Public Health Assessment

Public Comment Release

ORE KNOB MINE NPL SITE

ASHE COUNTY, NORTH CAROLINA

EPA FACILITY ID: NCN000409895

Prepared by
North Carolina Department of Health and Human Services

APRIL 14, 2010

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Prepared under a Cooperative Agreement with the
U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Agency for Toxic Substances and Disease Registry
Division of Health Assessment and Consultation
Atlanta, Georgia 30333

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Occupational and Environmental Epidemiology Branch
Under Cooperative Agreement with the
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Agency for Toxic Substances and Disease Registry

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Acronyms

AF	Attenuation factor
ATSDR	Agency for Toxic Substances and Disease Registry
CDC	Center for Disease Control and Prevention
CF	Conversion factor
cm	Centimeter
CREG	ATSDR Cancer Risk Evaluation Guide
CR	Contact rate
CV	Comparison Value
DAF	Dermal absorption efficiency
DPH	N.C. DHHS Division of Public Health
DWM	N.C. DENR Division of Waste Management
DWQ	N.C. DENR Division of Water Quality
ED	Exposure duration
EF	Exposure frequency
EMEG	ATSDR Environmental Media Evaluation Guide
EPA	U.S. Environmental Protection Agency
HG	Health Guideline value
IRi	Inhalation rate
IUR	Inhalation Unit Risk factor
Kg	Kilogram
L	Liter
LOAEL	Lowest Observed Adverse Effect Level
LTHA	EPA's Lifetime Health Advisory Level for drinking water
MCLG	EPA Maximum Contaminant Level Goal
MCL	EPUSA Maximum Contaminant Level
M	Meter
mg	milligram
µg/m^3	micro-gram per cubic meter
µg	microgram
ng	nano-gram
NA	Not applicable
N.C. DENR	North Carolina Department of the Environment and Natural Resources
N.C. DHHS	North Carolina Department of Health and Human Services
NIOSH	National Institute for Occupational Safety and Health
NOAEL	No Observed Adverse Effect Level
ppm	Parts per million
ppb	Parts per billion
RfC	Reference Concentration
RfD	Reference Dose
RMEG	ATSDR Reference Dose Media Evaluation Guide
SVOC	Semi-volatile organic compound
VOC	Volatile organic compound

*** These acronyms may or may not be used in this report**

Foreword

The North Carolina Department of Public Health (N.C. DPH) Medical Evaluation and Risk Assessment Unit's Health Assessment, Consultation and Education (HACE) program has prepared this Public Health Assessment in cooperation with the Agency for Toxic Substances and Disease Registry (ATSDR). ATSDR is part of the U.S. Department of Health and Human Services and is the principal federal public health agency responsible for the health issues related to hazardous waste. This health assessment was prepared in accordance with the methodologies and guidelines developed by ATSDR.

The purpose of this Public Health Assessment is to identify and prevent harmful health effects resulting from exposure to hazardous substances in the environment. Health assessments focus on health issues associated with specific exposures that have happened in the past, are currently occurring, or are believed to be possible in the future based on current site conditions. The HACE Program evaluates sampling data collected from a hazardous waste site, determines whether exposures have occurred or could occur in the future, reports any potential harmful effects, and then recommends actions to protect public health. The findings in this report are relevant to conditions at the site during the time this health assessment was conducted and may not be applicable if site conditions or land uses change in the future.

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SUMMARY

INTRODUCTION

The N.C. Division of Public Health's (DPH) top priority is to make sure the community near the Ore Knob Mine NPL site (EPA ID: NCN000409895) has the best science information available to safeguard its health.

The N.C. DPH performed a comprehensive evaluation of available environmental analytical data associated with the Ore Knob Mine NPL site, collected from 1987 through 2008. This public health assessment evaluates potential public health hazards related to exposures to soils, sediments, surface waters and mine waste materials on the site. It also evaluates private well drinking water and soils from residences near the site, and surface waters, sediments, and floodplain soils, and fish tissue associated with water bodies downstream of the site. Many of the samples evaluated were collected in areas expected to represent the highest potential contamination related to mining activities, and thus represent the greatest potential to result in adverse health effects associated with coming into contact with these materials.

Copper mining occurred intermittently at the Ore Knob Mine from the 1850s through 1962, with 2 main periods of activity from 1873 to 1883 and 1957 to 1962. Mining and mineral-related activities at the site included mining, concentration, roasting, smelting, and waste management. Wastes from site operations are known to have contaminated on-site surface waters and sediments with acid and heavy metals. Multiple areas of mining and processing waste material are present on the site, including a 20-acre tailings impoundment holding an estimated 720,000 cubic yards of material. The tailings impoundment is held in place by a 60 foot high, 700 foot wide earthen dam. Mining-related activities have also affected downstream surface waters, sediment, and floodplain soils as a result of surface soil and water runoff. Currently, EPA is on-site to remediate and stabilize the site to prevent further environmental damage to the surrounding areas.

OVERVIEW

The N.C. DPH reached four important conclusions about the Ore Knob Mine site:

CONCLUSION 1

The N.C. DPH concludes that drinking water from private wells of some residences near the Ore Knob Mine NPL site for many years could harm people's health due to elevated concentrations of the metals manganese and cadmium. It is not known if the elevated metals are due to the former mining operations.

BASIS FOR DECISION

Manganese concentrations found in 3 residential private wells sampled once in 2007 (identified as locations OK702, OK706 and OK707) were at concentrations that indicate the potential for adverse health effects to children and adults if they drank the water over many years. Concentrations at all 3 locations exceeded EPA's non-regulatory Lifetime Health Advisory (LTHA) level for drinking water and the estimated exposure doses exceeded EPA oral reference dose (RfD).

Cadmium was found at one location (OK702) at a concentration less than EPA's Maximum Contaminant Level ("MCL") for drinking water, but at a level that indicates the potential for adverse health effects to children that consume the waters for many years. These wells are located between the 1950s mine and mill and 19^{th} century operations area of Ore Knob Mine site.

The information currently available is not adequate to determine if these elevated metals are due to the former mining operations. The concentrations of these metals do not exceed EPA regulatory levels used for evaluation of public water systems, but do exceed values used by ATSDR to identify concentrations that may be associated with negative health impacts to sensitive individuals drinking the water for many years.

NEXT STEPS

The N.C. DPH makes the following recommendations:

- Identify if groundwater flowing away from the site is contaminated and impacting area residential private wells.
- Collect and analyze additional samples for analysis from the previously sampled residential private wells to better characterize the metal concentrations. If the additional manganese and cadmium analyses indicate the potential for adverse health effects, provide the residents with information on the alternatives to reduce their exposure or the potential for negative health effects.
- Identify additional private residential wells in the area that may be affected by the site, including those of residences on the access drive to the 1950s mine and mill area, and analyze their drinking water sources for metals, cyanide and sulfide species
- Perform periodic sampling and analysis of residential private wells that may be affected by Ore Knob Mine to provide adequate characterization to identify potential health impacts associated with drinking the water.
- If concentrations of substances are found in residential private wells in the vicinity of the site at concentrations that exceed regulatory or health guidelines, and these substances can be linked to sources emanating from the Ore Knob Mine NPL site, a clean source of drinking water should be provided. Drilling new wells or providing whole-house filter or reverse osmosis systems would be suitable

means of permanently providing a clean source of drinking water.

- If elevated concentrations of substances are identified that are not associated with the mine operations that may pose health risks, inform the residents and provide them with options to reduce their exposure or potential health risks.
- Include analysis of the metals aluminum, arsenic, cadmium, copper, iron and manganese in new wells installed in the area around Ore Knob Mine.

CONCLUSION 2

The N.C. DPH concludes that the metals copper, iron and aluminum are at concentrations in the soils from some residential lawns in the vicinity of the site that could cause adverse health effects to children ingesting (eating) the soil. It is not known if these concentrations are typical for soils in this area or if they are related to historical mining operations.

BASIS FOR DECISION

High concentrations of copper and iron were identified in the soils located at one residence (OK406, located between the east side of the 1950s mine and mill area and Little Peak Creek Road). Children accidently ingesting (eating) these soils daily over a number of years may be subject to harmful health effects. Children playing in these yards could be exposed to copper by putting dirty hands or toys in their mouth. Some children may intentionally eat the soil, or eat the soil on unwashed items grown in the family garden.

The concentration of copper in the soils at 2 residences (OK406 and OK407, located between the southeast corner of the 1950s mine and mill area and Little Peak Creek Road) and the concentration of aluminum in soils at all 3 residences (OK406, OK407 and OK408, located between the south end of the 1950s mine and mill area and Ore Knob Road) if ingested by children in very large quantities over a short time period (1-day “pica” ingestion rates) could cause adverse health effects.

The aluminum concentrations identified for the above residential soils may be typical of area soil background concentrations and may not have been impacted by mining activities. The copper and iron residential soil concentrations are greater than those identified for the local area background. The residential soil samples may represent areas of higher metal concentrations than those throughout the given property.

NEXT STEPS

The N.C. DPH makes the following recommendations:

- Inform parents at these residences of the potential hazards to children accidently ingesting the soils. To protect their children they could:

1. Monitor their children's behavior when playing outdoors to prevent them from eating soil.
2. Regularly wash outdoor toys.
3. After playing outdoors have children wash their hands before they eat.
4. Wash all homegrown garden produce before it is eaten.
5. Seek advice from your private physician or a N.C. DPH Public Health physician if you think your child may have consumed large amounts of soil.
6. Prevent children from playing in areas of bare soil. Children will have less direct contact with the soil if they play in areas covered by grass. Establish ground cover (grass) in areas with bare soil to decrease children's exposure.

CONCLUSION 3

N.C. DPH concludes that concentrations of copper, aluminum and zinc found in soils, sediments and mine waste materials in several areas on the Ore Knob Mine site could harm the health of children that accidently ingest these materials while on the site for recreational activities.

BASIS FOR DECISION

High concentrations of the metal copper were found on the Ore Knob Mine site in the soils, Ore Knob Branch sediments near the main tailings impoundment, and tailings and other mine waste materials found on site. Children accessing the site occasionally over several years for recreational activities and accidently ingesting these materials may be at risk of adverse health effects.

The concentrations of the metals copper, aluminum and zinc found in some areas of the site are at concentration high enough to harm children ingesting very large amounts of these materials in a short time period, such as 1 day.

NEXT STEPS

The N.C. DPH recommends:

- All recreational visits to the Ore Knob Mine site be discouraged, especially those by children.
- Access to the site should be controlled and limited to remediation and regulatory personnel. Post "No Trespassing" or "hazard identification" signs around the perimeter of the site.
- Remediation (capping) of the on-site tailings piles should continue to prevent direct contact to contaminated soil or mine waste materials.
- Members of the hunting club that have been granted access to areas connected to the mine site should be told of the potential hazards to

themselves and their children.

- Limit residential development on or near areas of the site that contain mine wastes, highly contaminated surface waters or soils, or acid mine drainage.

CONCLUSION 4	**The N.C. DPH concludes that incidental ingestion of metals in off-site sediments and floodplain soils during recreational activities on waterways downstream of Ore Knob Mine is not expected to harm people's health.**
BASIS FOR DECISION	While elevated concentrations of copper, aluminum and zinc were found in sediments and floodplain soils associated with Peak Creek and South Fork New River, it is not expected that persons would come into contact with these areas with a frequency over a number of years that would lead to ingestion of a sufficient amount of sediment or soil to cause harm.
NEXT STEPS	The N.C. DPH recommends: ▪ Continue to monitor and implement efforts to control the release of contaminated media such as surface waters, sediments and soils from the site. If these environmental media show elevated concentrations of metals (above the range of what is normally expected for the area) or other contaminants that may present a health hazard, steps should be taken to inform the community that may have contact with these media. ▪ If releases of surface waters, sediments or soils from the site show elevated contaminant concentrations, periodically monitor the level of metals in the types of fish commonly caught and eaten by anglers downstream of the site. Inform anglers of potential hazards to themselves or their family members associated with eating these fish due to elevated metal concentrations.
FOR MORE INFORMATION	If you have concerns about your health as it relates to this site you should contact your health care provider. You can also call the N.C. Division of Public Health at (919) 707-5900, or send an e-mail to nchace@dhhs.nc.gov, and ask for information on the Ore Knob Mine NPL Site Public Health Assessment.

PURPOSE AND HEALTH ISSUES

The Ore Knob Mine NPL ("Superfund") site is located in Ashe County, North Carolina, 12 miles south of the Virginia state line, 15 miles east of the Tennessee border, and 8 miles east of the town of Jefferson, North Carolina (Appendix A, Figure 1). Mining for copper ore occurred intermittently from the 1850s through 1962, with the two main periods of activity from 1873 to 1883 and 1957 to 1962. Mining and mineral-related activities at the site included mining, concentration, roasting, smelting, and waste management. Wastes from site operations are known to have contaminated surface water and sediment with acid and heavy metals. The site consists of three principal areas that were directly affected by mining: the 19^{th} century operations area, the 1950s mine and mill area, and the main tailings impoundment. Multiple areas of mining and processing waste material, as well as mining related structures, are present on the site. Waste materials present on the site include a 20-acre tailings impoundment holding an estimated 720,000 cubic yards of material held in place behind a 60 foot high, 700 foot wide earthen dam. Mining-related activities have also affected downstream surface waters, sediment, and floodplain soils as a result of surface soil and water runoff (EPA 2008). In June 2006 the N.C. Department of Environment and Natural Resources (DENR) requested the U.S. Environmental Protection Agency (EPA) to evaluate the site for a "Removal Action", allowing EPA to remediate and stabilize the site. The N.C. Division of Land Resources has classified the tailing pile dam as having "high hazard potential" (EPA 2008). A number of private single family homes are present along the border of the former mine areas. All use private wells as a source of drinking and household water supplies. In addition, the area is known to be used for recreational purposes including: hiking, camping, hunting, fishing, and riding off-road recreational vehicles.

The objective of this Public Health Assessment (PHA) is to determine if the site presents a health hazard to the community. Concentrations of substances contaminating a site in the soil, groundwater, surface water and air are compared to standard values to determine if the substances may present a health hazard if persons should come into contact with the contaminated medium. An important component of a PHA is the determination of a person's possibility to come into contact with any potentially harmful substances, how that contact may occur, and for how long that contact may have occurred in the past, or may occur in the future. This information is used to determine whether past, current, or future contact with the substances may result in adverse (negative) health effects. Highly health protective methods are used throughout the PHA process so that the potential for negative health effects associated with contacting site contaminants are identified at the most sensitive (lowest) adverse health effect levels.

For the Ore Knob Mine NPL Site PHA, N.C. DPH evaluated drinking water and soil samples collected at nearby private residences; soils and surface waters collected throughout the mine site; and soil, surface water and sediment data collected off-site. The information reviewed for the PHA was taken from reports and analytical data generated by EPA and their contractors, and N.C.DENR. All available analytical data, collected from 1987 through 2008, was evaluated for this PHA.

BACKGROUND

SITE DESCRIPTION AND HISTORY

The Ore Knob Mine National Priorities List (NPL or "Superfund") site is located in Ashe County, North Carolina, 12 miles south of the Virginia state line, 15 miles east of the Tennessee border, 8 miles east of the town of Jefferson, and 4.5 miles east of Laurel Springs, North Carolina (Appendix A, Figure 1). The site GPS coordinates are latitude 36.405667, Longitude -81.323889, at an elevation of 3127 feet (EPA 2009a). The site was proposed for addition to the NPL list in April 2009 and listed as final in September 2009.

The NPL or Superfund is a federal program to clean-up abandoned hazardous waste sites that threaten to harm the environment or people. The program is administered through the U.S. EPA. Superfund also authorizes the Agency for Toxic Substances and Disease Registry (ATSDR), also a federal agency and part of the Centers for Disease Control and Prevention (CDC), to assist in evaluating public health impacts associated with Superfund and other releases of harmful substances to the environment.

Mining for copper ore occurred intermittently from the 1850s through 1962, with the two main periods of activity from 1873 to 1883 and 1957 to 1962 (EPA 2008). Mining and mineral-related activities on the site included mining, concentration, roasting, smelting, and waste management (HRS 2009). The site consists of three main areas that were directly impacted by mining (Appendix A, Figures 2 and 3):

- the 19th century operations and smelter area
- the 1950s mine and mill area
- the main tailings impoundment area

The **19th century operations and smelter area** encompasses approximately 5 acres near the top of Ore Knob that received waste rock from mine (vertical) shafts, and an additional 5 acres to the north where ore was "roasted" (heated) to drive off sulfur and smelted (heated with charcoal) to recover copper (Appendix A, Figure 4). A partially barren area contains waste materials up to several feet deep. Acid mine drainage (AMD, see Appendix E, Glossary) reportedly discharges from 5 horizontal shafts (adits) located in a wooded area between the 19th century operations area and the tailings impoundment. AMD from 4 of the adits have been treated with buried limestone drains since the early 1990s. Drainage from this area flows northeast to a small stream that flows into the southwest corner of the main tailings impoundment, eventually forming Ore Knob Branch (EPA 2008, HRS 2009).

The **1950s mine and mill area** is a 15-acre area approximately 0.3 miles west-southwest of the 19th century operations (Appendix A, Figure 5). Ore was processed in this area in preparation for separation of the mineral from 1957 to 1962. Remnants of a number of old structures exist in this area, including ore bins, concrete foundations and a transformer building (Appendix A, Figure 6 and 7). A small sawmill currently operates in this area within a wooden structure (Appendix A, Figure 8). These structures likely were built on fill material made-up of waste rock from mine shaft development. Approximately 20,000 cubic yards of tailings, mostly covered by tree stumps, are located on the north end of this area. Northeast of this stump area is a 2-acre former pond where process water was stored. This pond is now described as a wetland. The headwaters of Little Peak Creek form immediately upstream (south) of the former pond. Little Peak Creek flows 2.25 miles downstream (north/northwest) to Peak Creek (EPA 2008).

The **20-acre main tailings impoundment** lies approximately 0.3 miles northeast of the 19th century operations area and contains an estimated 720,000 cubic yards of tailings primarily generated from 1957 to 1962 operations (Appendix A, Figure 9). (Tailings are fine-grain materials left over after separating, usually by grinding, the desired metal fraction from the ore.) Surface water tributaries flow into the impoundment forming small ponds around the perimeter and on the impoundment. Most of the surface waters flow into a 24-inch concrete pipe that was laid beneath the tailings impoundment, running south to north, where it discharges at the base of the impoundment dam. Site visit reports indicate that the pipe becomes clogged at the inflow end (south end) resulting in ponding of the surface water inflow. The 60 foot high by 700 foot wide tailings impoundment dam is approximately 1000 feet north of the southern reach of the tailings impoundment (Appendix A, Figures 10 and 11). The dam appears to be constructed of waste rock at the base that serves to support the upper portion of the dam which consists of successive lifts of tailings deposited as a slurry. Severe erosion has impacted the dam and eroded tailings have filled a settling basin at the base of the dam (north end). Water has been observed discharging from the northern face of the dam in several places, mostly near where the pipe emerges at the base of the dam (Appendix A, Figure 12) (EPA 2008). Seeps emanating from the face of the tailings dam have extremely high concentrations of several metals (including aluminum, copper, iron, manganese, silver and zinc), acidity, sulfate, and total dissolved solids (EPA 2008b). The areas where tailings have been deposited are void of vegetation, likely due to the high metals and/or sulfide concentrations and low pH.

Acid mine drainage (AMD) from the three areas mentioned above has degraded downstream receiving waters, including the entire 1.5-mile length of Ore Knob Branch, the entire 2.25-mile length of Little Peak Creek, and an estimated 2.9 miles of Peak Creek (Appendix A, Figure 2) (EPA 2008a). The long-term release of metals from the site to surface water is evidenced by bright orange stained surface water and sediments, and Ore Knob Branch, Little Peak Creek and Peak Creek being devoid of fish (HRS 2009). The site sits in the Peak Creek watershed which is a tributary to South Fork New River. The areas affected by mining and mine wastes lie in the watersheds of Little Peak Creek and Ore Knob Branch, both of which are tributaries to Peak Creek. Peak Creek flows into South Fork New River which is also degraded for some length down stream of its confluence with Peak Creek. Run-off from the site has also carried soils and solid mining materials downstream. The State of North Carolina has designated Peak Creek and Little Peak Creek as “trout waters” and South Fork New River as an “outstanding resource water”. The South Fork New River flows into New River, which was the first in the United States designated as a “National Wild and Scenic River”. New River is also designated as an “American Heritage River” and one of four rivers designated as a “State Scenic River” by North Carolina. These waterways are classified for consumption of fish and for primary recreational activities, including swimming. In 2005, the State identified the aquatic environment of Ore Knob Branch, Little Peak Creek, and Peak Creek as “impaired” due to habitat degradation and toxic impacts associated with the AMD. The DENR has identified that South Fork New River receives significant loading of heavy metals from the Ore Knob Mine site (EPA 2008a). Peak Creek and South Fork New River are used for recreational activities including fishing and swimming. A portion of the New River State Park is located on the South Fork New River (Appendix A, Figure 10). Recreational activities in the park include camping, canoeing, picnicking and fishing (HRS 2009).

The mining operation would have used a variety of industrial materials typical of mid-20th century industrial operations. The mill would have used flotation reagents and other chemicals, possibly including cyanide for pyrite (iron sulfide, FeS_2) suppression. The former machine shop and electrical shop would have used various solvents, and PCBs may have been used in transformers or other purposes (EPA 2008a).

Past analyses of site soils, solid waste materials, and surface waters and ponded waters, indicate elevated concentrations of the metals arsenic, cadmium, chromium, copper, lead, manganese, mercury, nickel, selenium, silver, and zinc. Analysis of sediments collected from Little Peak Creek, Peak Creek and South Fork New River downstream of the site indicated elevated concentrations of copper (HRS 2009).

In 2000, the U.S. Army Corp of Engineers (USACE) analyzed 5 wells in the vicinity of the 1950s mill and 19th century operations areas for metals. Details on the locations sampled, the analytical methods used, and the results are not available. Reports state most metals were "well under applicable primary drinking water standards", also noting reporting limits for some metals were greater than drinking water standards (for antimony, beryllium, and thallium). Reports also noted aluminum, iron, manganese, sulfate, and pH exceeded their respective secondary drinking water standards. It could not be determined if the elevations were due to mining impacts.

The State of North Carolina was concerned with the potential of the tailings impoundment dam to fail, resulting in "catastrophic and probable irreversible damage to one of North Carolina's most used fisheries", as well as the potential for the strongly acid-generating tailings to be deposited along floodplains and in residential farmlands along the river. The State referred the site to EPA because of the complexity and costs involved with environmental restoration on the Ore Knob Mine site and downstream surface water bodies. The EPA concurred that the conditions at the Ore Knob Mine site presented a "substantial threat to the public health or welfare, and the environment", and agreed the site met criteria for a time-critical removal action (EPA 2008b).

EPA, its contractors and the NC DENR Division of Waste Management (DWM) mobilized to the site in July 2007 for a site assessment. During the site assessment, samples were collected on-site from soils, waste materials and surface waters. Site samples were collected in areas believed to represent areas of highest contamination related to the historical mining operations. Additional samples were collected in surface waters, sediments and flood-plain soils downstream of the site. Samples of private drinking water wells and soils from lawns of near-by residences were also collected. The off-site samples were also collected in areas that were expected to represent the highest concentrations of contaminants that may have been influenced by the mine site. Background samples were collected from a near-by private well and residential soils to determine concentrations of substances in these sample types not impacted by the mine (EPA 2008a). In October 2008, EPA began a time-critical removal action. Planned activities included developing an access road to the main tailings impoundment area, excavation of sediment from the settling pond on the north side of the main tailings impoundment dam, determination of the stability of the dam, construction of a stream diversion channel around the tailings impoundment, and stabilization of the dam structure. Once stabilized, the main tailings impoundment will be recontoured and covered in place with materials to provide a pH buffer and clean soil to promote re-vegetation.

The area surrounding the site includes dispersed single family residences and mixed small-scale agriculture and forestry operations. Many of the residences in the area are seasonal homes and are not occupied year-round. A local hunting club has leased an area bordering the main tailings impoundment. The region is primarily rural, with agriculture and tourism as major sources of employment. The dam is located in the Blue Ridge Mountains, a highly popular year-round vacation destination (EPA 2008b).

CURRENT SITE CONDITIONS

EPA and their contractors are currently on site for a "time-critical removal action" to stabilize the imminent physical and environmental hazards and provide remediation activities identified for the 20-acre main tailings impoundment area. The site was proposed for addition to EPA's National Priority List (NPL, or "Superfund") in April 2009 and final listed in September 2009. Site activities involve heavy earth-moving equipment and blasting of bed rock. Access to this area of the site is controlled by EPA and their contractors.

Two run-off ponds on the north end of the 20-acre main tailings impoundment have been filled with tailings, covered with 3-12 inches of lime to reduce the pH, capped with 2 feet of clean subsoil soil, a thin layer of topsoil and re-vegetated (Appendix A, Figure 14). Two other run-off ponds also located on the perimeter of the 20-acre tailings impoundment are in various stages of the same process. To stabilize the 20-acre main tailings impoundment dam face the stream (Ore Knob Branch) that is piped under the impoundment and discharges at the bottom of the face of the dam is being re-routed through a 0.5-mile diversion channel on the east side perimeter of the impoundment (Appendix A, Figures 15 and 16). The diversion channel has been completed. The sediment pond on the dam (north) end of the main tailings impoundment continues to function as intended. A "shear key" is being constructed at the base of the dam for stabilization. The shear key construction includes 30-by-30 feet of granite, followed laterally by a 30 feet high by 2 feet wide sand and gravel filter, then a second 30-by-30 feet of granite (EPA 2009b). EPA expects the shear key and dam stabilization activities to be completed in the spring of 2010.

The mine site is privately owned and the owner operates a small sawmill in the 19th century operations area. This 19th century operations area is enclosed by a 7-foot chain-link fence and a lockable gate.

DEMOGRAPHICS

Approximately 128 people live within 1-mile of the Ore Knob Mine site. Six residences have been identified as located in the vicinity of formerly mined areas. The surrounding area is very rural, largely undeveloped, and sparsely populated. Approximately 1,328 people live within a 4-mile radius (HRS 2009). Further Census 2000 demographics data are provided in Appendix B.

SITE GEOLOGY AND HYDROGEOLOGY

The Appalachian Mountains belt of the eastern United States and Canada has many deposits of massive sulfide ores that are typically a mixture of pyrite (FeS_2), iron sulfide minerals including ($Fe_{1-x}S$, with x = 0-2), and chalcopyrite ($CuFeS_2$). These deposits form long, narrow belts that contain scattered bodies of massive iron sulfides. The Ore Knob complex is a group of massive sulfide deposits, with the ore containing 15% sulfur. Discarded tailings contain 12.5% sulfur and 18.7% iron. The ore body ranges in texture from fine grained massive sulfide deposits to coarse grained sulfide scattered in coarse grained silicates. The ore sheet at Ore Knob is at least 4,000 feet long.

Groundwater investigations during the EPA site assessment activities were limited to sampling six residential supply wells located in the area between the 1950s mine and mill area and the 19th century operations area. Local residents rely on groundwater for their drinking water supply. No municipal drinking water service is available in this area of the county. The extent to which contaminants in the soil, sediments and surface waters may be migrating to the groundwater is not known. The site lies within fractured bedrock terrain. It is likely that at least some of the abandoned mine shafts and adits contain contaminated water, but it is not known if these contaminated waters are able to migrate into the ground water aquifer (EPA 2008a).

SITE VISIT

The N.C. DPH Health Assessment, Consultation and Education (HACE) team visited the Ore Knob Mine NPL site on October 23, 2009. HACE toured the site with the on-site representatives of the EPA site contractor (Environmental Restoration LLC Response Manger and the US Coast Guard Environmental Strike Team staff providing oversight on behalf of the EPA). HACE also met with the N.C. DENR Division of Waste Management (DWM) Project Manager. The visit included walking tours of the main tailings impoundment and dam, the stream diversion channel, and upstream and downstream surface waters. HACE observed site run-off identified as iron-rich bright orange solids discharging from Ore Knob Branch to Little Peak Creek (Appendix A, Figure 17). In the same area, floodplain soils carried downstream of the site that were devoid of vegetation (Appendix A, Figure 18). The iron discoloration (orange in color) was visible further downstream of the site, where Little Peak Creek flows into Peak Creek (Appendix A, Figure 19). HACE also walked throughout the 19th century operations and current sawmill area (Appendix A, Figures 6 – 8.

DISCUSSION

THE ATSDR HEALTH EFFECTS EVALUATION PROCESS

This section provides a summary of the ATSDR health effects evaluation process. A more detailed discussion is provided in Appendix C.

The ATSDR health effects evaluation process consists of two steps: a screening analysis of environmental monitoring data and evaluation of how the community may come into contact with the identified substances (the exposure pathway analysis). At some sites based on the results of the screening analysis and community health concerns, a more in-depth analysis is undertaken to determine possible public health implications of site-specific exposure estimates.

The two step screening analysis process provides a consistent means to identify site contaminants to be evaluated more closely through the use of “comparison values” (CVs). The first step of the screening analysis is the “environmental guideline comparison” which involves comparing site contaminant concentrations to water, soil, air, or food chain comparison values derived by ATSDR from standard exposure default values. The highest concentration of a chemical found in a particular sample type (such as air, drinking water, soil) is compared to CVs to provide a highly health protective “worst-case” exposure estimate. The average concentration for chemicals found in more than one sample of a particular type is also compared to CVs to provide an average exposure estimate. An exposure dose is an estimate of the amount of a substance a person may come into contact with in the environment during a specific time period, expressed relative to body weight. The second step is the “health guideline comparison” and involves looking more closely at site-specific exposure conditions, estimating exposure doses, and comparing the exposure dose estimate to dose-based health-effect comparison values. ATSDR’s comparison values are set at levels that are highly health protective, well below levels known or anticipated to result in adverse health effects. When chemicals are found on a site at concentrations greater than the comparison values it does not mean that adverse health effects would be expected. Contaminant concentrations at or below the CV may reasonably be considered safe.

After completing a screening analysis, site contaminants are divided into two categories. Those not exceeding their CVs do not require further analysis. Contaminants exceeding CVs are selected for a more in-depth site-specific analysis to evaluate the likelihood of possible harmful health effects. Contaminant concentrations exceeding the appropriate CVs are further evaluated against ATSDR health guidelines (HGs). Health guidelines represent daily human exposure levels to a substance that is likely to be without appreciable risk of adverse health effects during a specific exposure duration. To determine exposure dose when site-specific information is not available, N.C. DPH uses standard assumptions about typical body weights, ingestion or inhalation rates, and duration of exposure. Important factors in determining the potential for adverse health effects include the concentration of the chemical, the duration of exposure, the frequency of the exposure, the route of exposure, and the health status of those exposed. Site contaminant concentrations and site-specific exposure conditions are used to calculate highly health protective estimates of site-specific exposure doses for children and adults. These values are then compared to ATSDR health guideline values (HGs).

Exposure dose estimates are also compared to data collected in animal and human health effect studies for the chemicals of concern. The health study data is generally taken from ATSDR or EPA references that summarize data from studies that have undergone extensive validation review. Comparisons are made on the basis of the exposure route (ingestion/eating, inhalation/breathing, or dermal/skin contact) and the length of the exposure. Preference is given to human study data and chemical doses or concentrations where no adverse health effects were observed. If human data or no adverse effect data is not available, animal data or the lowest chemical dose where adverse health effects were observed, may be used.

There are limitations inherent to the public health assessment process. These include the availability of analytical data collected for a site, the type and quantity of health effect study information, and the risk estimation process itself. To overcome some of these limitations, highly health protective (i.e., “worst-case”) exposure assumptions are used to evaluate site data and interpret the potential for adverse health effects. ATSDR screening values (CVs) and health guideline values (HGs) incorporate large margins-of-safety to protect groups of the exposed population that may be particularly sensitive, such as children, the elderly, or persons with impaired immune response. Exposure concentrations are calculated using the highest concentration of a chemical found in the water, soil or air on the site. Large margins-of-safety are also employed when comparing exposure concentrations to health effect study data. The assumptions, interpretations, and recommendations made throughout this public health assessment err in the direction of protecting public health.

REVIEW OF SITE ENVIRONMENTAL DATA

N.C. DPH reviewed all available analytical data generated by N.C. DENR and EPA. Data sets evaluated for this Public Health Assessment include:

- On-site and off-site surface waters and sediments collected in 1987, 1990, 1991, 1992, 1994, 1996 and 2006 by N.C. DENR
- Ore Knob Branch sediment collected in 1990 by N.C. DENR
- On-site and off-site surface waters, sediments and floodplain soils collected in 2007 and 2008 by EPA
- On-site soils, tailings, slag, ore bin solids, other mine process material and waste rock collected in 2007 by EPA
- Private well waters and residential (lawn) soils collected in 2007 by EPA
- Downstream receiving waters fish tissue data collected in 1998, 2005 and 2008 by N.C. DENR
- Fish tissue samples collected by N.C. DENR downstream of the site in South Fork New River in 1998, 2005 and 2008, and in the New River in 2008

Samples collected and analyzed by EPA and their contractors used EPA-approved protocols (EPA 2008a). No documentation was available regarding the surface water and sediment data collected and analyzed by N.C. DENR. Sampling locations were selected by EPA to indicate the highest concentrations of substances, if present, in those areas that would be associated with contamination from the former mining operations.

All samples collected on-site and off-site were analyzed for a variety of metals. Some soils and other solid materials were also analyzed for organic contaminants including PCBs (polychlorinated biphenyls) as Aroclors, SVOCs (semi-volatile organic compounds), VOCs (volatile organic compounds), and PAHs (polynuclear aromatic hydrocarbons). The PCBs, VOCs, SVOCs and PAHs are EPA-standardized analytical methods used to identify and quantify groups of organic compounds commonly seen at hazardous waste sites. Selection of organic contaminant analyses for a particular sample set was based on the known or suspected historical operations that took place in that area. Some samples were also analyzed for additional inorganic compounds including sulfur species and cyanide. The following discussions of analytical data will focus only on substances detected in a particular sample set and those that exceed ATSDR-defined comparison values (CVs). The average chemical concentration was used for evaluations for samples collected in duplicate. Comparison values were not available for 4 of the metals detected in most of the samples (calcium, magnesium, potassium and sodium). These metals are essential nutrients and are not typically harmful under most environmental exposures (ATSDR 2005). Detections of these metals are noted in the sample set discussions and the summary tables. ATSDR also does not provide CVs or health guideline comparison values for iron. N.C.DPH used EPA's Preliminary Remediation Goals (PRG) to assess the iron environmental and exposure data (EPA PRG).

Residential Private Drinking Water Wells: In July 2007, EPA contractors collected water from 6 private wells located near the Ore Knob Mine site (see Appendix A, Figure 20 for locations). Five of the wells were located between the 19th century operations and the former mill site, and one was southeast of the 19th century operations area (OK703). One sample was collected in duplicate (OK702). A background well sample was collected approximately 1.5 miles southwest of the site off of NC Highway 88 (OK701). The background well sample provides information on the native groundwater make-up without influences related to historical Ore Knob Mine activities that may have impacted the well samples collected near the site. The private well samples were analyzed for metals, sulfates, VOCs and SVOCs. Seventeen of the 24 metals analyzed were detected in one or more of the 6 private well waters. Sulfates were detected in all 6 samples. No VOCs or SVOCs were detected. The data is summarized in Appendix C, Table 2. Many of the homes in the area around the mine site are seasonal homes and are not occupied year round. Some of these residents were not available to provide access to their private well waters when EPA was in the area collecting private well samples.

Residential Soils: Surface soils (taken from 0 to 6 inches below the surface) were collected by EPA contractors in July 2007 from 3 residential properties near the east and south side of the 1950s mine and mill area (locations OK406, OK407 and OK408, see Appendix A, Figure 5). Samples were collected in areas of the residential properties that would be expected to be the most impacted by contaminants moving down stream from the mine site. Seventeen metals were detected in one or more of the 3 sample locations. A single SVOC compound was detected in sample OK406 (benzaldehyde). No VOCs or PCBs were detected in sample OK408, the only sample analyzed for VOCs or PCBs (EPA 2008a).

Ore Knob Mine Site Soils: Thirteen soils were collected in the 1950s mine and mill area, and 9 were collected in the 19th century operations historic smelter area. The depth of the samples ranged from 0 to 4 inches below ground surface (bgs) to 0 to 12 inches bgs. Soils from both areas were analyzed for metals, PCBs and SVOCs. The soils from the 1950s mine and mill area were also analyzed for VOCs. Twenty metals and 13 SVOCs were detected in the soils from each of these 2 areas.

Waste Rock, Slag, Ore Bin and Processed Materials: Thirteen samples of waste rock, slag, ore bin waste and processed materials wastes located throughout the site generated during historical mining and ore recovery operations were sampled by EPA in July 2007. These materials were analyzed for metals, PCBs and SVOCs. Twenty-three metals and 11 SVOCs (all PAHs) were detected in the waste material samples.

Tailings Piles: Nine total samples were collected from 0 to 18 inches below ground surface (bgs) from tailings piles located in 2 areas of the site. Seven were from the main 20-acre tailings pile and the remaining 2 were from material eroded from the 1950s mine and mill site tailings pile. All the samples were analyzed for metals. One sample from the 1950s mine and mill area was analyzed for PCBs, and both were analyzed for SVOCs. There were no PCBs or SVOCs detected. Twenty metals were detected in the 9 samples.
Ponded Waters and Seeps Associated with the Main Tailings Impoundment: Twenty two samples were collected by EPA and DENR between 1990 and 2008 to characterize the water collecting on and around the 20-acre main tailings impoundment and water seeping from the dam face. The samples were analyzed for metals, with 23 different metals detected.

On-site and Downstream Surface Waters, Sediments and Floodplain Soils: The four surface water bodies impacted by the site were evaluated separately. From 1987 through 2008 surface water samples were collected and analyzed for metals 9 times from Ore Knob Branch and its on-site tributaries downstream of the main tailings impoundment. The metals analyzed varied with the sampling events. Seventeen different metals were detected in the Ore Knob Branch waters.

A total of 9 sediment and floodplain soil samples were collected from Ore Knob Branch in 1990 and 2007. All 9 samples were analyzed for metals. The 8 samples collected in 2007 were also analyzed for PCBs and SVOCs. Twenty-two different metals and 4 organic compounds were detected.

A total of 10 surface water samples were collected from Little Peak Creek and its tributaries during 7 sampling events between 1990 and 2007. All samples were analyzed for metals and the 2007 samples were also analyzed for PCBs, VOCs, and SVOCs. Sixteen metals were detected over that period. No organic compounds were detected.

Eight sediment and floodplain soils were collected from Little Peak Creek and its tributaries in 2007. Eighteen metals and 2 SVOCs (*o*-cresol and benzaldehyde) were detected.

Forty-six water samples were collected from Peak Creek in 10 sampling events between 1987 and 2008, with fourteen different metals were detected. All samples were analyzed for metals, with the suite of metals analyzed varying with the sampling event. Fourteen metals were detected.

Nine Peak Creek sediments and floodplain soil samples were collected in 2007 and analyzed for metals, PCBs and SVOCs. Twenty-one metals and 3 SVOCs were detected in the sediments and soils.

Five surface water samples were collected in the South Fork New River in 2007, 630 feet downstream of the confluence with Peak Creek. The 5 water samples were collected in a transect across the channel. The water samples were analyzed for metals and SVOCs. Fourteen different metals were detected. No SVOCs were detected in the water samples.

Six sediment samples were collected in 2007 in the South Fork New River and analyzed for metals, PCBs and SVOCs. A 3 sample transect across the channel was collected 630 feet downstream of the confluence with Peak Creek, 2 samples were collected at 1,550 feet downstream of Peak Creek, and single sample was collected at 1,930 feet downstream of Peak Creek. Twenty different metals were detected in the 6 samples. No PCBs or SVOCs were detected in any of the South Fork New River sediments.

Fish Tissue Samples: N.C. DENR collected fish on the South Fork New River less than 1.5 miles downstream of its confluence with Peak Creek in 1998, 2005 and 2008, collecting a total of 25 fish during the 3 sampling events. An additional 18 fish were collected in the New River near Sparta NC, 32 miles downstream of Peak Creek in 2008. Fish collected were those the N.C. Wildlife Resources Commission (WRC) identified as commonly consumed by recreational anglers in the area and were not species being stocked in the area. Fish species sampled included: rock bass, smallmouth bass, white sucker, rainbow trout, brown trout, redbreast sunfish, northern hog sucker and brown trout. The fish tissue samples were analyzed for the metals mercury, arsenic, cadmium, total chromium, copper, nickel, lead and zinc. Mercury, copper and zinc was detected in all fish. Selenium was also analyzed and detected in all fish collected in 2008.

Other Biota: No data is available for other biota (plants and animals) that live on or near the site. It is not known if they may accumulate the metals identified as elevated in the site surface waters, sediments and soils and ultimately serve as a source of exposure to persons that consume them.

EXPOSURE PATHWAY ANALYSIS

An exposure to a chemical and the possibility of adverse health effects requires persons come into contact with the chemical through:

- ingestion (eating the chemical),
- inhalation (breathing the chemical), or
- absorbing the chemical through the skin (dermal exposure)

Having contact with a chemical does not necessarily result in adverse (harmful) health effects. A chemical’s ability to result in adverse health effects is influenced by a number of factors in the exposure situation, including:

- how much of the chemical a person is exposed to (the dose)
- how long a time period a person is exposed to the chemical (the duration)
- how often the person is exposed (the frequency)
- the amount and type of damage the chemical can cause in the body (the toxicity of the chemical)

To result in adverse health effects, the chemical must be present at concentrations high enough and for long enough to cause harm. Exposures at concentrations or time periods less than these levels do not cause adverse health effects. Knowing or estimating the frequency with which people have contact with hazardous substances is essential to assessing the public health importance of these contaminants.

Responses of persons to potentially harmful substances may vary with the individual or particular groups of individuals, such as children, the elderly, or persons with weakened immune responses, or other chronic health issues. These susceptible populations may have different or enhanced responses as compared to most persons exposed at the same concentration to a particular chemical in the environment. Reasons for these differences may include:

- genetic makeup
- age
- health status
- nutritional status
- exposure to other toxic substances (like cigarette smoke or alcohol).

These factors may limit that persons' ability to detoxify or eliminate the harmful chemicals from their body, or may increase the effects of damage to their organs or physiological systems. Child-specific exposure situations and susceptibilities are also considered in DPH health evaluations.

The exposure pathway (how people may come into contact with substances contaminating their environment) is evaluated to determine if people have come into contact with site contaminants, or if they may in the future. A completed exposure pathway is one that contains the following elements:

- a **source** of chemical of concern (contamination), such as a hazardous waste site or contaminated industrial site,
- movement **(transport)** of the contaminant through **environmental media** such as air, water, or soil,
- a **point of exposure** where people come in contact with a contaminated medium, such as drinking water, soil in a garden, or in the air,
- a **route of exposure**, or how people come into contact with the chemical, such as drinking contaminated well water, eating contaminated soil on homegrown vegetables, or inhaling contaminated air, and
- an **exposed population** of persons that can come into contact with the contaminants

The elements of an exposure pathway may change over time, so the time frame of potential exposure (contact) is also considered. Exposure may have happened in the past, may be taking place at the present time, or may occur in the future. A **completed pathway** is one in which all five pathway components exist in the selected time frame (the past, present, or future). If one of the five elements is not present, but could be at some point, the exposure is considered a **potential exposure pathway**. The length of the exposure period, the concentration of the contaminants at the time of exposure, and the route of exposure (skin contact, ingestion, and inhalation), are all critical elements considered in defining a particular exposure event. If one of the five elements is not present and will not occur in the future it is considered an **eliminated exposure pathway**.

SUMMARY OF ENVIRONMENTAL EXPOSURE POTENTIAL AT THE SITE

The population of concern for the Ore Knob Mine site is those persons living in the immediate vicinity of the site that may be impacted by mining waste or impacted soil, surface water, sediment, or groundwater moving off the site. Persons that may visit the site with or without permission ("trespassers") are also of concern. These would be persons using the site for recreational purposes, such as the hunting club members that have been given permission to use the area for hunting, and persons hiking, camping, or riding recreational vehicles without permission. Exposure pathways identified for the Ore Knob Mine NPL site and the status of those pathways are summarized below in Table 1.

Table 1. Summary of Ore Knob Mine NPL site exposure pathways and pathway status.

Source	Environmental Transport and media	Exposure point	Exposure Route	Exposed population	Time Frame	Pathway status
Surface soil	Contaminated surface soil	Soil	Eating, Breathing	People living near or visiting the site	Past Current Future	Complete for on-site, Potential for some off-site residences
Ground-water	Contaminated groundwater	Private wells	Drinking	People living near the site on private wells	Past Current Future	Complete for residential exposures *
Surface water and Sediment	Contaminated surface water and sediment	Ponded waters on-site and local streams	Drinking	Local residents and recreational users on and off-site	Past Current Future	Complete for recreational users
Mine Waste Materials	Contaminated water, soil and air	Waste soils, rocks	Eating, Breathing	People living near or visiting the site	Past Current Future	Complete for recreational users
Fish	Contaminated surface water and sediment	Fish	Eating	Persons fishing downstream of site	Past Current Future	Complete for recreational anglers

***The metals in private well water may not be site-related.**

SITE-SPECIFIC EXPOSURE CONDITIONS USED FOR THE HEALTH EVALUATIONS

Long-term daily exposures were considered for persons living on or near the Ore Knob Mine property (residential private wells and soils). Thirty-year exposure periods were used to estimate the maximum length of residence at one location for drinking water and soil exposures.

Recreational exposure scenarios were developed to estimate how persons that may hunt, hike, camp or use recreational vehicles on the site may be exposed. An additional set of exposure parameters were used to estimate the accidental drinking of water ("incidental ingestion ") by children during swimming or wading in the surface waters on and around the site. Tables 42 and 43 (Appendix C) list the exposure calculation parameters that were used to estimate child and adult recreational exposures. The parameters selected for these exposure estimates (amount consumed, frequency of exposure, years or exposure) were all selected to be health protective by maximizing the selected values to represent the potential for persons to be in contact with the environmental contamination that may exist on the site. The soil ingestion rates used reflect values twice the typical rates used for incidental ingestion of soil. These values were selected to provide a health protective estimate of additional exposure that may be incurred by occasional recreational site visitors, including those accessing the site in recreational vehicles, and during camping, hiking or hunting activities. The 400 mg/day ingestion rate used for child recreational exposure estimates also represents the upper percentile values determined by EPA; the 200 mg/day adult value is 4 times the mean rate (EPA 1997).

Acute exposures of young children based on pica behavior were also evaluated for those contaminants detected on the site for which ATSDR has developed pica exposure comparison values. Pica is an eating disorder associated with consumption of large amounts of non-nutritive substances such as soil. ATSDR recommends evaluating acute exposures for pica-behavior based on the consumption of large amounts of soil (5000 mg per day) (ATSDR 2005). This very high rate of pica soil intake is generally observed in young children (2-3 years of age). Children this age would not be expected to visit the site frequently, thus pica behavior is not likely occur frequently under most circumstances. EPA does not consider child pica-type exposure situations when performing their evaluation of a site.

PAH compounds detected in site samples were evaluated for cancer effects by adjusting the concentrations of the individual PAH compounds to the benzo(a)pyrene-equivalent concentration using toxicity equivalency factors (TEFs) developed by EPA or Nisbet and LaGoy (TEF 2002). A theoretical additional cancer risk was calculated for the sum of the TEF-adjusted concentrations. The evaluation of PAH compound data is discussed in more detail in Appendix D.

EVALUATION OF POTENTIAL PUBLIC HEALTH ISSUES

The substances detected in environmental samples collected at the site at concentrations greater than comparison values are discussed below. The tables in Appendix C summarize the data for the detected substances, lists comparison values used for data screening, and identify site-specific exposure estimates. Table 44 in Appendix C summarizes the health study effect levels used for final evaluation of the potential for site contaminants to cause adverse health effects. All available site data generated from 1987 through 2008 was considered as a single data set since site conditions have not changed to any extent since prior to that time when mining activities ended on the site in the 1960s and until recently when EPA began remediation and stabilization activities.

Residential Private Drinking Water Wells: Four metals (cadmium, cobalt, manganese and nickel) detected in the July 2007 residential private drinking water well samples were present at concentrations greater than ATSDR comparison values (CVs). Appendix C, Table 2 summarizes the substances detected and lists comparison values used for ingestion exposures. Table 3 lists well water exposure dose estimates and health guideline values. Cadmium, cobalt and nickel were not detected in the background well water sample (at reporting limits of 0.1, 0.1 and 0.5

micrograms per liter, µg/L, respectively). All 4 metals, including the highest concentration of manganese (17,800 µg/L), were detected in well OK702. Manganese was the only metal detected at a concentration greater than the CV in more than one location (also detected at OK706 and OK707). All manganese detections were more than twice the background well sample concentration (92.5 J µg/L). (A "J" notation indicates that the reported analytical concentration is an "estimated" value.) Both child and adult exposure dose estimates for manganese at all 3 locations was greater than the health guideline comparison value and the lowest health study value, indicting the potential for adverse health effects with long-term ingestion of these well waters. EPA lists a 50 µg/L as the secondary drinking water guideline for manganese. EPA's secondary drinking water guidelines are non-regulatory guidelines for substances in public water systems that may cause negative odor or taste effects, or discoloration of the skin or teeth. The drinking waters from well locations OK702, OK703, OK706 and OK707 were all greater than the EPA secondary drinking water value. Sulfate was detected in all 6 private well samples. ATSDR does not provide CVs for sulfate. EPA provides a secondary drinking water guideline of 250,000 µg/L for sulfates. The samples collected from OK702 and OK706 wells exceed EPA's guideline value. Sample collection locations are identified in Appendix A, Figure 20.

Exposure dose estimates for drinking (ingesting) well water containing cobalt and nickel at the concentrations observed in the 2007 private well samples were less than ATSDR health guideline ("HG") values and thus do not indicate the potential for adverse health effects.

The cadmium concentration in well OK702 was greater than the ATSDR CVs, but less than the EPA "maximum contaminant level" (MCL) value. EPA's MCL values are regulatory limits set for public water systems as a maximum permissible concentration of a contaminant in drinking water. MCLs are based on health data, but also consider the economic and technical feasibility of achieving a desired treatment level. ATSDR considers only health issues when deriving their comparison values, thus ATSDR CVs may be lower than the MCL values. The cadmium exposure dose estimated for children was greater than the ATSDR health guideline. Comparison of the exposure dose for children ingesting water at the concentration observed in well OK702 to the low human health effect study data (Appendix C, Table 41) indicates the potential for non-cancer adverse health effects for children ingesting water over a number of years. Exposure dose estimates and health guideline values used for the health effect evaluations for the well waters are listed in Appendix C, Table 3.

There were no arsenic detections in the private well samples, but the reporting limit (1.5 µg/L) was greater than the cancer-effect health guideline screening value (CREG), so arsenic was evaluated for potential health effects at the reporting limit concentration. Arsenic was evaluated for cancer effects at the minimum reporting limit (1.5 µg/L) which exceeds the ATSDR cancer comparison value (0.02 µg/L CREG). The minimum reporting limit does not exceed the MCL (10 µg/L). Estimates of the number of increased cancers at the reporting limit indicate a "low" level of additional cancers (less than 1 additional cancer per 10,000 persons exposed) would be anticipated. This theoretical increased cancer risk estimate does not equal the increased number of cancer cases that will actually occur in the exposed population, but estimates a theoretical excess cancer risk expressed as the proportion of a population that may be affected by a carcinogen during the selected period of exposure. In this instance, the number of predicted cancers would be less, because the reporting limit represents a concentration greater than the maximum concentration in the well water. Exposure dose and increased cancer risk estimates for arsenic are listed in Appendix C, Table 4.

Residential Soil Samples: The metals aluminum, copper, and iron were the only detected compounds exceeding ATSDR comparison values. Aluminum exceeded comparison values in all 3 residential soils (locations OK406, OK407 and OK408), copper in two locations (OK406 and OK407), and iron at one location (OK406). The detected metals data is summarized in Appendix C, Table 5. The locations of the residential soil samples collections are noted in Appendix A, Figure 5.

The exposure dose estimate for children based on the iron concentration (60,000 J mg/kg) exceeding the CV also exceeded the EPA residential health guideline screening value, indicating the potential for adverse health effects for long term exposures to children. Exposure dose estimates were compared to EPA's oral reference dose (0.70 mg/kg/d RfD_{oral}). The exposure dose estimates for children exposed at the concentration of copper and iron observed at the OK406 location (1800 and 60,000 mg/kg, respectively) also indicate the potential for adverse health effects for long term exposures to children. Adverse health effects are also indicated for children for pica ingestion rates for the aluminum concentrations observed at OK408, both at the maximum and the average concentration. The residential soil samples were collected in areas of each property that would potentially be most influenced by contaminant moving down stream from the mine and represents the highest possible exposure concentration, such as along a stream bank. The detected metal concentrations may not represent an average concentration throughout the property, or the areas where children may be most likely play.

EPA collected 6 background soils samples on the site in 2007, 3 each in the 1950s mine and mill and the 19^{th} century operations areas. The samples were collected in areas that appeared to not have been impacted by mining operations. N.C. DPH considers concentrations less than twice the average background concentration of a substance to be indicative of "native" concentrations, or within the concentration range that would be anticipated for soils in the Ore Knob Mine area without influence of mining operations. All 3 residential soil aluminum concentrations were within the range expected for the area background. This would indicate that the potential health hazard that may be associated with pica ingestion of aluminum in the soils is the same for the native background soils in the area. Background soil concentrations for select substances analyzed on the site are listed in Appendix C, Table 41. Exposure dose estimates and health guideline values are listed in Appendix C, Table 6.

Ore Knob Mine Site Soils: Four metals detected in the 1950s mine and mill area soils were at concentrations greater than comparison values (aluminum, arsenic, cobalt and copper). Only copper at a single location in the 19^{th} century operations area exceeded comparison values. One SVOC (benzo(a)pyrene, a PAH) exceeded comparison values in each area. The detected substances in both areas and comparison values are summarized in Appendix C, Tables 7 through 10.

Estimates of the recreational exposure dose for persons in contact with soils in these areas indicates the potential for adverse health effects only to children associated with copper ingestion in the 1950s mine and mill area. Adverse health effects are indicated for children exposed at the highest soil copper concentrations (9,600 mg/kg), using the health protective recreational exposure scenario parameters (35 days per year for 6 years). Adverse health effects are not indicated for children exposed at less than 15 days per year. Exposure dose estimates and health guidelines values for metals are listed in Appendix C, Table 11.

The additional cancer risk associated with recreational exposure to PAHs in soils in the 1950s mine and mill and 19th century operations areas both indicate "no increased" risk (or, less than 1 additional cancer for every 1 million persons exposed). No adverse health effects are indicated for recreational exposures to the PAH compounds in the site soils. Cancer risk estimates for PAHs in soils are listed in Appendix C, Table 12.

Waste Rock, Slag, Ore Bin and Processed Materials: Four metals (aluminum, cadmium, copper and manganese) were detected in the waste materials at concentrations greater than comparison values (Appendix C, Table 13). Copper exceeded the comparison value in 9 of 13 waste samples, not unexpected for a copper mine. The other metals exceeded comparison values in a single sample. Benzo(a)pyrene was the only PAH compound that exceeded a comparison value (Appendix C, Table 14). The exposures estimates for these materials were based on the recreational exposure parameters developed for this site (Appendix C, Table 42).

The exposure dose estimates for children were greater than health guideline comparison values for the maximum and average copper concentrations. The estimated maximum copper dose for children [0.049 $(mg/kg/d)^{-1}$] is slightly above the lowest health effect study level selected for comparison [0.042 $(mg/kg/d)^{-1}$] (Appendix C, Table 44). The health effect study value represents a "no observed adverse effect level" for a daily exposure over a 2 month period. The "lowest observed adverse effect level" from the same study is [0.091 $(mg/kg/d)^{-1}$]. The potential for adverse health effects to children are indicated for the recreational exposure scenario (36 days per year on the site, for 6 years). Decreases in the frequency of visits to the site, or the amount of waste material (accidently) ingested by children while on the site would reduce their exposure and the likelihood of adverse health effects for copper. Further exposure reductions would be expected by the likely limited ability to absorb the copper from the waste materials when ingested. ATSDR states in their *Toxicological Profile for Copper* (ATSDR 2004 Cu) that in studies, healthy humans absorb 24% to 60% of ingested copper (presumably from food or water). Copper binds tightly to soils. Copper associated with the waste slag and ore is likely tightly bound to the solid substrate and not appreciably available for absorption in the gastrointestinal tract. It is likely that absorption from ingested mine waste materials, such as ore, slag or rock, would be much less. The decreased ability to absorb the copper from any accidentally ingested mine waste materials would reduce the ultimate exposure and the likelihood of adverse health effects. Recreational exposure dose estimates for the other 3 metals were less than health guideline comparison values. Exposure does estimates and health guideline comparison values for the metals are listed in Appendix C, Table 15.

The theoretical additional cancer risk for recreational exposures to the PAHs detected in the waste materials indicated no increased cancer risk (less than 1 additional cancer in 1 million persons). Exposure doses and increased cancer risk estimates for the combined PAHs are in Appendix C, Table 16.

Tailings Piles: Copper was detected at concentrations greater than the soil ingestion comparison value in 6 tailings samples. Recreational exposure dose estimates were calculated with the highest and average copper concentration observed in the samples (6,000 J and 1,800 mg/kg). The dose estimate for children [0.015 $(mg/kg/d)^{-1}$] using the highest copper concentration was greater than the health guideline value. While the estimated children's maximum dose [0.015 $(mg/kg/d)^{-1}$] is less than the lowest health study value [0.042 $(mg/kg/d)^{-1}$], the potential for adverse health effects to sensitive individuals for the recreational exposure scenario can not be ruled out. The recreational exposure estimates for children are based on contact with the tailings for 36 days per year for 6 years. If the exposures are reduced to 24 days per year for children the exposure dose is reduced to less than the health guideline comparison value, indicating that adverse health effects would not be expected. In addition, in the past there was limited ability to come into direct contact with the tailings. Currently, site remediation and stabilization activities include burying and capping the tailings, pH stabilization and re-vegetation. This activity will eliminate the potential for future direct contact with the tailings.

Ponded Waters and Seeps Associated with the Main Tailings Impoundment: Ten metals were detected at concentrations greater than comparison values (Appendix C, Table 19). None of the recreational exposure dose estimates for children accidently consuming these waters exceeded health guideline values, indicating that adverse health effects are not predicted for incidental ingestion. The exposure dose estimates and health guideline values used for the metals evaluation are listed in Appendix C, Table 20.

On-site and Downstream Surface Waters, Sediments and Floodplain Soils:
Ore Knob Branch - Concentrations of 8 metals (aluminum, cadmium, chromium, cobalt, copper, iron, manganese, and zinc) detected in Ore Knob Branch and its tributaries from 1987 through 2008 were greater than comparison values and were evaluated for incidental ingestion by children (Appendix C, Table 21). Exposure dose estimates for all 8 metals were less than health guideline comparison values and indicate that adverse health effects would not be expected for children playing in Ore Knob Branch and its tributaries (Appendix C, Table 22).

Copper was the only metal detected in the Ore Knob Branch sediments or floodplain soils at a concentration greater than the comparison value (Appendix C, Table 23). Copper exceeded comparison values in 6 of 9 samples (average concentration = 980 mg/kg). The exposure dose estimate for children participating in recreational activities using the highest detected copper concentration (4,200 J mg/kg) was greater than the health guideline value (Appendix C, Table 24). Although the exposure dose estimate for children was less than the lowest health study "no-effect" level, negative health impacts may be indicated for sensitive individuals coming into contact with the sediments at the frequency used for the recreational exposure estimates. If the frequency of contact is reduced to 32 days per year or less, then negative health impacts are not indicated. The high copper concentration was observed in the sample collected from Ore Knob Branch just before it flows into the north end of the main tailings impoundment, a location where children may not be expected to visit. All other copper concentrations for the sediments and floodplain soils were much less than the high concentration and negative health impacts associated with recreational exposures are not expected.

Four PAH compounds were detected in a single Ore Knob Branch sediment sample collected above the main tailings impoundment (Appendix C, Table 25). Cancer risk estimates for the concentration of the combined PAH compounds indicated no increased cancer risk for recreational exposures (less than 1 additional cancer per 1 million exposed persons) (Appendix C, Table 26).

Little Peak Creek – Manganese was detected in 2 samples of Little Peak Creek water at concentrations greater than comparison values. All other metals were at concentrations less than comparison values (Appendix C, Table 27). Dose estimates for manganese incidental ingestion exposures for children were less than health guideline values, indicting that negative health effects to children associated with recreational contact would not be expected (Appendix C, Table 28).

Copper was detected at concentrations greater than comparison values in 2 Little Peak Creek sediment and floodplain soil samples (Appendix C, Table 29), at locations above and just below the former freshwater pond (locations OK025 and OK426, Appendix A, Figure 5). All other detected metal concentrations were less than comparison values. Dose estimates for recreational exposures to the soils did not indicate the potential for negative health impacts associated with copper in the Little Peak Creek soils (Appendix C, Table 30). Neither of the detected SVOCs (*o*-cresol and benzaldehyde) was at concentrations greater than the comparison values.

Peak Creek - Copper was detected (330 µg/L) at a concentration greater than the comparison value in a single sample of Peak Creek surface water collected in 1987 just below the confluence with Ore Knob Branch (Appendix C, Table 32). The copper dose estimate for recreational exposures to children at this concentration did not indicate the potential for adverse health effects Appendix C, Table 33).

Four metals (arsenic, cobalt, copper and iron) were detected at concentrations greater than the comparison values in Peak Creek sediments and floodplain soils Appendix C, Table 34). Copper was the only metal to exceed the comparison value in more than 1 location, at 3 locations collected in a transverse across the channel, 60 feet below the confluence with Ore Knob Branch. The dose estimates for arsenic and cobalt for recreational exposures did not indicate the potential for adverse health effects. The iron recreational exposure dose estimate for children at the highest detected sediment and soil concentration (940,000 J mg/kg) was greater than the EPA reference dose (RfD). (ATSDR does not provide comparison values for iron.) This iron detection was from the same location as the elevated copper detections, just below the confluence with Ore Knob Branch. Although the dose estimate indicates the potential for negative health effects to children associated with long-term ingestion of the Peak Creek sediment with the highest iron concentration, the sample is from a location that would be of limited access due to the size of the creek at this location. Recreational exposure dose estimates for the maximum and average copper detections in the Peak Creek sediments also indicated the potential adverse health effects to both children and adults with long-term exposures. The dose estimates for children are also greater than the low health study values. Again, as with the sediment iron, the elevated copper sediment detections are from an area where there is limited potential to come into contact with the sediment. Negative health impacts associated with long-term recreational exposures to metals observed in Peak Creek sediments and floodplain soils would not be anticipated because of the limited exposure possibilities. The recreational exposure estimates and health guideline screening values are provided in Appendix C, Table 35.

The 3 SVOCs were detected in a single sample of the Peak Creek floodplain soil at the confluence with the South Fork New River. None were detected at concentrations greater than the selected comparison values (Appendix C, Table 36). Two of the 3 detected SVOCs were PAHs. No increased cancer risk was indicated for their benzo(a)pyrene adjusted concentrations (less than 1 additional cancer in 1 million persons exposed) (Appendix C, Table 37). No negative health effects are expected for recreational exposures to the SVOCs in the floodplain soil.

South Fork New River - None of the metals detected in South Fork New River surface water samples were detected at concentrations exceeding comparison values (Appendix C, Table 38). Copper was the only metal detected in the sediments or floodplain soils at a concentration greater than the comparison value. The copper detection (570 mg/kg) was from the sediment sample collected the furthest downstream (1,930 ft below the confluence with Peak Creek) (Appendix C, Table 39). Recreational exposure dose estimates for the copper detection were less than health guideline comparison values (Appendix C, Table 40), indicting that negative health effects are not anticipated for long-term recreational exposures.

Fish Tissue: Metals data for fish tissue samples collected in 1998, 2005 and 2008 in South Fork New River less than 1.5 miles downstream of its confluence with Peak Creek and the New River 32 miles downstream of Peak Creek were unremarkable, although data review was limited by the unavailability of upstream data for comparison (personal communication with NCDENR DWQ, Dec. 18, 2009). One of 2 rock bass (0.49 mg/kg) samples collected in 1998 (average rock bass concentration = 0.36 mg/kg mercury) in the South Fork New River exceeded the N.C. DPH action level for mercury (0.4 mg/kg). The mercury concentration for all other samples was less than the action level. All selenium concentrations were less than the N.C. DPH action level of 10 mg/kg. The fish tissue data indicates the fish are not taking up elevated concentrations of these metals from the environment as compared to fish collected from other nearby areas. The fish tissue data does not indicate a potential for adverse health effects associated with eating fish caught at these locations. The fish sample collection locations are noted on Appendix A, Figure 21.

HEALTH EFECTS OF SELECTED SUBSTANCES

Aluminum - Animal studies show that the nervous system is a sensitive target of aluminum toxicity. Obvious signs of damage were not seen in animals after high oral doses of aluminum. However, the animals did not perform as well in tests that measured the strength of their grip or how much they moved around. Persons that store large amounts of aluminum in their bodies (may occur with kidney disease) sometimes develop bone or brain diseases. It is not certain this is caused by the aluminum storage. Some studies show that people exposed to high levels of aluminum may develop Alzheimer’s disease, but other studies have not found this to be true. It is not know for certain whether aluminum causes Alzheimer’s disease. It is not known if aluminum will affect reproduction in people. Aluminum does not appear to affect fertility in animals. Children with kidney problems who were given aluminum in their medical treatments developed bone diseases. It does not appear that children are more sensitive to aluminum than adults. Birth defects have not been seen in animals. It is not known if aluminum will cause birth defects in people. Aluminum in large amounts has been shown to be harmful to unborn and developing animals by delaying skeletal and neurological development. Aluminum is found in breast milk, but only a small amount enters the infant's body through breastfeeding. The carcinogenicity of aluminum to humans has not been classified, but it has not been shown to cause cancer in animals (ATSDR 2008 FAQ Al). Aluminum is poorly absorbed in humans following oral (<1%) exposure. Aluminum does not bioaccumulate in plants (TOX 2008).

Cadmium - Long-term exposure to lower levels of cadmium in air, food, or water leads to a buildup of cadmium in the kidneys and possible kidney disease. Other long-term effects are lung damage and fragile bones. Eating food or drinking water with very high levels severely irritates the stomach, leading to vomiting and diarrhea. The health effects in children are expected to be similar to the effects seen in adults (kidney, lung, and bone damage depending on the route of exposure). A few studies in animals indicate that younger animals absorb more cadmium than adults. Animal studies indicate that the young are more susceptible than adults to a loss of bone and decreased bone strength from exposure to cadmium. It is not known if cadmium causes birth defects in people. The babies of animals exposed to high levels of cadmium during pregnancy had changes in behavior and learning ability. There is also some information from animal studies that high enough exposures to cadmium before birth can reduce body weights and affect the skeleton in the developing young. Cadmium is a known human carcinogen (ATSDR 2008 FAQ Cd). Reports of the ability of cadmium to cause cancer in animals following oral exposure are conflicting; with a negative cancer response reported in multiple studies in rats and mice (IRIS 2009), while a positive cancer response has been reported for animals in other references (TOX 2008). EPA states there are no positive studies of cadmium causing cancer after oral exposure (IRIS 2009). Humans absorb 5 to 10% of ingested cadmium. Animals accumulate cadmium in the liver and kidney. Plants readily accumulate aluminum from the soil (TOX 2008). Neither EPA nor ATSDR provide values to estimate cancer risk for oral exposures.

Copper - Copper is an essential nutrient. People need small amounts of copper in their diets to maintain their health, but high levels can harm health. Ingesting high levels of copper can cause nausea, vomiting, and diarrhea. Very high doses of copper can cause damage to the liver and kidneys, and can even cause death. Children exposed to high levels of copper experience the same types of effects as adults. It is not known if children are more sensitive to the adverse effects of copper at lower doses. Although not confirmed in human studies, animal studies suggest that young children may have more severe effects than adults to copper. There are a very small percentage of infants and children who are unusually sensitive to copper. It is not knows if copper causes birth defects or other developmental effects in humans at high levels. Studies in animals suggest that high levels of copper may cause a decrease in fetal growth. It is not known if exposure to copper causes cancer in humans and the carcinogenicity of copper to humans has not been classified (ATSDR 2004 FAQ Cu). Humans absorb 55 to 75% of ingested copper (TOX 2008).

Manganese - Manganese is an essential nutrient required for many metabolic and cellular functions (TOX 2008). Eating a small amount of it each day is important to stay healthy. The most common health problems in workers exposed to high levels of manganese involve the nervous system. These health effects include behavioral changes and other nervous system effects, which include movements that may become slow and clumsy. This combination of symptoms when sufficiently severe is referred to as "manganism". Other less severe nervous system effects such as slowed hand movements have been observed in some workers exposed to lower concentrations in the work place. Nervous system and reproductive effects have been observed in animals after high oral doses of manganese (ATSDR 2008 FAQ Mn). Nervous system damage has been reported following ingestion of water contaminated with manganese between 1,800 to 14,000 µg/L (TOX 2008). Studies in children have suggested that extremely high levels of manganese exposure may produce undesirable effects on brain development, including changes in behavior and decreases in the ability to learn and remember. It is not known if these changes were due to manganese alone, or if they were temporary or permanent. It is not known if children are more sensitive than adults to the effects of high levels of manganese. Studies of manganese workers have not found increases in birth defects or low birth weight in their offspring. No birth defects were observed in animals exposed to manganese. It is not known if exposure to manganese causes cancer in humans and the carcinogenicity of manganese to humans has not been classified (ATSDR 2008 FAQ Mn). Humans absorb 1 to 5% of ingested manganese (TOX 2008).

***Zinc* -** Zinc is an essential element in our diet required for many metabolic processes. Too little zinc can cause health problems, but too much zinc is also harmful. Harmful effects generally begin at levels 10-15 times higher than the amount needed for good health. Large doses taken by mouth even for a short time can cause stomach cramps, nausea, and vomiting. Taken longer, it can cause anemia and decrease the levels of good cholesterol. It is not knows if high levels of zinc affect reproduction in humans. Rats that were fed large amounts of zinc became infertile. It is not known if exposure to zinc causes cancer in humans and the carcinogenicity of zinc to humans has not been classified (ATSDR 2005 FAQ Zn). There are indications that ingesting too little zinc may be associated with an increased risk of developing some types of cancer in humans (TOX 2008). Twenty to 30% of ingested zinc is absorbed (TOX 2008).

HEALTH OUTCOME DATA

In addition to studying exposure and chemical-specific toxicity data as part of the public health assessment process, N.C. DPH also considers health outcome data, such as mortality and morbidity data. The following criteria are evaluated when determining if a study of health outcome data is reasonable: (1) presence of a completed human exposure pathway, (2) high enough concentrations of contaminants to result in measureable adverse health effects, (3) sufficient numbers of exposed people in the pathway for effects to be measured, and (4) a health outcome database where disease rates for the population of concern can be identified.

No health outcome data has been collected for the Ore Knob Mine NPL site.

COMMUNITY HEALTH CONCERNS

The primary concerns associated with the Ore Knob Mine site include potential groundwater impacts for persons living in close proximity to the site and using private drinking water wells and the physical hazard associated with the main tailings impoundment. In addition, surface water impacts caused by acid mine drainage and surface water run-off impacted by mining waste materials on the site could impact persons living and recreating in the vicinity of the site. In the past, prior to the main tailings pile being capped by clean soils and re-vegetated, persons exposed to airborne dust could have experienced upper respiratory irritation associated with inhalation of the fine tailings materials, especially during periods of extended dry weather. N.C. DENR noted experiencing this phenomenon during their visits to the site.

A number of physical hazards also exist at the site. These include the mine shafts and adits, the remaining former mine equipment and structures, the earthen dam structure of the main tailings impoundment and the construction and remediation activities on-going on the site. Controlling access to the site will reduce or eliminate these potential hazards. A fence (6 or more feet high) is in place around portions of the 1950s mine and mill area.

County health officials and EPA site personnel both indicated that the community has not expressed particular concern with the site and current activities. This may be related to the community's familiarity with the historical presence of the mine, or lack of knowledge of the potential site issues. In November 2009, EPA staff held a public availability meeting in the community. Sixteen persons from the community attended the meeting. The main concern expressed to the EPA staff were concerns with potential negative impacts to the groundwater and private drinking water wells in the area.

CHILD HEALTH CONSIDERATIONS

The ATSDR recognizes there are unique exposure risks concerning children that do not apply to adults. Children are at a greater risk than are adults to certain kinds of exposures to hazardous substances. Because they play outdoors and because they often carry food into contaminated areas, children are more likely to be exposed to contaminants in the environment. Children are shorter than adults and as a result, they are more likely to breathe more dust, soil, and heavy vapors that accumulate near the ground. They are also smaller, resulting in higher doses of chemical exposure per body weight. If toxic exposures occur during critical growth stages, the developing body systems of children can sustain permanent damage. Probably most important, however, is that children depend on adults for risk identification and risk management, housing, and access to medical care. Thus, adults should be aware of public health risks in their community, so they can guide their children accordingly. Child-specific exposure situations and health effects are taken into account in N.C. DPH health effect evaluations.

Soil pica exposures to young children were considered in this Public Health Assessment. Pica exposures are acute exposures taking place over a short period of time (1-day) applying to young children (0-6 years of age). ATSDR recommends evaluating pica behavior using consumption of a large amount of soil (5,000 mg/day) (ATSDR 2005). Non-pica recreational soil exposures of 400 mg/day were also used in this study to represent the upper percentile soil ingestion rate determined by EPA (EPA 1997). The 400 mg/day value is twice the rate generally applied by ATSDR and N.C. DPH for incidental soil ingestion by children.

Exposure estimates for pica behavior in children indicated the potential for adverse health effects associated with copper and aluminum intake in the sampled residential soils. In addition, the potential for adverse health effects are indicated for pica behavior for children exposed to site soils and waste materials, and sediment and floodplain soils for copper, aluminum and zinc. The ultimate occurrence of adverse health effects related to these exposures maybe reduced by the likelihood that young children would be on the site for recreational activities and the lack of access to some of these media, such as the sediments in the larger downstream water bodies and the tailing wastes.

In addition to the potential chemical hazards associated with this site, children may be especially drawn to want to play on or near the potential physical hazards areas of the site. Limiting access to the site and educating the local community of the potential physical hazards are warranted.

CONCLUSIONS

N.C. DPH evaluated all the available environmental data for Ore Knob Mine which included water, soil and waste materials. Surface water and sediment samples collected on the site, as well as those collected downstream from the site, were also evaluated. Samples of private drinking water wells and soils collected from the lawns of nearby residences were also evaluated. The time period of environmental samples evaluated included 1987 through 2008. Many of the samples, both on-site and off-site, were collected to characterize areas thought to represent the greatest potential impact (contamination) due to historical mining operations. These samples may not be representative of the typical concentrations of the detected substances throughout the area. As such, the health impacts indicated would likely represent the greatest potential for adverse health effects anticipated from contact with the discussed media.

N.C DPH concluded:

- Concentrations of the metals cadmium and manganese in some of the private drinking water well samples collected from residences located near the Ore Knob Mine site may cause adverse health effects to persons drinking the water over many years. Cadmium at well location OK702 was at a concentration high enough to indicate the potential for adverse health effects to children. The manganese concentration at locations OK702, OK706 and OK707 indicate the potential to cause health effects to children and adults. The information currently available is not adequate to determine if these elevated metals are due to the former mining operations.
- Concentrations of the metals copper and iron in soils collected from the lawn of the residence identified as OK406 near the Ore Knob Mine site indicates the potential to cause adverse health effects to children unintentionally ingesting (eating) the soil over many years. The information currently available is not adequate to determine if these concentrations are typical for soils in this area or if they are related to the former mining operations.
- Concentrations of the metals copper and aluminum in the soils collected from lawns of residences near the Ore Knob Mine site may cause adverse health effects to children exhibiting “pica” behavior. Pica behavior is characterized by the ingestion of very large quantities of soil in a short period of time (such as 1 day). The concentrations of copper at residential locations OK406 and OK407, and aluminum at all 3 residential soil sampling

locations (OK406, OK407 and OK408) were at concentrations that indicate the potential for adverse health effects with pica ingestion rates. The aluminum concentrations observed in the residential soils were all within the range expected for area soils not impacted by the mine site. The copper and iron residential soil concentrations are greater than those identified for the local area background.

- The concentrations of the metals aluminum, copper and zinc found in soils, waste materials, tailings and sediments found on-site were at concentrations high enough to potentially cause adverse health effects to children exhibiting pica behavior. However, it is not likely that children of the age that exhibit pica behavior (2-3 years of age) would be expected to frequent the site.
- The concentration of copper found in multiple areas on-site were at concentrations high enough to cause adverse health effects to children accidently ingesting large amounts of these environmental media while participating in frequent recreational activities (such as camping or hiking) in these areas over many years. On-site media that exhibited elevated copper concentrations at these levels include some soils, Ore Knob Branch sediments near the main tailing impoundment, the tailings and other waste materials. Future exposures to the tailings will be eliminated by covering the main tailings impoundment with clean soil and re-vegetation. Most of the main tailing pile was covered by the end of 2009.
- The concentrations of the metals aluminum, copper and zinc found in floodplain soils and sediments associated with downstream water bodies as far as the South Fork New River were found at concentrations high enough to potentially cause adverse health effects to children exhibiting pica behavior and ingesting the soils and sediments. It is not likely that young children (2-3 years of age) that generally exhibit pica behavior are likely to frequently have access to these areas.
- Copper concentrations off-site in Peak Creek sediments just below the confluence with Ore Knob Branch were at concentrations high enough to cause adverse health effects to children and adults accidently ingesting the sediments participating in frequent recreational activities in these areas over many years. Sediment iron concentrations in this same area were also high enough to potentially cause adverse health effects to children exposed in frequent recreational activities in these areas over many years.

RECOMMENDATIONS

The N.C. DPH makes the following recommendations:

- Determine if groundwater flowing away from the site is contaminated by site waste materials and impacting private wells in the area. Test private wells that may be impacted for metals and other associated site contaminants (such as cyanide and sulfur species). .
- Re-test the private wells with the elevated manganese and cadmium. State or local health agencies should inform residents at locations where the private wells contain elevated concentrations of the metals manganese and cadmium of the potential for adverse health effects associated with long-term drinking of the well water. Assist them in identifying the alternatives to reduce their exposure or the potential for negative health impacts.

- Testing is recommended of the wells for the 2 mobile homes located on the access road to the 1950s mine and mill area. Testing of private wells should be adequate to identify future impacts related to the mine site in a health-protective time-frame
- If concentrations of substances are found in residential private wells in the vicinity of the site at concentrations that exceed regulatory or health guidelines a clean source of drinking water should be provided. Drilling new wells or providing whole-house filter or reverse osmosis systems would be suitable means of permanently providing a clean source of drinking water.
- If elevated concentrations of substances are identified in private wells that may pose health risks that are not associated with the mine operations, inform the residents and provide them with options to reduce their exposure or potential health risks.
- Tests waters supplied by any new wells placed in the area for the metals aluminum, arsenic, cadmium, copper, iron and manganese.
- Inform parents of children that may be living at the residences where elevated levels of copper, aluminum and iron were found in the lawn soils of the potential hazards and provide ways to reduce the potential exposure to their children. Means to reduce the exposure of children to the high metals in the residential soils include:
    - Monitor their play to prevent soil ingestion
    - Regularly wash outdoor toys
    - Have children wash their hands before eating after playing outdoors
    - Wash home grown produce before it is eaten
    - Limit children from playing in areas of bare soil. Use ground covers such as grass or mulch to limit direct contact with soil in areas where children play.
    - Seek medical attention from your family physician or consult with N.C. DPH physicians if you are concerned that your children have ingested large quantities of soil or had daily contact with contaminated soil.
- Inform the community and others that may use the site for recreational activities of the potential hazards. To reduce the potential for coming into contact with these hazards:
    - Control access to all areas of the site to reduce potential health hazards associated with high levels of metals-containing media and physical hazards associated with the site. Post warning signs addressing these hazards at locations where persons may gain access to the site.
    - Identify site-specific activities that persons maybe involved in (such as hiking, camping, fishing, or riding recreational vehicles) that could result in exposures to site media. This information is important to effectively communicate the potential hazards associated with these activities. Inform parents of the specific hazards to children.
    - Inform members of the hunting club that have been given access to nearby areas of the potential hazards associated with environmental materials on the site, and particularly those to children.

- Inform the site owner, the hunting club members that have been given access to areas bordering the site, and the local residents of the potential physical and health hazards (particularly those to children) associated with the site.

PUBLIC HEALTH ACTION PLAN

The purpose of the Public Health Action Plan (PHAP) is to ensure that this Public Health Assessment provides a plan of action designed to mitigate or prevent potential adverse health effects.

A. Public Health Actions Completed

- N.C. DPH has evaluated site information, environmental media analytical data, and health effects information to determine the potential for the health of the local community to be adversely impacted by substances identified on the Ore Knob Mine NPL site.

B. Public Health Actions Planned

- A draft copy of N.C. DPH's Public Health Assessment (PHA) will be made available to U.S. EPA, N.C. DENR, Ashe County officials, and the local community prior to final publication through ATSDR. DPH will review the comments and edit the PHA as necessary.
- A final draft copy of the PHA will be made available to the public for review prior to final publication by ATSDR. Copies will be available electronically from HACE and ATSDR web sites. Hard copies will be made available to the public at locations in selected document repositories.
- The final PHA will be available on the ATSDR and HACE web site. Print copies can be requested through ATSDR.
- N.C. DPH will contact the Ashe County Health Department to inform them of the concerns with the elevated manganese and cadmium in the residential private wells.
- HACE staff will either attend the site status update meeting planned in the spring of 2010 by U.S. EPA or hold a public availability meeting. HACE will be available to provide an overview of the findings of the PHA and respond to the community's questions and concerns.
- An Ore Knob Mine NPL Site PHA update summary factsheet will be prepared by HACE and be made available to the public and government agencies. Availability will include print copies provided at Ashe County locations selected as document repositories and electronic copies available from the HACE web site.
- N.C. DPH will continue to monitor health and analytical data generated by Federal, State, or County agencies, or other groups, relevant to this site or potentially affected areas near the site.
- N.C. DPH will monitor the follow-up of the recommendations made in this PHA to protect public health.

- N.C. DPH will provide contact information to agencies, organizations, and the public desiring additional inquiries about the site or the PHA.

CONTACT INFORMATION

Contact information for additional inquiries regarding the Ore Knob Mine NPL Site Public Health Assessment, or to contact N.C. DPH Public Health physicians:

Web links:

N.C. DPH HACE: http://www.epi.state.nc.us/epi/oee/hace/reports.html

ATSDR access to the Ore Knob Mine NPL Site Public Health Assessment:
http://www.atsdr.cdc.gov/HAC/PHA/index.asp

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CERTIFICATION

This Public Health Assessment for the Ore Knob Mine NPL Site (EPA ID: NCN000409895) was prepared by the North Carolina Division of Public Health (N.C. DHHS) under a cooperative agreement with the Federal Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with approved methodology and procedures existing at the time the health consult and update was initiated. Editorial review was completed by the cooperative agreement partner.

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The Division of Health Assessment and Consultation, ATSDR, has reviewed this health consultation, and concurs with its findings.

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Appendix A

Figures

Figure 1. Location of the Ore Knob Mine NPL site, Ashe County, NC and regional downstream surface waters.

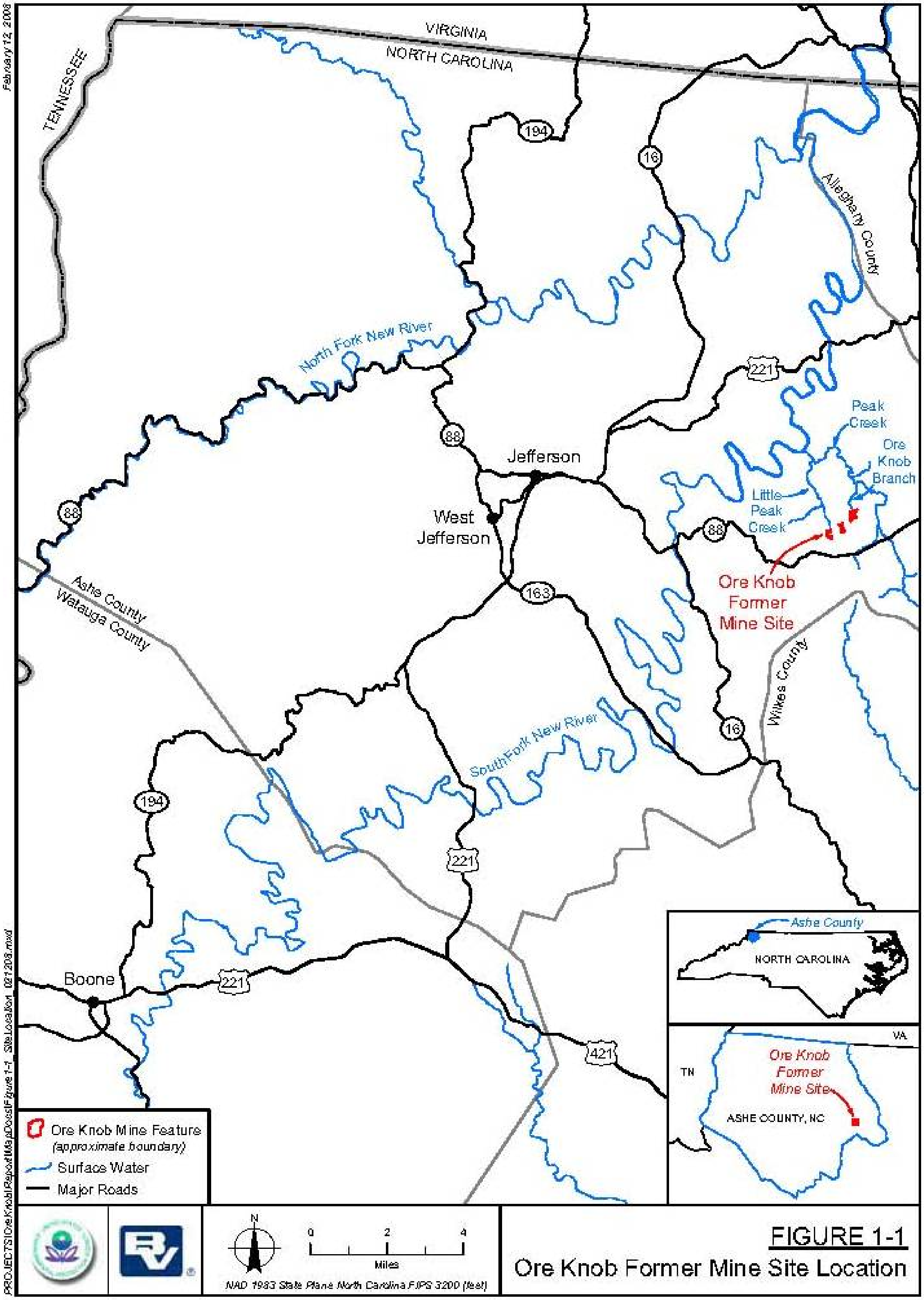


Figure 2. Location of the source areas making up the Ore Knob Mine NPL site and local downstream surface waters.

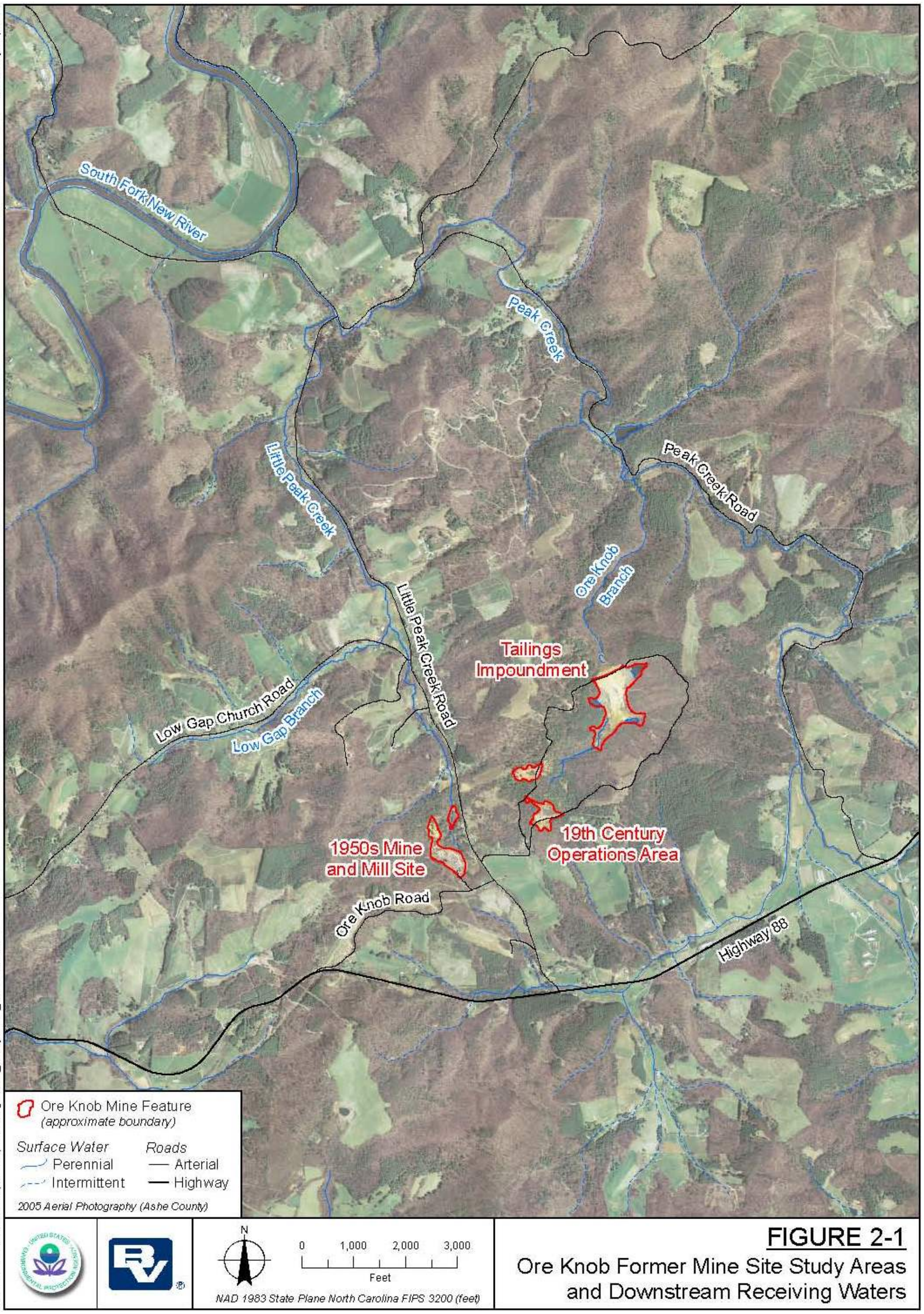


Figure 3. Topographical map of the Ore Knob Mine NPL site source areas.

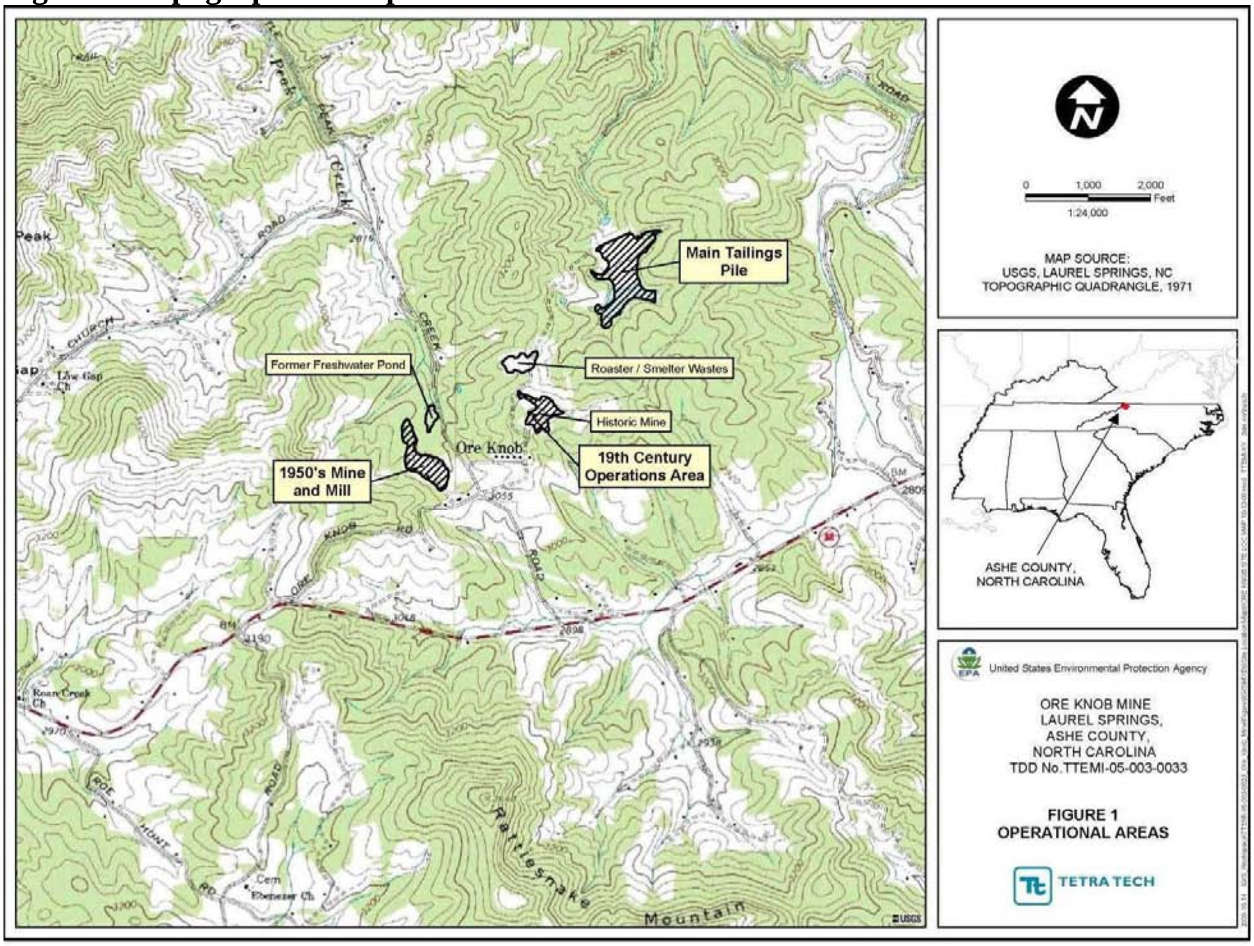


Figure 4. Ore Knob Mine 19th century operations area.

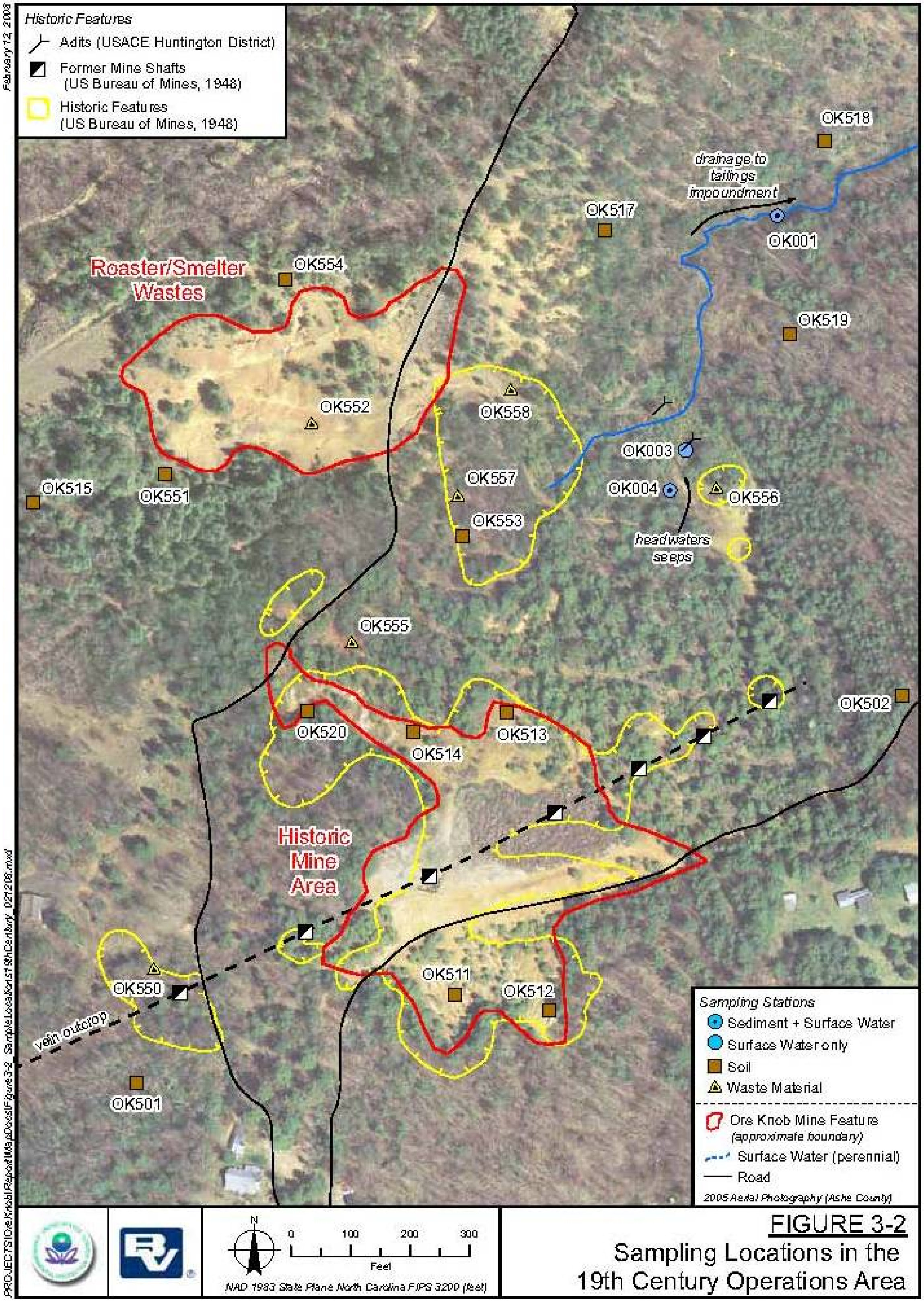


Figure 5. 1950s mine and mill area, Ore Knob Mine site. The residential soil sample locations are OK406, OK407 and OK408.

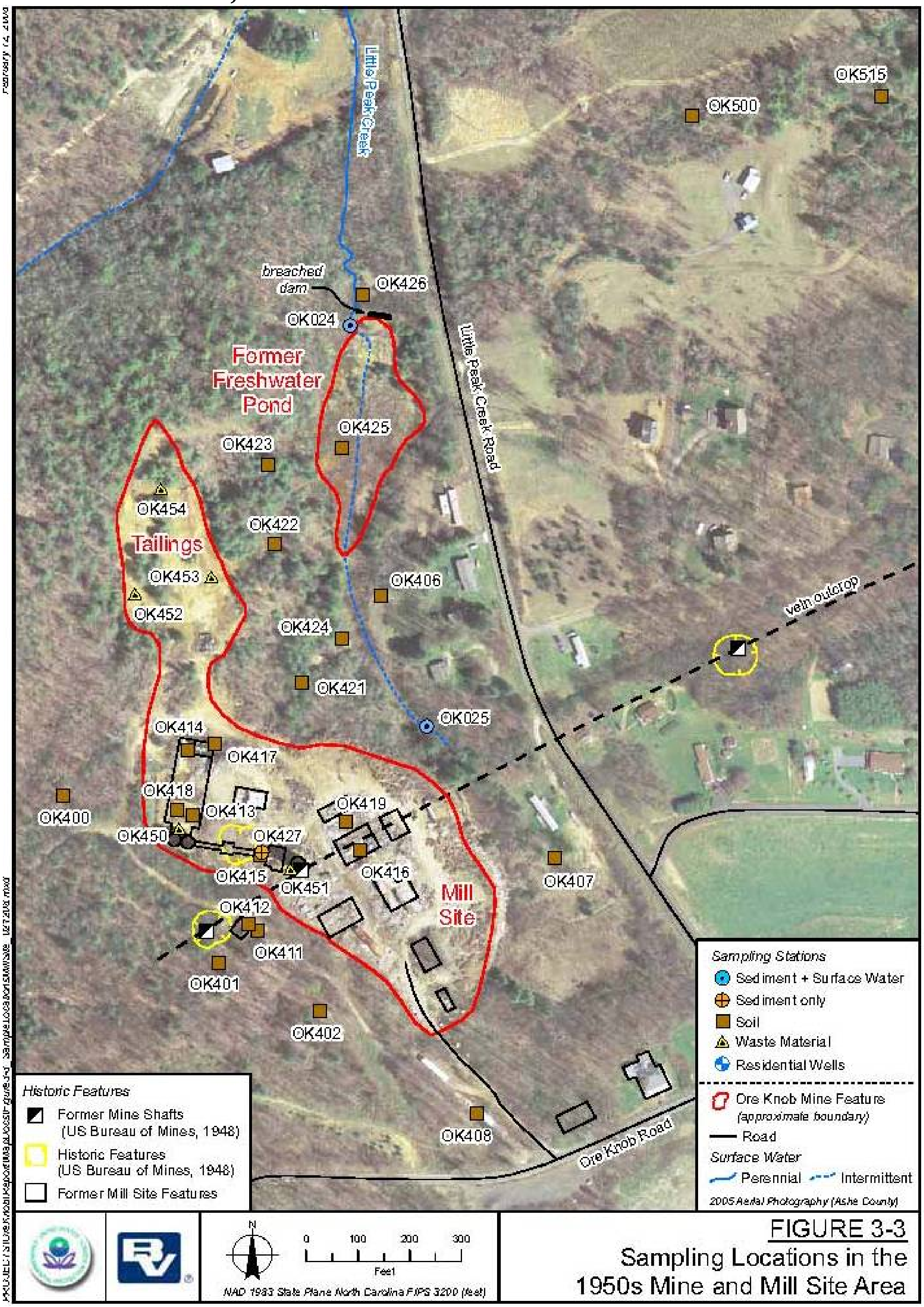


Figure 6. Ore Knob Mine NPL site, October 2009. Ore bin remnants in 19th century operations area.

Figure 7. Ore Knob Mine NPL site, October 2009. Structure remnants in 19th century operations area.

Figure 8. Ore Knob Mine NPL site, October 2009. Sawmill operating in 19th century operations area.

Figure 9. Ore Knob Mine NPL site tailings impoundment area.

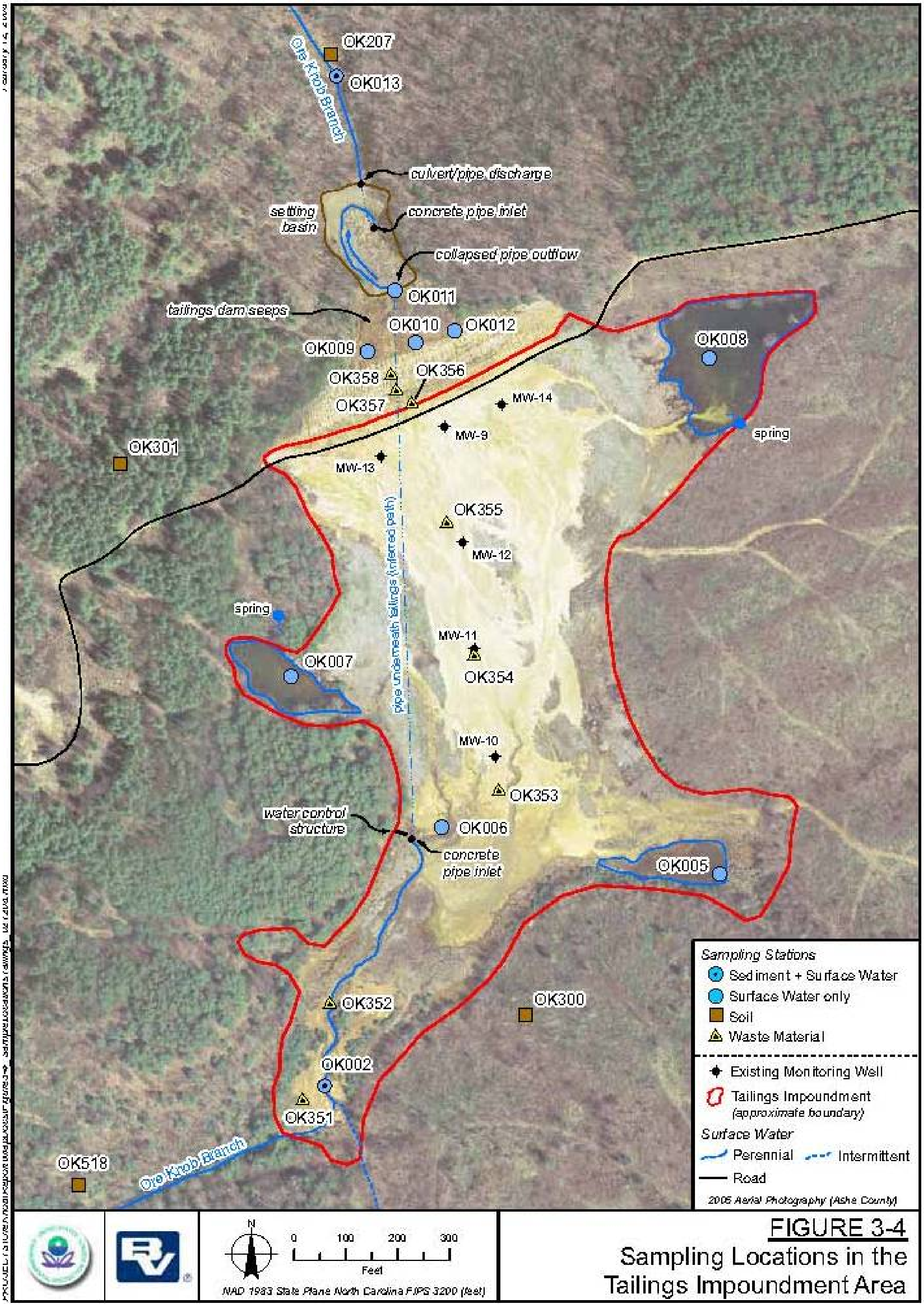


Figure 10. Ore Knob Mine NPL site. Facing south toward tailings impoundment. EPA photo, October 2008.

Figure 11. Ore Knob Mine NPL site, October 2009. Tailings impoundment dam, from west side, facing east.

Figure 12. Ore Knob Mine NPL site, October 2009. Water discharging from face of tailings impoundment dam around area of 24-inch pipe carrying surface water under the impoundment and discharging at the base of the dam.

Figure 13. Location of New River State Park in relation to the Ore Knob Mine site. Ore Knob Mine areas represented by pink markers.

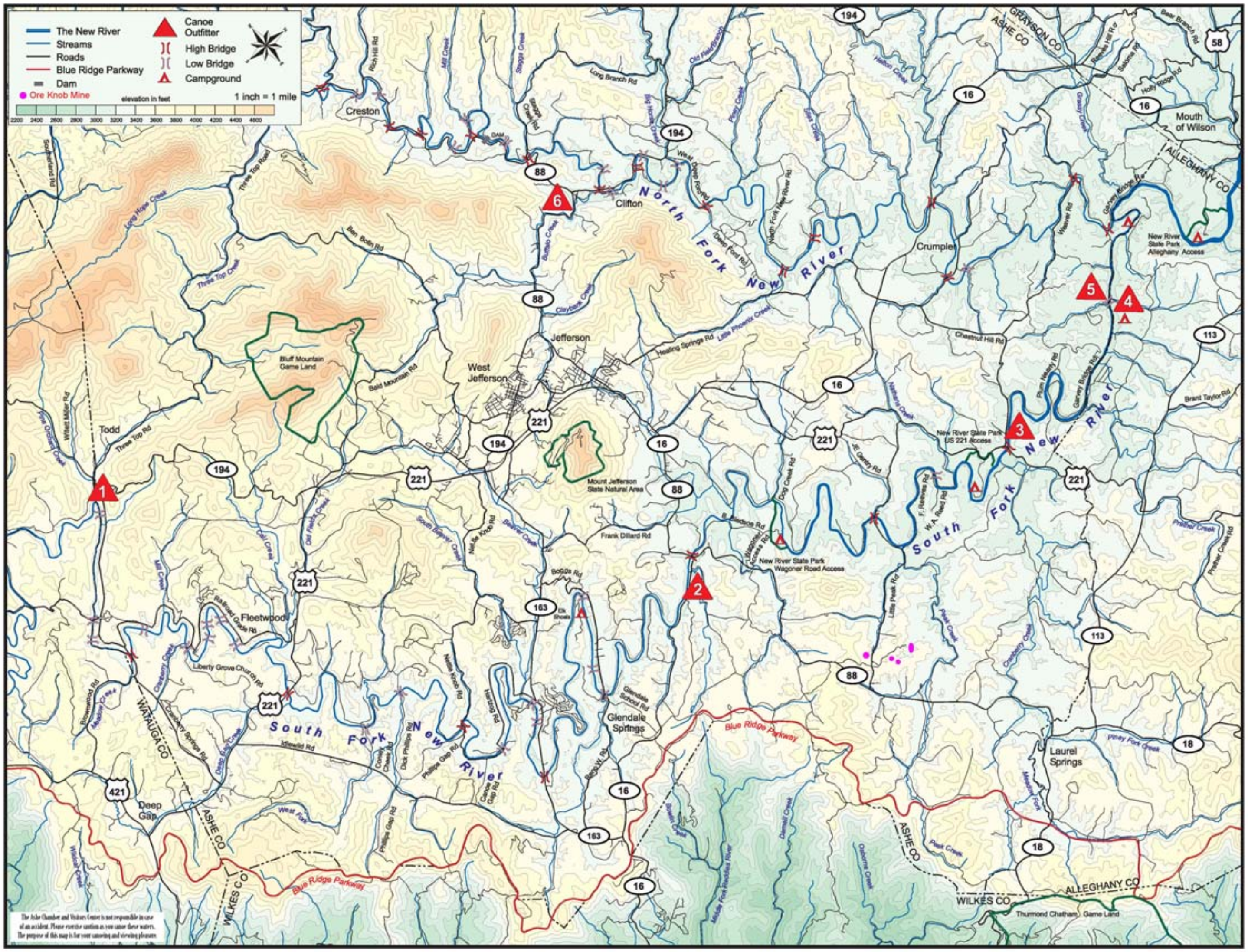


Figure 14. Ore Knob Mine NPL site, October 2009. View of capped and re-vegetated surface water pond on perimeter of 20-acre main tailings impoundment.

Figure 15. Ore Knob Mine NPL site, October 2009. View of channel under construction re-routing stream around outside northwest perimeter of 20-acre main tailings impoundment.

Figure 16. Ore Knob Mine NPL site, October 2009. View of channel under construction re-routing stream around outside southwest perimeter of 20-acre main tailings impoundment.

Figure 17. Confluence of Ore Knob Branch and Little Peak Creek downstream of the Ore Knob Mine NPL site. Note bright orange color of iron-rich site run-off in Ore Knob Branch (background) entering Little Peak Creek (flowing laterally in the fore ground). HACE October 2009.

Figure 18. Apparent floodplain soils carried downstream of the Ore Knob Mine NPL site. Observed near the confluence of Ore Knob Branch and Little Peak Creek. HACE October 2009.

Figure 19. Iron (orange) discoloration downstream of the Ore Knob Mine NPL site in the Little Peak Creek immediately upstream of the confluence with Peak Creek. HACE October 2009.

Figure 20. Location of residential private drinking water well samples collected in July 2007. Location OK701 is the background private well water location.

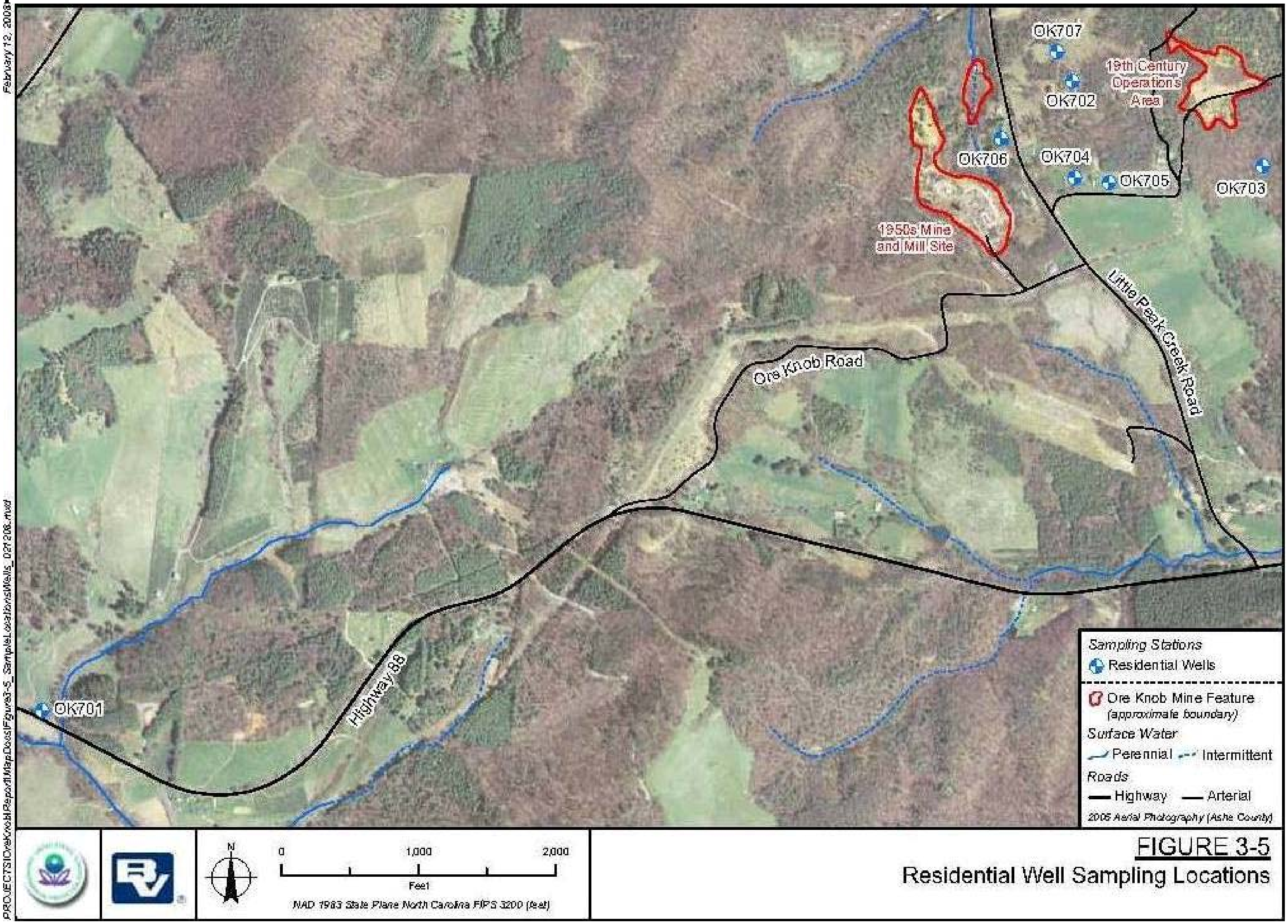
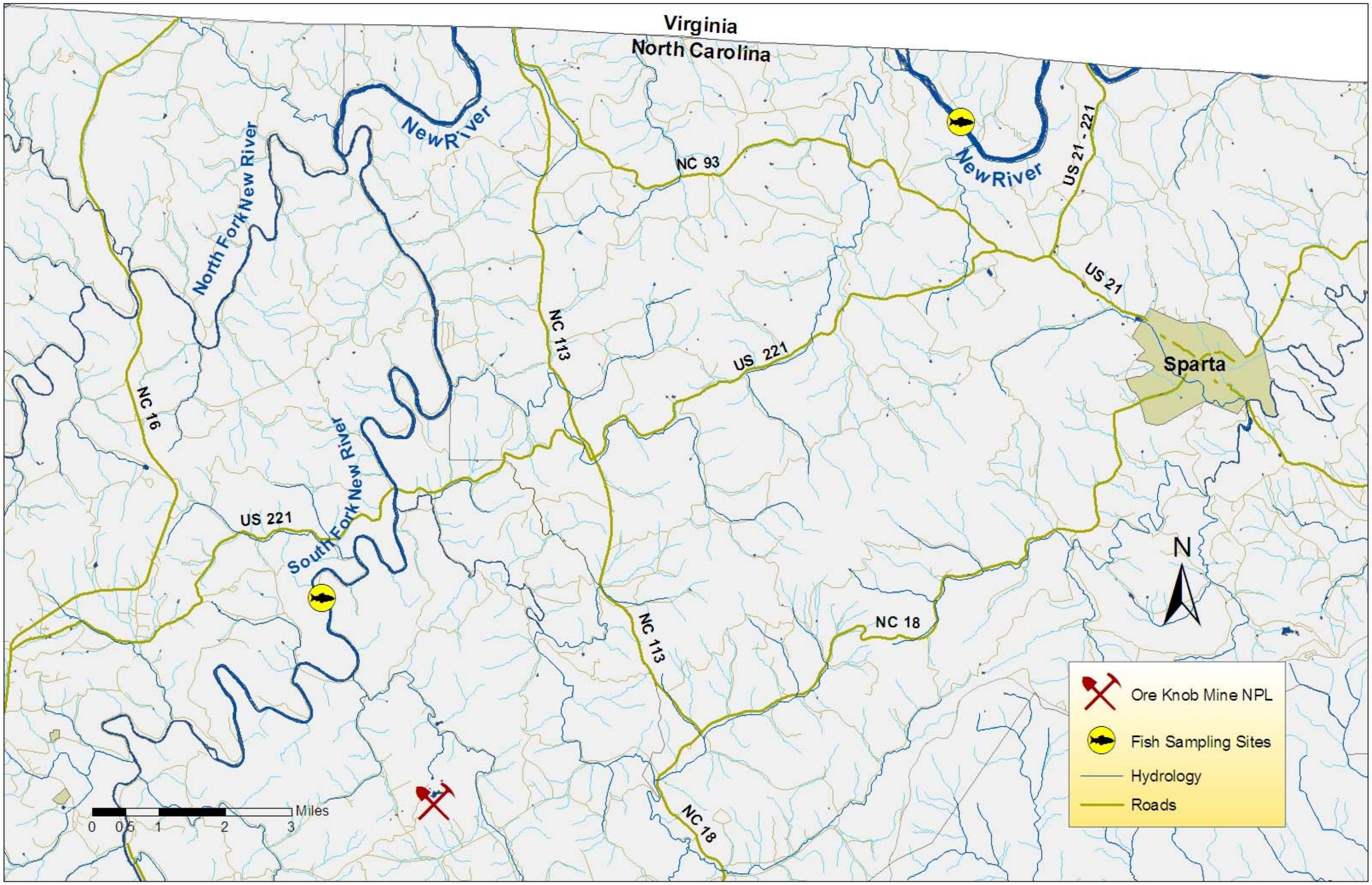


Figure 21. N.C. DENR/Div. of Water Quality fish collection locations downstream of the Ore Knob Mine NPL site. The location on South fork New River is approximately 1.5 miles downstream of the Peak Creek. The location on the New River is 32 miles downstream of Peak Creek.



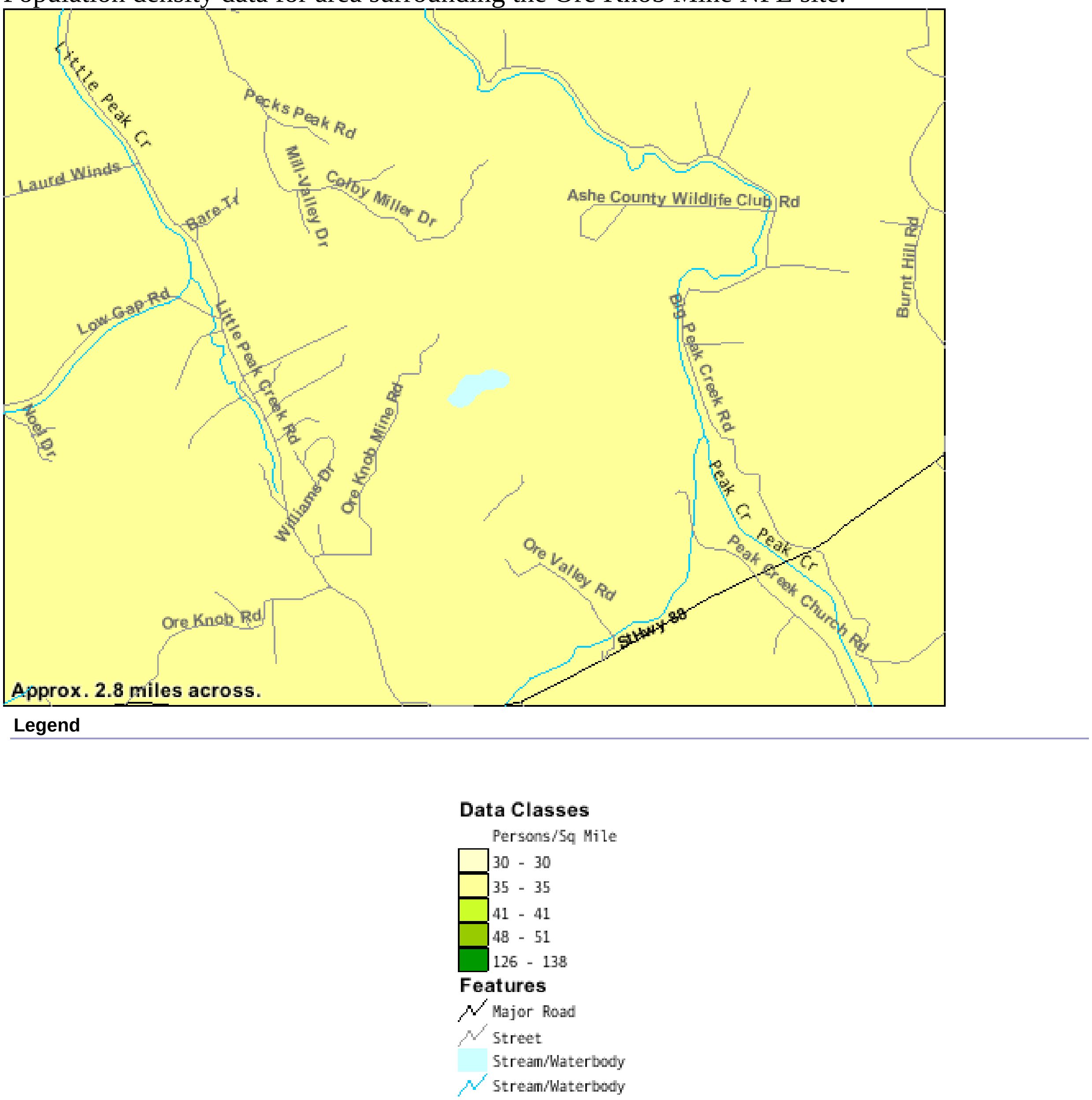
Appendix B

Demographics Data

According to Census 2000 figures, Ashe County has a population of 24,384. The majority of the population in the county is White (97%), with 1% African-American and 2% Hispanic. The educational attainment of the population is lower than the state and the country with 69% having a high school diploma or higher compared to 77% in the state and 80% in the country. In addition, 14% of the population has less than a 9th grade education, almost twice the percentage for the state and the country (8%).

It is estimated that there are 13,268 housing units in the county of which 10,411 are occupied (79%). Of the occupied housing units, 1,983 are occupied by renters (19%). The population density within 3 miles of the Ore Knob Mine Site is approximately 35 persons per square mile (DPH 2009).

Population density data for area surrounding the Ore Knob Mine NPL site.



Ashe County, NC - Demographics (Census 2000 figures)

	Ashe County	North Carolina	U.S.
Total population	24,384	8,049,313	281,421,906
Percent Minority			
Ethnicity			
White	97%	72%	75%
African-American	1%	22%	12%
Hispanics	2%	5%	13%
Asians	<1%	1%	4%
American Indians	<1%	1%	1%
Poverty Level	14%	12%	12%
High school diploma or higher	69%	77%	80%
Less than 9th grade	14%	8%	8%

HOUSING OCCUPANCY	Number	Percent
Total housing units	**13,268**	**100.0**
Occupied housing units	10,411	78.5
Vacant housing units	2,857	21.5
For seasonal, recreational, or occasional use	1,974	14.9
Homeowner vacancy rate (percent)	1.7	(X)
Rental vacancy rate (percent)	9.8	(X)
HOUSING TENURE		
Occupied housing units	**10,411**	**100.0**
Owner-occupied housing units	8,428	81.0
Renter-occupied housing units	1,983	19.0

Ashe County, NC continued -

General Characteristics -	Number	Percent	U.S.
Total population	24,384		
Male	12,031	49.3	49.1%
Female	12,353	50.7	50.9%
Median age (years)	42.1		35.3
Under 5 years	1,295	5.3	6.8%
18 years and over	19,557	80.2	74.3%
65 years and over	4,377	18.0	12.4%

General Characteristics -	**Number**	**Percent**	**U.S.**
One race	24,248	99.4	97.6%
White	23,691	97.2	75.1%
Black or African American	162	0.7	12.3%
American Indian and Alaska Native	79	0.3	0.9%
Asian	57	0.2	3.6%
Native Hawaiian and Other Pacific Islander	2	0.0	0.1%
Some other race	257	1.1	5.5%
Two or more races	136	0.6	2.4%
Hispanic or Latino (of any race)	590	2.4	12.5%
Household population	24,083	98.8	97.2%
Group quarters population	301	1.2	2.8%
Average household size	2.31		2.59
Average family size	2.75		3.14
Total housing units	13,268		
Occupied housing units	10,411	78.5	91.0%
Owner-occupied housing units	8,428	81.0	66.2%
Renter-occupied housing units	1,983	19.0	33.8%
Vacant housing units	2,857	21.5	9.0%

Social Characteristics -	**Number**	**Percent**	**U.S.**
Population 25 years and over	17,722		
High school graduate or higher	12,158	68.6	80.4%
Bachelor's degree or higher	2,141	12.1	24.4%
Civilian veterans (civilian population 18 years and over)	2,534	13.0	12.7%
Disability status (population 5 years and over)	6,052	26.5	19.3%
Foreign born	467	1.9	11.1%
Male, Now married, except separated (population 15 years and over)	6,528	65.6	56.7%
Female, Now married, except separated (population 15 years and over)	6,528	62.3	52.1%
Speak a language other than English at home (population 5 years and over)	772	3.3	17.9%

Economic Characteristics -	Number	Percent	U.S.
In labor force (population 16 years and over)	11,944	59.3	63.9%
Mean travel time to work in minutes (workers 16 years and over)	26.6		25.5
Median household income in 1999 (dollars)	28,824		41,994
Median family income in 1999 (dollars)	36,052		50,046
Per capita income in 1999 (dollars)	16,429		21,587
Families below poverty level	748	10.1	9.2%
Individuals below poverty level	3,246	13.5	12.4%

Housing Characteristics -	Number	Percent	U.S.
Single-family owner-occupied homes	4,830		
Median value (dollars)	91,600		119,600
Median of selected monthly owner costs			
With a mortgage (dollars)	733		1,088
Not mortgaged (dollars)	201		295

Source: U.S. Census Bureau, Summary File 1 (SF 1) and Summary File 3 (SF 3)

Reference:

EnviroMapper. U.S.EPA. http://www.epa.gov/emefdata/em4ef.home

Appendix C

Tables

Table 2. Data summary and screening value analysis for substances detected in private drinking water well samples collected near the Ore Knob Mine NPL site in July 2007. Table continued on next page.

Contaminant	Number of Samples	Number of Detections	No. of Detections Greater than CV	Range of Detections (μg/L)	Mean Concentration > CV [2] (μg/L)	Comparison Values (CV), (μg/L)	Type of CV
Aluminum	6	5	0	5.6 – 179	----	10,000 child 40,000 adult	Chronic EMEG
Arsenic[1]	6	0	0	<1.5	----	0.02	CREG
						10	MCL
Barium	6	6	0	11.3 – 39.8	----	2,000 child 7,000 adult	Chronic EMEG
Beryllium	6	4	0	0.26 – 0.42	----	20 child 40 adult	Chronic EMEG
						4	MCL
Cadmium	6	4	1	0.63 – 2.5	2.5	1 child 4 adult	Chronic EMEG
						5	MCL, MCLG
Calcium	6	6	----	5,080 – 159,000	48,700 [2]	No CVs	----
Chromium [3]	6	1	0	1.5	1.5	10 child 40 adult	Chronic EMEG [3]
						100	MCL
Cobalt	6	5	1	0.18 - 136	49.7	100 child 400 adult	Intermediate EMEG
Copper	6	6	0	1.6 – 41.8	----	100 child 400 adult	Intermediate EMEG
Iron	6	6	0	35.1 – 14,800	----	26,000	EPA PRG tap water
Lead	6	3	0	0.55 – 9.9	----	15	EPA MCL AL
Magnesium	6	6	----	1,270 – 126,500	24,400 [2]	No CVs	----

Table 2, continued. Data summary and screening value analysis for substances detected in private drinking water well samples collected near the Ore Knob Mine NPL site in July 2007.

Contaminant	Number of Samples	Number of Detections	No. of Detections Greater than CV	Range of Detections (µg/L)	Mean Concentration > CV (µg/L)	Comparison Values (CV), (µg/L)	Type of CV
Manganese	6	6	3	2.1 – 17,750	8,670	500 child 2,000 adult	RMEG
						300 50	EPA LTHA EPA 2nd DW[4]
Nickel	6	6	1	0.84 – 113	----	200 child 700 adult	RMEG
						100	EPA LTHA
Potassium	6	6	----	1,340 – 5,660	3,340 [2]	No CVs	----
Sodium	6	6	----	2,450 – 9,580	4,650 [2]	No CVs	----
Sulfate, Total	6	6	----	11,500 J – 472,000 J	168,000 J [2]	No CVs	----
						250,000	EPA 2nd DW[4]
Zinc	6	6	0	14.6 – 838	----	3,000 child 10,000 adult	Chronic EMEG
						2,000	EPA LTHA

Notes:
[1] Retained for Health Evaluation because reporting limit is greater than CREG comparison value
[2] Listed value is average detected concentration for substances with no CV
[3] CV given is for hexavalent chromium, the more toxic soluble form
[4] EPA secondary drinking water regulation. Non-enforceable guideline for compounds that may cause taste, odor, or appearance effects in drinking water.
CV = Comparison value (ATSDR established screening values)
AL = Action Level
J = estimated value
RMEG = Reference Dose Media Evaluation Guide
EMEG = Environmental Media Evaluation Guide
CREG = Cancer Risk Evaluation Guide
LTHA = Lifetime Health Advisory for Drinking Water (EPA)
µg/L = micrograms per liter, parts per billion (ppb)

Table 3. Site-specific exposure dose estimates and health guideline comparison values for residential private drinking water well samples collected near the Ore Knob Mine NPL site in July 2007.

<table>
<tr><th>Contaminant</th><th>Calculated Maximum Exposure Dose (mg/kg-d)</th><th>Calculated Mean Exposure Dose (mg/kg-d)</th><th>ATSDR MRL (non-cancer) (mg/kg-d)</th><th>Does Calculated Maximum Exposure Dose Exceed non-CA HG (child/adult) ?</th></tr>
<tr><td>Cadmium</td><td>0.00016 child
7.1e-05 adult</td><td>----</td><td>0.0001</td><td>child YES
adult NO</td></tr>
<tr><td>Manganese at OK702 (17,800 µg/L)</td><td>1.1 child
0.51 adult</td><td>----</td><td rowspan="3">0.050 EPA RfD
0.14 IRIS RfD</td><td>child YES
adult YES</td></tr>
<tr><td>Manganese at OK706 (6,370 µg/L)</td><td>0.40 child
0.18 adult</td><td>----</td><td>child YES
adult YES</td></tr>
<tr><td>Manganese at OK707 (1,900 µg/L)</td><td>0.12 child
0.054 adult</td><td>----</td><td>child YES
adult YES</td></tr>
<tr><td>Cobalt</td><td>0.0085 child
0.0039 adult</td><td>----</td><td>0.010</td><td>child NO
adult NO</td></tr>
<tr><td>Nickel</td><td>0.0071 child
0.0032 adult</td><td>----</td><td>0.02</td><td>child NO
adult NO</td></tr>
</table>

Notes: MRL = minimum Risk Level
RfD = Reference Dose
HG = Health Guideline
Non-CA = non-cancer

Table 4. Site-specific exposure dose estimates and increased cancer risk for residential private drinking water well samples collected near the Ore Knob Mine NPL site in July 2007. Estimates represent maximum values based on the arsenic analytical reporting limit.

Contaminant	Calculated Maximum Exposure Dose (mg/kg-d)	Cancer Slope Factor, CSF (mg/kg-d)	Calculated Theoretical Increased Cancer Risk (in 10,000 exposed persons)	Equal 1 Increased Cancer in a Population of -
Arsenic	9.4e-05 child 4.3e-05 adult	1.5	Less than 1	15,500

Table 5. Data summary and screening value analysis for substances detected in soil samples collected from lawns of residences near the Ore Knob Mine NPL site in July 2007. Table continued on the next page.

Contaminant	Number of Samples	Number of Detections	No. of Detections Greater than CV	Range of Detections (mg/kg)	Mean Concentration > CV (mg/kg)	Comparison Values (CV), (mg/kg)	Type of CV
Aluminum	3	3	3	10,000 J - 19,000	14,000	50,000 child 700,000 adult	Chronic EMEG
						2,000 child	Pica Intermediate
Arsenic	3	1	0	2 J	---	20 child 200 adult	Chronic EMEG
						20	CREG
Barium	3	3	0	71 J – 110	----	10,000 child 100,000 adult	Chronic EMEG
						400 child	Pica Intermediate
Beryllium	3	1	0	0.78	----	100 child 1,000 adult	Chronic EMEG
Calcium	3	3	----	410 J – 2,600 J	1,600	No CVs	----
Chromium	3	3	0	17 J – 27	----	80,000 child 1,000,000 adult	RMEG

Table 5, continued. Data summary and screening value analysis for substances detected in soil samples collected from lawns of residences near the Ore Knob Mine NPL site in July 2007.

Contaminant	Number of Samples	Number of Detections	No. of Detections Greater than CV	Range of Detections (mg/kg)	Mean Concentration > CV (mg/kg)	Comparison Values (CV), (mg/kg)	Type of CV
Cobalt	3	3	0	7.7 J – 19 J	----	500 child 7,000 adult	Intermediate EMEG
Copper	3	3	2	17 J – 1,800 J	985	500 child 7,000 adult	Intermediate EMEG
						20 pica child	Pica, acute, Intermediate
Iron	3	3	1	19,000 J – 60,000 J	----	55,000	EPA PRG residential
Lead	3	3	0	12 J – 15 J	----	400	EPA PRG residential
Magnesium	3	3	----	2,700 J – 2,900 J	2,800	No CVs	----
Manganese	3	3	0	250 J – 1,200 J	----	3,000 child 40,000 adult	RMEG
Mercury	3	1	0	0.48	----	23	EPA PRG residential
Nickel	3	2	0	9.8 J – 10 J	----	1,000 child 10,000 adult	RMEG
Potassium	3	3	----	1,900 J – 4,000	2,900	No CVs	----
Vanadium	3	3	0	29 J – 47	----	200 child 2,000 adult	Intermediate EMEG
Zinc	3	3	0	48 J – 170 J	----	20,000 child 200,000 adult	Chronic EMEG
						600 child	Pica intermediate
Benzaldehyde	3	1	0	27 J	----	5,000,000 child 70,000,000 adult	RMEG

Table 6. Site-specific exposure dose estimates and health guideline comparisons for residential soil samples collected near the Ore Knob Mine NPL site in July 2007.

Contaminant	Calculated Maximum Exposure Dose (mg/kg-d)	Calculated Mean Exposure Dose (mg/kg-d)	ATSDR MRL (non-cancer) (mg/kg-d)	Does Calculated Maximum Exposure Dose Exceed non-CA HG (child/adult) ?	Does Calculated Geometric Mean Exposure Dose Exceed non-CA HG (child/adult) ?
Copper at OK406 (1,800 mg/kg)	0.022 child 0.0026 adult 0.56 pica child	----	0.01	child YES adult NO pica child YES	----
Copper at OK407 (170 mg/kg)	0.0021 child 0.00024 adult 0.053 pica child	----		child No adult NO pica child YES	----
Iron at OK406	0.75 child 0.086 adult	----	0.70 EPA PRG residential oral RfD	child YES adult NO	----
Aluminum	0.24 child 0.027 adult 5.9 pica child	0.18 child 0.020 adult 4.4 pica child	1.0	child NO adult NO pica child YES	child NO adult NO pica child YES

Notes: EPA PRG oral RfD = EPA Preliminary Remediation Goal oral reference dose

Table 7. Data summary and screening value analysis for substances detected in soils collected in the 1950s mine and mill area. Samples collected in 2007. Table continued on the next page.

Contaminant	Number of Samples	Number of Detections	No. of Detections Greater than CV	Range of Detections (mg/kg)	Mean Concentration > CV (mg/kg)	Comparison Values (CV), (mg/kg)	Type of CV
Aluminum	13	13	13	3,800 – 16,000 J	9,200	50,000 child 700,000 adult	Intermediate EMEG
						2,000 child	Pica Intermediate EMEG
Arsenic	8	6	2	0.54 J – 150 J	85	20 child 200 adult	RMEG
						20	CREG
Barium	13	13	0	41 J – 260	----	10,000 child 100,000 adult	Chronic EMEG
						400 child	Pica Intermediate
Beryllium	12	6	0	0.25 J – 0.8	----	100 child 1,000 adult	RMEG
Cadmium	12	4	0	0.76 J – 10.2	----	30 child 400 adult	Intermediate EMEG
Calcium	13	12	0	150 J – 27,000 J	3,400	No CVs	----
Chromium[1]	13	13	0	9.9 – 120	----	80,000 child 1,000,000 adult	RMEG
Cobalt	13	10	1	4.7 J – 500	500	500 child 7,000 adult	Intermediate EMEG
Copper	13	13	6	19 J – 9,600 J	3,900	500 child 7,000 adult	Intermediate EMEG
						20 pica child	Pica, acute, Intermediate

Table 7, continued. Data summary and screening value analysis for substances detected in soils collected in the 1950s mine and mill area. Samples collected in 2007.

Contaminant	Number of Samples	Number of Detections	No. of Detections Greater than CV	Range of Detections (mg/kg)	Mean Concentration > CV (mg/kg)	Comparison Values (CV), (mg/kg)	Type of CV
Cyanide	10	1	0	1.7	----	1000 child 10,000 adult	RMEG
Iron	13	13	0	14,000 J – 370,000 J	----	720,000	EPA PRG Industrial
Lead	13	13	0	3.4 J – 49 J	----	400	EPA PRG residential
Magnesium	13	13	0	570 J – 5,300 J	2,100	No CVs	----
Manganese	13	13	0	51 – 810	----	3,000 child 40,000 adult	RMEG
Mercury	13	9	0	0.12 – 0.28	----	23	EPA PRG residential
Nickel	13	10	0	5.4 J – 41 J	----	1,000 child 10,000 adult	RMEG
Potassium	13	13	0	670 J – 9,600	3,000	No CVs	----
Selenium	11	6	0	2.4 J – 71 J	----	300 child 4,000 adult	RMEG
Silver	9	2	0	1.4 – 4.1	----	300 child 4,000 adult	RMEG
Sodium	13	2	0	400 J – 940 J	----	No CVs	----
Zinc	13	13	0	22 J – 2,700 J	----	20,000 child 200,000 adult	Chronic EMEG
						600 child	Pica intermediate

[1] as Hexavalent chromium

Table 8. Data summary and screening value analysis for metals detected in soils collected in the 19th century operations area. Samples collected in 2007. Table continued on the next page.

Contaminant	Number of Samples	Number of Detections	No. of Detections Greater than CV	Range of Detections (mg/kg)	Mean Concentration > CV (mg/kg)	Comparison Values (CV), (mg/kg)	Type of CV
Aluminum	9	9	0	12,000 J – 35,000	----	50,000 child 700,000 adult	Intermediate EMEG
						2,000 child	Pica Intermediate EMEG
Arsenic	9	8	0	1.2 J – 20 J	----	20 child 200 adult	RMEG
						20	CREG
Barium	9	9	0	26 J – 140 J	----	10,000 child 100,000 adult	Chronic EMEG
						400 child	Pica Intermediate
Beryllium	9	3	0	0.65 – 0.85	----	100 child 1,000 adult	RMEG
Cadmium	9	1	0	0.52 J	----	30 child 400 adult	Intermediate EMEG
Calcium	9	7	0	110 J – 950 J	520	No CVs	----
Chromium[1]	9	9	0	16 J – 42	----	80,000 child 1,000,000 adult	RMEG
Cobalt	9	8	0	5.7 - 20	----	500 child 7,000 adult	Intermediate EMEG
Copper	9	9	1	33 J – 680 J	680	500 child 7,000 adult	Intermediate EMEG
						20 pica child	Pica, acute, Intermediate

Table 8, continued. Data summary and screening value analysis for metals detected in soils collected in the 19th century operations area. Samples collected in 2007.

Contaminant	Number of Samples	Number of Detections	No. of Detections Greater than CV	Range of Detections (mg/kg)	Mean Concentration > CV (mg/kg)	Comparison Values (CV), (mg/kg)	Type of CV
Iron	9	9	0	28,000 J – 110,000	----	720,000	EPA PRG Industrial
Lead	9	9	0	8.2 J – 37 J	----	400	EPA PRG residential
Magnesium	9	9	0	1,600 J – 4,600 J	2,300	No CVs	----
Manganese	9	9	0	110 J - 480	----	3,000 child 40,000 adult	RMEG
Mercury	9	2	0	0.15 – 0.76	----	23	EPA PRG residential
Nickel	9	9	0	5 J – 19 J	----	1,000 child 10,000 adult	RMEG
Potassium	9	9	0	1,200 J – 5,100 J	2,700	No CVs	----
Selenium	7	1	0	9.4 J	----	300 child 4,000 adult	RMEG
Silver	9	2	0	0.13 J – 0.36 J	----	300 child 4,000 adult	RMEG
Vanadium	9	9	0	25 - 52	----	200 child 2,000 adult	Intermediate EMEG
Zinc	9	9	0	32 J – 180 J	----	20,000 child 200,000 adult	Chronic EMEG
						600 child	Pica intermediate

[1] as Hexavalent chromium

Table 9. Data summary and screening value analysis for organic compounds detected in the 1950s mine and mill area soil samples. Samples collected in 2007.

Contaminant	Number of Samples	Number of Detections	No. of Detections Greater than CV	Range of Detections (µg/kg)	Mean Concentration > CV (µg/kg)	Comparison Values (CV), (µg/kg)	Type of CV
2-Methylnaphthalene	13	2	0	26 J – 570 J	----	200,000 child 3,000,000 adult	RMEG
Benzaldehyde	13	3	0	44 J – 580 J	----	5,000,000 child 70,000,000 adult	RMEG
Benzo(a)anthracene	13	3	0	46 J – 180 J	----	2,100	EPA Industrial
Benzo(b)fluoranthene	13	6	0	31 J – 310 J	----	2,100	EPA Industrial
Benzo(g,h.i)perylene	13	4	0	27 J – 180 J	----	No CVs	----
Benzo(k)fluoranthene	13	5	0	26 J – 260 J	----	2,100	EPA Industrial
Benzo(a)pyrene	13	4	1	29 J – 260	260	100	CREG
Bis(2-ethylhexyl)-phthalate	13	2	0	42 J – 370	----	120,000	EPA Industrial
Carbazole	13	1	0	34 J	----	86,000	EPA Industrial
Chrysene	13	2	0	51 J – 230	----	210,000	EPA Industrial
Dibenzo(a,h)-anthracene	13	1	0	45 J	----	210	EPA Industrial
Fluoranthene	13	3	0	72 J – 390	----	20,000,000 child 300,000,000 adult	Intermediate EMEG
Indeno(1,2,3-cd)-pyrene	13	3	0	28 J – 190 J	----	2,100	EPA Industrial

Table 10. Data summary and screening value analysis for organic compounds detected in the 19th century operations area soil samples. Samples collected in 2007.

Contaminant	Number of Samples	Number of Detections	No. of Detections Greater than CV	Range of Detections (µg/kg)	Mean Concentration > CV (µg/kg)	Comparison Values (CV), (µg/kg)	Type of CV
Acenaphthylene	9	1	0	33 J	-----	No CVs	----
Benzaldehyde	9	2	0	32 J – 150 J	----	5,000,000 child 70,000,000 adult	RMEG
Benzo(a)anthracene	9	2	0	53 J - 150 J	----	2,100	EPA Industrial
Benzo(b)fluoranthene	9	2	0	120 J – 190 J	----	2,100	EPA Industrial
Benzo(g,h.i)perylene	9	2		110 J – 140 J		No CVs	----
Benzo(k)fluoranthene	9	2	0	110 J – 200 J	----	2,100	EPA Industrial
Benzo(a)pyrene	9	2	1	87 J – 200 J	200 J	100	CREG
Chrysene	9	2	0	75 J – 150 J	----	210,000	EPA Industrial
Dibenzo(a,h)-anthracene	9	1	0	31 J	----	210	EPA Industrial
Fluoranthene	9	2	0	110 J – 160 J	----	20,000,000 child 300,000,000 adult	Intermediate EMEG
Indeno(1,2,3-cd)-pyrene	9	2	0	99 J – 130 J	----	2,100	EPA Industrial
Phenanthrene	9	1		54 J		No CVs	----
Pyrene	9	2	0	90 J – 130 J	----	2,000,000 child 20,000,000 adult	RMEG

Table 11. Site-specific exposure dose estimates and health guideline comparison for the child and adult recreational exposure scenarios for soil samples collected from the 1950s mine and mill and 19th century operations areas. Samples collected in 2007.

Contaminant	Calculated Maximum Exposure Dose [1] (mg/kg-d)	Calculated Mean Exposure Dose [1] (mg/kg-d)	ATSDR MRL (non-cancer) (mg/kg-d)	Does Calculated Maximum Exposure Dose Exceed non-CA HG (child/adult)	Does Calculated Geometric Mean Exposure Dose Exceed non-CA HG (child/adult) ?
1950s Mine and Mill area					
Arsenic	0.00037 child 0.000042 adult	0.00021 child 0.000024 adult	0.005	child NO adult NO	child NO adult NO
Cobalt	0.0012 child 0.00014 adult	----	0.01	child NO adult NO	----
Copper	0.024 child 0.0027 adult	0.0096 child 0.0011 adult	0.01	child YES adult NO	child NO adult NO
19th Century Operations area					
Copper, Historic Smelter area	0.0017 child 0.00019 adult	----	0.01	child NO adult NO	----

[1] Child trespasser: 400 mg/d IR; 36 d/yr exposure frequency; 6 yr exposure period
Adult trespasser: 200 mg/d IR; 36 d/yr exposure frequency; 30 yr exposure period

Table 12. Site-specific recreational exposure dose estimates and health guideline comparison for the child and adult recreational exposure scenarios for soil samples collected from the 1950s mine and mill and 19th century operations areas. Samples collected in 2007.

Contaminant	Calculated Maximum Exposure Dose [1] (mg/kg-d)	Cancer Slope Factor (CSF) (mg/kg-d)	Calculated Theoretical Increased Cancer Risk (in 1,000,000 exposed persons)	Equals 1 Increased Cancer in a Population of -
1950s Mine and Mill Area				
Total PAHs as Benzo(a)pyrene equivalent	9.4e-07 child 1.1e-7 adult	7.3	Less than 1	1,200,000
19th Century Operations area				
Total PAHs as Benzo(a)pyrene equivalent	7.0e-7 child 8.0e-8 adult	7.3	Less than 1	1,700,000

[1] Child trespasser: 400 mg/d IR; 36 d/yr exposure frequency; 6 yr exposure period
Adult trespasser: 200 mg/d IR; 36 d/yr exposure frequency; 30 yr exposure period

Table 13. Data summary and screening value analysis for metals detected in waste rock, slag, ore bin and processed materials collected in 2007. Table continued on the next page.

Contaminant	Number of Samples	Number of Detections	No. of Detections Greater than CV	Range of Detections (mg/kg)	Mean Concentration > CV (mg/kg)	Comparison Values (CV), (mg/kg)	Type of CV
Aluminum	12	12	1	1,300 – 82,000	82,000	50,000 child 700,000 adult	Intermediate EMEG
						2,000 child	Pica Intermediate
Antimony	7	1	0	7.4 J	----	20 child 300 adult	RMEG
Arsenic	11	2	0	3.2 J – 4 J	----	20 child 200 adult	RMEG
						20	CREG
Barium	13	13	0	58 – 375	----	10,000 child 100,000 adult	Chronic EMEG
						400 child	Pica Intermediate
Beryllium	12	6	0	0.11 J – 1.9	----	100 child 1,000 adult	RMEG
Cadmium	13	6	1	1.5 – 7	7	30 child 400 adult	Intermediate EMEG
Calcium	12	11	0	120 – 61,000	15,500	No CVs	----
Chromium[1]	13	13	0	5.4 – 77	----	80,000 child 1,000,000 adult	RMEG
Cobalt	13	12	0	7.5 J – 390	----	500 child 7,000 adult	Intermediate EMEG

Table 13, continued. Data summary and screening value analysis for metals detected in waste rock, slag, ore bin and processed materials collected in 2007.

Contaminant	Number of Samples	Number of Detections	No. of Detections Greater than CV	Range of Detections (mg/kg)	Mean Concentration > CV (mg/kg)	Comparison Values (CV), (mg/kg)	Type of CV
Copper	13	13	9	170 J – 20,000	7,400	500 child 7,000 adult	Intermediate EMEG
						20 pica child	Pica, acute, Intermediate
Iron	13	13	0	21,000 J – 270,000 J	----	720,000	EPA PRG Industrial
Lead	13	13	0	11 J – 250 J	----	400	EPA PRG residential
Magnesium	12	12	0	170 J – 11,000 J	3,200	No CVs	----
Manganese	12	12	1	73 – 7,100	7,100	3,000 child 40,000 adult	RMEG
Mercury	13	10	0	0.15 – 0.5	----	23	EPA PRG residential
Nickel	13	8	0	4.2 J – 30 J	----	1,000 child 10,000 adult	RMEG
Potassium	12	12	0	980 – 10,000 J	5,900	No CVs	----
Selenium	13	10	0	3.7 J – 38	----	300 child 4,000 adult	RMEG
Silver	13	11	0	2.8 – 9.6 J	----	300 child 4,000 adult	RMEG
Sodium	12	8	0	310 J – 15,000	2,400	No CVs	----
Thallium	10	2	0	4.1 – 8.6	6.4	No CVs	----
Vanadium	13	13	0	18 – 130	----	200 child 2,000 adult	Intermediate EMEG
Zinc	12	12	0	47 J – 3,900 J	----	20,000 child 200,000 adult	Chronic EMEG
						600 child	Pica intermediate

[1] as Hexavalent chromium

Table 14. Data summary and screening value analysis for organic compounds detected in waste rock, slag, ore bin and processed materials. Samples collected in 2007.

Contaminant	Number of Samples	Number of Detections	No. of Detections Greater than CV	Range of Detections (µg/kg)	Mean Concentration > CV (µg/kg)	Comparison Values (CV), (µg/kg)	Type of CV
Anthracene	9	1	0	30 J	----	500,000,000 child 1,000,000,000 adult	Intermediate EMEG
Benzo(a)anthracene	9	4	0	38 J – 130 J	----	2,100	EPA Industrial
Benzo(b)fluoranthene	9	4	0	26 J – 130 J	----	2,100	EPA Industrial
Benzo(g,h.i)perylene	9	3	0	26 J – 64 J	----	No CVs	----
Benzo(k)fluoranthene	9	4	0	30 J – 130 J	----	2,100	EPA Industrial
Benzo(a)pyrene	9	3	1	41 J – 110 J	110 J	100	CREG
Chrysene	9	3	0	37J – 120 J	----	210,000	EPA Industrial
Fluoranthene	9	4	0	57 J – 250	----	20,000,000 child 300,000,000 adult	Intermediate EMEG
Indeno(1,2,3-cd)-pyrene	9	3	0	30 J – 86 J	----	2,100	EPA Industrial
Phenanthrene	9	2	0	58 J – 150 J	----	No CVs	----
Pyrene	9	3	0	53 J – 83 J	----	2,000,000 child 20,000,000 adult	RMEG

Table 15. Site-specific recreational exposure dose estimates and health guideline comparison for ingestion of metals detected in waste rock, slag, ore bin and processed materials collected in 2007.

Contaminant	Calculated Maximum Exposure Dose (mg/kg-d)	Calculated Mean Exposure Dose (mg/kg-d)	ATSDR MRL (non-cancer) (mg/kg-d)	Does Calculated Maximum Exposure Dose Exceed non-CA HG (child/adult) ?	Does Calculated Geometric Mean Exposure Dose Exceed non-CA HG (child/adult) ?
Aluminum	0.020 child 0.023 adult	----	1	child NO adult NO	----
Cadmium	1.7e-05 child 2.0e-06 adult	----	0.0005	child NO adult NO	----
Manganese	0.018 child 0.0020 adult	----	0.05 EPA chronic oral RfD	child NO adult NO	----
Copper	0.049 child 0.00056 adult	0.018 child 0.0021 adult	0.01	child YES adult NO	child YES adult NO

Table 16. Site-specific recreational exposure dose estimates and health guideline comparison for the child and adult trespasser exposure scenarios for waste rock, slag, ore bin and processed materials. Samples collected in 2007.

Contaminant	Calculated Maximum Exposure Dose [1] (mg/kg-d)	Cancer Slope Factor (CSF) (mg/kg-d)	Calculated Theoretical Increased Cancer Risk (in 1,000,000 exposed persons)	Equals 1 Increased Cancer in a Population of -
Total PAHs as Benzo(a)pyrene equivalent	3.6e-07 child 4.2e-08 adult	7.3	Less than 1	3,300,000

[1] Child trespasser: 400 mg/d IR; 36 d/yr exposure frequency; 6 yr exposure period
Adult trespasser: 200 mg/d IR; 36 d/yr exposure frequency; 30 yr exposure period

Table 17. Data summary and screening value analysis for metals detected in tailings pile samples collected in 2007. **Table continued on the next page.**

Contaminant	Number of Samples	Number of Detections	No. of Detections Greater than CV	Range of Detections (mg/kg)	Mean Concentration > CV (mg/kg)	Comparison Values (CV), (mg/kg)	Type of CV
Aluminum	9	9	0	780 – 6300	----	50,000 child 700,000 adult	Intermediate EMEG
						2,000 child	Pica Intermediate
Arsenic	8	8	0	2.2 J – 16 J	----	20 child 200 adult	RMEG
						20	CREG
Barium	9	9	0	70 – 240 J	----	10,000 child 100,000 adult	Chronic EMEG
						400 child	Pica Intermediate
Cadmium	7	4	0	0.81 J – 13	----	30 child 400 adult	Intermediate EMEG
Calcium	8	8	0	170 J – 32,000 J	14,000	No CVs	----
Chromium	9	9	0	5.2 – 79 J	----	80,000 child 1,000,000 adult	RMEG
Cobalt	9	8	0	8.9 – 230	----	500 child 7,000 adult	Intermediate EMEG
Copper	9	9	6	56 J – 6,000 J	1,800	500 child 7,000 adult	Intermediate EMEG
						20 pica child	Pica, acute, Intermediate
Iron	9	9	0	55,000 – 180,000	----	720,000	EPA PRG Industrial
Lead	9	9	0	6.3 J – 23 J	----	400	EPA PRG residential
Magnesium	9	9	0	180 J – 3,500 J	1,000	No CVs	----

Table 17, continued. Data summary and screening value analysis for metals detected in tailings pile samples collected in 2007.

Contaminant	Number of Samples	Number of Detections	No. of Detections Greater than CV	Range of Detections (mg/kg)	Mean Concentration > CV (mg/kg)	Comparison Values (CV), (mg/kg)	Type of CV
Manganese	9	9	0	68 – 280 J	----	3,000 child 40,000 adult	RMEG
Mercury	9	9	0	0.13 – 0.71	----	23	EPA PRG residential
Nickel	9	5	0	5.5 J – 26 J	----	1,000 child 10,000 adult	RMEG
Potassium	9	9	0	2,800 – 8,200	5,800	No CVs	----
Selenium	9	9	0	13 J – 87 J	----	300 child 4,000 adult	RMEG
Silver	9	8	0	1 J - 2.8	----	300 child 4,000 adult	RMEG
Sodium	9	4	0	330 J – 1,200	570	No CVs	----
Vanadium	9	9	0	12 J – 170 J	----	200 child 2,000 adult	Intermediate EMEG
Zinc	9	9	0	45 J – 1,500 J	----	20,000 child 200,000 adult	Chronic EMEG
						600 child	Pica intermediate

Table 18. Site-specific exposure dose estimates and health guideline comparison for the child and adult recreational exposure scenarios for the tailings pile samples. Samples collected in 2007.

Contaminant	Calculated Maximum Exposure Dose (mg/kg-d)	Calculated Mean Exposure Dose (mg/kg-d)	ATSDR MRL (non-cancer) (mg/kg-d)	Does Calculated Maximum Exposure Dose Exceed non-CA HG (child/adult) ?	Does Calculated Geometric Mean Exposure Dose Exceed non-CA HG (child/adult) ?
Copper	0.015 child 0.0017 adult	0.0044 child 0.00051 adult	0.01	child YES adult NO	child NO adult NO

Table 19. Data summary and screening value analysis for substances detected in ponded and seep surface waters associated with the main tailings impoundment. Samples collected from 1990 through 2008. Table continued on the next page.

Contaminant	Number of Samples	Number of Detections	No. of Detections Greater than CV	Range of Detections (µg/L)	Mean Concentration > CV (µg/L)	Comparison Values (CV), (µg/L)	Type of CV
Aluminum	17	17	3	142 – 110,000	48,900	10,000 child 40,000 adult	Intermediate EMEG
Arsenic	14	2	1	2 - 4.5	4.5	3 child 10 adult	RMEG
						10	MCL
Barium	16	13	0	12.5 – 140	----	2,000 child 7,000 adult	Chronic EMEG
Beryllium	7	5	0	0.19 – 2.3	----	20 child 70 adult	RMEG
						4	MCL, MCLG
Cadmium	21	16	3	0.22 – 31	23.3	5 child 20 adult	Intermediate EMEG
						5	MCL, MCLG
Calcium	19	19	----	2,000 – 463,000 J	73,700	No CVs	----
Chromium[1]	19	7	3	3.3 – 120	101	50 child 200 adult	Intermediate EMEG [1]
						100	MCL, MCLG
Cobalt	7	7	3	1.3 J – 743	433	100 child 400 adult	Intermediate EMEG
Copper	21	21	14	3 J – 9,200	2,060	100 child 400 adult	Intermediate EMEG
Iron	19	19	12	720 – 4,090,000	756,000	26,000	EPA PRG tap water
Lead	13	1	0	1.7 J	----	15	EPA MCL AL
Magnesium	20	20	----	481 – 130,000	19,400	No CVs	----
Manganese	20	20	16	37.3 J – 25,900	5,500	500 child 2,000 adult	RMEG
						300	EPA LTHA

Table 19, continued. Data summary and screening value analysis for substances detected in ponded and seep surface waters associated with the main tailings impoundment. Samples collected from 1990 through 2008.

Contaminant	Number of Samples	Number of Detections	No. of Detections Greater than CV	Range of Detections (µg/L)	Mean Concentration > CV (µg/L)	Comparison Values (CV), (µg/L)	Type of CV
Mercury	10	3	0	0.031 – 0.083 (dissolved)	----	11	EPA Tap Water
Molybdenum	7	2	0	0.17 – 0.62	----	50 child 200 adult	RMEG
						40	EPA LTHA
Nickel	18	17	0	0.53 J – 180	----	200 child 700 adult	RMEG
						100	EPA LTHA
Potassium	13	13	----	1,400 – 46,300	12,400	No CVs	----
Selenium	12	5	0	2.8 (dissolved) - 12	----	50 child 100 adult	RMEG
						50	MCL, MCLG, LTHA
Silver	7	3	0	1.4 – 4.9	----	50 child 200 adult	RMEG
						100	EPA LTHA
Sodium	13	13	----	770 – 8,490	2,690	No CVs	----
Thallium	7	1	0	0.6	----	2 0.5 0.5	MCL MCLG EPA LTHA
Vanadium	7	3	1	7.4 – 36.4 (dissolved)	36.4	30 child 100 adult	Intermediate EMEG
Zinc	21	21	3	6.9 J – 4,900	4,460	3,000 child 10,000 adult	Chronic EMEG
						2,000	EPA LTHA

[1] as Hexavalent chromium

Table 20. Site-specific exposure dose estimates and health guideline comparison values for incidental ingestion recreational exposures of seep and ponded surface waters near the main tailings impoundment. Samples collected from 1990 through 2008.

Contaminant	Calculated Maximum Exposure Dose (mg/kg-d)	Calculated Mean Exposure Dose (mg/kg-d)	ATSDR MRL (non-cancer) (mg/kg-d)	Does Calculated Maximum Exposure Dose Exceed non-CA HG (child/adult) ?	Does Calculated Geometric Mean Exposure Dose Exceed non-CA HG (child/adult) ?
Aluminum	0.011 child	0.050 child	1	child NO	child NO
Arsenic	4.6e-07 child	----	0.005	child NO	----
Cadmium	3.2e-06 child	2.4e-06 child	0.0005	child NO	----
Chromium	1.2e-05 child	1.0e-05 child		child NO	child NO
Cobalt	7.6e-05 child	4.4e-05 child	0.01	child NO	child NO
Copper	9.4e-04 child	2.1e-04 child	0.01	child NO	child NO
Iron	0.42 child	0.078 child		child NO	----
Manganese	0.0027 child	5.6e-04 child	0.05 EPA chronic oral RfD	child NO	child NO
Vanadium	3.7e-06 child	----	0.003	child NO	----
Zinc	5.0e-04 child	4.6e-04 child	0.3	child NO	child NO

Table 21. Data summary and screening value analysis for substances detected in Ore Knob Branch and its tributaries surface water samples. Samples collected from 1987 through 2008. Table continued on the next page.

Contaminant	Number of Samples	Number of Detections	No. of Detections Greater than CV	Range of Detections (µg/L)	Mean Concentration > CV (µg/L)	Comparison Values (CV), (µg/L)	Type of CV
Aluminum	23	21	1	590 – 17,000	----	10,000 child 40,000 adult	Intermediate EMEG
Barium	5	5	0	15.5 – 35.9 J	----	2,000 child 7,000 adult	Chronic EMEG
Beryllium	5	5	0	0.67 – 1.1	----	20 child 40 adult	Chronic EMEG
						4	MCL
Cadmium	28	12	2	0.94 – 5.5	5.4	5 child 20 adult	Intermediate EMEG
						5	MCL, MCLG
Calcium	17	17	----	39,000 – 130,000	----	No CVs	----
Chromium[1]	22	5	1	4.5 - 51	51	50 child 200 adult	Intermediate EMEG [1]
						100	MCL
Cobalt	3	3	1	63.4 – 124	124	100 child 400 adult	Intermediate EMEG
Copper	26	26	23	170 – 1,600	546	100 child 400 adult	Intermediate EMEG
Iron	19	19	19	49,000 – 840,000	187,000	26,000	EPA PRG tap water
Lead	24	4	0	0.5 J – 13	----	15	EPA MCL AL

Table 21, continued. Data summary and screening value analysis for substances detected in Ore Knob Branch and Tributaries surface water samples. Samples collected from 1987 through 2008.

Contaminant	Number of Samples	Number of Detections	No. of Detections Greater than CV	Range of Detections (µg/L)	Mean Concentration > CV (µg/L)	Comparison Values (CV), (µg/L)	Type of CV
Magnesium	23	23	----	6,400 – 180,000	31,000	No CVs	----
Manganese	22	22	22	1,180 – 22,000	4,300	500 child 2,000 adult	RMEG
						300	EPA LTHA
Molybdenum	5	1	0	0.21B	----	50 child 200 adult	RMEG
						40	EPA LTHA
Nickel	26	21	0	11.9 - 130	----	200 child 700 adult	RMEG
						100	EPA LTHA
Potassium	4	4	----	5,700 – 17,000	12,000	No CVs	----
Selenium	3	3	0	5	----	50 child 100 adult	RMEG
						50	MCL, MCLG LTHA
Silver	3	3	0	5	----	50 child 200 adult	RMEG
						100	LTHA
Sodium	4	4	----	1,800 – 3,330	2,700	No CVs	----
Thallium	3	1	0	0.3		2 0.5 0.5	MCL MCLG LTHA
Zinc	30	25	3	4,100 – 10,000	7,400	3,000 child 10,000 adult	Chronic EMEG
						2,000	EPA LTHA

[1] as Hexavalent chromium

Table 22. Site-specific exposure dose estimates and health guideline comparison for incidental ingestion during recreational activities of surface waters collected in Ore Knob Branch. Samples collected from 1987 through 2008.

Contaminant	Calculated Maximum Exposure Dose (mg/kg-d)	Calculated Mean Exposure Dose (mg/kg-d)	ATSDR MRL (non-cancer) (mg/kg-d)	Does Calculated Maximum Exposure Dose Exceed non-CA HG (child/adult) ?	Does Calculated Geometric Mean Exposure Dose Exceed non-CA HG (child/adult) ?
Aluminum	0.0018 child	----	1	child NO	----
Cadmium	5.6e-07 child	5.6e-07 child	0.0001	child NO	----
Chromium	5.2e-06 child	----	0.005	child NO	----
Cobalt	1.3e-05 child	----	0.01	child NO	----
Copper	1.6e-04 child	5.6e-05 child	0.01	child NO	child NO
Iron	0.086 child	0. 19 child	0.7 EPA PRG RfD_{oral}	child NO	child NO
Manganese	0.0023 child	4.4e-04 child	0.05 EPA Chronic RfD_{oral}	child NO	child NO
Zinc	0.0010 child	7.6e-4 child	0.03	child NO	child NO

Notes: MRL = minimum Risk Level
RfD = Reference Dose
HG = Health Guideline
Non-CA = non-cancer

Table 23. Data summary and screening value analysis for metals detected in Ore Knob Branch sediment and floodplain soil. Table continued on the next page. Samples collected in 2007.

Contaminant	Number of Samples	Number of Detections	No. of Detections Greater than CV	Range of Detections (mg/kg)	Mean Concentration > CV (mg/kg)	Comparison Values (CV), (mg/kg)	Type of CV
Aluminum	9	9	0	1,900 J – 4,900 J	----	50,000 child 700,000 adult	Intermediate EMEG
						2,000 child	Pica Intermediate
Arsenic	8	7	0	1.6 J – 3.8 J	----	20 child 200 adult	RMEG
						20	CREG
Barium	8	8	0	59 J – 220	----	10,000 child 100,000 adult	Chronic EMEG
						400 child	Pica Intermediate
Beryllium	8	6	0	0.074 J – 2.2	----	100 child 1,000 adult	RMEG
Cadmium	9	5	0	0.7 – 6.7	----	30 child 400 adult	Intermediate EMEG
Calcium	8	8	0	180 J – 3,100 J	730	No CVs	----
Chromium[1]	9	9	0	2.4 – 44	----	80,000 child 1,000,000 adult	RMEG
Cobalt	8	8	0	2.1 J – 140	----	500 child 7,000 adult	Intermediate EMEG
Copper	9	9	6	93 – 4,200 J	980	500 child 7,000 adult	Intermediate EMEG
						20 pica child	Pica, acute, Intermediate

Table 23, continued. Data summary and screening value analysis for metals detected in Ore Knob Branch sediment and floodplain soil. Samples collected in 2007.

Contaminant	Number of Samples	Number of Detections	No. of Detections Greater than CV	Range of Detections (mg/kg)	Mean Concentration > CV (mg/kg)	Comparison Values (CV), (mg/kg)	Type of CV
Iron	8	8	0	51,000 – 550,000	----	720,000	EPA PRG Industrial
Lead	9	9	0	4.6 – 24 J	----	400	EPA PRG residential
Magnesium	9	9	0	540 J – 6,200 J	2,500	No CVs	----
Manganese	9	9	0	17 – 820	----	3,000 child 40,000 adult	RMEG
Mercury	8	8	0	0.16 – 0.29	----	23	EPA PRG residential
Nickel	9	2	0	17 J – 19 J	----	1,000 child 10,000 adult	RMEG
Potassium	8	8	0	1,600 J – 10,000	4,700	No CVs	----
Selenium	8	6	0	12 J – 20 J	----	300 child 4,000 adult	RMEG
Silver	9	7	0	0.62 J – 1.6 J	----	300 child 4,000 adult	RMEG
Sodium	8	1	0	600 J	----	No CVs	----
Thallium	6	1	0	4.4	----	No CVs	----
Vanadium	8	8	0	22 J – 73	----	200 child 2,000 adult	Intermediate EMEG
Zinc	9	9	0	27 J – 1,000 J	----	20,000 child 200,000 adult	Chronic EMEG
						600 child	Pica intermediate

as Hexavalent chromium

Table 24. Site-specific exposure dose estimates and health guideline comparison for child and adult recreational exposure scenarios for Ore Knob Branch sediments and floodplain soils. Samples collected in 2007.

Contaminant	Calculated Maximum Exposure Dose (mg/kg-d)	Calculated Mean Exposure Dose (mg/kg-d)	ATSDR MRL (non-cancer) (mg/kg-d)	Does Calculated Maximum Exposure Dose Exceed non-CA HG (child/adult) ?	Does Calculated Geometric Mean Exposure Dose Exceed non-CA HG (child/adult) ?
Copper	0.010 child 0.0012 adult	0.0024 child 0.00027 adult	0.01	child YES adult NO	child NO adult NO

Table 25. Data summary and screening value analysis for organic compounds detected in Ore Knob Branch sediments and floodplain soils. Samples collected in 2007.

Contaminant	Number of Samples	Number of Detections	No. of Detections Greater than CV	Range of Detections (µg/kg)	Mean Concentration > CV (µg/kg)	Comparison Values (CV), (µg/kg)	Type of CV
Benzo(a)anthracene	8	1	0	45 J	----	2,100	EPA Industrial
Benzo(b)fluoranthene	8	1	0	37 J	----	2,100	EPA Industrial
Benzo(k)fluoranthene	8	1	0	42 J	----	2,100	EPA Industrial
Fluoranthene	8	1	0	83 J	----	20,000,000 child 300,000,000 adult	Intermediate EMEG

Table 26. Site-specific exposure dose estimates and health guideline comparison for the child and adult trespasser exposure scenarios for Ore Knob Branch sediments and floodplain soils. Samples collected in 2007.

Contaminant	Calculated Maximum Exposure Dose [1] (mg/kg-d)	Cancer Slope Factor (CSF) (mg/kg-d)	Calculated Theoretical Increased Cancer Risk (in 1,000,000 exposed persons)	Equals 1 Increased Cancer in a Population of -
Total PAHs as Benzo(a)pyrene equivalent	2.2e-08 child 2.4e-09 adult	7.3	Less than 1	57,000,000

[1] Child trespasser: 400 mg/d IR; 36 d/yr exposure frequency; 6 yr exposure period
Adult trespasser: 200 mg/d IR; 36 d/yr exposure frequency; 30 yr exposure period

Table 27. Data summary and screening value analysis for substances detected in Little Peak Creek and its tributaries surface water samples. Samples collected from 1990 through 2007. Table continued on the next page.

Contaminant	Number of Samples	Number of Detections	No. of Detections Greater than CV	Range of Detections (µg/L)	Mean Concentration > CV (µg/L)	Comparison Values (CV), (µg/L)	Type of CV
Aluminum	10	10	0	284 J – 3590 J	----	10,000 child 40,000 adult	Intermediate EMEG
Barium	4	4	0	22.8 – 34	----	2,000 child 7,000 adult	Chronic EMEG
Beryllium	4	2	0	0.37 – 1.2	----	20 child 40 adult	Chronic EMEG
						4	MCL
Cadmium	10	2	0	0.3 – 0.91	----	5 child 20 adult	Intermediate EMEG
						5	MCL, MCLG
Calcium	10	10	0	2,210 – 33,700	8,900	No CVs	----
Chromium	10	1	0	1.9	----	50 child 200 adult	Intermediate EMEG [1]
						100	MCL
Cobalt	4	4	0	0.52 J – 77.5 J	----	100 child 400 adult	Intermediate EMEG
Copper	10	10	0	1.7 J – 81.3 J	----	100 child 400 adult	Intermediate EMEG
Iron	10	10	0	120 – 4,890	----	26,000	EPA PRG tap water
Lead	10	2	0	0.6 – 0.59 J	----	15	EPA MCL AL

Table 27, continued. Data summary and screening value analysis for substances detected in Little Peak Creek and its tributaries surface water samples. Samples collected from 1990 through 2007.

Contaminant	Number of Samples	Number of Detections	No. of Detections Greater than CV	Range of Detections (µg/L)	Mean Concentration > CV (µg/L)	Comparison Values (CV), (µg/L)	Type of CV
Magnesium	10	10	0	799 – 7,560	----	No CVs	----
Manganese	10	10	2	1,320 – 3,570	2,440	500 child 2,000 adult	RMEG
						300	EPA LTHA
Nickel	10	7	0	2.2 J – 14 J	----	200 child 700 adult	RMEG
						100	EPA LTHA
Potassium	4	4	0	1,210 – 3,910	2,160	No CVs	----
Sodium	4	4	0	1,950 – 4,570	2,800	No CVs	----
Zinc	10	10	0	4.5 J - 139 J	----	3,000 child 10,000 adult	Chronic EMEG
						2,000	EPA LTHA

[1] as Hexavalent chromium

Table 28. Site-specific exposure dose estimates and health guideline comparison for incidental ingestion during recreational activities of surface waters collected in Little Peak Creek. Samples collected from 1990 through 2007.

Contaminant	Calculated Maximum Exposure Dose (mg/kg-d)	Calculated Mean Exposure Dose (mg/kg-d)	ATSDR MRL (non-cancer) (mg/kg-d)	Does Calculated Maximum Exposure Dose Exceed non-CA HG (child/adult) ?
Manganese	3.7e-04 child	2.5e-04 child	0.05 EPA oral RfD	child NO

Table 29. Data summary and screening value analysis for metals detected in Little Peak Creek sediments and floodplain soils. Samples collected in 2007. Table continued on the next page.

Contaminant	Number of Samples	Number of Detections	No. of Detections Greater than CV	Range of Detections (mg/kg)	Mean Concentration > CV (mg/kg)	Comparison Values (CV), (mg/kg)	Type of CV
Aluminum	8	8	0	2,500 J – 18,000	----	50,000 child 700,000 adult	Intermediate EMEG
						2,000 child	Pica Intermediate
Arsenic	8	2	0	1.1 J – 1.5 J	----	20 child 200 adult	RMEG
						20	CREG
Barium	8	8	0	20 J – 120 J	----	10,000 child 100,000 adult	Chronic EMEG
						400 child	Pica Intermediate
Beryllium	8	2	0	0.75 – 0.9	----	100 child 1,000 adult	RMEG
Calcium	8	8	0	120 J – 610 J	350	No CVs	----
Chromium	8	8	0	12 J - 46	----	80,000 child 1,000,000 adult	RMEG
Cobalt	8	6	0	2.8 J - 15	----	500 child 7,000 adult	Intermediate EMEG
Copper	8	8	2	5.7 J – 900 J	750	500 child 7,000 adult	Intermediate EMEG
						20 pica child	Pica, acute, Intermediate
Iron	8	8	0	12,000 – 43,000	----	720,000	EPA PRG Industrial

Table 29, continued. Data summary and screening value analysis for metals detected in Little Peak Creek sediments and floodplain soils. Samples collected in 2007.

Contaminant	Number of Samples	Number of Detections	No. of Detections Greater than CV	Range of Detections (mg/kg)	Mean Concentration > CV (mg/kg)	Comparison Values (CV), (mg/kg)	Type of CV
Lead	8	8	0	3.1 J – 10 J	----	400	EPA PRG residential
Magnesium	8	8	0	750 J – 3,700 J	1,800	No CVs	----
Manganese	8	8	0	120 - 470	----	3,000 child 40,000 adult	RMEG
Nickel	8	4	0	5.4 J – 14 J	----	1,000 child 10,000 adult	RMEG
Potassium	8	8	0	600 J – 3,500 J	2,000	No CVs	----
Selenium	6	1	0	19 J	----	300 child 4,000 adult	RMEG
Silver	5	1	0	0.93 J	----	300 child 4,000 adult	RMEG
Vanadium	8	8	0	13 J – 70 J	----	200 child 2,000 adult	Intermediate EMEG
Zinc	8	8	0	18 J – 81 J	----	20,000 child 200,000 adult	Chronic EMEG
						600 child	Pica Intermediate

Table 30. Site-specific recreational exposure dose estimates and health guideline comparison values for Little Peak Creek sediments and floodplain soils. Samples collected in 2007.

Contaminant	Calculated Maximum Exposure Dose (mg/kg-d)	Calculated Mean Exposure Dose (mg/kg-d)	ATSDR MRL (non-cancer) (mg/kg-d)	Does Calculated Maximum Exposure Dose Exceed non-CA HG (child/adult) ?	Does Calculated Geometric Mean Exposure Dose Exceed non-CA HG (child/adult) ?
Copper	0.0022 child 0.00025 adult	0.0018 child 0.00021 adult	0.01	child NO adult NO	child NO adult NO

Table 31. Data summary and screening value analysis for organic compounds detected in Little Peak Creek sediments and floodplain soils. Samples collected in 2007.

Contaminant	Number of Samples	Number of Detections	No. of Detections Greater than CV	Range of Detections (µg/kg)	Mean Concentration > CV (µg/kg)	Comparison Values (CV), (µg/kg)	Type of CV
o-Cresol	8	1	0	45 J	----	3,000 child 40,000 adult	RMEG
						100	Pica Intermediate
Benzaldehyde	8	1	0	100 J	----	5,000 child 70,000 adult	RMEG

Table 32. Data summary and screening value analysis for substances detected in Peak Creek and its tributaries surface water samples. Samples collected from 1987 through 2008.

Contaminant	Number of Samples	Number of Detections	No. of Detections Greater than CV	Range of Detections (µg/L)	Mean Concentration > CV (µg/L)	Comparison Values (CV), (µg/L)	Type of CV
Aluminum	43	40	0	93 - 633	----	10,000 child 40,000 adult	Intermediate EMEG
Barium	11	10	0	11.7 – 24	----	2,000 child 7,000 adult	Chronic EMEG
Cadmium	46	10	0	0.11 – 0.94 J	----	5 child 20 adult	Intermediate EMEG
						5	MCL, MCLG
Calcium	45	45	0	500 – 9,270	4,420	No CVs	----
Chromium[1]	36	8	0	1.3 – 1.7	----	50 child 200 adult	Intermediate EMEG
						100	MCL
Cobalt	7	7	0	0.58 J – 8.5 J	----	100 child 400 adult	Intermediate EMEG
Copper	46	42	1	0.56 J – 330	330	100 child 400 adult	Intermediate EMEG
Iron	45	45	0	72 – 12,900	----	26,000	EPA PRG tap water
Magnesium	45	45	0	730 – 16,000	1,700	No CVs	----
Manganese	45	45	0	8.1 – 226 J	----	500 child 2,000 adult	RMEG
						300	EPA LTHA
Nickel	44	16	0	0.58 J – 10	----	200 child 700 adult	RMEG
						100	EPA LTHA
Potassium	9	9	0	1000 – 1900	----	No CVs	----
Sodium	9	9	0	2,110 – 2,690	----	No CVs	----
Zinc	46	39	0	3.2 J – 850	----	3,000 child 10,000 adult	Chronic EMEG
						2,000	EPA LTHA

[1] as Hexavalent chromium

Table 33. Site-specific recreational exposure dose estimates and health guideline comparison values for surface waters collected in Peak Creek. Samples collected from 1987 through 2008.

Contaminant	Calculated Maximum Exposure Dose (mg/kg-d)	Calculated Mean Exposure Dose (mg/kg-d)	ATSDR MRL (non-cancer) (mg/kg-d)	Does Calculated Maximum Exposure Dose Exceed non-CA HG (child/adult) ?	Does Calculated Geometric Mean Exposure Dose Exceed non-CA HG (child/adult) ?
Copper	3.4e-05 child	----	0.01	child NO	----

Table 34. Data summary and screening value analysis for metals detected in Peak Creek sediments and floodplain soils. Samples collected in 2007. Table continued on the next page.

Contaminant	Number of Samples	Number of Detections	No. of Detections Greater than CV	Range of Detections (mg/kg)	Mean Concentration > CV (mg/kg)	Comparison Values (CV), (mg/kg)	Type of CV
Aluminum	9	9	0	2,900 – 13,000	----	50,000 child 700,000 adult	Intermediate EMEG
						2,000 child	Pica Intermediate
Arsenic	8	4	1	0.67 J – 67 J	67	20 child 200 adult	RMEG
						20	CREG
Barium	9	9	0	19 J - 220	----	10,000 child 100,000 adult	Chronic EMEG
						400 child	Pica Intermediate
Beryllium	9	2	0	0.27 J – 0.65	----	100 child 1,000 adult	RMEG
Cadmium	9	1	0	15	----	30 child 400 adult	Intermediate EMEG
Calcium	9	7	0	210 J – 10,000 J	2,600	No CVs	----
Chromium[1]	9	9	0	11 - 390	----	80,000 child 1,000,000 adult	RMEG
Cobalt	9	8	1	3.7 J – 500	500	500 child 7,000 adult	Intermediate EMEG
Copper	9	9	3	5.7 J – 99,000 J	54,000	500 child 7,000 adult	Intermediate EMEG
						20 pica child	Pica, acute, Intermediate

Table 34, continued. Data summary and screening value analysis for metals detected in Peak Creek sediments and floodplain soils. Samples collected in 2007.

Contaminant	Number of Samples	Number of Detections	No. of Detections Greater than CV	Range of Detections (mg/kg)	Mean Concentration > CV (mg/kg)	Comparison Values (CV), (mg/kg)	Type of CV
Iron	9	9	1	6,400 J – 940,000 J	940,000	720,000	EPA PRG Industrial
Lead	9	9	0	1.7 J – 370 J	----	400	EPA PRG residential
Magnesium	9	9	0	480 J – 4,400 J	2,200	No CVs	----
Manganese	9	9	0	94 J - 770	----	3,000 child 40,000 adult	RMEG
Mercury	9	1	0	1.2	----	23	EPA PRG residential
Nickel	9	7	0	6 J – 350 J	----	1,000 child 10,000 adult	RMEG
Potassium	9	9	0	310 J – 14,000 J	----	No CVs	----
Selenium	4	3	0	7 - 260	----	300 child 4,000 adult	RMEG
Silver	9	3	0	1.7 - 23	----	300 child 4,000 adult	RMEG
Sodium	9	2	0	320 J – 1,200 J	3,800	No CVs	----
Vanadium	9	9	0	12 - 88	----	200 child 2,000 adult	Intermediate EMEG
Zinc	9	9	0	14 J – 6,900 J	----	20,000 child 200,000 adult	Chronic EMEG
						600 child	Pica intermediate

[1] as Hexavalent chromium

Table 35. Site-specific recreational exposure dose estimates and health guideline comparison values for metals in Peak Creek sediments and floodplain soils. Samples collected in 2007.

Contaminant	Calculated Maximum Exposure Dose (mg/kg-d)	Calculated Mean Exposure Dose (mg/kg-d)	ATSDR MRL (non-cancer) (mg/kg-d)	Does Calculated Maximum Exposure Dose Exceed non-CA HG (child/adult) ?	Does Calculated Geometric Mean Exposure Dose Exceed non-CA HG (child/adult) ?
Arsenic	0.00016 child 1.9e-05 adult	----	0.005	child NO adult NO	----
Cobalt	0.0012 child 0.00014 adult	----	0.01	child NO adult NO	----
Copper	0.24 child 0.028 adult	0.13 child 0.015 adult	0.01	child YES adult YES	child YES adult YES
Iron	2.3 child 0.26 adult	----	0.70 EPA oral RfD	child YES adult NO	----

Table 36. Data summary and screening value analysis for organic compounds detected in Peak Creek sediments and floodplain soils. Samples collected in 2007.

Contaminant	Number of Samples	Number of Detections	No. of Detections Greater than CV	Range of Detections (µg/kg)	Comparison Values (CV), (µg/kg)	Type of CV
Benzaldehyde	9	1	0	180 J	5,000,000 child 70,000,000 adult	RMEG
Benzo(b)fluoranthene	9	1	0	22 J	2,100	EPA Industrial
Benzo(k)fluoranthene	9	1	0	22 J	2,100	EPA Industrial

Table 37. Site-specific recreational exposure dose estimates and health guideline comparison values for PAHs detected in Peak Creek sediments and floodplain soils. Samples collected in 2007.

Contaminant	Calculated Maximum Exposure Dose [1] (mg/kg-d)	Cancer Slope Factor (CSF) (mg/kg-d)	Calculated Theoretical Increased Cancer Risk (in 1,000,000 exposed persons)	Equals 1 Increased Cancer in a Population of -
Total PAHs as Benzo(a)pyrene equivalent	6.0e-09 child 6.8e-10 adult	7.3	Less than 1	200,000,000

[1] Child trespasser: 400 mg/d IR; 36 d/yr exposure frequency; 6 yr exposure period
Adult trespasser: 200 mg/d IR; 36 d/yr exposure frequency; 30 yr exposure period

Table 38. Data summary and screening value analysis for metals detected in South Fork New River surface water samples collected 630 feet downstream of Peak Creek. Sample collection in 2007.
Table continued on the next page.

Contaminant	Number of Samples	Number of Detections	No. of Detections Greater than CV	Range of Detections (µg/L)	Mean Concentration > CV (µg/L)	Comparison Values (CV), (µg/L)	Type of CV
Aluminum	5	5	0	175 – 298	----	10,000 child 40,000 adult	Intermediate EMEG
Barium	5	5	0	11.6 - 12.6	----	2,000 child 7,000 adult	Chronic EMEG
Calcium	5	5	0	4,510 – 5,220	4,800	No CVs	----
Chromium[1]	5	4	0	1.4 – 1.6	----	50 child 200 adult	Intermediate EMEG [1]
						100	MCL
Cobalt	5	5	0	0.28 J – 1.2 J	----	100 child 400 adult	Intermediate EMEG
Copper	5	5	0	1.5 J – 3.6 J	----	100 child 400 adult	Intermediate EMEG
Iron	5	5	0	492 – 766	----	26,000	EPA PRG tap water
Magnesium	5	5	0	1,830 – 2,120	1,980	No CVs	----
Manganese	5	5	0	20.7 J - 54.2 J	----	500 child 2,000 adult	RMEG
						300	EPA LTHA
Molybdenum	5	3	0	0.11 – 0.15	----	50 child 200 adult	RMEG
						40	EPA LTHA
Nickel	5	5	0	0.63 J – 3.1 J	----	200 child 700 adult	RMEG
						100	EPA LTHA

Table 38, continued. Data summary and screening value analysis for metals detected in South Fork New River surface water samples collected 630 feet downstream of Peak Creek. Sample collection in 2007.

Contaminant	Number of Samples	Number of Detections	No. of Detections Greater than CV	Range of Detections (µg/L)	Mean Concentration > CV (µg/L)	Comparison Values (CV), (µg/L)	Type of CV
Potassium	5	5	0	1,230 – 1,390	1,340	No CVs	----
Sodium	5	5	0	5,075 J – 5,860 J	5,440	No CVs	----
Zinc	5	5	0	2.4 J – 22.3 J	----	3,000 child 10,000 adult	Chronic EMEG
						2,000	EPA LTHA

[1] as Hexavalent chromium

Table 39. Data summary and screening value analysis for metals detected in South Fork New River sediments and floodplain soils. Samples collected in 2007. Table continued on the next page.

Contaminant	Number of Samples	Number of Detections	No. of Detections Greater than CV	Range of Detections (mg/kg)	Mean Concentration > CV (mg/kg)	Comparison Values (CV), (mg/kg)	Type of CV
Aluminum	6	8	0	2,500 J – 19,000	----	50,000 child 700,000 adult	Intermediate EMEG
						2,000 child	Pica Intermediate
Arsenic	6	2	0	1.4 J – 1.9 J	----	20 child 200 adult	RMEG
						20	CREG
Barium	6	6	0	8.5 J - 150	----	10,000 child 100,000 adult	Chronic EMEG
						400 child	Pica Intermediate
Beryllium	6	1	0	0.9	----	100 child 1,000 adult	RMEG
Calcium	6	6	0	180 – 1,500 J	620	No CVs	----
Chromium[1]	6	6	0	4 J - 32	----	80,000 child 1,000,000 adult	RMEG
Cobalt	6	4	0	3.4J - 16	----	500 child 7,000 adult	Intermediate EMEG
Copper	6	6	1	4J – 570 J	----	500 child 7,000 adult	Intermediate EMEG
						20 pica child	Pica, acute, Intermediate
Iron	6	6	0	5,400 J – 130,000 J	----	720,000	EPA PRG Industrial
Lead	6	6	0	0.76 J – 16 J	----	400	EPA PRG residential

Table 39, continued. Data summary and screening value analysis for metals detected in South Fork New River sediments and floodplain soils. Samples collected in 2007.

Contaminant	Number of Samples	Number of Detections	No. of Detections Greater than CV	Range of Detections (mg/kg)	Mean Concentration > CV (mg/kg)	Comparison Values (CV), (mg/kg)	Type of CV
Magnesium	6	6	0	200 J – 4,800 J	1,700	No CVs	----
Manganese	6	6	0	82 J – 470 J	----	3,000 child 40,000 adult	RMEG
Mercury	6	1	0	0.29	----	310	EPA Industrial
Nickel	6	3	0	3.6 J – 19 J	----	1,000 child 10,000 adult	RMEG
Potassium	6	6	0	110 J – 6,600	2,200	No CVs	----
Selenium	6	2	0	0.89 J – 11 J	----	300 child 4,000 adult	RMEG
Silver	6	1	0	1.3 J	----	300 child 4,000 adult	RMEG
Sodium	6	1	0	320 J	----	No CVs	----
Vanadium	6	6	0	6.2 J - 52	----	200 child 2,000 adult	Intermediate EMEG
Zinc	6	6	0	10 J – 81 J	----	20,000 child 200,000 adult	Chronic EMEG
						600 child	Pica intermediate

[1] as Hexavalent chromium

Table 40. Site-specific recreational exposure dose estimates and health guideline comparison values for South Fork new River sediments and floodplain soils. Samples collected in 2007.

Contaminant	Calculated Maximum Exposure Dose (mg/kg-d)	ATSDR MRL (non-cancer) (mg/kg-d)	Does Calculated Maximum Exposure Dose Exceed non-CA HG (child/adult) ?
Copper	0.0014 child 0.00016 adult	0.01	child NO adult NO

Table 41. Local background concentrations of substances found on the Ore Knob Mine site. Samples collected in 2007.

Substance	In Soils, mg/kg
Aluminum	13,000
Copper	38
Iron	29,000
Zinc	48

Table 42. Exposure estimation parameters used for recreational exposures to soils, sediments and waste materials.

Exposure Calculation Parameter	Child	Adult
Soil ingestion rate (IR), mg/d	400	200
Number of days per year exposed, days	36	36
Number of years exposed, years	6	30
Body weight (BW), kg	16	70

Table 43. Exposure estimation parameters used for incidental ingestion of surface waters by children while swimming or wading.

Exposure Calculation Parameter	Value
Number of times per week	1
Number of times per year	12
Number of hours per each activity	1
Number of years	6
Volume of water accidentally ingested, mls	50
Body weight (BW), kg	16

Table 44. ATSDR health effects study data values used for evaluation of site-specific exposure dose estimates for determination of the potential for adverse health effects.

Contaminant of Concern	Health Effect Values (mg/kg-d)	Notes	Reference
Cadmium	 0.0003 0.0021 0.0078	Oral, chronic, human - NOAEL, female, renal effects NOAEL, life-time exposure, renal effects NOAEL, >25 year lifetime exposure, hematological/musculoskeletal/renal effects	ATSDR 2008 Cd
Manganese	 0.0048 0.059 0.06 0.26	Oral, chronic, human - NOAEL, 50 yr exposure in drinking water, neurological effects LOAEL, 50 yr exposure in drinking water, mild neurological effects LOAEL, male, 5 yr exposure in drinking water, affecting general, verbal and visual memory and learning skills; inattentiveness; lack of focus LOAEL, ≤1 yr exposure in drinking water, increased fatality among children <1 yr of age	ATSDR 2008 Mn
Aluminum	 0.6 1.2 100	[No human data] NOAEL – Rat, 2.5 yr exposure in drinking water, respiratory, cardiac, hepatic, renal & BW effects Mouse, lifetime exposure in water, respiratory, cardiac, hepatic, renal & BW effects LOAEL, female mouse, 2-yr exposure in food, BW effects, decreased limb strength, decreased thermal sensitivity	ATSDR 2008 Al
Copper	 0.042 0.091 0.14	Oral, intermediate, human – NOAEL, daily x 2 months in drinking water, gastrointestinal effects LOAEL, daily x 2 months in drinking water, gastrointestinal effects NOAEL, 12 weeks, gastrointestinal effects	ATSDR 2004 Cu

Notes: NOAEL = No observed adverse effect level
LOAEL = Lowest observed adverse effect level
yr = year
BW = body weight

Appendix D

The ATSDR Health Effects Evaluation Process

THE ATSDR HEALTH EFFECTS EVALUATION PROCESS

The ATSDR health effects evaluation process consists of two steps: a screening analysis, and at some sites, based on the results of the screening analysis and community health concerns, a more in-depth analysis to determine possible public health implications of site-specific exposure estimates.

In evaluating data, ATSDR uses comparison values (CVs) to determine which chemicals to examine more closely. CVs are the contaminant concentrations found in a specific medium (soil, water, or air) and are used to select contaminants for further evaluation. CVs incorporate assumptions of daily exposure to the chemical and a standard amount of air, water and soil that someone may inhale or ingest each day.

The two step screening analysis process provides a consistent means to identify site contaminants that need to be evaluated more closely through the use of "comparison values" (CVs). The first step of the screening analysis is the "environmental guideline comparison" which involves comparing site contaminant concentrations to medium-specific comparison values derived by ATSDR from standard exposure default values. The second step is the "health guideline comparison" and involves looking more closely at site-specific exposure conditions, estimating exposure doses, and comparing them to dose-based health-effect comparison values.

As health-based thresholds, CVs are set at a concentration below which no known or anticipated adverse human health effects are expected to occur. CVs are not thresholds of toxicity and do not predict adverse health effects. CVs serve only as guidelines to provide an initial screen of human exposure to substances. Contaminant concentrations at or below the relevant CV may reasonably be considered safe, but it does not automatically follow that any environmental concentration that exceeds a CV would be expected to produce adverse health effects. Different CVs are developed for cancer and non-cancer health effects. Non-cancer levels are based on validated toxicological studies for a chemical, with appropriate safety factors included, and the assumption that small children (22 pounds) and adults are exposed every day. Cancer levels are the media concentrations at which there could be a one additional cancer in a one million person population (one in a million excess cancer risk for an adult) eating contaminated soil or drinking contaminated water every day for 70 years. For chemicals for which both cancer and non-cancer CVs exist, the lower level is used to be protective. Exceeding a CV does not mean that health effects will occur, just that more evaluation is needed.

After completing a screening analysis, site contaminants are divided into two categories. Those not exceeding CVs usually require no further analysis, and those exceeding CVs are selected for a more in-depth analysis to evaluate the likelihood of possible harmful effects.

The North Carolina Department of Public Health (N.C. DPH) uses the following screening values for public health assessments:

1. **Environmental Media Evaluation Guide (EMEG):** EMEGs are estimated contaminant concentrations in water, soil or air to which humans may be exposed over specified time periods and are not expected to result in adverse non-cancer health effects. EMEGs are

based on ATSDR "minimum risk levels" (MRLs) and conservative (highly health protective) assumptions about exposure, such as intake rate, exposure frequency and duration, and body weight.

2. **Reference Dose Media Evaluation Guides (RMEGs):** RMEGs represent concentrations of substances in water and soil to which humans may be exposed over specified time periods without experiencing non-cancer adverse health effects. The RMEG is derived from the U.S. Environmental Protection Agency's (EPA's) oral reference dose (RfD).

3. **Cancer Risk Evaluation Guide (CREG**): CREGs are estimated media-specific contaminant concentrations that would be expected to cause no more than one additional excess cancer in one million persons exposed over a 70-year lifetime. CREGs are calculated from EPA's cancer slope factors (CSFs) or inhalation unit risk (IUR) values.

4. **Maximum Contaminant Levels (MCL):** A Federal Maximum Contaminant Level (MCL) is the regulatory limit set by EPA that establishes the maximum permissible level of a contaminant in water that is deliverable to the user of a public water system. MCLs are based on health data, also taking into account economic and technical feasibility to achieve that level. (ATSDR 2005a)

5. **EPA Regional Screening Levels (RSL):** "Regional Screening Levels for Chemical Contaminants at Superfund Sites" are tables of risk-based screening levels, calculated using the latest toxicity values, default exposure assumptions and physical and chemical properties. The Regional Screening table was developed with input from EPA Regions III, VI, and IX in an effort to improve consistency and incorporate updated guidance. (http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm)

Contaminant concentrations exceeding the appropriate CVs are further evaluated against ATSDR health guidelines. N.C. DPH also retains for further assessment contaminants that are known or suspected to be cancer-causing agents. To determine exposure dose, N.C. DHHS uses standard assumptions about body weight, ingestion or inhalation rates, and duration of exposure. Important factors in determining the potential for adverse health effects also include the concentration of the chemical, the duration of exposure, the route of exposure, and the health status of those exposed. Site contaminant concentrations and site-specific exposure conditions are used to make conservative estimates of site-specific exposure doses for children and adults that are compared to ATSDR health guidelines (HGs), generally expressed as Minimal Risk Levels (MRLs). An exposure dose (generally expressed as milligrams of chemical per kilogram of body weight per day or "mg/kg/day") is an estimate of how much of a substance a person may come into contact based on their actions and habits. Exposure dose calculations are based on the following assumptions as outlined by the ATSDR (ATSDR 2005a):

- Children between the ages of 1 and 6 ingest an average of 1 liter of water per day
- Children weigh an average of 15 kilograms
- Infants weigh an average of 10 kilograms
- Adults ingest an average of 2 liters of water per day
- Adults weigh an average of 70 kilograms

Ingestion of contaminants present in drinking water

Exposure doses for ingestion of contaminants present in groundwater are calculated using the maximum and average detected concentrations of contaminants in milligrams per liter (mg/kg [mg/kg = ppm]). The following equation is used to estimate the exposure doses resulting from ingestion of contaminated groundwater:

$$ED_w = \frac{C \times IR \times AF \times EF}{BW}$$

Where:

ED_w = exposure dose water (mg/kg/day)
C = contaminant concentration (mg/kg)
IR = intake rate of contaminated medium (liters/day)
AF = bioavailability factor (unitless)
EF = exposure factor
BW = body weight (kilograms)

Ingestion of contaminants present in soil

Exposure doses for ingestion of contaminants present in soil are calculated using the maximum and average detected concentrations of contaminants in milligrams per kilogram (mg/kg [mg/kg = ppm]). The following equation is used to estimate the exposure doses resulting from ingestion of contaminated soil:

$$ED_s = \frac{C \times IR \times AF \times EF}{BW}$$

Where:

ED_s = exposure dose soil (mg/kg/day)
C = contaminant concentration (mg/kg)
IR = intake rate of contaminated medium (kilograms/day)
EF = exposure factor (unitless)
BW = body weight (kilograms)

The exposure factor is an expression of how often and how long a person may contact a substance in the environment. The exposure factor is calculated with the following general equation:

$$EF = \frac{F \times ED}{AT}$$

Where:

F = frequency of exposure (days/year)
ED = exposure duration (years)
AT = averaging time (ED x 365 days/year)

Inhalation (breathing) of contaminants present in air

Inhalation is an important pathway for human exposure to contaminants that exist as atmospheric gases or are adsorbed to airborne particles or fibers. Exposure doses for breathing contaminants in air were calculated using the maximum or average detected concentrations in milligrams per cubic meter (mg/m^3) or parts per billion by volume (ppbv). The following equation is used to estimate the exposure doses resulting from inhalation of contaminated air.

$$D = (C \times IR \times EF) / BW$$

Where:

- D = exposure dose (mg/kg/day)
- C = contaminant concentration (mg/m^3)
- IR = intake rate (m^3/day)
- EF = exposure factor (unitless)
- BW = body weight (kg)

Calculations of Contaminant Exposures During Showering

When showering in contaminated water a person may be exposed to the chemicals in the water by breathing a portion of the chemical that comes out of the water into the air (inhalation exposure), or by absorbing the chemical from the water through their skin (dermal exposure). Inhalation and dermal exposures to volatile organic compounds (VOCs) in the shower or bath may be equal to or greater than exposures from drinking the contaminated water. ATSDR uses conservative assumptions to estimate "worst case" exposures to VOCs during showering with contaminated water. The maximum concentration of VOC in the bathroom air is estimated with the following equation (Andelman 1990).

$$C_a = (C_w \times f \times F_w \times t)/V_a$$

Where:

- C_a = bathroom air concentration (mg/m^3)
- C_w = tap water concentration (mg/L)
- f = fractional volatilization rate (unitless)
- F_w = shower water flow rate (L/min)
- t = exposure time (min)
- V_a = bathroom volume (m^3)

Conservative calculation parameters are assumed, including a fractional volatilization of 0.9 for chlorinated VOCs, a flow rate of 8 L/min, and a small bathroom volume of 10 m^3. Conservative calculations are also made by using the maximum concentration found for each VOC in the tap water. Calculated bathroom air concentrations of VOCs can then be compared to ATSDR inhalation comparison values. Inhalation exposure dose estimates can be made using ATSDR's inhalation dose calculations.

Health guidelines represent daily human exposure to a substance that is likely to be without appreciable risk of adverse health effects during the specified exposure duration. The potential for adverse health effects exists under the representative exposure conditions if the estimated site-specific exposure doses exceed the health guidelines and they are retained for further evaluation. A MRL is an estimate of daily human exposure to a substance (in milligrams per kilogram per day [mg/kg/day] for oral exposures) that is likely to be without non-cancer health effects during a specified duration of exposure. Exposures are based on the assumption a person is exposed to the maximum concentration of the contaminant with a daily occurrence.

Generally, site-specific exposure doses that do not exceed screening values are dropped from further assessment. Exposure doses that exceed MRLs, or are known or suspected cancer-causing agents, are carried through to the health-effects evaluation. The health-effects evaluation includes an in-depth analysis examining and interpreting reliable substance-specific health effects data (toxicological, epidemiologic, medical, and health outcome data) related to dose-response relationships for the substance and pathways of interest. The magnitude of the public health issue may be estimated by comparing the estimated exposures to "no observed" (NOAELs) and "lowest observed" (LOAELs) adverse effect levels in animals and in humans, when available.

ATSDR's toxicological profiles serve as the primary source of the health-effects data. Other sources of toxicological data include EPA's Integrated Risk Information System (IRIS) database, International Agency for Research on Cancer (IARC) Monographs, and the National Toxicology Program (NTP). Standard toxicology textbooks and peer-reviewed scientific journals of environmental toxicology or environmental health can also be consulted.

Polynuclear Aromatic Hydrocarbons (PAHs)

ATSDR does not provide individual comparison values (CVs) for the group of structurally related multi-carbon ring compounds known as polynuclear aromatic hydrocarbons or PAHs (PAHs my also be called "polycyclic aromatic hydrocarbons"). ATSDR does provide a CREG the PAH compound benzo(a)pyrene (BaP). BaP is the most studied of the individual chemicals of the PAH group, and is thought to be the most toxic. To evaluate potential adverse health effects associated with incidental ingestion of soil PAH concentrations, the concentrations of individual detected PAH compounds are converted to an equivalent BaP concentration and summed to provide a "BaP-equivalent" concentration for all detected PAHs. BaP-equivalent exposure dose are calculated by multiplying the concentration of individual detected PAH compounds by their "toxicity equivalency factor" (TEF), a value that relates the relative toxicity of the individual PAH compounds to the toxicity of BaP. Below is a table of TEF values used by N.C. DPH to calculated BaP-equivalent concentrations. An estimated soil ingestion BaP-equivalent exposure dose is calculated using soil exposure rates. Estimated numbers of increased cancers for the combined PAH exposure is calculated by multiplying the CREG value by the BaP-equivalent exposure dose.

$$PAH_{BaP\text{-}eq} = PAH_{conc} \times TEF$$

$$\text{Combined Cancer Risk}_{PAHs} = \sum PAH_{adj} \times CSF$$

Where:

$PAH_{BaP\text{-}eq}$ = Benzo(a)pyrene equivalent TEF adjusted PAH compound concentration, mg/kg

PAH_{conc} = concentration of PAH compound, mg/kg
TEF = = Toxicity Equivalency Factor for PAH compound, unitless
Combined Cancer $Risk_{PAHs}$
= Summed cancer risk of all detected PAH compounds
$\sum PAH_{adj}$ = summed TEF-adjusted concentrations of all detected PAH compounds, mg/kg
CSF = Cancer Slope Factor, mg/kg-d

PAH Toxicity Equivalency Factors ("TEFs")

PAH compounds	TEF value
acenaphthene	0.001
acenaphthylene	0.001
anthracene	0.01
benzo(a)anthracene	0.1
benzo(a)pyrene	1.00
benzo(b,k)fluoranthene	na
benzo(g,h,i)perylene	0.01
benzo(b)fluoranthene	0.1
benzo(k)fluoranthene	0.01
chrysene	0.001
dibenzo(a,h)anthracene	1.00
fluoranthene	0.001
fluorene	0.001
indeno(1,2,3-cd)pyrene	0.1
2-methylnaphthalene	0.001
naphthalene	0.001
phenanthrene	0.001
pyrene	0.001

Source: *Toxicity equivalency factors for PAH and their applicability in shellfish pollution monitoring studies.* J Environ Monit, 2002, **4**, 383-388
na = not available

Cancer Health Effect Evaluations

Theoretical increased numbers of cancers are calculated for known or suspected cancer-causing contaminants using the estimated site-specific exposure dose and cancer slope factor (CSF) provided in ATSDR health guideline documents. This theoretical calculation is based on the assumption that there is no safe level of exposure to a chemical that causes cancer. However, the theoretical calculated risk is not exact and tends to overestimate the actual risk associated with exposures that may have occurred. This theoretical increased cancer risk estimate does not equal the increased number of cancer cases that will actually occur in the exposed population, but estimates a theoretical excess cancer risk expressed as the proportion of a population that may be affected by a carcinogen during a lifetime or other selected period of exposure. For example, an estimated cancer risk of 1×10^{-4} predicts the probability of one additional cancer over the background number of cancers in a population of 10,000. Qualitative assessment of the predicted increased numbers of cancers is also used and represents terminology suggested by ATSDR and N.C. DPH.

The N.C. Central Cancer Registry states:

"*Although much has been learned about cancer over the past couple of decades, there is still much that is not known about the causes of cancer. What we do know is that cancer is not one disease, but a group of diseases that behave similarly. We know that different types of cancers are caused by different things. For example, cigarette smoking has been implicated in causing lung cancer, some chemical exposures are associated with leukemia, and prolonged exposure to sunlight causes some types of skin cancer. Genetic research has shown that defects in certain genes result in a much higher likelihood that a person will get cancer. What is not known is how genetic factors and exposures to cancer causing agents interact.*

Many people do not realize how common cancers are. It is estimated that one out of every two men and one out of every three women will develop a cancer of some type during his or her lifetime. As a result, it is common to find what appear to be cancer cases clustering in neighborhoods over a period of years. This will occur in any neighborhood. As people age, their chance of getting cancer increases, and so as we look at a community, it is common to see increasing numbers of cancer cases as the people in the community age.

Cancers are diseases that develop over many years. As a result, it is difficult to know when any specific cancer began to develop, and consequently, what the specific factor was which caused the cancer. Because people in our society move several times during their lives, the evaluation of clusters of cancer cases is quite challenging. One can never be certain that a specific cancer was caused by something in the community in which the person currently resides. When we investigate clusters of cancer cases, we look for several things that are clues to likely associations with exposures in the community. These are:

1. *Groups of cases of all the same type of cancer (such as brain cancer or leukemia). Because different types of cancer are caused by different things, cases of many different types of cancer do not constitute a cluster of cases.*
2. *Groups of cases among children, or ones with an unusual age distribution.*
3. *Cases diagnosed during a relatively short time interval. Cases diagnosed over a span of years do not constitute a cluster of cases unless there is consistency in the type of cancer.*
4. *Clusters of rare cancers. Because lung, breast, colon, and prostate cancers are so common, it is very difficult to find any association between them and exposures in a community."*

Estimates of Increased Number of Cancers Qualitative Assessment Categories Utilized by N.C. DPH

Estimated Number of Increased Cancers [a]	Qualitative Increased Risk Term
<1/1,000,000	No Increase
<1/100,000	Very Low
<1/10,000	Low
<1/1,000	Moderate
<1/100	High
>1/100	Very High

[a] As number of increased cancers above typical background numbers of cancers in the stated population size. "<1/1,000,000" = less than one additional cancer in a population of 1 million persons.

Limitations of the Health Evaluation Process

Uncertainties are inherent in the public health assessment process. These uncertainties fall into the following categories: 1) the imprecision of the risk assessment process, 2) the incompleteness of the information collected and used in the assessment, and 3) the differences in opinion as to the implications of the information. These uncertainties are addressed in public health assessments by using worst-case assumptions when estimating or interpreting health risks. The health assessment calculations and screening values also incorporate safety margins. The assumptions, interpretations, and recommendations made throughout this public health assessment err in the direction of protecting public health.

Assessment of Chemical Interactions

To evaluate the risk for noncancerous effects in a mixture, ATSDR's guidance manual (*Guidance Manual for the Assessment of Joint Toxic Action of Chemical Mixtures*, 2004) prescribes the calculation of a hazard quotient (HQ) for each chemical. The HQ is calculated using the following formula:

$$HQ = \text{estimated dose} \div \text{applicable health guideline}$$

Generally, whenever the HQ for a chemical exceeds 1, concern for the potential hazard of the chemical increases. Individual chemicals that have HQs less than 0.1 are considered unlikely to pose a health hazard from interactions and are eliminated from further evaluation. If all of the chemicals have HQs less than 0.1, harmful health effects are unlikely, and no further assessment of the mixture is necessary. If two or more chemicals have HQs greater than 0.1, then these chemicals are to be evaluated further as outlined below.

Since the HQ is greater than 1 for both adults and children the hazard index (HI) will be calculated. The HQ for each chemical then is used to determine the (HI) for the mixture of chemicals. An HI is the sum of the HQs and is calculated as follows:

$$HI = HQ_1 + HQ_2 + HQ_3 + \ldots HQ_n$$

The HI is used as a screening tool to indicate whether further evaluation is needed. If the HI is less than 1.0, significant additive or toxic interactions are highly unlikely, so no further evaluation is necessary. If the HI is greater than 1.0, then further evaluation is necessary, as described below.

For chemical mixtures with an HI greater than 1.0, the estimated doses of the individual chemicals are compared with their NOAELs or comparable values. IF the dose of one or more of the individual chemicals is within one order of magnitude of its respective NOAEL (0.1 x NOAEL), then potential exists for additive or interactive effects. Under such circumstances, an in-depth mixtures evaluation should proceed as described in ATSDR's *Guidance Manual for the Assessment of Joint Action of Chemical Mixtures*.

If the estimated doses of the individual chemicals are less than 1/10 of their respective NOAELs, then significant additive or interactive effects are unlikely, and no further evaluation is necessary.

Reference:

(Andelman 1990). *Total Exposure of Volatile Organic Compounds in Potable Water*. In: Significance and Treatment of Volatile Organic Compounds in Water Supplies, Chapter 20. Lewis Publishers, Chelsea, MI.

Appendix E

ATSDR Glossary

ATSDR Glossary

Absorption
The process of taking in. For a person or animal, absorption is the process of a substance getting into the body through the eyes, skin, stomach, intestines, or lungs.

Acid mine drainage (AMD)
AMD is highly acidic water flowing out of metal or coal mines or areas with high mineral content. The pH of AMD can be as low as 1. AMD is formed when water comes into contact with sulfide-containing metal ores (such as the mineral pyrite, FeS_2) and air, resulting in the formation of sulfuric acid and dissolved iron. Orange or red sediments can be formed when the iron precipitates out of the water. The acid can dissolve other metals and metalloids in the surrounding rock and carry them to surface waters where the dissolved metals or low pH can harm fish and other aquatic organisms, or to ground water that may be used as a drinking water source and potentially impacting people's health.

Acute
Occurring over a short time [compare with chronic].

Acute exposure
Contact with a substance that occurs once or for only a short time (up to 14 days) [compare with intermediate duration exposure and chronic exposure].

Additive effect
A biologic response to exposure to multiple substances that equals the sum of responses of all the individual substances added together [compare with antagonistic effect and synergistic effect].

Adverse health effect
A change in body functions or cell structure that might lead to disease or health problems.

Aerobic
Requiring oxygen [compare with anaerobic].

Ambient
Surrounding (for example, *ambient* air).

Anaerobic
Requiring the absence of oxygen [compare with aerobic].

Analyte
A substance measured in the laboratory. A chemical for which a sample (such as water, air, or blood) is tested in a laboratory. For example, if the analyte is mercury, the laboratory test will determine the amount of mercury in the sample.

Analytic epidemiologic study
A study that evaluates the association between exposure to hazardous substances and disease by testing scientific hypotheses.

Antagonistic effect
A biologic response to exposure to multiple substances that is less than would be expected if the known effects of the individual substances were added together [compare with additive effect and synergistic effect].

Background level
An average or expected amount of a substance or radioactive material in a specific environment, or typical amounts of substances that occur naturally in an environment.

Biodegradation
Decomposition or breakdown of a substance through the action of microorganisms (such as bacteria or fungi) or other natural physical processes (such as sunlight).

Biologic indicators of exposure study
A study that uses (a) biomedical testing or (b) the measurement of a substance [an analyte], its metabolite, or another marker of exposure in human body fluids or tissues to confirm human exposure to a hazardous substance [also see exposure investigation].

Biologic monitoring
Measuring hazardous substances in biologic materials (such as blood, hair, urine, or breath) to determine whether exposure has occurred. A blood test for lead is an example of biologic monitoring.

Biologic uptake
The transfer of substances from the environment to plants, animals, and humans.

Biomedical testing
Testing of persons to find out whether a change in a body function might have occurred because of exposure to a hazardous substance.

Biota
Plants and animals in an environment. Some of these plants and animals might be sources of food, clothing, or medicines for people.

Body burden
The total amount of a substance in the body. Some substances build up in the body because they are stored in fat or bone or because they leave the body very slowly.

CAP See Community Assistance Panel.

Cancer
Any one of a group of diseases that occurs when cells in the body become abnormal and grow or multiply out of control.

Cancer risk
A theoretical risk of for getting cancer if exposed to a substance every day for 70 years (a lifetime exposure). The true risk might be lower.

Carcinogen
A substance that causes cancer.

Case study
A medical or epidemiologic evaluation of one person or a small group of people to gather information about specific health conditions and past exposures.

Case-control study
A study that compares exposures of people who have a disease or condition (cases) with people who do not have the disease or condition (controls). Exposures that are more common among the cases may be considered as possible risk factors for the disease.

CAS registry number
A unique number assigned to a substance or mixture by the American Chemical Society Abstracts Service.

Central nervous system
The part of the nervous system that consists of the brain and the spinal cord.
CERCLA [see Comprehensive Environmental Response, Compensation, and Liability Act of 1980]

Chronic
Occurring over a long time (more than 1 year) [compare with acute].

Chronic exposure
Contact with a substance that occurs over a long time (more than 1 year) [compare with acute exposure and intermediate duration exposure].

Cluster investigation
A review of an unusual number, real or perceived, of health events (for example, reports of cancer) grouped together in time and location. Cluster investigations are designed to confirm case reports; determine whether they represent an unusual disease occurrence; and, if possible, explore possible causes and contributing environmental factors.

Community Assistance Panel (CAP)
A group of people, from a community and from health and environmental agencies, who work with ATSDR to resolve issues and problems related to hazardous substances in the community. CAP members work with ATSDR to gather and review community health concerns, provide information on how people might have been or might now be exposed to hazardous substances, and inform ATSDR on ways to involve the community in its activities.

Comparison value (CV)
Calculated concentration of a substance in air, water, food, or soil that is unlikely to cause harmful (adverse) health effects in exposed people. The CV is used as a screening level during the public health assessment process. Substances found in amounts greater than their CVs might be selected for further evaluation in the public health assessment process.

Completed exposure pathway [see exposure pathway].

Comprehensive Environmental Response,
Compensation, and Liability Act of 1980 (CERCLA) CERCLA, also known as Superfund, is the federal law that concerns the removal or cleanup of hazardous substances in the environment and at hazardous waste sites. ATSDR, which was created by CERCLA, is responsible for assessing health issues and supporting public health activities related to hazardous waste sites or other environmental releases of hazardous substances.

Concentration
The amount of a substance present in a certain amount of soil, water, air, food, blood, hair, urine, breath, or any other media.

Contaminant
A substance that is either present in an environment where it does not belong or is present at levels that might cause harmful (adverse) health effects.

Delayed health effect
A disease or injury that happens as a result of exposures that might have occurred in the past.

Dermal
Referring to the skin. For example, dermal absorption means passing through the skin.

Dermal contact
Contact with (touching) the skin [see route of exposure].

Descriptive epidemiology
The study of the amount and distribution of a disease in a specified population by person, place, and time.

Detection limit
The lowest concentration of a chemical that can reliably be distinguished from a zero concentration.

Disease prevention
Measures used to prevent a disease or reduce its severity.

Disease registry
A system of ongoing registration of all cases of a particular disease or health condition in a defined population.

DOD
United States Department of Defense.

DOE
United States Department of Energy.

Dose (for chemicals that are not radioactive)
The amount of a substance to which a person is exposed over some time period. Dose is a measurement of exposure. Dose is often expressed as milligram (amount) per kilogram (a measure of body weight) per day (a measure of time) when people eat or drink contaminated water, food, or soil. In general, the greater the dose, the greater the likelihood of an effect. An "exposure dose" is how much of a substance is encountered in the environment. An "absorbed dose" is the amount of a substance that actually got into the body through the eyes, skin, stomach, intestines, or lungs.

Dose (for radioactive chemicals)
The radiation dose is the amount of energy from radiation that is actually absorbed by the body. This is not the same as measurements of the amount of radiation in the environment.

Dose-response relationship
The relationship between the amount of exposure [dose] to a substance and the resulting changes in body function or health (response).

Environmental media
Soil, water, air, biota (plants and animals), or any other parts of the environment that can contain contaminants.

Environmental media and transport mechanism
Environmental media include water, air, soil, and biota (plants and animals). Transport mechanisms move contaminants from the source to points where human exposure can occur.

EPA
United States Environmental Protection Agency.

Epidemiologic surveillance
The ongoing, systematic collection, analysis, and interpretation of health data. This activity also involves timely dissemination of the data and use for public health programs.
Epidemiology
The study of the distribution and determinants of disease or health status in a population; the study of the occurrence and causes of health effects in humans.

Exposure
Contact with a substance by swallowing, breathing, or touching the skin or eyes. Exposure may be short-term [acute exposure], of intermediate duration, or long-term [chronic exposure].

Exposure assessment
The process of finding out how people come into contact with a hazardous substance, how often and for how long they are in contact with the substance, and how much of the substance they are in contact with.

Exposure-dose reconstruction
A method of estimating the amount of people's past exposure to hazardous substances. Computer and approximation methods are used when past information is limited, not available, or missing.

Exposure investigation
The collection and analysis of site-specific information and biologic tests (when appropriate) to determine whether people have been exposed to hazardous substances.

Exposure pathway
The route a substance takes from its source (where it began) to its end point (where it ends), and how people can come into contact with (or get exposed to) it. An exposure pathway has five parts: a source of contamination (such as an abandoned business); an environmental media and transport mechanism (such as movement through groundwater); a point of exposure (such as a private well); a route of exposure (eating, drinking, breathing, or touching), and a receptor population (people potentially or actually exposed). When all five parts are present, the exposure pathway is termed a completed exposure pathway.

Exposure registry
A system of ongoing follow-up of people who have had documented environmental exposures.

Feasibility study
A study by EPA to determine the best way to clean up environmental contamination. A number of factors are considered, including health risk, costs, and what methods will work well.

Geographic information system (GIS)
A mapping system that uses computers to collect, store, manipulate, analyze, and display data. For example, GIS can show the concentration of a contaminant within a community in relation to points of reference such as streets and homes.

Grand rounds
Training sessions for physicians and other health care providers about health topics.

Groundwater
Water beneath the earth's surface in the spaces between soil particles and between rock surfaces [compare with surface water].

Half-life (t½)
The time it takes for half the original amount of a substance to disappear. In the environment, the half-life is the time it takes for half the original amount of a substance to disappear when it is changed to another chemical by bacteria, fungi, sunlight, or other chemical processes. In the human body, the half-life is the time it takes for half the original amount of the substance to disappear, either by being changed to another substance or by leaving the body. In the case of radioactive material, the half life is the amount of time necessary for one half the initial number of radioactive atoms to change or transform into another atom (that is normally not radioactive). After two half lives, 25% of the original number of radioactive atoms remain.

Hazard
A source of potential harm from past, current, or future exposures.

Hazardous Substance Release and Health Effects Database (HazDat)
The scientific and administrative database system developed by ATSDR to manage data collection, retrieval, and analysis of site-specific information on hazardous substances, community health concerns, and public health activities.

Hazardous waste
Potentially harmful substances that have been released or discarded into the environment.

Health consultation
A review of available information or collection of new data to respond to a specific health question or request for information about a potential environmental hazard. Health consultations are focused on a specific exposure issue. Health consultations are therefore more limited than a public health assessment, which reviews the exposure potential of each pathway and chemical [compare with public health assessment].

Health education
Programs designed with a community to help it know about health risks and how to reduce these risks.

Health investigation
The collection and evaluation of information about the health of community residents. This information is used to describe or count the occurrence of a disease, symptom, or clinical measure and to estimate the possible association between the occurrence and exposure to hazardous substances.

Health promotion
The process of enabling people to increase control over, and to improve, their health.

Health statistics review
The analysis of existing health information (i.e., from death certificates, birth defects registries, and cancer registries) to determine if there is excess disease in a specific population, geographic area, and time period. A health statistics review is a descriptive epidemiologic study.

Indeterminate public health hazard
The category used in ATSDR's public health assessment documents when a professional judgment about the level of health hazard cannot be made because information critical to such a decision is lacking.

Incidence
The number of new cases of disease in a defined population over a specific time period [contrast with prevalence].

Ingestion
The act of swallowing something through eating, drinking, or mouthing objects. A hazardous substance can enter the body this way [see route of exposure].

Inhalation
The act of breathing. A hazardous substance can enter the body this way [see route of exposure].

Intermediate duration exposure
Contact with a substance that occurs for more than 14 days and less than a year [compare with acute exposure and chronic exposure].

In vitro
In an artificial environment outside a living organism or body. For example, some toxicity testing is done on cell cultures or slices of tissue grown in the laboratory, rather than on a living animal [compare with in vivo].

In vivo
Within a living organism or body. For example, some toxicity testing is done on whole animals, such as rats or mice [compare with in vitro].

Lowest-observed-adverse-effect level (LOAEL)
The lowest tested dose of a substance that has been reported to cause harmful (adverse) health effects in people or animals.

Maximum Contaminant Level (MCL)
The highest level of a contaminant that EPA allows in drinking water. MCLs ensure that drinking water does not pose either a short-term or long-term health risk. EPA sets MCLs at levels that are economically and technologically feasible. Some states set MCLs which are more strict than EPA's.

Medical monitoring
A set of medical tests and physical exams specifically designed to evaluate whether an individual's exposure could negatively affect that person's health.

Metabolism
The conversion or breakdown of a substance from one form to another by a living organism.

Metabolite
Any product of metabolism.

mg/kg
Milligram per kilogram.

mg/cm^2
Milligram per square centimeter (of a surface).

mg/m^3
Milligram per cubic meter; a measure of the concentration of a chemical in a known volume (a cubic meter) of air, soil, or water.

Migration
Moving from one location to another.

Minimal risk level (MRL)
An ATSDR estimate of daily human exposure to a hazardous substance at or below which that substance is unlikely to pose a measurable risk of harmful (adverse), noncancerous effects. MRLs are calculated for a route of exposure (inhalation or oral) over a specified time period (acute, intermediate, or chronic). MRLs should not be used as predictors of harmful (adverse) health effects [see reference dose].

Morbidity
State of being ill or diseased. Morbidity is the occurrence of a disease or condition that alters health and quality of life.

Mortality
Death. Usually the cause (a specific disease, condition, or injury) is stated.

Mutagen
A substance that causes mutations (genetic damage).

Mutation
A change (damage) to the DNA, genes, or chromosomes of living organisms.

National Priorities List for Uncontrolled Hazardous Waste Sites (National Priorities List or NPL)
EPA's list of the most serious uncontrolled or abandoned hazardous waste sites in the United States. The NPL is updated on a regular basis.

No apparent public health hazard
A category used in ATSDR's public health assessments for sites where human exposure to contaminated media might be occurring, might have occurred in the past, or might occur in the future, but where the exposure is not expected to cause any harmful health effects.

No-observed-adverse-effect level (NOAEL)
The highest tested dose of a substance that has been reported to have no harmful (adverse) health effects on people or animals.

No public health hazard
A category used in ATSDR's public health assessment documents for sites where people have never and will never come into contact with harmful amounts of site-related substances.

NPL [see National Priorities List for Uncontrolled Hazardous Waste Sites]

Physiologically based pharmacokinetic model (PBPK model)
A computer model that describes what happens to a chemical in the body. This model describes how the chemical gets into the body, where it goes in the body, how it is changed by the body, and how it leaves the body.

Pica
A craving to eat nonfood items, such as dirt, paint chips, and clay. Some children exhibit pica-related behavior.

Plume
A volume of a substance that moves from its source to places farther away from the source. Plumes can be described by the volume of air or water they occupy and the direction they move. For example, a plume can be a column of smoke from a chimney or a substance moving with groundwater.

Point of exposure
The place where someone can come into contact with a substance present in the environment [see exposure pathway].

Population
A group or number of people living within a specified area or sharing similar characteristics (such as occupation or age).

Potentially responsible party (PRP)
A company, government, or person legally responsible for cleaning up the pollution at a hazardous waste site under Superfund. There may be more than one PRP for a particular site.

ppb
Parts per billion.

ppm
Parts per million.

Prevalence
The number of existing disease cases in a defined population during a specific time period [contrast with incidence].

Prevalence survey
The measure of the current level of disease(s) or symptoms and exposures through a questionnaire that collects self-reported information from a defined population.

Prevention
Actions that reduce exposure or other risks, keep people from getting sick, or keep disease from getting worse.

Public comment period
An opportunity for the public to comment on agency findings or proposed activities contained in draft reports or documents. The public comment period is a limited time period during which comments will be accepted.

Public availability session
An informal, drop-by meeting at which community members can meet one-on-one with ATSDR staff members to discuss health and site-related concerns.

Public health action
A list of steps to protect public health.

Public health advisory
A statement made by ATSDR to EPA or a state regulatory agency that a release of hazardous substances poses an immediate threat to human health. The advisory includes recommended measures to reduce exposure and reduce the threat to human health.

Public health assessment (PHA)
An ATSDR document that examines hazardous substances, health outcomes, and community concerns at a hazardous waste site to determine whether people could be harmed from coming into contact with those substances. The PHA also lists actions that need to be taken to protect public health [compare with health consultation].

Public health hazard
A category used in ATSDR's public health assessments for sites that pose a public health hazard because of long-term exposures (greater than 1 year) to sufficiently high levels of hazardous substances or radionuclides that could result in harmful health effects.

Public health hazard categories
Public health hazard categories are statements about whether people could be harmed by conditions present at the site in the past, present, or future. One or more hazard categories might be appropriate for each site. The five public health hazard categories are no public health hazard, no apparent public health hazard, indeterminate public health hazard, public health hazard, and urgent public health hazard.

Public health statement
The first chapter of an ATSDR toxicological profile. The public health statement is a summary written in words that are easy to understand. The public health statement explains how people might be exposed to a specific substance and describes the known health effects of that substance.

Public meeting
A public forum with community members for communication about a site.

Radioisotope
An unstable or radioactive isotope (form) of an element that can change into another element by giving off radiation.

Radionuclide
Any radioactive isotope (form) of any element.

RCRA [See Resource Conservation and Recovery Act (1976, 1984)]

Receptor population
People who could come into contact with hazardous substances [see exposure pathway].

Reference dose (RfD)
An EPA estimate, with uncertainty or safety factors built in, of the daily lifetime dose of a substance that is unlikely to cause harm in humans.

Registry
A systematic collection of information on persons exposed to a specific substance or having specific diseases [see exposure registry and disease registry].

Remedial Investigation
The CERCLA process of determining the type and extent of hazardous material contamination at a site.

Resource Conservation and Recovery Act (1976, 1984) (RCRA)
This Act regulates management and disposal of hazardous wastes currently generated, treated, stored, disposed of, or distributed.

RFA
RCRA Facility Assessment. An assessment required by RCRA to identify potential and actual releases of hazardous chemicals.

RfD See reference dose

Risk
The probability that something will cause injury or harm.

Risk reduction
Actions that can decrease the likelihood that individuals, groups, or communities will experience disease or other health conditions.

Risk communication
The exchange of information to increase understanding of health risks.

Route of exposure
The way people come into contact with a hazardous substance. Three routes of exposure are breathing [inhalation], eating or drinking [ingestion], or contact with the skin [dermal contact].

Safety factor [see uncertainty factor]

SARA [see Superfund Amendments and Reauthorization Act]

Sample
A portion or piece of a whole. A selected subset of a population or subset of whatever is being studied. For example, in a study of people the sample is a number of people chosen from a larger population [see population]. An environmental sample (for example, a small amount of soil or water) might be collected to measure contamination in the environment at a specific location.

Sample size
The number of units chosen from a population or environment.

Solvent
A liquid capable of dissolving or dispersing another substance (for example, acetone or mineral spirits).

Source of contamination
The place where a hazardous substance comes from, such as a landfill, waste pond, incinerator, storage tank, or drum. A source of contamination is the first part of an exposure pathway.

Special populations
People who might be more sensitive or susceptible to exposure to hazardous substances because of factors such as age, occupation, sex, or behaviors (for example, cigarette smoking). Children, pregnant women, and older people are often considered special populations.

Stakeholder
A person, group, or community who has an interest in activities at a hazardous waste site.

Statistics
A branch of mathematics that deals with collecting, reviewing, summarizing, and interpreting data or information. Statistics are used to determine whether differences between study groups are meaningful.

Substance
A chemical.

Substance-specific applied research
A program of research designed to fill important data needs for specific hazardous substances identified in ATSDR's toxicological profiles. Filling these data needs would allow more accurate assessment of human risks from specific substances contaminating the environment. This research might include human studies or laboratory experiments to determine health effects resulting from exposure to a given hazardous substance.

Superfund Amendments and Reauthorization Act (SARA)
In 1986, SARA amended CERCLA and expanded the health-related responsibilities of ATSDR. CERCLA and SARA direct ATSDR to look into the health effects from substance exposures at hazardous waste sites and to perform activities including health education, health studies, surveillance, health consultations, and toxicological profiles.

Surface water
Water on the surface of the earth, such as in lakes, rivers, streams, ponds, and springs [compare with groundwater].

Surveillance [see epidemiologic surveillance]

Survey
A systematic collection of information or data. A survey can be conducted to collect information from a group of people or from the environment. Surveys of a group of people can be conducted by telephone, by mail, or in person. Some surveys are done by interviewing a group of people [see prevalence survey].

Synergistic effect
A biologic response to multiple substances where one substance worsens the effect of another substance. The combined effect of the substances acting together is greater than the sum of the effects of the substances acting by themselves [see additive effect and antagonistic effect].

Teratogen
A substance that causes defects in development between conception and birth. A teratogen is a substance that causes a structural or functional birth defect.

Toxic agent
Chemical or physical (for example, radiation, heat, cold, microwaves) agents which, under certain circumstances of exposure, can cause harmful effects to living organisms.

Toxicological profile
An ATSDR document that examines, summarizes, and interprets information about a hazardous substance to determine harmful levels of exposure and associated health effects. A toxicological profile also identifies significant gaps in knowledge on the substance and describes areas where further research is needed.

Toxicology
The study of the harmful effects of substances on humans or animals.

Tumor
An abnormal mass of tissue that results from excessive cell division that is uncontrolled and progressive. Tumors perform no useful body function. Tumors can be either benign (not cancer) or malignant (cancer).

Uncertainty factor
Mathematical adjustments for reasons of safety when knowledge is incomplete. For example, factors used in the calculation of doses that are not harmful (adverse) to people. These factors are applied to the lowest-observed-adverse-effect-level (LOAEL) or the no-observed-adverse-effect-level (NOAEL) to derive a minimal risk level (MRL). Uncertainty factors are used to account for variations in people's sensitivity, for differences between animals and humans, and for differences between a LOAEL and a NOAEL. Scientists use uncertainty factors when they have some, but not all, the information from animal or human studies to decide whether an exposure will cause harm to people [also sometimes called a safety factor].

Urgent public health hazard
A category used in ATSDR's public health assessments for sites where short-term exposures (less than 1 year) to hazardous substances or conditions could result in harmful health effects that require rapid intervention.

Volatile organic compounds (VOCs)
Organic compounds that evaporate readily into the air. VOCs include substances such as benzene, toluene, methylene chloride, and methyl chloroform.