weathered bedrock, in the shallow bedrock aquifer and under confined conditions in the deeper bedrock. The fractured bedrock groundwater system consists of dipping, layered fractured bedrock with groundwater flow within partings developed along bedding planes and joints. Vertical fractures may cut across beds providing local routes of groundwater flow or leakage between beds. Once in the subsurface, aqueous contaminants may diffuse into the bedrock matrix or hydraulically isolated fractures within the fractured rock aquifer. Contaminants thus isolated will be flushed very slowly, requiring the movement of many pore volumes of water through the higher conductivity layers to flush a few pore volumes of water through the less permeable zones.

In a majority of the site area the unsaturated zone extends from the overburden and into the bedrock (i.e., the water table is in the bedrock). Moreover, the water table is within the landfilled waste. Commonly in fractured bedrock systems, the termination of fractures results in confined conditions. The unconfined system supplies recharge to the underlying fractured bedrock aquifer. Precipitation infiltrates downward through soils, eventually reaching the saturated zone and providing recharge to groundwater. Groundwater moves toward areas of lower hydraulic potential. However, groundwater flow direction will be affected by the orientation of openings (bedding planes and joints) in the bedrock, and will not be perpendicular to equipotential lines.

Sediment/Soil Chemistry

Soil properties potentially affecting contaminant persistence and mobility include:

- redox potential (Eh)
- surface area
- pH
- cation exchange capacity (CEC)
- clay mineralogy
- total organic carbon (TOC) content
- inorganic carbon (IOC) content
- carbonate content
- free aluminum oxide content
- iron oxide content

Of these properties, those that most control the fate and transport of contaminants are Eh, pH, CEC, clay abundance and mineralogy, and TOC.

Subsurface Eh affects the speciation of contaminants, helping determine (along with pH) the charge carried by the contaminant as a dissolved species. The contaminant's charge has a profound effect on its subsurface mobility as a result of its increased or decreased tendency to accumulate opposite formation minerals due to electrostatic attractions. Microbial activity and organic contaminants may create reducing conditions. Depending on the specific contaminant, its reduced species may have greater or reduced mobility. Site surface water and stream sediment was generally found to be under oxidizing to nitrate-reducing conditions.

The pH of soils affects hydrolysis rates, contaminant solubility, sorption potential and biodegradation rates. Solubility of inorganics generally increases as pH decreases. Biodegradation rates are typically maximized when soil pH is between 5.5 and 8.5 (EPA 1989). The natural soils as well as the made land (or fill material) found at the site proper are typically moderately to highly acidic.

The CEC is defined as the total amount of exchangeable cations that a soil can adsorb. This property depends on the mineralogy of the soils, specifically the abundance and type of clays and the amount of organic matter. Increasing the organic matter content will increase the CEC. CEC is highly pH-dependent, increasing in magnitude as the pH of the aqueous soil environment increases. As pH increases, deprotonation occurs on the edges of layer silicates, on variably charged minerals such as oxides of iron and aluminum, and on functional groups extending from organic matter. Site soils typically range between 10 to 32 percent clay content, by weight. Since the CEC is primarily in the clay sized fraction of a soil, high clay content in site soils will lead to significant cation sorption potential.

High soil TOC tends to increase contaminant adsorption and hinder the movement of contaminants through the soil. Soils which are composed of at least 0.1 percent organic matter are generally considered to be of high organic content.

TOC content of West Branch of Skippack Creek sediments ranged from 0.2 to 1.7 percent, while TOC content of landfill soils ranged from 0.68 to 5.34 percent, indicating high TOC for all tested soils.

Geology

Salford Quarry is located within the Piedmont physiographic province and is underlain by sedimentary rocks of the Triassic Newark Group. In the vicinity of the site, the Newark Group has been divided into the Stockton, Lockatong, and Brunswick Formations, proceeding from the oldest to the youngest sediments.

The site overlies the Brunswick Formation. The Brunswick Formation consists typically of reddish-brown shale, siltstone, and mudstone, with a few thin beds of green and brown shale. The Brunswick Formation has a moderately well developed, blocky joint pattern. Two thin bands of the Lockatong Formation, trending northeast-southwest, subcrop to the east and west of the site. This formation consists of dark gray to black argillite including some zones of black shale with thin layers of impure calcareous shale, locally. Bedding in the Lockatong Formation is massive and moderately well developed, with beds ranging from thick to flaggy. Joints are moderately developed, forming a blocky pattern. Joints within the Brunswick and Lockatong Formations are nearly vertical. The strike of the primary joint set is between N30^{0}E and N40^{0}E, with an average distance between joints of about six inches.

Soils in the vicinity of the quarry are mapped as the Lansdale and Reaville series. Lansdale soils form in materials weathered from gray or yellowish-brown sandstone, conglomerate, and shale. Lansdale soils are well drained, coarse loamy soils with permeability that is moderately slow to moderate in the A horizon, moderately slow to moderately rapid in the B horizon, moderately rapid in the substratum and moderately slow in the bedrock. The CEC for Lansdale soils ranges from 4.0 to 16 meq/100g. The range of pH measured for Lansdale soils is from 4.5 to 5.0. Clay content ranges from 10 to 25 percent by weight in horizons deeper than ten inches. Organic matter ranges from 0.5 to 1.0 percent by weight in strata greater than 10 inches depth. Depth to bedrock is generally two to six feet (USDA 1990).

Reaville soils form in materials weathered from shale and siltstone. Reaville soils are moderately well to somewhat poorly drained fine loamy soils. Permeability is moderate in the A horizon and slow in the B and C horizons. The CEC for Reaville soils ranges from 10 to 20 meq/100g. The range of pH measured for Reaville soils is from 5.1 to 6.5. Clay content ranges from 15 to 32 percent by weight. Illite is the dominant clay mineral, but the soil contains small amounts of kaolinite and vermiculite. Organic matter ranges from 0.0 to 0.5 percent by weight in strata greater than 9 inches depth. The depth to bedrock under these soils generally ranges from two to six feet.

Potential Contaminant Transport Pathways

Several potential contaminant transport pathways have been identified at the site, including:

- surface runoff to the West Branch of Skippack Creek
- downward migration of contaminants in soil to the underlying aquifer system
- discharge of contaminated groundwater into the spring and West Branch of Skippack Creek
- migration of contaminants via windblown dusts
- volatilization of contaminants in surface soil or in the shallow aquifer into ambient air
- uptake of contaminants in soil or surface water by biota

2.4.2.2 Chemical and Physical Properties of Contaminants

To predict the persistence and potential migration of contaminants in soils, it is necessary to identify which contaminants are likely to leach, degrade (biotically or abiotically), or volatilize. The fate of a given contaminant is dependent on its physical and chemical properties and the properties of the media through which it migrates. Site environmental contaminants can be grouped into two classes: chlorinated VOCs and inorganics. Each class of contaminants exhibits characteristic properties with respect to fate and transport and will be discussed separately. The following sections describe the persistence and mobility of the identified contaminant groups, focusing on such properties as degradation, dissolution/precipitation, volatilization, biotransformation, adsorption, and bioaccumulation or bioconcentration.

Contaminant Persistence (Fate)

Contaminant persistence describes the length of time that a contaminant will remain in its original molecular state in the environment. Chemicals that will persist in a given medium are those that form insoluble precipitates, or resist biodegradation, hydrolysis, and volatilization.

The major characteristics affecting the fate, or persistence, of each class of contaminant are shown in the following table.

Contaminant Class	Dominant Fate Process
Chlorinated VOCs	Moderate to rapid anaerobic biodegradation/biotransformation; volatilization
Inorganics	Dissolution/precipitation -pH dependent

Degradation/Transformation describes the process by which a contaminant will degrade or change due to naturally occurring chemical reactions. The resulting daughter products may have significantly different environmental mobilities and toxicological properties than the original chemical.

Biodegradation is the degradation of aqueous phase chemicals by microbes in soil or water. Microbial consortia catalyze oxidation/reduction (redox) reactions which involve the transfer of electrons between two chemical species, either under aerobic or anaerobic conditions. Biological degradation only occurs in the aqueous phase. Sorbed contaminants are not biodegraded. Metals do not undergo biodegradation.

Sorption includes adsorption (adhesion to a solid's surface) and absorption (penetration into the solid). Sorption can retard the transport of a sorbed species. Aqueous solubility, polarity, organic carbon/water partition coefficient (K_{oc}), pH, and Eh influence sorption.

Hydrolysis is the reaction of a compound with water resulting in a new chemical species. Hydrolysis is strongly pH-dependent, and is typically too slow to be a significant contaminant reduction process in groundwater systems. Hydrolysis of chlorinated hydrocarbons can become significant if conditions are not conducive to biologically catalyzed transformation.

Volatilization is the partitioning of contaminants from the liquid to the vapor phase. Volatilization can be an important contaminant transport process depending on the physical properties of the contaminant and the partially saturated medium through which the vapor phase of the contaminant moves. Movement of the vapor phase is typically controlled by molecular diffusion, and can be a significant factor in developing a mass balance for site contaminants.

Dissolution and precipitation are processes by which contaminants partition from the aqueous phase to the solid phase and vice versa. The phase relationship can be purely physical or can involve a chemical reaction. Redox conditions and pH govern the stability of inorganics, determining which ionic species will be present in the aqueous phase and whether a given metal will precipitate or dissolve.

For organic compounds, dissolution is the process by which chemicals existing in a nonaqueous phase enter the aqueous phase. Behavior of immiscible fluids in the subsurface is controlled by interfacial tension and relative fluid density. Fluids less dense than water accumulate at the upper surface of the saturated zone, while dense fluids can travel downward through the saturated zone. When immiscible fluids contact the saturated zone, the rate at which compounds enter the aqueous phase is controlled by the geometry of the interface, the aqueous solubility of each contaminant, and the composition of the immiscible phase.

Contaminant Persistence

Described in this section are the chemical, physical, and biological factors that affect the persistence of each class of chemical contaminants.

Chlorinated VOCs - The chlorinated solvents that have been detected (cis-1,2-DCE and CFC-113) are moderately persistent in the environment. They are resistant to abiotic degradation and are moderately susceptible to biodegradation under anaerobic conditions. CFC 113 has been detected in site groundwater. Cis-1,2-DCE has been detected in soil and surface water.

Inorganics - The persistence of inorganics is controlled by the rate of leaching, amount of rainfall and the physical properties of the metal of interest. Inorganic persistence is complicated by processes such as pH-dependent precipitation and dissolution, the presence of certain ions or complexing agents, and concentrations of the inorganics in solution. These factors are discussed further under mobility.

Contaminant Mobility (Transport)

The major processes affecting the transport of each chemical class are shown in the following table.

Contaminant Group	Dominant Transport Process
Chlorinated VOCs	Volatilization, dissolution
Inorganics	Sorption, dissolution, bioaccumulation

Volatilization - The process by which chemicals partition from a solid or liquid phase into the gas phase. Volatilization is an important contaminant transport process at the soil/air and liquid/air interface. The physical characteristics of the contaminant including vapor pressure, Henry's Law constant (K_H), possible cosolvent effects, and water solubility determine volatilization rates.

Adsorption - The organic carbon partition coefficient (K_{oc}) expresses the tendency of a contaminant to sorb to organic matter.

Bioaccumulation/bioconcentration - Some inorganic constituents, such as lead and mercury, tend to partition into animal or plant tissue.

Dissolution/precipitation - Whether a chemical partitions into water or is precipitated out of solution depends on the compound's aqueous solubility and the physical properties of the ground or surface water. Chlorinated VOCs, being highly soluble chemicals, are readily leached from wastes and soils into groundwater, where they continue to be highly mobile as dissolved contaminants. The solubility of inorganics is highly variable due to its dependence upon redox conditions and pH.

Mobility of Organic Compounds

Chlorinated VOCs - Chlorinated VOCs are generally very mobile in the environment. They are highly volatile, do not adsorb readily to soils, and are highly soluble in water. Chlorinated VOCs that have been identified as environmental COPCs at the site are associated with solvent-contaminated water that was discharged to the former landfill. TCE was used to wash various equipment at the tile manufacturing plant. Cis-1,2-DCE is a daughter product of TCE.

When solvent-contaminated water was originally released to the landfill, a significant fraction of the VOCs would have partitioned to the vapor phase, due to their high Henry's Law constants and vapor pressures. Then, since these chlorinated solvents are moderately to highly soluble in water and have a low tendency to partition into soils, the fraction remaining in the soil would infiltrate through the unsaturated zone as an aqueous phase contaminant, ultimately leaching into groundwater. Accordingly, chlorinated VOCs were detected primarily in groundwater, with three detections in surface water.

Mobility of Inorganic Compounds

A variety of factors affect the mobility of inorganics in soils, including:

- the presence of water (soil moisture content)
- the pH and Eh, which affect the speciation of all inorganics and the availability of sorption sites
- soil properties, such as CEC, the presence of hydrous oxides of iron and magnesium, and the presence of organic matter

For a given inorganic constituent, soil sorption constants may vary over several orders of magnitude depending primarily on soil moisture, soil type, TOC, and pH. Because of the wide range of soil conditions in the environment and the resulting high variability of certain physical parameters, it is difficult to predict the mobility of inorganics sorption capacity.

Generally, the inorganic analytes that exceed screening levels at the site are relatively insoluble in water. As a result, they tend to sorb to soil or organic matter. However, due to the varying properties of each inorganic analyte, and dependent on environmental conditions, some inorganics will leach from areas of deposition into aqueous media.

The relative mobilities for some of the inorganic analytes found at the Salford Quarry site are described below.

<u>Aluminum</u> - Mobility of aluminum is enhanced by low pH. Acidic aqueous solutions effectively leach aluminum from the surface of aluminum-containing formation minerals. The mobile aluminum species in solution is typically Al(OH). Site soil conditions are slightly to strongly acid, indicating a strong tendency for aluminum to leach to groundwater. Aluminum is not known to bioconcentrate.

<u>Antimony</u> - Based on the results of several studies, antimony appears to sorb strongly to soil and sediment. Its sorption is correlated with the content of iron, manganese, and aluminum in the soil. With these minerals, antimony can coprecipitate as hydroxylated oxides. Adsorption does not appear to be correlated with the organic carbon content of the soil. Antimony released to water tends to partition into sediment; however, at Salford antimony was detected were in both sediment and groundwater. After prolonged leaching, residual antimony appears to convert to a less mobile form, thereby reducing the potential for future leaching. However, under reducing conditions such as those measured in a minority of the West Branch of Skippack Creek sediment samples, antimony can be methylated by microorganisms and thereby mobilized.

Arsenic - Arsenic (As) is generally mobile, although significant sorption occurs under conditions of abundant organic carbon and low pH. The reduced species of As can be a mobile aqueous contaminant, moving with groundwater virtually unretarded. However, under acidic soil conditions, such as those encountered in Salford soils, the oxidized species (As 5+) is extensively sorbed. Sorbed As 5+ may be remobilized if conditions become sufficiently reduced for As 5+ to form As 3+. In Salford soils, mobility of As will be low to moderate, due to the acidic and loamy nature of the soils. However, local reducing conditions, such as encountered in source areas, may increase leaching of As.

Barium - The solubility and mobility of barium increases with decreasing pH and decreasing TOC. Barium mobility is decreased by reaction with metal oxides and hydroxides, such as the iron oxides found in Salford soils. Site soil conditions are moderately to highly acid with high TOC, properties that act in opposition to one another with respect to the solubility and mobility of barium. However, TOC is typically low in deeper portions of aquifers, helping explain reported detections of barium in residence and monitoring wells. Barium can bioconcentrate in aquatic organisms.

Boron - Boron in the environment is always found chemically bound to oxygen; elemental boron is not found in nature. The predominant species of boron in aqueous systems at or below pH 9.2 is undissociated boric acid, which has a strong charge distribution allowing it to form a surface complex with negatively charged minerals. Boric acid may sorb to iron and aluminum hydroxy compounds, clay minerals, or organic carbon. Boron sorption maxima are located near pH 7 to 8 for sorption to mineral oxides and from pH 9 to 10 for clay or organic-rich soils; however, significant sorption occurs at lower pH.

At a field site in Cape Cod, Massachusetts, the USGS conducted tracer tests to investigate the solute transport characteristics of contaminants, including boron, in a plume of groundwater contaminated with sewage effluent. Tracer tests provide an excellent method for quantifying site-specific solute transport characteristics; however, relating the experimental findings to the Salford site requires significant interpretation, taking into account differences in hydrology, aqueous chemistry, and aquifer sorptive characteristics.

- The experimental aquifer was 40 to 50 ft thick, composed of fine to medium sand with local gravelly zones, whereas the site aquifer consisted of less than 10 ft of loamy soil overlying a fractured rock aquifer.
- For the experimental aquifer, the CEC was low, ranging from 0.5 to 2.0 meq/100g. For Salford soils the CEC ranges from 4.0 to 20 meq/100g. The CEC for a typical shale, representing the fractured bedrock aquifer, ranges from 7.0 to 14 meq/100 g.
- In the experimental aquifer, groundwater pH ranged from 5.0 to 7.2, whereas measured pH in Salford groundwater ranged from 6.76 to 8.35.

From the solute transport experiments conducted at the USGS field site, retardation factors from 1.3 to 2.1 were calculated for boron. Retardation of boron was greater in the unsaturated zone than in the saturated zone, possibly as a result of spacial heterogeneity in exchange properties and preferential saturated zone flow through coarse gained sediments not present in the unsaturated zone. Despite its tendency to partition into the aqueous phase at low pH, boron was clearly retarded under the experimental conditions. The experimental findings would imply a retardation factor of greater than 1.3 to 2.1 for the Salford site, considering that Salford aquifer materials would be expected to have a greater CEC and measured groundwater pH was typically higher. However, the effect of preferential flow through connected fractures is not known. In the experimental aquifer, the USGS speculated that preferential flow served to reduce boron retardation, and it is possible that preferential flow within the fractured bedrock may reduce boron retardation at Salford as well (DeSimone 1997).

Cadmium - Cadmium adsorption correlates closely with soil CEC. The sorbed fraction increases with soil pH and organic content. In soil, cadmium may lose mobility by conversion to more insoluble forms such as cadmium carbonate in aerobic environments and cadmium sulfide in anaerobic ones.

Aqueous cadmium can be found in several chemical forms - hydrates, metal-inorganic complexes, and metal-organic complexes. Aqueous cadmium is typically in the Cd^{+2} valence. Redox potential has little effect on the valence state of aqueous cadmium. Much of the cadmium in surface waters adsorbs onto particulate matter and settles out. As a result, cadmium concentrations in bed sediment are typically an order of magnitude higher than in the overlying water. Bottom sediment tends to become more reduced, under reducing conditions and in the presence of sulfur, insoluble cadmium sulfide may form. Remobilization of cadmium may occur when anoxic bottom sediment is exposed to an oxidizing environment.

Chromium - The mobility of chromium in soils depends on its oxidation state. It is most often found in the oxidation state Cr(III) and, to a lesser extent, Cr(VI). Chromium can be adsorbed or complexed to soil particles, metal oxides, or organic matter and is therefore rather immobile. Most of the Cr(III) found in soils is mixed Cr(III) and Fe(III) oxides or in the lattice of minerals, although Cr(III) complexed with organic ligands may stay in solution for over a year. Cr(III) is mobilized only in very acidic soil media. Cr(VI), by contrast, is easily mobilized, independent of the soil pH. The absorption of chromium onto clays is pH dependent; Cr(III) adsorption increases as pH increases, whereas Cr(VI) adsorption decreases as pH increases.

Iron - The species of iron found in a given system is primarily dependent on the Eh, pH, and the presence of sulfur. In the absence of sulfur, two insoluble iron species and four soluble species are possible. If sulfur is introduced, soluble ferrous sulfide and insoluble ferrous disulfide also may occur. The mobility of iron is controlled by its speciation, with insoluble forms remaining on sediment and soluble forms advecting with groundwater.

Lithium - Lithium will readily leach through soils due to its low sorption potential. In groundwater, the lithium cation typically advects unretarded. Because most lithium salts are soluble, the effect of pH will be minimal upon the mobility of lithium in soil. Volatilization from water or soil surfaces is not an important fate process. A limited number of monitoring studies have shown that lithium bioaccumulates to a small degree in a variety of fish species.

Manganese - Manganese exists in the soil in a variety of forms which have varying mobility. The exact distribution of these forms depends on pH: lower pH results in a greater dissolved fraction. Typically, only a small fraction of manganese is water soluble. A larger fraction is either exchangeable, bound to organics, or bound to iron oxides. Hydrous manganese oxides exist in amorphous or microcrystalline forms yielding great surface area for the sorption of other metals. The binding of a variety of metals to manganese oxides has been observed. However, under strongly reducing conditions, such as those encountered in an organic contaminant source area, microbial reduction of manganese oxides will reduce manganese 3+ and 4+ compounds, resulting in the formation of soluble manganese 2+ compounds. Thus solubilized, the manganese, plus any associated metal cations, will be remobilized.

Mercury - Most inorganic mercury compounds have low solubility. Once mercury compounds are released into moist soil environments, they may dissociate depending upon their solubility. Upon dissolution, mercury will either be associated with its respective anion or be associated with humic matter. Studies indicate that mercury compounds, once deposited on soil, are absorbed to the soil and do not leach. However, mercury compounds can be methylated by microorganisms indigenous to soils and fresh water. This process is mediated by various microbial populations under both aerobic and anaerobic conditions.

Nickel - Nickel is highly mobile in soils relative to other heavy metals. Adsorption experiments conducted on a mixture of low concentrations of nickel, cadmium, cobalt and zinc, in soils with varying pH's, clay content and organic carbon content, indicated nickel was more mobile than cadmium, less mobile than cobalt and had approximately the same mobility as zinc. Nickel complexes with organic substances and sulfate, increasing its mobility. Conversely, abundant sulfide can decrease the mobility of nickel through the formation of insoluble sulfide complexes.

Nickel is one of the most mobile of the heavy metals in the aquatic environment. Its aqueous mobility is increased by association with various complexes, such as hydrous oxides of iron and manganese and organic material. However, in reducing environments, insoluble nickel sulfide may be formed. Nickel is bioaccumulated, but the concentration factors suggest that partitioning into the biota is not a dominant fate process.

Selenium - Selenium is a fairly immobile environmental contaminant. Under oxidizing conditions, selenium occurs as an oxide with sorptive affinity for hydrous metal oxides, clays and organic materials. Reducing conditions favor the formation of elemental selenium or the precipitate ferroselanite. In sediments, reduced and tightly bound selenium will remain relatively immobile unless the sediments are chemically or biologically oxidized.

Thallium - Thallium is a fairly immobile environmental contaminant. Thallium (Tl) exists in two oxidation states, Tl 1+ and Tl 3+. Thallium compounds can be mobilized in groundwater under oxidizing conditions. In reducing environments, Tl 1+ may precipitate as a sulfide and Tl 3+ forms several organo-metallic compounds and may thus become bound to mineral surfaces. Thallium bioaccumulates.

Vanadium -In soil, the mobility of vanadium is primarily determined by soil pH. Mobility is expected to be lower in acidic soils, such as those encountered at Salford. In the presence of humic acids, mobility is greatly decreased, resulting in local accumulation of vanadium in soil zones with high organic content. Under acid soil conditions, vanadium tends to adsorb to organic matter, manganese oxides, ferric hydroxides, and silicate clay materials, providing an explanation for reported detections in unfiltered samples from Salford surface water and groundwater. Under oxidizing, unsaturated conditions some mobility is observed, but under reducing, saturated conditions vanadium is essentially immobile.

2.4.2.3 Summary of Contaminant Fate and Transport

The majority of the chemicals detected in site surface water, groundwater, soil, sediment, and waste can be grouped into two general categories that describe their persistence and mobility in the environment:

Chlorinated VOCs - Chlorinated VOCs were detected in the subsurface soils and thus remain a likely source of groundwater contamination, having the capacity to be transported vertically through the soil into fracture and joint systems in the bedrock underlying the site. Chlorinated VOCs do not sorb strongly to soils making them relatively mobile in groundwater. Their persistence will be determined by their rates of biodegradation, and their mobility by their partitioning coefficients (K_d).

Inorganics - Inorganics are generally low to moderately mobile in silty, clayey soils and may be strongly retarded on organic carbon. The presence of complexing chemicals in solution, pH, Eh, and the surface mineralogy of the soil strongly influence the transport of inorganics. The persistence of inorganics is highly dependent on pH and the presence of certain ions or chelating agents. Each inorganic compound will therefore behave differently.

2.4.3 Ecotoxicity

Ecotoxicological information for the contaminants detected at the highest concentrations and also contributing the most to the total potential risk is provided in the following sections.

Arsenic

Arsenic is widely distributed in nature and is found in many different forms that are constantly changing through oxidation and reduction. Arsenic can be absorbed through ingestion, inhalation, or dermal contact. Trivalent compounds of arsenic are the most toxic form. The primary toxic action of arsenic is caused by its effect on mitochondrial enzymes and tissue respiration. Arsenic inhibits energy functions in mitochondria by disrupting oxidative phosphorylation and inhibiting the energy-linked reduction of nicotinamide adenine dinucleotide (NAD) (Goyer 1993).

Chronic toxicity caused by arsenic exposure includes neurotoxicity of the central and peripheral nervous system, liver damage (cirrhosis), and vascular disease (Goyer 1993). Arsenic is a known carcinogen causing skin and lung cancer in humans (Goyer 1993) but there is insufficient data linking it to cancer in animals (HSDB 2003). Toxicity testing of arsenic compounds on mammals has revealed the following. Inorganic arsenate injected into pregnant hamsters increased the mortality of embryos at concentrations as low as 5 mg/kg. Malformations in hamster embryos were noted at 20 mg/kg. Chronic exposure to 12 milligrams per kilogram per day (mg/kg/day) of arsenate and arsenite in rats diets for two years caused enlargement of the bile ducts and fibrosis in the liver. LD_{50} values for rats ranged from 15 mg/kg to 145 mg/kg depending on the type of rat. Wild Norway rats had a LD_{50} of 104 mg/kg. LD_{50} values for mice ranged from 26 to 32 mg/kg (HSDB 2003).

A chronic NOAEL of 2.46 mg/kg/day and chronic lowest observable adverse effects level (LOAEL) of 7.38 mg/kg/day were calculated from data collected from a 7 month study on brown headed cowbirds which received four dietary doses of 25, 75, 225, and 675 parts per million (ppm) of arsenic. A chronic NOAEL of 5.14 mg/kg was calculated from studies of mallard ducks (*Anas platyrhynchos*) exposed to arsenic in the diet for 128 days (Sample et al. 1996). Abnormalities were noted in leghorn chicken embryos in eggs treated with arsenate at concentrations of 3 ug/egg. After 4 days, 32.5 percent of the eggs had abnormalities (HSDB 2003).

Aluminum

Aluminum has been shown to have toxic effects on the brain and central nervous system in some animals. Cats and rabbits exposed to aluminum so that the concentration in brain tissue reaches 4 micrograms per gram (ug/g) showed behavioral changes that start with poor motor function and progress to tremors, in-coordination, weakness and ataxia, and eventually seizure and death. Aluminum causes the accumulation of tangles in nerve cell bodies and proximal axons which results in the loss of nerve synapses. In animals, aluminum competes with or alters calcium metabolism in the brain, specifically affecting calcium regulation and consequentially neurotransport functions (Goyer 1993). In rats, chronic exposure to aluminum by ingestion elevated AMP dependant proteins in the cerebral cortices. Exposure to aluminum salts (hydroxide, chloride, or sulfate) injected under the skin or by ingestion resulted in lethargy, anorexia, or death. No LD_{50} value is available for aluminum because death occurs by precipitation of aluminum in the gut, which causes blockage before the toxic effects of aluminum act on the subject (HSDB 2003). Birds seem to be less sensitive to aluminum. A study of the ringed dove resulted in a chronic NOAEL value of 109.7 mg/kg/day (Sample et al. 1996). Ingestion of aluminum by chickens at a concentration of 1,400 ppm lowered levels of inorganic phosphorous in blood and bone tissue resulting in severe rickets (HSDB 2003).

Boron

Boric acid (H_3BO_3) is the predominant form of boron in aqueous solution at physiological pH. Unlike many inorganics, boron toxicity is not affected by water hardness (Butterwick et al. 1989). Boron can bioaccumulate at higher concentrations but there is no biomagnification up the trophic levels (Whitworth et al. 1991). Due to its polarity, boron does not bioaccumulate in fat tissue (Moseman 1994). Instead, the target areas include the brain, spinal cord, and liver (Whitworth et al. 1991).

Boron is an essential nutrient for plants; however, boron becomes highly toxic at elevated levels (Butterwick et al. 1989). Toxicity symptoms include needle tip necrosis and discoloration in pines (Neary et al. 1975) and burning of leaf edges in other plants. Relatively little aquatic toxicity information is available for boron.

Gersich (1984) reported a chronic value (CV) of 9.33 mg/L for *D. Magna* while Lewis and Valentine (1981) reported a slightly lower CV of 8.83 mg/L for the same species. Chronic exposures to sodium tetraborate significantly inhibited midge larvae growth at 20.0 mg/L (Maier and Knight 1991). Chronic toxicity to aquatic plants was assessed during a 32-day study exposing *Myriophyllum spicatum* to 40.3 mg/L boron tetraborate. Root growth was inhibited by 50 percent (Butterwick et al. 1989). Boron levels in aquatic vegetation seeds have been as high as 3500 mg/kg, a concentration sufficient to adversely affect birds that feed upon it (Schuler 1987, as cited in Smith and Anders 1989).

The toxicity of boron to the early life states of rainbow trout (*Oncorhyncus mykiss*) is typically a restrictive criterion in setting water quality standards. Embryo-larval studies have determined no observable effect concentrations of 3 to 25 mg boron (as boric acid) per liter (B/L) for amphibians, 0.2 to 5.5 mg B/L for catfish, 0.2 to 1.4 mg B/L for goldfish and 0.001 to 0.1 mg B/L for rainbow trout. Lowest observed effect concentrations (LOECs) for rainbow trout have been reported to be as low as 0.001 to 0.008 mg B/L (Birge and Black as cited in Loewengart 2000). These results suggest that rainbow trout are particularly sensitive to boron. However, this low range for the LOECs has not proven to be consistent with the majority of findings, nor has the response been verified in the field (Lowengart 2000). Boron has been measured in wild trout streams and trout hatcheries at concentrations up to 1.0 mg B/L with no observed adverse effects. The dose-response relationship of boron in trout have been shown to follow a U-shaped dose-response curve, consistent with the characteristic shape of an essential nutrient. Considering the weight of evidence from both laboratory and field studies, it appears that concentrations less than 1.0 mg B/L result in no observable adverse effects on rainbow trout (Lowengart 2000).

As a result of high concentrations of boron in aquatic food webs associated with agricultural drainwater, mallard ducks and other waterfowl may be placed at risk of boron toxicosis (Hoffman et al. 1991). Smith and Anders (1989) fed mallard ducks diets containing 8, 35, 288, and 1000 mg B/kg (as boric acid) for 3 weeks prior to, during, and 3 weeks post reproduction. Consumption of 100 mg B/kg diet reduced egg fertility by 48 percent, increased embryo mortality 7.5-fold and increased duckling mortality by 81 percent at seven days. While all boron containing diets reduced weight gain by ducklings, no adverse reproductive effects were observed among other dose levels. Based on the results of Smith and Anders (1989), Sample et al. (1996) estimated the NOAEL and LOAEL for reproductive effects in mallards to be 28.8 and 100 mg B/kg/day, respectively. Because the study considered exposure throughout reproduction, the 288-ppm dose was considered to be a chronic NOAEL and the 1000-ppm dose was considered a chronic LOAEL.

Stanley et al. (1995) supplemented the feed for 126 pairs of 1-year-old mallard drakes and hens (*Anas platyrhynchos*) with boron as boric acid at 0 ppm, 450 ppm, and 900 ppm concentrations. On a dry-weight basis, boron in adult liver in the control, 450, and 900 ppm boron treatment groups was 2, 15, and 27 ppm, respectively. The authors found that boron accumulates rapidly in adult mallard liver and is estimated to take 2.8 days to reach 95 percent of its maximum observed concentration in the liver. Dry-weight concentrations of boron in eggs were 0.6, 22, and 38 ppm in the boron control, 450 and 900 ppm treatment groups, respectively. Boron in the 900 ppm treatment group caused weight loss in females between treatment onset and pairing, whereas controls gained weight. Egg weight and egg fertility were lower in the 900 ppm boron group when compared to controls. Boron did not increase embryo deformities, but at 900 ppm it reduced hatching success by more than 42 percent. In the 450 ppm boron treatment group, hatching success was not affected. However, egg concentrations in the treatment groups were considerably higher than reported for eggs from boron contaminated sites; therefore it seems unlikely that boron would be a significant factor in reducing hatching success in ducks even at highly contaminated sited in the field. No direct field evidence exists that duckling production is reduced at boron contaminated sites. However, dietary concentrations of boron that can be equaled in nature caused reduced duckling weights in laboratory studies. In the wild, lower duckling weights could result in lower survival (Stanley et al. 1995).

Most mammalian boron toxicity studies have been conducted using rats and dogs. While not completely understood, a number of theories concerning the mechanisms of boron toxicity in mammals have been proposed. It is believed that involuntary hyperactive movements expressed during boron toxicosis are due to boron interference in the extrapyramidal system. Boron may also interact with estrogen and testosterone by influencing mineral metabolism through endocrine mechanisms (Nielsen et al. 1987 as cited in Sisk et al. 1990). Boron has been shown to decrease male fertility in rats and dogs (Lee et al. 1978). Chronic exposure of both rats and dogs leads to testicular atrophy, spermatogenic arrest, and germinal aplasia (Bouissou and Castanol 1965, as cited in Lee et al. 1978). Lee et al. (1979) investigated germinal aplasia induced by boron exposure and found that accumulation in the testes increased with dose concentration and dose length. At 30 to 60 days post-exposure, there was a significant drop in germinal elements in animal groups exposed to 1000 mg/L borax. At 60 days post-exposure, there was a drop in liver (13.79 to 10.41 g), testicular (1.81 to 0.63 g), and epidermis (1.23 to 0.8 g) weights in both the 100 mg/L and 2000 mg/L groups (Lee et al. 1978). Testicular atrophy was seen 90 days post-exposure at 1170 mg/L in a similar study conducted by Weir and Fisher (1972).

Weir and Fisher (1972) fed rats diets containing 117, 350, and 1170 mg boron/kg (B/kg, as borax or boric acid) for three generations. No adverse effects were observed among individuals on the 117 and 350 mg B/kg diets; reproductive performance, as measured by fertility and lactation indices, exceeded controls. In contrast, rats consuming the 1170 mg B/kg diet were sterile; atrophied testes were observed among males while females displayed decreased ovulation. Based on the results of Weir and fisher (1972), Sample et al. (1996) estimated a NOAEL and LOAEL for reproduction in rats to be 28 mg B/kg/day and 93.6 mg B/kg/day, respectively.

Cadmium

Cadmium bioaccumulates in both aquatic and terrestrial animals, primarily in the liver and kidney, with higher bioconcentration in aquatic organisms. Data shows that cadmium accumulates in grasses, crops, earthworms, poultry, cattle, horses, and wildlife; however, data on biomagnification of cadmium are inconclusive (ATSDR 1991). Freshwater biota are more sensitive to cadmium exposure than terrestrial animals, with toxicity inversely proportional to water hardness. Cadmium accumulated from water is slowly excreted, while cadmium accumulated from food is eliminated more rapidly (EPA 1985). Cadmium adsorption is inversely proportional to intake of other metals, particularly iron and calcium. Cadmium crosses the placental barrier (Venugopal 1978). Absorbed cadmium is excreted very slowly, with urinary and fecal excretion being approximately equal (Kjellstrom and Nordberg 1978).

Cadmium, a known carcinogen and teratogen, has been implicated as the cause of severe deleterious effects on fish and wildlife. It is conservatively estimated that adverse effects on fish or wildlife are either pronounced or probable when cadmium concentrations exceed 3 ppb in freshwater. Several studies have illustrated teratogenic effects on aquatic biota. For example, adult fathead minnows were reared in water with cadmium concentrations of 37 to 57 µg/L. Minnow embryos, as well as eggs transferred into exposed water, showed reduced percent hatching, increased deformities, and development of blood clots. Edema, microcephalia, and malformed caudal fins were observed in bluegill embryos after they were exposed to 80 µg/L cadmium in water (Eisler 1985).

Birds and mammals are comparatively more resistant than aquatic biota to effects of cadmium contamination. Sublethal effects in birds include growth retardation, anemia, and testicular damage. Teratogenic effects have also been observed in birds. For example, chickens hatched from eggs injected with 0.1 to 1.0 ppm of cadmium chloride showed caudal and hindlimb abnormalities (Eisler 1985). There is some evidence that cadmium may have teratogenic, mutagenic, and carcinogenic effects on mammals. The offspring of pregnant rats dosed daily with 6 mg/kg body weight cadmium showed haw defects, cleft palates, club feet, and pulmonary hyperplasia. Chromosomal abnormalities were observed shortly after mice were injected with 3 or 6 mg cadmium chloride per kg body weight, and similar effects were observed in hamsters (Eisler 1985). A study of the effects of cadmium on growth, survival, and tissue levels in the mouse resulted in a chronic LOAEL of 3.00 mg/kg/day and a chronic NOAEL of 0.30 mg/kg/day (Shore and Douben 1994). A study of the effects of cadmium on growth, survival, and tissue levels in the rat resulted in a chronic LOAEL of 14.0 mg/kg/day and a chronic NOAEL of 1.40 mg/kg/day (Shore and Douben 1994) A study of the effects of cadmium on growth, survival, and tissue levels in the mallard duck resulted in a chronic LOAEL of 20.0 mg/kg/day and a chronic NOAEL of 1.45 mg/kg/day (Sample et al. 1996).

Copper

Copper is an essential nutrient for plants and animals at low concentrations. Copper can bioaccumulate in aquatic organisms such as algae and mollusks, however, it is not known to biomagnify (EPA 1985). In mammals, the exposure routes include inhalation, ingestion, and dermal absorption. Bioaccumulation of copper is not known to occur in mammalian species. However, copper is associated with immunologicial, hematological, hepatic, developmental, immunological, and renal effects in mammals.

Copper has been observed to inhibit photosynthesis and plant growth by interfering with enzyme functioning (Mukherji and Das Gupta 1972). A chronic study found that the root and shoot weights of little bluestem *(Andropogon scoparius)*, grown from seed for 12 weeks in sandy soil, decreased approximately sixty-eight percent (Miles and Parker 1979). Copper was added to the soil as 100 mg/kg of copper sulfate ($CuSO_4$). The soil pH and percent organic matter were 7.8 and 2.5, respectively.

A ninety day subchronic study that administered varying amounts copper cyanide (CuCN) to rats caused an increased mortality due to hemolytic anemia (EPA 1986). This increased mortality was observed in both male and female rats that received a dose of 50 mg/kg/day by gavage. Conversely, increased mortality was not observed in those rats receiving less than 5 mg/kg/day. Rats that received approximately10 mg/day exhibited depressed growth; those receiving 20 mg/day exhibited little growth, and those receiving 40 mg/day exhibited weight loss that lead to mortality (Boyden et al. 1938). A study of the effects of copper on growth, survival, and tissue levels in the mouse resulted in a chronic LOAEL of 390 mg/kg/day and a chronic NOAEL of 39.0 mg/kg/day (SRC 1990). A study of the effects of copper on growth, survival, and tissue levels in rats resulted in a chronic LOAEL of 140 mg/kg/day and a chronic NOAEL of 14.0 mg/kg/day (SRC 1990). A study of the effects of copper on growth, survival, and tissue levels in chicks (1 day) resulted in a chronic LOAEL of 20.0 mg/kg/day and a chronic NOAEL of 1.45 mg/kg/day (Sample et al. 1996).

Lead

Lead is the most common toxic metal and is detectable in all phases of the environment and biological systems. Lead has been shown to be toxic to birds, mammals, amphibians, and reptiles in terrestrial environments. Toxicity to mammals is known to include increased mortality, reproductive effects, reduced growth, alterations of blood chemistry, and behavioral changes. Lead affects the nervous system, the blood system, gastrointestinal system, and reproductive system. It is known to be a powerful neurotoxin and acts by depressing neurotransmission through inhibition of cholinergic function, impairment of dopamine uptake, and the disruption of other neurotransmitters. Lead causes anemia by impairment of blood cell production and shortening of the life span for a blood cell (Goyer 1993).

Lead is a confirmed animal carcinogen, causing tumors in multiple sites. Feeding studies using bank voles (*Clethrionomys glareolus*) caused mortality and impaired development in young voles when their mothers received lead-contaminated food (HSDB 2003). A sharp decrease in pregnancy was noted in rats receiving an oral dose of lead acetate of 390 mg/kg/day, with an identified LOAEL of 39 mg/kg/day (HSDB 2003). Northern leopard frogs (*Rana pipiens*) exposed to 25 ppm lead exhibit loss of erect posture, sloughing of skin, excretion of bile, and hypertrophy of the liver, spleen, and stomach. Mortality of the frogs increased when the dose exceeded 25 ppm (HSDB 2003). A chronic ingestion study using the American kestrel determined an oral dose of 3.85 mg/kg/day to be the NOAEL value and calculated a chronic LOAEL of 38.5 mg/kg/day (Sample et al. 1996). A study of the effects of lead on growth, survival, and tissue levels in the mouse resulted in a chronic LOAEL of 1.50 mg/kg/day and a chronic NOAEL of 0.15 mg/kg/day (SRC 1990).A study of the effects of lead on growth, survival, and tissue levels in the rat resulted in a chronic LOAEL of mg/kg/day and a chronic NOAEL of mg/kg/day (SRC 1990).

Lithium

Lithium is an element that does not occur naturally in its free form; however, it has been found in various minerals. It is not known to bioaccumulate or biomagnify. Studies have shown that elevated levels of lithium and lithium related compounds can cause adverse developmental and reproductive effects in mammals (Marathe and Thomas 1986, Chernoff and Kavlock 1982).

In a study conducted by Marathe and Thomas, exposure of pregnant rats to 100 mg/kg/day of lithium carbonate on gestation days 6 to 15 caused a significant reduction of live fetuses and fetal body weight. No developmental effects were observed on those rats that received a dose of 50 mg/kg/day. Significant reductions in litter size and growth have been caused by excess lithium within the diet (Ibrahim and Conolty 1990).

A study by Thakur et al. (2003) investigated the adverse effect of subchronic exposure of lithium carbonate on reproductive organs of the male rat. Rats were exposed to lithium carbonate at doses of 500, 800, 1100 mg/kg of diet for 90 days. The weight of reproductive organs, histology of testis, epididymis, seminal vesicle, prostate, testicular interstitial fluid volume (IFV), testosterone level, sperm morphology, and fertility index were analyzed. Treatment with higher doses of lithium carbonate (i.e. 800, 1100 mg/kg diet) significantly reduced testes, epididymis, and accessory sex organ weights, whereas a lower dose (500 mg/kg diet) did not show any negative effects. When the lithium carbonate-treated males were mated with normal cyclic females, the fertility index declined to 50 percent even after 30 days of withdrawal of lithium carbonate treatment. These results clearly suggest that subchronic exposure of lithium carbonate promotes reproductive toxicity and reduces fertility of male rats (Thakur et al. 2003).

Mercury

Mercury is a naturally occurring element in the environment that does not readily mobilize from sediment or soil. However, mercury is extremely toxic and has no biological function. It bioaccumulates and biomagnifies in food chains. Various studies have shown that mercury is a mutagen, teratogen, and carcinogen. The inorganic forms of mercury are not as toxic as the organic forms (Eisler 1987). Mammalian species tend to absorb organic forms of mercury through the respiratory tract, gastrointestinal tract, and skin. The organic forms can cross placental barriers.

Chronic mercury poisoning in fish can cause emaciation due to appetite loss, brain lesions, diminished response to light intensity, inability to capture food, and abnormal muscle coordination (Eisler 1987). In general, aquatic species accumulate mercury rapidly and excretion is slow.

In mammals, subchronic exposure to mercury can cause deleterious effects on reproduction, growth and development, behavior, blood and serum chemistry, histology, and metabolism. Methylmercury irreversibly destroys neurons of the central nervous system. Symptoms to mercury exposure may not be evident for years after initial exposure (Eisler 1987). Smaller mammals are more sensitive to mercury exposure. Also, carnivorous mammals have been found to have greater concentrations of mercury within the liver and kidney than herbivorous species.

A chronic study of methylmercury exposure to mallards found that a dietary concentration of 0.5 mg/kg caused pronounced behavioral and reproductive abnormalities over three generations (Eisler 1987). The female mallards laid a high percentage of eggs outside of the nesting boxes, laid few eggs, and produced fewer ducklings than the controls. A study of the effects of mercury on growth, survival, and issue levels in the Japanese quail (*Coturnix coturnix*)resulted in a chronic LOAEL of 0.90 mg/kg/day and a chronic NOAEL of 0.45 mg/kg/day (Sample et al. 1996). A study of the effects of mercury on growth, survival, and issue levels in the mink (*Mustela vison*) resulted in a chronic LOAEL of 0.32 mg/kg/day and a chronic NOAEL of 3.85 mg/kg/day (Sample et al. 1996). A study of the effects of mercury on growth, survival, and issue levels in the mouse resulted in a chronic LOAEL of 38.5 mg/kg/day and a chronic NOAEL of 3.85 mg/kg/day (Sample et al. 1996).

Nickel

Nickel is a naturally occurring element that can be found in various types of media. However, nickel tends to adsorb to soil and sediment particles. Ingestion is the primary exposure route of nickel into the body.

Baccouch et al. (1998) exposed hydroponically grown corn (*Zea mays*) plants to nutrient solutions containing nickel at concentrations of 0.00, 1.17, 2.93, 5.87, 14.7, and 29.4 mg/L. Plants supplied with an excess of nickel developed toxicity symptoms two days after treatment. At 1.17, 2.93, and 5.87 mg/L nickel concentrations, leaves yellowed or whitened because of a decreased amounts of chlorophyll. At higher concentrations of nickel, toxicity was manifested by leaf necrosis and browning of the root system. Nickel reduced dry matter yields more significantly in roots than in shoots. Nickel was found to induce leaf accumulation of carbohydrates, in part explaining the observed root growth inhibition (Baccouch et al. 1998) .

Baccouch et al. (2001) treated seven day-old corn plants with 14.7 mg/L $NiCl_2$ for four days. The relationship between nickel toxicity and oxidative reactions was studied in the root structures during metal accumulation. After 6 hours, membrane lipid peroxidation was enhanced, and roots revealed a decrease in growth. Catalase enzyme activity increased 24 hour after treatment. Ascorbate peroxidase and monodehydroascorbate reductase were stimulated as well. The results suggest that oxidative disorder is part of the overall expression of nickel toxicity in roots of corn plants and that enhanced lipid peroxidation could be a consequence of primary effects of nickel stress. Growth reduction caused by nickel may be linked to a loss of cellular turgor perhaps the result of potassium leakage from the cells (Baccouch et al. 2001).

Elevated levels of nickel have been shown to cause deleterious effects to soil invertebrate growth and reproduction (Fordsmand et al. 1999). A common soil invertebrate, *Folsomia fimetaria*, was used to determine the toxic effects of nickel on invertebrate communities. Significant mortality was observed for adult and juveniles exposed to soil nickel concentrations of 1000 mg/kg. However, mortality was not significantly observed below nickel concentrations of 700 mg/kg. A study of the effects of nickel on growth, survival, and issue levels in the rat resulted in a chronic LOAEL of 50.0 mg/kg/day and a chronic NOAEL of 5.0 mg/kg/day (IRIS 2003). A study of the effects of nickel on growth, survival, and issue levels in the mallard duckling resulted in a chronic LOAEL of 107 mg/kg/day and a chronic NOAEL of 77.4 mg/kg/day (Sample et al. 1996). A study of the effects of nickel on growth, survival, and issue levels in the dog resulted in a chronic LOAEL of 250 mg/kg/day and a chronic NOAEL of 25.0 mg/kg/day (IRIS 2003).

Zinc

Zinc is an essential nutrient but can be toxic at very high industrial levels. Exposure to zinc dust and fumes have been shown to cause lung damage in guinea pigs. Injections of zinc into chickens and rats have caused testicular tumors (Goyer 1993). A study of zinc toxicity to reproductive function in chickens determined a chronic NOAEL of 14.5 mg/kg/day and a LOAEL of 131 mg/kg/day (Sample et. al. 1996). A study conducted on rats evaluating effects on reproductive function indicated a chronic NOAEL value of 550 mg/kg/day and a chronic LOAEL value of 55.0 mg/kg/day (Eisler 1993). Pregnant rats fed high concentration of zinc (> 1000 ug Zn/g diet) resulted in copper deficiencies which in turn resulted in fetal abnormalities. Zinc concentrations in excess of 0.04 mg/L were teratogenic to frog embryos (HSDB 2003). A study conducted on mice evaluating effects on reproductive function indicated a chronic NOAEL value of 1090 mg/kg/day and a chronic LOAEL value of 109 mg/kg/day (Eisler 1993). Zinc is known to bioaccumulate.

Section 3
Screening Level Exposure Assessment

The purpose of this section is to evaluate the potential for receptor exposure to chemical constituents at the site. This evaluation involves the characterization of pathways and ecological receptors and determines the magnitude of exposure to the selected ecological receptors.

3.1 Receptor Species Exposure

Exposure scenarios were constructed for receptor species selected. Factors taken into consideration in the selection of scenarios were the spatial and temporal variations in exposure, mechanisms of migration, points of exposure, behavioral characteristics, and trophic relationships.

Based upon the exposure scenarios, the following exposures were evaluated in this SLERA via food chain modeling or by direct comparison of media concentrations with benchmark values:

Contaminated Media	Receptors	Exposures
Onsite surface soils	American robin, short-tailed shrew, meadow vole, red-tailed hawk, eastern garter snake, red fox*	Ingestion of food items and incidental ingestion of surface soil
Onsite surface soils, sediment, surface water, and groundwater		
	Aquatic and terrestrial invertebrates, fish, plants**	Direct surface soil, sediment, surface water, and groundwater exposure

* Exposures are estimated through food chain exposure modeling.

** Direct comparisons of soil, sediment, surface water, and groundwater contaminant exposures have been made to media quality guidelines (screening values).

The inhalation route of chemical exposure was considered to have a negligible impact on the total exposure of receptors, therefore, it was not considered in exposure dose calculations for this SLERA. The dermal exposure pathway was considered to also have a lesser impact than the ingestion exposure route on the total exposure of receptors. Considering this and the lack of appropriate wildlife uptake rate information for the dermal exposure route, dermal exposure was not factored into the exposure dose estimation of this SLERA.

3.2 Exposure Estimation

This section discusses the methods by which chemical exposures were estimated for the receptor species. The models used to estimate exposure doses, in mg/kg/day, are presented here.

The potential risk, as determined using the calculated exposure or doses, will ultimately be used to develop preliminary remediation goals (PRGs) for soil. To assist in development of PRGs, two exposure scenarios were used to model the exposure dose; a conservative scenario and a site specific scenario. Both types of models used maximum contaminant concentrations.

Conservative and site specific exposure parameter assumptions are listed in the following table.

Food Chain Model Exposure Parameters

Parameter	Conservative Assumptions	Site Specific Assumptions
Area Use Factor	100% Site Area = Home Range	Site Area ÷ Literature Reported Home Range
Contaminant Bioavailability	100% Available	100% Available
Contaminated Dietary Fraction	100% of Diet Consists of Most Contaminated Food Item	100% of Diet Consists of Most Contaminated Food Item
Body Weight	Minimum Body Weight	Mean Body Weight
Ingestion Rate	Maximum Ingestion Rate	Mean Ingestion Rate

The potential dietary exposure (dose) was determined by multiplying the ingestion rate of the receptor species by the estimated contaminant concentration in food items and the portion of the food item in the diet, summing these values, and dividing the summed value by the body weight of the receptor species. Bioaccumulation factors were included in the exposure model when estimating the contaminant concentration in food items.

Dietary exposure estimates to contaminants in surface soil and prey were generated for the short-tailed shrew, meadow vole, red fox, red-tailed hawk, American robin, and eastern garter snake.

The following equation expresses the method for determining the dose ofindividual COPCs via contamination in the site soil:

$$\text{Dose} = [(IR \times C \times P_s)+(IR \times C \times BAF \times P_f)]/BW$$

where,

Dose = potential dietary exposure dose from contact with soil (mg chemical/kg body weight/day)

IR = ingestion rate of food (kg diet/day)

C = concentration of COPC in soil (mg/kg)

P_s = proportion of diet that is soil (unitless)

P_f = proportion of diet for food item (unitless)

BAF = bioaccumulation factor specific for food item (unitless)

BW = body weight (kg)

More specifically, the following equations were used to determine the dietary exposure doses for the modeled receptors:

Insectivorous food chain receptor (applicable to short-tailed shrew and eastern garter snake)

$$Dose = [(IR \times C \times P_s)+(IR \times C \times BAF_i \times P_i)+(IR \times C \times BAF_a \times P_a)]/BW$$

where,

Dose = potential dietary exposure dose from contact with surface soil (mg chemical/kg body weight/day)

IR = ingestion rate of food (kg diet/day)

C = concentration of COPC in surface soil (mg/kg)

P_s = proportion of diet that is surface soil (unitless)

P_i = proportion of diet that is soil invertebrates (unitless)

P_a = proportion of diet that is amphibian (unitless)

BAF_i = bioaccumulation factor specific for soil invertebrates (unitless)

BAF_a = bioaccumulation factor specific for amphibian (unitless)

BW = body weight (kg)

Carnivorous food chain receptor (applicable to red fox and red-tailed hawk)

$$Dose = [(IR \times C \times P_s)+(IR \times C \times [BAF_i \times P_i] \text{ and/or } [BAF_m \times P_m])]/BW$$

where,

Dose = potential dietary exposure dose from contact with surface soil (mg chemical/kg body weight/day)

IR = ingestion rate of food (kg diet/day)

C = concentration of COPC in surface soil (mg/kg)

P_s = proportion of diet that is soil (unitless)

P_m = proportion of diet that is small mammals (unitless)

P_i = proportion of diet that is invertebrates (unitless)

AR304930

BAF_i = bioaccumulation factor specific for soil invertebrates (unitless)

BAF_m = bioaccumulation factor specific for small mammals (unitless)

BW = body weight (kg)

Herbivorous food chain receptor (meadow vole)

$$\text{Dose} = [(IR \times C_s \times P_s)+(IR \times C_s \times BAF_v \times P_v)]/BW$$

where,

Dose = potential dietary exposure dose from contact with surface soil (mg chemical/kg body weight/day)

IR = ingestion rate of food (kg diet/day)

C_s = concentration of COPC in surface soil (mg/kg)

P_s = proportion of diet that is surface soil (unitless)

P_v = proportion of diet that is vegetation (unitless)

BAF_v = bioaccumulation factor specific for vegetation (unitless)

BW = body weight (kg)

Omnivorous food chain receptor (American robin)

$$\text{Dose} = [(IR \times C_s \times P_s)+(IR \times C_s \times BAF_v \times P_v)+(IR \times C_s \times BAF_i \times P_i)]/BW$$

where,

Dose = potential dietary exposure dose from contact with surface soil (mg chemical/kg body weight/day)

IR = ingestion rate of food (kg diet/day)

C_s = concentration of COPC in surface soil (mg/kg)

P_s = proportion of diet that is surface soil (unitless)

P_v = proportion of diet that is vegetation (unitless)

P_i = proportion of diet that is invertebrates (unitless)

BAF_v = bioaccumulation factor specific for vegetation (unitless)

BAF_i = bioaccumulation factor specific for soil invertebrates (unitless)

BW = body weight (kg)

The percent of the receptor diet that a specific food item represents is given in Table 3-1. All of the receptors eat a variety of food items; however, only the primary food item was modeled in both the conservative and site specific models. For example, the fox's diet varies with the season, consisting primarily of small mammals but also including birds and bird eggs, invertebrates, and fruits. Because small mammals make up a greater percentage of the fox's diet, this was the primary food item that was modeled. The same is true for the red-tailed hawk. The models account for incidental ingestion of soil. Species-specific ingestion rates and body weights used in this assessment for both the conservative and site specific models are also provided in Table 3-1.

The contaminant concentration of a food item was calculated by multiplying the contaminant concentration in the inorganic medium by the food group-specific bioaccumulation factor. The bioaccumulation factors used are presented in Table 3-2. To be conservative, a value of one was applied when no bioaccumulation factor was found in the literature. No amphibian BAFs were found in the literature. Amphibians make up 68% of the diet of eastern garter snake (Fitch 1941). BAFs of small mammals were used as the surrogate amphibian BAFs in the food chain model for eastern garter snake.

The Ecological Risk Assessment Guidance (ERAG) (EPA 1997) recommends for the screening level exposure estimate that the home range used in food chain models for terrestrial animals equal the size of the site. This was accounted for in the model for each ecological receptor as a home range factor. For receptors with home ranges equal to or smaller than the size of the site (i.e., short-tailed shrew, eastern garter snake, meadow vole, and American robin), the home range factor for both the conservative and site specific scenario was 1.0. For those ecological receptors with a home range larger than the site (i.e., red fox and red-tailed hawk), the home range factor was 1.0 for the conservative scenario. For the site specific scenario, the home range factor was calculated by dividing the size of site in acres by the home range of each receptor as referenced in the literature. When a wide range of values was provided in the literature for the home range, the mean home range value was used to calculate the home range factor. This factor was used to adjust the calculated dose values in the site specific model by taking into account whether the receptor feeds and lives exclusively on the site or spends little time at the site and ranges over a larger area. Home range factors are listed in Table 3-1.

Section 4
Screening Level Ecological Effects Evaluation

The goal of the ecological effects evaluation is to determine the potential for toxic effects of all COPCs at the site on the selected ecological receptors. A database and literature search was performed to identify the ingestion toxicity values for use in the estimation of the ecological risk.

Toxicity values for receptors are listed in Table 4-1. Reptile toxicity values were not found in database and literature. As directed by the EPA Region III BTAG in the *Comments to the Draft Technical Approach to Complete the Screening Level Ecological Risk Assessment; Salford Quarry; Lower Salford Township, Montgomery County, Pennsylvania; December 2004* (Pluta 2005), avian toxicity values were used as surrogate reptile toxicity values for eastern garter snake in the absence of reptile data (EPA 2005).

Both chronic NOAELs and LOAELs were preferentially selected for COPCs to represent the benchmark toxicity values used in this assessment. Using both NOAEL and LOAEL values in the comparison provides a range of risk that may be more appropriate for developing clean-up numbers. Often, toxicity values were not available as chronic NOAELs and LOAELs, but only as acute LOAELs or LD_{50}'s. Where necessary, adjustments were made to these available toxicity values using safety factors to reflect levels of uncertainty. Currently there is little guidance available for the appropriate value for safety factors. Based upon guidance provided by Calabrese and Baldwin (1993), an acute LD_{50} was extrapolated to a chronic NOAEL by multiplication with a correction factor of 0.02 to obtain the benchmark toxicity value. When only a chronic NOAEL was available, a correction factor of 2 was applied to obtain a chronic LOAEL. When only a chronic LOAEL was found in the literature, the following scheme was used to obtain a chronic NOAEL for the adjusted benchmark toxicity value (Calabrese and Baldwin 1993):

- for a chronic LOAEL (or chronic LD_{50}), a correction factor of 0.1 was applied (multiplied); and
- for an acute LOAEL, a correction factor of 0.04 was applied (multiplied).

When toxicity data were not available for the selected receptor species, the use of toxicity values from other animal studies was necessary. No additional correction factors were applied to the available toxicity value if the value was for an animal within the same taxonomic class as the target receptor. Values from different taxonomic classes were not used. When more than one value was available, the most conservative value for the species most closely related to the target receptor(s) was used.

Section 5
Screening Level Risk Characterization

This section of the SLERA contains a discussion of screening level risk characterization for the site.

The potential risk to ecological receptors at the site was assessed by two methods:

- Risks from exposure to contaminated soil, sediment, surface water and groundwater were estimated for the general plant, invertebrate, and fish aquatic communities by comparing surface soil, sediment, surface water, and groundwater contaminant concentrations to soil, sediment, and surface water ecological screening values for the protection of terrestrial and aquatic species (see Section 5.1).

- Food chain risks were estimated for surface soil metals found at the site that are thought to have the most potential to bioaccumulate (i.e., cadmium, copper, lead, mercury, nickel, and zinc) (see Section 5.2). Food chains were developed for the short-tailed shrew, meadow vole, red fox, American robin, red-tailed hawk, and eastern garter snake by comparing estimated exposure levels (daily doses) with conservative dose-based toxicological benchmarks. Risks to each of these receptors were evaluated using HQs which were determined for each COPC by dividing estimated daily contaminant doses by ingestion toxicity values.

  For each receptor, receptor hazard indices (HIs) were determined by summing all of the COPC HQs for each target ecological receptor per medium (see Section 5.2). Cumulative HIs were ranked in accordance with an EPA (1992) ranking scheme that was used to evaluate potential ecological risks to individual organisms. The ranking scheme is as follows:

HI $\leq$ 1.0	no adverse effects
HI >1.0	possible adverse effects

It is important to note that this methodology is not a measure of and cannot be used to determine absolute quantitative risk. Use of this technique, however, can indicate the potential for the target ecological receptor to be at risk to an adverse effect from exposure to site COPCs.

5.1 Estimation of Direct Risk to Terrestrial and Aquatic Receptors

For this section, comparisons were made between the concentrations of the contaminants detected in various media (i.e., ground water, surface water, sediment, and soil) and ecological screening values. The comparisons are provided in Tables 2-3, 2-5, 2-7, and 2-9. Chemicals that were not detected at the Salford Quarry site are included in Tables 2-4, 2-6, 2-8, and 2-10. Summaries for the detected chemical results of this ecological screening are provided below. Discussions of background data are included for informational purposes, however concentrations approximating background values was not alone sufficient to eliminate a contaminant from further consideration in the ecological risk assessment process.

5.1.1 Groundwater

Twenty-four inorganics (i.e., metals) were detected in groundwater. Thirteen metals (aluminum, antimony, calcium, chromium, cobalt, copper, lead, magnesium, nickel, potassium, sodium, vanadium, and zinc) had maximum detected values below the BTAG screening values. No screening value was available for beryllium, however the mean exceeded the average background concentration. Ten metals had HQs above 1.0 (arsenic, barium, boron, cadmium, cyanide, iron, lithium, manganese, mercury, and selenium). All ten metals, with the exception of cyanide, had both maximum and mean concentrations exceeding the BTAG screening value. Six metals (beryllium, cadmium, cobalt, copper, iron, and nickel) were detected with maximum values below the average background values. Two metals (aluminum and chromium) were detected with maximum concentrations (77.3 and 3.1 µg/L respectively) just above the average background concentrations (76.6 and 3.05 µg/L respectively).

Twenty-three organic chemicals were detected in groundwater. Nineteen organic chemicals (1,1,1-tricholoroethane,1,1-dichloroethane, 1,1-dichloroethylene, 1,2,4-trichlorobenzene, 1,2-dichloroethane, 1,4-dichlorobenzene, 2-butanone, acetone, benzene, bis(2-ethylhexyl)phthalate, carbon tetrachloride, chloroform, dichloromethane, m-dichlorobenzene, tert-butyl-methyl ether, tetrachloroethene, toluene, trans-1,2-dichloroethene, and vinyl chloride) had maximum detected values below the ecological screening values. No screening value was available for chloromethane or cis-1,2-DCE. Two organic compounds (carbon disulfide and TCE) had HQs above 1.0. The HQs for carbon disulfide and TCE were 9.46 and 1.33, respectively.

A total of eleven inorganic and four organic chemicals have been retained for further consideration in the ecological risk assessment process. A list of these retained chemicals along with details of the ecological screening for each chemical is provided in Table 2 -3.

5.1.2 Surface Water

Twenty-two inorganics (i.e., metals) were detected in surface water at the Salford Quarry site. Fourteen metals (antimony, arsenic, calcium, chromium, cobalt, copper, cyanide, magnesium, manganese, nickel, potassium, sodium, vanadium, and zinc) had maximum detected values below the BTAG ecological screening values. Seven metals had HQs above 1.0 (aluminum, barium, boron, cadmium, iron, selenium, and thallium). All of these metals had maximum and mean concentrations that exceeded the BTAG value. Nine metals (antimony, cadmium, chromium, cobalt, cyanide, nickel, selenium, thallium, and zinc) were detected with maximum concentrations below the average background concentrations. One metal (lithium) with an HQ over 1.0 will not be considered further. The HQ for the maximum detected concentration for lithium was 1.99. However, the BTAG freshwater screening value of 14 µg/L was only exceeded in one out of 20 samples, for a frequency of five percent. The mean concentration of lithium (7.45 µg/L) was approximately equal to the average background concentration of 7.13 µg/L.

Four organic chemicals (acetone, cis-1,2-dichloroethene, dichloromethane, and TCE) were detected in surface water at the Salford Quarry site. Of these detected chemicals, three (acetone, dichloromethane, and TCE) were detected below BTAG screening levels. There is no screening value for cis-1,2-DCE, however it was only detected in two out of 20 samples for a detection frequency of 10% and will not be considered further. In addition, the mean concentration of 0.264 µg/L is just above the average background concentration of 0.25 µg/L.

A total of seven inorganic chemicals have been retained for further consideration in the ecological risk assessment process. A list of these retained chemicals along with details of the ecological screening for each chemical is provided in Table 2 -5.

5.1.3 Sediment

Twenty-five inorganics (i.e., metals) were detected in sediment. Three metals (cobalt, mercury, and silver) had maximum detected concentrations below the BTAG ecological screening values. Three other metals (chromium, lead, and zinc) had detected concentrations equal to or just above the screening values. One sample (52.2 mg/kg) out of twenty exceeded the screening value of 43.4 mg/kg for chromium resulting in an HQ of 1.2. The mean chromium concentration of 26.21 mg/kg was well below the screening value. The maximum concentration for lead was just above the screening value resulting in an HQ of 1.09. However, the mean concentration of 25.59 mg/kg for lead was lower than the screening value of 35.8 mg/kg. The maximum detected concentration for zinc of 121 mg/kg is identical to the screening value of 121 mg/kg, resulting in an HQ of 1.0. The mean concentration of 82.96 mg/kg is also slightly lower than the average background concentration of 83.98 mg/kg.

Seven metals (aluminum, barium, beryllium, boron, lithium, thallium, and vanadium) do not have an EPA Region III BTAG screening value, yet were detected with mean concentrations greater than the average background concentrations. Four of these metals (aluminum, barium, boron, and thallium) were detected at their maximum concentration at sample location SD01 (see Figure 2-4), which is the sediment sample located at the spring west of the landfill (i.e., between the landfill and the West Branch of Skippack Creek).

The maximum and mean concentrations for antimony, arsenic, cyanide, iron, manganese, and nickel exceeded the BTAG screening values. The average background concentrations for antimony, cyanide, iron, and manganese also exceeded the BTAG screening values. For cadmium and copper, the maximum concentrations exceeded the screening values while the mean concentrations were below the screening values. Calcium, magnesium, potassium, and sodium are essential nutrients that are also present in background samples at significant levels.

Five organic chemicals were detected in sediments at the Salford Quarry site. These chemicals were acetone, CFC-11, cyclohexane, dichloromethane, and toluene. There were no ecological screening values available for any of these chemicals. Four of these chemicals (acetone, CFC-11, cyclohexane, and toluene) had relatively low detection frequencies of either five or ten percent and were found at mean concentrations that were below or approximately equal to the average background concentrations. The mean and maximum detected concentrations of dichloromethane were both below the average background concentration.

A total of fifteen inorganic and no organic chemicals have been retained for further consideration in the ecological risk assessment process. A list of these retained chemicals along with details of the ecological screening for each chemical is provided in Table 2-7.

5.1.4 Soil

Twenty-two inorganics (i.e., metals) were detected in the surface soil at the Salford Quarry site. The maximum and mean detected concentrations for several of the metals were at levels above the screening criteria and the average background values. The metals that fell within this category were aluminum, boron, cadmium, chromium, copper, iron, lead, lithium, manganese, mercury, nickel, vanadium, and zinc. All of these metals were retained for further consideration in the ecological risk assessment process. Even though magnesium is an essential nutrient, it was also retained due to the magnitude by which the maximum (8,040 mg/kg) and mean (6,680 mg/kg) detected concentrations exceeded the screening value of 4,400 mg/kg, resulting in HQs of 1.83 and 1.52 respectively.

A total of eight metals (arsenic, barium, beryllium, calcium, cobalt, potassium, silver, and sodium) have been eliminated as COPCs for the Salford Quarry site. The maximum concentrations of arsenic and beryllium were below the ecological screening values. The mean concentration of 220.41 mg/kg for barium was below the screening value of 330 mg/kg, while only one sample out of ten exceeded the screening value. There is no screening value for calcium, potassium, or sodium, however, each of these metals is an essential nutrient. All three chemicals were measured at levels comparable to the average background concentrations. The maximum concentration (16.2 mg/kg) for cobalt slightly exceeded the screening value resulting in an HQ of 1.25. The mean concentration was 13.72 mg/kg, just above the screening value of 13 mg/kg. Cobalt was also present in background with an average concentration of 9 mg/kg. The maximum concentration (10.8 mg/kg) for silver exceeded the screening value of 4.04 mg/kg once out of ten samples. However, the mean concentration of 2.18 mg/kg was below the screening value.

A general statement could be made concerning the results of the soil sampling at the Salford Quarry site. The maximum concentrations of fourteen of the twenty-one metals detected in samples at the Salford site were found at SL08 from 0.5 to 2 feet below ground surface. This indicates that the area from which this particular sample was taken could be a hot spot for metal contamination. Additionally, stressed vegetation was observed surrounding this sampling location.

Six organic chemicals were detected in surface soils at the Salford Quarry site. These chemicals were acetone, cis-1,2-DCE, dichloromethane, tetrachloroethene, toluene, and TCE. The maximum concentrations for five of these organics (acetone, dichloromethane, tetrachloroethene, toluene, and TCE) were below the ecological screening values. One organic chemical (cis-1,2-DCE) was detected in soil at a maximum concentration of 19 µg/kg. The chemical was detected in only one out of ten samples. No screening criteria was available for this chemical, however, the Dutch Ministry 2000 screening value is 200 µg/kg. A total of fourteen inorganic and no organic chemicals have been retained for further consideration in the ecological risk assessment process. A list of these chemicals along with details of the rationale for screening for each chemical is provided in Table 2 -9.

Six of the retained metals (cadmium, copper, lead, mercury, nickel, and zinc) have a tendency to bioaccumulate (EPA Region III). To estimate the risks as a result of bioaccumulation, food chain models were developed for these six metals. The results of these food chain models are discussed in detail in Section 5.2.

5.2 Estimation of Food Chain Risks

The potential ecological risk from exposure to contamination via the food chain was calculated for surface soil collected from the Salford Quarry site using maximum contaminant concentrations detected in this media. Food chain modeling was completed for the meadow vole, short-tailed shrew, red fox, eastern garter snake, American robin, and red-tailed hawk.

The potential risks from food chain exposure were assessed for each receptor by comparing estimated exposure dose levels with dose-based toxicological benchmark values. The resultant HQs for each COPC and HIs (cumulative HQs) for each receptor are presented in Tables 5-1 through 5-12. Two tables were prepared for each receptor; the first utilizing conservative exposure factor inputs and the second utilizing site specific exposure factors. A summary of the results is provided in Table 5-13.

The results of the models indicate that there is a potential for significant food chain risks from exposure to contaminants in site soil to all receptors except the red-tailed hawk. These results are discussed below for each receptor.

Meadow Vole

High HI values were generated for the meadow vole from both the conservative and site specific models. Tables 5-1 and 5-2 present the results for both models. NOAEL based HI values were 335 and 301 respectively for the conservative and site specific models. The LOAEL based HQ values were 33 for the conservative and 30 for the site specific models. The primary contaminant of concern for the meadow vole was lead, as it contributed over 91% of the total risk for all conservative and site specific scenarios. The next highest risk contributor was zinc, at 3% for all scenarios.

Short-Tailed Shrew

Very high HI values were generated for the shrew from both the conservative and site specific models. Tables 5-3 and 5-4 present the results for both models. NOAEL based HI values were 2,855 and 2,554 respectively for the conservative and site specific models. The LOAEL based HQ values were 286 for the conservative model and 255 for the site specific model. The primary contaminant of concern to the shrew was lead, as it contributed over 85% of the total risk for all conservative and site specific scenarios. The next highest contributor to risk was cadmium, at 11% for all scenarios.

Red Fox

Elevated HI values were generated for the red fox for the conservative model only, while the HI values for the site specific model were below 1.0. Tables 5-5 and 5-6 present the results for both models. NOAEL based HI values were 23 and 0.30 respectively for the conservative and site specific models. The LOAEL based HQ values were 2.32 for the conservative model and 0.03 for the site specific model. The primary contaminant of concern to the red fox was mercury, as it contributed over 80% of the total risk for all conservative and site specific scenarios. The next highest contributor to risk was lead, at 15% for all scenarios.

Eastern Garter Snake

Elevated HI values were generated for the garter snake for the conservative model and for the NOAEL based site specific model. The HI value for the LOAEL based site specific model was below 1.0. Tables 5-7 and 5-8 present the results for both models. NOAEL based HI values were 18 and 5.74 respectively for the conservative and site specific models. The LOAEL based HQ values were 2.84 for the conservative model and 0.89 for the site specific model. The primary contaminant of concern to the garter snake was zinc as it contributed over 71% of the total risk for the NOAEL based scenarios and over 50% for the LOAEL based scenarios. The next highest contributor to risk was mercury at over 10% in the NOAEL based models and over 30% in the LOAEL based models.

American Robin

Very high HI values were generated for the American robin in both the conservative and site specific models. Tables 5-9 and 5-10 present the results for both models. NOAEL based HI values were 1,606 and 247, respectively, for the conservative and site specific models. The LOAEL based HQ values were 305 for the conservative model and 47 for the site specific model. The primary contaminant of concern to the robin was zinc in the NOAEL based models as it contributed over 69% of the total risk. For the LOAEL based models, mercury (over 47% of the total risk) and zinc (over 40% of total risk) made up the majority of the total risk.

Red-tailed Hawk

Low HI values (i.e, below 1.0) were generated for the red-tailed hawk for both the conservative and the site specific model. Tables 5-11 and 5-12 present the results for both models. NOAEL based HI values were 0.62 and 0.002 respectively for the conservative and site specific models. The LOAEL based HQ values were 0.24 for the conservative model and 0.001 for the site specific model. The primary chemical modeled for the hawk was mercury with over 69% contribution for the NOAEL based scenario and over 90% for the LOAEL based scenario.

5.3 Risk Summary and Conclusions

In this section, the risks posed by COPCs are quantified. Additional risk analysis was performed on those COPCs that bioaccumulate, based on food chain modeling.

5.3.1 Risks Based on Direct Toxicity

Risks based on direct toxicity for groundwater, surface water, sediment, and soil are quantified.

Groundwater

The identified COPCs in groundwater (based on a comparison of detected groundwater concentrations with surface water ecological screening values) are arsenic, barium, beryllium, boron, cadmium, cyanide, iron, lithium, manganese, mercury, selenium, carbon disulfide, chloromethane, cis-1,2-DCE, and TCE. The greatest risk to ecological receptors coming in contact with groundwater seems to be from boron. The HQ for boron was extremely high (148,125). The other eleven metals and four organics had HQs ranging from 1.18 for cadmium to 81 for barium. The biggest difference between the boron results and those of the other groundwater COPCs is that the mean boron concentrations were over 600 times greater than the average boron concentration measured in background groundwater samples. This relationship is in contrast to the mean concentrations of the other COPCs that were, in most cases, comparable to the background concentrations.

At locations where impacted groundwater flows near, or out of, the land surface, risk to boron and other site contaminants would be expected to be the greatest. Near or at surface groundwater is believed to occur at two areas. At the toe of the landfill near the east side of Quarry Road, groundwater may flow near, or out of, the land surface during high precipitation events. Stressed and dead vegetation, which is postulated to be due to boron, has been observed in this area of the site. Also, in the water of the spring at the base of the slope on the west side of Quarry Road, elevated concentrations of boron have been detected. The water is groundwater that has flowed out of the land surface. Areas at and near the spring, have been identified to be devoid of vegetation or, where vegetation exists, it is dead or stressed.

Groundwater also reaches the surface at the creek, but discharging groundwater is diluted with other creek water and contaminant concentrations are reduced. Ecological receptors that come in contact with contaminated ground water could be at risk, especially from boron. Further consideration is needed concerning the direct toxicity of contaminants in groundwater at the Salford Quarry site.

Surface Water

The surface water COPCs determined as the result of screening detected surface water values with EPA Region III freshwater BTAG screening values are aluminum, barium, boron, cadmium, iron, selenium, and thallium. The greatest risk to ecological receptors coming in contact with groundwater seems to be from boron. The HQ for boron was extremely high (44,000). The other six COPCs had HQs ranging from 1.75 for cadmium to 28.25 for barium. Mean boron concentrations were over 140 times greater than the average boron concentration measured in background samples. This relationship is in contrast to the mean concentrations for the other four metals that are all greater than the average background concentrations, however, none are greater than 1.5 times the background concentration.

Surface water samples were collected from two bodies of water: the spring at the toe of the slope on the west side of Quarry Road and the West Branch Skippack Creek. Boron's high HQ is due to the elevated concentration (70,400 µg/L) detected in the spring. In the creek, the highest detected boron concentration is 458 µg/L. Therefore, risk to surface water contamination is expected to be greatest at the spring. Risk is lower at the creek, but contaminant concentrations (most notably boron) in surface water appear to increase in concentration cross-gradient and downgradient from the landfill. Background boron concentrations range from non-detect to 42.5 B µg/L. However, in samples collected cross-gradient and downgradient from the landfill, the concentrations range from non-detect to 458 µg/L and concentrations above 100 µg/L are common. Based on the boron concentration trend, it appears that risk to boron in creek water would increase at locations cross-gradient and downgradient from the landfill.

Ecological receptors that come in contact with contaminated surface water could be at risk, especially from boron. Further consideration is needed concerning the direct toxicity of contaminants in surface water at the Salford Quarry site.

Sediment

The sediment COPCs are aluminum, antimony, arsenic, barium, beryllium, boron, cadmium, copper, cyanide, iron, lithium, manganese, nickel, thallium, and vanadium. No screening values were available for aluminum, barium, beryllium, boron, lithium, thallium, or vanadium. Therefore, HQs could not be calculated for these analytes. The COPCs for which sediment screening values were available for were antimony (HQ of 3), arsenic (HQ of 2.64), cadmium (HQ of 1.41), copper (HQ of 1.3), cyanide (HQ of 7.9), iron (HQ of 2.44), manganese (HQ of 11.37), and nickel (HQ of 1.65). A comparison of mean concentrations with average background concentrations is provided in the table below. As seen in the table, all of the mean concentrations for all listed COPCs exceed the average background concentrations except for cadmium. However, it is important to note that none of the mean concentrations exceed the average background concentrations by more than a factor of two.

Comparison of Mean and Average Background Sediment Concentrations

COPC	Mean Concentration (mg/kg)	Average Background Concentration (mg/kg)
Aluminum	13,596	12,305
Antimony	3.99	3.51
Arsenic	13.45	8.28
Barium	168	130
Beryllium	1.31	0.98

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Comparison of Mean and Average Background Sediment Concentrations (Cont'd)

COPC	Mean Concentration (mg/kg)	Average Background Concentration (mg/kg)
Boron	16	8
Cadmium	0.72	0.85
Copper	26.6	19.58
Cyanide	0.96	0.67
Iron	28,615	20,800
Lithium	33	26
Manganese	1198	779
Nickel	25.78	20.93
Thallium	1.99	1.59
Vanadium	39	29

Sediment samples were collected from the spring and creek at the same locations as the surface water samples. The highest HQ was determined to be for manganese. The HQ for manganese was calculated from the highest concentration, which was detected in a sample from the spring. Additionally, creek results show that the majority of the COPCs had maximum concentrations detected at one location (SD07), which is located cross-gradient from the landfill.

At this point, the current risk to ecological receptors is unknown for a number of the COPCs without screening values. There appears to be some risk for the COPCs with screening values. However, the mean concentrations for the COPCs do not appear to be greatly elevated above the background conditions.

Ecological receptors that come in contact with contaminated sediment could be at risk. Further consideration is needed to determine the direct toxicity of contaminants in sediment at the Salford Quarry site.

Soil

The soil COPCs determined as the result of screening detected soil concentrations with soil ecological screening values are aluminum, boron, cadmium, chromium, copper, iron, lead, lithium, magnesium, manganese, mercury, nickel, vanadium, and zinc. HQs for the 14 COPCs ranged from 1.82 for magnesium to 43,600 for boron. A comparison of mean concentrations with average background concentrations is provided in the table below. Aluminum, chromium, iron, lithium, magnesium, manganese, nickel, and vanadium are within 1.5 to 2 times the average background concentrations. Even though boron had the highest HQ, the mean concentration (12.51 mg/kg) was almost equal to the average background concentration (12.26 mg/kg).

The mean concentrations for mercury (120 times), lead (14 times), copper (11 times), zinc (5 times), and cadmium (4 times) are all significantly above average background concentrations.

Comparison of Mean and Average Background Soil Concentrations

COPC	Mean Concentration (mg/kg)	Average Background Concentration (mg/kg)
Aluminum	17,690	12,033
Boron	12.51	12.26
Cadmium	1.38	0.31
Chromium	34	17
Copper	213	19
Iron	34,030	16,950
Lead	268	18
Lithium	28	17
Magnesium	6,680	3,568
Manganese	1,038	689
Mercury	7.2	0.06
Nickel	31	17
Vanadium	35	24
Zinc	349	59

The distribution of maximum detected concentrations in soil samples suggests that a hot spot exists in the stressed/dead vegetation area at the toe of the landfill near the west side of Quarry Road. The maximum concentrations for 10 of the 14 COPCs were detected at sample location SL08 and were collected from 0.5 to 2 ft bgs. This sample was collected from the stressed/dead vegetation area. Additionally, two COPCs had maximum concentrations detected at SL07 (depth of 0.5 to 2 ft bgs), which is located adjacent to SL08 and near the stressed/dead vegetation. Therefore, the area surrounding SL07 and SL08 is considered to be a hot spot for contaminated soil. During high precipitation events, contaminated groundwater may approach or seep out of the land surface in this area (specifically the SL08 area where stressed/dead vegetation has been observed). The soil contaminants may have been transported in groundwater from the landfill. This hot spot area would be expected to present the most risk to ecological receptors exposed to soil. Elevated risk to soil may also occur in other site areas where contaminated groundwater approaches or reaches the land surface (e.g., along the toe of the slope at the west side of Quarry Road).

Direct toxicity in soils appears possible from a number COPCs, especially those which have mean concentrations significantly above average background concentrations. Ecological receptors (including plants and animals) that come in contact with contaminated soil appear to be at significant risk. Further consideration is needed to determine the direct toxicity of contaminants in soils at the Salford Quarry site.

5.3.2 Risks Based on Food Chain Modeling

Six of the soil COPCs (i.e., cadmium, copper, lead, mercury, nickel, and zinc) thought to have greatest tendency to bioaccumulate were modeled. To estimate the risks as a result of bioaccumulation, food chain models for the meadow vole, short-tailed shrew, red fox, eastern garter snake, American robin, and red-tailed hawk were developed for these metals. The results of these food chain models have been discussed in detail in Section 5.2. The metals that were responsible for the majority of the risk were lead, mercury and zinc: lead in the vole (91% of risk) and shrew (85% of risk); mercury in the fox (80% of risk), robin (up to 47% of risk), and hawk (70 to 90% of risk); and zinc in the garter snake (50 to 71% of risk) and robin (40 to 70% of risk). The maximum soil concentrations of lead, mercury and zinc were detected at soil sample location SL08 and were collected from a depth of 0.5 to 2 ft bgs. This sample has been identified to be in a hot spot area. Additional analysis and data may be required to fully characterize the ecological risk from lead, mercury, and zinc to food chain receptors. This may involve additional sampling of the soil and biota in the vicinity of the Salford Quarry site.

5.3.3 Assessment Endpoint Risk Questions

A qualitative assessment of the protection of each assessment endpoint is provided below using risk questions.

- Are levels of site-related contaminants in soil sufficiently low to protect the soil invertebrate community from the toxic effects (on survival, reproduction, and growth), and also to minimize the risk of bioaccumulative effects of those contaminants in higher trophic levels?

No. Concentrations of COPCs in soil exceed the ecological screening values for soil and soil-based food chain models indicate risk to ecological receptors. The maximum HQ for soil was identified to be for boron that was detected at soil sample location SL08 (depth of 0.5 to 2 ft bgs). The majority of the maximum COPC concentrations were detected at this location. In addition, the maximum soil concentrations for the three metals (lead, mercury and zinc) that contribute to the majority of the bioaccumulative risk were detected at the same location. The area around soil sample location SL08 and neighboring sample location SL07 has been identified to be a hot spot for soil contamination. The maximum concentrations detected at the hot spot exceeded the NOAEL for soil invertebrates for four of the six modeled COPCs

- Are levels of site-related contaminants in soil sufficiently low to protect the plant community on site and in West Branch of Skippack Creek from the toxic effects (on survival, reproduction, and growth) and also to minimize the risk of bioaccumulative effects of those contaminants in higher trophic levels?

No. Concentrations of COPCs in soil exceed the ecological screening values for soil and soil-based food chain models indicate risk for plant eating ecological receptors. Stressed/dead vegetation has been documented in the hot spot area next to the toe of the landfill. In addition, stressed/dead vegetation has been documented at and surrounding the spring that is located at the toe of the slope on the west side of Quarry Road. The poor condition of the vegetation may be due to elevated contaminant concentrations in soil, but it is more likely due to contaminated groundwater that is nearing or reaching the ground surface where the water (and contaminants) becomes available to the plant community. High concentrations of boron, as found in site groundwater, are toxic to plants. Also, the maximum concentrations at the hot spot exceeded the NOAEL for plants for four of the six modeled COPCs.

- Are levels of site-related contaminants in soil sufficiently low to protect the mammal community that live and feed on and near the site from toxic effects (on survival, reproduction, and growth)?

No. The soil-based food chain models indicate risk. The maximum soil concentrations for the three metals (lead, mercury, and zinc) that contribute to the majority of the bioaccumulative risk were detected at soil sample location SL08. The area around sample location SL08 and neighboring sample location SL07 has been identified to be a hot spot for soil contamination.

- Are levels of site-related contaminants in sediment, soil, and water sufficiently low to protect the amphibian and reptile community that live and feed on and near the site from toxic effects (on survival, reproduction, and growth)?

No. Concentrations of COPCs in sediment, soil, and water exceed the ecological screening values for sediment, soil, and water. Maximum COPC concentrations in water are found in the groundwater immediately downgradient from the landfill. Contaminated groundwater reaches ground surface at the spring that is located west of Quarry Road. Also, during high precipitation events, groundwater surfaces or nears the ground surface at the toe of the landfill in the hot spot area. Groundwater also discharges into the creek, but dilution with upgradient creek water limits concentrations in the surface water body. Lastly, soil-based food chain modeling for the garter snake indicate risk.

- Are levels of site-related contaminants in soil sufficiently low to protect the avian community that feeds on and near the site from toxic effects (on survival, reproduction, and growth)?

No. Food chain modeling indicates risk for the American robin. The risk is associated with the COPCs whose maximum soil concentrations were detected in the hot spot area at the toe of the landfill.

- Are levels of site-related contaminants in sediment and water sufficiently low to protect the benthic invertebrate community from the toxic effects (on survival, reproduction, and growth) and also to minimize the risk of bioaccumulative effects of those contaminants in higher trophic levels?

No. Concentrations of COPCs in sediment and water exceed ecological screening criteria. The highest concentrations of COPCs in sediment and surface water were identified in the spring west of the site. The spring is formed from groundwater discharging to the surface. Groundwater also discharges to the creek. However, dilution with upgradient water reduces the observed concentrations. If benthic invertebrates (or a community of invertebrates) were located in the creek at a discrete groundwater discharge point, then the risk associated with the exposure would be elevated.

- Are levels of site-related contaminants in sediment, water, and prey sufficiently low to protect the fish community that lives in the creek near the site from the toxic effects (on survival, reproduction, and growth)?

No. Concentrations of COPCs in sediment and water exceed ecological screening criteria. The highest concentrations of COPCs in sediment and surface water were identified in the spring that is located west of the site. No fish have been reported to reside in the spring. However, screening criteria are exceeded in the creek where there is an existing fish population. A relatively small, but detectable, trend in contaminant concentrations (mainly boron) has been identified in the creek water. It appears that boron concentrations increase by approximately one order of magnitude from background locations to points downstream of the site.

Section 6
Screening Level Uncertainty Assessment

For any risk assessment, it is necessary to make assumptions. Assumptions carry with them associated uncertainties which must be identified to put risk estimates in perspective. The following describes the major assumptions used in this SLERA and their associated uncertainties.

There are several large uncertainties associated with the approach taken at this site. Specifically, data that are missing from this assessment are quantitative site data regarding numbers and types of receptors at the site, tissue concentrations from organisms captured on site, and soil data that would help determine the bioavailability of site contaminants. The bioavailability and tissue data are the most important and would verify the doses calculated in the food chain models for each receptor. The following sections detail the uncertainty associated with this risk assessment.

6.1 Ecotoxicity Uncertainty

Bioaccumulation factors used to estimate the exposure of receptors via diet were limited and may not have accurately represented actual site-specific conditions. Actual bioaccumulation into food items is variable and site-specific, depending upon such factors as chemical state, composition of the media of exposure, and chemical concentration within the media of exposure. Thus, the bioaccumulation factors used may have over- or under-estimated receptor exposure. The model used to estimate the bioaccumulation of COPCs in invertebrate prey species is based on an earthworm model. The earthworm model is not representative of the insect prey eaten by the avian receptors and may over-or under-estimate risk.

In selecting benchmark toxicity values, generally the most conservative available toxicity value was selected for each receptor from the literature searched. The use of these values may over-estimate ecological risk. Additionally, because of the unavailability of toxicity values reflecting field conditions, some toxicity values are derived from experiments conducted under laboratory conditions, with genetically-uniform individuals. Most of these studies were done with different species but the results were used for the selected receptor species. The use of these values may have over-or under-estimated ecological risks.

Receptor risks were characterized from possible impacts from individual contaminants without regard to interactions between contaminants. However, ecological receptors are simultaneously exposed to a range of contaminants. These compounds may interact synergistically or antagonistically to either mitigate or aggravate adverse health effects. This assumption may over-estimate or under-estimate ecological risks.

In determining the benchmark toxicity values, toxicity correction factors were employed to account for differences in toxicity between length of exposure (i.e., acute and chronic) and toxicological endpoints (i.e., NOAELs, LOAELs, LD_{50}s). Uncertainties associated with the factors used may have resulted in over-or under-estimation of risks to receptors. With regard to interspecies differences, smaller animals have higher metabolic rates and are usually more resistant to toxic chemicals because of their higher rates of detoxification (Opresko, et al. 1993). In this assessment, benchmark toxicity values have not been normalized for receptor body weights. This may have under-estimated the risks to receptors that have a mass smaller than the reported test species and over-estimated the risks to receptors that have a mass larger than the reported test species.

6.2 Receptor Life History and Exposure Uncertainty

The conservative exposure models assumed that receptors will spend one hundred percent of the time exposed to maximum contaminant levels within the area of concern if the site was the same size as or larger than the receptor's home range. The site specific models accounted for the true home range of each organism so that time at the site and overall exposure could be more accurately assessed. In reality, some of the receptors may spend very little time on this site. The use of the property by all of these species probably varies throughout the year. As a result, modeled food chain exposures for some receptors may be over-estimated.

In accordance with EPA guidance for SLERAs (EPA 1997), modeled food chain exposure estimates assumed that receptor diets were composed entirely of the type of food that is most contaminated. For many of the receptors, the actual diet may be more varied and may change over the course of the year. Therefore, exposure estimates may be over-estimated for some receptors, or under-estimated for others.

Life history information taken from the literature related to home range, ingestion rates, body weights, and diet for the receptors has some associated uncertainty. The information on incidental soil ingestion is uncertain for some of the receptor species. When values were not available a soil ingestion rate was taken from a similar species. The studies referenced may have been completed in other parts of the country, in different habitats, and under different conditions. The use of these values may under- or over-estimate risk.

The inhalation and dermal exposure pathways were not evaluated in this assessment due to a lack of appropriate models. Risk to receptors may be under-estimated by the lack of evaluation of these pathways. As noted, amphibians may take up contaminants through dermal absorption, however this was not evaluated. Potential toxicological risks to individual receptors have been evaluated in this SLERA. Sometimes, adverse effects on individuals will not be reflected on the population and community level. The predicted risks may over-estimate the actual population or community level effects.

6.3 Uncertainty Summary

Of all the noted uncertainties, several types of uncertainty can be considered more significant. The lack of site specific data related to bioavailability of contaminants, soil toxicity, and the lack of actual tissue data is significant, as this would provide confirmatory evidence of actual risk to receptors at the site. Having tissue and soil toxicity data would remove uncertainty associated with literature based bioaccumulation factors, reference toxicity factors, and would clarify the actual doses receptors are receiving from consuming prey items at the site. Tissue data would also be helpful in confirming negative impacts from exposure to site contaminants.

Section 7
Preliminary Remediation Goals (PRGs)

EPA Region III provided the following guidance concerning PRGs for the Salford Quarry SLERA on January 7, 2004. *"If the SLERA indicates the potential for risk to ecological receptors, the feasibility study must consider appropriate ecological risk-based 'PRGs' to ensure that the evaluation of alternatives adequately addresses these remedial considerations and the associated costs are considered. As the timeline of the feasibility study is typically expected to overlap the RI, including the BERA, the PRGs used are just that - preliminary. Ecological RGOs and clean-up levels are developed considering the findings of the BERA."* As directed by EPA, the following sections include a general discussion of PRGs for the COPCs at the Salford Quarry site. These PRGs are preliminary in nature as this SLERA represents only Steps 1 and 2 of the eight step EPA Ecological Risk Assessment process.

7.1 PRGs for Modeled Metals

Table 7-1 includes a list of PRGs that were determined for each modeled receptor (meadow vole, short-tailed shrew, eastern garter snake, red-tailed hawk, and american robin) for each modeled chemical (cadmium, copper, lead, mercury, nickel, and zinc). This calculation was completed by manipulating the soil concentrations in the food chain models to generate a HQ value of 1.0. This was done using both a NOAEL and LOAEL comparison to provide a range for the soil cleanup value. Only the site specific food chain models were manipulated to calculate the PRGs. It should be noted that the model is not based on any biota tissue data.

Site specific data needed to develop PRGs that are protective of plants and soil invertebrates was not collected for this SLERA. Literature based PRGs that are protective of invertebrates and plants have also been listed on Table 7-1 for comparison to the food chain developed PRGs.

The plant values were taken from the document, *"Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants: 1997 Revision"* (Efroymson et al. 1997a). The soil invertebrate values were taken from the document, *"Toxicological Benchmarks for Contaminants of Potential Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Process: 1997 revision"* (Efroymson et al. 1997b). To be conservative, the lowest benchmark value listed for a plant or invertebrate was selected for comparison to the calculated PRGs.

No conclusions have been drawn from these PRGs concerning remediation at the site.

7.2 PRGs for Direct Toxicity COPCs

The screening values used for groundwater, surface water, sediment, and soil have been listed in Table 7-2 for all of the COPCs. PRGs have been provided for surface water, sediment, and soil COPCs. The source for these PRG values is from the document *"Preliminary Remediation Goals for Ecological Endpoints"* (Efroymson et al. 1997c).

Section 8 References

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Table 2-1
Groundwater, Surface Water, Sediment, and Soil Samples used to determine Exposure Point Concentrations
Salford Quarry Site

Location	Sample ID	Sample Date	Sample Time	Matrix	QC	Top Depth (fbgs)	Bottom Depth (fbgs)
MW-07	MW-07	10/7/2002	10:44	Groundwater	N	NA	NA
MW-07	MW07072904	7/29/2004	11:35	Groundwater	N	NA	NA
MW-08	MW-08	10/3/2002	14:44	Groundwater	N	NA	NA
MW-08	MW08072904	7/29/2004	10:35	Groundwater	N	NA	NA
MW-09	MW-09	10/2/2002	10:10	Groundwater	N	NA	NA
MW-09	MW09072704	7/27/2004	10:00	Groundwater	N	NA	NA
MW-10	MW-10	9/30/2002	15:55	Groundwater	N	NA	NA
MW-10	MW10073004	7/30/2004	14:12	Groundwater	N	NA	NA
SD01	SD01071904	7/19/2004	14:07	Sediment	N	NA	NA
SD01	SD01111104	11/11/2004	15:20	Sediment	N	NA	NA
SD02	SD02071404	7/14/2004	10:12	Sediment	N	NA	NA
SD02	SD02110904	11/9/2004	10:55	Sediment	N	NA	NA
SD03	SD03071404	7/14/2004	11:34	Sediment	N	NA	NA
SD03	SD03110904	11/9/2004	11:30	Sediment	N	NA	NA
SD04	SD04071404	7/14/2004	13:52	Sediment	N	NA	NA
SD04	SD04110904	11/9/2004	13:50	Sediment	N	NA	NA
SD05	SD05071404	7/14/2004	14:42	Sediment	N	NA	NA
SD05	SD05071404D	7/14/2004	14:45	Sediment	FD	NA	NA
SD05	SD05110904	11/9/2004	14:40	Sediment	N	NA	NA
SD05	SD05110904D	11/9/2004	15:15	Sediment	FD	NA	NA
SD06	SD06071904	7/19/2004	08:40	Sediment	N	NA	NA
SD06	SD06111104	11/11/2004	10:15	Sediment	N	NA	NA
SD07	SD07071904	7/19/2004	09:32	Sediment	N	NA	NA
SD07	SD07111104	11/11/2004	10:50	Sediment	N	NA	NA
SD08	SD08071904	7/19/2004	10:12	Sediment	N	NA	NA
SD08	SD08111104	11/11/2004	11:45	Sediment	N	NA	NA
SD09	SD09071904	7/19/2004	10:54	Sediment	N	NA	NA
SD09	SD09111104	11/11/2004	12:15	Sediment	N	NA	NA
SD10	SD10071904	7/19/2004	12:15	Sediment	N	NA	NA
SD10	SD10111104	11/11/2004	13:25	Sediment	N	NA	NA
SW01	SW01071904	7/19/2004	14:07	Surface water	N	NA	NA
SW01	SW01111104	11/11/2004	15:15	Surface water	N	NA	NA
SW02	SW02071404	7/14/2004	10:04	Surface water	N	NA	NA
SW02	SW02110904	11/9/2004	10:55	Surface water	N	NA	NA
SW03	SW03071404	7/14/2004	11:15	Surface water	N	NA	NA
SW03	SW03110904	11/9/2004	11:30	Surface water	N	NA	NA
SW04	SW04071404	7/14/2004	13:30	Surface water	N	NA	NA
SW04	SW04110904	11/9/2004	13:50	Surface water	N	NA	NA
SW05	SW05071404	7/14/2004	14:19	Surface water	N	NA	NA
SW05	SW05071404D	7/14/2004	14:21	Surface water	FD	NA	NA
SW05	SW05110904	11/9/2004	14:40	Surface water	N	NA	NA
SW05	SW05110904D	11/9/2004	15:05	Surface water	FD	NA	NA
SW06	SW06071904	7/19/2004	08:15	Surface water	N	NA	NA
SW06	SW06072004	7/20/2004	17:30	Surface water	N	NA	NA
SW06	SW06111104	11/11/2004	10:15	Surface water	N	NA	NA
SW07	SW07071904	7/19/2004	09:15	Surface water	N	NA	NA
SW07	SW07111104	11/11/2004	10:50	Surface water	N	NA	NA
SW08	SW08071904	7/19/2004	09:56	Surface water	N	NA	NA
SW08	SW08111104	11/11/2004	11:45	Surface water	N	NA	NA
SW09	SW09071904	7/19/2004	10:40	Surface water	N	NA	NA
SW09	SW09111104	11/11/2004	12:15	Surface water	N	NA	NA
SW10	SW10071904	7/19/2004	12:00	Surface water	N	NA	NA
SW10	SW10111104	11/11/2004	13:25	Surface water	N	NA	NA
SL04	SL040630040_5-02	6/30/2004	10:45	Soil	N	0.5	2
SL04	SL0406300400-0_5	6/30/2004	10:35	Soil	N	0	0.5
SL05	SL050630040_5-02	6/30/2004	12:15	Soil	N	0.5	2
SL05	SL0506300400-0_5	6/30/2004	11:50	Soil	N	0	0.5
SL06	SL060630040_5-02	6/30/2004	13:50	Soil	N	0.5	2
SL06	SL0606300400-0_5	6/30/2004	13:30	Soil	N	0	0.5
SL07	SL070630040_5-02	6/30/2004	14:40	Soil	N	0.5	2
SL07	SL0706300400-0_5	6/30/2004	14:20	Soil	N	0	0.5
SL08	SL080701040_5-02	7/1/2004	09:50	Soil	N	0.5	2
SL08	SL0807010400-0_5	7/1/2004	09:36	Soil	N	0	0.5
SL08	SL0807010400-0_5D	7/1/2004	09:45	Soil	FD	0	0.5

Notes:

fbgs - feet below ground surface
NA - Not applicable
FD - Field duplicate.
N - Normal
It should be noted that the maximum result was used in the screening comparison when a chemical was detected in both the parent and field duplicate sample.

Table 2-2
List of Groundwater, Surface Water, Sediment, and Soil Background Samples
Salford Quarry Site

Location	Sample ID	Sample Date	Sample Time	Matrix	QC	Top Depth (fbgs)	Bottom Depth (fbgs)
MW-06	MW-06	10/7/2002	11:49	Groundwater	N	NA	NA
MW-06	MW06072904	7/29/2004	12:58	Groundwater	N	NA	NA
SD11	SD11071904	7/19/2004	12:35	Sediment	N	NA	NA
SD11	SD11111104	11/11/2004	14:15	Sediment	N	NA	NA
SD12	SD12071904	7/19/2004	13:45	Sediment	N	NA	NA
SD12	SD12111104	11/11/2004	15:00	Sediment	N	NA	NA
SW11	SW11071904	7/19/2004	12:45	Surface water	N	NA	NA
SW11	SW11111104	11/11/2004	14:15	Surface water	N	NA	NA
SW12	SW12071904	7/19/2004	13:30	Surface water	N	NA	NA
SW12	SW12111104	11/11/2004	15:00	Surface water	N	NA	NA
SL01	SL010701040_5-02	7/1/2004	13:40	Soil	N	0.5	2
SL01	SL0107010400-0_5	7/1/2004	13:28	Soil	N	0	0.5
SL02	SL020701040_5-02	7/1/2004	12:45	Soil	N	0.5	2
SL02	SL0207010400-0_5	7/1/2004	12:15	Soil	N	0	0.5
SL03	SL030701040_5-02	7/1/2004	11:35	Soil	N	0.5	2
SL03	SL030701040_5-02D	7/1/2004	11:40	Soil	FD	0.5	2
SL03	SL0307010400-0_5	7/1/2004	11:20	Soil	N	0	0.5

Notes:
NA - Not applicable
FD - Field duplicate.
N - Normal
fbgs - feet below ground surface
It should be noted that samples collected from background locations were not used in the screening comparison.

Table 2-3
Groundwater Summary and Screening Value Comparison
Salford Quarry Site

Chemical	Detection Limit Range	Frequency of Detection	Maximum Concentration Detected	Sample ID of Maximum Concentration	Minimum Concentration Detected	Arithmetic Mean	Freshwater Screening Value[1]	Frequency of Exceedence	Average Background Concentration	Maximum Hazard Quotient	HQ Type	COPC	Rationale[2]	Bioaccumulative
INORGANICS (ug/L)														
ALUMINUM	200 - 200	3 / 4	77.3	MW-07	38.7	64.18	87	0 / 4	76.6	0.89	Max Detect	No	BSL	No
ANTIMONY	4 - 60	1 / 8	0.33	MW09072704	0.33	15.79	30	0 / 8	16	0.01	Max Detect	No	BSL	No
ARSENIC	2 - 10	5 / 8	10.8	MW-08	0.91	5.05	5	2 / 8	3.3	2.16	Max Detect	Yes	ASL	Yes
BARIUM	20 - 200	8 / 8	324	MW09072704	66.8	153.29	4	8 / 8	175	81	Max Detect	Yes	ASL	No
BERYLLIUM	2 - 5	2 / 8	0.36	MW-07	0.12	1.19	NV	0 / 8	0.645	NV	NV	Yes	NV	No
BORON	50 - 500	8 / 8	237000	MW-08	11800	78662.5	1.6	8 / 8	120	148125	Max Detect	Yes	ASL	No
CADMIUM*	2 - 5	1 / 8	0.33	MW07072904	0.33	1.67	0.28	1 / 8	1.385	1.18	Max Detect	Yes	ASL	Yes
CALCIUM METAL	5000 - 5000	4 / 4	81800	MW-07	35900	58900	116000	0 / 4	38900	0.71	Max Detect	No	BSL, Essential Nutrient	No
CHROMIUM (Total)*	4 - 10	6 / 8	3.1	MW09072704	0.72	2.82	88.9	0 / 8	3.05	0.03	Max Detect	No	BSL	No
COBALT	2 - 50	4 / 8	2.7	MW-07	0.18	9.98	23	0 / 8	12.73	0.12	Max Detect	No	BSL	No
COPPER*	4 - 25	6 / 8	7.8	MW10073004	1.3	6.34	10.84	0 / 8	8.95	0.72	Max Detect	No	BSL	Yes
CYANIDE	10 - 10	7 / 8	6.2	MW-08	1	3.51	5	3 / 8	3	1.24	Max Detect	Yes	ASL	No
IRON	100 - 100	4 / 4	20200	MW-07	103	6247.8	300	2 / 4	14400	67.33	Max Detect	Yes	ASL	No
LEAD*	2 - 3	3 / 8	0.41	MW08072904	0.23	1.0	2.5	0 / 8	1.1	0.16	Max Detect	No	BSL	Yes
LITHIUM	20 - 100	2 / 8	41	MW-09	40	32.63	14	2 / 8	30	2.93	Max Detect	Yes	ASL	No
MAGNESIUM	5000 - 5000	4 / 4	22200	MW-09	15500	20125	82000	0 / 4	21700	0.27	Max Detect	No	BSL, Essential Nutrient	No
MANGANESE	2 - 15	8 / 8	541	MW-08	6.3	162.78	120	3 / 8	155.5	4.51	Max Detect	Yes	ASL	No
MERCURY	0.2 - 0.2	2 / 8	3.6	MW-07	0.1	0.54	0.1	1 / 8	0.4	36	Max Detect	Yes	ASL	No
NICKEL*	2 - 40	7 / 8	4.6	MW-07	1.7	5.10	61.11	0 / 8	3.2	0.08	Max Detect	No	BSL	Yes
POTASSIUM	5000 - 5000	4 / 4	4560	MW-09	997	2046.8	53000	0 / 4	1040	0.09	Max Detect	No	BSL, Essential Nutrient	No
SELENIUM	5 - 10	5 / 8	8.1	MW08072904	4	4.35	1	5 / 8	3.75	8.1	Max Detect	Yes	ASL	Yes
SODIUM	5000 - 5000	4 / 4	104000	MW-08	18200	51425	680000	0 / 4	10600	0.15	Max Detect	No	BSL, Essential Nutrient	No
VANADIUM (FUME OR DUST)	2 - 50	3 / 8	5.3	MW08072904	1.5	10.84	20	0 / 8	1.9	0.27	Max Detect	No	BSL	No
ZINC*	4 - 20	8 / 8	17.5	MW-07	1.2	7.65	138.85	0 / 8	18.55	0.13	Max Detect	No	BSL	Yes
ORGANICS (ug/L)														
1,1,1-TRICHLOROETHANE	0.5 - 0.5	3 / 8	0.51	MW08072904	0.15	0.29	11	0 / 8	0.25	0.05	Max Detect	No	BSL	No
1,1-DICHLOROETHANE	0.5 - 0.5	5 / 8	1.4	MW08072904	0.12	0.56	47	0 / 8	0.25	0.03	Max Detect	No	BSL	No
1,1-DICHLOROETHYLENE	0.5 - 0.5	4 / 8	0.77	MW08072904	0.11	0.33	25	0 / 8	0.25	0.03	Max Detect	No	BSL	No
1,2,4-TRICHLOROBENZENE	0.5 - 0.5	1 / 8	0.2	MW08072904	0.2	0.24	24	0 / 8	0.25	0.008	Max Detect	No	BSL	Yes
1,2-DICHLOROETHANE	0.5 - 0.5	1 / 8	0.24	MW-10	0.24	0.25	100	0 / 8	0.25	0.002	Max Detect	No	BSL	No
1,4-DICHLOROBENZENE	0.5 - 0.5	1 / 8	0.15	MW08072904	0.15	0.24	26	0 / 8	0.25	0.006	Max Detect	No	BSL	Yes
2-BUTANONE	5 - 5	2 / 2	0.64	MW-07	0.23	0.44	14000	0 / 2	0.31	0.00005	Max Detect	No	BSL	No
ACETONE	5 - 5	8 / 8	4	MW07072904	1.6	3.16	1500	0 / 8	2.45	0.003	Max Detect	No	BSL	No
BENZENE	0.5 - 0.5	3 / 8	0.35	MW08072904	0.17	0.26	370	0 / 8	0.25	0.0009	Max Detect	No	BSL	No
BIS(2-ETHYLHEXYL)PHTHALATE	10 - 11.4	1 / 4	2	MW-10	2	4.42	16	0 / 4	5.2	0.13	Max Detect	No	BSL	No
CARBON DISULFIDE	0.5 - 0.5	2 / 8	8.7	MW-07	0.12	1.29	0.92	1 / 8	0.365	9.46	Max Detect	Yes	ASL	No
CARBON TETRACHLORIDE	0.5 - 0.5	1 / 8	0.29	MW09072704	0.29	0.26	13.3	0 / 8	0.25	0.02	Max Detect	No	BSL	No
CHLOROFORM	0.5 - 0.5	1 / 8	0.32	MW08072904	0.32	0.26	1.8	0 / 8	0.25	0.18	Max Detect	No	BSL	No
CHLOROMETHANE	0.5 - 0.5	1 / 8	0.11	MW07072904	0.11	0.23	NV	0 / 8	0.25	NV	NV	Yes	NV	No
CIS-1,2-DICHLOROETHENE	0.5 - 0.5	6 / 8	7	MW08072904	0.18	3.07	NV	0 / 8	0.25	NV	NV	Yes	NV	No
DICHLOROMETHANE	0.5 - 0.5	5 / 8	0.94	MW-10	0.11	0.31	98.1	0 / 8	0.235	0.010	Max Detect	No	BSL	No
M-DICHLOROBENZENE	0.5 - 0.5	1 / 8	0.18	MW08072904	0.18	0.24	150	0 / 8	0.25	0.001	Max Detect	No	BSL	Yes
TERT-BUTYL-METHYL ETHER	0.5 - 0.5	2 / 8	0.28	MW10073004	0.18	0.25	11070	0 / 8	0.25	0.00003	Max Detect	No	BSL	No
TETRACHLOROETHENE	0.5 - 0.5	1 / 8	0.7	MW-09	0.7	0.31	111	0 / 8	0.25	0.006	Max Detect	No	BSL	No
TOLUENE	0.5 - 0.5	1 / 8	1.3	MW09072704	1.3	0.38	2	0 / 8	0.25	0.65	Max Detect	No	BSL	No
TRANS-1,2-DICHLOROETHENE	0.5 - 0.5	1 / 8	0.25	MW-10	0.25	0.25	970	0 / 8	0.25	0.0003	Max Detect	No	BSL	No
TRICHLOROETHYLENE	0.5 - 5	8 / 8	28	MW08072904	0.42	9.09	21	2 / 8	0.25	1.33	Max Detect	Yes	ASL	No
VINYL CHLORIDE	0.5 - 0.5	4 / 8	6.1	MW08072904	1.8	2.29	930	0 / 8	0.25	0.007	Max Detect	No	BSL	No

Notes: All units are in ug/L.
SL - Screening Level
ASL - Above Screening Level
BSL - Below Screening Level
COPC - Contaminant of Potential Concern
NA - Not Available
NV - No Screening Value
DF - Detection Frequency
FE - Frequency of Exceedance of screening values.
HQ - Hazard Quotient
SQL - Sample Quantitation Limit
* Compound whose screening level was adjusted for hardness. The hardness was chosen based on the location of maximum concentrations in surface water.
For example, the maximum concentration of cadmium was located at SW06, therefore, the hardness at SW06 was used to adjust the screening level.
The Average Background Concentration is based on two rounds of sampling of MW-06 (in 2002 and 2004)
The reporting detection limit range is based on sample quantitation limits.
The arithmetic mean incorporates 1/2 x SQL for non-detected chemicals.

1. U.S. Environmental Protection Agency. 2004. Region III BTAG Freshwater Screening Benchmarks. Website: http://www.epa.gov/reg3hwmd/risk/eco/ btag/sbv/fw/screenbench.htm
2. ***This table compares groundwater values to surface water screening values. This comparison is extremely conservative in that it assumes the values measured in groundwater will be available to ecological receptors. However, by the time the groundwater is expressed, the maximum value in surface water will have decreased dramatically.***

Table 2-4
Summary of Non-Detects in Groundwater Samples
Salford Quarry Site

Chemical	Detection Limit Range	Frequency of Detection	Maximum Concentration Detected	Sample ID of Maximum Concentration	Minimum Concentration Detected	Arithmetic Mean	Freshwater Screening Value [1]	Frequency of Exceedence	Maximum Hazard Quotient	HQ Type	COPC	Detect	Rationale	Bioaccumulative
INORGANICS (ug/L)														
SILVER	2 - 10	0 / 8	NA	NA	NA	3.00	3.2	0 / 8	3.13	Max Detect Limit	No	Not Detected	ASL/ND	Yes
THALLIUM	2 - 10	0 / 8	NA	NA	NA	3.00	0.8	0 / 8	12.5	Max Detect Limit	No	Not Detected	ASL/ND	No
XYLENES (TOTAL)	0.5 - 0.5	0 / 8	NA	NA	NA	0.25	13	0 / 8	0.04	Max Detect Limit	No	Not Detected	BSL/ND	No
ORGANICS (ug/L)														
1,1,1-TRICHLORO-2,2-BIS (P-METHOXPHENYL)-ETHANE	0.5 - 0.57	0 / 4	NA	NA	NA	0.26	0.019	0 / 4	30	Max Detect Limit	No	Not Detected	ASL/ND	Yes
1,1,2,2-TETRACHLOROETHANE	0.5 - 0.5	0 / 8	NA	NA	NA	0.25	610	0 / 8	0.001	Max Detect Limit	No	Not Detected	BSL/ND	No
1,1,2-TRICHLOROETHANE	0.5 - 0.5	0 / 8	NA	NA	NA	0.25	1200	0 / 8	0.0004	Max Detect Limit	No	Not Detected	BSL/ND	No
1,1-BIPHENYL	10 - 11.4	0 / 4	NA	NA	NA	5.17	14	0 / 4	0.81	Max Detect Limit	No	Not Detected	BSL/ND	No
1,2,3-TRICHLOROBENZENE	0.5 - 0.5	0 / 8	NA	NA	NA	0.25	8	0 / 8	0.06	Max Detect Limit	No	Not Detected	BSL/ND	No
1,2-BENZPHENANTHRACENE	10 - 11.4	0 / 4	NA	NA	NA	5.17	NV	NV / 4	NV	NV	No	Not Detected	NV/ND	Yes
1,2-DIBROMO-3-CHLOROPROPANE (DBCP)	0.5 - 0.5	0 / 7	NA	NA	NA	0.25	NV	NV / 7	NV	NV	No	Not Detected	NV/ND	No
1,2-DIBROMOETHANE	0.5 - 0.5	0 / 8	NA	NA	NA	0.25	NV	NV / 8	NV	NV	No	Not Detected	NV/ND	No
1,2-DICHLOROBENZENE	0.5 - 0.5	0 / 8	NA	NA	NA	0.25	0.7	0 / 8	0.71	Max Detect Limit	No	Not Detected	BSL/ND	Yes
1,2-DICHLOROPROPANE	0.5 - 0.5	0 / 8	NA	NA	NA	0.25	NV	NV / 8	NV	NV	No	Not Detected	NV/ND	No
2,2-OXYBIS(1-CHLOROPROPANE)	10 - 11.4	0 / 4	NA	NA	NA	5.17	NV	NV / 4	NV	NV	No	Not Detected	NV/ND	No
2,4,5-TRICHLOROPHENOL	25 - 28.5	0 / 4	NA	NA	NA	12.94	NV	NV / 4	NV	NV	No	Not Detected	NV/ND	No
2,4,6-TRICHLOROPHENOL	10 - 11.4	0 / 4	NA	NA	NA	5.17	NV	NV / 4	NV	NV	No	Not Detected	NV/ND	No
2,4-DICHLOROPHENOL	10 - 11.4	0 / 4	NA	NA	NA	5.17	NV	NV / 4	NV	NV	No	Not Detected	NV/ND	No
2,4-DIMETHYLPHENOL	10 - 11.4	0 / 4	NA	NA	NA	5.17	NV	NV / 4	NV	NV	No	Not Detected	NV/ND	No
2,4-DINITROPHENOL	25 - 28.5	0 / 4	NA	NA	NA	12.94	NV	NV / 4	NV	NV	No	Not Detected	NV/ND	No
2,4-DINITROTOLUENE	10 - 11.4	0 / 4	NA	NA	NA	5.17	NV	NV / 4	NV	NV	No	Not Detected	NV/ND	No
2,6-DINITROTOLUENE	10 - 11.4	0 / 4	NA	NA	NA	5.17	81	0 / 4	0.14	Max Detect Limit	No	Not Detected	BSL/ND	No
2-CHLORONAPHTHALENE	10 - 11.4	0 / 4	NA	NA	NA	5.17	NV	NV / 4	NV	NV	No	Not Detected	NV/ND	No
2-CHLOROPHENOL	10 - 11.4	0 / 4	NA	NA	NA	5.17	24	0 / 4	0.47	Max Detect Limit	No	Not Detected	BSL/ND	No
2-HEXANONE	5 - 5	0 / 8	NA	NA	NA	2.50	99	0 / 8	0.05	Max Detect Limit	No	Not Detected	BSL/ND	No
2-METHYLNAPHTHALENE	10 - 11.4	0 / 4	NA	NA	NA	5.17	4.7	0 / 4	2.43	Max Detect Limit	No	Not Detected	ASL/ND	No
2-METHYLPHENOL	10 - 11.4	0 / 4	NA	NA	NA	5.17	13	0 / 4	0.88	Max Detect Limit	No	Not Detected	BSL/ND	No
2-NITROANILINE	25 - 28.5	0 / 4	NA	NA	NA	12.94	NV	NV / 4	NV	NV	No	Not Detected	NV/ND	No
2-NITROPHENOL	10 - 11.4	0 / 4	NA	NA	NA	5.17	1920	0 / 4	0.01	Max Detect Limit	No	Not Detected	BSL/ND	No
3,3'-DICHLOROBENZIDINE	10 - 11.4	0 / 4	NA	NA	NA	5.17	4.5	0 / 4	2.53	Max Detect Limit	No	Not Detected	ASL/ND	No
3,5,5-TRIMETHYL-2-CYCLOHEXENE-1-ONE	10 - 11.4	0 / 4	NA	NA	NA	5.17	NV	NV / 4	NV	NV	No	Not Detected	NV/ND	No
3-NITROANILINE	25 - 28.5	0 / 4	NA	NA	NA	12.94	NV	NV / 4	NV	NV	No	Not Detected	NV/ND	No
4,4-DDD	0.1 - 0.105	0 / 4	NA	NA	NA	0.05	0.011	0 / 4	9.55	Max Detect Limit	No	Not Detected	ASL/ND	Yes
4,4-DDE	0.1 - 0.105	0 / 4	NA	NA	NA	0.05	NV	NV / 4	NV	NV	No	Not Detected	NV/ND	Yes
4,4-DDT	0.1 - 0.105	0 / 4	NA	NA	NA	0.05	0.001	0 / 4	105	Max Detect Limit	No	Not Detected	ASL/ND	Yes
4,6-DINITRO-2-METHYLPHENOL	25 - 28.5	0 / 4	NA	NA	NA	12.94	NV	NV / 4	NV	NV	No	Not Detected	ASL/ND	No
4-BROMOPHENYL PHENYL ETHER	10 - 11.4	0 / 4	NA	NA	NA	5.17	1.5	0 / 4	7.60	Max Detect Limit	No	Not Detected	ASL/ND	Yes
4-CHLORO-3-METHYLPHENOL	10 - 11.4	0 / 4	NA	NA	NA	5.17	NV	NV / 4	NV	NV	No	Not Detected	NV/ND	No
4-CHLOROPHENYL PHENYL ETHER	10 - 11.4	0 / 4	NA	NA	NA	5.17	NV	NV / 4	NV	NV	No	Not Detected	NV/ND	Yes
4-METHYL-2-PENTANONE	5 - 5	0 / 8	NA	NA	NA	2.50	170	0 / 8	0.03	Max Detect Limit	No	Not Detected	BSL/ND	No
4-METHYLPHENOL	10 - 11.4	0 / 4	NA	NA	NA	5.17	543	0 / 4	0.02	Max Detect Limit	No	Not Detected	BSL/ND	No
4-NITROPHENOL	25 - 28.5	0 / 4	NA	NA	NA	12.94	60	0 / 4	0.47	Max Detect Limit	No	Not Detected	BSL/ND	No
ACENAPHTHENE	10 - 11.4	0 / 4	NA	NA	NA	5.17	5.8	0 / 4	1.97	Max Detect Limit	No	Not Detected	ASL/ND	Yes
ACENAPHTHYLENE	10 - 11.4	0 / 4	NA	NA	NA	5.17	NV	NV / 4	NV	NV	No	Not Detected	NV/ND	Yes
ACETOPHENONE	10 - 11.4	0 / 4	NA	NA	NA	5.17	NV	NV / 4	NV	NV	No	Not Detected	NV/ND	No
ALDRIN	0.05 - 0.052	0 / 4	NA	NA	NA	0.03	3	0 / 4	0.02	Max Detect Limit	No	Not Detected	BSL/ND	Yes
ALPHA-BHC	0.05 0.052	0 4	NA	NA	NA	0.03	NV	NV / 4	NV	NV	No	Not Detected	NV/ND	Yes
ALPHA-CHLORDANE	0.05 - 0.052	0 / 4	NA	NA	NA	0.03	NV	NV / 4	NV	NV	No	Not Detected	NV/ND	NA
ANTHRACENE	10 - 11.4	0 / 4	NA	NA	NA	5.17	0.012	0 / 4	950	Max Detect Limit	No	Not Detected	ASL/ND	Yes
AROCLOR-1016	1 - 1.05	0 / 4	NA	NA	NA	0.51	0.000074	0 / 4	14189	Max Detect Limit	No	Not Detected	ASL/ND	Yes
AROCLOR-1221	2 - 2.1	0 / 4	NA	NA	NA	1.01	0.000074	0 / 4	28378	Max Detect Limit	No	Not Detected	ASL/ND	Yes
AROCLOR-1232	1 - 1.05	0 / 4	NA	NA	NA	0.51	0.000074	0 / 4	14189	Max Detect Limit	No	Not Detected	ASL/ND	Yes
AROCLOR-1242	1 - 1.05	0 / 4	NA	NA	NA	0.51	0.000074	0 / 4	14189	Max Detect Limit	No	Not Detected	ASL/ND	Yes
AROCLOR-1248	1 - 1.05	0 / 4	NA	NA	NA	0.51	0.000074	0 / 4	14189	Max Detect Limit	No	Not Detected	ASL/ND	Yes
AROCLOR-1254	1 - 1.05	0 / 4	NA	NA	NA	0.51	0.000074	0 / 4	14189	Max Detect Limit	No	Not Detected	ASL/ND	Yes
AROCLOR-1260	1 - 1.05	0 / 4	NA	NA	NA	0.51	0.000074	0 / 4	14189	Max Detect Limit	No	Not Detected	ASL/ND	Yes
ATRAZINE	10 - 11.4	0 / 4	NA	NA	NA	5.17	1.8	0 / 4	6.33	Max Detect Limit	No	Not Detected	ASL/ND	No
BENZALDEHYDE	10 - 11.4	0 / 4	NA	NA	NA	5.17	NV	NV / 4	NV	NV	No	Not Detected	NV/ND	NA
BENZO(A)ANTRACENE	10 - 11.4	0 / 4	NA	NA	NA	5.17	0.018	0 / 4	633	Max Detect Limit	No	Not Detected	ASL/ND	Yes
BENZO(A)PYRENE	10 - 11.4	0 / 4	NA	NA	NA	5.17	0.015	0 / 4	760	Max Detect Limit	No	Not Detected	ASL/ND	Yes
BENZO(B)FLUORANTHENE	10 - 11.4	0 / 4	NA	NA	NA	5.17	NV	NV / 4	NV	NV	No	Not Detected	NV/ND	Yes
BENZO(G,H,I)PERYLENE	10 - 11.4	0 / 4	NA	NA	NA	5.17	NV	NV / 4	NV	NV	No	Not Detected	NV/ND	Yes
BENZO(K)FLUORANTHENE	10 - 11.4	0 / 4	NA	NA	NA	5.17	NV	NV / 4	NV	NV	No	Not Detected	NV/ND	Yes
BENZYL BUTYL PHTHALATE	10 - 11.4	0 / 4	NA	NA	NA	5.17	19	0 / 4	0.6	Max Detect Limit	No	Not Detected	BSL/ND	No

Table 2-4
Summary of Non-Detects in Groundwater Samples
Salford Quarry Site

Chemical	Detection Limit Range	Frequency of Detection	Maximum Concentration Detected	Sample ID of Maximum Concentration	Minimum Concentration Detected	Arithmetic Mean	Freshwater Screening Value [1]	Frequency of Exceedance	Maximum Hazard Quotient	HQ Type	COPC	Detect	Rationale	Bioaccumulative
ORGANICS (ug/L) cont.														
BETA-BHC	0.05 - 0.052	0 / 4	NA	NA	NA	0.03	NV	NV / 4	NV	NV	No	Not Detected	NV/ND	No
BIS(2-CHLOROETHOXY)METHANE	10 - 11.4	0 / 4	NA	NA	NA	5.17	NV	NV / 4	NV	NV	No	Not Detected	NV/ND	No
BIS-(2-CHLOROETHYL)ETHER	10 - 11.4	0 / 4	NA	NA	NA	5.17	NV	NV / 4	NV	NV	No	Not Detected	NV/ND	No
BROMODICHLOROMETHANE	0.5 - 0.5	0 / 8	NA	NA	NA	0.25	NV	NV / 8	NV	NV	No	Not Detected	NV/ND	No
BROMOMETHANE	0.5 - 0.5	0 / 8	NA	NA	NA	0.25	NV	NV / 8	NV	NV	No	Not Detected	NV/ND	No
CAMPHECHLOR	5 - 5.25	0 / 4	NA	NA	NA	2.53	0.0002	0 / 4	26250	Max Detect Limit	No	Not Detected	ASL/ND	Yes
CAPROLACTAM	10 - 11.4	0 / 4	NA	NA	NA	5.17	NV	NV / 4	NV	NV	No	Not Detected	NV/ND	NA
CARBAZOLE	10 - 11.4	0 / 4	NA	NA	NA	5.17	NV	NV / 4	NV	NV	No	Not Detected	NV/ND	NA
CFC-11	0.5 - 0.5	0 / 8	NA	NA	NA	0.25	NV	NV / 8	NV	NV	No	Not Detected	NV/ND	No
CFC-12	0.5 - 0.5	0 / 8	NA	NA	NA	0.25	NV	NV / 8	NV	NV	No	Not Detected	NV/ND	No
CHLORINATED FLUOROCARBON (FREON 113)	0.5 - 0.5	0 / 8	NA	NA	NA	0.25	NV	NV / 8	NV	NV	No	Not Detected	NV/ND	No
CHLOROBENZENE	0.5 - 0.5	0 / 8	NA	NA	NA	0.25	1.3	0 / 8	0.38	Max Detect Limit	No	Not Detected	BSL/ND	No
CHLOROBROMOMETHANE	0.5 - 0.5	0 / 8	NA	NA	NA	0.25	NV	NV / 8	NV	NV	No	Not Detected	NV/ND	No
CHLORODIBROMOMETHANE	0.5 - 0.5	0 / 8	NA	NA	NA	0.25	NV	NV / 8	NV	NV	No	Not Detected	NV/ND	No
CHLOROETHANE	0.5 - 0.5	0 / 8	NA	NA	NA	0.25	NV	NV / 8	NV	NV	No	Not Detected	NV/ND	No
CIS-1,3-DICHLOROPROPENE	0.5 - 0.5	0 / 8	NA	NA	NA	0.25	NV	NV / 8	NV	NV	No	Not Detected	NV/ND	No
CYCLOHEXANE	0.5 - 0.5	0 / 8	NA	NA	NA	0.25	NV	NV / 8	NV	NV	No	Not Detected	NV/ND	No
DELTA-BHC	0.05 - 0.052	0 / 4	NA	NA	NA	0.03	141	0 / 4	0.0004	Max Detect Limit	No	Not Detected	BSL/ND	No
DIBENZO(A,H)ANTHRACENE	10 - 11.4	0 / 4	NA	NA	NA	5.17	NV	NV / 4	NV	NV	No	Not Detected	NV/ND	Yes
DIBENZOFURAN	10 - 11.4	0 / 4	NA	NA	NA	5.17	3.7	0 / 4	3.08	Max Detect Limit	No	Not Detected	ASL/ND	No
DIELDRIN	0.1 - 0.105	0 / 4	NA	NA	NA	0.05	0.056	0 / 4	1.87	Max Detect Limit	No	Not Detected	ASL/ND	Yes
DIETHYL PHTHALATE	10 - 11.4	0 / 4	NA	NA	NA	5.17	210	0 / 4	0.05	Max Detect Limit	No	Not Detected	BSL/ND	No
DIMETHYL PHTHALATE	10 - 11.4	0 / 4	NA	NA	NA	5.17	NV	NV / 4	NV	NV	No	Not Detected	NV/ND	No
DI-N-BUTYLPHTHALATE	10 - 11.4	0 / 4	NA	NA	NA	5.17	19	0 / 4	0.60	Max Detect Limit	No	Not Detected	BSL/ND	No
DI-N-OCTYLPHTHALATE	10 - 11.4	0 / 4	NA	NA	NA	5.17	22	NV / 4	0.52	Max Detect Limit	No	Not Detected	BSL/ND	No
ENDOSULFAN I	0.05 - 0.052	0 / 4	NA	NA	NA	0.03	0.051	0 / 4	1.03	Max Detect Limit	No	Not Detected	ASL/ND	Yes
ENDOSULFAN II	0.1 - 0.105	0 / 4	NA	NA	NA	0.05	0.051	0 / 4	2.06	Max Detect Limit	No	Not Detected	ASL/ND	Yes
ENDOSULFAN SULFATE	0.1 - 0.105	0 / 4	NA	NA	NA	0.05	NV	NV / 4	NV	NV	No	Not Detected	NV/ND	No
ENDRIN	0.1 - 0.105	0 / 4	NA	NA	NA	0.05	0.036	0 / 4	2.92	Max Detect Limit	No	Not Detected	ASL/ND	Yes
ENDRIN ALDEHYDE	0.1 - 0.105	0 / 4	NA	NA	NA	0.05	NV	NV / 4	NV	NV	No	Not Detected	NV/ND	No
ENDRIN KETONE	0.1 - 0.105	0 / 4	NA	NA	NA	0.05	NV	NV / 4	NV	NV	No	Not Detected	NV/ND	NA
ETHYLBENZENE	0.5 - 0.5	0 / 8	NA	NA	NA	0.25	90	0 / 8	0.01	Max Detect Limit	No	Not Detected	BSL/ND	No
FLUORANTHENE	10 - 11.4	0 / 4	NA	NA	NA	5.17	0.04	0 / 4	285	Max Detect Limit	No	Not Detected	ASL/ND	Yes
FLUORENE	10 - 11.4	0 / 4	NA	NA	NA	5.17	3	0 / 4	3.80	Max Detect Limit	No	Not Detected	ASL/ND	Yes
GAMMA-BHC (LINDANE)	0.05 - 0.052	0 / 4	NA	NA	NA	0.03	0.01	0 / 4	5.25	Max Detect Limit	No	Not Detected	ASL/ND	Yes
GAMMA-CHLORDANE	0.05 - 0.052	0 / 4	NA	NA	NA	0.03	NV	NV / 4	NV	NV	No	Not Detected	NV/ND	NA
HEPTACHLOR	0.05 - 0.052	0 / 4	NA	NA	NA	0.03	0.0038	0 / 4	13.82	Max Detect Limit	No	Not Detected	ASL/ND	Yes
HEPTACHLOR EPOXIDE	0.05 - 0.052	0 / 4	NA	NA	NA	0.03	0.0038	0 / 4	13.82	Max Detect Limit	No	Not Detected	ASL/ND	Yes
HEXACHLORO-1,3-BUTADIENE	10 - 11.4	0 / 4	NA	NA	NA	5.17	1.3	0 / 4	8.77	Max Detect Limit	No	Not Detected	ASL/ND	Yes
HEXACHLOROBENZENE	10 - 11.4	0 / 4	NA	NA	NA	5.17	0.0003	0 / 4	38000	Max Detect Limit	No	Not Detected	ASL/ND	Yes
HEXACHLOROCYCLOPENTADIENE	10 - 11.4	0 / 4	NA	NA	NA	5.17	NV	NV / 4	NV	NV	No	Not Detected	NV/ND	Yes
HEXACHLOROETHANE	10 - 11.4	0 / 4	NA	NA	NA	5.17	12	0 / 4	0.95	Max Detect Limit	No	Not Detected	BSL/ND	Yes
INDENO(1,2,3-CD)PYRENE	10 - 11.4	0 / 4	NA	NA	NA	5.17	NV	NV / 4	NV	NV	No	Not Detected	NV/ND	Yes
ISOPROPYLBENZENE	0.5 - 0.5	0 / 8	NA	NA	NA	0.25	2.6	0 / 8	0.19	Max Detect Limit	No	Not Detected	BSL/ND	No
METHYL ACETATE	0.5 - 0.5	0 / 7	NA	NA	NA	0.25	NV	NV / 7	NV	NV	No	Not Detected	NV/ND	NA
METHYLCYLOHEXANE	0.5 - 0.5	0 / 8	NA	NA	NA	0.25	NV	NV / 8	NV	NV	No	Not Detected	NV/ND	NA
NAPHTHALENE	10 - 11.4	0 / 4	NA	NA	NA	5.17	1.1	0 / 4	10.36	Max Detect Limit	No	Not Detected	ASL/ND	No
NITROBENZENE	10 - 11.4	0 / 4	NA	NA	NA	5.17	NV	NV / 4	NV	NV	No	Not Detected	NV/ND	No
N-NITROSO-DI-N-PROPYLAMINE	10 - 11.4	0 / 4	NA	NA	NA	5.17	NV	NV / 4	NV	NV	No	Not Detected	NV/ND	No
N-NITROSODIPHENYLAMINE	10 - 11.4	0 / 4	NA	NA	NA	5.17	NV	NV / 4	NV	NV	No	Not Detected	NV/ND	NA
P-CHLOROANILINE	10 - 11.4	0 / 4	NA	NA	NA	5.17	232	0 / 4	0.05	Max Detect Limit	No	Not Detected	BSL/ND	No
PENTACHLOROPHENOL	25 - 28.5	0 / 4	NA	NA	NA	12.94	0.5	0 / 4	57.0	Max Detect Limit	No	Not Detected	ASL/ND	Yes
PHENANTHRENE	10 - 11.4	0 / 4	NA	NA	NA	5.17	0.4	0 / 4	28.5	Max Detect Limit	No	Not Detected	ASL/ND	Yes
PHENOL	10 - 11.4	0 / 4	NA	NA	NA	5.17	4	0 / 4	2.85	Max Detect Limit	No	Not Detected	ASL/ND	Yes
P-NITROANILINE	25 - 28.5	0 / 4	NA	NA	NA	12.94	NV	NV / 4	NV	NV	No	Not Detected	NV/ND	No
PYRENE	10 - 11.4	0 / 4	NA	NA	NA	5.17	0.025	0 / 4	456	Max Detect Limit	No	Not Detected	ASL/ND	Yes
STYRENE (MONOMER)	0.5 - 0.5	0 / 8	NA	NA	NA	0.25	72	0 / 8	0.01	Max Detect Limit	No	Not Detected	BSL/ND	No
TRANS-1,3-DICHLOROPROPENE	0.5 - 0.5	0 / 8	NA	NA	NA	0.25	NV	NV / 8	NV	NV	No	Not Detected	NV/ND	No
TRIBOMOMETHANE	0.5 - 0.5	0 / 8	NA	NA	NA	0.25	320	0 / 8	0.002	Max Detect Limit	No	Not Detected	BSL/ND	No

Notes:
All units are in ug/L.
ASL/ND - 1/2 x SQL is above screening level. Chemical is not retained as COPC because it was not detected.
BSL/ND - 1/2 x SQL is below screening level.
COPC = Contaminant of Potential Concern
NA - Not Available
NV/ND - No Screening Value. Chemical is not retained as COPC because it was not detected.
HQ = Hazard Quotient
SQL - Sample Quantitation Limit
* Compound whose screening level was adjusted for hardness. The hardness was chosen based on the location of maximum concentrations. For example, the maximum concentration of cadmium was located at SW06, therefore, the hardness at SW06 was used to adjust the screening level.
Background sample locations include: MW-06, 605QUA, and 451QUA.
The reporting detection limit range is based on sample quantitation limits.
The arithmetic mean incorporates 1/2 x SQL for non-detected chemicals.

1. U.S. Environmental Protection Agency. 2004. Region III BTAG Freshwater Screening Benchmarks. Website: http://www.epa.gov/reg3hwmd/risk/eco/ btag/sbv/fw/screenbench.htm

Table 2-5
Surface Water Summary and Screening Value Comparison
Sallford Quarry Site

Chemical	Detection Limit Range	Frequency of Detection	Maximum Concentration Detected	Sample ID of Maximum Concentration	Minimum Concentration Detected	Freshwater Screening Value [1]	Arithmetic Mean	Frequency of Exceedence	Average Background Concentration	Maximum Hazard Quotient	HQ Type	COPC	Rationale	Bioaccumulative
INORGANICS (ug/L)														
ALUMINUM	**200 - 200**	**11 / 20**	**1680**	**SW05071404D**	**175**	**87**	**564.10**	**11 / 20**	**395.93**	**19.31**	**Max Detect**	**Yes**	**ASL**	**No**
ANTIMONY	60 - 60	4 / 20	6.4	SW02110904	5.3	30	25.15	0 / 20	30	0.21	Max Detect	No	BSL	No
ARSENIC	10 - 10	5 / 20	4.9	SW09111104	1.8	5	4.53	0 / 20	4	0.98	Max Detect	No	BSL	Yes
BARIUM	**200 - 200**	**20 / 20**	**113**	**SW06111104**	**69.2**	**4**	**99.55**	**20 / 20**	**99.88**	**28.25**	**Max Detect**	**Yes**	**ASL**	**No**
BORON	**111 - 200**	**20 / 20**	**70400**	**SW01111104**	**34.5**	**1.6**	**5070.52**	**20 / 20**	**36.25**	**44000**	**Max Detect**	**Yes**	**ASL**	**No**
CADMIUM*	**5 - 5**	**5 / 20**	**0.49**	**SW06111104**	**0.31**	**0.28**	**1.97**	**5 / 20**	**1.97**	**1.75**	**Max Detect**	**Yes**	**ASL**	**Yes**
CALCIUM METAL	5000 - 5000	20 / 20	60700	SW01111104	32600	116000	37520	0 / 20	34775	0.52	Max Detect	No	BSL, Essential Nutrient	No
CHROMIUM (Total)*	10 - 10	9 / 20	1.9	SW05071404D	0.82	88.9	3.34	0 / 20	3.965	0.02	Max Detect	No	BSL	No
COBALT	50 - 50	1 / 20	0.83	SW04110904	0.83	23	23.79	0 / 20	25	0.04	Max Detect	No	BSL	No
COPPER*	25 - 25	20 / 20	6.1	SW09071904	0.98	10.84	3.03	0 / 20	3.175	0.56	Max Detect	No	BSL	Yes
CYANIDE	10 - 10	4 / 20	2.9	SW05071404D	1.6	5	4.39	0 / 20	5	0.58	Max Detect	No	BSL	No
IRON	**100 - 100**	**14 / 20**	**1220**	**SW05071404D**	**5.7**	**300**	**368.41**	**9 / 20**	**266.70**	**4.07**	**Max Detect**	**Yes**	**ASL**	**No**
LITHIUM	22.2 - 70	13 / 20	27.8	SW01111104	2.2	14	7.45	1 / 20	7.13	1.99	Max Detect	No	Mean < SL, HQ close to 1, FE 5%	No
MAGNESIUM	5000 - 5000	20 / 20	15400	SW01111104	9320	82000	11946	0 / 20	11675	0.19	Max Detect	No	BSL, Essential Nutrient	No
MANGANESE	15 - 15	20 / 20	83.7	SW03071404	6.8	120	22.26	0 / 20	22.6	0.70	Max Detect	No	BSL	No
NICKEL*	40 - 40	4 / 20	2	SW01071904	1.8	61.11	16.38	0 / 20	20	0.03	Max Detect	No	BSL	Yes
POTASSIUM	5000 - 5000	20 / 20	7020	SW01111104	2590	53000	3792	0 / 20	3582.5	0.13	Max Detect	No	BSL, Essential Nutrient	No
SELENIUM	**35 - 35**	**4 / 20**	**10.4**	**SW01111104**	**4.9**	**1**	**15.28**	**4 / 20**	**14.95**	**10.40**	**Max Detect**	**Yes**	**ASL**	**Yes**
SODIUM	5000 - 5000	20 / 20	74800	SW01111104	22400	680000	28020	0 / 20	25425	0.11	Max Detect	No	BSL, Essential Nutrient	No
THALLIUM	**25 - 25**	**5 / 20**	**4.1**	**SW05110904**	**3.2**	**0.8**	**10.29**	**5 / 20**	**12.50**	**5.13**	**Max Detect**	**Yes**	**ASL**	**No**
VANADIUM (FUME OR DUST)	50 - 50	20 / 20	4	SW05071404D	0.45	20	1.73	0 / 20	1.7	0.20	Max Detect	No	BSL	No
ZINC*	60 - 60	18 / 20	10.2	SW01111104	1.4	138.85	7.10	0 / 20	4.575	0.07	Max Detect	No	BSL	Yes
ORGANICS (ug/L)														
ACETONE	5 - 5	12 / 20	2.8	SW04071404	1.4	1500	2.17	0 / 20	2.5	0.002	Max Detect	No	BSL	No
CIS-1,2-DICHLOROETHENE	0.5 - 0.5	2 / 20	0.55	SW01111104	0.23	NV	0.264	NV / NV	0.25	NV	NV	No	DF 10%	No
DICHLOROMETHANE	0.5 - 0.5	8 / 20	0.34	SW01071904	0.27	98.1	0.27	0 / 20	0.2575	0.003	Max Detect	No	BSL	No
TRICHLOROETHYLENE	0.5 - 0.5	2 / 20	3.9	SW01111104	1.9	21	0.52	0 / 20	0.25	0.19	Max Detect	No	BSL	No

Notes:
All units are in ug/L.
ASL - Above Screening Level
BSL - Below Screening Level
COPC - Contaminant of Potential Concern
DF - Detection Frequency
NA - Not Available
NV - No Screening Value
FE - Frequency of Exceedance of screening values.
HQ - Hazard Quotient
SQL - Sample Quantitation Limit
* Compound whose screening level was adjusted for hardness. The hardness was chosen based on the location of maximum concentrations.
For example, the maximum concentration of cadmium was located at SW06, therefore, the hardness at SW06 was used to adjust the screening level.
Background sample locations include SW11 and SW12.
The reporting detection limit range is based on sample quantitation limits.
The arithmetic mean incorporates 1/2 x SQL for non-detected chemicals.

1. U.S. Environmental Protection Agency. 2004. Region III BTAG Freshwater Screening Benchmarks. Website: http://www.epa.gov/reg3hwmd/risk/eco/ btag/sbv/fw/screenbench.htm

Table 2-6
Summary of Non-Detects in Surface Water Samples
Salford Quarry Site

Chemical	Detection Limit Range	Frequency of Detection	Maximum Concentration Detected	Sample ID of Maximum Concentration	Minimum Concentration Detected	Freshwater Screening Value[1]	Arithmetic Mean	Frequency of Exceedence	Average Background Concentration	Maximum Hazard Quotient	HQ Type	COPC	Detect	Rationale	Bioaccumulative
INORGANICS (ug/L)															
BERYLLIUM	5 - 5	0 / 20	NA	NA	NA	NV	2.5	NV / 20	2.5	NV	NV	No	Not Detected	NV/ND	No
LEAD	10 - 10	0 / 20	NA	NA	NA	2.5	5.00	NV / 20	5.00	4.00	Max Detect Limit	No	Not Detected	ASL/ND	Yes
MERCURY	0.2 - 0.2	0 / 20	NA	NA	NA	0.1	0.10	NV / 20	0.10	2.00	Max Detect Limit	No	Not Detected	ASL/ND	No
SILVER	10 - 10	0 / 20	NA	NA	NA	3.2	5.00	NV / 20	5.00	3.13	Max Detect Limit	No	Not Detected	ASL/ND	Yes
ORGANICS (ug/L)															
1,1,1-TRICHLOROETHANE	0.5 - 0.5	0 / 20	NA	NA	NA	11	0.25	0 / 20	0.25	0.05	Max Detect Limit	No	Not Detected	BSL/ND	No
1,1,2,2-TETRACHLOROETHANE	0.5 - 0.5	0 / 20	NA	NA	NA	610	0.25	0 / 20	0.25	0.001	Max Detect Limit	No	Not Detected	BSL/ND	No
1,1,2-TRICHLOROETHANE	0.5 - 0.5	0 / 20	NA	NA	NA	1200	0.25	0 / 20	0.25	0.0004	Max Detect Limit	No	Not Detected	BSL/ND	No
1,1-DICHLOROETHANE	0.5 - 0.5	0 / 20	NA	NA	NA	47	0.25	0 / 20	0.25	0.01	Max Detect Limit	No	Not Detected	BSL/ND	No
1,1-DICHLOROETHYLENE	0.5 - 0.5	0 / 20	NA	NA	NA	25	0.25	0 / 20	0.25	0.02	Max Detect Limit	No	Not Detected	BSL/ND	No
1,2,3-TRICHLOROBENZENE	0.5 - 0.5	0 / 20	NA	NA	NA	8	0.25	0 / 20	0.25	0.06	Max Detect Limit	No	Not Detected	BSL/ND	No
1,2,4-TRICHLOROBENZENE	0.5 - 0.5	0 / 20	NA	NA	NA	24	0.25	0 / 20	0.25	0.02	Max Detect Limit	No	Not Detected	BSL/ND	Yes
1,2-DIBROMO-3-CHLOROPROPANE (DBCP)	0.5 - 0.5	0 / 10	NA	NA	NA	NV	0.25	NV / 10	0.25	NV	NV	No	Not Detected	NV/ND	No
1,2-DIBROMOETHANE	0.5 - 0.5	0 / 20	NA	NA	NA	NV	0.25	NV / 20	0.25	NV	NV	No	Not Detected	NV/ND	No
1,2-DICHLOROBENZENE	0.5 - 0.5	0 / 20	NA	NA	NA	0.7	0.25	0 / 20	0.25	0.71	Max Detect Limit	No	Not Detected	BSL/ND	Yes
1,2-DICHLOROETHANE	0.5 - 0.5	0 / 20	NA	NA	NA	100	0.25	0 / 20	0.25	0.01	Max Detect Limit	No	Not Detected	BSL/ND	No
1,2-DICHLOROPROPANE	0.5 - 0.5	0 / 20	NA	NA	NA	NV	0.25	NV / 20	0.25	NV	NV	No	Not Detected	NV/ND	No
1,4-DICHLOROBENZENE	0.5 - 0.5	0 / 20	NA	NA	NA	26	0.25	0 / 20	0.25	0.02	Max Detect Limit	No	Not Detected	BSL/ND	Yes
2-BUTANONE	5 - 5	0 / 10	NA	NA	NA	14000	2.5	0 / 10	2.5	0.0004	Max Detect Limit	No	Not Detected	BSL/ND	No
2-HEXANONE	5 - 5	0 / 10	NA	NA	NA	99	2.5	0 / 10	2.5	0.05	Max Detect Limit	No	Not Detected	BSL/ND	No
4-METHYL-2-PENTANONE	5 - 5	0 / 20	NA	NA	NA	170	2.5	0 / 20	2.5	0.03	Max Detect Limit	No	Not Detected	BSL/ND	No
BENZENE	0.5 - 0.5	0 / 20	NA	NA	NA	370	0.25	0 / 20	0.25	0.001	Max Detect Limit	No	Not Detected	BSL/ND	No
BROMODICHLOROMETHANE	0.5 - 0.5	0 / 20	NA	NA	NA	NV	0.25	NV / 20	0.25	NV	NV	No	Not Detected	NV/ND	No
BROMOMETHANE	0.5 - 0.5	0 / 20	NA	NA	NA	NV	0.25	NV / 20	0.25	NV	NV	No	Not Detected	NV/ND	No
CARBON DISULFIDE	0.5 - 0.5	0 / 20	NA	NA	NA	0.92	0.25	0 / 20	0.25	0.54	Max Detect Limit	No	Not Detected	BSL/ND	No
CARBON TETRACHLORIDE	0.5 - 0.5	0 / 20	NA	NA	NA	13.3	0.25	0 / 20	0.25	0.04	Max Detect Limit	No	Not Detected	BSL/ND	No
CFC-11	0.5 - 0.5	0 / 20	NA	NA	NA	NV	0.25	NV / 20	0.25	NV	NV	No	Not Detected	NV/ND	No
CFC-12	0.5 - 0.5	0 / 20	NA	NA	NA	NV	0.25	NV / 20	0.25	NV	NV	No	Not Detected	NV/ND	No
CHLORINATED FLUOROCARBON (FREON 113)	0.5 - 0.5	0 / 20	NA	NA	NA	NV	0.25	NV / 20	0.25	NV	NV	No	Not Detected	NV/ND	No
CHLOROBENZENE	0.5 - 0.5	0 / 20	NA	NA	NA	1.3	0.25	0 / 20	0.25	0.38	Max Detect Limit	No	Not Detected	BSL/ND	No
CHLOROBROMOMETHANE	0.5 - 0.5	0 / 20	NA	NA	NA	NV	0.25	NV / 20	0.25	NV	NV	No	Not Detected	NV/ND	No
CHLORODIBROMOMETHANE	0.5 - 0.5	0 / 20	NA	NA	NA	NV	0.25	NV / 20	0.25	NV	NV	No	Not Detected	NV/ND	No
CHLOROETHANE	0.5 - 0.5	0 / 20	NA	NA	NA	NV	0.25	NV / 20	0.25	NV	NV	No	Not Detected	NV/ND	No
CHLOROFORM	0.5 - 0.5	0 / 20	NA	NA	NA	1.8	0.25	0 / 20	0.25	0.28	Max Detect Limit	No	Not Detected	BSL/ND	No
CHLOROMETHANE	0.5 - 0.5	0 / 20	NA	NA	NA	NV	0.25	NV / 20	0.25	NV	NV	No	Not Detected	NV/ND	No
CIS-1,3-DICHLOROPROPENE	0.5 - 0.5	0 / 20	NA	NA	NA	NV	0.25	NV / 20	0.25	NV	NV	No	Not Detected	NV/ND	No
CYCLOHEXANE	0.5 - 0.5	0 / 20	NA	NA	NA	NV	0.25	NV / 20	0.25	NV	NV	No	Not Detected	NV/ND	No
ETHYLBENZENE	0.5 - 0.5	0 / 20	NA	NA	NA	90	0.25	0 / 20	0.25	0.01	Max Detect Limit	No	Not Detected	BSL/ND	No
ISOPROPYLBENZENE	0.5 - 0.5	0 / 20	NA	NA	NA	2.6	0.25	0 / 20	0.25	0.19	Max Detect Limit	No	Not Detected	BSL/ND	No
M-DICHLOROBENZENE	0.5 - 0.5	0 / 20	NA	NA	NA	150	0.25	0 / 20	0.25	0.003	Max Detect Limit	No	Not Detected	BSL/ND	Yes
METHYL ACETATE	0.5 - 0.5	0 / 20	NA	NA	NA	NV	0.25	NV / 20	0.25	NV	NV	No	Not Detected	NV/ND	NA
METHYLCYLOHEXANE	0.5 - 0.5	0 / 20	NA	NA	NA	NV	0.25	NV / 20	0.25	NV	NV	No	Not Detected	NV/ND	NA
STYRENE (MONOMER)	0.5 - 0.5	0 / 20	NA	NA	NA	72	0.25	0 / 20	0.25	0.01	Max Detect Limit	No	Not Detected	BSL/ND	No
TERT-BUTYL-METHYL ETHER	0.5 - 0.5	0 / 20	NA	NA	NA	11070	0.25	0 / 20	0.25	0.00005	Max Detect Limit	No	Not Detected	BSL/ND	No
TETRACHLOROETHENE	0.5 - 0.5	0 / 20	NA	NA	NA	111	0.25	0 / 20	0.25	0.005	Max Detect Limit	No	Not Detected	BSL/ND	No
TOLUENE	0.5 - 0.5	0 / 20	NA	NA	NA	2	0.25	0 / 20	0.25	0.25	Max Detect Limit	No	Not Detected	BSL/ND	No
TRANS-1,2-DICHLOROETHENE	0.5 - 0.5	0 / 20	NA	NA	NA	970	0.25	0 / 20	0.25	0.001	Max Detect Limit	No	Not Detected	BSL/ND	No
TRANS-1,3-DICHLOROPROPENE	0.5 - 0.5	0 / 20	NA	NA	NA	NV	0.25	NV / 20	0.25	NV	NV	No	Not Detected	NV/ND	No
TRIBOMOMETHANE	0.5 - 0.5	0 / 20	NA	NA	NA	320	0.25	0 / 20	0.25	0.002	Max Detect Limit	No	Not Detected	BSL/ND	No
VINYL CHLORIDE	0.5 - 0.5	0 / 20	NA	NA	NA	930	0.25	0 / 20	0.25	0.001	Max Detect Limit	No	Not Detected	BSL/ND	No
XYLENES (TOTAL)	0.5 - 0.5	0 / 20	NA	NA	NA	13	0.25	0 / 20	0.25	0.04	Max Detect Limit	No	Not Detected	BSL/ND	No

Notes:
All units are in ug/L
ASL/ND - 1/2 x SQL is above screening level. Chemical is not retained as COPC because it was not detected.
BSL/ND - 1/2 x SQL is below screening level.
COPC - Contaminant of Potential Concern
NA - Not Available
NV/ND - No Screening Value. Chemical is not retained as COPC because it was not detected.
HQ = Hazard Quotient
SQL - Sample Quantitation Limit
* Compound whose screening level was adjusted for hardness. The hardness was chosen based on the location of maximum concentrations.
For example, the maximum concentration of cadmium was located at SW06, therefore, the hardness at SW06 was used to adjust the screening level.
Background sample locations include SW11 and SW12.
The reporting detection limit range is based on sample quantitation limits.
The arithmetic mean incorporates 1/2 x SQL for non-detected chemicals.

1. U.S. Environmental Protection Agency. 2004. Region III BTAG Freshwater Screening Benchmarks. Website: http://www.epa.gov/reg3hwmd/risk/eco/ btag/sbv/fw/screenbench.htm

Table 2-7
Sediment Summary and Screening Value Comparison
Salford Quarry Site

Chemical	Detection Limit Range	Frequency of Detection	Maximum Concentration Detected	Sample ID of Maximum Concentration	Minimum Concentration Detected	Sediment Screening Value[1]	Arithmetic Mean	Frequency of Exceedence	Average Background Concentration	Maximum Hazard Quotient	HQ Type	COPC	Rationale	Bioaccumulative
INORGANICS (mg/kg)														
ALUMINUM	24.42 - 35.09	20 / 20	23200	SD01111104	7910	NV	13956.00	NV / NV	12305.00	NV	NV	Yes	NV	NA
ANTIMONY	7.73 - 10.53	10 / 20	6	SD07111104	1.9	2	3.99	9 / 20	3.51	3.00	Max Detect	Yes	ASL	No
ARSENIC	1.22 - 1.75	20 / 20	25.9	SD07111104	5.3	9.8	13.45	14 / 20	8.28	2.64	Max Detect	Yes	ASL, The mean is < Smith and CCME SL of 17 mg/kg	Yes
BARIUM	24.42 - 35.09	20 / 20	505	SD01111104	109	NV	167.95	NV / NV	129.75	NV	NV	Yes	NV, Mean > Ave Bk	NA
BERYLLIUM	0.61 - 0.88	20 / 20	1.9	SD07111104	0.79	NV	1.31	NV / NV	0.98	NV	NV	Yes	NV, Mean > Ave Bk	NA
BORON	12.11 - 17.54	20 / 20	84.2	SD01111104	4.9	NV	16.00	NV / NV	7.95	NV	NV	Yes	NV, Mean > Ave Bk	NA
CADMIUM	0.61 - 0.87	10 / 20	1.4	SD09071904	0.54	0.99	0.72	6 / 20	0.85	1.41	Max Detect	Yes	ASL, Mean < SL, HQ close to 1	Yes
CALCIUM METAL	611 - 877	20 / 20	3190	SD06111104	919	NV	1816.20	NV / NV	1882.50	NV	NV	No	Essential Nutrient	NA
CHROMIUM (Total)	1.22 - 1.75	20 / 20	52.2	SD09071904	16.2	43.4	26.21	1 / 20	19.73	1.20	Max Detect	No	1 Detect over SL (FE 5%), Mean < SL, HQ close to 1	No
COBALT	6.11 - 8.77	20 / 20	24.2	SD01111104	8.9	50	15.61	0 / 20	11.4	0.484	Max Detect	No	BSL	No
COPPER	3.05 - 4.39	20 / 20	41.1	SD07111104	11.7	31.6	26.60	5 / 20	19.58	1.30	Max Detect	Yes	ASL, Mean < SL, HQ close to 1	Yes
CYANIDE	3.05 - 4.33	11 / 20	0.79	SD09071904	0.1	0.1	0.96	10 / 20	0.67	7.90	Max Detect	Yes	ASL	No
IRON	12.21 - 17.54	20 / 20	48800	SD07111104	15600	20000	28615.00	15 / 20	20800.00	2.44	Max Detect	Yes	ASL	No
LEAD	1.22 - 1.75	20 / 20	38.9	SD01111104	15	35.8	25.59	2 / 20	24.50	1.09	Max Detect	No	HQ=1, 2 Detects just over SL (FE 10%), Mean < SL	Yes
LITHIUM	2.42 - 3.51	20 / 20	46.1	SD08071904	25.6	NV	33.47	NV / NV	25.83	NV	NV	Yes	NV, Mean > Ave Bk	NA
MAGNESIUM	611 - 877	20 / 20	8180	SD07111104	3060	NV	5133.50	20 / 20	4095.00	NV	NV	No	Essential Nutrient	NA
MANGANESE	1.83 - 4.20	20 / 20	5230	SD01111104	277	460	1197.75	17 / 20	778.75	11.37	Max Detect	Yes	ASL	No
MERCURY	0.14 - 0.15	3 / 20	0.047	SD09111104	0.02	0.18	0.07	0 / 20	0.06	0.26	Max Detect	No	BSL	No
NICKEL	4.88 - 7.02	20 / 20	37.4	SD07111104	16.8	22.7	25.78	12 / 20	20.93	1.65	Max Detect	Yes	ASL, HQ just over 1 (1.65)	Yes
POTASSIUM	611 - 877	20 / 20	1630	SD07111104	474	NV	854.75	20 / 20	729.25	NV	NV	No	Essential Nutrient	NA
SILVER	1.22 - 1.73	12 / 20	0.46	SD01111104	0.06	1	0.40	0 / 20	0.42	0.46	Max Detect	No	BSL	Yes
SODIUM	611 - 877	20 / 20	374	SD01071904	98.7	NV	208.34	20 / 20	230.25	NV	NV	No	Essential Nutrient	NA
THALLIUM	3.34 - 4.17	11 / 20	8.9	SD01111104	0.51	NV	1.99	NV / NV	1.59	NV	NV	Yes	NV, Mean > Ave Bk	NA
VANADIUM (FUME OR DUST)	6.11 - 8.77	20 / 20	69.8	SD09071904	22.2	NV	38.80	NV / NV	28.80	NV	NV	Yes	NV, Mean > Ave Bk	NA
ZINC	7.33 - 10.53	20 / 20	121	SD07111104	48.4	121	82.96	1 / 20	83.98	1.00	Max Detect	No	HQ=1, 1 Detect just over SL (FE 5%), Mean < SL	Yes
ORGANICS (ug/kg)														
ACETONE	10.87 - 15.21	2 / 20	9	SD06071904	4	NV	5.72	NV / NV	6.72	NV	NV	No	NV, DF 10%	NA
CFC-11	7.08 - 7.08	1 / 20	3	SD09111104	3	NV	5.69	NV / NV	5.22	NV	NV	No	NV, DF 5%	NA
CYCLOHEXANE	5.38 - 12.54	2 / 20	4	SD10111104	1	NV	5.52	NV / NV	5.97	NV	NV	No	NV, DF 10%	NA
DICHLOROMETHANE	5.38 - 15.21	10 / 20	5	SD03110904	1	NV	4.77	NV / NV	5.97	NV	NV	No	NV	NA
TOLUENE	5.38 - 5.38	1 / 20	1	SD08111104	1	NV	5.64	NV / NV	6.85	NV	NV	No	NV, DF 5%	NA

Notes:
Organic chemical units = ug/kg
Inorganic chemical units = mg/kg

SL - Screening Level
ASL - Above Screening Level
BSL - Below Screening Level
COPC - Contaminant of Potential Concern
NA - Not Available
NV - No Screening Value
DF - Detection Frequency
FE - Frequency of Exceedance of screening values.
Ave - Average
Bk - Background
HQ - Hazard Quotient
SQL - Sample Quantitation Limit
TOC - Total Organic Carbon
* Screening level for this compound was adjusted for TOC. The lowest measured TOC was used during the calculations of screening levels to give the most conservative benchmark. The lowest TOC was equal to 0.2% at SD04.
Background sample locations include: SD11 and SD12.
The reporting detection limit range is based on sample quantitation limits.
The arithmetic mean incorporates 1/2 x SQL for non-detected chemicals.

1. U.S. Environmental Protection Agency. 2005. Region III BTAG Freshwater Sediment Screening Benchmarks. Website: http://www.epa.gov/reg3hwmd /risk/eco/btag/sbv/fwsed/screenbench.htm

Table 2-8
Summary of Non-Detects in Sediment Samples
Salford Quarry Site

Chemical	Detection Limit Range	Frequency of Detection	Maximum Concentration Detected	Sample ID of Maximum Concentration	Minimum Concentration Detected	Sediment Screening Value[1]	Arithmetic Mean	Frequency of Exceedence	Average Background Concentration	Maximum Hazard Quotient	HQ Type	COPC	Detect	Rationale	Bioaccumulative
INORGANICS (mg/kg)															
SELENIUM	4.27 - 6.14	0 / 20	NA	NA	NA	2	2.55	0 / 20	2.53	3.07	Max Detect Limit	No	Not Detected	ASL/ND	Yes
ORGANICS (ug/kg)															
1,1,1-TRICHLOROETHANE*	5.38 - 21.14	0 / 20	NA	NA	NA	6.03	5.72	0 / 20	6.72	3.50	Max Detect Limit	No	Not Detected	ASL/ND	No
1,1,2,2-TETRACHLOROETHANE*	5.38 - 21.14	0 / 20	NA	NA	NA	272.90	5.72	0 / 20	6.72	0.08	Max Detect Limit	No	Not Detected	BSL/ND	No
1,1,2-TRICHLOROETHANE*	5.38 - 21.14	0 / 20	NA	NA	NA	248.68	5.72	0 / 20	6.72	0.08	Max Detect Limit	No	Not Detected	BSL/ND	No
1,1-DICHLOROETHANE	5.38 - 21.14	0 / 20	NA	NA	NA	NV	5.72	NV / 20	6.72	NV	NV	No	Not Detected	NV/ND	NA
1,1-DICHLOROETHYLENE*	5.38 - 21.14	0 / 20	NA	NA	NA	6.21	5.72	0 / 20	6.72	3.40	Max Detect Limit	No	Not Detected	ASL/ND	No
1,2,4-TRICHLOROBENZENE*	5.38 - 21.14	0 / 20	NA	NA	NA	420.10	5.72	0 / 20	6.72	0.05	Max Detect Limit	No	Not Detected	BSL/ND	Yes
1,2-DIBROMO-3-CHLOROPROPANE (DBCP)	5.38 - 21.14	0 / 20	NA	NA	NA	NV	5.72	NV / 20	6.72	NV	NV	No	Not Detected	NV/ND	NA
1,2-DIBROMOETHANE	5.38 - 21.14	0 / 20	NA	NA	NA	NV	5.72	NV / 20	6.72	NV	NV	No	Not Detected	NV/ND	NA
1,2-DICHLOROBENZENE*	5.38 - 21.14	0 / 20	NA	NA	NA	3.3	5.72	0 / 20	6.72	6.41	Max Detect Limit	No	Not Detected	ASL/ND	Yes
1,2-DICHLOROETHANE	5.38 - 21.14	0 / 20	NA	NA	NA	NV	5.72	NV / 20	6.72	NV	NV	No	Not Detected	NV/ND	NA
1,2-DICHLOROPROPANE	5.38 - 21.14	0 / 20	NA	NA	NA	NV	5.72	NV / 20	6.72	NV	NV	No	Not Detected	NV/ND	NA
1,4-DICHLOROBENZENE*	5.38 - 21.14	0 / 20	NA	NA	NA	119.71	5.72	0 / 20	6.72	0.18	Max Detect Limit	No	Not Detected	BSL/ND	Yes
2-BUTANONE	5.38 - 21.14	0 / 20	NA	NA	NA	NV	5.72	NV / 20	6.72	NV	NV	No	Not Detected	NV/ND	NA
2-HEXANONE	5.38 - 21.14	0 / 20	NA	NA	NA	NV	5.72	NV / 20	6.72	NV	NV	No	Not Detected	NV/ND	NA
4-METHYL-2-PENTANONE	5.38 - 21.14	0 / 20	NA	NA	NA	NV	5.72	NV / 20	6.72	NV	NV	No	Not Detected	NV/ND	NA
BENZENE	5.38 - 21.14	0 / 20	NA	NA	NA	NV	5.72	NV / 20	6.72	NV	NV	No	Not Detected	NV/ND	NA
BROMODICHLOROMETHANE	5.38 - 21.14	0 / 20	NA	NA	NA	NV	5.72	NV / 20	6.72	NV	NV	No	Not Detected	NV/ND	NA
BROMOMETHANE	5.38 - 21.14	0 / 20	NA	NA	NA	NV	5.72	NV / 20	6.72	NV	NV	No	Not Detected	NV/ND	NA
CARBON DISULFIDE*	5.38 - 21.14	0 / 20	NA	NA	NA	0.17	5.72	0 / 20	6.72	124.15	Max Detect Limit	No	Not Detected	ASL/ND	No
CARBON TETRACHLORIDE*	5.38 - 21.14	0 / 20	NA	NA	NA	12.85	5.72	0 / 20	6.72	1.65	Max Detect Limit	No	Not Detected	ASL/ND	No
CFC-12	5.38 - 21.14	0 / 20	NA	NA	NA	NV	5.72	NV / 20	6.72	NV	NV	No	Not Detected	NV/ND	NA
CHLORINATED FLUOROCARBON (FREON 113)	5.38 - 21.14	0 / 20	NA	NA	NA	NV	5.72	NV / 20	6.72	NV	NV	No	Not Detected	NV/ND	NA
CHLOROBENZENE*	5.38 - 21.14	0 / 20	NA	NA	NA	1.69	5.72	0 / 20	6.72	12.54	Max Detect Limit	No	Not Detected	ASL/ND	No
CHLORODIBROMOMETHANE	5.38 - 21.14	0 / 20	NA	NA	NA	NV	5.72	NV / 20	6.72	NV	NV	No	Not Detected	NV/ND	NA
CHLOROETHANE	5.38 - 21.14	0 / 20	NA	NA	NA	NV	5.72	NV / 20	6.72	NV	NV	No	Not Detected	NV/ND	NA
CHLOROFORM	5.38 - 21.14	0 / 20	NA	NA	NA	NV	5.72	NV / 20	6.72	NV	NV	No	Not Detected	NV/ND	NA
CHLOROMETHANE	5.38 - 21.14	0 / 20	NA	NA	NA	NV	5.72	NV / 20	6.72	NV	NV	No	Not Detected	NV/ND	NA
CIS-1,2-DICHLOROETHENE	5.38 - 21.14	0 / 20	NA	NA	NA	NV	5.72	NV / 20	6.72	NV	NV	No	Not Detected	NV/ND	Yes
CIS-1,3-DICHLOROPROPENE	5.38 - 21.14	0 / 20	NA	NA	NA	NV	5.72	NV / 20	6.72	NV	NV	No	Not Detected	NV/ND	NA
ETHYLBENZENE*	5.38 - 21.14	0 / 20	NA	NA	NA	219.87	5.72	0 / 20	6.72	0.10	Max Detect Limit	No	Not Detected	BSL/ND	No
ISOPROPYLBENZENE*	5.38 - 21.14	0 / 20	NA	NA	NA	17.2	5.72	0 / 20	6.72	1.23	Max Detect Limit	No	Not Detected	ASL/ND	No
M-DICHLOROBENZENE*	5.38 - 21.14	0 / 20	NA	NA	NA	885.91	5.72	0 / 20	6.72	0.02	Max Detect Limit	No	Not Detected	BSL/ND	Yes
METHYL ACETATE	5.38 - 21.14	0 / 20	NA	NA	NA	NV	5.72	NV / 20	6.72	NV	NV	No	Not Detected	NV/ND	NA
METHYLCYLOHEXANE	5.38 - 21.14	0 / 20	NA	NA	NA	NV	5.72	NV / 20	6.72	NV	NV	No	Not Detected	NV/ND	NA
STYRENE (MONOMER)*	5.38 - 21.14	0 / 20	NA	NA	NA	111.86	5.72	0 / 20	6.72	0.19	Max Detect Limit	No	Not Detected	BSL/ND	No
TERT-BUTYL-METHYL ETHER	5.38 - 21.14	0 / 20	NA	NA	NA	NV	5.72	NV / 20	6.72	NV	NV	No	Not Detected	NV/ND	NA
TETRACHLOROETHENE*	5.38 - 21.14	0 / 20	NA	NA	NA	93.59	5.72	0 / 20	6.72	0.23	Max Detect Limit	No	Not Detected	BSL/ND	No
TRANS-1,2-DICHLOROETHENE*	5.38 - 21.14	0 / 20	NA	NA	NA	210.33	5.72	0 / 20	6.72	0.10	Max Detect Limit	No	Not Detected	BSL/ND	No
TRANS-1,3-DICHLOROPROPENE	5.38 - 21.14	0 / 20	NA	NA	NA	NV	5.72	NV / 20	6.72	NV	NV	No	Not Detected	NV/ND	NA
TRIBROMOMETHANE*	5.38 - 21.14	0 / 20	NA	NA	NA	130.77	5.72	0 / 20	6.72	0.16	Max Detect Limit	No	Not Detected	BSL/ND	No
TRICHLOROETHYLENE*	5.38 - 21.14	0 / 20	NA	NA	NA	19.38	5.72	0 / 20	6.72	1.09	Max Detect Limit	No	Not Detected	ASL/ND	No
VINYL CHLORIDE	5.38 - 21.14	0 / 20	NA	NA	NA	NV	5.72	NV / 20	6.72	NV	NV	No	Not Detected	NV/ND	NA
XYLENES (TOTAL)	5.38 - 21.14	0 / 20	NA	NA	NA	NV	5.72	NV / 20	6.72	NV	NV	No	Not Detected	NV/ND	NA

Notes:
Organic chemical units = ug/kg
Inorganic chemical units = mg/kg
ASL/ND - 1/2 x SQL is above screening level. Chemical is not retained as COPC because it was not detected.
BSL/ND - 1/2 x SQL is below screening level.
COPC - Contaminant of Potential Concern
NA - Not Available
NV/ND - No Screening Value. Chemical is not retained as COPC because it was not detected.
HQ = Hazard Quotient
SQL - Sample Quantitation Limit
TOC - Total Organic Carbon
* Compound whose screening level was adjusted for TOC. The lowest TOC was used during the calculations of screening levels to give the most conservative benchmark. The lowest TOC was equal to 0.2% at SD04.
Background sample locations include: SD11 and SD12.
The reporting detection limit range is based on sample quantitation limits.
The arithmetic mean incorporates 1/2 x SQL for non-detected chemicals.

1. U.S. Environmental Protection Agency. 2005. Region III BTAG Freshwater Sediment Screening Benchmarks. Website: http://www.epa.gov/reg3hwmd /risk/eco/btag/sbv/fwsed/screenbench.htm

Table 2-9
Soil Summary and
Screening Value Comparison
Salford Quarry Site

Chemical	Detection Limit Range	Frequency of Detection	Maximum Concentration Detected	Sample ID of Maximum Concentration	Minimum Concentration Detected	Arithmetic Mean	Soil Screening Value	Screening Value Source	Frequency of Exceedence	Average Background Concentration	Maximum Hazard Quotient	HQ Type	COPC	Rationale	Bioaccumulative
INORGANICS (mg/kg)															
ALUMINUM	**20 - 20**	**10 / 10**	**24200**	**SL080701040_5-02**	**14300**	**17690**	**1**	**4**	**10 / 10**	**12033**	**24200**	**Max Detect**	**Yes**	**ASL**	**NA**
ARSENIC	25.71 - 25.71	1 / 10	25.7	SL080701040_5-02	25.7	12.91	328	4	0 / 10	12.26	0.08	Max Detect	No	BSL	Yes
BARIUM	20 - 20	10 / 10	1080	SL080701040_5-02	97.4	220.41	330	1	1 / 10	122.67	3.27	Max Detect	No	ASL, 1 Detect over SL, (FE 10%), Mean < SL	NA
BERYLLIUM	0.5 - 0.5	10 / 10	1.5	SL070630040_5-02	0.6	1.14	36	1	0 / 10	0.91	0.04	Max Detect	No	BSL	NA
BORON	**20 - 20**	**1 / 10**	**21.8**	**SL080701040_5-02**	**21.8**	**12.51**	**0.0005**	**4**	**1 / 0**	**12.26**	**43600**	**Max Detect**	**Yes**	**ASL, 1 Detect over SL, (FE 10%), Mean > SL**	**NA**
CADMIUM	**0.5 - 2.5**	**2 / 10**	**9.5**	**SL080701040_5-02**	**0.6**	**1.38**	**0.38**	**1**	**2 / 10**	**0.31**	**25**	**Max Detect**	**Yes**	**ASL, Included in food chain model**	**Yes**
CALCIUM METAL	500 - 500	10 / 10	3270	SL0406300400-0_5	960	1780	NV	NV	NV / NV	1251.17	NV	NV	No	Essential Nutrient	NA
CHROMIUM	**1 - 1**	**10 / 10**	**91.5**	**SL080701040_5-02**	**25.5**	**34.28**	**0.0075**	**4**	**10 / 10**	**16.65**	**12200**	**Max Detect**	**Yes**	**ASL**	**No**
COBALT	5 - 25	7 / 10	16.2	SL0406300400-0_5	8.2	13.72	13	1	4 / 10	9.00	1.25	Max Detect	No	HQ just over 1, Mean=SL	No
COPPER	**2.5 - 2.5**	**10 / 10**	**1820**	**SL080701040_5-02**	**22.6**	**213.01**	**15**	**4**	**10 / 10**	**18.57**	**121.33**	**Max Detect**	**Yes**	**ASL, Included in food chain model**	**Yes**
IRON	**10 - 10**	**10 / 10**	**63600**	**SL080701040_5-02**	**20100**	**34030**	**12**	**4**	**10 / 10**	**16950**	**5300**	**Max Detect**	**Yes**	**ASL**	**No**
LEAD	**5 - 5**	**10 / 10**	**1940**	**SL080701040_5-02**	**19.7**	**268.42**	**16**	**1**	**10 / 10**	**18.10**	**121.25**	**Max Detect**	**Yes**	**ASL, Included in food chain model**	**Yes**
LITHIUM	**20 - 20**	**9 / 10**	**33**	**SL0506300400-0_5**	**23.3**	**27.81**	**2**	**3**	**9 / 10**	**16.67**	**16.5**	**Max Detect**	**Yes**	**ASL**	**No**
MAGNESIUM	**500 - 500**	**10 / 10**	**8040**	**SL0406300400-0_5**	**4750**	**6680**	**4400**	**4**	**10 / 10**	**3568**	**1.82**	**Max Detect**	**Yes**	**HQ just over 1, Essential Nutrient, Mean >SL**	**NA**
MANGANESE	**1.5 - 1.5**	**10 / 10**	**2050**	**SL0706300400-0_5**	**663**	**1038.4**	**330**	**4**	**10 / 10**	**689**	**6.21**	**Max Detect**	**Yes**	**ASL**	**No**
MERCURY	**0.1 - 0.1**	**3 / 10**	**71.4**	**SL080701040_5-02**	**0.24**	**7.2**	**0.058**	**4**	**3 / 10**	**0.06**	**1231.03**	**Max Detect**	**Yes**	**ASL, Included in food chain model**	**Yes**
NICKEL	**4 - 4**	**10 / 10**	**46.8**	**SL080701040_5-02**	**21.8**	**31.41**	**2**	**4**	**10 / 10**	**17.30**	**23.4**	**Max Detect**	**Yes**	**ASL, Included in food chain model**	**Yes**
POTASSIUM	500 - 500	10 / 10	1420	SL0406300400-0_5	479	905.2	NV	NV	NV / NV	420.33	NV	NV	No	Essential Nutrient	NA
SILVER	1 - 5	1 / 10	10.8	SL080701040_5-02	10.8	2.18	4.04	2	1 / 10	0.61	2.67	Max Detect	No	ASL, 1 Detect over SL, (FE 10%), Mean < SL	Yes
SODIUM	100 - 100	1 / 10	290	SL080701040_5-02	290	80.68	NV	NV	NV / NV	61.30	NV	NV	No	Essential Nutrient	NA
VANADIUM (FUME OR DUST)	**5 - 5**	**10 / 10**	**49.9**	**SL070630040_5-02**	**25.3**	**35.27**	**0.5**	**4**	**10 / 10**	**24.17**	**99.8**	**Max Detect**	**Yes**	**ASL**	**NA**
ZINC	**2 - 2**	**10 / 10**	**2390**	**SL080701040_5-02**	**74.4**	**348.53**	**10**	**4**	**10 / 10**	**59.08**	**239**	**Max Detect**	**Yes**	**ASL, Included in food chain model**	**Yes**
ORGANICS (ug/kg)															
ACETONE	10.67 - 18.54	8 / 10	73	SL050630040_5-02	3	25.17	2500	2	0 / 10	5.96	0.03	Max Detect	No	BSL	NA
CIS-1,2-DICHLOROETHENE	9.22 - 18.54	1 / 10	19	SL080701040_5-02	19	7.56	NV	NV	NV / NV	5.70	NV	NV	No	NV, (DF 10%), Dutch Ministry 2000 value of 200 ug/kg	No
DICHLOROMETHANE	9.22 - 16.25	9 / 10	6	SL070630040_5-02	2	4.83	4050	2	0 / 10	3.83	0.001	Max Detect	No	BSL	NA
TETRACHLOROETHENE	9.22 - 18.54	10 / 10	11	SL080701040_5-02	3	6.50	9920	2	0 / 10	4	0.001	Max Detect	No	BSL	No
TOLUENE	12.99 - 12.99	1 / 10	5	SL080701040_5-02	5	6.16	100	4	0 / 10	5.70	0.05	Max Detect	No	BSL	NA
TRICHLOROETHYLENE	12.99 - 12.99	1 / 10	160	SL080701040_5-02	160	21.66	12400	2	0 / 10	5.70	0.01	Max Detect	No	BSL	No

Notes:
Organic chemical units = ug/kg
Inorganic chemical units = mg/kg

SL - Screening Level
ASL - Above Screening Level
BSL - Below Screening Level
COPC - Contaminant of Potential Concern
DF - Detection Frequency
FE - Frequency of Exceedance
NA - Not Available
NV - No Screening Value
HQ - Hazard Quotient
SQL - Sample Quantitation Limit
Background sample locations include: SL01, SL02, and SL03.
The reporting detection limit range is based on sample quantitation limits.
The arithmetic mean incorporates 1/2 x SQL for non-detected chemicals.

Screening value sources:
1. USEPA 2003. Ecological Soil Screening Levels, website http://www.epa.gov/ecotox/ecossl/
2. USEPA 1999a. RCRA Corrective Action-Region 5 Ecological Data Quality Levels (EDQLs), MRL Values for All Media, October 4.
3. Efroymson, R. A, G.W. Suter II, M.E. Will, and A.C. Wooten. 1997. Toxicological benchmarks for screening contaminants of potential concern for effects on terrestrial plants: 1997 Revision. ES/ER/TM-85/R3.
Oak Ridge National Laboratory, Oak Ridge, TN. Available at: http://www.esd.ornl.gov/programs/ecorisk/documents/tm85r3.pdf
4. USEPA 1995. Region III BTAG Screening Levels.

Table 2-10
Summary of Non-Detects in Soil Samples
Salford Quarry Site

Chemical	Detection Limit Range	Frequency of Detection	Maximum Concentration Detected	Sample ID of Maximum Concentration	Minimum Concentration Detected	Arithmetic Mean	Soil Screening Value	Screening Value Source	Frequency of Exceedence	Average Background Concentration	Maximum Hazard Quotient	HQ Type	COPC	Detect	Rationale	Bioaccumulative
INORGANICS (mg/kg)																
ANTIMONY	6 - 30	0 / 10	NA	NA	NA	5.36	0.29	1	NV / 10	3.68	103.44	Max Detect Limit	No	Not Detected	ASL/ND	No
CYANIDE	1 - 1	0 / 10	NA	NA	NA	0.59	NV	NV	NV / 10	0.62	NV	NV	No	Not Detected	NV/ND	No
SELENIUM	22.17 - 128.53	0 / 10	NA	NA	NA	28.46	1800	5	0 / 10	12.26	0.07	Max Detect Limit	No	Not Detected	BSL/ND	Yes
THALLIUM	20 - 100	0 / 10	NA	NA	NA	28.46	1	5	NV / 10	12.26	100	Max Detect Limit	No	Not Detected	ASL/ND	NA
ORGANICS (ug/kg)																
1,1,1-TRICHLOROETHANE	9.22 - 18.54	0 / 10	NA	NA	NA	6.31	29800	4	0 / 10	5.70	0.0006	Max Detect Limit	No	Not Detected	BSL/ND	No
1,1,2,2-TETRACHLOROETHANE	9.22 - 18.54	0 / 10	NA	NA	NA	6.31	127	4	0 / 10	5.70	0.15	Max Detect Limit	No	Not Detected	BSL/ND	No
1,1,2-TRICHLOROETHANE	9.22 - 18.54	0 / 10	NA	NA	NA	6.31	28600	4	0 / 10	5.70	0.0006	Max Detect Limit	No	Not Detected	BSL/ND	No
1,1-DICHLOROETHANE	9.22 - 18.54	0 / 10	NA	NA	NA	6.31	20100	4	0 / 10	5.70	0.0009	Max Detect Limit	No	Not Detected	BSL/ND	NA
1,1-DICHLOROETHYLENE	9.22 - 18.54	0 / 10	NA	NA	NA	6.31	8280	4	0 / 10	5.70	0.002	Max Detect Limit	No	Not Detected	BSL/ND	No
1,2,4-TRICHLOROBENZENE	9.22 - 18.54	0 / 10	NA	NA	NA	6.31	11100	4	0 / 10	5.70	0.002	Max Detect Limit	No	Not Detected	BSL/ND	Yes
1,2-DIBROMO-3-CHLOROPROPANE (DBCP)	9.22 - 18.54	0 / 9	NA	NA	NA	6.27	35.2	4	0 / 9	5.70	0.53	Max Detect Limit	No	Not Detected	BSL/ND	NA
1,2-DIBROMOETHANE	9.22 - 18.54	0 / 10	NA	NA	NA	6.31	1230	4	0 / 10	5.70	0.02	Max Detect Limit	No	Not Detected	BSL/ND	NA
1,2-DICHLOROBENZENE	9.22 - 18.54	0 / 10	NA	NA	NA	6.3	10	3	NV / 10	5.70	1.85	Max Detect Limit	No	Not Detected	ASL/ND	Yes
1,2-DICHLOROETHANE	9.22 - 18.54	0 / 10	NA	NA	NA	6.3	0.87	5	NV / 10	5.70	21.31	Max Detect Limit	No	Not Detected	ASL/ND	NA
1,2-DICHLOROPROPANE	9.22 - 18.54	0 / 10	NA	NA	NA	6.31	32700	4	0 / 10	5.70	0.0006	Max Detect Limit	No	Not Detected	BSL/ND	NA
1,4-DICHLOROBENZENE	9.22 - 18.54	0 / 10	NA	NA	NA	6.31	100	2	0 / 10	5.70	0.19	Max Detect Limit	No	Not Detected	BSL/ND	Yes
2-BUTANONE	9.22 - 18.54	0 / 10	NA	NA	NA	6.31	89600	4	0 / 10	5.70	0.0002	Max Detect Limit	No	Not Detected	BSL/ND	NA
2-HEXANONE	9.22 - 18.54	0 / 10	NA	NA	NA	6.3	NV	NV	NV / 10	5.70	NV	NV	No	Not Detected	NV/ND	NA
4-METHYL-2-PENTANONE	9.22 - 18.54	0 / 10	NA	NA	NA	6.31	100000	5	0 / 10	5.70	0.0002	Max Detect Limit	No	Not Detected	BSL/ND	NA
BENZENE	9.22 - 18.54	0 / 10	NA	NA	NA	6.29	100	5	0 / 10	5.70	0.19	Max Detect Limit	No	Not Detected	BSL/ND	NA
BROMODICHLOROMETHANE	9.22 - 18.54	0 / 10	NA	NA	NA	6.31	540	4	0 / 10	5.70	0.03	Max Detect Limit	No	Not Detected	BSL/ND	NA
BROMOMETHANE	9.22 - 18.54	0 / 10	NA	NA	NA	6.3	NV	NV	NV / 10	5.70	NV	NV	No	Not Detected	NV/ND	NA
CARBON DISULFIDE	9.22 - 18.54	0 / 10	NA	NA	NA	6.31	94.1	4	0 / 10	5.70	0.20	Max Detect Limit	No	Not Detected	BSL/ND	No
CARBON TETRACHLORIDE	9.22 - 18.54	0 / 10	NA	NA	NA	6.31	2980	4	0 / 10	5.70	0.006	Max Detect Limit	No	Not Detected	BSL/ND	No
CFC-11	9.22 - 18.54	0 / 10	NA	NA	NA	6.31	16400	4	0 / 10	5.70	0.001	Max Detect Limit	No	Not Detected	BSL/ND	NA
CFC-12	9.22 - 18.54	0 / 10	NA	NA	NA	6.31	39500	4	0 / 10	5.70	0.0005	Max Detect Limit	No	Not Detected	BSL/ND	NA
CHLORINATED FLUOROCARBON (FREON 113)	9.22 - 18.54	0 / 10	NA	NA	NA	6.3	NV	NV	NV / 10	5.70	NV	NV	No	Not Detected	NV/ND	NA
CHLOROBENZENE	9.22 - 18.54	0 / 10	NA	NA	NA	6.31	100	5	0 / 10	5.70	0.19	Max Detect Limit	No	Not Detected	BSL/ND	No
CHLORODIBROMOMETHANE	9.22 - 18.54	0 / 10	NA	NA	NA	6.31	2050	4	0 / 10	5.70	0.009	Max Detect Limit	No	Not Detected	BSL/ND	NA
CHLOROETHANE	9.22 - 18.54	0 / 10	NA	NA	NA	6.31	100	3	0 / 10	5.70	0.19	Max Detect Limit	No	Not Detected	BSL/ND	NA
CHLOROFORM	9.22 - 18.54	0 / 10	NA	NA	NA	6.31	1190	4	0 / 10	5.70	0.02	Max Detect Limit	No	Not Detected	BSL/ND	NA
CHLOROMETHANE	9.22 - 18.54	0 / 10	NA	NA	NA	6.31	100	3	0 / 10	5.70	0.19	Max Detect Limit	No	Not Detected	BSL/ND	NA
CIS-1,3-DICHLOROPROPENE	9.22 - 18.54	0 / 10	NA	NA	NA	6.31	398	4	0 / 10	5.70	0.05	Max Detect Limit	No	Not Detected	BSL/ND	NA
CYCLOHEXANE	9.22 - 18.54	0 / 10	NA	NA	NA	6.31	100	3	0 / 10	5.70	0.19	Max Detect Limit	No	Not Detected	BSL/ND	NA
ETHYLBENZENE	9.22 - 18.54	0 / 10	NA	NA	NA	6.31	100	5	0 / 10	5.70	0.19	Max Detect Limit	No	Not Detected	BSL/ND	No
ISOPROPYLBENZENE	9.22 - 18.54	0 / 10	NA	NA	NA	6.3	NV	NV	NV / 10	5.70	NV	NV	No	Not Detected	NV/ND	No
M-DICHLOROBENZENE	9.22 - 18.54	0 / 10	NA	NA	NA	6.31	100	2	0 / 10	5.70	0.19	Max Detect Limit	No	Not Detected	BSL/ND	Yes
METHYL ACETATE	9.22 - 18.54	0 / 10	NA	NA	NA	6.3	NV	NV	NV / 10	5.70	NV	NV	No	Not Detected	NV/ND	NA
METHYLCYLOHEXANE	9.22 - 18.54	0 / 10	NA	NA	NA	6.3	NV	NV	NV / 10	5.70	NV	NV	No	Not Detected	NV/ND	NA
STYRENE (MONOMER)	9.22 - 18.54	0 / 10	NA	NA	NA	6.31	100	5	0 / 10	5.70	0.19	Max Detect Limit	No	Not Detected	BSL/ND	No
TERT-BUTYL-METHYL ETHER	9.22 - 18.54	0 / 10	NA	NA	NA	6.3	NV	NV	NV / 10	5.70	NV	NV	No	Not Detected	NV/ND	NA
TRANS-1,2-DICHLOROETHENE	9.22 - 18.54	0 / 10	NA	NA	NA	6.31	784	4	0 / 10	5.70	0.02	Max Detect Limit	No	Not Detected	BSL/ND	No
TRANS-1,3-DICHLOROPROPENE	9.22 - 18.54	0 / 10	NA	NA	NA	6.31	398	4	0 / 10	5.70	0.05	Max Detect Limit	No	Not Detected	BSL/ND	NA
TRIBROMOMETHANE	9.22 - 18.54	0 / 10	NA	NA	NA	6.31	15900	4	0 / 10	5.70	0.001	Max Detect Limit	No	Not Detected	BSL/ND	No
VINYL CHLORIDE	9.22 - 18.54	0 / 10	NA	NA	NA	6.31	300	5	0 / 10	5.70	0.06	Max Detect Limit	No	Not Detected	BSL/ND	NA
XYLENES (TOTAL)	9.22 - 18.54	0 / 10	NA	NA	NA	6.31	10000	4	0 / 10	5.70	0.002	Max Detect Limit	No	Not Detected	BSL/ND	NA

Notes:
Organic chemical units = ug/kg
Inorganic chemical units = mg/kg
ASL/ND - 1/2 x SQL is above screening level. Chemical is not retained as COPC because it was not detected.
BSL/ND - 1/2 x SQL is below screening level.
COPC - Contaminant of Potential Concern
NA - Not Available
NV/ND - No Screening Value. Chemical is not retained as COPC because it was not detected.
HQ = Hazard Quotient
SQL - Sample Quantitation Limit
Background sample locations include: SL01, SL02, and SL03.
The reporting detection limit range is based on sample quantitation limits.
The arithmetic mean incorporates 1/2 x SQL for non-detected chemicals.

Screening value sources:
1. USEPA 2003. Ecological Soil Screening Levels, website http://www.epa.gov/ecotox/ecossl/
2. Canadian Council of Ministers of the Environment (CCME) 2002. Canadian Sediment Quality Guidelines for the Protecton of Aquatic Life.
3. USEPA 2001. Region 4 Ecological Risk Assessment Bulletins-Supplement to RAGS, website http://www.epa.gov/region04/waste/ots/ecolbul.htm.
4. USEPA 1999a. RCRA Corrective Action-Region 5 Ecological Data Quality Levels (EDQLs), MRL Values for All Media, October 4.
5. USEPA 1995. Region III BTAG Screening Levels.

Table 2-11
Assessment Endpoints, Risk Hypotheses, Measurement Endpoints, and Receptors
Salford Quarry Site

Assessment Endpoint	Risk Hypothesis	Measurement Endpoint	Receptor Species
Protection of plant communities from the toxic effects (on survival, reproduction, and growth) of site-related chemicals present in surface soil (0-24"), sediment, or surface water.	Are levels of site-related chemicals present in shallow soil sufficient to cause adverse effects on the survival, reproduction, and growth of plants at the site?	Comparison of exposure HQs to an HQ of 1.0. Exposure HQs are calculated for individual chemicals by dividing the soil concentrations by vegetation-based soil screening values. An HQ of 1.0 represents a condition where the soil concentration is equal to the screening value.	Plants
Protection of soil invertebrate communities from the toxic effects (on survival, reproduction, and growth) of site-related chemicals present in surface soil (0-24").	Are levels of site-related chemicals present in shallow soil sufficient to cause adverse effects on the survival, reproduction, and growth of soil invertebrates at the site?	Comparison of exposure HQs to an HQ of 1.0. Exposure HQs are calculated for individual chemicals by dividing the soil concentrations by invertebrate-based soil screening values. An HQ of 1.0 represents a condition where the soil concentration is equal to the screening values.	Soil Invertebrates
Protection of aquatic invertebrate communities from the toxic effects (on survival and growth) of site-related chemicals present in sediment and surface water.	Are levels of site-related chemicals present in sediment and surface water sufficient to cause adverse effects on the survival and growth of aquatic invertebrates at the site?	Comparison of exposure HQs to a reference HQ of 1.0. Exposure HQs are calculated for individual chemicals by dividing the sediment or surface water concentrations by invertebrate based sediment and surface water screening values. A reference HQ of 1.0 represents a condition where the sediment concentration is equal to the screening values.	Aquatic Invertebrates
Protection of fish from the toxic effects (on survival and growth) of site-related chemicals present in sediment and surface water.	Are levels of site-related chemicals present in sediment and surface water sufficient to cause adverse effects on the survival and growth of fish at the site?	Comparison of exposure HQs to a reference HQ of 1.0. Exposure HQs are calculated for individual chemicals by dividing the sediment or surface water concentrations by invertebrate based sediment and surface water screening values. A reference HQ of 1.0 represents a condition where the sediment concentration is equal to the screening values.	Fish
Protection of amphibians and reptiles to ensure that ingestion of contaminants in soil and prey does not have a negative impact on growth, survival, and reproduction	Are levels of site contaminants in soil/sediment sufficient to cause adverse effects on the growth, survival, and reproductive success of amphibians and reptiles using the site?	Comparison of dietary HQs to an HQ of 1.0. Dietary HQs are calculated for individual chemicals by dividing an estimated level of exposure by an ecotoxicity value that is equivalent to a chronic NOAEL. An HQ of 1.0 represents a dietary dose that is equal to the ecotoxicity value.	Eastern garter snake
Protection of insectivorous mammals to ensure that ingestion of contaminants in soil/sediment and prey does not have a negative impact on growth, survival, and reproduction	Are levels of site contaminants in soil/sediment sufficient to cause adverse effects on the growth, survival, and reproductive success of insectivorous mammals using the site?	Comparison of dietary HQs to an HQ of 1.0. Dietary HQs are calculated for individual chemicals by dividing an estimated level of exposure by an ecotoxicity value that is equivalent to a chronic NOAEL. An HQ of 1.0 represents a dietary dose that is equal to the ecotoxicity value.	Short-tailed shrew
Protection of carnivorous mammals to ensure that ingestion of contaminants in soil/sediment and prey does not have negative impacts on growth, survival, and reproduction	Are levels of site contaminants in soil/sediment sufficient to cause adverse effects on the growth, survival, and reproductive success of carnivorous mammals using the site?	Comparison of dietary HQs to an HQ of 1.0. Dietary HQs are calculated for individual chemicals by dividing an estimated level of exposure by an ecotoxicity value that is equivalent to a chronic NOAEL. An HQ of 1.0 represents a dietary dose that is equal to the ecotoxicity value.	Red fox
Protection of herbivorous mammals to ensure that ingestion of contaminants in soil/sediment and forage does not have negative impacts on growth, survival, and reproduction	Are levels of site contaminants in soil/sediment sufficient to cause adverse effects on the growth, survival, and reproductive success of herbivorous mammals using the site?	Comparison of dietary HQs to an HQ of 1.0. Dietary HQs are calculated for individual chemicals by dividing an estimated level of exposure by an ecotoxicity value that is equivalent to a chronic NOAEL. An HQ of 1.0 represents a dietary dose that is equal to the ecotoxicity value.	Meadow vole
Protection of insectivorous birds to ensure that ingestion of contaminants in soil/sediment, prey, and forage does not have negative impacts on growth, survival, and reproduction	Are levels of site contaminants in soil/sediment sufficient to cause adverse effects on the growth, survival, and reproductive success of insectivorous birds using the site?	Comparison of dietary HQs to a reference of 1.0. Dietary HQs are calculated for individual chemicals by dividing an estimated level of exposure by an ecotoxicity value that is equivalent to a chronic NOAEL. An HQ of 1.0 represents a dietary dose that is equal to the ecotoxicity value.	American Robin
Protection of carnivorous birds to ensure that ingestion of contaminants in soil/sediment and prey does not have negative impacts on growth, survival, and reproduction	Are levels of site contaminants in soil/sediment sufficient to cause adverse effects on the growth, survival, and reproductive success of carnivorous birds using the site?	Comparison of dietary HQs to an HQ of 1.0. Dietary HQs are calculated for individual chemicals by dividing an estimated level of exposure by an ecotoxicity value that is equivalent to chronic NOAEL. An HQ of 1.0 represents a dietary dose that is equal to the ecotoxicity value.	Red-Tailed Hawk

Table 2-12
Summary of COPCs for each Media
Salford Quarry Site

Chemical	Groundwater	Surface Water	Sediment	Surface Soil
INORGANICS				
ALUMINUM		X	X	X
ANTIMONY			X	
ARSENIC	X		X	
BARIUM	X	X	X	
BERYLLIUM	X		X	
BORON	X	X	X	X
CADMIUM	X	X	X	X
CHROMIUM				X
COPPER			X	X
CYANIDE	X		X	
IRON	X	X	X	X
LEAD				X
LITHIUM	X		X	X
MAGNESIUM				X
MANGANESE	X		X	X
MERCURY	X			X
NICKEL			X	X
SELENIUM	X	X		
THALLIUM		X	X	
VANADIUM			X	X
ZINC				X
ORGANICS				
CARBON DISULFIDE	X			
CHLOROMETHANE	X			
CIS-1,2-DICHLOROETHENE	X			
TRICHLOROETHYLENE	X			

Notes:
X - Denotes COPC
COPC - Contaminant of Potential Concern

Table 3-1
Ecological Exposure Parameters
Salford Quarry Site

Species	Exposure Parameter	Reported Value	Conservative Assessment Value	Site Specific Values [1]
Short-tailed Shrew (*Blarina brevicauda*)	Home Range Factor	<0.2471 - 4.5 acres	1	1
	Diet	invertebrates (insects, worms, snails), mammals, fungi, vegetation	Soil Invertebrates: 87% soil/sediment : 13%	Soil Invertebrates: 87% soil/sediment : 13%
	Food Ingestion Rate [2]	0.49 - 0.62 g/g-day	0.00966 kg/day	0.00965 kg/day
	Soil Ingestion Rate	1.25 - 1.26 g/day	0.00126 kg/day	0.00125 kg/day
	Body Weight (kg)	0.01558 - 0.01921	0.01558	0.01740
Red-Tailed Hawk *Buteo jamaicensis*	Home Range Factor	941.5 - 2443.9 acres	1	0.0032
	Diet	mammals and birds	mammals: 100%	mammals: 100%
	Food Ingestion Rate	0.086 - 0.11 g/g-day	0.113 kg/day	0.110 kg/day
	Soil Ingestion Rate	0 g/day	0 kg/day	0 kg/day
	Body Weight (kg)	1.028 - 1.224	1.028	1.224
American Robin *Turdus migratorius*	Home Range Factor	0.296 - 2.076 acres	1	1
	Diet	fruits, invertebrates	vegetation: 68% invertebrates: 32%	vegetation: 68% invertebrates: 32%
	Food Ingestion Rate	1.22 - 1.96 g/g-day	0.124 kg/day	0.132 kg/day
	Soil Ingestion Rate	0 g/day	0 kg/day	0 kg/day
	Body Weight (kg)	0.0635 - 0.121	0.0635	0.121
Red Fox *Vulpes vulpes*	Home Range Factor	240 - 4860 acres	1	0.018
	Diet	mammals, birds, arthropods, plants, unspecified/other	small mammals: 97.2% Soil: 2.8%	small mammals: 97.2% Soil: 2.8%
	Food Ingestion Rate [2]	0.069 - 0.16 g/g-day	0.6304 kg/day	0.5267 kg/day
	Soil Ingestion Rate	14.7 - 17.7 g/day	0.0177 kg/day	0.0147 kg/day
	Body Weight (kg)	3.94 - 5.25	3.94	4.60
Meadow Vole *Microtus pennsylvanicus*	Home Range Factor	0.0005 - 0.21 acres	1	1
	Diet [3]	plants, fungi, insects	vegetation: 97.6% soil: 2.4%	vegetation: 97.6% soil: 2.4%
	Food Ingestion Rate [2]	0.30 - 0.35 g/g-day	0.00595 kg/day	0.011 kg/day
	Soil Ingestion Rate	0.14 -0.26 g/day	0.00028 kg/day	0.00014 kg/day
	Body Weight (kg)	0.017 - 0.0524	0.017	0.035
Eastern Garter Snake *Thamnophis sirtalis*	Home Range Factor *	1.98 - 34.6 acres	1	1
	Diet**	amphibians, earthworm/invertebrate, unspecified/other	amphibians: 68% invertebrates: 27.5% soil:4.5%	amphibians: 68% invertebrates: 27.5% soil:4.5%
	Food Ingestion Rate***	0.0125 - 0.0365 g/g-day	3.47E-05 kg/day	5.82E-05 kg/day
	Soil Ingestion Rate	0.002 - 0.003 g/day	0.000003 kg/day	0.000002 kg/day
	Body Weight (kg)****	0.00095 - 0.0038	0.00095	0.0038

Notes:
kg - kilograms
kg/day - kilograms per day
g/g-day - grams per gram per day
g/day - grams per day
% - percent

All species listed were included in the modeling exercise.
Unless otherwise specified, reported values were obtained from the USEPA Wildlife Exposure Factors Handbook, Volume 1 of 2, Washington, D.C., December 1993.

1. The site specific assessment value was calculated as the mean of values presented where multiple values were provided which differentiated between sex, age, season and location.
2. Conservative Ingestion Rate (kg/day)= Max. Food Ingestion Rate Value (g/g-day) x Minimum Body Weight (kg)
   Site Specific Ingestion Rate (kg/day) = Ave. Food Ingestion Rate Value (g/g-day) x Average Body Weight (kg)
3. Obtained from Estimates of Soil Ingestion by Wildlife, Beyer, et al, J. Wildlife Management 58(2):375-382.

* NatureServe Explorer website http://www.natureserve.org/explorer/servlet/NatureServe?searchName=thamnophis+sirtalis
** Fitch, H. S., 1941. The feeding habaits of California garter snakes. Calif Fish Game 27:1-32. from California ecoTox database http://www.oehha.org/scripts/cal_ecotox/exposurefactordescription.asp
*** Ingestion rate calculated using the reptiles and amphibians (insectivores) as provided in Section 3.1.3 of the EPA Wildlife Exposure Factors Handbook, Volume 1

**** Larsen, K.W. and P. T. Gregory 1993. Reproductive ecology of the common garter snake, *Thamnophis sirtalis*, at the northern limit of its range. Am. Midl. Nat. 129:338-345 from California ecoTox database http://www.oehha.org/scripts/cal_ecotox/exposurefactordescription.asp

Table 3-2
Bioaccumulation/ Bioconcentration Factors
Salford Quarry Site

COPC	Bioaccumulation/Bioconcentration Factors [1]					
	Vegetation		Invertebrates		Small Mammals	
Cadmium	0.550	A	17.4	B	0.000055	C
Copper	0.400	A	0.35	B	0.001	C
Lead	0.045	A	0.2	B	0.00003	C
Mercury	0.900	A	1		0.025	C
Nickel	0.060	A	1		0.0006	C
Zinc	1.500	A	7.67	B	0.01	C

Notes:
1. Where applicable bioaccumulation factors (BAFs) were unavailable, the BAF of 1 was applied.

COPC - Contaminants of potential concern
SCF - soil to plant concentration factor
BTF - biota transfer factor
BAF - bioaccumulation factor
kg - kilograms
kg/day - kilograms per day

A - SCF (concentration in dry weight of plant/concentration in dry weight of soil) for inorganics from Baes, et al. (1984).

B - Based on average inorganic BAFs for invertebrates (concentration in earthworm/concentration in soil) as reported in Van Hook (1974) and Diercxsens, et al. (1985).

C - Estimation of small mammal BAF for inorganics derived by multiplying the carnivore (red-tailed hawk) ingestion rate (0.1 kg/day) by the BTF, diet to meat transfer factor (days/kg wet meat), taken directly from Baes et al. (1984).

Table 4-1
Ingestion Toxicity Values Used in Food Chain Model
Salford Quarry Site

COPC	Short-tailed shrew			Red-tailed Hawk		
	Test Species	LOAEL (mg/kg/d)	NOAEL (mg/kg/d)	Test Species	LOAEL (mg/kg/d)	NOAEL (mg/kg/d)
Cadmium	mouse[1]	3.00E+00	**3.00E-01**	mallard duck[2]	**2.00E+01**	**1.45E+00**
Copper	mouse[3]	3.90E+02	**3.90E+01**	chicks (1 day)[2]	**6.17E+01**	**4.70E+01**
Lead	mouse[3]	**1.50E+00**	1.50E-01	American kestrel[2]	3.85E+01	**3.85E+00**
Mercury	mouse[2]	1.32E+02	**1.32E+01**	Japanese quail[2]	**9.00E-01**	**4.50E-01**
Nickel	rat[4]	5.00E+01	**5.00E+00**	mallard duckling[2]	**1.07E+02**	**7.74E+01**
Zinc	mouse[5]	**1.09E+03**	**1.09E+02**	leghorn hen[2]	1.31E+02	**1.45E+01**

Notes:
mg/kg/d = milligrams of the COPC per kilograms of receptor species body weight per day
LOAEL - Lowest Observed Adverse Effect Level
NOAEL - No Observed Adverse Effect Level
Avian NOAEL and LOAEL are used where no reptile toxicity values are available
Bold = Experimentally derived value
Non-bold = Adjusted value
COPC - Contaminant of Potential Concern

References:

1. Shore, R.F. and Douben, P.E. 1994. The Ecotoxicological Significance of Cadmium Intake and Residues in Terrestrial Small Mammals. Ecotoxicology and Environmental Safety 29: 101-112.

2. Sample, B.E., D.M. Opresko, and G.W. Suter II. 1996. Toxicological Benchmarks for Wildlife: 1996 revision. Oak Ridge, TN: Oak Ridge National Laboratory. ES/ER/TM-86/R3

3. Syracuse Research Corporation (SRC). 1990. Toxicological Profile for Copper. Atlanta, GA: Prepared for Agency for Toxic Substances and Disease Registry (ATSDR), U.S. Health Service. TP-90-08. December.

4. Integrated Risk Information System (IRIS). National Library of Medicine, Institutes of Health; Bethesda, MD. Database created by EPA on the National Library of Medicine's Toxicology Data Network (TOXNET).

5. Eisler, R. 1993. Zinc Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review. Washington, D.C.: U.S. Fish and Wildlife Service. Biological Report 10. Contaminant Hazard Reviews Report 26. April.

Table 4-1
Ingestion Toxicity Values Used in Food Chain Model
Salford Quarry Site

COPC	Red fox Test Species	Red fox LOAEL (mg/kg/d)	Red fox NOAEL (mg/kg/d)	Meadow vole Test Species	Meadow vole LOAEL (mg/kg/d)	Meadow vole NOAEL (mg/kg/d)
Cadmium	rat[1]	1.40E+01	**1.40E+00**	mouse[1]	3.00E+00	**3.00E-01**
Copper	rat[3]	1.40E+02	**1.40E+01**	mouse[3]	3.90E+02	**3.90E+01**
Lead	rat[3]	**2.50E+01**	2.50E+00	mouse[3]	**1.50E+00**	1.50E-01
Mercury	mink[2]	3.20E-01	**3.20E-02**	mouse[2]	1.32E+02	**1.32E+01**
Nickel	dog[4]	2.50E+02	**2.50E+01**	rat[4]	5.00E+01	**5.00E+00**
Zinc	rat[5]	5.50E+02	**5.50E+01**	mouse[5]	1.09E+03	**1.09E+02**

Notes:
mg/kg/d = milligrams of the COPC per kilograms of receptor species body weight per day
LOAEL - Lowest Observed Adverse Effect Level
NOAEL - No Observed Adverse Effect Level
Avian NOAEL and LOAEL are used where no reptile toxicity values are available
Bold = Experimentally derived value
Non-bold = Adjusted value
COPC - Contaminant of Potential Concern

References:

1. Shore, R.F. and Douben, P.E. 1994. The Ecotoxicological Significance of Cadmium Intake and Residues in Terrestrial Small Mammals. Ecotoxicology and Environmental Safety 29: 101-112.
2. Sample, B.E., D.M. Opresko, and G.W. Suter II. 1996. Toxicological Benchmarks for Wildlife: 1996 revision. Oak Ridge, TN: Oak Ridge National Laboratory. ES/ER/TM-86/R3
3. Syracuse Research Corporation (SRC). 1990. Toxicological Profile for Copper. Atlanta, GA: Prepared for Agency for Toxic Substances and Disease Registry (ATSDR), U.S. Health Service. TP-90-08. December.
4. Integrated Risk Information System (IRIS). National Library of Medicine, Institutes of Health; Bethesda, MD. Database created by EPA on the National Library of Medicine's Toxicology Data Network (TOXNET).
5. Eisler, R. 1993. Zinc Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review. Washington, D.C.: U.S. Fish and Wildlife Service. Biological Report 10. Contaminant Hazard Reviews Report 26. April.

Table 4-1
Ingestion Toxicity Values Used in Food Chain Model
Salford Quarry Site

COPC	American Robin			Eastern Garter Snake		
	Test Species	LOAEL (mg/kg/d)	NOAEL (mg/kg/d)	Test Species	LOAEL (mg/kg/d)	NOAEL (mg/kg/d)
Cadmium	mallard duck[2]	**2.00E+01**	**1.45E+00**	mallard duck[2]	**2.00E+01**	**1.45E+00**
Copper	chicks (1 day)[2]	**6.17E+01**	**4.70E+01**	chicks (1 day)[2]	**6.17E+01**	**4.70E+01**
Lead	American kestrel[2]	3.85E+01	**3.85E+00**	American kestrel[2]	3.85E+01	**3.85E+00**
Mercury	Japanese quail[2]	**9.00E-01**	**4.50E-01**	Japanese quail[2]	**9.00E-01**	**4.50E-01**
Nickel	mallard duckling[2]	**1.07E+02**	**7.74E+01**	mallard duckling[2]	**1.07E+02**	**7.74E+01**
Zinc	leghorn hen[2]	1.31E+02	**1.45E+01**	leghorn hen[2]	1.31E+02	**1.45E+01**

Notes:
mg/kg/d = milligrams of the COPC per kilograms of receptor species body weight per day
LOAEL - Lowest Observed Adverse Effect Level
NOAEL - No Observed Adverse Effect Level
Avian NOAEL and LOAEL are used where no reptile toxicity values are available
Bold = Experimentally derived value
Non-bold = Adjusted value
COPC - Contaminant of Potential Concern

References:

1. Shore, R.F. and Douben, P.E. 1994. The Ecotoxicological Significance of Cadmium Intake and Residues in Terrestrial Small Mammals. Ecotoxicology and Environmental Safety 29: 101-112.

2. Sample, B.E., D.M. Opresko, and G.W. Suter II. 1996. Toxicological Benchmarks for Wildlife: 1996 revision. Oak Ridge, TN: Oak Ridge National Laboratory. ES/ER/TM-86/R3

3. Syracuse Research Corporation (SRC). 1990. Toxicological Profile for Copper. Atlanta, GA: Prepared for Agency for Toxic Substances and Disease Registry (ATSDR), U.S. Health Service. TP-90-08. December.

4. Integrated Risk Information System (IRIS). National Library of Medicine, Institutes of Health; Bethesda, MD. Database created by EPA on the National Library of Medicine's Toxicology Data Network (TOXNET).

5. Eisler, R. 1993. Zinc Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review. Washington, D.C.: U.S. Fish and Wildlife Service. Biological Report 10. Contaminant Hazard Reviews Report 26. April.

Table 5-1
Hazard Quotient Calculations for Meadow Vole
Conservative Assessment - NOAEL and LOAEL
Surface and Subsurface Soil
Salford Quarry Site

Meadow Vole
(Conservative Inputs)

Body Weight	0.017 kg
Food Ingestion Rate	0.00595 kg/day
Soil Ingestion Rate	0.00014 kg/day
Home Range Factor	1

Inorganics									
COPC	Maximum Soil Concentration (mg/kg)	Vegetation Concentration (mg/kg)	Dose (mg/kg/day)	Ingestion Toxicity Value NOAEL (mg/kg/day)	Ingestion Toxicity Value LOAEL (mg/kg/day)	Toxicity Hazard Quotient NOAEL	Toxicity Hazard Quotient LOAEL	Percent of Hazard Index NOAEL	Percent of Hazard Index LOAEL
Cadmium	9.5	5.10	1.86	3.00E-01	3.00E+00	6.22E+00	6.22E-01	1.86%	1.86%
Copper	1820	710.53	263.97	3.90E+01	3.90E+02	6.77E+00	6.77E-01	2.02%	2.02%
Lead	1940	85.20	46.12	1.50E-01	1.50E+00	3.07E+02	3.07E+01	91.86%	91.86%
Mercury	71.4	62.72	22.55	1.32E+01	1.32E+02	1.71E+00	1.71E-01	0.51%	0.51%
Nickel	46.8	2.74	1.35	5.00E+00	5.00E+01	2.70E-01	2.70E-02	0.08%	0.08%
Zinc	2390	3498.96	1244.71	1.09E+02	1.09E+03	1.14E+01	1.14E+00	3.41%	3.41%
					Hazard Index =	3.35E+02	3.35E+01		

COPC - Contaminant of Potential Concern
LOAEL - Lowest Observed Adverse Effect Level
NOAEL - No Observed Adverse Effect Level
kg - kilogram
kg/day - kilogram per day
mg/kg/day - milligram per kilogram per day

Table 5-2
Hazard Quotient Calculations for Meadow Vole
Site Specific Assessment - NOAEL and LOAEL
Surface and Subsurface Soil
Salford Quarry Site

Meadow Vole
(Site Specific Inputs)

Body Weight	0.035	kg
Food Ingestion Rate	0.011	kg/day
Soil Ingestion Rate	0.00026	kg/day
Home Range Factor	1	

Inorganics									
COPC	Maximum Soil Concentration (mg/kg)	Vegetation Concentration (mg/kg)	Dose (mg/kg/day)	Ingestion Toxicity Value NOAEL (mg/kg/day)	Ingestion Toxicity Value LOAEL (mg/kg/day)	Toxicity Hazard Quotient NOAEL	Toxicity Hazard Quotient LOAEL	Percent of Hazard Index NOAEL	Percent of Hazard Index LOAEL
Cadmium	9.5	5.10	1.67	3.00E-01	3.00E+00	5.58E+00	5.58E-01	1.86%	1.86%
Copper	1820	710.53	237.04	3.90E+01	3.90E+02	6.08E+00	6.08E-01	2.02%	2.02%
Lead	1940	85.20	41.41	1.50E-01	1.50E+00	2.76E+02	2.76E+01	91.86%	91.86%
Mercury	71.4	62.72	20.25	1.32E+01	1.32E+02	1.53E+00	1.53E-01	0.51%	0.51%
Nickel	46.8	2.74	1.21	5.00E+00	5.00E+01	2.43E-01	2.43E-02	0.08%	0.08%
Zinc	2390	3498.96	1117.70	1.09E+02	1.09E+03	1.03E+01	1.03E+00	3.41%	3.41%
					Hazard Index =	3.01E+02	3.01E+01		

COPC - Contaminant of Potential Concern
LOAEL - Lowest Observed Adverse Effect Level
NOAEL - No Observed Adverse Effect Level
kg - kilogram
kg/day - kilogram per day
mg/kg/day - milligram per kilogram per day

Table 5-3
Hazard Quotient Calculations for Short-Tailed Shrew
Conservative Assessment - NOAEL and LOAEL
Surface and Subsurface Soil
Salford Quarry Site

Short-Tailed Shrew
(Conservative Inputs)

Body Weight	0.01558	kg
Food Ingestion Rate	0.00966	kg/day
Soil Ingestion Rate	0.00126	kg/day
Home Range Factor	1	

Inorganics									
COPC	Maximum Soil Concentration (mg/kg)	Invertebrate Concentration (mg/kg)	Dose (mg/kg/day)	Ingestion Toxicity Value NOAEL (mg/kg/day)	Ingestion Toxicity Value LOAEL (mg/kg/day)	Toxicity Hazard Quotient NOAEL	Toxicity Hazard Quotient LOAEL	Percent of Hazard Index NOAEL	Percent of Hazard Index LOAEL
Cadmium	9.5	143.81	89.93	3.00E-01	3.00E+00	3.00E+02	3.00E+01	10.50%	10.50%
Copper	1820	554.19	490.31	3.90E+01	3.90E+02	1.26E+01	1.26E+00	0.44%	0.44%
Lead	1940	337.56	365.67	1.50E-01	1.50E+00	2.44E+03	2.44E+02	85.37%	85.37%
Mercury	71.4	62.12	44.27	1.32E+01	1.32E+02	3.35E+00	3.35E-01	0.12%	0.12%
Nickel	46.8	40.72	29.02	5.00E+00	5.00E+01	5.80E+00	5.80E-01	0.20%	0.20%
Zinc	2390	15948.23	10080.95	1.09E+02	1.09E+03	9.25E+01	9.25E+00	3.24%	3.24%
					Hazard Index =	2.86E+03	2.86E+02		

COPC - Contaminant of Potential Concern
LOAEL - Lowest Observed Adverse Effect Level
NOAEL - No Observed Adverse Effect Level
kg - kilogram
kg/day - kilogram per day
mg/kg/day - milligram per kilogram per day

Table 5-?
Hazard Quotient Calculations for Short-Tailed Shrew
Site Specific Assessment - NOAEL and LOAEL
Surface and Subsurface Soil
Salford Quarry Site

Short-Tailed Shrew
(Site Specific Inputs)

Body Weight	0.01740 kg
Food Ingestion Rate	0.00965 kg/day
Soil Ingestion Rate	0.00125 kg/day
Home Range Factor	1

Inorganics									
COPC	Maximum Soil Concentration (mg/kg)	Invertebrate Concentration (mg/kg)	Dose (mg/kg/day)	Ingestion Toxicity Value NOAEL (mg/kg/day)	Ingestion Toxicity Value LOAEL (mg/kg/day)	Toxicity Hazard Quotient NOAEL	Toxicity Hazard Quotient LOAEL	Percent of Hazard Index NOAEL	Percent of Hazard Index LOAEL
Cadmium	9.5	143.81	80.44	3.00E-01	3.00E+00	2.68E+02	2.68E+01	10.50%	10.50%
Copper	1820	554.19	438.57	3.90E+01	3.90E+02	1.12E+01	1.12E+00	0.44%	0.44%
Lead	1940	337.56	327.08	1.50E-01	1.50E+00	2.18E+03	2.18E+02	85.37%	85.37%
Mercury	71.4	62.12	39.60	1.32E+01	1.32E+02	3.00E+00	3.00E-01	0.12%	0.12%
Nickel	46.8	40.72	25.96	5.00E+00	5.00E+01	5.19E+00	5.19E-01	0.20%	0.20%
Zinc	2390	15948.23	9017.17	1.09E+02	1.09E+03	8.27E+01	8.27E+00	3.24%	3.24%
					Hazard Index =	2.55E+03	2.55E+02		

COPC - Contaminant of Potential Concern
LOAEL - Lowest Observed Adverse Effect Level
NOAEL - No Observed Adverse Effect Level
kg - kilogram
kg/day - kilogram per day
mg/kg/day - milligram per kilogram per day

Table 5-5
Hazard Quotient Calculation for Red Fox
Conservative Assessment - NOAEL and LOAEL
Surface and Subsurface Soil
Salford Quarry Site

Red Fox
(Conservative Inputs)

Body Weight	3.94	kg
Food Ingestion Rate	0.6304	kg/day
Soil Ingestion Rate	0.0177	kg/day
Home Range Factor	1	

Inorganics									
COPC	Maximum Soil Concentration (mg/kg)	Sm. Mammal Concentration (mg/kg)	Dose (mg/kg/day)	Ingestion Toxicity Value NOAEL (mg/kg/day)	Ingestion Toxicity Value LOAEL (mg/kg/day)	Toxicity Hazard Quotient NOAEL	Toxicity Hazard Quotient LOAEL	Percent of Hazard Index NOAEL	Percent of Hazard Index LOAEL
Cadmium	9.5	0.001	0.04	1.40E+00	1.40E+01	3.05E-02	3.05E-03	0.13%	0.13%
Copper	1820	1.769	8.44	1.40E+01	1.40E+02	6.03E-01	6.03E-02	2.60%	2.60%
Lead	1940	0.057	8.70	2.50E+00	2.50E+01	3.48E+00	3.48E-01	15.02%	15.02%
Mercury	71.4	1.735	0.60	3.20E-02	3.20E-01	1.87E+01	1.87E+00	80.56%	80.56%
Nickel	46.8	0.027	0.21	2.50E+01	2.50E+02	8.56E-03	8.56E-04	0.04%	0.04%
Zinc	2390	23.23	14.42	5.50E+01	5.50E+02	2.62E-01	2.62E-02	1.13%	1.13%
					Hazard Index =	2.32E+01	2.32E+00		

COPC - Contaminant of Potential Concern
LOAEL - Lowest Observed Adverse Effect Level
NOAEL - No Observed Adverse Effect Level
kg - kilogram
kg/day - kilogram per day
mg/kg/day - milligram per kilogram per day

Table 5-6
Hazard Quotient Calculations for Red Fox
Site Specific Assessment - NOAEL and LOAEL
Surface and Subsurface Soil
Salford Quarry Site

Red Fox
(Site Specific Inputs)

Body Weight	4.60	kg
Food Ingestion Rate	0.5267	kg/day
Soil Ingestion Rate	0.0147	kg/day
Home Range Factor	0.018	

Inorganics									
COPC	Maximum Soil Concentration (mg/kg)	Sm. Mammal Concentration (mg/kg)	Dose (mg/kg/day)	Ingestion Toxicity Value		Toxicity Hazard Quotient		Percent of Hazard Index	
				NOAEL (mg/kg/day)	LOAEL (mg/kg/day)	NOAEL	LOAEL	NOAEL	LOAEL
Cadmium	9.5	0.001	0.001	1.40E+00	1.40E+01	3.92E-04	3.92E-05	0.13%	0.13%
Copper	1820	1.77	0.11	1.40E+01	1.40E+02	7.76E-03	7.76E-04	2.60%	2.60%
Lead	1940	0.06	0.11	2.50E+00	2.50E+01	4.48E-02	4.48E-03	15.02%	15.02%
Mercury	71.4	1.74	0.01	3.20E-02	3.20E-01	2.41E-01	2.41E-02	80.56%	80.56%
Nickel	46.8	0.03	0.003	2.50E+01	2.50E+02	1.10E-04	1.10E-05	0.04%	0.04%
Zinc	2390	23.23	0.19	5.50E+01	5.50E+02	3.38E-03	3.38E-04	1.13%	1.13%
					Hazard Index =	2.99E-01	2.99E-02		

COPC - Contaminant of Potential Concern
LOAEL - Lowest Observed Adverse Effect Level
NOAEL - No Observed Adverse Effect Level
kg - kilogram
kg/day - kilogram per day
mg/kg/day - milligram per kilogram per day

Table 5-7
Hazard Quotient Calculations for Eastern Garter Snake
Conservative Assessment - NOAEL and LOAEL
Surface and Subsurface Soil
Salford Quarry Site

Eastern Garter Snake
(Conservative Inputs)

Body Weight	0.001	kg
Food Ingestion Rate	0.00003	kg/day
Soil Ingestion Rate	0.000002	kg/day
Home Range Factor	1	

Inorganics										
COPC	Maximum Soil Concentration (mg/kg)	Amphibians Concentration (mg/kg)	Invertebrate Concentration (mg/kg)	Dose (mg/kg/day)	Ingestion Toxicity Value		Toxicity Hazard Quotient		Percent of Hazard Index	
					NOAEL (mg/kg/day)	LOAEL (mg/kg/day)	NOAEL	LOAEL	NOAEL	LOAEL
Cadmium	9.5	0.0004	45.458	1.68	1.45E+00	2.00E+01	1.16E+00	8.38E-02	6.36%	2.95%
Copper	1820	1.2376	175.18	9.44	4.70E+01	6.17E+01	2.01E-01	1.53E-01	1.10%	5.38%
Lead	1940	0.0396	106.70	7.09	3.85E+00	3.85E+01	1.84E+00	1.84E-01	10.13%	6.48%
Mercury	71.4	1.2138	19.64	0.88	4.50E-01	9.00E-01	1.95E+00	9.77E-01	10.75%	34.35%
Nickel	46.8	0.0191	12.87	0.55	7.74E+01	1.07E+02	7.08E-03	5.12E-03	0.04%	0.18%
Zinc	2390	16.25	5041.11	188.66	1.45E+01	1.31E+02	1.30E+01	1.44E+00	71.61%	50.66%
						Hazard Index =	1.82E+01	2.84E+00		

COPC - Contaminant of Potential Concern
LOAEL - Lowest Observed Adverse Effect Level
NOAEL - No Observed Adverse Effect Level
kg - kilogram
kg/day - kilogram per day
mg/kg/day - milligram per kilogram per day

Table 5-8
Hazard Quotient Calculations for Eastern Garter Snake
Site Specific Assessment - NOAEL and LOAEL
Surface and Subsurface Soil
Salford Quarry Site

Eastern Garter Snake
(Site Specific Inputs)

Body Weight	0.004	kg
Food Ingestion Rate	0.00006	kg/day
Soil Ingestion Rate	0.000003	kg/day
Home Range Factor	1	

Inorganics

COPC	Maximum Soil Concentration (mg/kg)	Amphibians Concentration (mg/kg)	Invertebrate Concentration (mg/kg)	Dose (mg/kg/day)	Ingestion Toxicity Value NOAEL (mg/kg/day)	Ingestion Toxicity Value LOAEL (mg/kg/day)	Toxicity Hazard Quotient NOAEL	Toxicity Hazard Quotient LOAEL	Percent of Hazard Index NOAEL	Percent of Hazard Index LOAEL
Cadmium	9.5	0.0004	45.458	0.53	1.45E+00	2.00E+01	3.68E-01	2.67E-02	6.41%	3.01%
Copper	1820	1.2376	175.18	2.99	4.70E+01	6.17E+01	6.37E-02	4.85E-02	1.11%	5.46%
Lead	1940	0.0396	106.70	2.26	3.85E+00	3.85E+01	5.87E-01	5.87E-02	10.21%	6.60%
Mercury	71.4	1.2138	19.64	0.27	4.50E-01	9.00E-01	5.91E-01	2.96E-01	10.29%	33.26%
Nickel	46.8	0.0191	12.87	0.17	7.74E+01	1.07E+02	2.25E-03	1.63E-03	0.04%	0.18%
Zinc	2390	16.25	5041.11	59.93	1.45E+01	1.31E+02	4.13E+00	4.57E-01	71.94%	51.49%
						Hazard Index =	5.74E+00	8.88E-01		

COPC - Contaminant of Potential Concern
LOAEL - Lowest Observed Adverse Effect Level
NOAEL - No Observed Adverse Effect Level
kg - kilogram
kg/day - kilogram per day
mg/kg/day - milligram per kilogram per day

AR304982

Table 5-9
Hazard Quotient Calculations for American Robin
Conservative Assessment - NOAEL and LOAEL
Surface and Subsurface Soil
Salford Quarry Site

American Robin
(Conservative Inputs)

Body Weight	0.064	kg
Food Ingestion Rate	0.1240	kg/day
Soil Ingestion Rate	0.0000	kg/day
Home Range Factor	1	

Inorganics										
COPC	Maximum Soil Concentration (mg/kg)	Vegetation Concentration (mg/kg)	Invertebrate Concentration (mg/kg)	Dose (mg/kg/day)	Ingestion Toxicity Value NOAEL (mg/kg/day)	Ingestion Toxicity Value LOAEL (mg/kg/day)	Toxicity Hazard Quotient NOAEL	Toxicity Hazard Quotient LOAEL	Percent of Hazard Index NOAEL	Percent of Hazard Index LOAEL
Cadmium	9.5	3.55	52.896	110.23	1.45E+00	2.00E+01	7.60E+01	5.51E+00	4.73%	1.80%
Copper	1820	495.04	203.84	1364.74	4.70E+01	6.17E+01	2.90E+01	2.21E+01	1.81%	7.24%
Lead	1940	59.36	124.16	358.38	3.85E+00	3.85E+01	9.31E+01	9.31E+00	5.80%	3.05%
Mercury	71.4	43.70	22.85	129.95	4.50E-01	9.00E-01	2.89E+02	1.44E+02	17.98%	47.28%
Nickel	46.8	1.91	14.98	32.97	7.74E+01	1.07E+02	4.26E-01	3.08E-01	0.03%	0.10%
Zinc	2390	2437.80	5866.02	16215.33	1.45E+01	1.31E+02	1.12E+03	1.24E+02	69.65%	40.53%
						Hazard Index =	1.61E+03	3.05E+02		

COPC - Contaminant of Potential Concern
LOAEL - Lowest Observed Adverse Effect Level
NOAEL - No Observed Adverse Effect Level
kg - kilogram
kg/day - kilogram per day
mg/kg/day - milligram per kilogram per day

Table 5-1
Hazard Quotient Calculations for American Robin
Site Specific Assessment - NOAEL and LOAEL
Surface and Subsurface Soil
Salford Quarry Site

American Robin
(Site Specific Inputs)

Body Weight	0.121	kg
Food Ingestion Rate	0.0363	kg/day
Soil Ingestion Rate	0.0000	kg/day
Home Range Factor	1	

Inorganics										
COPC	Maximum Soil Concentration (mg/kg)	Vegetation Concentration (mg/kg)	Invertebrate Concentration (mg/kg)	Dose (mg/kg/day)	Ingestion Toxicity Value NOAEL (mg/kg/day)	Ingestion Toxicity Value LOAEL (mg/kg/day)	Toxicity Hazard Quotient NOAEL	Toxicity Hazard Quotient LOAEL	Percent of Hazard Index NOAEL	Percent of Hazard Index LOAEL
Cadmium	9.5	3.55	52.896	16.93	1.45E+00	2.00E+01	1.17E+01	8.47E-01	4.73%	1.80%
Copper	1820	495.04	203.84	209.66	4.70E+01	6.17E+01	4.46E+00	3.40E+00	1.81%	7.24%
Lead	1940	59.36	124.16	55.06	3.85E+00	3.85E+01	1.43E+01	1.43E+00	5.80%	3.05%
Mercury	71.4	43.70	22.85	19.96	4.50E-01	9.00E-01	4.44E+01	2.22E+01	17.98%	47.28%
Nickel	46.8	1.91	14.98	5.07	7.74E+01	1.07E+02	6.54E-02	4.73E-02	0.03%	0.10%
Zinc	2390	2437.80	5866.02	2491.14	1.45E+01	1.31E+02	1.72E+02	1.90E+01	69.65%	40.53%
						Hazard Index =	2.47E+02	4.69E+01		

COPC - Contaminant of Potential Concern
LOAEL - Lowest Observed Adverse Effect Level
NOAEL - No Observed Adverse Effect Level
kg - kilogram
kg/day - kilogram per day
mg/kg/day - milligram per kilogram per day

Table 5-11
Hazard Quotient Calculations for Red-tailed Hawk
Conservative Assessment - NOAEL and LOAEL
Surface and Subsurface Soil
Salford Quarry Site

Red-tailed Hawk
(Conservative Inputs)

Body Weight	1.028	kg
Food Ingestion Rate	0.1130	kg/day
Soil Ingestion Rate	0	kg/day
Home Range Factor	1	

Inorganics									
COPC	Maximum Soil Concentration (mg/kg)	Sm. Mammals Concentration (mg/kg)	Dose (mg/kg/day)	Ingestion Toxicity Value NOAEL (mg/kg/day)	Ingestion Toxicity Value LOAEL (mg/kg/day)	Toxicity Hazard Quotient NOAEL	Toxicity Hazard Quotient LOAEL	Percent of Hazard Index NOAEL	Percent of Hazard Index LOAEL
Cadmium	9.5	0.0005	0.00006	1.45E+00	2.00E+01	3.96E-05	2.87E-06	0.01%	0.00%
Copper	1820	1.8200	0.20006	4.70E+01	6.17E+01	4.26E-03	3.24E-03	0.68%	1.34%
Lead	1940	0.0582	0.00640	3.85E+00	3.85E+01	1.66E-03	1.66E-04	0.27%	0.07%
Mercury	71.4	1.7850	0.19621	4.50E-01	9.00E-01	4.36E-01	2.18E-01	69.96%	90.27%
Nickel	46.8	0.0281	0.00309	7.74E+01	1.07E+02	3.99E-05	2.88E-05	0.01%	0.01%
Zinc	2390	23.90	2.62714	1.45E+01	1.31E+02	1.81E-01	2.01E-02	29.07%	8.30%
					Hazard Index =	6.23E-01	2.42E-01		

COPC - Contaminant of Potential Concem
LOAEL - Lowest Observed Adverse Effect Level
NOAEL - No Observed Adverse Effect Level
kg - kilogram
kg/day - kilogram per day
mg/kg/day - milligram per kilogram per day

Table 5-12
Hazard Quotient Calculations for Red-tailed Hawk
Site Specific Assessment - NOAEL and LOAEL
Surface and Subsurface Soil
Salford Quarry Site

Red-tailed Hawk
(Site Specific Inputs)

Body Weight	1.224	kg
Food Ingestion Rate	0.1100	kg/day
Soil Ingestion Rate	0	kg/day
Home Range Factor	0.0032	

Inorganics									
COPC	Maximum Soil Concentration (mg/kg)	Sm. Mammals Concentration (mg/kg)	Dose (mg/kg/day)	Ingestion Toxicity Value NOAEL (mg/kg/day)	Ingestion Toxicity Value LOAEL (mg/kg/day)	Toxicity Hazard Quotient NOAEL	Toxicity Hazard Quotient LOAEL	Percent of Hazard Index NOAEL	Percent of Hazard Index LOAEL
Cadmium	9.5	0.0005	0.00000	1.45E+00	2.00E+01	1.04E-07	7.51E-09	0.01%	0.00%
Copper	1820	1.8200	0.00052	4.70E+01	6.17E+01	1.11E-05	8.48E-06	0.68%	1.34%
Lead	1940	0.0582	0.00002	3.85E+00	3.85E+01	4.35E-06	4.35E-07	0.27%	0.07%
Mercury	71.4	1.7850	0.00051	4.50E-01	9.00E-01	1.14E-03	5.70E-04	69.96%	90.27%
Nickel	46.8	0.0281	0.00001	7.74E+01	1.07E+02	1.04E-07	7.55E-08	0.01%	0.01%
Zinc	2390	23.90	0.00687	1.45E+01	1.31E+02	4.74E-04	5.25E-05	29.07%	8.30%
					Hazard Index =	1.63E-03	6.32E-04		

COPC - Contaminant of Potential Concern
LOAEL - Lowest Observed Adverse Effect Level
NOAEL - No Observed Adverse Effect Level
kg - kilogram
kg/day - kilogram per day
mg/kg/day - milligram per kilogram per day

Table 5-13
Summary of Food Chain Model Hazard Indices (HI*)
Salford Quarry Site

Receptor	Conservative HI		Site Specific HI		Metal Contributing Highest Percent of Risk
	NOAEL Based	LOAEL Based	NOAEL Based	LOAEL Based	
Meadow Vole	**334.70**	**33.47**	**300.55**	**30.05**	91.86% from Lead for NOAEL and LOAEL
Short-tailed Shrew	**2855.46**	**285.55**	**2554.14**	**255.41**	85.37% from Lead for NOAEL and LOAEL
Red Fox	**23.18**	**2.32**	0.30	0.03	80.56% from Mercury for NOAEL and LOAEL
Eastern Garter Snake	**18.17**	**2.84**	**5.74**	0.89	71.61% from Zinc for NOAEL, 50.66% from Zinc for LOAEL
American Robin	**1605.64**	**305.41**	**246.67**	**46.92**	69.65% from Zinc for NOAEL, 47.28% from Mercury and 40.53% from Zinc for LOAEL
Red-tailed Hawk	0.62	0.24	0.002	0.001	69.96% from Mercury for NOAEL, 90.27% from Mercury for LOAEL

* A HI less than 1.0 indicates no adverse effects. A HI greater than 1.0 indicates possible adverse effects (indicated in bold type).

% - Percentage of hazard index resulting from ecological risk calculations
HI - Hazard Index
LOAEL - Lowest Observed Adverse Effect Level
NOAEL - No Observed Adverse Effect Level

Table 7-1
PRG Summary
Site Specific - NOAEL and LOAEL
Surface and Subsurface Soil
Salford Quarry Site

COPC	PRG Soil Concentration Range (mg/kg)															
	Meadow Vole		Short-Tailed Shrew		Eastern Garter Snake		Red-tailed Hawk		Red Fox		American Robin		Plants		Soil Invertebrates	
	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
Cadmium	1.71	17.02	0.0355	0.355	25.8	356	91627717	1263830579	24202	242018	0.814	11.22	4	10 (1)	150	1843 (2)
Copper	299.3	2993	161.8	1618	28572	37509	163350103	214440454	234345	2343443	407.8	535.4	100	200 (1)	300	500 (2)
Lead	7.03	70.3	0.89	8.9	3306	33060	446026875	4460268750	43255	432549	135.6	1356	20	50 (1)	100	500 (2)
Mercury	46.6	465.2	23.79	237.9	121	242	62560	125120	296.8	2968	1.61	3.22	34.9	103 (1)	2.5	12.5 (2)
Nickel	192.7	1927	9.02	90.12	20770	28713	448343898	619803580	424165	4241642	714.8	988.1	20	50 (1)	100	300 (2)
Zinc	233	2330	28.88	288.8	578	5222	5039525	45529497	707125	7071244	13.91	125.7	10	222 (1)	97	136 (2)

Notes:
LOAEL - Lowest Observed Adverse Effect Level (based on PRG)
NOAEL - No Observed Adverse Effect Level (based on PRG)
PRG - Preliminary Remediation Goal

Sources:
(1) Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants: 1997 Revision. Prepared for the U.S. DOE by Lockheed Martin Energy Systems, Inc. ES/ER/TM-85/R3. November 1997.
(2) Toxicological Benchmarks for Contaminants of Potential Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Process: 1997 revision. Prepared for the U.S. DOE by Lockheed Martin Energy Systems, Inc. ES/ER/TM-126/R2. November 1997.

Table 7-2
PRG Summary for Direct Toxicity COPCs
Salford Quarry Site

COPC	Groundwater Screening Level [1] (ug/L)	Surface Water Screening Level [1] (ug/L)	Surface Water PRGs [2] (ug/L)	Sediment Screening Level [3] (mg/kg)	Sediment Based PRGs [2] (mg/kg)	Soil Based PRGs (mg/kg)			
						Soil Screening Level [4] (mg/kg)	Wildlife [2]	Plants (Soil) [2]	Invertebrates [2]
Inorganics									
ALUMINUM	NC	87	87	NV	NV	1	NV	NV	NV
ANTIMONY	NC	NC	30	2	NV	NC	NC	NC	NC
ARSENIC	5	NC	3.1 - 190	9.8	42	NC	NC	NC	NC
BARIUM	4	4	4	NV	NV	NC	NC	NC	NC
BERYLLIUM	NV	NC	0.66	NV	NV	NC	NC	NC	NC
BORON	1.6	1.6	1.6	NV	NV	0.0005	NV	0.5	NV
CADMIUM	0.28	0.28	1.1	0.99	4.2	0.38	4	4	NV
CHROMIUM	NC	NC	NC	NC	159	0.0075	NV	NV	0.4
COPPER	NC	NC	NC	31.6	77.7	15	NV	NV	60
CYANIDE	5	NC	5.2	0.1	NV	NC	NC	NC	NC
IRON	300	300	1000	20000	NV	12	NV	NV	NV
LEAD	NC	NC	NC	NC	110	16	40.5	NV	NV
LITHIUM	14	NC	14	NV	NV	2	NV	2	NV
MANGANESE	120	NC	120	460	NV	330	NV	NV	NV
MAGNESIUM	NC	NC	NV	NC	NV	4400	NV	NV	NV
MERCURY	0.1	NC	1.3	NC	NC	0.058	0.00051	NV	NV
NICKEL	NC	NC	NC	22.7	38.5	2	NV	30	NV
SELENIUM	1	1	0.39	NC	NV	NC	NC	NC	NC
THALLIUM	NC	0.8	9	NV	NV	NC	NC	NC	NC
VANADIUM	NC	NC	NC	NV	NV	0.5	NV	2	NV
ZINC	NC	NC	NC	NC	270	10	8.5	NV	NV
Organics									
CARBON DISULFIDE	0.92	NC	0.92	NC	NC	NC	NC	NC	NC
CHLOROMETHANE	1.8	NC	NV	NC	NC	NC	NC	NC	NC
CIS-1,2-DICHLOROETHENE	NV	NC	590	NC	NC	NC	NC	NC	NC
TRICHLOROETHYLENE	21	NC	470	NC	NC	NC	NC	NC	NC

Notes:
NC - Not retained as COPC
NV - No screening value available
PRG - Preliminary Remediation Goal

Sources:
1. USEPA 2004. Region III BTAG Freshwater Screening Benchmarks http://www.epa.gov/reg3hwmd/risk/eco/btag/sbv/fw/screenbench.htm
2. Preliminary Remediation Goals for Ecological Endpoints. Prepared for the U.S. Department of Energy (DOE) by Lockheed Martin Energy Systems, Inc. ES/ER/TM-162/R2. August 1997.
3. Pluta, Bruce. 8 March 2005. Region III BTAG Freshwater Sediment Screening Benchmarks. Email to Aaron Frantz of CDM Federal Programs Corp., Wayne, Pennsylvania.
4. Soil screening levels are from a variety of sources. Please refer to Table 2-7 for a comprehensive list of soil screening level sources.

Figures

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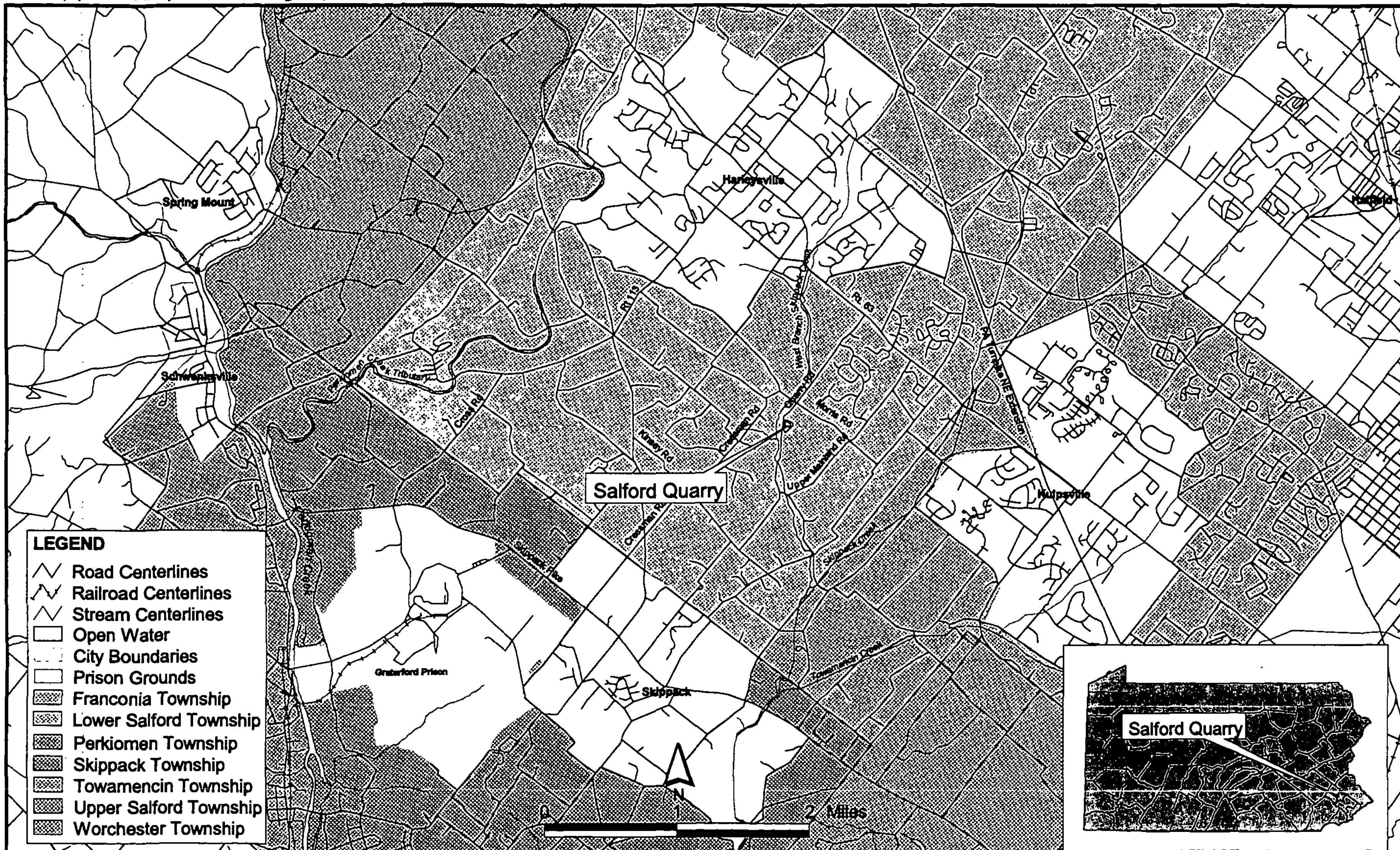

Salford Quarry
Lower Salford Township
Montgomery County, Pennsylvania

Figure 2-1
Site Location Map

CDM

AR304991

AR101200

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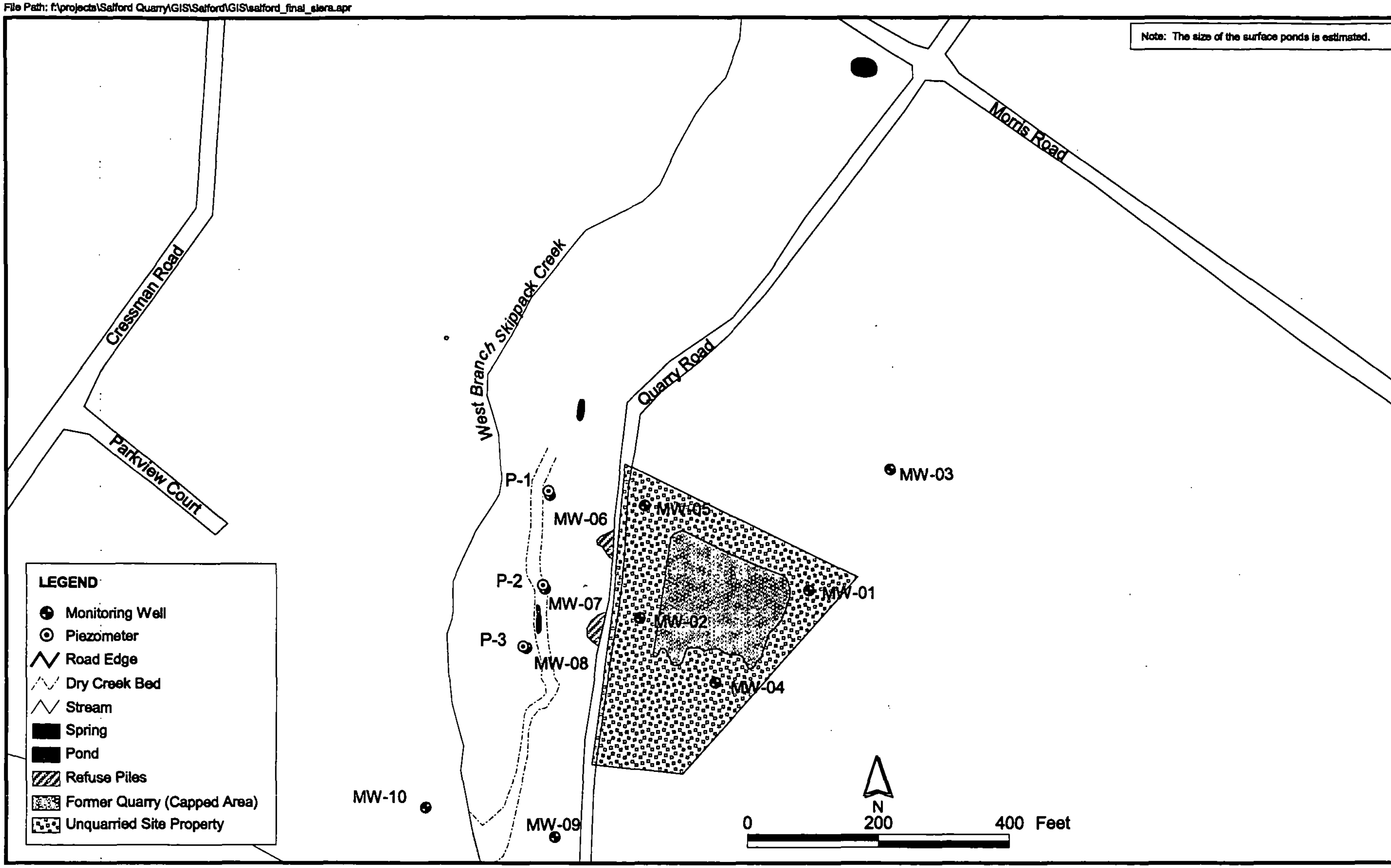

Salford Quarry
Lower Salford Township
Montgomery County, Pennsylvania

Figure 2-2
Site Map

CDM

AR304992

AR101201

Figure 2-3
2002-2004 Groundwater Sample Location Map
has been removed for privacy and
security purposes

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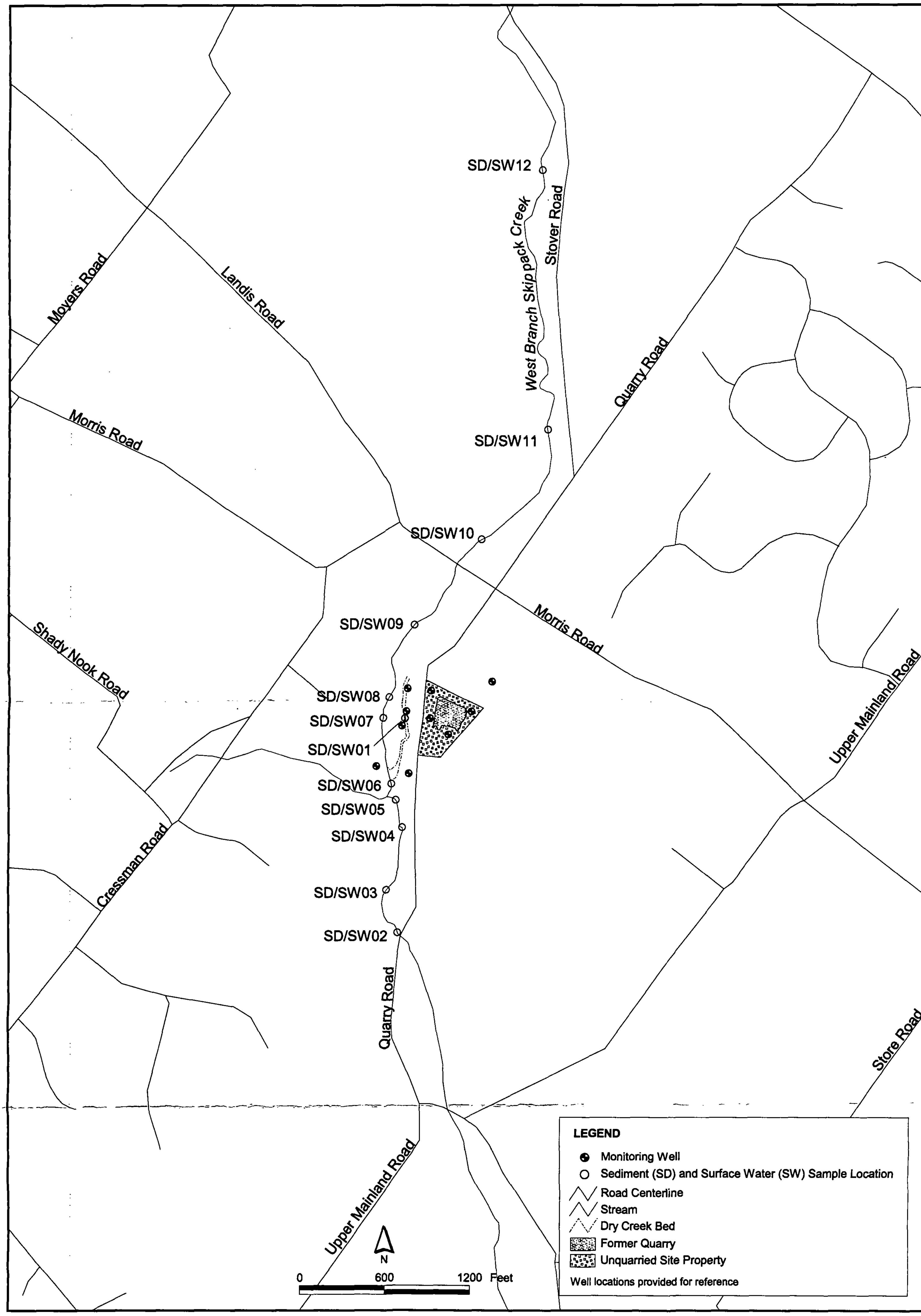

Salford Quarry
Lower Salford Township
Montgomery County, Pennsylvania

Figure 2-4
Surface Water/Sediment
Sample Location Map

CDM

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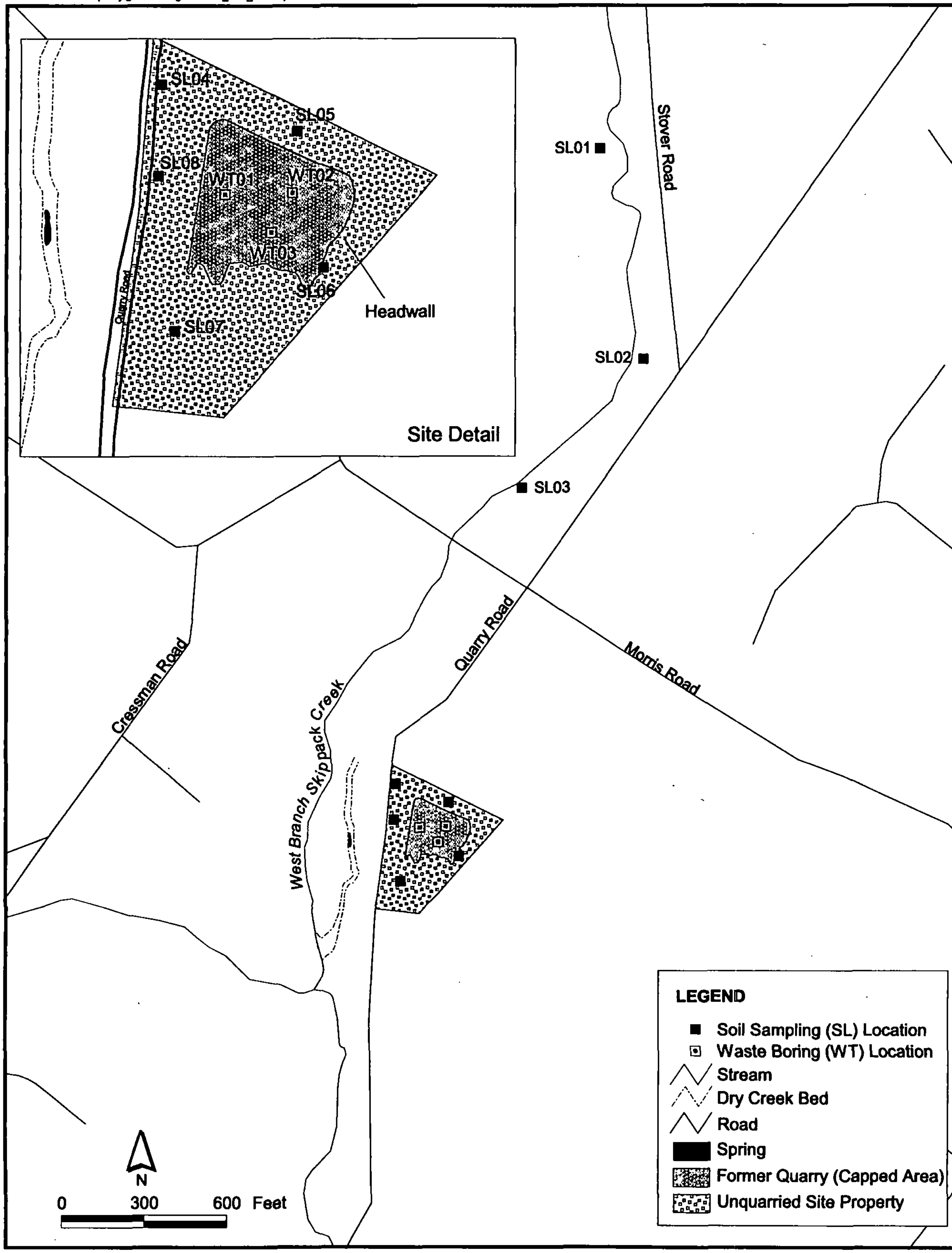

Salford Quarry
Lower Salford Township
Montgomery County, Pennsylvania

Figure 2-5
Surface/Subsurface Soil Sample and Waste Sample Location Map

CDM

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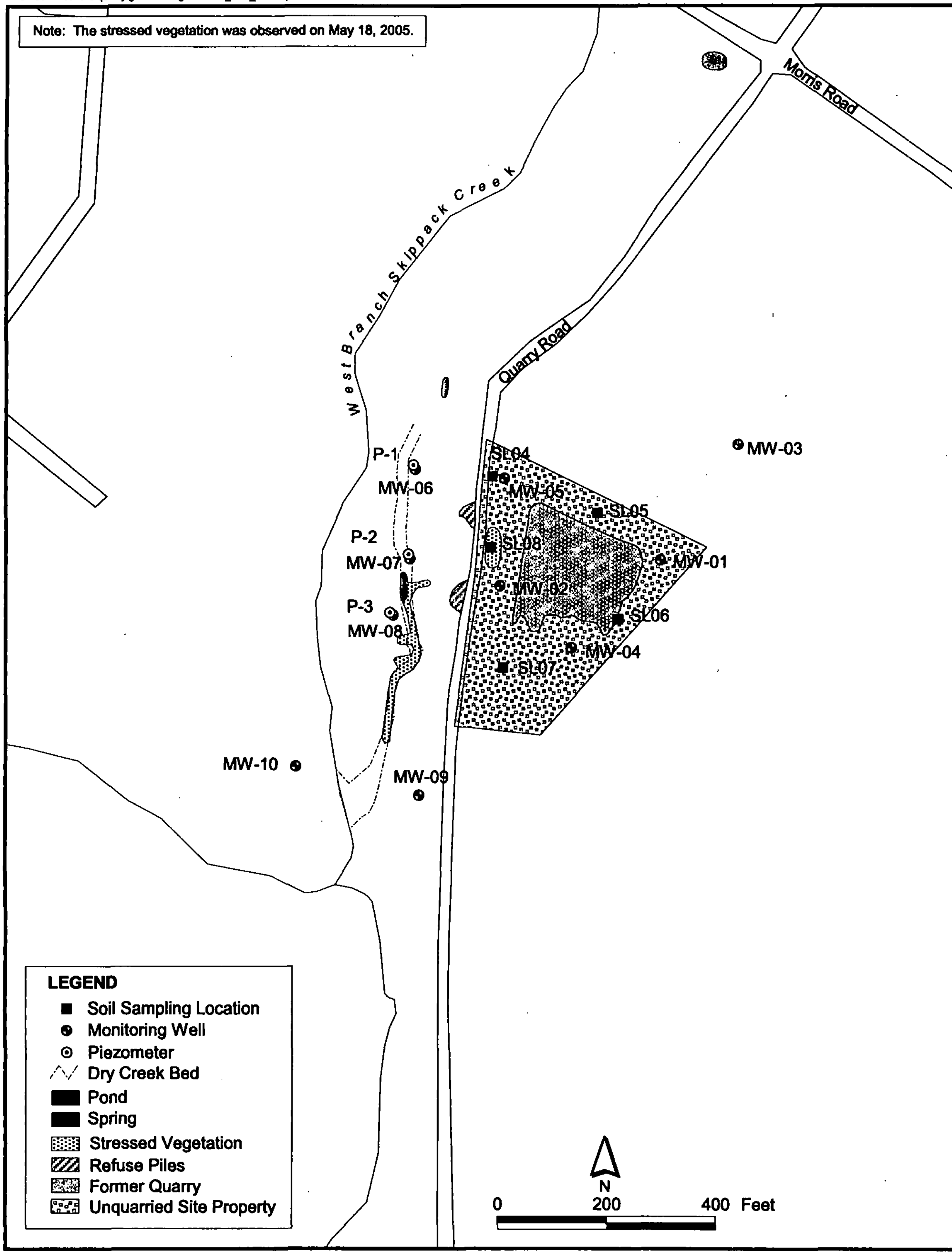


CDM

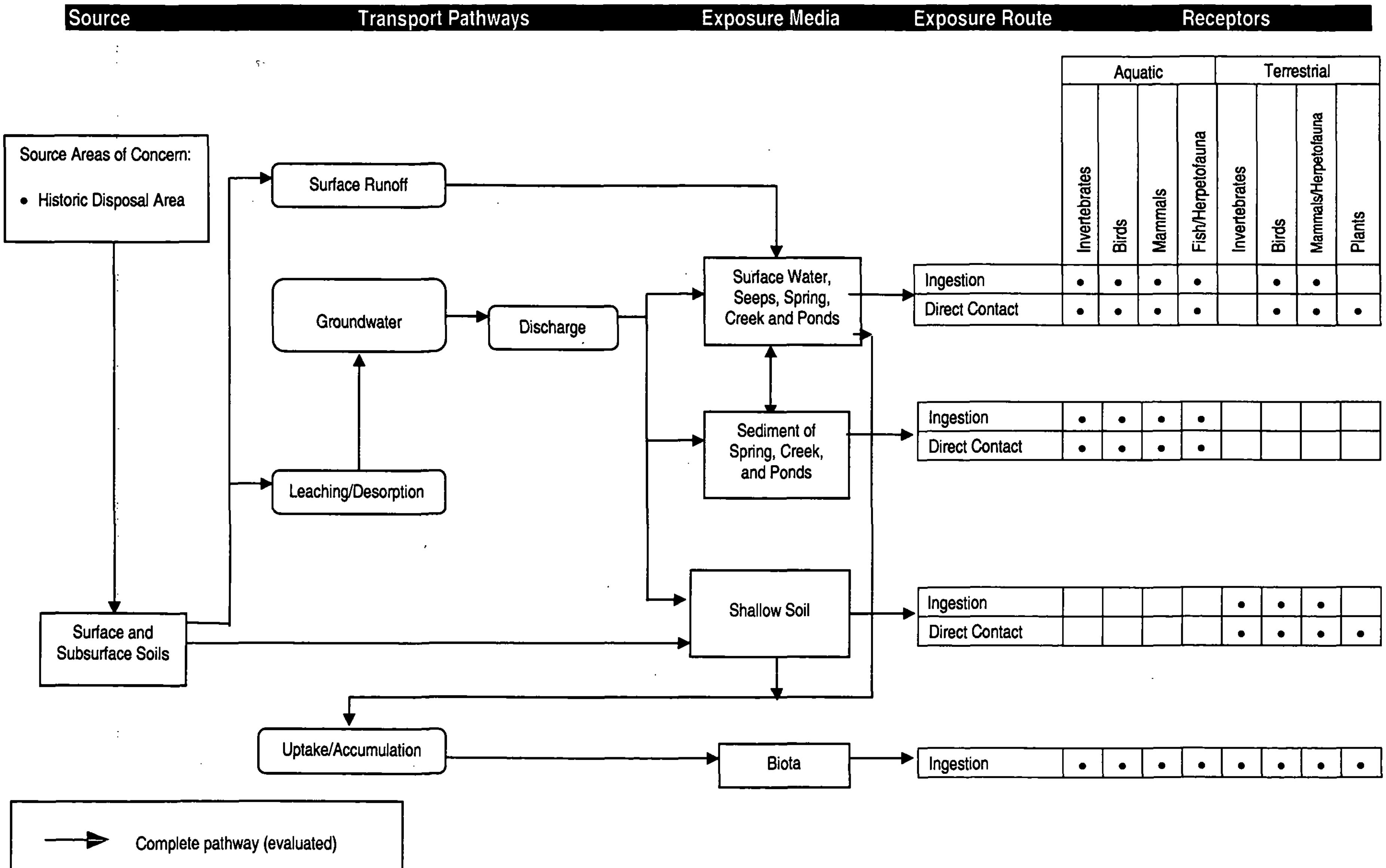
Salford Quarry
Lower Salford Township
Montgomery, Pennsylvania

Figure 2-6
Stressed Vegetation
Location Map

AR304996

AR101205

FIGURE 2-7
CONCEPTUAL MODEL FOR
THE SALFORD QUARRY SITE
LOWER SALFORD TOWNSHIP, MONTOGOMERY COUNTY, PA



AR304997

AR101206

ATTACHMENT A

"Natural Resources Inventory and Analysis Report" prepared by Eastern States Environmental Associates

263168
Re: 3d
ORIGINAL (Red)

TRANSMITTAL LETTER

ENVIRON

TO: CESAR LEE
REMEDIAL PROJECT OFFICER
MAIL CODE 3HW21
UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION III
841 CHESTNUT BUILDING
PHILADELPHIA PA 19107

RE: Ecological Survey Report and Draft Wetlands Map

WE ARE SENDING YOU HEREWITH THE FOLLOWING:

☐ Specifications ☐ Reports ☐ Samples ☐ Letters ☐ Other ☐ Drawings

Quantity	Description
3	Copies of the ecological survey report entitled "Natural Resources Inventory and Analysis Report" prepared by Eastern States Environmental Associates
3	Copies of the draft wetlands map prepared by Van Note Harvey Associates
File 1 copy only	
	Cesar -
	As you requested, we are providing you with additional copies of these materials previously provided to Ms. Gerallyn Valls.

BY: Bob North

DATE: February 11, 1992

VIA: ☒ First Class ☐ Federal Express ☐ Messenger ☐ UPS

COPIES TO: Bruce Pluta - CDM-FPC - 1 Copy of each enclosure
David Ewald - PADER - 1 Copy of each enclosure

✓ 1 - Copy to L. Baker for NUS - 12/16/92 - CL

EASTERN STATES ENVIRONMENTAL ASSOCIATES INC.

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Stockholm, NJ 07460
(201) 208-0701

November 5, 1990

Ms. Mary Ann Baviello
Senior Associate
ENVIRON Corporation
210 Carnegie Center, Suite 201
Princeton, NJ 08540

Re: PROGRESS REPORT: Natural Resources Inventory - (Salford Quarry) \ Township of Lower Salford, Montgomery County, Pennsylvania. (File #: 1038.101).

Dear Mary Ann:

As per your recent request, enclosed please find a "Supplemental Information and Analysis" letter pertaining to the matters which we discussed with regards to the referenced project. This letter includes data and analysis pertaining to the temperatures and dissolved oxygen levels of the Aquatics Sampling Stations.

I apologize for the delay in supplying this material to you. Due to unexpected responsibilities out of town and my desire in personally drafting said letter, this delay was unavoidable. Should you have any further question pertaining to this or any other matter, please do not hesitate to contact me at our Central Office.

Sincerely,

Edward A. Kuc
Principal
Central Office

EAK\jmc
Enclosure

EASTERN STATES
ENVIRONMENTAL ASSOCIATES
INC.

CENTRAL OFFICE:
974 Rabens Avenue
Manville, NJ 08835
(201) 218-9649

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ORIGINAL (Red)

November 5, 1990

SUPPLEMENTAL INFORMATION AND ANALYSIS

Re: NATURAL RESOURCES INVENTORY AND ANALYSIS REPORT - SECTION VI. AQUATIC RESOURCES: Salford Quarry, Township of Lower Salford, Montgomery County, Pennsylvania. - Prepared by Eastern States Environmental Associates, Inc., September 7, 1990.

Table #6.1 includes both air and water temperatures recorded at the time of sampling at each of the Aquatic Sampling Stations.

TABLE #6.1 - AIR AND WATER TEMPERATURE READINGS

(Sampling Dates: August 27-29, 1990)

Sample Station	Time	Air Temp (-C)	Water Temp (-C)
1	1:15pm	33	25
2	2:00pm	32	27
3	2:30pm	31	27
4	3:10pm	31	27
5	4:20pm	30	26
6	4:00pm	29	26
7	3:30pm	31	26

As illustrated in Table #6.1, relatively high water temperatures were recorded at all of the sampling stations. It must be noted that water levels of the West Branch of Skippack Creek at the time of sampling were very low. As such, it can be expected that such low water volumes would be influenced by the ambient temperature to a greater extent than that of normal or high water volumes. In addition, the average stream vegetation cover throughout the Study Area was generally fair to good. Therefore, due to the rather low to moderate amounts of provided shade, higher water temperatures are likely to occur.

The dissolved oxygen levels of the stream were determined in the field by using the azide modification of the Winkler Titration Method. This test employs the use of a LaMotte Direct Reading Titrator in the final titration. This LaMotte Chemical Test Model AG-30 - Code 7414 is an EPA Accepted test. Table #6.2 includes the dissolved oxygen level of the stream recorded at each of the Aquatic Sampling Stations.

TABLE #6.2 - DISSOLVED OXYGEN LEVELS (ppm - parts per million)

Sample Station	Dissolved Oxygen Level (ppm)
1	11.4
2	11.8
3	12.0
4	11.2
5	8.4
6	11.8
7	10.6

As illustrated in Table #6.2, relatively high dissolved oxygen levels were recorded despite the high water temperatures. All recorded dissolved oxygen levels were greater than 10 parts per million with the exception of Station #5. Although 8.4 ppm is a very good dissolved oxygen level for a water of such high temperatures, it is noticeably lower than the levels recorded at the other Aquatic Sampling Stations. This may be attributed to a number of factors.

Dissolved oxygen levels in the stream are highly influenced by photosynthesis of aquatic vegetation and algae along with the interaction of the water with the atmosphere. These levels are also influenced by the biological oxygen demand of the stream. Most portions of the stream in the Study Area were found to possess a good portion of riffle areas which serve to agitate the water which increases its interaction with the atmosphere thereby increasing the dissolved oxygen level of the water. However, portions of the West Branch of Skippack Creek upstream from Station #5 may not possess the amount of riffle areas as other areas of the stream in the Study Area. During the field research, trespass was not permitted of the area directly upstream from Station #5 and therefore no aquatic samplings could be conducted of this area. The area in which trespass was forbidden included approximately 900 feet of the stream extending from the downstream end of Station #4 to the upstream end of Station #5. However, visual observations of this unsampled area concluded that the nature of the stream was quite shallow and slow moving with little if any ripple areas. As such, it can be expected that the water entering Station #5 would be lower in dissolved oxygen due to the upstream absence of activities which normally serve to increase these levels.

As stated in Section VI-B (Aquatic Resources - Results and Determinations) of the Natural Resources Inventory and Analysis Report pertaining to this research, it was not determined that the portion of West Branch of Skippack Creek inclusive of Sample Station #5 is experiencing any significant degradation which is not typical of the watershed throughout the Study Area. It must be reiterated that the aquatic community sampled at Station #5 was found to be of somewhat higher quality than a stream having similar characteristics due to the determined macroinvertebrate and fishery species composition of this particular area. As such, the lower dissolved oxygen content of the waters sampled at Station #5 in relation to other Sample Stations in the Study Area is not determined to be a significant indicator of any unique degradation of the aquatic community inclusive of Sample Station #5.

Re: 3d

ORIGINAL (Red)

ENVIRON

March 26, 1991

FEDERAL EXPRESS

Ms. Gerallyn Valls
Remedial Project Manager
US Environmental Protection Agency
Region III
841 Chestnut Building
Philadelphia, PA 19107

Dear Ms. Valls:

As per your March 12, 1991 letter, I have enclosed a copy of the following documents for the Salford Quarry Site: an ecological survey entitled Natural Resources Inventory and Analysis Report, and a supplemental information and analysis letter prepared by Eastern States Environmental Associates; and aquatic toxicity test results prepared by Aqua-Survey. You will notice that two aquatic toxicity tests (using the fathead minnow or *Pimephales promelas*) for Stream Sampling Stations 5 (upstream of the quarry) and 7 (downstream of the quarry) were repeated because of excessive treatment variablility. If you have any questions, do not hesitate to contact me at 609-243-9849.

Sincerely,

Mary Ann Baviello

Mary Ann Baviello
Senior Consultant

MAB:rdp
0826B:PAA01014.W51

Enclosure

AR305004

AR101213

Sketch of Wetlands
has been removed for privacy and
security purposes

EASTERN STATES

ENVIRONMENTAL ASSOCIATES INC.

NATURAL RESOURCES INVENTORY AND ANALYSIS REPORT

VEGETATION AND NATURAL COMMUNITIES - WILDLIFE
RARE\THREATENED\ENDANGERED SPECIES - AQUATICS

Salford Quarry

Township of Lower Salford

Montgomery County, Pennsylvania

September 7, 1990

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NATURAL RESOURCES INVENTORY AND ANALYSIS REPORT

VEGETATION AND NATURAL COMMUNITIES - WILDLIFE
RARE\THREATENED\ENDANGERED SPECIES - AQUATICS

Salford Quarry

Township of Lower Salford

Montgomery County, Pennsylvania

Prepared For:

ENVIRON Corporation

210 Carnegie Center
Suite 201
Princeton, New Jersey 08540

Prepared By:

Eastern States Environmental Associates, Inc.

September 7, 1990

EASTERN STATES
ENVIRONMENTAL ASSOCIATES
INC.

ORIGINAL (Red)

NATURAL RESOURCES INVENTORY AND ANALYSIS REPORT

VEGETATION AND NATURAL COMMUNITIES - WILDLIFE
RARE\THREATENED\ENDANGERED SPECIES - AQUATICS

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

I. INTRODUCTION.

A comprehensive inventory of the natural resources associated with the study area, consisting of the project site and lands in the immediate vicinity, including Vegetation and Natural Communities, Wildlife, Rare \ Threatened \ Endangered Species, and Aquatics, was conducted by Eastern States Environmental Associates, Inc. Such inventory procedures were conducted to identify and analyze the major components of these natural resources which are associated with this study area at the present time and in its present condition. This research is conducted in accordance with the Remedial Investigation Site Operations Plan and RI\FS Work Plans pertaining to the Salford Quarry submitted to the U.S. Environmental Protection Agency (USEPA) and prepared by ENVIRON Corporation, Princeton, New Jersey. The information obtained by the research of the existing conditions of these natural resources is the basis for the determination of the significance of impact which the Salford Quarry presently has on the inventoried natural resources associated with the study area.

II. SURVEY METHODOLOGY.

A. VEGETATION AND NATURAL COMMUNITIES, WILDLIFE, RARE \ THREATENED \ ENDANGERED SPECIES;

Field inspections of the Study Area, consisting of the Quarry and immediate surrounding lands, were conducted in August, 1990. This inventory included a total of 99.0 man hours of field observations. Table #2.1 summarizes the dates, times, and weather conditions associated with the field observations during the study period.

TABLE #2.1 - SUMMARY OF FIELD INSPECTIONS

Date	Times	# of Biologist	General Weather Conditions
8\27\90	10:30am-7:30pm	3	Sunny, 85° - 90°F
8\28\90	7:00am-7:30pm	3	Sunny, 75° - 90°F
8\29\90	7:00am-6:30pm	3	Sunny, 75° - 90°F

The field research conducted of this study area was designed to identify the types and general characteristics of the vegetative communities and associated habitats present not only on the subject property, but also in the general vicinity of this property. This area was then evaluated pertaining to overall size, continuity, levels of disturbance, and overall uniqueness to the general region.

In accordance with the inventoried habitats associated with this study area, the ranges and preferred habitats of potentially occurring wildlife and rare \ threatened \ endangered species were analyzed in relation to the the geographic location of this area and to the habitat characteristics presently associated with this study area. Determinations were then made pertaining to the possibility of the occurrence of certain wildlife species in this area.

Confirmation of wildlife and rare\threatened\endangered species usage of the habitats associated with this study area was determined by actual sightings, and\or observation of tracks, scats, vocal, and\or other apparent signs. Rocks and logs were overturned, inspected, and then replaced in the preferred habitats of amphibian and reptilian species during this inventory process.

B. AQUATICS:

Field sampling of the aquatics resources of this study area was conducted on August 27 through 29, 1990. Seven (7) areas were chosen along the West Branch of Skippack Creek to serve as sampling stations for a number of aquatic parameters including physical and biological characteristics such as substrate type; average width, depth and flow; siltation; bank cover; bank stability; pool/riffle/run ratio; benthos quality; fishery populations; and water quality. The selected stations possessed characteristics which were representative of the stream in that general area.

Each selected station consisted of an overall length ranging from one-hundred and fifty to two-hundred and fifty (150-250) feet. The average width and depth of the stream was determined along with the average flow rate. The bottom substrate was inventoried and the percentage of each occurring type of substrate (i.e. silt, sand, small gravel, large gravel, small rubble, large rubble, boulder, and bedrock) was estimated. The extent of siltation was determined at each station along with the quality of stream cover and bank stability. Pool/riffle/run ratio characteristics of the stream in the general vicinity of each station were determined along with pool habitat quality.

Macroinvertebrates were sampled, identified, and counted in the riffle area of each station. The fishery population of each sample station was sampled via Smith-Root Battery Type Electrofishing equipment at a voltage ranging from 400 to 600 volts. The fish were collected, identified, counted, and returned to the stream. A Scientific Collector's Permit #46 - Type III was issued to Edward A. Kuc, Principal, by the Pennsylvania Fish Commission on 8\10\90 to conduct this sampling procedure. Water quality tests pertaining to the stream's Dissolved Oxygen, pH, Alkalinity, Hardness, Salinity, and Phosphates were also conducted at each station.

III. VEGETATION AND NATURAL COMMUNITIES

A. INTRODUCTION:

Vegetation is a major component of the ecological community of a given area and its functions are of great importance. One important function of the vegetative community is the restoration of oxygen to the atmosphere via the photosynthetic process, and the filtering of potentially harmful gases from the air that living organisms breathe.

Vegetation is of great significance to the environment in many additional ways. It accounts for two of the major determining factors influencing the occurrence of wildlife in that it provides food and cover for most wildlife species. It plays a significant role in controlling the erosion of soils and ensuring the quality of water bodies. It is an excellent indicator of the general health of the entire community. Vegetation also has numerous non-biological attributes such as providing pleasing aesthetics, controlling wind and noise, providing shade, and many other amenities.

B. RESULTS AND DETERMINATIONS:

The field inventory of the study area, inclusive the Quarry site and lands in its immediate vicinity, determined that a variety of general habitat types are present in this area. These general habitat types include agriculture; low density residential development; early successional disturbed field; and stream corridor habitats consisting of open grove\meadow, forested woodlands, forested wetlands, and scrub\shrub wetlands. Appendix A illustrates the habitat types associated with this study area. Appendix B, Table #1B lists the species of vegetation associated with these habitats of included in the study area.

The major habitats associated with the study area are indicated and described as follows:

Agriculture:

This type of habitat includes the largest area in the vicinity of the subject property. This habitat type was found to exist extensively to the east of the quarry and also on lands to the west of the West Branch of Skippack Creek. Along with low to moderate density residential development, agriculture land is the predominant habitat type associated with the West Branch of Skippack Creek watershed upstream from the subject property. This habitat type is not unique to the area nor to the overall region of the State.

Residential Development:

This type of habitat includes a substantial area in the vicinity of the subject property and appears to be increasing over the past years. The components of this habitat type generally consist of a single family residential dwelling with associated driveways and individual septic systems along with landscaped lawns and ornamental plantings. This habitat type was found to exist to the north of the quarry and also on lands to the west of the West Branch of Skippack Creek. Along with agriculture, such development is an increasingly occurring habitat type associated with the West Branch of Skippack Creek watershed upstream from the subject property. This habitat type is not unique to the area nor to the overall region of the State.

Open Grove \ Meadow:

This type of habitat includes a substantial area in the vicinity of the subject property and is primarily associated with the overall stream corridor habitat associated with the West Branch of Skippack Creek. This habitat type is characterized by its open parklike appearance with scattered trees and patches of canopy vegetation. This habitat type generally has very little understory vegetation and a very lush ground cover. This habitat types includes both upland field and emergent wetland characteristics. With the exception of the forested upland and wetland areas along with the scrub\shrub wetland area, a large portion of the stream corridor of the West Branch of Skippack Creek in the vicinity of the Quarry Site consists this habitat type. This habitat type is not unique to the overall region of the State. Although this habitat type is abundant in the study area, due to current land use practices, this habitat type may not be in abundance in the general region of this site. A significant portion of this habitat type in the vicinity of the Quarry Site consists of a Township Park.

Canopy vegetation of this habitat is generally scattered and therefore has an low to moderated overall coverage density (10-50%

coverage) consisting primarily of Black Walnut (Juglans nigra), W Ash (Fraxinus americana), Red Oak (Quercus rubra), White Oak (Quer alba), Shagbark Hickory (Carya ovata), Mockernut Hickory (Cary tomentosa), Elm (Ulmus americana), Black Cherry (Prunus serotina), and Eastern Red Cedar (Juniperus virginiana). Subcanopy vegetation of this habitat is virtually nonexistent with the exception of scattered patches and thereby generally has a low coverage density (0-30% coverage) consisting primarily of Multiflora Rose (Rosa multiflora), Raspberry (Rubus idaeus), Blackberry (Rubus pensylvanicus), Black Cherry, and Elm. Ground cover throughout this habitat generally has a high coverage density (100% coverage) and consists primarily of Grasses, White Clover (Trifolium repens), Red Clover (Trifoliumpratense), Plantain (Plantago major), Cinquefoil (Potentilla canadensis), Tall Goldenrod (Solidago altissima), Yarrow (Achillea millefolium), Foxtail (Alopecurus spp.), Queen Anne Lace (Daucus carota), Ragweed (Ambrosia artemisiifolia), Daisy Fleabane (Erigeron annuus), and numerous other herbaceous species.

Forested Broad-leaved Deciduous Woodlands:

This type of habitat includes a rather small area in the vicinity of the subject property and is primarily associated with the overall stream corridor habitat associated with the West Branch of Skippack Creek. A small patch of this forested woodland habitat is located immediately adjacent to the disturbed portion of the quarry and this habitat is also associated with the rather steep slope existing between the West Branch of Skippack Creek and Quarry Road in the immediate vicinity of the quarry. The habitat type also exists in a relatively narrow strip to the west of the West Branch of Skippack Creek in the vicinity of the quarry and also for a distance upstream from Morris Road. This habitat type is not unique to the overall region of the State; however, due to current land use practices, this habitat type is not in abundance in the general area of this site.

Canopy vegetation of this habitat generally has a high coverage density (80-100% coverage) and consists primarily of Black Walnut (Juglans nigra), White Ash (Fraxinus americana), Red Oak (Quercus rubra), White Oak (Quercus alba), Shagbark Hickory (Carya ovata), Mockernut Hickory (Carya tomentosa), Elm (Ulmus americana), Black Cherry (Prunus serotina), and Eastern Red Cedar (Juniperus virginiana). Subcanopy vegetation of this habitat generally has a moderate to high coverage density (60-90% coverage) and consists primarily of Multiflora Rose (Rosa multiflora), Raspberry (Rubus idaeus), Blackberry (Rubus pensylvanicus), Black Cherry, and Elm. Ground cover throughout this habitat generally has a moderate to high coverage density (50-90% coverage) and consists primarily of Poison Ivy (Toxicodendron radicans), Japanese Honeysuckle (Lonicera japonica), Virginia Creeper (Parthenocissus quinquefolia), and False Solomon's Seal (Smilacina).

Forested Broad-leaved Deciduous Wetlands:

This type of habitat includes a rather small area in the vicinity of the subject property and is primarily associated with the overall stream corridor habitat associated with the West Branch of Skippack Creek. This particular habitat type exists in certain areas directly associated with the West Branch of Skippack Creek and also with the small stream which joins with the West Branch of Skippack Creek to the southwest of the Quarry Site. This habitat type is not unique to the overall region of the State; however, due to current land use practices, this habitat type is not in abundance in the general area of this site and it appears to be limited primarily to stream corridor areas.

Canopy vegetation of this habitat generally has a high coverage density (80-100% coverage) and consists primarily of Green Ash

(Fraxinus pennsylvanica), Black Walnut, White Ash, Elm, American Sycamore (Platanus occidentalis), Pin Oak (Quercus palustris), and Shagbark Hickory. Subcanopy vegetation of this habitat generally has a moderate to high coverage density (60-90% coverage) and consists primarily of Multiflora Rose, Raspberry, Blackberry, Elm, Green Ash, American Sycamore, and Arrowwood (Vibunum dentatum). Ground cover throughout this habitat generally has a moderate to high coverage density (50-90% coverage) and consists primarily of Jewelweed (Impatiens capensis), Poison Ivy (Toxicodendron radicans), Japanese Honeysuckle (Lonicera japonica), Violets (Viola spp.), Halberd-leaved Tearthumb (Polygonum arifolium), and False Solomon's Seal (Smilacina).

Scrub\Shrub Broad-leaved Deciduous Wetlands:

This type of habitat includes a very small area in the vicinity of the subject property and is primarily associated with the overall stream corridor habitat associated with the West Branch of Skippack Creek. This particular habitat type appears to be limited to a small area along the West Branch of Skippack Creek to the southwest of the Quarry Site. This habitat type is not unique to the overall region of the State; however, due to current land use practices, this habitat type is not in abundance in the general area of this site and it appears to be limited primarily to stream corridor areas.

Canopy vegetation of this habitat generally has a low coverage density (10-30% coverage) and consists primarily of Green Ash, Black Walnut, Elm, and American Sycamore. Subcanopy vegetation of this habitat generally has high coverage density (90% coverage) and consists primarily of Multiflora Rose, Raspberry, Blackberry, Elm, Green Ash, and Willow (Salix spp.). Ground cover throughout this habitat generally has a high coverage density (100% coverage) and consists primarily of Jewelweed, Smartweeds (Polygonum spp.), Reed Canary Grass (Phalaris arundinacea), Halberd-leaved Tearthumb (Polygonum arifolium), Sedges (Carex spp.), Rushes (Juncus spp.), and Rough-leaf Goldenrod (Solidago patula).

Early Succession Field:

This type of habitat is limited to the actual capped area of the Quarry itself. This habitat type is quite typical of disturbed and\or waste areas. It is not unique to the overall region of the State; however, due to current land use practices, this habitat type is not in abundance in the general area of this site and it appears to be limited primarily to the Quarry itself.

Canopy vegetation of this habitat is nonexistent. Likewise, subcanopy vegetation of this habitat is generally nonexistent with the exception of scattered Multiflora Rose and Eastern Red Cedar. Ground cover throughout this habitat generally has a high coverage density (100% coverage) and consists primarily of Vetch (Vicia spp.), Cinquefoil, Tall Goldenrod, Lance-leaved Goldenrod (Solidago graminifolia), Yarrow, Common Mullein (Verbascum thapus), Foxtail, Queen Anne Lace, Ragweed, Daisy Fleabane, and numerous other herbaceous species typical of disturbed areas.

C. ANALYSIS, IMPACT, AND RECOMMENDATIONS:

Consisting primarily of agriculture along with residential development, disturbed field, and maintained Township parkland, a significant amount of the habitats included and in the vicinity of the study area undergo a high amount of manipulation. Whereas unmanipulated forested areas are located within the study area, these particular habitats were found to be of a very small overall size and were isolated from other similar areas in the general region due to the land use practices. Although the habitats of the study area which receive minor amounts of manipulation (Open Grove\Meadow) and those that receive minimal amounts of manipulation (Forested and Scrub\Shrub Areas) are small in size and abundance, the study area was found to possess a good variety and distribution of habitat types. This type of habitat configuration and isolation is quite typical of areas dominated by agricultural operations.

Due to the extent in which the general region experiences manipulation, the disturbed nature of the Quarry does not significantly impact the overall habitat configuration of the general area. In addition, the existing natural habitats associated with the study area do not indicate any evidence of significant impact resulting from the existence of the quarry.

IV. WILDLIFE UTILIZATION

A. INTRODUCTION:

The quality of a given area with regards to wildlife utilization is determined by the diversity of habitat types present, the amounts of such habitats, and the overall distribution of the various habitat types. Whereas species of wildlife are generally specific as to a particular type of habitat, an area which possesses a good diversity of quality habitats distributed in a manner which promotes plentiful transition areas, will generally possess a good diversity of wildlife species which utilize the area.

B. RESULTS AND DETERMINATIONS:

The field inventory of the various habitats and associated wildlife utilization of this study area consisting of the Salford Quarry and immediately surrounding areas determined that the study area exhibits an overall fair quality with regards to wildlife usage. There is a good distribution in the variety of habitats represented on and in the general vicinity of this property. These mentioned habitat types are described in detail in Section III (Vegetation and Natural Communities) of this report. The various types of habitats associated with this property were found to be of sufficient quality to support many of the wildlife species typically associated with those habitat types; however, their small size appears to be a limiting factor. Additionally, the variety and distribution of habitats associated with this property allow for a good availability of transition areas. It is in these habitat transition areas that a majority of wildlife utilization actually occurs.

Each of the habitats present in the study area was determined to provide sufficient habitat components to encourage the occurrence of wildlife species typically associated with that habitat type. Additionally, the distribution of the various of habitats providing food, cover, and water for wildlife allows an excellent opportunity for wildlife utilization. The limiting factor affecting this study area; however, is its relatively small size and isolation within the general region.

Appendix C, Tables #1C, 2C, and 3C list in more detail the species of wildlife which have a potential of occurrence on the lands associated with this site, along with the habitats in which they are likely to be found. Notation is also made as to the wildlife species encountered during the inventory process.

C. ANALYSIS, IMPACT, AND RECOMMENDATIONS:

As previously stated, whereas the study area possesses a good diversity and distribution of wildlife habitats, these habitats are of rather small size and are generally isolated amidst a much larger area which is presently altered. In that these habitats appear to be of good quality, high levels of utilization by a variety of wildlife species cannot be expected due to the study area's rather small size and isolation.

The major factor determining the rather low expected wildlife usage of this study area is its small size and isolation in relation to the vast surrounding area which is presently manipulated. As such, there appears to be no correlation between the low expected wildlife utilization of this area and the existence of the subject Quarry.

V. RARE \ THREATENED \ ENDANGERED SPECIES SUPPORT POTENTIAL

A. INTRODUCTION:

An endangered species is referred to as a native fish \ wildlife \ vegetation species which is threatened with extinction whenever its existence is endangered because of actual or threatened habitat destruction, drastic modification, and\or severe curtailment; overexploitation; disease; predation; and\or other factors. The survival of such species requires assistance. A threatened species is referred to as a native fish \ wildlife \ vegetation species which may become endangered if conditions surrounding the species begin or continue to deteriorate.

B. RESULTS AND DETERMINATIONS:

During field inspections of the study area in August, 1990, no threatened and\endangered species were observed nor was there any indication as to their occurrences. However, existing habitats associated with this study area were analyzed in accordance with the ranges and potential habitats of certain endangered species to determine if the occurrence of certain threatened and\or endangered species on this study area is a possibility.

Threatened and\or endangered species whose range includes and potential habitat is present on the study area include:

SPECIES:	HABITAT TYPE:
Short-eared Owl (Asio flammeus)	Open Grove\Meadow
Upland Sandpiper (Bartramia longicauda)	Open Grove\Meadow
King Rail (Rallus elegans)	Open Grove\Meadow, Scrub\Shrub Wetlands
American Bittern (Botaurus lentiginosus)	Open Grove\Meadow, Scrub\Shrub Wetlands
Henslow's Sparrow (Ammodramus henslowii)	Open Grove\Meadow
Sedge Wren (Cistothorus platensis)	Open Grove\Meadow
Mud Salamander (Pseudotriton montanus)	Forested and Scrub\Shrub Wetlands
Eastern Sand Darter (Ammocrypta pellucida)	Stream
Banded Sunfish (Enneacanthus obesus)	Stream

C. ANALYSIS, IMPACT AND RECOMMENDATIONS:

Upon correlation of the preferred habitats of threatened and\or endangered species which have a potential of utilizing this study area with the characteristics and qualities of the available habitats on this property, it is determined that utilization of the habitats of this study area by a limited number of rare, threatened and/or endangered species is possible.

As stated in previous sections of this report, the habitats associated with this study area are of rather small size and are generally isolated amidst a much larger area which is presently altered. In that these habitats may consists of potential habitats for certain threatened and\or endangered species, high probability of utilization of this these habitats by such species cannot be expected due to the study area's rather small size and isolation.

The major factor determining the rather low probability of threatened and\or endangered species usage of this study area is its small size and isolation in relation to the vast surrounding area which is presently manipulated. As such, there appears to be no correlation between the low possibility of utilization of the subject area and the existence of the subject Quarry.

VI. AQUATIC RESOURCES.

A. INTRODUCTION:

Water resources such as lakes and streams are invaluable assets to the natural environment. In addition to the most obvious benefit of drinking water supply, streams provide various agricultural and domestic benefits such as groundwater supply, livestock and crop watering, fire protection, wastewater processing, etc. Streams provide critical benefits to wildlife such as providing drinking water, fish habitat, wildlife habitat, and endangered species habitat. The waterways also provide recreational benefits such as fishing, hunting, swimming, camping, bird watching, and aesthetics.

Stream water quality is dependent largely on land-use practices in the stream corridor and drainage basin. The stream corridor serves the major role in ensuring the quality of the stream. Sufficient amounts and types of natural vegetation in the stream corridor serve to provide necessary shade to the stream as well as providing stability to the banks of the stream. The natural vegetation of the stream corridor also serves the major roles of filtering pollutants which would otherwise enter the stream and of controlling sedimentation and siltation to the stream. Organic pollutants in a stream act to increase the oxygen demand on the stream thereby reducing the oxygen levels. Siltation of a stream acts to embed the substrate of the stream thereby reducing the habitat for aquatic insects which are the major food for the fishery resource of the stream.

Dealing with the stream itself, a good ratio of pool, riffle, and run areas serves to provide a sufficient variety of habitats for a fishery resource by providing resting and cover areas (pools), and food production areas (riffles and runs). Riffle areas also serve the major function of increasing the stream's interaction with the air thereby increasing the dissolved oxygen of the stream.

Both the fisheries and invertebrate populations of a stream are a biological means to monitor the general health of a stream. A healthy stream generally possesses a good diversity of species with a moderate population of most. As species diversity in a stream decreases, an indication of declining stream health, there are generally fewer species present with the population of certain species being exceptionally high at the expense of others. When species diversity becomes minimal and the aquatic populations as a whole become small, either heavy organic pollution or toxic poisoning is indicated.

Whereas the diversity of species gives indication as to the general health of a stream, so does the occurrence or non-occurrence of individual species give indication as to stream health. As the health of a stream deteriorates, certain species intolerant of pollution will begin to become rare in the system while pollution tolerant species will become more abundant.

B. RESULTS AND DETERMINATIONS:

Skippack Creek - West Branch:

The Salford Quarry, which is the subject of this Natural Resources Inventory and Analysis is located in the West Branch of Skippack Creek watershed with the West Branch of Skippack Creek flowing approximately 500 feet to the west of the subject quarry. This stream originates approximately 3 miles upstream from the subject property and generally flows in a southerly direction until its confluence with Skippack Creek approximately 1.7 miles south of the quarry. Skippack Creek then joins with Perkiomen Creek approximately 8 miles to the south which then flows into the Schuylkill River.

From its origin to the vicinity of the project site, the watershed of the West Branch of Skippack Creek is dominated by agriculture lands with low to moderate density residential development also present. Paved roadways are also located in close proximity to this stream and run-off waters from the parking area of a large shopping center enters this stream approximately 1.1 miles upstream from the project site.

A total of seven (7) sampling stations were incorporated into this stream analysis of the West Branch of Skippack Creek in the vicinity of the Salford Quarry. Four (4) sampling stations were located upstream from the quarry and three (3) sampling stations were located downstream from the quarry. Figure #6.1 illustrates the location of these sample stations.

Biological and physical parameters of the West Branch of Skippack Creek inventoried at the various sampling stations along this stream are detailed as follows:

-Sample Station #1:

This sample station of 150 feet in length is located approximately 2000 feet upstream from the Salford Quarry Site. This station was located on a portion of the stream which flows through the Open Grove \ Meadow area north of the project site.

The average width of the stream at this sample station was approximately 13.8 feet and the average channel depth was approximately 6 inches. The average flow rate of the stream at this sampling station was calculated to be approximately 0.65 feet per second. At the time of sampling, low water levels were experienced. The bottom substrate of the stream at this station consists primarily of Bedrock (approximately 80%) with Large Rubble (6.0-12.0 inches) comprising approximately 10% of the substrate. Silt, Sand, Small Gravel, Large Gravel, and Small Rubble comprised the remaining 10% of the substrate at this station. Cobble embeddedness was found to be

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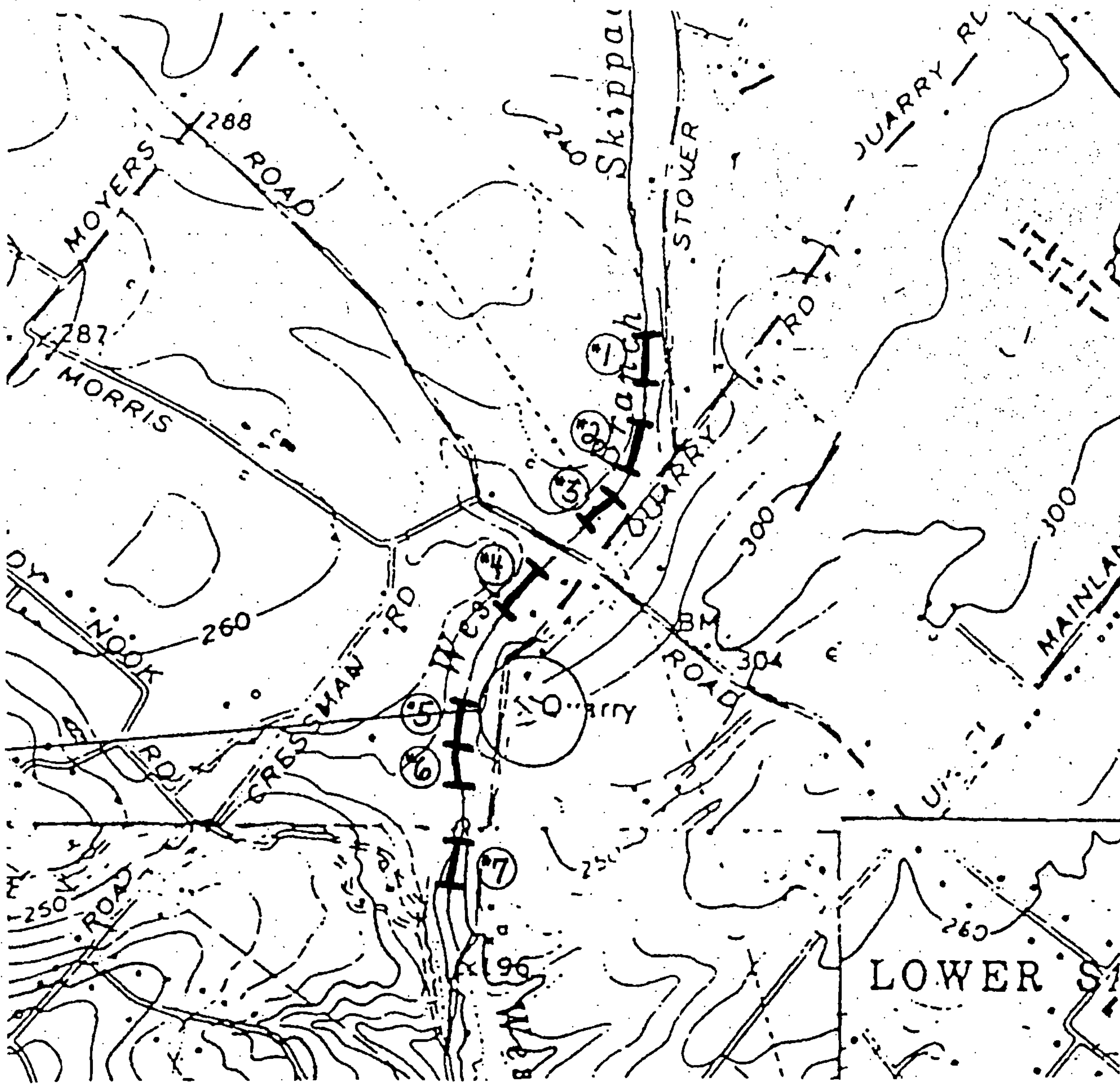

FIGURE #6.1 Locations of Aquatic Sampling Stations.

moderate to high indicating a moderate to high siltation impact. The stream bank cover in this area is good with regards to canopy vegetation and fair with regards to shrub vegetation. Bank stability is fair in this area, consisting of tree roots and herbaceous vegetation. A moderate degree of bank erosion was observed at this station. This sampling station possesses a good distribution of pool, riffle, and run habitats. The overall quality of the pools was good consisting of good size, fair depth, and poor cover.

Sampling of the invertebrates indicated a moderate abundance of Trichoptera spp. (Caddisfly sp.), Coleoptera psephenus (Beetle sp.), and Planaria (Flat-worm). Other invertebrates present included Ephemeroptera spp. (Mayfly sp.), Diptera spp. (Two-winged Fly sp.), Placobdella (Leech sp.), and Crustaceans (Crayfish). The types and amounts of each species of invertebrates collected at this sample station indicate a moderate amount of organic enrichment of this stream is occurring.

Sampling of the fisheries population produced the capture of 179 individuals consisting of 5 species. These species included Black nose Dace (Notropis heterolepis) (84.4%), Banded Killifish (Fundulus diaphanus) (12.9%), Redbreast Sunfish (Lepomis auritus) (1.1%), Pumpkinseed Sunfish (Lepomis gibbosus) (1.1%), and Common Shiner (Notropis cornutus) (0.5%). Young of the year were documented of all of the species captured indicating natural reproduction of these species. The collected fisheries species are commonly associated with moderate to good quality waters thereby indicating a moderate quality of the sampled stream.

General field conducted water tests produced the following results: dissolved oxygen - 11.4 parts per million (ppm); pH - 9.0; Bicarbonate Alkalinity - 152 ppm; Hardness (Total - 168 ppm), (Calcium 100 ppm), (Magnesium - 68 ppm); Salinity - 1.6 ppm; and Phosphate <1 ppm.

Given the determined physical and biological characteristics of this portion of the stream, it is determined that the section of the stream associated with Sample Station #1 is of fair to good quality. The invertebrates sampled give an indication of organic enrichment which appears to be caused mainly from fertilizer run-off from the high amount of agriculture present in the watershed along with the leaching of septic systems associated with the residential development present in the watershed. However, observed aquatic species at this station do not indicate high amounts of degradation and were found to be typical of a stream having similar characteristics.

-Sample Station #2:

This sample station of 150 feet in length is located approximately 1500 feet upstream from the Salford Quarry Site. This station was located on a portion of the stream which flows through the Open Grove \ Meadow area north of the project site; however, this particular portion of the stream is primarily forested.

The average width of the stream at this sample station was approximately 27 feet and the average channel depth was approximately 6 inches. The average flow rate of the stream at this sampling station was calculated to be approximately 0.7 feet per second. At the time of sampling, low water levels were experienced. The bottom substrate of the stream at this station consists of Small Rubble (3-6 inches) (35%), Large Gravel (1-3 inches) (35%), Small Gravel (0.25-1 inches) (20%), Sand (5%), and Large Rubble (5%). Cobble embeddedness was found to be moderate to high indicating a moderate to high siltation impact. The stream bank cover in this area is excellent with regards to canopy vegetation and fair to good with regards to shrub vegetation. Bank stability is good in this area consisting primarily of tree roots. A small degree of bank erosion was observed at this station. This sampling station possesses a fair to good distribution of pool, riffle, and run habitats with pool habitat lacking. The overall quality of the pools was fair to good consisting of fair size, good depth, and fair to good cover.

Sampling of the invertebrates indicated a high abundance of Trichoptera spp. (Caddisfly sp.), and a moderate abundance of Ephemeroptera spp. (Mayfly sp.) and Coleoptera psephenus (Beetle sp.). Other invertebrates present included Planaria (Flat-worm), Diptera spp. (Two-winged Fly sp.), Placobdella (Leech sp.), and Crustaceans (Crayfish and Asellus). The types and amounts of each species of invertebrates collected at this sample station indicate a moderate amount of organic enrichment of this stream is occurring.

Sampling of the fisheries population produced the capture of 147 individuals consisting of 7 species. These species included Black nose Dace (Notropis heterolepis) (69.4%), Banded Killifish (Fundulus diaphanus) (18.4%), Redbreast Sunfish (Lepomis auritus) (6.1%), White Sucker (Catostomus commersoni) (2.7%), Common Shiner (Notropis cornutus) (1.4%), Pumpkinseed Sunfish (Lepomis gibbosus) (1.4%), and Brown Bullhead (Ictalurus nebulosus) (0.7%). Young of the year were documented of all of the species captured indicating natural reproduction of these species. The collected fisheries species are commonly associated with moderate to good quality waters thereby indicating a moderate quality of the sampled stream.

General field conducted water tests produced the following results: dissolved oxygen - 11.8 parts per million (ppm); pH - 9.0; Bicarbonate Alkalinity - 152 ppm; Hardness (Total - 172 ppm), (Calcium 104 ppm), (Magnesium - 68 ppm); Salinity - 1.6 ppm; and Phosphate <1 ppm.

Given the determined physical and biological characteristics of this portion of the stream, it is determined that the section of the stream associated with Sample Station #2 is of fair to good quality. The invertebrates sampled give an indication of organic enrichment which appears to be caused mainly from fertilizer run-off from the high amount of agriculture present in the watershed along with the leaching of septic systems associated with the residential development present in the watershed. However, observed aquatic species at this station do not indicate high amounts of degradation and were found to be typical of a stream having similar characteristics.

-Sample Station #3:

This sample station of 150 feet in length is located approximately 1000 feet upstream from the Salford Quarry Site. This station was located on a portion of the stream which flows through the Open Grove \ Meadow area north of the project site.

The average width of the stream at this sample station was approximately 20.4 feet and the average channel depth was approximately 12-15 inches. The average flow rate of the stream at this sampling station was calculated to be approximately 0.5 feet per second. At the time of sampling, low water levels were experienced. The bottom substrate of the stream at this station consists of Bedrock (95%) and Boulders (>12 inches) (5%). It appears that this sample station experiences low to moderate siltation impact. The stream bank cover in this area is good with regards to canopy vegetation and fair to good with regards to shrub vegetation. Bank stability is good to excellent in this area consisting primarily of bedrock and tree roots. A very small degree of bank erosion was observed at this station. This sampling station possesses a fair to good distribution of pool, riffle, and run habitats with pool habitat lacking. The overall quality of the pools was good consisting of good size, good depth, and good cover.

Sampling of the invertebrates indicated a moderate abundance of Trichoptera spp. (Caddisfly sp.). Other invertebrates present included Ephemeroptera spp. (Mayfly sp.), Coleoptera psephenus (Beetle sp.), Planaria (Flat-worm), Crustaceans (Crayfish and Asellus), and Physa (Molluscs sp.). The types and amounts of each species of invertebrates collected at this sample station indicate a moderate amount of organic enrichment of this stream is occurring.

Sampling of the fisheries population produced the capture of 156 individuals consisting of 6 species. These species included Banded Killifish (Fundulus diaphanus) (30.8%), Redbreast Sunfish (Lepomis auritus) (25.7%), Black nose Dace (Notropis heterolepis) (18.6%), Pumpkinseed Sunfish (Lepomis gibbosus) (14.7%), White Sucker (Catostomus commersoni) (5.1%), and Tesselated Darter (5.1%). Young of the year were documented of all of the species captured indicating natural reproduction of these species. The collected fisheries species are commonly associated with moderate to good quality waters thereby indicating a moderate quality of the sampled stream.

General field conducted water tests produced the following results: dissolved oxygen - 12 parts per million (ppm); pH - 9.0; Bicarbonate Alkalinity - 148 ppm; Hardness (Total - 164 ppm), (Calcium 104 ppm), (Magnesium - 60 ppm); Salinity - 1.2 ppm; and Phosphate <1 ppm.

Given the determined physical and biological characteristics of this portion of the stream, it is determined that the section of the stream associated with Sample Station #3 is of fair to good quality. The invertebrates sampled along with the high amounts of algae present give an indication of organic enrichment which appears to be caused mainly from fertilizer run-off from the high amount of agriculture present in the watershed along with the leaching of septic systems associated with the residential development present in the watershed. However, observed aquatic species at this station do not indicate high amounts of degradation and were found to be typical of a stream having similar characteristics.

-Sample Station #4:

This sample station of 250 feet in length is located approximately 500 feet upstream from the Salford Quarry Site. This station was located on a portion of the stream which flows through the Forested and Residential area north of the project site and south of Morris Road.

The average width of the stream at this sample station was approximately 20.7 feet and the average channel depth was approximately 6-24 inches. The average flow rate of the stream at this sampling station was calculated to be approximately 0.8 feet per second. At the time of sampling, low water levels were experienced. The bottom substrate of the stream at this station consists of Bedrock (40%), Large Rubble (40%), Small Rubble (10%), Boulders (5%), and Small Gravel (5%). It appears that this sample station experiences low to moderate siltation impact. The stream bank cover in this area is good with regards to canopy vegetation and fair to good with regards to shrub vegetation. Bank stability is fair to good in this area consisting primarily of tree roots and vegetation. A very small degree of bank erosion was observed at this station. This sampling station possesses a good distribution of pool, riffle, and run habitats. The overall quality of the pools was good consisting of good size, good depth, and good cover.

Sampling of the invertebrates indicated a moderate abundance of Ephemeroptera spp. (Mayfly sp.) and Trichoptera spp. (Caddisfly sp.). Other invertebrates present included Coleoptera psephenus (Beetle sp.), Planaria (Flat-worm), and Crustaceans (Crayfish). The types and amounts of each species of invertebrates collected at this sample station indicate a moderate amount of organic enrichment of this stream is occurring.

Sampling of the fisheries population produced the capture of 182 individuals consisting of 7 species. These species included Black nose Dace (Notropis heterolepis) (57.1%), Banded Killifish (Fundulus diaphanus) (24.7%), White Sucker (Catostomus commersoni) (8.8%), Redbreast Sunfish (Lepomis auritus) (6.6%), Pumpkinseed Sunfish (Lepomis gibbosus) (1.6%), Tesselated Darter (0.6%), and Common Shiner (Notripis cornutus) (0.6%). Young of the year were documented of most of the species captured indicating natural reproduction of these species. The collected fisheries species are commonly associated with moderate to good quality waters thereby indicating a moderate quality of the sampled stream.

General field conducted water tests produced the following results: dissolved oxygen - 11.2 parts per million (ppm); pH - 9.0; Bicarbonate Alkalinity - 148 ppm; Hardness (Total - 168 ppm), (Calcium 108 ppm), (Magnesium - 60 ppm); Salinity - 1.2 ppm; and Phosphate <1 ppm.

Given the determined physical and biological characteristics of this portion of the stream, it is determined that the section of the stream associated with Sample Station #4 is of fair to good quality. The invertebrates sampled along with the moderate to high amounts of algae present give an indication of organic enrichment which appears to be caused mainly from fertilizer run-off from the high amount of agriculture present in the watershed along with the leaching of septic systems associated with the residential development present in the watershed. However, observed aquatic species at this station do not indicate high amounts of degradation and were found to be typical of a stream having similar characteristics.

-Sample Station #5:

This sample station of 150 feet in length is located approximately 200 feet downstream from the Salford Quarry Site. This station was located on a portion of the stream which flows through the Forested and Scrub\Shrub Wetland area south of the project site.

The average width of the stream at this sample station was approximately 18.4 feet and the average channel depth was approximately 6-8 inches. The average flow rate of the stream at this sampling station was calculated to be approximately 0.7 feet per second. At the time of sampling, low water levels were experienced. The bottom substrate of the stream at this station consists of Large Rubble (50%), Small Rubble (30%), and Large Gravel (20%). It appears that this sample station experiences low to moderate siltation impact. The stream bank cover in this area is fair with regards to canopy vegetation and good with regards to shrub vegetation. Bank stability is good in this area consisting primarily of tree roots and vegetation. A very small degree of bank erosion was observed at this station. This sampling station possesses an excellent distribution of pool, riffle, and run habitats. The overall quality of the pools was good consisting of good size, good depth, and good cover.

Sampling of the invertebrates indicated a moderate abundance of Ephemeroptera spp. (Mayfly sp.), Trichoptera spp. (Caddisfly sp.), Planaria (Flat-worm), and Coleoptera psephenus (Beetle sp.). Other invertebrates present included Crustaceans (Crayfish and Asellus).

The types and amounts of each species of invertebrates collected at this sample station indicate a moderate amount of organic enrichment of this stream is occurring.

Sampling of the fisheries population produced the capture of 367 individuals consisting of 9 species. These species included Black nose Dace (Notropis heterolepis) (54.5%), White Sucker (Catostomus commersoni) (27.2%), Redbreast Sunfish (Lepomis auritus) (7.6%), Banded Killifish (Fundulus diaphanus) (4.1%), Brown Bullhead (Ictalurus nebulosus) (1.6%), Madtom (Noturus funebris) (1.4%), Bluegill Sunfish (Lepomis macrochirus) (1.4%), Smallmouth Bass (Micropterus dolomieui) (1.4%), and Tesselated Darter (0.8%). Young of the year were documented of most of the species captured indicating natural reproduction of these species. The collected fisheries species are commonly associated with good quality waters thereby indicating a moderate to good quality of the sampled stream.

General field conducted water tests produced the following results: dissolved oxygen - 8.4 parts per million (ppm); pH - 8.5; Bicarbonate Alkalinity - 142 ppm; Hardness (Total - 164 ppm), (Calcium 104 ppm), (Magnesium - 60 ppm); Salinity - 1.2 ppm; and Phosphate <1 ppm.

Given the determined physical and biological characteristics of this portion of the stream, it is determined that the section of the stream associated with Sample Station #5 is of good quality. The invertebrates sampled give an indication of organic enrichment which appears to be caused mainly from fertilizer run-off from the high amount of agriculture present in the watershed along with the leaching of septic systems associated with the residential development present in the watershed. However, observed aquatic species at this station do not indicate high amounts of degradation and were found to be of higher quality than a stream having similar characteristics.

-Sample Station #6:

This sample station of 150 feet in length is located approximately 350 feet downstream from the Salford Quarry Site. This station was located on a portion of the stream which flows through the Forested and Scrub\Shrub Wetland area south of the project site.

The average width of the stream at this sample station was approximately 20.5 feet and the average channel depth was approximately 12-24 inches. The average flow rate of the stream at this sampling station was minimal due in part to the pool character of the station. At the time of sampling, low water levels were experienced. The bottom substrate of the stream at this station consists of Small Gravel (40%), Large Gravel (30%), Small Rubble (20%), Large Rubble (5%), and Sand (5%). It appears that this sample station experiences moderate to high siltation impact which is typical of a pool area. The stream bank cover in this area is fair with regards to canopy vegetation and good with regards to shrub vegetation. Bank stability is fair to good in this area consisting primarily of tree roots and vegetation. Some degree of bank erosion was observed at this station. This sampling station consists entirely of pool habitats with riffle and run areas virtually nonexistent. The overall quality of the pools was good consisting of good size, good depth, and good cover.

Sampling of the invertebrates indicated a moderate abundance of Trichoptera spp. (Caddisfly sp.), Planaria (Flat-worm), and Coleoptera psephenus (Beetle sp.). Other invertebrates present included Ephemeroptera spp. (Mayfly sp.), Crustaceans (Crayfish), and

Physa (Molluscs sp.). The types and amounts of each species of invertebrates collected at this sample station indicate a moderate amount of organic enrichment of this stream is occurring.

Sampling of the fisheries population produced the capture of 181 individuals consisting of 8 species. These species included White Sucker (Catostomus commersoni) (69.1%), Largemouth Bass (Micropterus salmoides) (9.4%), Redbreast Sunfish (Lepomis auritus) (7.7%), Common Shiner (Notropis cornutus) (3.8%), Bluegill Sunfish (Lepomis macrochirus) (3.3%), Madtom (Noturus funebris) (1.4%), Pumpkinseed Sunfish (Lepomis gibbosus) (2.8%), and Brown Bullhead (Ictalurus nebulosus) (1.1%). Young of the year were documented of many of the species captured indicating natural reproduction of these species. The collected fisheries species are commonly associated with moderate to good quality waters thereby indicating a moderate quality of the sampled stream.

General field conducted water tests produced the following results: dissolved oxygen - 11.8 parts per million (ppm); pH - 8.5; Bicarbonate Alkalinity - 148 ppm; Hardness (Total - 164 ppm), (Calcium 104 ppm), (Magnesium - 60 ppm); Salinity - 1.6 ppm; and Phosphate <1 ppm.

Given the determined physical and biological characteristics of this portion of the stream, it is determined that the section of the stream associated with Sample Station #6 is of moderate quality. The invertebrates sampled along with the moderate amounts of algae present give an indication of organic enrichment which appears to be caused mainly from fertilizer run-off from the high amount of agriculture present in the watershed along with the leaching of septic systems associated with the residential development present in the watershed. However, observed aquatic species at this station do not indicate high amounts of degradation and were found to be typical of a stream having similar characteristics.

-Sample Station #7:

This sample station of 150 feet in length is located approximately 500 feet downstream from the Salford Quarry Site and just downstream from the confluence of a small tributary stream with the West Branch of Skippack Creek. This station was located on a portion of the stream which flows through the Open Meadow area south of the project site.

The average width of the stream at this sample station was approximately 9.3 feet and the average channel depth was approximately 12-16 inches. The average flow rate of the stream at this sampling station was calculated to be approximately 0.75 feet per second. At the time of sampling, low water levels were experienced. The bottom substrate of the stream at this station consists of Large Gravel (50%), Small Rubble (30%), Small Gravel (15%), and Large Rubble (5%). It appears that this sample station experiences moderate siltation impact. The stream bank cover in this area is poor with regards to canopy vegetation and poor with regards to shrub vegetation. Bank stability is fair in this area consisting primarily of herbaceous vegetation. Some degree of bank erosion was observed at this station. This sampling station possess a good distribution of pool and run habitats with riffle areas virtually nonexistent. The overall quality of the pools was good consisting of good size, good depth, and good cover.

Sampling of the invertebrates indicated a high abundance of Planaria (Flat-worm) and Coleoptera psephenus (Beetle sp.). Other invertebrates present included Trichoptera spp. (Caddisfly sp.) and Ephemeroptera spp. (Mayfly sp.). The types and amounts of each species of invertebrates collected at this sample station indicate a moderate to high amount of organic enrichment of this stream is occurring.

Sampling of the fisheries population produced the capture of 267 individuals consisting of 8 species. These species included White Sucker (Catostomus commersoni) (74.9%), Black nose Dace (Notropis heterolepis) (7.9%), Redbreast Sunfish (Lepomis auritus) (6.3%), Banded Killifish (Fundulus diaphanus) (4.1%), Madtom (Noturus funebris) (1.9%), Largemouth Bass (Micropterus salmoides) (9.4%), Creek Chub (Semotilus atromaculatus) (1.9%), and Bluegill Sunfish (Lepomis macrochirus) (1.1%). Young of the year were documented of most of the species captured indicating natural reproduction of these species. The collected fisheries species are commonly associated with moderate to good quality waters thereby indicating a moderate quality of the sampled stream.

General field conducted water tests produced the following results: dissolved oxygen - 10.6 parts per million (ppm); pH - 8.75; Bicarbonate Alkalinity - 138 ppm; Hardness (Total - 164 ppm), (Calcium 104 ppm), (Magnesium - 60 ppm); Salinity - 1.2 ppm; and Phosphate <1 ppm.

Given the determined physical and biological characteristics of this portion of the stream, it is determined that the section of the stream associated with Sample Station #7 is of fair to moderate quality. The invertebrates sampled along with the moderate amounts of algae present give an indication of organic enrichment which appears to be caused mainly from fertilizer run-off from the high amount of agriculture present in the watershed along with the leaching of septic systems associated with the residential development present in the watershed. However, observed aquatic species at this station do not indicate extraordinary high amounts of degradation and were found to be typical of a stream having similar characteristics.

Seepage Area and Drainage Channel:

A small seepage area and drainage channel exists at the base of the steep slope in the forested area to the west of the quarry and to the east of the West Branch of Skippack Creek. This area appears to be influenced by groundwater seepage and also serves as a collection area for run-off waters from the steep slope. This area experiences routine water level fluctuations as a result of periods of wet and dry weather. Although definite hydrology and wetland characteristics are associated with this particular area, no aquatic community was found to be associated with this area at the time of field research. The only inundation in this particular area consisted of a small puddle with a size of approximately 16 square feet and a depth of approximately 1 inch. Due to the size and present characteristics, this particular area was not sampled or inventoried as an aquatic community, but rather, is considered as part of the Forested Wetland Stream Corridor Habitat.

C. ANALYSIS, IMPACT, AND RECOMMENDATIONS:

The stream survey and inventories of the aquatic communities and parameters of the West Branch of Skippack Creek in the vicinity of the subject Salford Quarry Site were conducted to determine if the Quarry is presently having a significant impact on the aquatic community of this stream. The locations of the sampling stations were designed to provide an opportunity for a comparison of the aquatic community upstream and not influenced from the subject site with the aquatic community downstream where potential impacts would be directed and observed.

As previously stated, the West Branch of Skippack Creek watershed associated with this quarry site is dominated by agriculture land use practices along with some extent of residential development. Additionally, this stream is not free from impacts associated with roadway and development run-off waters. Run-off of fertilizers from agriculture lands generally has an impact on associated streams by adding organic enrichment to the aquatic system. Leaching from septic systems also has a similar effect on aquatic systems. Such appears to be the case with the portions of the West Branch of Skippack Creek included in this survey. Whereas some natural vegetation buffer exists, significant amounts of nutrient rich run-off enters this stream from the adjacent agriculture fields in the watershed. The close proximity of septic systems associated with residential development to this stream is also expected to add to the organic enrichment of this stream.

The amount of algae and the types and abundance of invertebrates collected in Sample Stations # 1 through 4 give an indication that a fair amount of nutrient enrichment to the stream occurs. Whereas the types and abundance of invertebrate species collected in these stations give an indication that organic enrichment is a problem in the stream, degradation of this stream is not of exceptionally high levels. The types and abundance of fishery species collected at these stations is generally representative of an aquatic ecosystem of at least moderately good quality. As such, the West Branch of Skippack Creek upstream of the subject quarry is representative of a stream which has undergone organic enrichment but the extent of this degradation is not of very high levels at present.

The amount of algae and the types and abundance of invertebrate species collected in Sample Stations # 5 and 6 located downstream from the subject quarry give an indication that some amount of organic enrichment to the stream occurs. Whereas some impact due to organic enrichment is indicated at these stations, high levels of stream degradation is not apparent. The types and abundance of fishery species collected at these stations is generally representative of an aquatic ecosystem of good quality.

The amount of algae, and the types and abundance of invertebrate and fishery species collected at Sample Station #7 located downstream of the quarry give an indication that a substantial amount of organic enrichment to the stream occurs. This sample station is directly influenced by adjacent fields and is also located downstream from the confluence of a small stream with the West Branch of Skippack Creek. This small stream was determined to be significantly influenced by run-off from adjacent agriculture fields and also from septic system leaching. Due to the direct influences of the land character on the stream in the vicinity of Sample Station #7 along with the influx of nutrients associated with the small stream discharging into the particular section of the West branch of Skippack Creek, such indications of higher levels of impact can be expected.

As the stream and aquatic community inventories have indicated, the West Branch of Skippack Creek, both upstream and downstream of the quarry, is impacted to a moderate extent by organic enrichment generated by the land uses of the watershed. A comparison of the results from the sample stations located upstream of the quarry with the results from the sample stations downstream of the quarry do not indicate any significant differences which may be attributed to the Salford Quarry. Given the relevant characteristics of the stream along with the present influencing problems associated with the watershed, it does not appear that the Salford Quarry presently contributes levels of pollution or toxicity to the stream to significantly impact the associated aquatic communities.

VII. APPENDICES

APPENDIX A - General Habitat Types Associated With The Study Area.

APPENDIX B - Vegetation Associated With The Study Area.

APPENDIX C - Wildlife Species Associated With The Study Area.

APPENDIX D - Photographs of Study Area Habitats.

APPENDIX E - Photographs of Aquatic Sampling Stations.

APPENDIX F - Professional Credentials.

APPENDIX G - Certification.

APPENDIX A

GENERAL HABITAT TYPES ASSOCIATED WITH THE STUDY AREA

APPENDIX B

VEGETATION ASSOCIATED WITH THE STUDY AREA

KEY:

-OCCURRENCE

A = Agriculture
B = Residential Development
C = Open Grove \ Meadow
D = Forested Woodlands
E = Forested Wetlands
F = Scrub\Shrub Wetlands
G = Disturbed Field

* = Predominant occurrence of this species has been observed in noted area of the site during the inventory process.

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Sumac, Smooth	Rhus glabra	C\D\G
Sumac, Staghorn	Rhus typhina	C\G
Sunflower, Tickseed	Bidens coronata	C\F
Sweetclover, White	Meliltus alba	C\G
Sycamore, American	Platanus occidentalis	C\E\F
Tear-Thumb, Arrow-leaved	Polygonum sagittatum	C\E\F*
Tear-Thumb, Halbred-Leaf	Polygonum arifolium	C\E\F*
Trefoil, Birdsfoot	Lotus corniculatus	C\G
Vervain, Blue	Verbena hastata	C\F
Vetch, Crown	Vicia sativa	C\G*
Violet, Common Blue	Viola papilionacea	C\D\E
Virginia Creeper	Parthenocissus quinquefol	C\D*\G*
Walnut, Black	Juglans nigra	B\C*\D*\E*
Willowherb, Hairy	Epilobium hirsutum	C\F
Woolgrass	Scirpus cyperinus	C\F
Yarrow	Achillea millefolium	C*\G*

APPENDIX C

WILDLIFE SPECIES ASSOCIATED WITH THE PROJECT SITE

Table 1C - Mammal Species Associated with the Project Site.

Table 2C - Bird Species Associated with the Project Site.

Table 3C - Reptile and Amphibian Species Associated with the Project Site.

KEY:

-OCCURRENCE

A = Agriculture
B = Residential Development
C = Open Grove \ Meadow
D = Forested Woodlands
E = Forested Wetlands
F = Scrub\Shrub Wetlands
G = Disturbed Field

* = Occurrence of this species has been observed in noted area of the site during the inventory process.

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TABLE #1C
MAMMAL SPECIES ASSOCIATED WITH THE PROJECT SITE

COMMON NAME	SCIENTIFIC NAME	OCCURRENCE
Bat, Big Brown	Eptesicus fuscus	A\B\C*\D\E\F\G
Bat, Evening	Nycticeius humeralis	A\B\C\D\E\F\G
Bat, Red	Lasiurus borealis	A\B\C\D\E\F\G
Bat, Silver-haired	Lasionycteris noctivagans	B\C\D\E\F\G
Beaver	Castor canadensis	C
Chipmunk, Eastern	Tamias straitus	B*\C\D*\E\F
Deer, White-tailed	Odocoileus virginianus	A*\B\C*\D*\E\F\G
Fox, Gray	Urocyon cinereoargenteus	C\D\E
Fox, Red	Vulpes vulpes	A\C*\D*\E\F\G*
Mink	Mustela vison	A\E\F
Mole, Eastern	Scalopus aquaticus	A\B\C*\D\E\F\G*
Mole, Hairy-tailed	Parascalops breweri	C\D\E
Mole, Star-nosed	Condylura cristata	C\E\F
Mouse, Deer	Peromyscus maniculatus	A\B\C*\G
Mouse, Meadow Jumping	Zapus hudsonicus	C\G
Mouse, White-footed	Peromyscus leucopus	B\C\D*\E\F\G
Muskrat	Ondatra zibethicus	C*\E\F
Myotis, Keen's	Myotis keenii	C\D\E\F\G
Myotis, Little Brown	Myotis lucifunus	B\C\D\E\F\G
Opossum, Virginia	Didelphis virginiana	A\B\C*\D*\E\F*\G*
Rabbit, Eastern Cottontail	Sylvilagus floridanus	A\B*\C*\F\G*
Raccoon	Procyon lotor	A\B\C*\D\E*\F*\G*
Shrew, Least	Cryptotis parva	C\D\E
Shrew, Masked	Sorex cinereus	C\D\E
Shrew, Short-tailed	Blarina brevicauda	C\D\E
Skunk, Striped	Mephitis mephitis	A\B\C*\D*\E\F\G
Squirrel, Gray	Sciurus carolinensis	B\C*\D*\E*
Squirrel, Red	Tamiasciurus hudsonicus	C\D\E
Squirrel, Southern Flying	Glaucomys volans	C\D\E
Vole, Meadow	Microtus pennsylvanicus	A\B*\C*\G*
Vole, Southern Red-backed	Clethrionomys gapperi	C\E\F
Vole, Woodland	Microtus pinetorum	C\D\E
Weasel, Long-tailed	Mustela frenata	C\D\E\F\G
Woodchuck	Marmota monax	A\B\C*\D*\G

EASTERN STATES
ENVIRONMENTAL ASSOCIATES
INC.

TABLE #2C
BIRD SPECIES ASSOCIATED WITH THE PROJECT SITE

COMMON NAME	SCIENTIFIC NAME	OCCURRENCE
Bittern, American	Botaurus lentiginosus	C\E\F
Blackbird, Red-winged	Agelaius phoeniceus	A*\B\C*\D\E\F\G
Blue Jay	Cyanocitta cristata	B*\C*\D*\E*\F*\G*
Bluebird, Eastern	Sialia sialis	C
Bobolink	Dolichonyx oryzivorus	C
Bunting, Indigo	Passerina cyanea	C*
Cardinal, Northern	Cardinalis cardinalis	B*\C*\D*\E\F\G*
Catbird, Gray	Dumetella carolinensis	B\C*\D*\E*\F*\G*
Chat, Yellow-breasted	Icteria virens	C\D\E
Chickadee, Black-capped	Parus atricapillus	B\C*\D*\E*\F\G*
Cowbird, Brown-headed	Molothrus ater	A\B\C*\D\E\F*\G
Creeper, Brown	Certhia familiaris	C\D\E
Crow, American	Corvus brachyrhynchos	A*\B\C*\D*\E\F\G*
Dove, Mourning	Zenaida macroura	A*\B*\C*\D\E\F\G*
Dove, Rock	Columba livia	A*\C\D*\E\F\G
Egret, Great	Casmerodius albus	C\F
Finch, House	Carpodacus mexicanus	B\C\D\E\F\G
Finch, Purple	Carpodacus purpureus	B\C\D\E\F\G\
Flicker, Common	Colaptes auratus	B\C*\D\E\F*\G*
Flycatcher, Great-crested	Myiarchus crinitus	C\D\E\F\G
Flycatcher, Least	Empidonax minimus	C\D\E\F\G
Gnatcatcher, Blue-Gray	Polioptila caerulea	C\D\E\F\G
Goldfinch, American	Carduelis tristis	A\B\C*\D\E\F\G*
Goose, Canada	Branta canadensis	C
Goshawk, Northern	Accipiter gentilis	C\D\E\F
Grackle, Common	Quiscalus quiscula	A*\B\C*\D\E\F*\G*
Grebe, Pied-billed	Podilymbus podiceps	A
Grosbeak, Evening	Hesperiphona vespertina	B\C\D\E\F\G
Grosbeak, Rose-breasted	Pheucticus ludovicianus	C\D\E
Harrier, Northern	Circus cyaneus	C
Hawk, Broad-winged	Buteo platypterus	D\E
Hawk, Cooper's	Accipiter cooperii	C\D\E\F\G
Hawk, Red-shouldered	Buteo lineatus	C\D\E\F
Hawk, Red-tailed	Buteo jamaicensis	A*\C*\D\G
Hawk, Sharp-shinned	Accipiter striatus	C*\D*\E\F
Heron, Black-crowned Nigh	Nycticorax nycticorax	C\F
Heron, Great Blue	Ardea herodias	C\F
Heron, Green	Butorides striatus	C*\F*
Junco, Northern	Junco hyemalis	B\C\D\E\F\G\
Kestrel, American	Falco sparverius	C*\G
Killdeer	Charadrius vociferus	C*
Kingbird, Eastern	Tyrannus verticalis	C\D\E\F
Kingfisher, Belted	Megaceryle alcyon	C*\F
Kinglet, Golden-crowned	Regulus satrapa	C\D\E\F

Kinglet, Ruby-crowned	Regulus calendula	C\D\E\F
Meadowlark, Eastern	Sturnella magna	C\G
Mockingbird, Northern	Mimus polyglottos	B*\C*\D\E\F*\G*
Nighthawk, Common	Chordeiles minor	C\D\E\F
Nuthatch, Red-breasted	Sitta canadensis	C\D\E
Nuthatch, White-breasted	Sitta carolinensis	C\D*\E
Oriole, Northern	Icterus galbula	C*\D\E
Ovenbird	Seiurus aurocapillus	D\E*
Owl, Barred	Strix varia	E
Owl, Common Screech	Otus asio	C\D\E\F\G
Owl, Great-horned	Bubo virginianus	C\D\E\F
Owl, Short-eared	Asio flammeus	C
Parula, Northern	Parula americana	C\D\E\F
Pewee, Eastern	Contopus virens	C\D*\E*\F
Phobe, Eastern	Sayornis phoebe	C*\D\E*\F
Redstart, American	Setophaga ruticilla	C\D\E
Robin, American	Turdus migratorius	B*\C*\D\E\F\G
Sandpiper, Upland	Bartramia longicauda	C
Snipe, Common	Capella gallinago	C\F
Sparrow, Chipping	Spizella passerina	C*\G
Sparrow, Field	Spizella pusilla	C*\G
Sparrow, Fox	Passerella iliaca	C\D
Sparrow, Henslow's	Ammodramus henslowii	C
Sparrow, House	Passer domesticus	A\B*\C*\D\E\F\G*
Sparrow, Savannah	Passerculus sandwichensis	C
Sparrow, Song	Melospiza melodia	B\C*\D*\E\F\G*
Sparrow, Tree	Spizella arborea	C\D\E
Sparrow, Vesper	Pooecetes gramineus	C
Sparrow, White-throated	Zonotrichia albicollis	B\C\D\G
Starling, European	Sturnus vulgaris	A*\B\C*\D\E\F\G*
Swallow, Barn	Hirundo rustica	C\G
Swallow, Tree	Iridoprocne bicolor	C\D\E\G
Tanager, Scarlet	Piranga olivacea	C\D\E
Thrasher, Brown	Toxostoma rufum	C\D\E
Thrush, Hermit	Catharus guttatus	C\D\E
Thrush, Swainson's	Catharus ustulatus	C\D\E
Thrush, Wood	Hylocichla mustelina	D*\E
Titmouse, Tufted	Parus bicolor	B\C*\D*\E\F\G
Towhee, Rufous-sided	Pipilo erythrphthalmus	C*\D*\G
Veery	Catharus fuscescens	D*\E
Vireo, Red-eyed	Vireo olivaceus	D*\E*
Vulture, Turkey	Cathartes aura	A\C*\G
Warbler, Bay-breasted	Dendroica castanea	C\D\E
Warbler, Black and White	Mniotilta varia	C\D\E
Warbler, Black-thrt. Blue	Dendroica caerulescens	C\D\E
Warbler, Blackburnian	Dendroica fusca	C\D\E
Warbler, Blackpoll	Dendroica striata	C\D\E
Warbler, Blue-winged	Vermivora pinus	C*
Warbler, Canada	Wilsonia canadensis	C\D\E
Warbler, Chestnut-sided	Dendroica pensylvanica	C\D\E

Warbler, Hooded	Wilsonia citrina	C
Warbler, Magnolia	Dendroica magnolia	C\D\E
Warbler, Mourning	Oporornis philadelphia	C\D\E
Warbler, Palm	Dendroica palmarum	C\D\E
Warbler, Prairie	Dendroica discolor	C
Warbler, Tennessee	Vermivora peregrina	C\D\E
Warbler, Wilson's	Wilsonia pusilla	C\D\E
Warbler, Worm-eating	Helmitheros vermivorus	C\D\E
Warbler, Yellow	Dendroica petechia	C*\D\E
Warbler, Yellow-rumped	Dendroica coronata	C\D\E
Waterthrush, Louisiana	Seiurus motacilla	C\E
Waterthrush, Northern	Seiurus noveboracensis	C\E
Waxwing, Cedar	Bombycilla cedrorum	C*\D\E\F\G
Woodcock, American	Philohela minor	C\D\E\F
Woodpecker, Downy	Picoides pubescens	B\C*\D*\E\F\G
Woodpecker, Hairy	Picoides villosus	B\C*\D\E\F\G
Woodpecker, Red-bellied	Melanerpes carolinus	C*\D\E
Woodpecker, Red-headed	Melanerpes erythrocephalu	C
Wren, Carolina	Thryothorus ludovicianus	C\D\E
Wren, House	Troglodytes aedon	B\C*\D\E
Yellowthroat	Geothypis trichas	C*\G

EASTERN STATES
ENVIRONMENTAL ASSOCIATES
INC.

TABLE #3C

REPTILE\AMPHIBIAN SPECIES ASSOCIATED WITH THE PROPERTY

COMMON NAME	SCIENTIFIC NAME	OCCURRENCE
Bullfrog	Rana catesbiana	C*\F
Frog, Green	Rana clamitans	C*\E\F*
Frog, Northern Cricket	Acric crepitans	C\F
Frog, Pickerel	Rana palustris	C\F
Frog, Upland Chorus	Pseudacris triseriata	C\F
Frog, Wood	Rana sylvatica	C\D\E*\F
Newt, Red-Spotted	Notophthalmus viridescens	C\E\F
Salamander, Four-Toed	Hemidactylium scutatum	C\E\F
Salamander, Jefferson	Ambystoma jeffersonianum	C\E\F
Salamander, Long-Tailed	Eurycea longicauda	C\E\F
Salamander, Marbled	Ambystoma opacum	C\E\F
Salamander, Mountain Dusky	Desmognathus ochrophaeus	C\E\F
Salamander, Northern Dusky	Desmognathus fuscus	C\E\F
Salamander, Northern Red	Pseudotriton ruber	C\E\F
Salamander, Red-Backed	Plethodon cinereus	C\E\F
Salamander, Slimy	Plethodon glutinosis	E
Salamander, Spotted	Ambystoma maculatum	C\E\F
Salamander, Spring	Gyrinophilus porphyriticu	C\E\F
Salamander, Two-Lined	Eurycea bislineata	C\E\F
Skink, Five-Lined	Eumeces fasciatus	B\C\D\E\F\G
Snake, Black Racer	Coluber constrictor	C*\D\E\F\G*
Snake, Black Rat	Elaphe obsoleta	A\B\C*\D\E\F\G*
Snake, Eastern Garter	Thamnophis sirtalis	A\B\C*\D*\E\G*
Snake, Eastern Hognose	Heterodon platyrhinos	C\D\E
Snake, Eastern Ribbon	Thamnophis sauritus	C\E\F
Snake, Milk	Lampropeltis triangulum	C\E\F
Snake, Northern Brown	Storeria dekayi	B\C\D\E\G
Snake, Northern Ringneck	Diadophis punctatus	B\C\D\E\G
Snake, Northern Water	Natrix sipedon	C*\D\E\F*
Snake, Red-Bellied	Storeria occipitomaculata	C\D\E\F\G
Snake, Smooth Green	Opheodrys vernalis	C\D\E\F
Snake, Worm	Carphophis amoenus	C\D\E
Toad, American	Bufo americanus	C*\E*\F*
Turtle, Eastern Box	Terrapene carolina	C*\D\E\F
Turtle, Painted	Chrysemmys picta	C\E
Turtle, Snapping	Chelydra serpentina	C\E
Turtle, Wood	Clemmys insculpta	C\E\F

AR305055

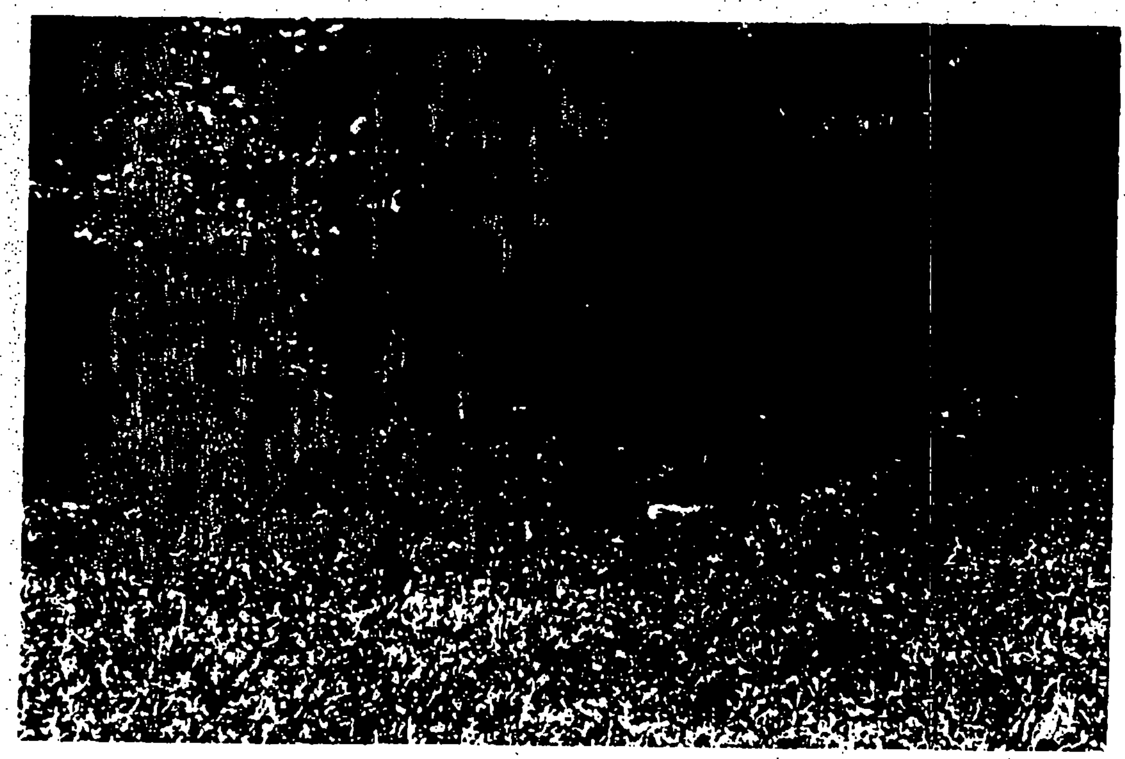
AR101264

ORIGINAL (Red)

APPENDIX D

PHOTOGRAPHS OF THE HABITATS ASSOCIATED WITH THE STUDY AREA

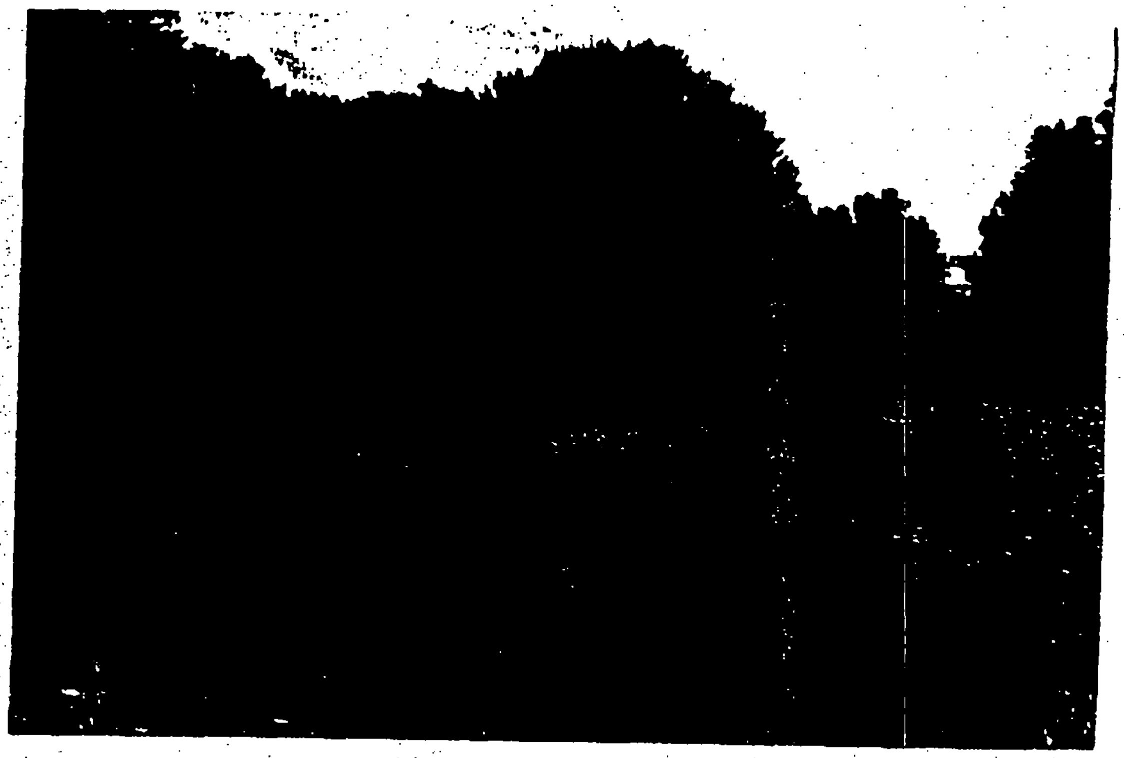
ORIGINAL (Red)



PHOTOGRAPH #1

Section of dense trees in open grove \ meadow area associated with the West Branch of Skippack Creek stream corridor north of the Quarry and Morris Road.

ORIGINAL (Red)



PHOTOGRAPH #2

Open grove \ meadow area associated with the West Branch of Skippack Creek stream corridor north of the Quarry and Morris Road.

ORIGINAL (Red)

PHOTOGRAPH #3

Section of dense canopy vegetation in open grove \ meadow area associated with the West Branch of Skippack Creek stream corridor north of the Quarry and Morris Road.

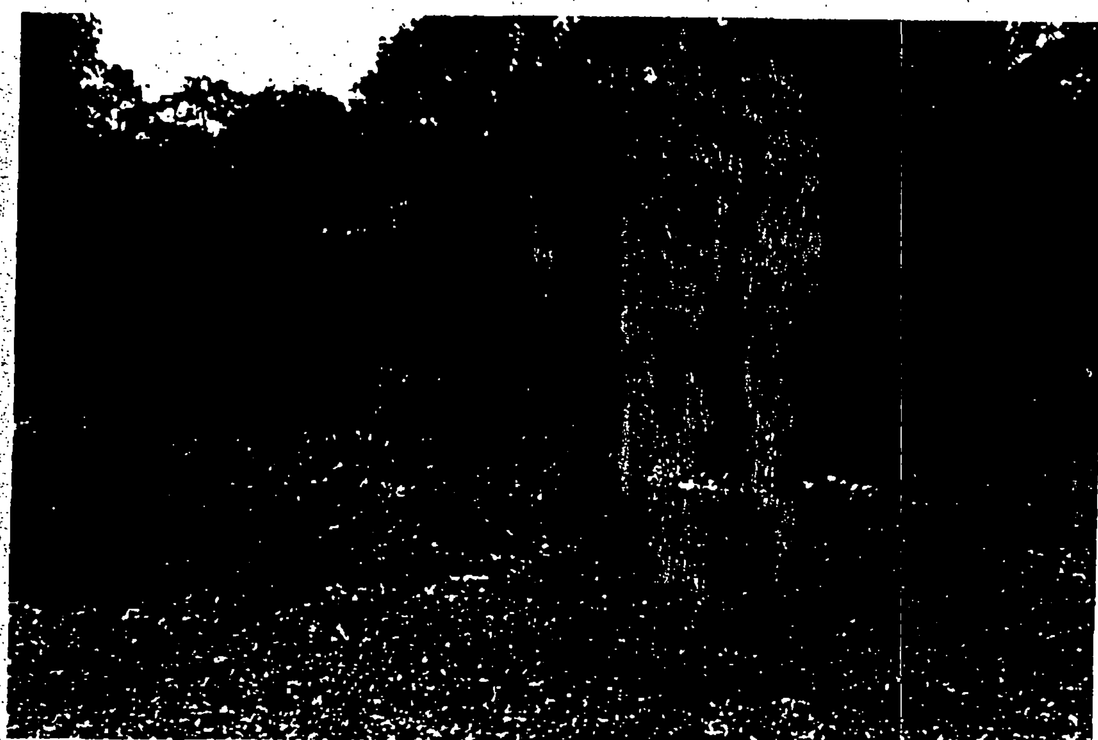
ORIGINAL (Red)

PHOTOGRAPH #4

Maintained lawn area of residential dwellings associated with the West Branch of Skippack Creek stream corridor to the north of the Quarry and south of Morris Road.

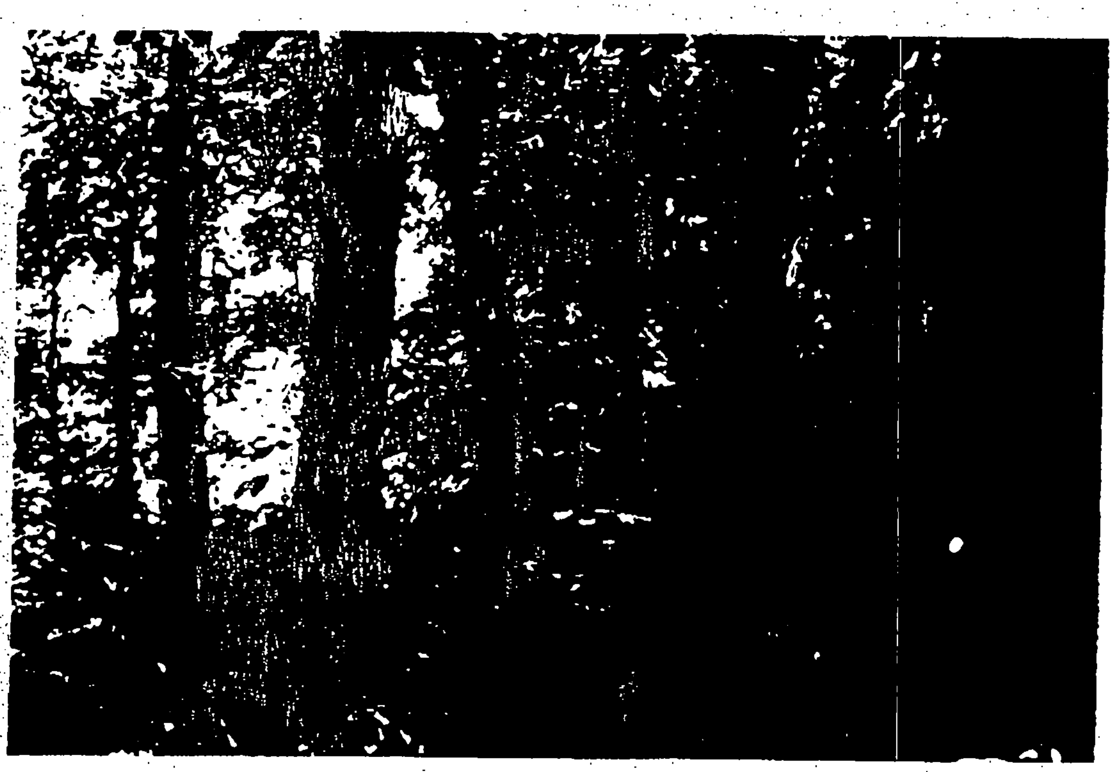
PHOTOGRAPH #5

Forested woodlands associated with the West Branch of Skippack Creek stream corridor directly west of the Quarry.



PHOTOGRAPH #6

Disturbed early successional field habitat present on the capped Quarry.



PHOTOGRAPH #7

Forested uplands immediately adjacent to the capped portion of the Quarry.

PHOTOGRAPH #8

Forested wetlands associated with the West Branch of Skippack Creek stream corridor directly west of the Quarry.

ORIGINAL
(Red)

PHOTOGRAPH #9

Scrub\Shrub wetland habitat associated with the West Branch of Skippack Creek stream corridor southwest of the Quarry.

PHOTOGRAPH #10

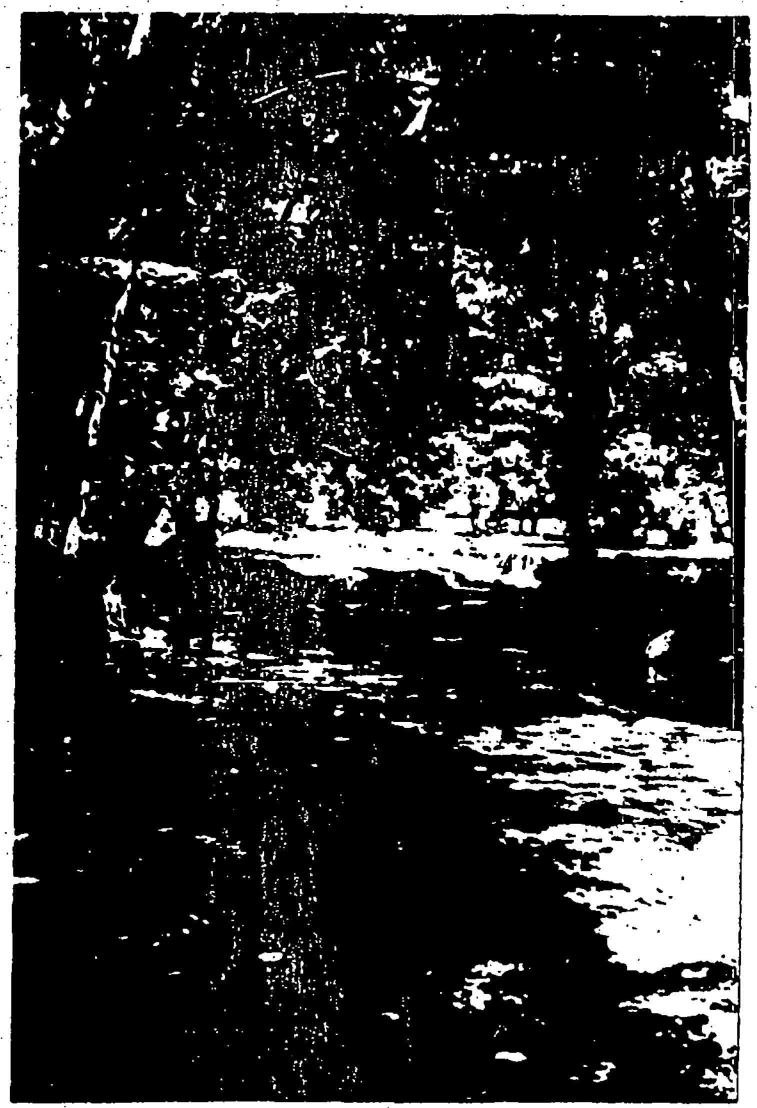
Open meadow habitat associated with the West Branch of Skippack Creek stream corridor south of the Quarry.

APPENDIX E

PHOTOGRAPHS OF THE AQUATIC SAMPLING STATIONS

PHOTOGRAPH #1

Aquatics Sample Station #1 located north of the Quarry and Morris Road.



PHOTOGRAPH #2

Aquatics Sampling Station #2 located north of the Quarry and Morris Road.

PHOTOGRAPH #3

Aquatics Sampling Station #3 located north of the Quarry and Morris Road.

PHOTOGRAPH #4

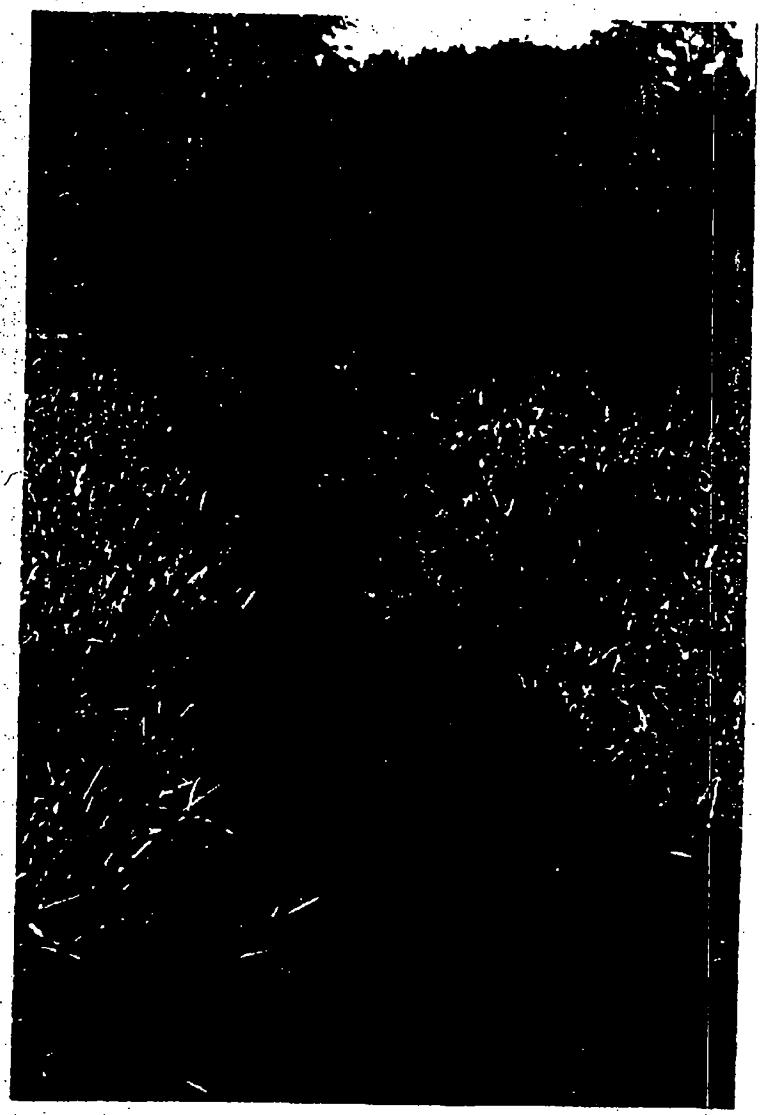
Aquatics Sampling Station #4 located to the north of the Quarry and south of Morris Road.

PHOTOGRAPH #5

Aquatics Sampling Station #5 located to the southwest of the Quarry.

PHOTOGRAPH #6

Aquatics Sampling Station #6 located to the southwest of the Quarry.



PHOTOGRAPH #7

Aquatics Sampling Station #7 located to the south, southwest of the Quarry.

APPENDIX F

PROFESSIONAL CREDENTIALS

PRINCIPALS:

Dr. Leonard J. Wolgast

Dr. Leonard Wolgast possesses a Doctorate degree in Wildlife Ecology along with a Masters degree in Environmental Sciences and a Bachelor of Science degree in Wildlife Sciences from Rutgers University. As a Principal of Eastern States Environmental Associates, Inc., Dr. Wolgast is involved extensively with numerous aspects of environmental consultation, regulatory compliance and permit application, and expert representation for a wide variety of clients, both private and public. Dr. Wolgast has assumed the responsibilities of the Head of the Forestry and Wildlife Section of Cook College, Rutgers University since 1981. Dr. Wolgast has been involved in many aspects of the environmental consulting field including environmental impact analysis, site feasibility, wetland inventory and analysis, natural resource inventories and associated conservation recommendations, environmental mitigation and habitat enhancement\restoration, etc. and has provided such consultation services to a wide variety of clients throughout the United States. Organizations for which he has provided service include the U.S. Fish and Wildlife Service, U.S. Environmental Protection Agency, U.S. General Services Administration, State Departments of Environmental Protection, municipal planning and zoning boards, environmental and health commissions, public utilities, professional developers and engineers, and land owners. Dr. Wolgast has authored numerous technical and popular publications on a variety of environmental subjects. He is also responsible for the review of such publications for certain professional environmental organizations.

Edward A. Kuc

Edward Kuc possesses a Bachelor of Science degree in Natural Resource Management from Rutgers University. As a Principal of Eastern States Environmental Associates, Inc., Edward Kuc is involved extensively with numerous aspects of environmental consultation, regulatory compliance and permit application, and expert representation for a wide variety of clients, both private and public. Edward Kuc has acquired extensive experience with a variety of aspects pertaining to the management of the natural resources and has been employed in numerous positions pertaining to such. Edward Kuc has assumed the responsibilities of Supervisory Natural Resource Biologist of the ecological staff of an environmental consulting firm dealing extensively with wetland inventory and analysis, environmental impact analysis, natural resource inventories and associated conservation recommendations, environmental mitigation, etc. Edward Kuc has held the position of Research Biologist for the U.S. Forest Service in Clearwater National Forest, Idaho, with responsibilities including the assumption of aquatic, fishery, wildlife, and natural resource impact analysis research projects. Edward Kuc has also been employed as a Research and Management Technician for the NJ Division of Fish, Game, and Wildlife for a variety of research programs including Freshwater Fisheries, Upland Game and Furbearer Management, Black Bear, Waterfowl, and Whitetail Deer Management. Edward Kuc has provided environmental consultation services for various municipal planning and zoning boards, environmental and health commissions, private developers, professional engineering firms, and land owners. Edward Kuc serves on the Executive Board of The NJ Chapter of The Wildlife Society.

ATTACHMENT B

Correspondence on Threatened, Endangered, or Special Concern Species

Commonwealth of Pennsylvania
Pennsylvania Fish and Boat Commission
Division of Environmental Services
450 Robinson Lane
Bellefonte, PA 16823
814-359-5115
December 17, 2002

IN REPLY REFER TO
SIR# 10786

CDM
Andrew P. Hopton, Biologist
993 Old Eagle School Road, Suite 408
Wayne, PA 19087

RE: Species Impact Review (SIR) – Rare, Candidate, Threatened and Endangered Species
Request for Natural Diversity Inventory Review
Lower Salford Township, Montgomery County, Pennsylvania

Dear Mr. Hopton:

I have examined the map accompanying your recent correspondence which shows the location for the proposed above referenced project.

Presently, none of the fishes, amphibians or reptiles we list as endangered or threatened are known to occur at or in the immediate vicinity of this study area.

To allow faster processing of Species Impact Reviews (SIRs) in the future, we are requesting that the enclosed, revised "SIR Request Form" be completed and returned to this office together with other relevant project information. Please make copies of the enclosed form and use with all future project reviews. If you have received, and in fact are using the new form, disregard the above request. Please note that the Pennsylvania Fish & Boat Commission conducts Species Impact Reviews **only for reptiles, amphibians, fishes, and aquatic invertebrates**. Reviews concerning other natural resources must be submitted to other appropriate agencies. In any future correspondence with us regarding this specific project, please refer to the SIR number above.

Thank you in advance for your cooperation.

Sincerely,

David E. Spotts

David E. Spotts, Chief
Watershed Analysis Section

DES:srh

Enclosure

Pennsylvania Fish & Boat Commission

established 1866

Division of Environmental Services
Natural Diversity Section
450 Robinson Lane
Bellefonte, PA 16823-9620
(814) 359-5237 Fax: (814) 359-5175

April 25, 2005

IN REPLY REFER TO
SIR # 19120

CDM
[redacted]
993 OLD EAGLE SCHOOL ROAD
SUITE 408
WAYNE, PA 19087

RE: **Species Impact Review (SIR) - Rare, Candidate, Threatened and Endangered Species**
SALFORD QUARRY
UPDATE TO SIR#10786
PNDI Search Number (if available):
LOWER SALFORD Township/Borough, MONTGOMERY County, Pennsylvania

This responds to your inquiry about a Pennsylvania Natural Diversity Inventory (PNDI) Internet Database search "potential conflict" or a threatened and endangered species impact review. These projects are screened for potential conflicts with rare, candidate, threatened or endangered species under Pennsylvania Fish & Boat Commission jurisdiction (fish, reptiles, amphibians, aquatic invertebrates only) using the Pennsylvania Natural Diversity Inventory (PNDI) database and our own files. These species of special concern are listed under the Endangered Species Act of 1973, the Wild Resource Conservation Act, and the Pennsylvania Fish & Boat Code (Chapter 75), or the Wildlife Code. The absence of recorded information from our files does not necessarily imply actual conditions on site. Future field investigations could alter this determination. The information contained in our files is routinely updated. A Species Impact Review is valid for one year only.

_X_ ***NO ADVERSE IMPACTS EXPECTED FROM THE PROPOSED PROJECT***

_X_ Except for occasional transient species, rare, candidate, threatened or endangered species under our jurisdiction are not known to exist in the vicinity of the project area. Therefore, no biological assessment or further consultation regarding rare species is needed with the Commission. Should project plans change, or if additional information on listed or proposed species becomes available, this determination may be reconsidered.

___ An element occurrence of a rare, candidate, threatened, or endangered species under our jurisdiction is known from the vicinity of the proposed project. However, given the nature of the proposed project, the immediate location, or the current status of the nearby element occurrence(s), no adverse impacts are expected to the species of special concern.

If you have any questions regarding this review, please contact the biologist indicated below:

___	Jeff Schmid	814-359-5236	___	J.R. Holtsmaster	814-359-5194
_X_	Kathy Derge	814-359-5186	___	Bob Morgan	814-359-5129

I am enclosing a copy of our "SIR Request Form", which is to be used for all future species impact review requests. Please make copies of the attached form and use with all future project reviews. Thank you in advance for your cooperation and attention to this important matter of species conservation and habitat protection.

AR305080

SIGNATURE: ______________________ DATE: April 25, 2005
Christopher A. Urban
Chief, Natural Diversity Section

United States Department of the Interior

FISH AND WILDLIFE SERVICE

Pennsylvania Field Office
315 South Allen Street, Suite 322
State College, Pennsylvania 16801-4850

November 22, 2002

Andrew P. Hopton
Biologist
CDM
993 Old Eagle School Road
Suite 408
Wayne, PA 19087

Dear Mr. Hopton:

This responds to your letter of November 11, 2002, requesting information about natural resource areas of special concern, and federally listed and proposed species in the vicinity of the proposed Salford Quarry site located in Lower Salford Township, Montgomery County, Pennsylvania. The following comments are provided pursuant to the Fish and Wildlife Coordination Act (48 Stat. 401, 16 U.S.C. 661 *et seq.*) and the Endangered Species Act of 1973 (87 Stat. 884, as amended; 16 U.S.C. 1531 *et seq.*).

Except for occasional transient species, no federally listed or proposed threatened or endangered species under our jurisdiction are known to occur within the project impact area. Therefore, no biological assessment nor further consultation under the Endangered Species Act are required with the Fish and Wildlife Service. This determination is valid for two years from the date of this letter. If the proposed project has not been fully implemented prior to this, an additional review by this office will be necessary. Should project plans change, or if additional information on listed or proposed species becomes available, this determination may be reconsidered. A compilation of certain federal status species in Pennsylvania is enclosed for your information.

Based on our office review of project information provided and map reconnaissance (i.e., County Soils maps and/or National Wetland Inventory maps), wetlands may occur within the boundaries of the proposed project. Work in wetlands requires permits from the Pennsylvania Department of Environmental Protection and/or the Army Corps of Engineers. We suggest you contact the DEP and the Corps at the addresses listed below for information on permit requirements.

Pennsylvania Department of
Environmental Protection
Division of Rivers and
Wetlands Conservation
P.O. Box 8554
Harrisburg, PA 17105-8554

District Engineer, Philadelphia District
U.S. Army Corps of Engineers
100 Penn Square East
Philadelphia, PA 19107

By copy of this letter, we are informing these agencies of the proposed project.

This response relates only to endangered and threatened species under our jurisdiction and a preliminary review for wetlands, based on an office review of the proposed project's location. No field inspection of the project area has been conducted by this office. Therefore, we suggest contacting a qualified consultant to evaluate your site for potential wetland impacts.

For information regarding State resources of special concern, including State-listed endangered and threatened species, please contact the Pennsylvania Game Commission (birds and mammals; State Game Lands), the Pennsylvania Fish and Boat Commission (fish, reptiles, amphibians and aquatic invertebrates; trout streams), the Pennsylvania Department of Conservation and Natural Resources (PNDI; plants and plant sanctuaries; State Forests; State Parks; Natural Areas; State Wild and Scenic Rivers) and the Department of Environmental Protection (Special Protection Watersheds; Wetlands).

If we can be of further assistance, please contact Michael Schmaus of my staff at 814-234-4090.

Sincerely,

David Densmore
Supervisor

Enclosure

FEDERALLY LISTED, PROPOSED AND CANDIDATE SPECIES
(in Pennsylvania)

Common Name	Scientific Name	Status[1]	Distribution
FISHES			
Shortnose sturgeon[2]	*Acipenser brevirostrum*	E	Delaware River & other Atlantic coastal waters
REPTILES			
Bog turtle	*Clemmys muhlenbergii*	T	Current - Adams, Berks, Bucks, Chester, Cumberland, Delaware, Franklin, Lancaster, Lebanon, Lehigh, Monroe, Montgomery, Northampton and York Co. Historic - Crawford, Mercer and Philadelphia Co.
Eastern massasauga rattlesnake	*Sistrurus catenatus catenatus*	C	Current - Butler, Crawford, Mercer and Venango Co. Historic - Allegheny and Lawrence Co.
BIRDS			
Bald eagle	*Haliaeetus leucocephalus*	T	Suitable habitats across the state. Recent nesting in Butler, Cameron, Centre, Chester, Crawford, Dauphin, Erie, Forest, Huntingdon, Lancaster, Lebanon, Mercer, Northumberland, Pike, Tioga, Venango, Warren and York Co. Wintering concentrations occur near ice-free sections of rivers, lakes and reservoirs, including the Delaware River.
Piping plover	*Charadrius melodus*	E	Presque Isle (Erie County). Migratory. No nesting in Pennsylvania since mid-1950s.
MAMMALS			
Indiana bat	*Myotis sodalis*	E	Winter hibernacula: Armstrong, Blair, Lawrence, Luzerne, Mifflin and Somerset Co.
MOLLUSKS			
Dwarf wedgemussel	*Alasmidonta heterodon*	E	Current - Delaware River (Wayne Co.). Historic - Delaware River watershed (Bucks, Carbon, Chester and Philadelphia Co.); Susquehanna River watershed (Lancaster Co.)
Clubshell mussel	*Pleurobema clava*	E	French Creek and Allegheny River watersheds (Clarion, Crawford, Erie, Forest, Mercer, Venango and Warren Co.)
Northern riffleshell	*Epioblasma torulosa rangiana*	E	French Creek and Allegheny River watersheds (Clarion, Crawford, Erie, Forest, Mercer, Venango and Warren Co.)
PLANTS			
Northeastern bulrush	*Scirpus ancistrochaetus*	E	Current - Adams, Bedford, Blair, Carbon, Centre, Clinton, Cumberland, Dauphin, Franklin, Huntingdon, Lackawanna, Lehigh, Lycoming, Mifflin, Monroe, Perry, Snyder and Union Co. Historic - Northampton Co.
Small-whorled pogonia	*Isotria medeoloides*	T	Current - Centre, Chester and Venango Co. Historic - Berks, Greene, Monroe, Montgomery and Philadelphia Co.

[1] E = Endangered, T = Threatened, PE = Proposed Endangered, PT = Proposed Threatened, C = Candidate *Revised 12/05/00*
[2] Shortnose sturgeon is under the jurisdiction of the National Marine Fisheries Service

U.S. FISH AND WILDLIFE SERVICE
315 SOUTH ALLEN ST., SUITE 322, STATE COLLEGE, PA 16801

FEDERALLY LISTED AND PROPOSED SPECIES THAT NO LONGER OCCUR IN PENNSYLVANIA

COMMON NAME	SCIENTIFIC NAME	STATUS**	FORMER DISTRIBUTION
MAMMALS			
Canada lynx	*Lynx canadensis*	PT	north-central PA (Tioga Co.)
Delmarva Peninsula fox squirrel	*Sciurus niger cinereus*	E	mature forests of southeastern PA (Delaware and Chester Co.)
Eastern cougar	*Felis concolor couguar*	E	state-wide
Grey wolf	*Canis lupus*	E	state-wide
MOLLUSKS			
Fanshell*	*Cyprogenia stegaria*	E	Ohio River drainage
Orange pimpleback*	*Plethobasus striatus*	E	Ohio River drainage
Pink mucket pearly mussel*	*Lampsilis abrupta*	E	Ohio River drainage
Ring pink mussel*	*Obovaria retusa*	E	Ohio River drainage
Rough pigtoe*	*Pleurobema plenum*	E	Ohio River drainage
INSECTS			
American burying beetle	*Nicrophorus americanus*	E	state-wide
Karner blue butterfly	*Lycaeides melissa samuelis*	E	pine barrens, oak savannas (wild lupine habitat) (Wayne Co.)
Northeastern beach tiger beetle	*Cicindela dorsalis dorsalis*	T	along large rivers in southeastern PA
PLANTS			
Eastern prairie fringed orchid	*Platanthera leucophaea*	T	wet prairies, bogs (Crawford Co.)
Sensitive joint-vetch	*Aeschynomene virginica*	T	freshwater tidal marshes of Delaware river (Delaware and Philadelphia Co.)
Virginia spiraea*	*Spiraea virginiana*	T	along Youghiogheny River (Fayette Co.)
Smooth coneflower	*Echinacea laevigata*	E	serpentine barrens (Lancaster Co.)

Revised 10/19/00

* *It is possible that remnant populations of some of these species (indicated with an *) may still occur in Pennsylvania, however, there have been no confirmed sightings of these species for over 70 years.*

** *E = Endangered, T = Threatened, PT = Proposed Threatened*

The following is a partial list of additional species that no longer occur in Pennsylvania: moose, bison, wolverine, passenger pigeon, Bachman's sparrow, greater prairie-chicken, olive-sided flycatcher, Bewick's wren, eastern tiger salamander, blue pike, butterfly mussel, Diana fritillary butterfly, precious underwing moth, deertoe mussel, marbled underwing moth, cobblestone tiger beetle, mountain clubmoss, crested yellow orchid, red milkweed, American barberry, small white lady's-slipper, etc. etc.

AR305084

U.S. FISH AND WILDLIFE SERVICE
315 SOUTH ALLEN ST., SUITE 322, STATE COLLEGE, PA 16801

United States Department of the Interior

FISH AND WILDLIFE SERVICE

Pennsylvania Field Office
315 South Allen Street, Suite 322
State College, Pennsylvania 16801-4850

May 5, 2005

[redacted]
CDM
993 Old Eagle School Road
Suite 408
Wayne, PA 19087

Re: USFWS Project #20051363

Dear [redacted]

This responds to your letter of April 8, 2005, requesting information about federally listed and proposed endangered and threatened species within the vicinity of the Salford Quarry Site located in Lower Salford Township, Montgomery County, Pennsylvania. The following comments are provided pursuant to the Endangered Species Act of 1973 (87 Stat. 884, as amended; 16 U.S.C. 1531 *et seq.*) to ensure the protection of endangered and threatened species.

The proposed project is within the known range of the bog turtle (*Clemmys muhlenbergii*), a species that is federally listed as threatened. Bog turtles inhabit shallow, spring-fed fens, sphagnum bogs, swamps, marshy meadows, and pastures characterized by soft, muddy bottoms; clear, cool, slow-flowing water, often forming a network of rivulets; high humidity; and an open canopy. Bog turtles usually occur in small, discrete populations occupying suitable wetland habitat dispersed along a watershed. The occupied "intermediate successional stage" wetland habitat is usually a mosaic of micro-habitats ranging from dry pockets, to areas that are saturated with water, to areas that are periodically flooded. Some wetlands occupied by bog turtles are located in agricultural areas and are subject to grazing by livestock.

To determine the potential effects of the proposed project on bog turtles and their habitat, begin by identifying all wetlands in, and within 300 feet of, the project area. The project area includes all areas that will be permanently or temporarily affected by any and all project features, including building, roads, staging areas, utility lines, outfall and intake structures, wells, stormwater retention or detention basins, parking lots, driveways, lawns, etc. The area of investigation should be expanded when project effects might extend more than 300 feet from the project footprint. For example, the hydrological effects of some projects (*e.g.*, large residential or commercial developments; golf courses; community water supply wells) might extend well beyond the project footprint due to the effects that impervious surfaces or groundwater pumping may have on the hydrology of nearby groundwater-dependent wetlands. Wetlands should be included on a map showing existing as well as proposed project features.

If someone qualified to identify and delineate wetlands has, through a field investigation, determined that no wetlands are located in or within 300 feet of the project area (or within the expanded investigation area, as described above), it is not likely that your project will adversely affect the bog turtle. If this is the case, no further consultation with the Fish and Wildlife Service is necessary, although we would appreciate receiving a courtesy copy of the wetland investigator's findings for our files.

If wetlands have been identified in or within 300 feet of the project area (or in an expanded investigation area, as described above), their potential suitability as bog turtle habitat should be assessed, as described under "*Bog Turtle Habitat Survey*" (Phase 1 survey) of the enclosed *Guidelines for Bog Turtle Surveys*. A list of qualified bog turtle surveyors is enclosed, although the habitat survey could also be conducted by someone not on this list (*e.g.*, a biologist or wetland scientist with training in bog turtle habitat identification). A Phase 1 field form and report template are enclosed for your convenience and use. Survey results should be submitted to the Service for review and concurrence.

If potential bog turtle habitat is found in or near the project area, efforts should be made to avoid any direct or indirect impacts to those wetlands (see enclosed *Bog Turtle Conservation Zones*). Avoidance of direct and indirect effects means no disturbance to or encroachment into the wetlands (*e.g.*, filling, ditching or draining) for any project-associated features or activities. Adverse effects may also be anticipated to occur when lot lines include portions of the wetland; when an adequate upland buffer is not retained around the wetland (see *Bog Turtle Conservation Zones*); or when roads, stormwater/sedimentation basins, impervious surfaces, or wells affect the hydrology of the wetland.

We recommend that if potential habitat is found, you submit (along with your Phase 1 survey results) a detailed project description and detailed project plans documenting how direct and indirect impacts to the wetlands will be avoided. If adverse effects to these wetlands cannot be avoided, a more detailed and thorough survey should be done, as described under "*Bog Turtle Survey*" (Phase 2 survey) of the *Guidelines*. The Phase 2 survey should be conducted by a qualified biologist with bog turtle field survey experience (see enclosed list of qualified surveyors), and survey results should be submitted to the Service for review and concurrence.

In cases where adverse effects to federally listed species cannot be avoided, further consultation with the Service would be necessary to avoid potential violations of section 9 (prohibiting "take" of listed species) and/or section 7 (requiring federal agencies to consult) of the Endangered Species Act. Information about the section 7 and section 10 consultation processes (for federal and non-federal actions, respectively) can be obtained by contacting this office or accessing the Service's Endangered Species Home Page (http://endangered.fws.gov).

This response relates only to endangered and threatened species under our jurisdiction based on an office review of the proposed project's location. No field inspection of the project area has been conducted by this office. Consequently, this letter is not to be construed as addressing potential Service concerns under the Fish and Wildlife Coordination Act or other authorities. A compilation of certain federal status species in Pennsylvania is enclosed for your information.

To avoid potential delays in reviewing your project, please use the above-referenced USFWS project tracking number in any future correspondence regarding this project.

Please contact Pam Spayd of my staff at 814-234-4090 if you have any questions or require further assistance regarding this matter.

Sincerely,

David Densmore
Supervisor

Enclosures

Federally Listed, Proposed, and Candidate Species in Pennsylvania

(revised July 27, 2004)

Common Name	Scientific Name	Status[1]	Distribution (Counties and/or Watersheds)
MAMMALS			
Indiana bat	*Myotis sodalis*	E	Hibernacula: Armstrong, Blair, Fayette, Lawrence, Luzerne, Mifflin and Somerset Co. Maternity sites: Blair Co.
BIRDS			
Bald eagle	*Haliaeetus leucocephalus*	T	Nesting: Armstrong, Berks, Butler, Centre, Chester, Crawford, Dauphin, Erie, Forest, Huntingdon, Lancaster, Lebanon, Lycoming, Mercer, Monroe, Montgomery, Northumberland, Pike, Tioga, Venango, Warren, Wayne and York Co. Winter: near ice-free sections of rivers, lakes and reservoirs (e.g., Delaware River, Pymatuning Reservoir)
Piping plover	*Charadrius melodus*	E	Migratory. No nesting in Pennsylvania since 1950s. Designated critical habitat on Presque Isle (Erie Co)
REPTILES			
Bog turtle	*Clemmys (Glyptemys) muhlenbergii*	T	Adams, Berks, Bucks, Chester, Cumberland, Delaware, Franklin, Lancaster, Lebanon, Lehigh, Monroe, Montgomery, Northampton, Schuylkill and York Co. [Historically found in Crawford, Mercer and Philadelphia Co.]
E. massasauga rattlesnake	*Sistrurus catenatus catenatus*	C	Butler, Crawford, Mercer and Venango Co. [Historically found in Allegheny and Lawrence Co.]
MUSSELS			
Clubshell	*Pleurobema clava*	E	French Creek and Allegheny River (and some tributaries) in Clarion, Crawford, Erie, Forest, Mercer, Venango, and Warren Co.; Shenango River (Mercer and Crawford Co.) [Has not been found recently in 13 streams of historical occurrence in Butler, Beaver, Fayette, Greene, Lawrence, Mercer, and Westmoreland Co.]
Dwarf wedgemussel	*Alasmidonta heterodon*	E	Delaware River (Wayne Co.). [Has not been found recently in streams of historical occurrence in the Delaware River watershed (Bucks, Carbon, Chester, Philadelphia Co.) or Susquehanna River watershed (Lancaster Co.)]
Northern riffleshell	*Epioblasma torulosa rangiana*	E	French Creek and Allegheny River (and some tributaries) in Clarion, Crawford, Erie, Forest, Mercer, Venango, and Warren Co. [Has not been found recently in streams of historical occurrence, including: Shenango River (Lawrence Co.), Conewango Creek (Warren Co.)]

AR305088

Common Name	Scientific Name	Status[1]	Distribution (Counties and/or Watersheds)
MUSSELS (continued)			
Rayed bean	*Villosa fabalis*	C	French Creek and Allegheny River (Armstrong, Clarion, Crawford, Erie, Forest, Mercer, Venango, Warren Co.); Cussewago Creek (Crawford Co.). [Has not been found recently in 5 streams of historical occurrence in Armstrong, Lawrence, Mercer and Warren Co.]
Sheepnose	*Plethobasus cyphyus*	C	Allegheny River (Forest and Venango Co.). [Has not been found recently in streams of historical occurrence, including: Allegheny River (Armstrong Co.), Beaver River (Lawrence Co.), Ohio River (Allegheny and Beaver Co.), and Monongahela River (Washington Co.)]
FISH			
Shortnose sturgeon[2]	*Acipenser brevirostrum*	E	Delaware River and other Atlantic coastal waters
PLANTS			
Northeastern bulrush	*Scirpus ancistrochaetus*	E	Adams, Bedford, Blair, Carbon, Centre, Clinton, Columbia, Cumberland, Dauphin, Franklin, Huntingdon, Lackawanna, Lehigh, Lycoming, Mifflin, Monroe, Perry, Snyder, Tioga, and Union Co. [Historically found in Northampton Co.]
Small-whorled pogonia	*Isotria medeoloides*	T	Centre, Chester, and Venango Co. [Historically found in Berks, Greene, Monroe, Montgomery and Philadelphia Co.]

[1] E = Endangered; T = Threatened; P = Proposed for listing; C = Candidate
[2] Shortnose sturgeon is under the jurisdiction of the National Marine Fisheries Service

AR305089

AR101298

PNDI Pennsylvania Natural Diversity Inventory
Scientific information and expertise for the conservation of Pennsylvania's native biological diversity

December 9, 2002

Fax 717-770-0271
717-772-0258

Bureau of Forestry

Andrew P. Hopton
CDM Federal Programs Co.
993 Old Eagle School Rd., Suite 408
Wayne, PA 19087

Re: Pennsylvania Natural Diversity Inventory Review for the Proposed CERCLA Remedial Investigation and Feasibility Study, Salford Quarry, Salford Twp. **PER NO: 13800**

Dear Mr. Hopton:

In response to your request November 11, 2002 to review the above mentioned project, we have reviewed the area using the Pennsylvania Natural Diversity Inventory (PNDI) information system. PNDI records indicate that no occurrences of species of special concern are known to exist within the project area, therefore we do not anticipate any impact on endangered, threatened, or rare species at this location. PNDI attempts to be a complete information resource on species of special concern within the Commonwealth. However, it may not contain all location information for species within the jurisdiction of other agencies. Please contact the Fish and Boat Commission and US Fish and Wildlife Service for information on species within their purview.

PNDI is a site specific information system that describes significant natural resources of Pennsylvania. This system includes data descriptive of plant and animal species of special concern, exemplary natural communities and unique geological features. PNDI is a cooperative project of the Department of Conservation and Natural Resources, The Nature Conservancy and the Western Pennsylvania Conservancy. This response represents the most up-to-date summary of the PNDI data files and is **good for one year**. An absence of recorded information does not necessarily imply actual conditions on-site. A field survey of any site may reveal previously unreported populations.

Feel free to phone our office if you have questions concerning this response or the PNDI system, and please refer to the P.E.R. Reference Number at the top of the letter in future correspondence concerning this project.

Sincerely,

Justin P. Newell
Environmental Review Specialist

ATTACHMENT C

Photographs of Stressed Vegetation

Photo No. 1
Site/Location: Salford Quarry Site, Lower Salford Township, PA
Description: Stressed vegetation located near soil sample location SL08 on western side of site property. This photograph was taken facing northwest.
Date: August 17, 2004 Time: 1113
Photographer: [redacted]

Photo No. 2
Site/Location: Salford Quarry Site, Lower Salford Township, PA
Description: Stressed vegetation located at spring location SW/SD01. This photograph was taken facing east.
Date: May 18, 2005 Time: 1742
Photographer: [redacted]

Photo No. 3
Site/Location: Salford Quarry Site, Lower Salford Township, PA
Description: Stressed vegetation located within the dry creek bed approximately 200 feet south of the spring. This photograph was taken facing north.
Date: May 18, 2005 Time: 1746
Photographer: [redacted]