CHAPTER 3

3.0 AFFECTED ENVIRONMENT

This chapter of the EIS describes the nature, extent, and importance of environmental resources in their existing setting on the MSR study area and adjacent areas. It provides a baseline for the assessment of potential effects of alternative future land uses described in Chapter 2. Some resources or features unlikely to affect or be affected by the alternatives (e.g., climate and geology) are described briefly. Other resources or features identified during the scoping process as important issues are described in greater detail.

3.1 Solid and Hazardous Waste

3.1.1 Regulatory History and Investigations of Hazardous Wastes

After various production facilities were shut down on the MSR, intermediate products and raw materials accumulated, and various quantities of unneeded chemicals and equipment were stored on site. Prior to passage of RCRA in 1976, there were very few environmental laws governing how waste should be handled and disposed. In keeping with industry standards at that time, TVA stored such waste on site in pits, stockpiles, drums, and other containments.

The Hazardous and Solid Waste Amendments (HSWA) of 1984 expanded RCRA by requiring corrective action for the release of hazardous wastes and constituents from a treatment, storage, and disposal (TSD) facility. The goal of the corrective action process is to ensure that hazardous waste and hazardous constituent releases associated with TSD facilities are remediated, regardless of when the waste was produced.

In the mid-1980s, TVA applied for a RCRA HSWA TSD Permit to maintain a drum storage facility at the ERC and to perform research on hazardous waste streams. As a result, USEPA and ADEM initiated a RCRA Corrective Action Program at ERC, and 205 SWMUs, areas of potential contamination, were identified and investigated over a 15-year period.

This process of implementing the Corrective Action Program involves the following ordered sequence of steps: (1) RCRA Facility Assessment (RFA), (2) RCRA Facility Investigation (RFI), (3) the Corrective Measures Study (CMS), and (4) Corrective Measures Implementation (CMI). Additionally, a potential fifth step, Postclosure Monitoring (PCM), occurs at facilities where waste remains in place after the facility is closed. Several SWMU areas at ERC were carried through the final CMI, along with the phosphorus entombment areas (SWMUs 17-37). These SWMU areas contain hazardous wastes and, therefore, will be subject to PCM (see Section 3.1.1.2).

3.1.1.1 Sites Investigated During the Resource Conservation and Recovery Act Investigation

The HSWA TSD Permit application initiated the RFA to identify all potential environmental hazards at the ERC site. The RFA findings were presented in September 1988. In July 1989, USEPA issued an HSWA TSD Permit for the ERC.

Sixty-two of 205 investigated SWMUs were identified as having a moderate, high, or unknown potential for release of hazardous waste; this potential requires an RFI. During the RFI, each of the 62 SWMUs was evaluated to identify the extent of each site's contamination. A summary of the RFI of those SWMUs, the findings, and the

recommendations are included in Appendix C. The RFI Final Report (TVA 1998c) recommended that 35 SWMUs be carried forward to the third step in the RCRA process, the CMS.

3.1.1.2 Primary Areas of Concern

After several years of sitewide extensive sampling, risk assessments, and remediation, consistent with the facilities investigation process, four areas were identified as requiring PCM because of remaining contamination:

Ash Settling Pond (SWMU 104). This site covers approximately 17.5 acres and contains about 800 tons of phosphorus beneath pond sediment, capped with water. The ash settling pond was constructed in the 1930s during the operation of the phosphorus furnaces and was in use until 1976 when the furnaces were shut down. The furnaces produced elemental phosphorus to support both national defense and agricultural programs. Fly ash and bottom ash were deposited in the pond from 1976 to 1986. The implemented corrective measures consist of maintaining appropriate water levels to keep the ash covered, conducting quarterly inspections, and monitoring groundwater for possible contamination.

Phosphate Development Works Landfill (SWMU 108). The entire SWMU covers about 27.4 acres, but the focus is on 9 acres, which started as a U.S. Army landfill. TVA operated the landfill from 1953 to 1957 under an MOA with the U.S. Army. During this period, undetermined amounts and types of wastes from PDW were disposed in the landfill. An attempt was made to halt general dumping in this area in 1977, but general construction materials, phosphorous slag, off-grade chemical fertilizers, and possibly skimmer-trough machine oil were disposed of at SWMU 108 through the early 1980s. General construction waste from the demolition of TVA's elemental phosphorous production facilities was disposed in the landfill until the site was closed in 1984. Implemented corrective measures include modifications to the existing cap, conducting quarterly inspections, and monitoring groundwater for possible contamination.

Precipitator Dust Piles (SWMU 112) and Trestle Drum Storage Area (SWMU 194). SWMU 112 consists of six piles of waste, covering a 14.4-acre site. The piles contain approximately 20,000 tons of phosphorous-laden precipitator dust from the furnaces operated at ERC. During the environmental investigations, no contaminants were found at SWMU 194. However, the boundary of SWMU 112 overlaps with SWMU 194, so both sites were included for the analysis of SWMU 112 contamination. Implemented corrective measures include installing a RCRA cap for SWMU 112/194, conducting quarterly inspections, and ongoing groundwater monitoring for possible contamination.

Phosphorus Entombment Areas (SWMUs 17-37). The phosphorus entombment areas were registered as CERCLA sites prior to the RCRA process at the ERC being initiated. For this reason, these areas were not investigated as part of the RCRA process; they were, however, identified as SWMUs 17-37 and included in the PCM Program. Phosphorus sludge by-product from furnace operations was collected in concrete pits, sumps, and railcars. Approximately 2,535 tons of phosphorus sludge and other phosphorus compounds remain on a 4.9-acre site after a portion of the sludge was recycled. The remaining material was covered with limestone and encapsulated in reinforced concrete. Implemented corrective measures include conducting quarterly inspections and ongoing groundwater monitoring for possible contamination.

The postclosure groundwater and surface water monitoring program began in August 2003. Samples were collected quarterly for the first two years and annually thereafter. Data results are reported annually to ADEM and USEPA. The locations of these four SWMU areas of primary concern are shown in Figure 1-2. Table 3-1 lists the size of the areas that are subject to ADEM PCM requirements.

Table 3-1. Areas of Solid Waste Management Units Undergoing Postclosure Monitoring

SWMU	Size (acres)
Phosphorus Entombment Areas (SWMUs 17-37)	4.13 (West) 0.80 (East)
SWMU 112/194	14.39
SWMU 104	17.46
SWMU 108	27.37
Total	**64.15 Acres**

3.1.1.3 Other Solid Waste Management Units of Concern

In addition to the SWMUs and phosphorus entombments listed above, 31 SWMUs (Table 3-2) were evaluated and closed during the RCRA Corrective Action Program using industrial clean-up standards instead of residential standards. TVA assumed that the future use of the site would remain industrial; therefore, cleanup to industrial standards avoided unnecessary remediation costs. Using industrial clean-up standards permits higher contamination levels to remain in soil but limits exposure to what an industrial worker would normally encounter (i.e., 40 hours/week for 50 weeks/year) as opposed to residential standards, which allow virtually unrestricted access to a site. The SWMUs evaluated with industrial standards are shown in Figure 3-1. All other SWMUs south of Reservation Road, with the exception of the SWMUs identified in Tables 3-1 and 3-2, were determined to contain levels of chemical contaminants at or below residential screening levels. This indicates that most of the land is suitable for unrestricted development.

Table 3-2. List of Solid Waste Management Units Evaluated With Industrial Screening Levels

SWMU Number	SWMU Name	Size	
		Square Feet	Acres
5	Outdoor Drum Storage Area No. 1	75,000	1.72
7	Furnace Building	27,000	0.62
9	Tank Car Wash Pit	9,800	0.23
10	Tank Car Washing Sumps	5,100	0.12
42 and 43	Phosphate Fertilizer Storage Building and Sulfur Cake Storage Area	102,400	2.35
53	Carpenter Shop Outdoor Drum Storage Area	1,600	0.037
59	PDW Service Pit	2,050	0.05
83	PDW Area 307 Drum Storage Area	7,650	0.17
84	PDW Surface Drainage Ditch	500	0.01
92	Ammonia From Coal Drum Storage Area No. 2	9,500	0.22
100	Ammonia From Coal Project Equalization Basin	38,550	0.89
105	Plant Drainage Ditch	2,250	0.052
106	Central Ditch	150,000	3.4
107	Scrap Yard	189,500	4.3
110	Coal Pile Run-Off Ditch	5,600	0.13

SWMU Number	SWMU Name	Size	
		Square Feet	Acres
117	Old Ammonia Plant	20,000	0.46
122	Building 321 Outdoor Drum Storage Area	22,500	0.52
128	Building 404 Outdoor Drum Storage Area	6,500	0.15
131	Waste Oil Storage Area	2,491	0.06
137	Building 407 Outdoor Drum Storage Area	2,000	0.05
141	Building 509 Drum Storage Area	31,692	0.73
151	Ammonia Plant Oil/Washer Separator	1,092	0.025
165	Urea Plant Waste Oil Accumulation Area No. 2	100	0.002
166	Urea Plant Waste Oil Catch Basin	100	0.002
168	Urea Plant Oil and Ammonia Sump	100	0.002
169	Urea Plant Oil Accumulation Area No. 4	100	0.002
196	Ammonia Pumping Station	19,600	0.45
197	Power Service Shop No. 2 West Wall	192	0.004
198	North End Storm Sewer	1,150	0.026
201	Ammonia From Coal Drum Storage Area No. 4	15,150	0.34
	Total		**17.12**

3.1.1.4 Other Waste Sites Not Included in the Resource Conservation and Recovery Act Investigation

There are two additional sites within the MSR study area that have contained, or presently contain, materials that may be considered hazardous but are not subject to the RCRA Corrective Action Program. These are SWMU 114 (the phosphate slag storage area) and the LLRWBS. SWMU 114 was not included because of the RCRA regulation exemption for ore and mineral processing wastes and materials. The LLRWBS was not included because it is regulated by the U.S. Nuclear Regulatory Commission (NRC) and not by the RCRA process.

SWMU 114 (Phosphate Slag Storage Area)

Phosphate slag, which is primarily calcium silicate, is a hard, refractory, water insoluble, coarse, sandlike material (TVA 1998c). Slag is created as a by-product when phosphate ore is burned to produce phosphorus. From 1934 to 1975, at least 250,000 tons per year of this slag were created from the production of phosphorus and phosphoric acid for fertilizer production.

The 90-acre phosphate slag storage area is located north of Reservation Road. This area now contains the remnants of an estimated 1.6 million tons of phosphate slag. The site is divided into two sections by an unimproved road; the stockpile to the east of the road forms a rough rectangle and is approximately 44 acres in size. The stockpile area to the west of the road is approximately 46 acres in size (May and Boyle 1990).

The Bevill Exclusion Amendment was added to RCRA in 1980 to exclude “solid waste from the extraction, beneficiation, and processing of ores and minerals” from regulation as hazardous waste [40 CFR § 261.4(b)(7)]. Phosphate slag is covered by this exclusion because the slag was derived from phosphate ore used in the production of elemental phosphorus. Because of this exclusion status, the USEPA determined that SWMU 114 did not require an RFI when issuing the ERC’s HSWA TSD Permit.

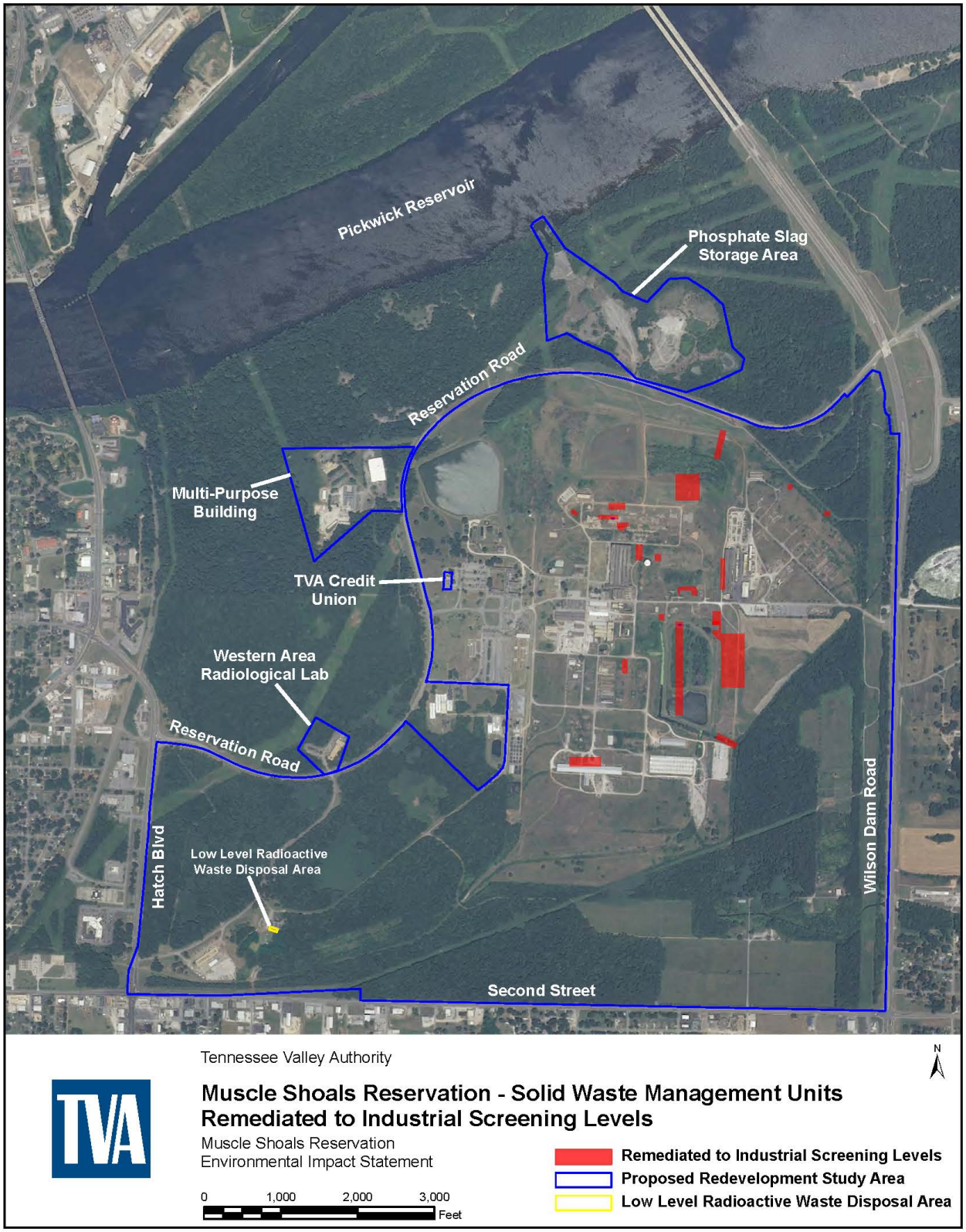


Figure 3-1. Locations of Solid Waste Management Units Closed With Industrial Screening Levels

The primary health concern at the phosphate slag storage area is radiation. Raw phosphate ore used in the production process contains naturally occurring radiation. During the production of phosphoric acid from ore, this radiation was concentrated in the slag by-product.

Table 3-3 lists some common sources and associated typical levels of radiation exposures for the average person. Radiation is energy that is transmitted (i.e., radiated) from a source as the source decays. A rem (roentgen equivalent in man) is a unit of radiation dose used to measure the effects of ionizing radiation on humans. This unit of dose is most commonly expressed in units of thousandths of a rem, or millirem (1,000 microrems [µrem] equal 1 millirem and 1,000 millirems [mrem] equal 1 rem). See Acronyms, Abbreviations, Units of Measure, and Symbols in the preface of this final EIS. In addition to the sources of radiation listed in Table 3-3, soil and bedrock are natural radiation sources that vary geographically.

Naturally occurring radiation in raw phosphate ore used in the production process is the primary human health concern. For example, in Ohio, natural radiation in soil and rocks contributes about 60 mrem per year of radiation exposure. In Colorado, exposure is about 105 mrem per year. Natural radiation varies with area according to the types of rock and mineral features found in the vicinity (different geologic features have different natural radiation emissions).

Table 3-3. Levels of Radiation Exposures by Typical Source for the Average Person Across the United States and by MSR Phosphate Slag Storage Area

Typical Exposure (mrem/year)	Source
0.1	Sleeping next to another person in the bed
0.2	Drinking a quart of Gatorade each week
0.3	Combustible fuels (e.g., coal, natural gas, and liquefied petroleum)
0.5	Eating 0.5 pound of Brazil nuts
1	Television receivers
1 to 6	Domestic water supplies
1.5	Each cross-country airline trip (one way)
2	Use of gas mantles
4	Highway and road construction materials
5	Foods grown on lands in which phosphate fertilizers are used
6	Each dental x-ray
7.5	Spouses of recipients of certain cardiac pacemakers
110	Each computerized tomography of the head and body
150	Each nuclear medicine examination of the lung
245	Each upper gastrointestinal tract series
405	Each barium enema
438	MSR phosphate slag storage area exposure 24 hours/day for one year
509	Each nuclear medicine examination of the thyroid
650	Each nuclear medicine examination of the brain
1,300	Average cigarette smoker

A 2002 survey measured the levels of radiation at the phosphate slag storage area. The radiation is concentrated where the slag is located. Two dose measurements 1 meter above the ground were taken each at the eastern and western slag stockpile areas. Recorded measurements were 50 microrems per hour (µrem/hr) or 0.05 millirem per hour (mrem/hr), at all four sampling points. Using the maximum measured dose of 0.05 mrem/hr and assuming a person stayed on the site 24 hours a day for 365 days, exposure at the slag storage area would yield a dose of 438 mrem/year.

In December 2009, TVA and the ADPH, Office of Radiation Control, conducted a radiation monitoring survey of the phosphate slag storage area. This survey was in response to comments provided by ADPH in July 2009, indicating concerns about the specific location of this area and about whether it could be more extensive than shown in TVA's public scoping information. During this survey, the western boundary of the phosphate slag storage area was confirmed, and a reading of 42 µrem/hr (0.042 mrem/hr), the highest measured value, was recorded. Survey readings were measured consistent with the 2002 survey mentioned above. The boundaries of the phosphate slag storage area extend from the old rail spur on the west to Pond Creek on the east.

ADPH is responsible for the protection of the public in Alabama from excess exposure to ionizing radiation. ADPH recently adopted a radiation protection standard of 25 mrem per year on July 21, 2010, which is the standard currently in effect for the NRC and the U.S. Department of Energy (DOE). If residual radioactivity does not exceed the threshold of 25 mrem per year, the NRC considers a site acceptable for unrestricted use; the DOE agrees with this threshold for all pathways of exposure. TVA, in compliance with this standard, limits access to the phosphate slag storage area to fewer than 500 hours per year per person. Additional soil cover can be used to allow longer exposures.

Low-Level Radioactive Waste Burial Site (LLRWBS)

The LLRWBS is a 0.23-acre fenced area (approximately 100-foot by 100-foot) located approximately a mile southwest of the ERC, near the old TVA Greenhouse Complex on the MSR study area (see Figures 3-1 and 3-2). It is vegetated, stable, and lies between the greenhouse buildings and the former TVA Garage, which is now the TVA Muscle Shoals Customer Service Center. This LLRWBS was originally authorized by the Atomic Energy Commission (pre-NRC) on July 15, 1964, and operated under a license issued to TVA's Office of Agricultural and Chemical Development from 1966 until January 29, 1981, when federal regulations changed and the burial site was closed. As described in Section 3.3.2.8, one monitoring well was installed at the LLRWBS in August 1996 to support an assessment of the environmental effects of the facility required by the NRC. Measured constituents were below instrument detection limits, and the site posed no human health risks. There continues to be no monitoring requirement for this site.

Low-level radioactive by-product material buried at the site was generated from agricultural experiments for fertilizer development and various lab analyses. The waste mainly consisted of isotopes of phosphorus, zinc, manganese, carbon, and sulfur. A small amount of waste containing uranium from quality control checks conducted at the Power Service Center on nonirradiated fuel pellets was also buried at the site.

LLRWBS waste material was buried in 40, 2-foot-diameter auger holes completed to depths of 10 feet in residual clay overburden during the area's 15 years of use. The lower 6 feet of each hole was then filled with radioactive waste material, and the remaining 4 feet of each hole was backfilled with clay soil. Records of each burial including location, date and type, and activity of the waste isotopes have been maintained by TVA.

Photograph taken by: Stacy McCluskey, November 22, 2010

Figure 3-2. Access Restricted Low-Level Radioactive Waste Burial Site

In response to NRC's "Branch Technical Position on Screening Methodology for Assessing Prior Land Burials of Radioactive Waste" (NRC 1997), TVA submitted two reports to the NRC, dated September 5, 1995 (Williams 1995) and September 4, 1997 (Sorrelle 1997). The 1995 report included a description of the burial site and the radioactive material that remains. The September 1997 report contained a dose-to-the-public site assessment and concluded that radioactive material removal was not necessary (see Appendix D). These reports were prepared assuming the LLRWBS would remain undisturbed and in TVA ownership.

In 1997, using RESRAD (RESidual RADioactivity) radiological dose calculating software, TVA showed the maximum aboveground dose to be 0.0000025 mrem (0.0025 microrem), which is far below current NRC and USEPA regulatory standards. TVA proposed that no additional remediation of the site was required and requested unrestricted access for the site. A letter from the NRC dated April 30, 1999 (Decker 1999), stated that no further remediation was required, and the site was released for unrestricted use (see Appendix D).

This unrestricted use only applies to the soil surface at grade above the existing clay cap. It does not apply to subsurface or belowground development such as building foundations,

basements, or trenching or excavation activities associated with underground utilities that could disturb or eliminate the shielding effects of the soil cap. TVA could retain ownership of the LLRWBS, dispose of it with a deed restriction designed to prevent subsurface disturbance, or clean it up and properly dispose of the low-level radioactive material buried there prior to transferring the property to another owner in the future.

3.1.2 Current Permit Status

The current RCRA HSWA TSD Permit covers 2,260 acres, which encompasses the entire MSR study area. This entire permit area is subject to ADEM HSWA Permit/USEPA Identification No. AL3 640 090 004. ADEM currently monitors and oversees all activities performed under the permit and has indicated that no land can be sold or transferred within the existing permit area unless it is either remediated to unrestricted use levels or regulated with the appropriate environmental covenants. TVA will be working with ADEM to develop the appropriate strategies to release the property from the provisions of the RCRA Permit, and ADEM has indicated that the permit should not prevent land in the study area from being sold or transferred out of federal ownership. The current RCRA permit over the study area would not limit potential future land use alternatives being considered in this EIS (see Section 4.1).

As indicated in Section 1.7, the first RCRA permit renewal application was submitted from TVA to ADEM in May 2010. Approval is anticipated by mid-2012.

3.2 Geology

General Geologic Setting and Stratigraphy

The MSR study area is located within the Interior Low Plateau Physiographic Province, commonly referred to as the Eastern Highland Rim. The Highland Rim consists of flat-lying carbonate rocks of Mississippian age. The project area is located generally along the flat river valley on the southern shore of the Tennessee River (Pickwick Reservoir). There is very little change in topography within the MSR study area.

The geology of the project area is homogeneous throughout. The entire project area is underlain by Tuscumbia Limestone. The apparent thickness of the formation in this province varies. Underlying the Tuscumbia Limestone and exposed nearer the shore of the Tennessee River is the Fort Payne Chert. The Fort Payne Chert is a very light to light-olive-gray limestone. Commonly present below the Fort Payne is a light-olive-gray claystone or shale (Maury Formation), which is mapped with the Fort Payne. The apparent thickness of the Fort Payne Chert in this province also varies.

The carbonate rocks that form the Eastern Highland Rim have formed a karst terrain. The term “karst” refers to carbonate rocks (e.g., limestone) in which groundwater flows through solution-enlarged channels and bedding planes within the rock. Karsts are characterized by sinkholes, springs, disappearing streams, and caves, as well as by rapid, highly directional groundwater flow in discrete channels or conduits. Several sinkholes occur within the Tuscumbia Limestone surrounding the MSR and three small sinkholes occur on the MSR study area (Figure 3-3; U.S. Geological Survey 1977).

3.3 Groundwater Resources

3.3.1 General Hydrostratigraphy and Structure

The MSR study area is located in the Interior Low Plateau Physiographic Province (see Section 3.2) along the southwestern flank of the Nashville Dome. Mississippian-aged

limestone rocks underlie the MSR study area. These rocks generally dip to the south-southwest at about 25 to 30 feet per mile. However, bedrocks at the MSR dip to the southeast at about 30 feet per mile (Raymond 1992). The relevant subsurface units underlying the MSR study area are shown on Figure 3-4. Exploratory drilling on the MSR study area has not penetrated Paleozoic rocks below the Chattanooga Shale.

3.3.1.1 Overburden

The MSR study area is covered by a thick layer of unconsolidated soil and rock material about 40 to 100 feet. The upper 10 to 50 feet are typically composed of silty, sandy clay. In places, the clay contains small amounts of cherty limestone fragments. A relatively thin layer less than 10 feet of debris and gravel may occur in some places on the top of the silty clay zone. The bottom half of the overburden consists of a mixture of silty clay and various amounts of residual rock fragments. The rock fragments are mostly weather-resistant chert and cherty limestone, which are similar to the underlying bedrock. Tests suggest that groundwater moves vertically through the clayey soil matrix at approximately 10^{-6} centimeters per second. These tests also suggest that the horizontal groundwater movement is approximately 10 times faster than the vertical (i.e., downward) movement.

Alluvial deposits are generally limited to narrow areas along Pond Creek and other streams, particularly along downstream reaches closest to the Tennessee River. The alluvium typically consists of mixed layers of clay, silt, sand, and gravel.

The transition between the overburden and underlying limestone bedrock layer is gradual. This limestone layer has weathered, producing a layer of material above bedrock, referred to as the epikarst zone, which consists of cherty gravel in a matrix of silty clay. This highly weathered zone possesses voids and hollow spaces where residual material has been passed through to the deeper bedrock drainage network. The epikarst zone is about 3 to 5 feet thick across the MSR study area.

3.3.1.2 Tuscumbia-Fort Payne Aquifer System

The Tuscumbia Limestone and the Fort Payne Chert are a major regional aquifer system in northwestern Alabama. The Tuscumbia Limestone is the uppermost bedrock layer beneath the MSR study area. It is exposed along the south bank of the Tennessee River and along the valleys of the larger tributaries (Harris et al. 1963). Tuscumbia Limestone is about 50 feet thick in the local area. It is a light gray, fine to medium crystalline limestone and contains abundant fossils and light colored chert (Thomas 1967).

The Fort Payne Chert, the next layer, is comprised of thin layers of light gray to blue-gray, finely crystalline, siliceous limestone containing abundant chert. The thickness ranges from 162 to 207 feet. The Fort Payne Chert underlies the entire MSR study area, and the upper portion of the formation is exposed along the south bank of the Tennessee River.

The Tuscumbia-Fort Payne aquifer system is highly permeable in places because of numerous bedrock fractures and joints. These openings generally occur at depths of less than 100 feet (Fry 1981) and allow the rapid movement of groundwater. Because weathering of the carbonate bedrocks diminishes with depth, the upper portion of this aquifer has higher permeability than the deeper portions.

Within the deeper Fort Payne formation, groundwater movement occurs along fractures and bedding planes. The network of bedrock fractures varies considerably in the vicinity of the MSR study area. Therefore, prediction of groundwater movement within the deeper bedrocks is much more difficult than in the shallow bedrock.

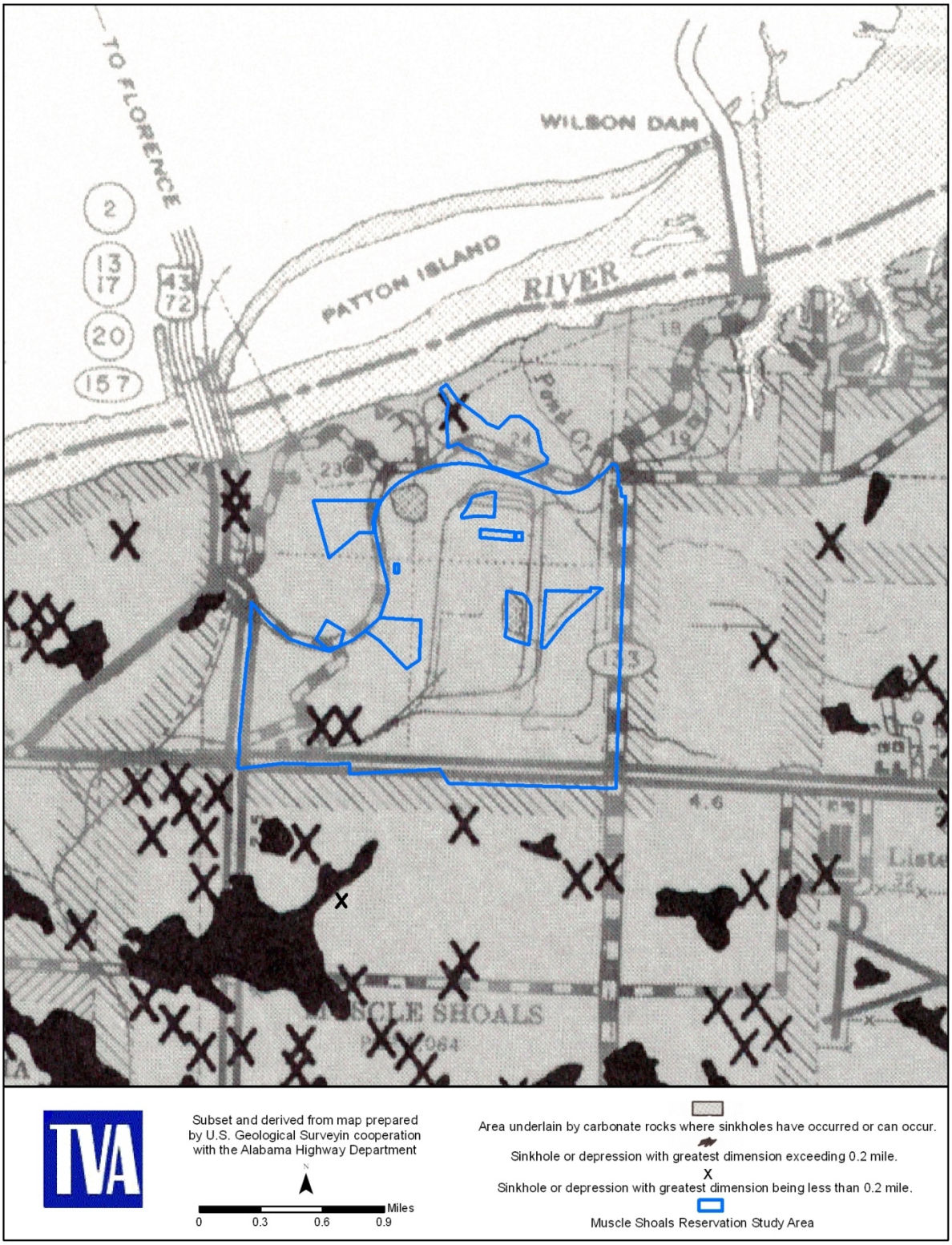


Figure 3-3. Sinkhole Locations on the Muscle Shoals Reservation Study Area

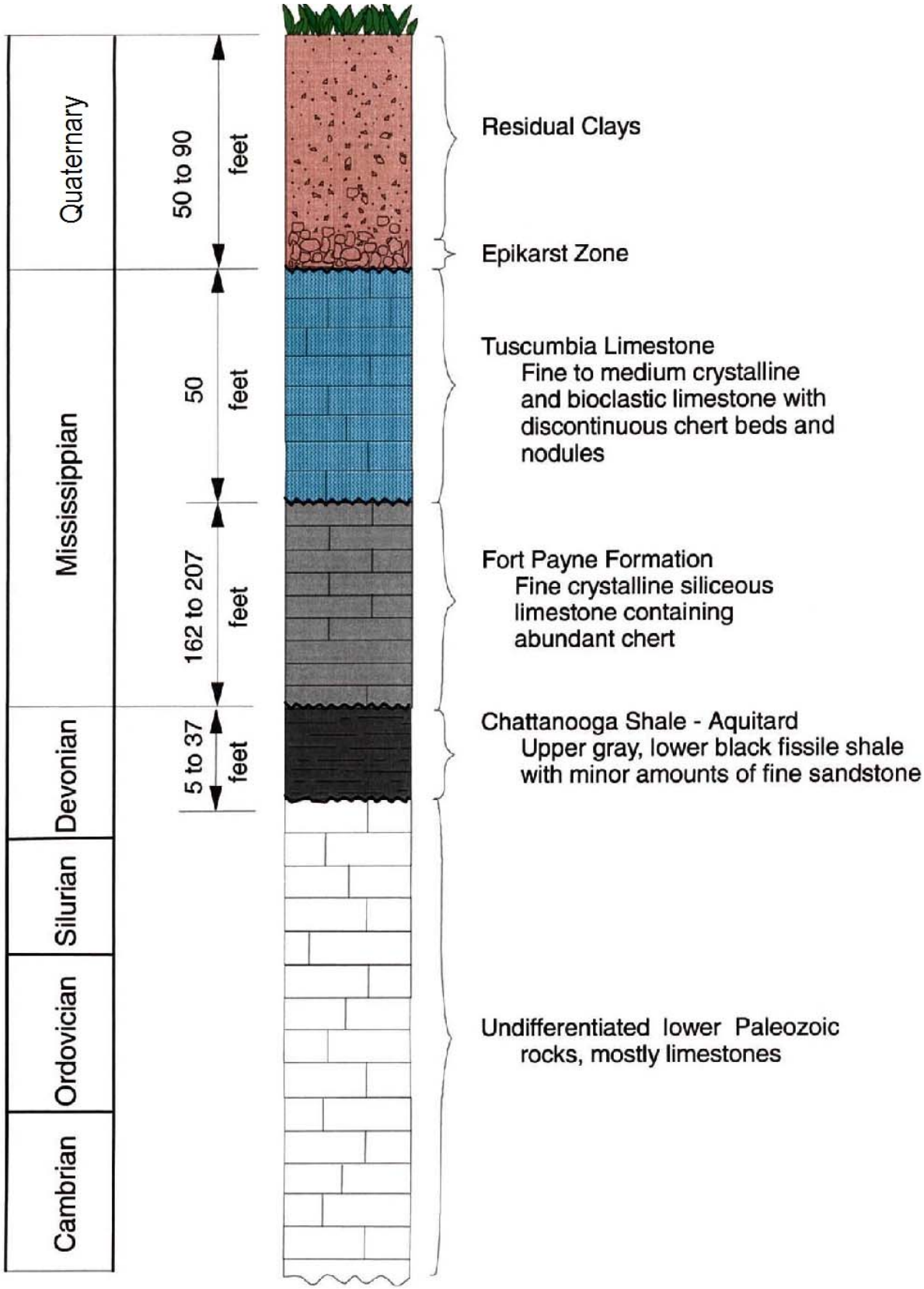


Figure 3-4. Generalized Stratigraphic Column for the Muscle Shoals Reservation Study Area

3.3.1.3 Chattanooga Shale

The Chattanooga Shale is comprised mainly of black shale and minor amounts of fine-grained sandstone. The Chattanooga Shale overlies the older undifferentiated Paleozoic rocks (see Figure 3-4). It does not outcrop in the region, but on-site drilling suggests that the Chattanooga Shale underlying the region is 5 to 37 feet thick. It ranges from 250 to 450 feet below the surface in the MSR study area (Julian et al. 1993). The Chattanooga Shale likely forms an aquitard below the Tuscumbia-Fort Payne aquifer, which restricts the further downward movement of groundwater to the underlying Paleozoic aquifers.

3.3.1.4 Groundwater Occurrence and Movement

Groundwater typically occurs beneath the MSR study area within the residual or alluvial overburden. Exceptions occur in certain areas, particularly areas close to the river, where the water table is found in upper bedrock. The water table generally ranges from approximately 0 to 90 feet below ground surface depending on location and time of year. The principal source of recharge is infiltration of precipitation, e.g., rainwater. Average net recharge from precipitation varies but ranges from 5 to 15 inches/year for the region (Curtis 1953; Bossong and Harris 1987; Golder Associates 1990). Additional lateral groundwater recharge of the Tuscumbia-Fort Payne aquifer occurs from upgradient areas along the eastern boundary of the MSR study area. On-site recharge may include leaky water and sewage lines, segments of streams such as Pond Creek, and impoundments such as the ash settling pond and water supply reservoir. The relative contribution of these artificial sources of recharge is small compared to natural recharge from precipitation and lateral inflow.

Infiltrating precipitation generally moves vertically downward through the overburden and drains into the epikarst zone, where flow becomes primarily horizontal through a network of discrete fractures enlarged by limestone dissolution. Localized areas of upward flow occur near some streams, topographic lows, and areas that receive direct recharge to the bedrock flow system (Julian et al. 1993).

The majority of groundwater flows northwestward and ultimately discharges to the Tennessee River either as springs or as diffused seepage through the riverbed (see Figure 3-5). Dye trace tests conducted at Wells F and G suggest groundwater may also flow to the southwest toward Tuscumbia Big Spring (also known as Tuscumbia Spring); however, tests were inconclusive because dye was not detected at Tuscumbia Spring. Although the southeast corner of the MSR study area lies within the well head protection area (WHPA) for Tuscumbia Spring (Raymond 1997), the location of dye injection points, as well as all existing MSR solid/hazardous waste facilities, fall outside of the WHPA (Figure 3-6).

The dye tracing studies and lineament surveys indicate an extensive network of enlarged fractures in the epikarst zone and upper bedrock. Results of dye trace tests at the MSR study area and in the Muscle Shoals area indicate that rapid horizontal groundwater movement and high dilution occur in the bedrock. Dye velocities ranging from 30 to 1,100 feet/day were observed following dye tracer injections at MSR Wells G and F1. Velocities of several miles/day have been estimated for areas south of the MSR study area. As shown on Figure 3-5, dye was detected at monitoring wells located northwest, northeast, and southwest of the dye injection well. Results of these tests support the notion that groundwater movement in upper bedrock follows large fractures in the bedrock. Results of flow meter tests consistently show a zone up to 5 feet thick of relatively high permeability corresponding to the epikarst zone. The horizontal hydraulic gradients are generally consistent across the MSR study area (Julian et al. 1993).

3.3.2 Groundwater Quality

Groundwater quality on the MSR study area has been affected by nearly 100 years of industrial activity and from other off-site industrial activities located hydraulically upgradient. A description of the solid and hazardous waste facilities located at MSR, including past industrial activities producing the waste, chemical characteristics of industrial waste products, and disposal facility descriptions and closure requirements, is provided in Section 3.1.

Beginning in the 1980s, TVA initiated a series of investigations to characterize groundwater quality and movement beneath the Reservation. The initial investigations focused on groundwater conditions beneath the PDW landfill (SWMU 108). SWMU 108 is one of the largest waste disposal areas on MSR and contains inorganic, organic, and radiological wastes. In response to USEPA's RCRA Facility Assessment Report (Kearney 1988), comprehensive environmental and corrective action studies (Young and Julian 1991; Julian et al. 1993; TVA 1998c) were performed at SWMU 108 and other SWMUs found to contain hazardous wastes. Other relevant off-site groundwater investigations include groundwater contaminant investigations performed on industrial properties located upgradient of the MSR study area (G&E Engineering 1991; Golder Associates 1990; CH2M Hill 1986) and regional groundwater studies covering the Muscle Shoals area (Chandler and Moore 1991; Raymond 1992; Harris et al. 1963).

The postclosure monitoring (PCM) of SWMU areas 108, 104, and 17-37 began in August 2003 following completion of required RCRA cleanup and waste stabilization actions. Quarterly monitoring was performed at these facilities from August 2003 to August 2005, followed by annual monitoring. Groundwater data acquired during the PCM period along with results of the past on-site and off-site groundwater investigations provide the basis for the following characterization of groundwater quality on the MSR study area.

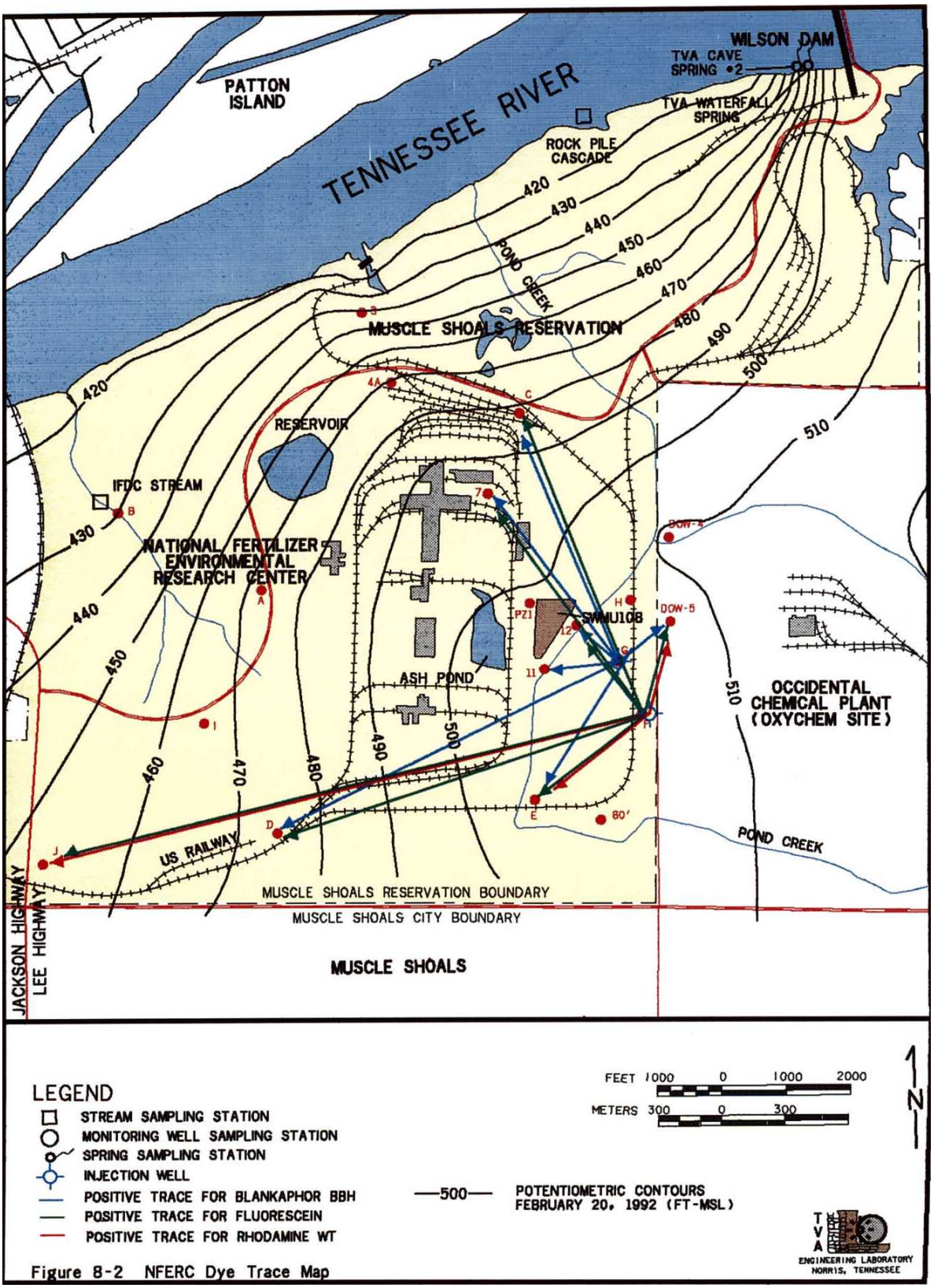


Figure 3-5. Horizontal Movement of Groundwater on the Muscle Shoals Reservation

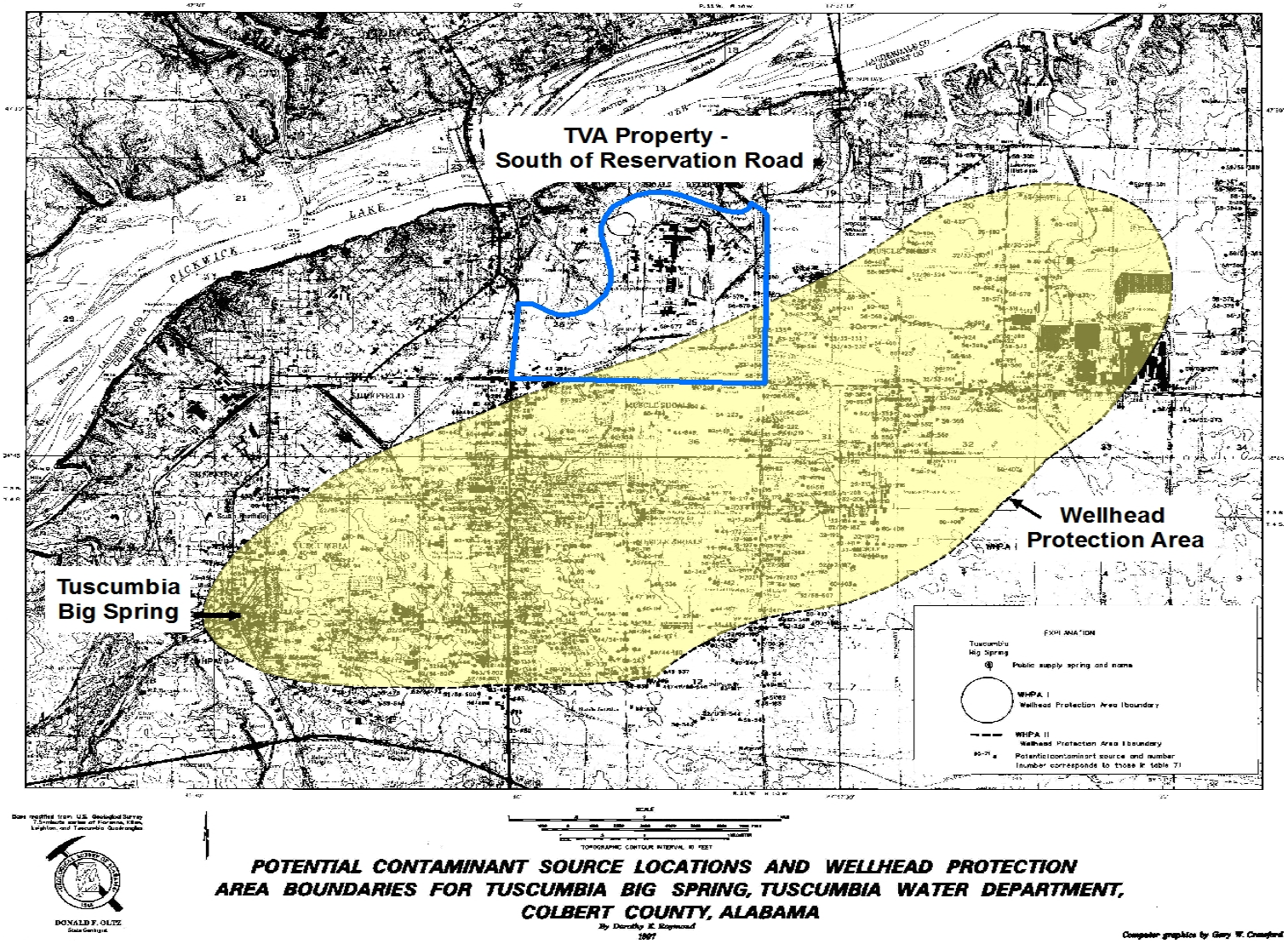


Figure 3-6. Tuscumbia Big Spring Wellhead Protection Area

3.3.2.1 Solid Waste Management Unit 108 (Phosphate Development Works Landfill)

A chronology of water quality investigations conducted at SWMU 108 between 1985 and 1997 is presented in Appendix E. Water quality sampling included only four monitoring wells from 1985 to 1987, and three of these wells were screened near or in bedrock. Well locations are shown on Figure 3-7. No water quality surveys were conducted in 1988, and surveys were conducted at only five shallow wells during 1989. The first comprehensive groundwater investigation was conducted from 1989 to 1990 (Young and Julian 1991). Thirteen wells were sampled during July 1990 for selected organic, inorganic, and radiological constituents. These wells were screened at different depths within the overburden and epikarst zone. Water and sediment were also sampled at several locations along Pond Creek in the vicinity of SWMU 108. Monitoring results are summarized in Table E-3 of Appendix E. Subsequent monitoring and analyses were performed in July 1991 at four wells for radionuclides and a broad spectrum of the different groups of hazardous compounds listed in Appendix IX of the *Interim Final RFI Guidance Manual of U.S. Environmental Protection Agency* (Table E-2 of Appendix E). Results for detected VOCs in samples collected between 1987 and 1997 are summarized in Table E-4 of Appendix E. Nitrate sampling was performed on several occasions between 1989 and 1997 at selected wells surrounding SWMU 108 (Table E-5 of Appendix E). Extensive sampling of 31 wells screened within the overburden and epikarst zone at SWMU 108 was performed in 1997 for contaminants of potential concern identified in TVA 1998c, including VOCs, nitrate-nitrite, cadmium, lead, and phosphate and total phosphorous (Table E-6 of Appendix E).

A summary of historical (1987-1997) groundwater data exceeding RCRA action levels in wells surrounding SWMU 108 is provided in Table E-7 of Appendix E. Elevated metal (including aluminum, arsenic, barium, chromium, copper, iron, and mercury) concentrations in all wells, except W9, W11, and W12, were shown by Young and Julian (1991) to be biased by the presence of suspended solids in groundwater samples derived from soil clay particles, which naturally contain metals. They further demonstrated that organic contaminant levels were positively correlated with suspended solids content and suggested that organics adsorbed (i.e., the binding of molecules or particles to a surface) to suspended soils particles present in samples likely biased organic measurements in samples showing high turbidity. Nitrate exceeded the maximum containment level (MCL) in 9 of 13 wells sampled in July 1990 (Table E-5 of Appendix E). Nitrate, which is unaffected by the presence of suspended material in samples, was attributed to leaching of off-grade nitrate fertilizers and nitric acid production wastes deposited in SWMU 108. While organic contaminants were detected in sediment samples from Pond Creek upstream of SWMU 108, no organics or elevated concentrations of inorganic contaminants were found in Pond Creek water samples collected at or downstream of SWMU 108. Contamination of stream sediments was attributed to off-site industrial contamination.

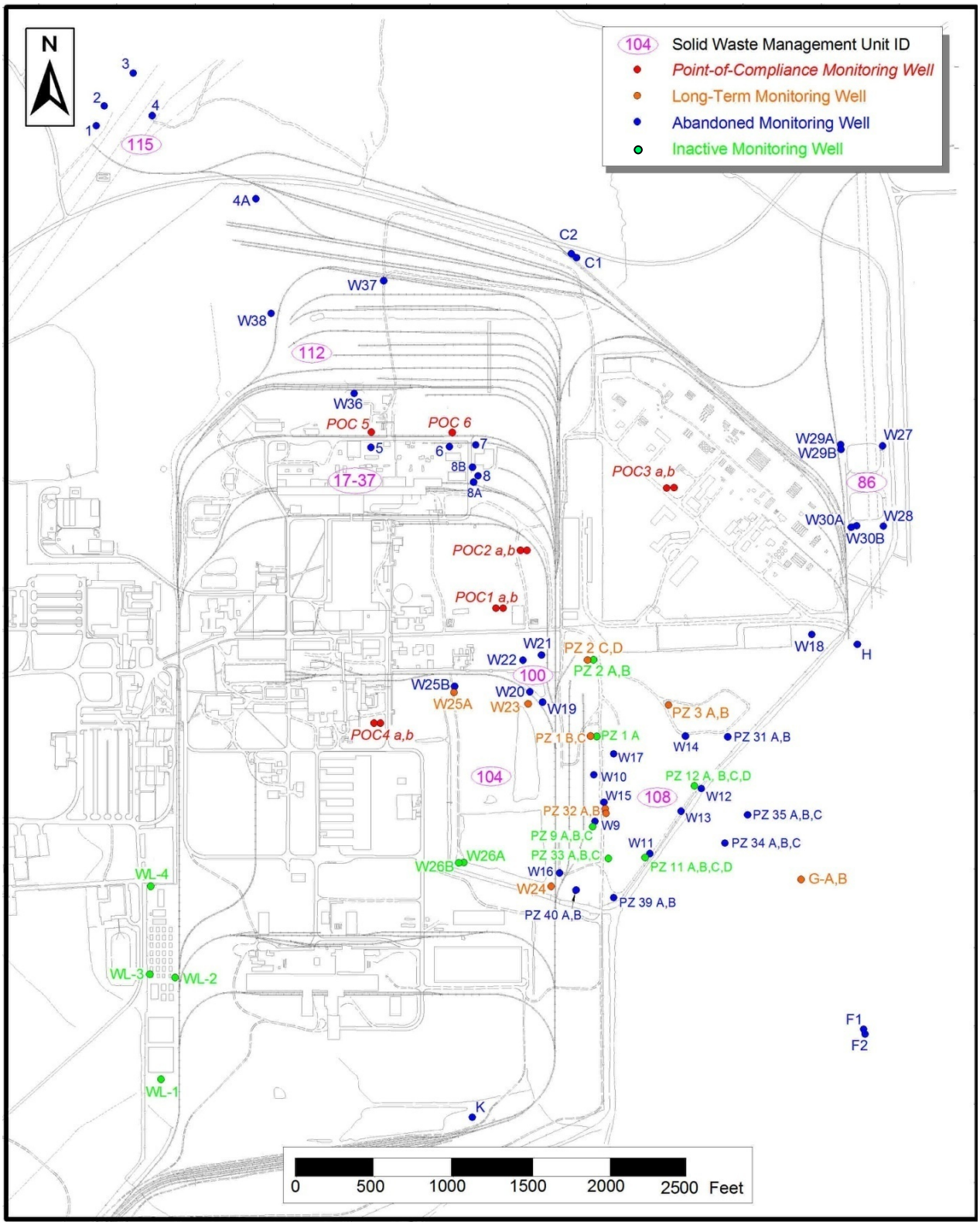


Figure 3-7. Location of Monitoring Wells on the Muscle Shoals Reservation

SWMU 108 was closed under a monitored natural attenuation closure program. This program was approved by ADEM on the basis of biogeochemical modeling analyses, which showed that concentrations of contaminants of concern present in leachate seepage entering groundwater beneath the facility would be reduced to acceptable levels before reaching streams or springs (TVA 1998c). The contaminants of potential concern at SWMU 108 are eight VOCs including tetrachloroethylene and carbon tetrachloride and their daughter products chloroform, trichloroethylene, cis-1,2 dichloroethylene, trans-1,2 dichloroethylene, chlorodibromomethane, and vinyl chloride. The monitoring network includes three pairs of staged, point-of-compliance (POC) wells, POC1A/B through POC3A/B, located 800 to 1,200 feet downgradient (i.e., the groundwater version of "downstream" surface water) of the SWMU 108 boundary (see Figure 3-7). The "A" well of each POC well pair was completed in soil overburden and the "B" well in bedrock. Eight additional noncompliance piezometer wells, located close to SWMU 108, are monitored to detect evidence of natural biodegradation of the VOCs present in the landfill. VOC monitoring results are evaluated against ADEM action limits listed in Table F-1 of Appendix F. SWMU 108 is considered in compliance, provided VOC action limits are not exceeded at the POC wells.

Postclosure groundwater monitoring at SWMU 108 began in August 2003. Monitoring was conducted approximately quarterly between August 2003 and August 2005 and annually thereafter (TVA 2003). The most recent VOC sampling event at SWMU 108 was performed in August 2009. None of the VOCs have exceeded ADEM action limits at POC monitoring wells during the postclosure period; in the past, however, tetrachloroethylene and several other VOCs have been detected in POC wells completed in bedrock (Table F-2 of Appendix F).

Contaminant plumes associated with the eight VOCs have been relatively stable since at least 2004. This stability is illustrated on Figures 3-8 and 3-9, which show the horizontal and vertical distributions of tetrachloroethylene concentration in the SWMU 108 vicinity for the August 2004 and August 2009 sampling events. For reference, Figure 3-10 shows the monitoring network, the August 2009 groundwater potentiometric surface, and inferred groundwater flow directions in the SWMU 108 vicinity. Differences between the spatial distributions of tetrachloroethylene in 2004 and 2009 in the horizontal and vertical dimensions are small, suggesting that the tetrachloroethylene plume is neither advancing nor dissipating. The lack of VOC plume movement during the PCM period is further indicated by the stability of the other VOC plumes and by the temporal stability of VOC concentration series (Appendix F).

Viewed in historical context, the absence of significant change in overall levels of tetrachloroethylene and other VOCs in the SWMU 108 vicinity during the PCM period is not unexpected. The period of active landfill operations at SWMU 108 occurred from 1953 to 1984; however, disposal of organic solvents was reportedly discontinued in 1977. Consequently, solvents such as tetrachloroethylene have been subject to natural chemical breakdown processes for more than 30 years. Currently, the rate at which dissolved phase VOCs are entering groundwater beneath the landfill is apparently roughly equal to the rate of natural breakdown, resulting in near-stable VOC plumes.

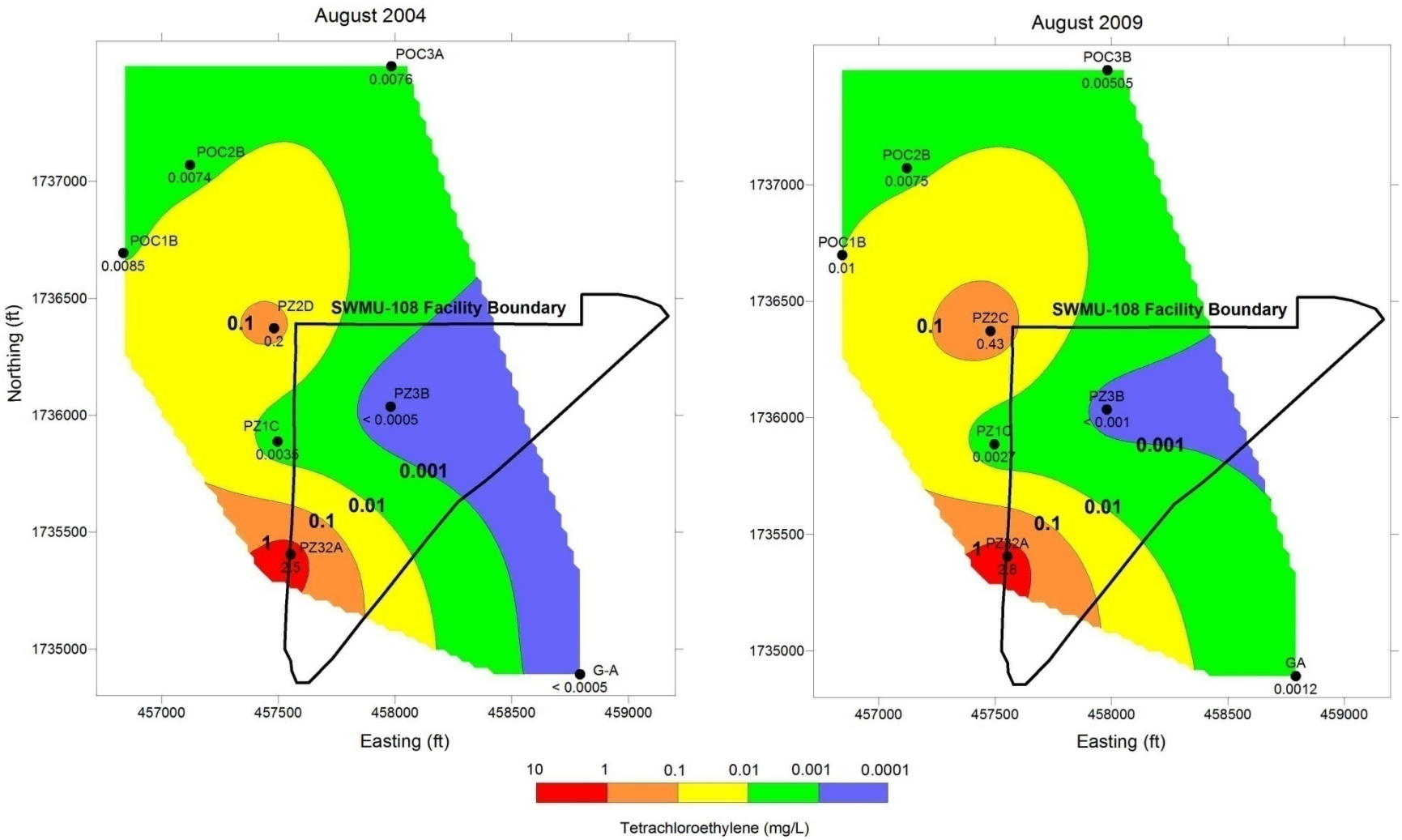


Figure 3-8. Horizontal Distribution of Tetrachloroethylene, August 2004 and August 2009

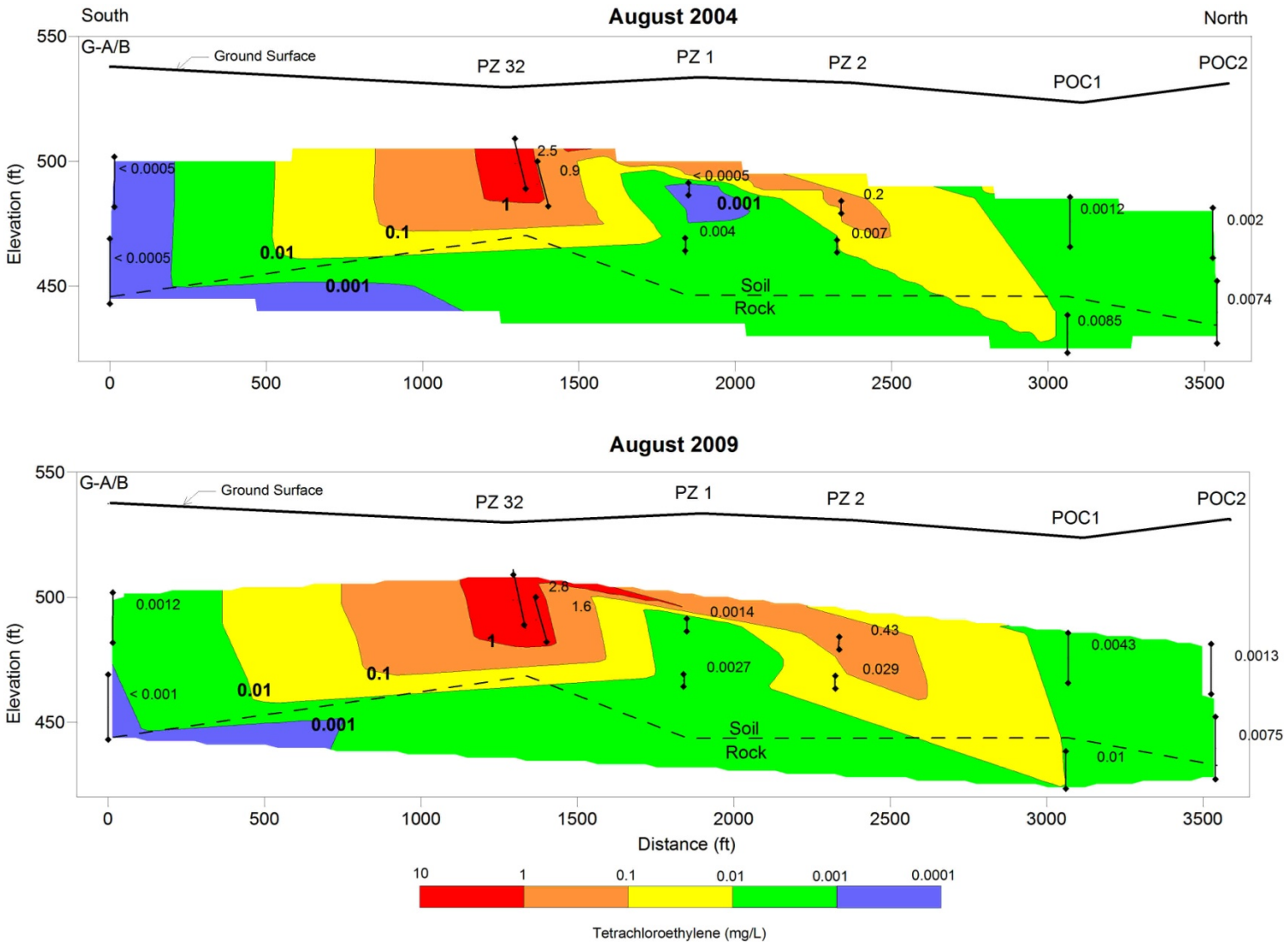


Figure 3-9. Vertical Distribution of Tetrachloroethylene, August 2004 and August 2009

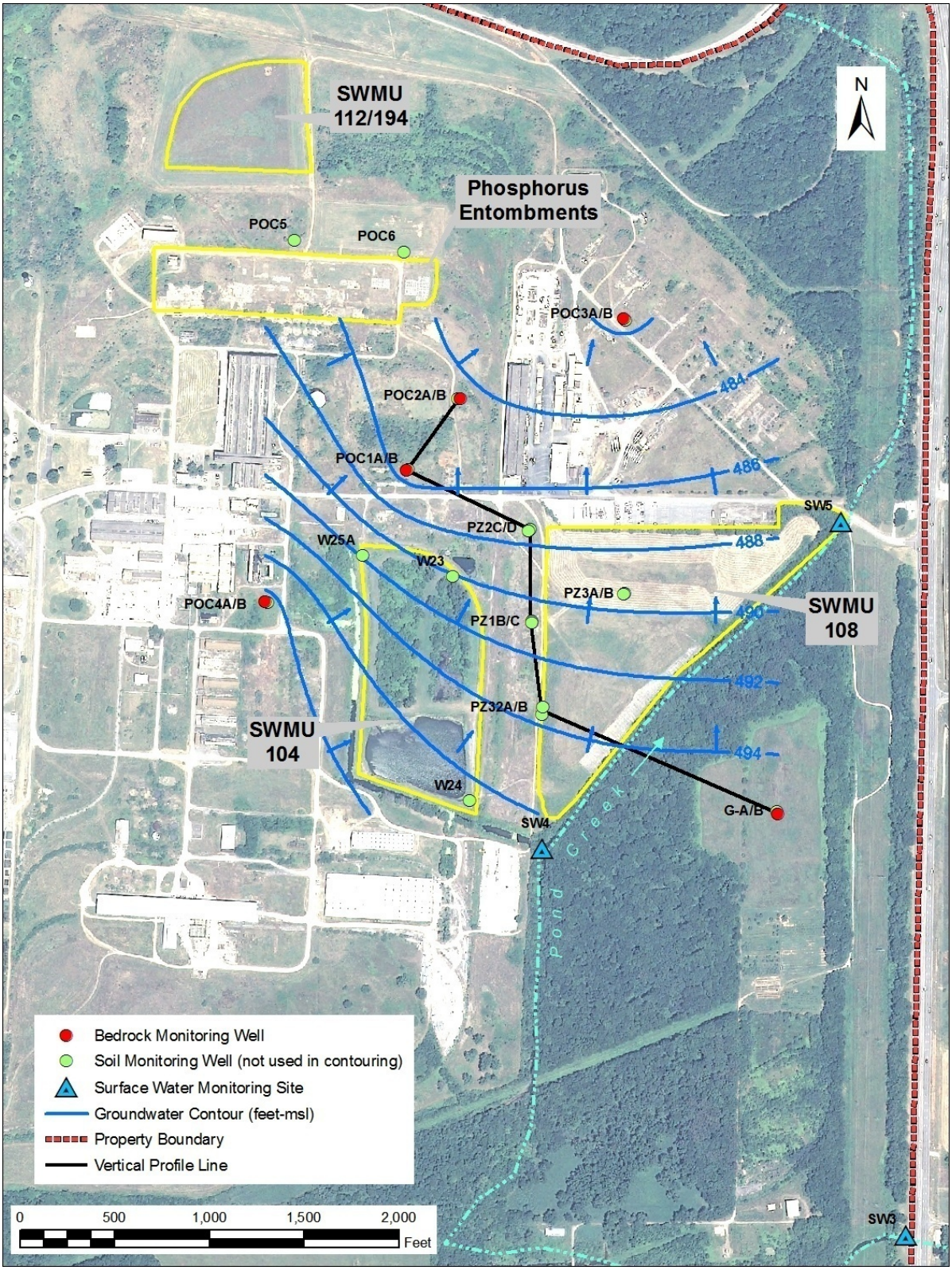


Figure 3-10. August 2009 Shallow Bedrock Potentiometric Surface Map at Solid Waste Management Unit 108

In conjunction with the groundwater monitoring program at SWMU 108, three sampling sites (SW3, SW4, and SW5) on Pond Creek are monitored for tetrachloroethylene as shown in Figure 3-10. Historically, the highest tetrachloroethylene concentrations and frequency of detections have generally been observed at upstream (off-site) location SW3, followed by SW4 and SW5. The spatial trend of decreasing tetrachloroethylene concentrations and detections in the downstream direction suggests an off-site source of tetrachloroethylene. Since 2006, however, SW5 has been the only monitoring station to show any detectable tetrachloroethylene levels. Although data continue to indicate an off-site tetrachloroethylene source, an on-site source cannot be ruled out.

3.3.2.2 Solid Waste Management Unit 104 (Ash Settling Pond) and Solid Waste Management Units 17-37 (Phosphorus Entombments)

The ash settling pond was constructed to contain potential spills from the elemental phosphorus production facility and to settle out phosphorus-containing solids from the waste stream. The phosphorus entombments are in the production plant's former furnace areas, within existing pits and sumps.

The potential contaminant of concern associated with these SWMUs is white phosphorous (P_4). The monitoring program for SWMU 104 includes two POC wells (POC 4A/B) located approximately 500 feet downgradient of the SWMU boundary and three noncompliance wells (W23, W24, and W25A) completed in shallow soils in the immediate vicinity of the SWMUs.

Groundwater monitoring at SWMUs 17-37 is conducted at two shallow overburden monitoring wells (POC5 and POC6), located approximately 100 feet downgradient of the facility boundary. PCM has been performed at SWMU 104 and SWMUs 17-37 since August 2003. Monitoring was conducted approximately quarterly between August 2003 and August 2005 and annually thereafter. No P_4 has been detected in groundwater samples from POC and noncompliance monitoring wells during the PCM period (Appendix G). Analytical detection limits for P_4 have varied from 0.023 to 0.25 micrograms per liter (µg/L) during the monitoring period.

The absence of P_4 in groundwater is expected due to its limited mobility in subsurface environments. Once P_4 dissolves in groundwater, it oxidizes to form phosphates that are quickly removed by processes of adsorption complexation (i.e., a combination of two or more substances), and precipitation (i.e., the formation of a solid) as the water flows through the soil (Nikandrov and Smirnov 1983; Campbell 1977; Brady 1974).

P_4 may occur in groundwater in two ways, ionic P_4 and particulate P_4. The rate at which the P_4 oxidizes to phosphates depends on the amount of available dissolved oxygen and water temperature. The higher the level of dissolved oxygen is, or the higher the temperature is, the faster the rate of oxidation is. For ionic P_4, the half-life ranges from 42 hours to 125 days (Spangord et al. 1985; Nikandrov and Smirnov 1983). For particulate P_4, the half-life may be as high as 2.4 years (Spangord et al. 1985). In the case of the particulate P_4, an oxidized phosphate layer will form on the particle making it reactive with soil to form compounds that immobilize the particulates.

Once the phosphates are formed in the water, they will quickly react with cations (e.g., calcium, magnesium, iron, and aluminum) dissolved in the water or as part of the soil matrix to form insoluble compounds. Therefore, the P_4 will be precipitated from the water column as insoluble phosphates. These are not likely to redissolve or migrate due to the very low solubility of metal phosphates.

3.3.2.3 Solid Waste Management Unit 86 (Phosphate Development Works Lagoons)

The two former PDW lagoons were located just northeast of SWMU 104 (Figure 3-7). The lagoons were designed to receive wastewater treatment effluent and storm water runoff and were constructed with a bentonite clay bottom liner and a capacity of 2.5 million gallons. Plant effluent contained chloride, phosphate, elemental phosphorus, oils, and grease. The production facilities at PDW ended operation in 1957. From 1957 until 1993, the lagoons handled only rainwater runoff. In September 1996, the dike next to Pond Creek was removed to prevent the lagoons from holding rainwater.

In November 1992, groundwater samples were collected from Wells W27 through W30, which were drilled at the corners of the SWMU (see Figure 3-7). The samples were analyzed for semi-VOCs (SVOCs), pesticides, and polychlorinated biphenyls (PCBs). No SVOCs or pesticides were detected in any of the samples; however, the chemical analysis on the water samples had a limited ability to detect the presence of several compounds. The chemical tests needed a higher concentration of those compounds even to detect them in the sample than the concentration designated as an “action limit” threshold (i.e., the chemical level for a compound that requires cleanup is lower than the amount actually needed to detect the compound in the first place).

An additional set of groundwater samples taken from Wells W27 through W30 in February 1993 for PCBs and pesticide analysis showed no detectable PCBs or pesticides, but again detection limits exceeded action limits in several cases (TVA 1998c).

3.3.2.4 Solid Waste Management Unit 100 (Ammonia From Coal Project Equalization Basin)

SWMU 100 received ammonia from coal project wastewater containing 0 to 200 ppm ammonia, 1 ppm sulfur, 2 ppm cyanide, and 100 to 2,000 ppm chemical oxygen demand. Surface runoff from the ammonia from the coal project plant area was also routed to the basin. The equalization basin associated with this SWMU had a capacity of 380,000 gallons and was lined with a 2-foot-thick compacted clay base covered with a 36-millimeter flexible membrane liner. Two upgradient monitoring wells (19 and 21) and two downgradient monitoring wells (20 and 22), all completed within the residual overburden, were installed around SWMU 100 in January 1991. Inferred groundwater movement in the SWMU 100 vicinity varied from westward to southwestward based on snapshots of water levels at Wells 19-22 performed in September 1991 and February 1997 (TVA 1998c).

Wells 19-22 were sampled in February 1996 for VOCs, SVOCs, pesticides, PCBs, and metals. Groundwater samples from downgradient Wells 20 and 22 exhibited chromium concentrations of 0.11 and 0.9 milligrams per liter (mg/L), which exceeded the chromium screening level. Screening level exceptions were also indicated at Wells 20 and 22 for lead (0.05-0.11 mg/L) and vanadium (0.11-0.35 mg/L). In addition, samples from Well 22 showed exceedences for beryllium (0.005 mg/L), cadmium (0.009 mg/L), and nickel (0.1 mg/L). Elevated concentrations of these trace metals were attributed to sample bias resulting from the presence of suspended soil particulate containing naturally occurring trace metals in unfiltered groundwater samples (TVA 1998c).

3.3.2.5 Solid Waste Management Unit 115 (Ammonia From Coal Gasification and Purification Plant Coal Slag Landfill)

This landfill was constructed to dispose of solid wastes generated by SWMU 115. The landfill is lined with 2 feet of compacted clay and measures approximately 400 feet long by 150 feet wide and 15 feet deep. The landfill contains only wastes generated by the

Ammonia From Coal Gasification and Purification Plant and ancillary waste treatment processes. Disposed wastes include slag generated from the gasification of coal and wastewater treatment sludge. This landfill has received no waste since October 1985.

One upgradient (Well 4) and three downgradient monitoring wells (Wells 1, 2, and 3) were installed prior to placing any waste in the landfill. Groundwater flow is generally in a northwesterly direction in conformity with the placement of the wells. Groundwater samples were collected from each well in April 1996 and analyzed for VOCs, SVOCs, pesticides, PCBs, and metals. No constituent or hazardous characteristics were detected in groundwater samples at concentrations higher than screening levels (TVA 1998c).

3.3.2.6 Solid Waste Management Unit 112/194 (Precipitator Dust Piles/Trestle Drum Storage Area)

SWMU 112/194 contains approximately 20,000 tons of phosphate containing precipitator dust from electric furnace elemental phosphorus operations, which ended in 1976. Precipitator dust sampling in November 1984 identified phosphorus pentoxide, elemental phosphorus, potassium oxide, silica dioxide, cadmium, lead, and the radionuclides radium-226, lead-210, polonium-210, uranium, and potassium-40. Groundwater investigations began at SWMU 112/194 in April 1997 with installation and sampling of monitoring Wells 36, 37, and 38, all of which were completed in residual overburden to depths ranging from 40 to 49 feet below grade (see Figure 3-7). Water level monitoring of these wells indicated westward movement of groundwater toward the Tennessee River. Wells were sampled for elemental phosphorus, gross alpha, gross beta, total radium, lead-210, polonium-210, potassium-40, total uranium, radon-222, and total lead and thallium (TVA 1998c).

Elemental phosphorous was below the detection level of 0.02 µg/L at all wells. Total lead and thallium concentrations were below the detection levels (0.001 and 0.002 mg/L, respectively) at Wells 36 and 37 but exceeded the RCRA action levels (0.015 and 0.002 mg/L, respectively) at Well 38. Although total lead and thallium values in Well 38 were 0.34 and 0.004 mg/L, respectively, dissolved (filtered) lead and thallium concentrations at Well 38 were below the detection levels. Lead and thallium strongly adsorb to clay particles. Results of groundwater sampling for dissolved lead and thallium suggest that they are being attenuated by low permeability clays underlying the site. Based on these results, no meaningful contamination of groundwater by lead and thallium was indicated at SWMU 112/194 (TVA 1998c).

Groundwater monitoring results from SWMU 112/194 indicated six radionuclides exceeded calculated preliminary remediation goals (Appendix H). These radionuclides included potassium-40, lead-210, polonium-210, radon-222, total radium, and total uranium. The RFI final report (TVA 1998c) concluded that groundwater downgradient of SWMU 112/194 appeared to be affected by radionuclide contaminants and that contamination probably originated from the precipitator dust piles. SWMU 112 was capped in accordance with RCRA standards in order to minimize future generation of contaminated leachate from the facility.

3.3.2.7 Solid Waste Management Unit 114 (Phosphate Slag Storage Area)

SWMU 114 contains approximately 1.6 million tons of phosphorus slag by-product from past phosphorus and phosphoric acid for fertilizer production. Phosphate slag contains calcium oxide, silicon dioxide, aluminum oxide, fluorine, potassium monoxide, phosphorus, ferric oxide, sodium oxide, and manganese monoxide. Phosphate slag also contains elevated levels of naturally occurring radioactive materials consisting mainly of radium-226.

The U.S. Bureau of Reclamation performed water sampling in the vicinity of the phosphate slag stockpiles in conjunction with chemical and radiological characterization of phosphate wastes (May and Boyle 1990). Five water samples were collected. These included one from a depression on the top of the east slag pile (Sample 1W), one from a groundwater seep flowing to Pond Creek (2W), and three samples (3W-5W) from Pond Creek (Appendix I). Each sample was analyzed for the presence of 32 elements, including 16 metals. Samples 1W and 2W, which were assumed to be representative of seepage from the slag pile, exceeded drinking water MCLs for chromium, mercury, and fluoride. Pond Creek Sample 4W also indicated an MCL exceedence for mercury. Complete water sampling results are given in Appendix I. Waste characterization studies found nothing to indicate that the phosphate slag was hazardous (May and Boyle 1990).

3.3.2.8 Low-Level Radioactive Waste Burial Site

The LLRWBS is located in the southwestern corner of the MSR study area and operated from 1966 to January 1981 (see Section 3.1.1.4). The currently inactive facility primarily received wastes from TVA's fertilizer research and radioanalytical laboratory quality control programs. A total of 51 different radionuclides were buried at the site (see 1997 letter in Appendix D).

A single monitoring well (LLRWBS-MW1) was installed at the LLRWBS in August 1996 to support an assessment of the environmental effects of the facility required by the NRC. The well was completed to a depth of approximately 61 feet in residual overburden. Depth to groundwater measured at this well on April 29, 1997, was approximately 51 feet below ground surface, thus indicating radioactive waste materials were stored approximately 40 feet above the water table. MW1 was sampled for tritium and carbon-14 in November 1996 and May 1997. Because tritium was deposited at the burial site in the form of tritiated water, it is highly mobile in the subsurface and should be detected before the other radionuclides, particularly metals, which tend to adsorb to soils. Liquid scintillation analysis indicated both tritium and carbon-14 were below instrument detection limits for both samples, i.e., less than 795 and less than 652 pico-curies per liter (pCi/L), respectively, for the November 1996 sample and less than 250 and less than 387 pCi/L for the May 1997 sample (W. L. Raines, TVA, personal communication, April 25, 2010).

As part of an assessment of the environmental effects of the inactive LLRWBS conducted in 1997 (see 1997 letter in Appendix D), a health risk analysis was performed to evaluate the total effective dose equivalent (TEDE) for a maximally exposed individual, assuming the individual's drinking water was derived from a hypothetical well located at or downgradient of the burial site. The predicted TEDE was 0.55 mrem during 1983 and 0.0000025 mrem during 1997. No future increase in dose after 1997 was indicated. Predicted TEDEs were well below current NRC and USEPA regulations.

3.3.2.9 Off-Site Groundwater Investigations

Several off-site studies of groundwater quality in the surrounding Muscle Shoals region were performed by other organizations during the 1980s and early 1990s. These included investigations at the Occidental Chemical Corporation site (G&E Engineering Inc. 1991) and the former Ford plant site (Golder Associates 1990) and regional studies by the Geologic Survey of Alabama (Chandler 1986; Chandler and Moore 1991; and Chandler et al. 1990).

The Occidental Chemical chlor-alkali production plant borders MSR to the east. In 2008, Occidental ended its chlor-alkali mercury cell production and decommissioned the plant. Occidental continues to manufacture potassium carbonate. The groundwater investigations

at the Occidental site confirmed the presence of plumes of mercury, cadmium, and chloride with elevated chloride concentrations that probably extend downgradient onto MSR property. The mercury concentrations in groundwater samples ranged from below 2 to 280 µg/L; cadmium concentrations from below 5 to 250 µg/L; and chloride concentrations from 1 to 170,000 mg/L (G&E Engineering Inc. 1991). Laboratory analysis of groundwater samples from the deep wells revealed mercury concentrations ranged from less than 0.2 to 20 µg/L; cadmium levels from less than 5 to 21 µg/L; and chloride from 102 to 16,400 mg/L. The former Ford plant, approximately 1.5 miles east of the MSR study area, used on-site evaporation and drying ponds for wastewater during its operation. The prevalent compounds identified at the Ford site were VOCs, including tetrachloroethane, trichloroethane, 1,2-dichloroethene, and vinyl chloride. Other compounds detected in the groundwater at the site include PCBs (PCB-1242), dense nonaqueous phase liquids, ethyl benzene, xylene, cyanide, zinc, and arsenic. Based on regional groundwater gradients and results of dye trace studies performed at the Occidental and Ford plant sites, subsurface contaminants originating at these neighboring industrial plants probably affect groundwater quality in the Tuscumbia-Fort Payne aquifer system beneath the MSR study area (Julian et al. 1993).

Chandler (1986) and Chandler and Moore (1991) evaluated effects of storm water drainage (Class V) wells on groundwater quality in the Muscle Shoals area. These studies found that high color and turbidity in samples of groundwater and surface water runoff entering the drainage wells accounted for the water quality problems associated with the drainage wells. Consequently, numerous storm water drainage wells located upgradient of MSR also likely influence groundwater quality in the bedrock aquifer beneath MSR.

3.3.2.10 Summary

Groundwater quality investigations at MSR have focused primarily on several of the larger SWMUs found to contain hazardous waste during the RFA/RFI process. Examination of the monitoring data from these investigations indicates groundwater quality has been unaffected in the vicinity of SWMUs 17-37, 104, or 115, all of which showed no RCRA action limit (RAL) exceedences in monitoring wells samples. Groundwater also appears unaffected at the LLRWBS, where limited sampling of one well at the site showed no detectable tritium, the most mobile of the stored wastes.

Groundwater monitoring results for SWMUs 86 and 100 were generally favorable but somewhat uncertain for some constituents. Preclosure groundwater monitoring in the SWMU 86 locality indicated no SVOC, PCB, or pesticide RAL exceedences. However, analytical detection limits were greater than RALs for some constituents, leaving the question of RAL exceedences open for those constituents. RAL exceptions were indicated for heavy metals (i.e., beryllium, cadmium, chromium, nickel, vanadium) in preclosure groundwater sampling results for SWMU 100. However, evidence was presented in the RFI report (TVA 1998c) indicating that elevated concentrations of metals were likely biased by the presence of soil particulates containing naturally occurring metals in unfiltered groundwater samples.

Although groundwater beneath and in the region downgradient of SWMU 108 is affected by waste leachate, the monitored natural attenuation closure program approved for this facility allows for elevated VOC concentrations, provided that VOC action limits are not exceeded at the POC monitoring wells. Postclosure groundwater monitoring indicates the presence of tetrachloroethylene and several other VOCs in downgradient POC monitoring wells, but concentrations have consistently been below ADEM action limits. Other overburden monitoring wells (not designed for compliance purposes) located in the immediate vicinity of

SWMU 108 continue to show elevated VOC concentrations. However, concentrations in these wells and the POC wells have remained relatively stable during the postclosure period. The stability of the VOC plumes during the past six years indicates that the rates at which dissolved VOCs are transported via groundwater away from the landfill are roughly equal to rates of natural attenuation of VOCs. Similar attenuation of nitrate and other contaminants detected in groundwater during preclosure investigations is expected. Periodic sampling of Pond Creek in the vicinity of SWMU 108 continues to indicate an off-site source of the low concentrations of tetrachloroethylene observed in samples, although some contribution of tetrachloroethylene from SWMU 108 cannot be ruled out.

Preclosure groundwater investigations at SWMUs 114 and 112/194 indicated some evidence of groundwater contamination. Limited groundwater monitoring at SWMU 114 suggested phosphate slag deposits might be affecting local groundwater and possibly Pond Creek water quality. Sampling of seepage from the phosphate slag storage area showed MCL exceedences for chromium, mercury, and fluoride. A water sample collected from Pond Creek directly downgradient of the phosphate slag storage area also showed a mercury MCL exception. Groundwater monitoring results for samples from SWMU 112/194 Wells 36-37 indicated six radionuclides exceeded calculated preliminary remediation goals (Appendix H). These radionuclides included potassium-40, lead-210, polonium-210, radon-222, total radium, and total uranium.

Given the prevailing westward groundwater gradients on the eastern side of the MSR study area, subsurface contamination originating at the neighboring Occidental Chemical Plant and former Ford plant sites has probably affected groundwater quality in the Tuscumbia-Fort Payne aquifer system beneath the MSR study area. Investigations confirmed the presence of cadmium, mercury, and chloride plumes beneath the Occidental site, which likely extend onto the MSR study area. A range of VOCs, chlorinated solvents, PCBs, and heavy metals were detected in groundwater at the Ford site. Many of the contaminants identified at elevated concentrations in groundwater beneath these upgradient properties are similar to contaminants found in MSR groundwater samples collected from bedrock monitoring wells, e.g., VOCs and heavy metals. However, the extent to which off-site contaminant sources contribute to groundwater contaminant levels at MSR is unknown and would be difficult to quantify with certainty using available information.

3.3.3 Local Groundwater Use

The groundwater use survey focused on wells and springs located on the south side of the Tennessee River and within approximately 5 miles of the MSR study area. Records of water-supply wells registered with the Geological Survey of Alabama (GSA) were obtained for the region and are summarized in Appendix J. The Alabama Office of Water Resources (AOWR) also provided a listing of large public, industrial, and irrigation well users in Colbert County from the 2005 national water use inventory coordinated by the U.S. Geological Survey (Tom Littlepage, AOWR director, personal communication, July 2009). AOWR data are presented in Appendix J. Additional water use information was obtained from the Julian et al. (1993) report.

A map showing the density of wells and springs within the vicinity of the MSR study area is shown as Figure 3-11. Precise well/spring location information is not available from GSA records; only township-range-section locations are recorded for each well. These data were used to determine the number of wells within each 1-square-mile map section shown on Figure 3-11. A total of 62 water supply wells and one public water supply spring are indicated within the 5-mile survey area. Approximately half of the wells were constructed prior to 1980. Some (perhaps many) of these wells are likely no longer used because of

the widespread availability of public water in the Tuscumbia-Sheffield-Muscle Shoals region. Well depths in the survey region range from 66 to 250 feet, with a median depth of 120 feet. The Tuscumbia-Fort Payne aquifer system is the source for all wells listed in the AOWR records within the 5-mile survey area. In most cases, GSA records do not identify the source aquifer. However, well depth information and drillers' logs (where available) indicate most wells are completed in the Tuscumbia-Fort Payne aquifer. Approximately 40 percent of the listed wells are used for industrial and commercial supply, 35 percent for private (or residential) supply, and 24 percent for irrigation. Given the age of many of the private wells listed in GSA records and the local availability of public water, many of these wells are likely no longer used for potable water supply.

Tuscumbia Spring (also known as Big Spring) is the largest known public groundwater supply in the area and is located about 4 miles southwest of the MSR study area (see Figure 3-11). Tuscumbia Spring serves the city of Tuscumbia, several adjoining areas outside of Tuscumbia, and the Littleville Water Department. Total withdrawals by the Tuscumbia Water Treatment Plant average 1.8 MGD (David Thornton, Tuscumbia Utilities manager, personal communication, May 6, 2010). The source of the spring is the Tuscumbia-Fort Payne aquifer. Average flow of Tuscumbia Spring is 42 MGD. However, seasonal variation of discharge is high, which is characteristic of most springs originating in karstic limestone. Chandler and Moore (1991) estimate a recharge area for Tuscumbia Spring of approximately 84 square miles, based on the regional recharge rate of 11.4 inches/year estimated by Curtis (1953) and mean spring flow of 42 MGD. Other public groundwater supplies located outside of the survey area include the Hawk Pride Mountain water system and the Leighton Water and Sewer Board system. The Hawk Pride Mountain system, located approximately 8 miles southwest of the MSR study area, operates two wells completed in the Tuscumbia-Fort Payne aquifer system. Combined pumpage from both wells in 2005 averaged approximately 1.08 MGD. The Leighton system, approximately 9 miles southeast of the MSR study area, consists of one Tuscumbia-Fort Payne well that produced pumpage averaging approximately 0.23 MGD in 2005. Other public water systems serving the MSR region, which include the Muscle Shoals Water Department and Colbert County Water Department, withdraw water from intakes on the Tennessee River.

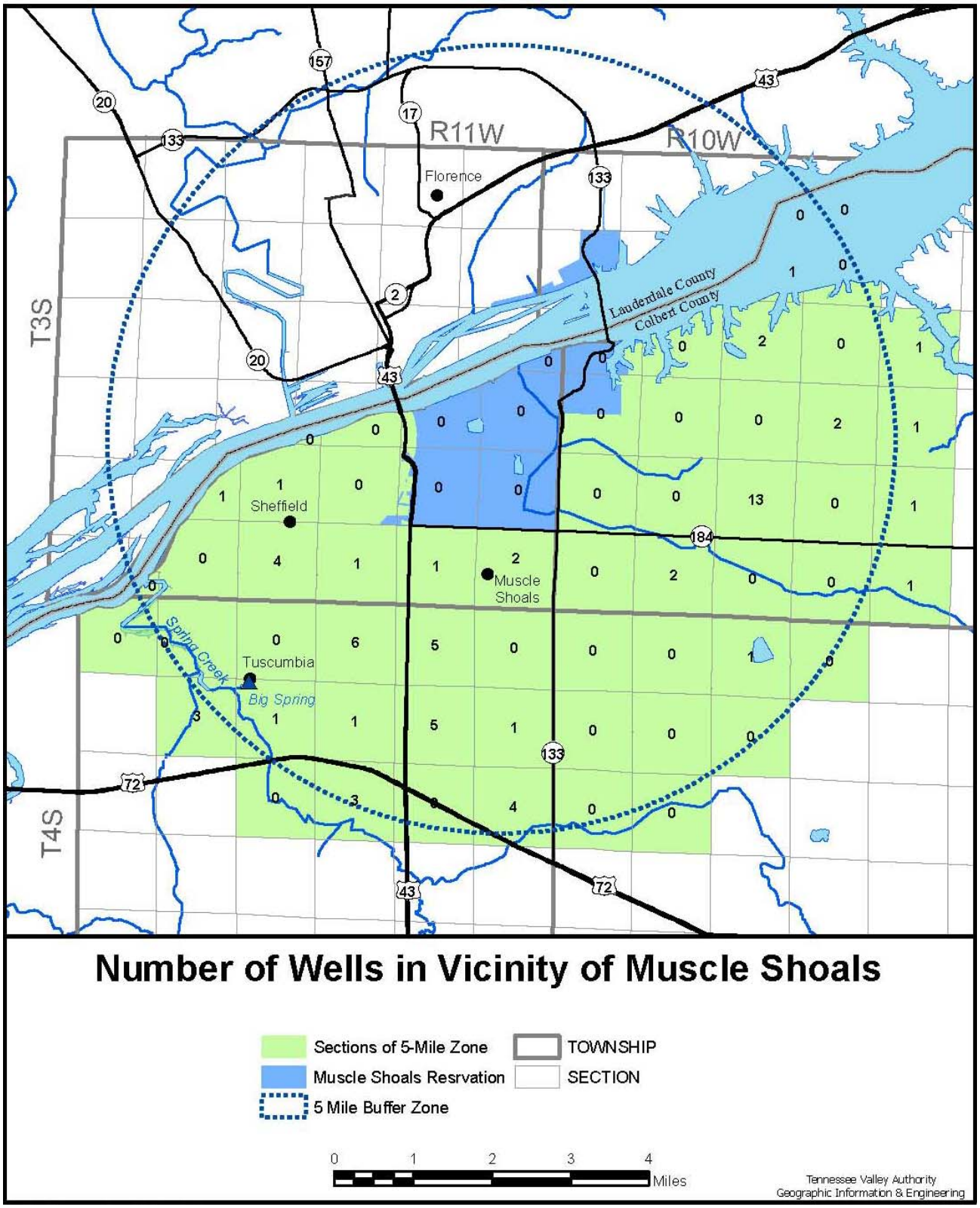


Figure 3-11. Groundwater Supply Wells in the Vicinity of the Muscle Shoals Reservation Study Area

3.4 Historic and Archaeological Resources

Cultural resources include properties such as prehistoric and historic archaeological sites, historic sites where important events or activities may have occurred, and buildings and structures that may be associated with significant events, people, or designers or of particular importance for research. Often, when there are many resources within a contiguous area, a historic district can be established to express the continuity and concentration of resources. Generally, properties determined to be eligible for listing in the NRHP meet one or more the following National Register Criteria for Eligibility:

- Criterion A: Properties associated with events that have made a significant contribution to the broad patterns of our history
- Criterion B: Properties associated with the lives of persons significant in our past
- Criterion C: Properties that embody the distinctive characteristics of a type, period, or method of construction, that represent the works of a master, that possess high artistic values, or that represent a significant and distinguishable entity whose components may lack individual distinction
- Criterion D: Properties that have yielded, or may be likely to yield, information important in prehistory or history

As a federal agency, TVA is required to examine the potential effects of its undertakings (i.e., proposed actions) on any cultural resources that may be included in or be eligible for inclusion in the NRHP. When these effects are determined to be adverse, TVA is required to take measures to mitigate the adverse effects. Cultural resources subject to this requirement include any historic properties that have historic significance to their community, the state, or the nation.

In accordance with Section 106 of the NHPA of 1966, as amended, TVA consulted the Alabama Historical Commission on the potential fate of the historic properties on the MSR study area. A critical step in the Section 106 consultation process is establishing the area of potential effects (APE). The APE is the geographic area or areas within which an undertaking may cause changes in the character or use of historic properties, if any such properties exist. The APE for the MSR redevelopment project is the approximately 1,400-acre project study area as shown in Figure 3-12 as well as in Appendix A of the Memorandum of Agreement (MOA; see Appendix A to this EIS) between TVA and the Alabama SHPO. The Alabama SHPO concurred with this APE determination in its June 14, 2010, letter. The Alabama SHPO also provided concurrences and comments on other parts of TVA's proposed undertaking (see Appendix K). TVA has identified seven historic contexts within which properties eligible for the NRHP occur in the study area. These contexts are listed in Table 3-4 with resource or historic chronology and context descriptions. Numerous individual buildings and structures are included within these larger resource types (i.e., district, complexes, or sites).

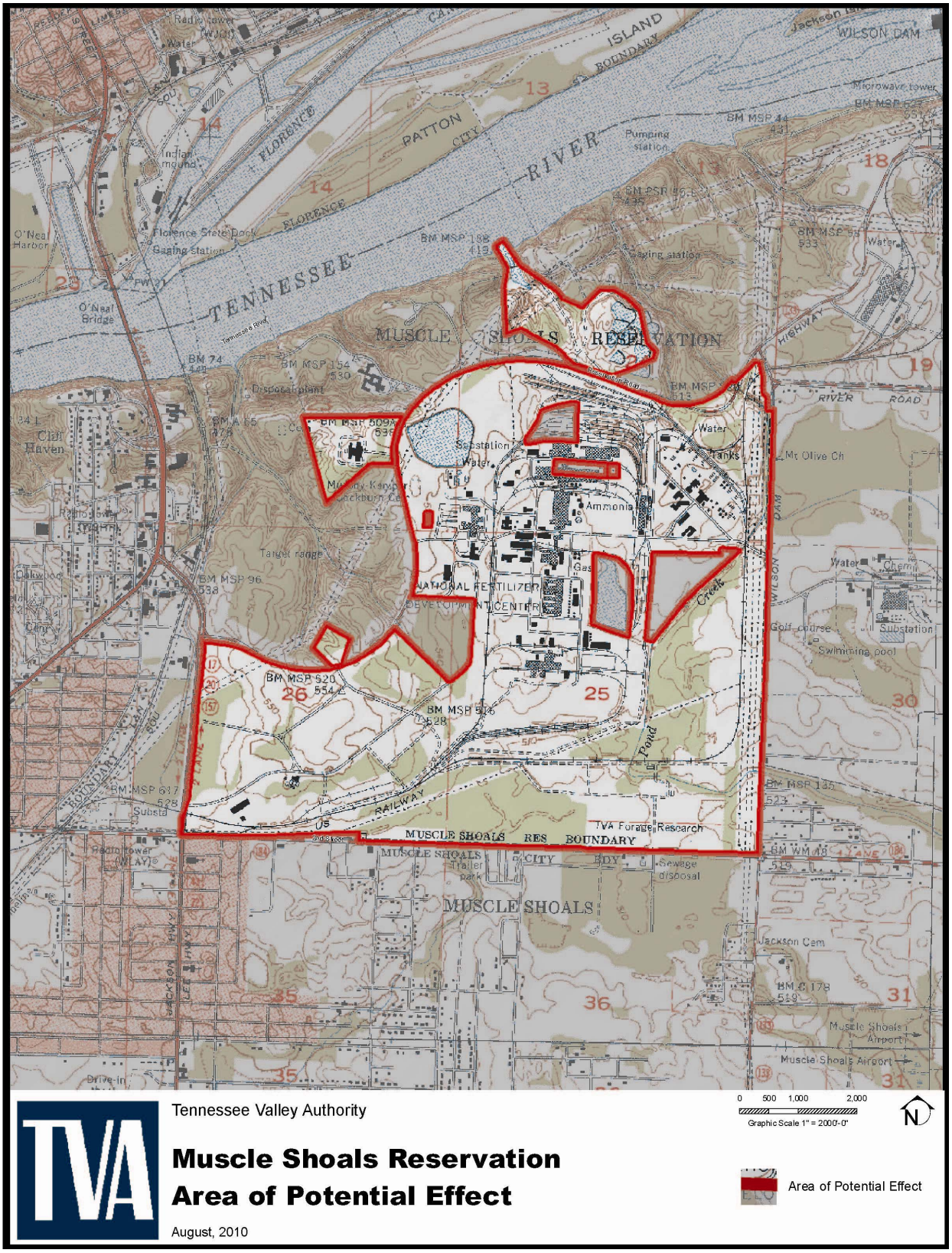


Figure 3-12. Area of Potential Effect, Muscle Shoals Reservation Study Area

Table 3-4. Eligible Properties Within the Muscle Shoals Reservation Study Area of Potential Effects

Resource Name	Resource Number	Resource Type	NRHP Status
Muscle Shoals Historic District	N/A	Historic District	Eligible
National Fertilizer Development Center (USNP2)	N/A	Building Complex	Eligible
TVA Greenhouse Research Complex	N/A	Building Complex	Eligible
TVA Environmental Research Center Building	N/A	Building Complex	Eligible
Foundations of Steam Plant Near TRM 258	1CT495	Historic Site	Contributing
Construction Village No. 2	1CT500	Historic Site	Contributing
Recreation Area (Village No. 2)	1CT575	Historic Site	Contributing

N/A = Not applicable

3.4.1 Archaeology

The prehistoric sequence of human occupation in north Alabama has been explored since the 19th century. The archaeological survey and excavations that took place during the construction of TVA's Guntersville, Wheeler, and Pickwick reservoirs began the systematic, scientific study of Native American occupation in this part of the Tennessee River Valley. Detailed reviews of the sequence of occupation can be found in Walthall (1980) and Futato (1983). Precontact archaeological cultures in Alabama are usually divided into five temporal units: the Paleo-Indian Period, the Archaic Period, the Gulf Formational Period, the Woodland Period, and the Mississippian Period.

3.4.1.1 The Paleo-Indian Period

The Paleo-Indian Period extends from approximately 10,000 to 8000 B.C. In Alabama, it is the first human occupation and is characterized as having a low population density and mobile lifestyle. Typically, small bands of Native Americans were thought to follow large migratory herd animals such as mammoth, mastodon, and bison. Undisturbed Paleo-Indian sites are rare, but there is growing evidence that they exploited a diverse range of animals and plants available in the southeastern U.S. The climate during this time was transitioning from cool temperatures favoring boreal forests and abundant open grasslands to a warmer, humid climate favoring deciduous forests. Usually, given the great age of these sites, only stone tools remain as evidence of their transitory occupation of the Tennessee River Valley. Stone projectile points designated as Clovis, Cumberland, Quad, and Beaver Lake are often used to identify sites of this age. Nearby Paleo-Indian sites such as Quad and the Stanfield-Worley bluff shelter attest to the fact that north Alabama was home to the earliest humans in the Southeast.

3.4.1.2 Archaic Period

During the Archaic Period (8000 to 1000 B.C.), population is thought to have increased and mobility to have decreased. As a more modern environment developed, Native Americans practiced seasonal migration to take advantage of plant and animal resources available, but in smaller territories. This is most obvious at the many shell middens that are found adjacent to the Tennessee River. It is unlikely that any group settled permanently in these areas but returned seasonally or annually to exploit freshwater mussels. In addition to

mussels, archaic peoples exploited a wide variety of nuts, plants, fish, waterfowl, and terrestrial mammals. Stone tools are still the most obvious tool left behind to support these theories. The diversity of shapes and sizes of projectile points and knives increased during this period. This is seen in the variety of names used by archaeologist to put them into types (e.g., Kirk, Palmer, Eva, Morrow Mountain, Ledbetter, Pickwick, and Little Bear Creek points). Most were used at the end of large spears, but toward the end of this period, they became smaller and may have been on thin spears thrown with the use of an atlatl. The atlatl is a hooked stick that extends the length of the arm, thereby increasing the force of the throw. Ground stone tools in the shapes of adzes and axes from this period were also found. Archaic sites are more abundant than those established in the previous Paleo-Indian Period. Fortuitous discoveries on Little Bear Creek offer tools made of bone and antler, such as pins, beads, and awls. At the very end of the Archaic Period, early ceramic vessels in the shape of wide-mouth beakers were used.

3.4.1.3 The Gulf Formational Period

The Gulf Formational Period (2500 to 200 B.C.) overlaps the more commonly used Archaic Period. Walthall and Jenkins (1976) first identified the period by the arrival of fiber-tempered, slab-built ceramic vessels, probably from the Gulf and southern Atlantic coasts. Called “Wheeler” ceramics, they were first used in the project area around 1000 B.C. Most are plain, but punctuations, simple stamping, and dentate stamping of the exterior vessel surface are sometimes found on these items. Toward the end of this period, ceramics tended to be tempered with sand and built from coils of clay. These items, known as “Alexander” ceramics, can have elaborately decorated, punctuated, and incised exterior surfaces. The way Native Americans made their living during this period is similar to the latter part of the Archaic Period. This was a seasonal round of hunting terrestrial, aquatic, and avian creatures, while also gathering a wide variety of edible plants, berries, and nuts. Walthall (1980) asserts that during the latter part of this period, one begins to see evidence of trade between different regions. He points out that graves found in the Pickwick Reservoir have shell beads made from Gulf Coast marine creatures. Steatite and sandstone pipes from east central Alabama and copper beads that may have come from the upper Midwestern U.S. also provide evidence of trade.

3.4.1.4 The Woodland Period

The Woodland Period (200 B.C. to A.D. 900) is characterized by increasing population and sedentism (i.e., staying in one place). Much occurred during this period. Production of ceramics flourished with respect to size, shape, and decoration. Materials added to clay improved its workability. Firing characteristics shifted from fiber to sand, crushed limestone, and even crushed potsherds called “grog.” There is evidence that Native Americans began to domesticate native plants such as squash, goosefoot, sunflower, sumpweed, and maygrass during this period. These never reached the state of full intensive cultivation, but there is evidence that people were moving around in smaller territories and intensifying their use of plants and animals in their territory. They probably helped to propagate the plants that provided useful nutrition and fibers. Maize (corn) has occasionally been found in late Woodland Period sites but appears to be just one of a number of plant foods in the diet.

During the middle of the Woodland Period, intentional burials in or under earthen mounds were practiced. Sometimes the individuals buried in these mounds were accompanied with clearly ceremonial objects sometimes made from nonlocal raw materials like obsidian, raw copper, and Gulf coast marine shell. There was some differentiation among the people of the Woodland Period, as not everyone was buried with exotic artifacts. Perhaps individuals achieved higher social status through exceptional hunting skills or superior knowledge of the healing properties of plants. In north Alabama, this period is called “Copena,” and is

characterized by burial mounds, long-distance exchange, and differential distribution of ceremonial objects.

Toward the end of the Woodland Period, projectile points small enough to have been actual arrowheads are found. There have been some suggestions that the bow and arrow had as much to do with increasing conflict between Woodland communities as they were improvements in hunting technology. At the end of the Woodland Period, burials were not in earthen mounds, and rarely did objects made from exotic materials accompany the dead.

3.4.1.5 The Mississippian Period

Walthall (1980) defines the Mississippian Period in Alabama as lasting from A.D. 900 to 1500. Archaeological cultures attributed to the Mississippian Period stretch from the upper Midwest through the South. The Spiro site in Oklahoma is one of the westernmost manifestations, and the Town Creek site in North Carolina is one of the easternmost. In Alabama, the Moundville site along the Black Warrior River is the best known Mississippian center, but an equally large Mississippian center, Bottle Creek, is found in the swamplands of the Tensas River just north of Mobile, Alabama.

Characteristics common to most of these Mississippian manifestations are the development of high-quality, thin-walled ceramics using crushed shell as a tempering agent. Many of the utilitarian pots were plain, but others had complex incised designs on the exterior surface. Although most Mississippian sites are small villages adjacent to floodplain fields of corn, beans, and squash, this period is also characterized “by the construction on or around a central plaza, of large earthen platforms that served as substructures for temples, elite residences, and council buildings” (Walthall 1980). Native American population density seems to be at its greatest at this time, and intensive agriculture was practiced to support this population as well as an elite group devoted not to food production but to politico-religious governance of large territories. The production of nonfunctional objects for politico-religious ceremonies also reached a peak during this period. The similarity of symbols and objects at Mississippian centers throughout the East has given rise to the idea that there was a “Southeastern Ceremonial Cult.” The shared iconography includes stylized depictions of peregrine falcons, bilobed arrows, sun circles, and forked eye designs that are found on different raw materials such as marine conch shells, ceramic pots, stone statues, and ground stone objects such as axes. In the Southeastern U.S., the Mississippian Period represents the height of precontact Native American art, politics, ceremony, and functional technology.

Protohistoric and Contact Period

In the 17th and 18th centuries, early European-American accounts of the Muscle Shoals area indicate that it was an area used by the Creek, Chickasaw, and Cherokee tribes. Each group appears to have claimed it as hunting territory, and there is evidence of intertribal conflicts in the Tennessee Valley in north Alabama. Groups of Cherokee, lead by historically known individuals, such as Dragging Canoe and Doublehead, settled in this area after the American Revolution because of strife with American settlers in the upper Tennessee River Valley.

American settlers made attempts to claim Indian land in the late 1700s with mixed success. The organization of the Mississippi Territory in 1798 and the development of the Natchez Trace (just west of Muscle Shoals) into a wagon road increased pressures on native tribes to cede land to white settlers. The Treaty of 1816 granted the land in the Muscle Shoals area to the U.S. In the following 30 years, land speculation and failed settlement were common, but by the 1830s, Florence was successfully established north of the Tennessee

River and Tuscumbia south of the river. Much of the early commercial life of these towns was based upon river traffic and the low water rocky shoals that blocked the movement of large ships further up river. Canals and railroads provided some solutions, but by the 1850s, south Florence and Tuscumbia were major ports for the transport of cotton down river to Memphis and New Orleans.

Because of the strategic location of both rail and boat traffic in the Muscle Shoals area, it was a focus of conflict during the Civil War. In 1862 and 1863, there were frequent clashes between Union and Confederate forces trying to control railroad bridges and river harbors. In November 1864, Muscle Shoals was the crossing point of Stewart's Corps of Hood's Army of Tennessee as they retreated from Atlanta and sought to reclaim Middle Tennessee.

After the Civil War, Sheffield grew as a result of the development of the iron furnaces in this area. Rail access led to the development of other industries in the area, including a rolling mill, cotton oil factory, and meat packing plant. Sheffield was also the location of railroad shops for the Memphis and Charleston Railroad and, subsequently, the Southern Railway system. These facilities attracted other industries to the Florence area north of the river such as a stove foundry, sawmill, cotton press, and brewery. The FWW was begun on the north shore of the river on land still controlled by TVA; it operated successfully through World War I.

Although there were attempts to harness Muscle Shoals' hydroelectric potential in 1903, it was the advent of World War I that stimulated Congress and President Wilson to authorize the National Defense Act in 1916. This act called for the construction of nitrate plants to produce ammunition for the war effort. These plants were to be powered by hydroelectric dams. Muscle Shoals was chosen as the location of one of these dams and two production plants in 1917.

Originally, Wilson Dam was designed to provide power for the two nitrate plants, but its construction took four years. Therefore, a coal-fired steam plant was constructed on the river's edge just north of the USNP2. Construction of the dam, steam plant, and two nitrate plants required 25,000 to 30,000 laborers and engineers. Wilson Dam Village No. 2 was constructed south of the river within the MSR study area during 1918 to house and feed the large influx of workers. Descriptions in the *Florence Times* (presently the *Times Daily*) indicate that streets were laid out, and a sewer system was constructed. Residences in this village were segregated into white and black areas commensurate with the Jim Crow laws of Alabama at that time. Residences included single-family, duplex, barracks, and tent platforms (D'Angelo et al. 2007).

Recent Archaeological Research

There have been two large-scale cultural resource surveys on the MSR in the 21st century. The first, in 2002, was in response to a land use request from the surrounding municipalities of Muscle Shoals, Florence, Tuscumbia, and Sheffield for a permanent recreation easement for the development of the Robert Trent Jones Golf Course by the Retirement Systems of Alabama. This request was subsequently withdrawn.

This survey, conducted by TRC, covered approximately 1,087 acres of the Muscle Shoals/Wilson Dam Reservation located primarily north of Reservation Road and north of the Tennessee River (Pietak et al. 2002). One survey area, Tract IV, was south of Reservation Road in the southwestern portion of the Reservation (Pietak et al. 2002). As a result of this survey, the consultants recommended that most of the MSR study area be

designated as a historic district. Within the Muscle Shoals Historic District (MSHD), five historic contexts—a prehistoric mortuary complex, the Civil War, Wilson Dam (1916-1933), the New Deal (1933-1942), and TVA's development of Muscle Shoals after the New Deal (1942-1970)—were identified. The first two contexts, a prehistoric mortuary complex and the Civil War, include archaeological resources while the other contexts include aboveground architectural resources (i.e., buildings and structures). Because a large number of buildings and structures, as a whole, demonstrate significant historic events associated with the area, the MSHD was recognized by the Alabama SHPO in October 2007 as eligible for listing in the NRHP.

The archaeological survey identified 44 previously unrecorded sites and reidentified eight sites that were previously recorded. These sites included prehistoric mortuary sites, Civil War fortifications (e.g., pits, trenches, and earthworks), the foundation of the steam plant, Civilian Conservation Corps' (CCC) features, and ground-level features from Wilson Dam Village No. 2.

Three archaeological sites were identified in the 2002 TRC survey that fall within the APE for the current proposed action. Site 1CT331 had been previously recorded, but little was known about it. TRC encountered fragments of chert derived from stone tools mixed with construction materials from the aforementioned steam plant. TRC concluded that the upper portions of this site nearer the ground surface had been disturbed but that there could be undisturbed buried deposits. Formal deep excavations at this site were completed in February 2010, and site 1CT331 is smaller than first thought. After consultation with the Alabama SHPO, site 1CT331 has been determined ineligible for listing in the NRHP (Laird et al. 2010).

Site 1CT495 constitutes the visible remains of the coal-fired steam plant built to provide electricity to the USNP2. This plant was removed in 1968, and only small portions of the foundation remain. This site is considered a contributing element to the MSHD and, therefore, eligible for listing in the NRHP.

Site 1CT500 encompasses most of what remains of Wilson Dam Village No. 2. Pietak et al. (2002) notes most of the site as having "been subject to extensive surface disturbance, during the village's initial construction phase, during subsequent razing in the 1950s, as well as during more recent [pre-1966] power line and road construction." The report notes that the area is filled with debris, bush piles, and evidence of grading. However, some features, such as a road system, curbs, drains, fire hydrants, manholes, and partial foundations, remain. Although greatly disturbed, site 1CT500 is considered a contributing element of the MSHD and, therefore, eligible for listing in the NRHP.

In the summer of 2006, TRC undertook a cultural resources survey of the portions of the MSR study area not covered in the 2002 survey (D'Angelo et al. 2007). In this survey, approximately 1,040 acres were examined, primarily south of Reservation Road. In addition to verifying the boundaries of site 1CT500, the survey identified three additional sites, 1CT573, 1CT574, and 1CT575.

Site 1CT573 is a surface scatter of historic and modern trash. This site was determined to be ineligible for listing in the NRHP. Site 1CT574 is a 4,500-square-meter prehistoric lithic scatter that initially was considered potentially eligible. Subsequent formal excavations at this site revealed no intact cultural features or strata. Therefore, site 1CT574 has been determined ineligible for listing in the NRHP (D'Angelo 2009a). Site 1CT575 is composed of surface picnic or recreational features associated with the "Little Cuba" (segregated

African American) section of Wilson Village No. 2. Remaining features are a gravel road, the chimney and footings of a pavilion, foundations of a washroom, and barbeque pits (D'Angelo et al. 2007). This site is considered to be a contributing element of the larger MSHD and, therefore, eligible for listing in the NRHP.

TRC (D'Angelo et al. 2007) also noted the historic Murphy-Kemper-Cockburn Cemetery adjacent to Reservation Road. Although not eligible for listing in the NRHP, TRC advises avoidance of these graves. A cemetery associated with the Little Cuba Village was not identified during the 2006 survey. Subsequently, TVA personnel, using historic maps and pedestrian surveys, were able to identify multiple rectangular depressions on a hill in the Little Cuba area. Limited excavations verified that these are historic graves (D'Angelo 2009b). Nearby large depressions, however, turned out to be drainage features and a soil borrow area. Therefore, the longtime rumored mass burial graveyard site has not been found.

In summary, as a result of survey and testing in the MSR study area in the first decade of the 21st century, there remain three archaeological sites that are eligible for listing in the NRHP, sites 1CT495, 1CT500, and 1CT575. Sites 1CT500 and 1CT575 have been identified as the remains of Wilson Village No. 2 and show substantial disturbance. Site 1CT495 is the foundation remains of the coal-fired steam plant adjacent to the Tennessee River. These three sites are eligible for listing in the NRHP as contributing elements of the MSHD.

3.4.2 Architecture

Historic architectural resources within the proposed APE have been identified in previous TRC survey reports (Pietak et al. 2002; D'Angelo et al. 2007; D'Angelo 2009a, 2009b; and Laird et al. 2010). The 2002 research resulted in a recommendation for the development of the five previously described historic contexts (see Recent Archaeological Research above). As a part of the current TVA land disposal action, TVA exchanged correspondence and received a letter of concurrence from the Alabama SHPO on these and other reports in October 2007 (see Appendix K). TVA used these multiple reports and letters, along with more detailed information (Lord, Aeck, and Sargent Architecture 2009), during the preliminary consultation period with the Alabama SHPO.

There are 51 NRHP-eligible buildings and structures within the MSR study area, as well as a number of buildings and structures that are not eligible for listing in the NRHP. In 2007, TVA consulted with the Alabama SHPO, receiving concurrence on 21 buildings and structures that were determined to be ineligible for listing in the NRHP and ineligible as contributing elements to the MSHD. Since that time, TVA has removed these 21 noneligible and noncontributing buildings and structures.

In 2009, TVA commissioned the firm of Lord, Aeck, and Sargent Architecture to prepare an independent inventory and analysis of 45 of the NRHP-eligible buildings within the MSR study area. This study, titled *Muscle Shoals Reservation Adaptive Re-Use Study*, focused on the following:

- Existing architectural and structural conditions of each building and the flexibility of each building for uses other than its original function
- Viability of the buildings based on current and foreseeable market trends in the region

- Development of a draft concept plan illustrating examples of how the historic buildings might be reused in a larger redevelopment effort

As a result of the findings included in this study, TVA recommended four additional buildings (Table 3-5) as ineligible for listing in the NRHP. Therefore, 51 of the 92 buildings on the MSR study area have been determined eligible for listing in the NRHP.

Table 3-5. Additional Buildings and Structures Recommended by TVA as Not Eligible for Listing in the National Register of Historic Places and Not Contributing to the Muscle Shoals Historic District

Building Name	Building Number*	Approximate Square Footage*	Reason for Recommendation
Office Service Warehouse	134	41,896	Extensive alteration and loss of historic context
Substation No. 1	4	9,894	Extensive alteration and loss of historic context
Phosphate Development Works Warehouse	15	15,159	Loss of historic context
2A Nitrate House	86	9,711	Extensive alteration

*Source: Architectural and Historic Assessment, Lord, Aeck, and Sargent Architecture 2009

TVA used the data collected in the *Adaptive Re-Use Study* to further evaluate structural and architectural conditions, as well as the relative adaptability for reuse of each building considered in the study. The existing eligible aboveground properties within the APE are associated with the Wilson Dam, New Deal, and TVA contexts of the MSHD. These contexts are expressed as two dominant architectural types: Industrial Army Vernacular and New Deal/TVA. Considering the two significant architectural styles and periods of context, TVA recommended the exclusion of a portion of the extant aboveground properties from the Section 106 consultation due to the extent of deterioration of some buildings and structures. This exclusion would also apply to those buildings and structures that were not readily adaptable for uses other than their original function. See Section 4.4 for discussion of the results of the Section 106 consultation process for eligible buildings and structures.

Industrial Army Vernacular

The buildings associated with this architectural style comprise the remaining features of the original USNP2. Built in just over eight months during 1918, the plant was planned as a strategic production facility for munitions-grade nitrates, capable of producing over 100,000 tons of ammonium nitrate per year. The Air Nitrates Corporation oversaw the design and construction of 73 buildings, 2,165 temporary buildings, and 190 structures during the accelerated construction schedule. The design and use of materials suggest the expediency with which USNP2 was constructed. Most of the facilities were designed and built by the largest subcontractor, Westinghouse, Church, Kerr, and Company (WCK) of New York. Only a small portion of the buildings and structures were dedicated to the production of ammonium nitrate. Most were used in support of the production facility and included permanent and temporary housing and barracks, medical facilities, dining halls, storage, washrooms, dry goods markets, and entertainment facilities. The extant WCK buildings have the following character-defining features:

- Rectangular massing
- Low slope roofs with monitor and clerestory

- Exposed structural steel columns
- Hollow clay tile masonry units with brick quoins
- Hopper windows
- Precast concrete sills and lintels

The buildings are oriented on a defined axis from north to south, as was the production of materials when the plant was operational. The general arrangement of USNP2 is shown in Figure 3-13. Photographs of general arrangement/fenestration and details of materials are shown in Figures 3-14 through 3-17. These buildings are eligible for listing in the NRHP under Criterion A as a building complex and as a contributing element to the MSHD. Table 3-6 includes a listing of the industrial army vernacular buildings that make up the USNP2 Complex.

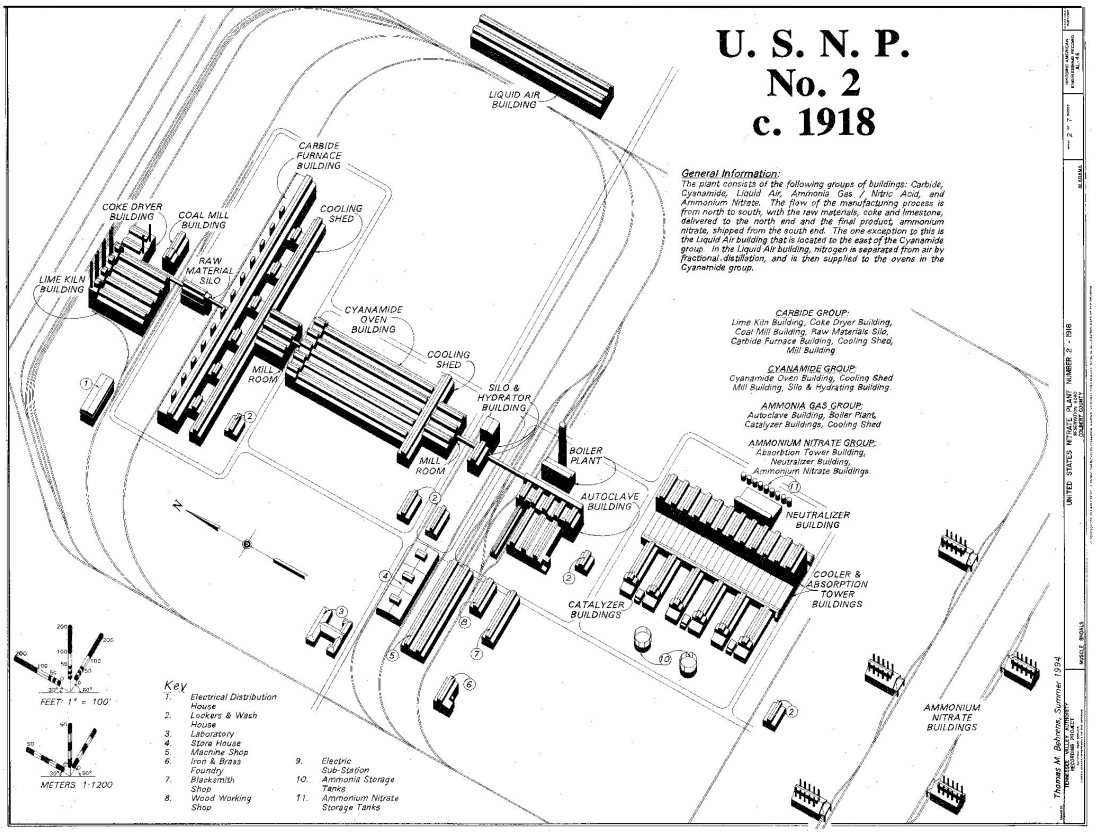


Figure 3-13. Orientation and Arrangement of Original National Fertilizer Development Center (USNP2) Facilities, ca. 1918

Photograph taken by: Jon Riley, April 2009

Figure 3-14. Example of Precast Sills/Lintels and Hopper Windows in Catalyzer Building No. 5

Photograph taken by: Jon Riley, April 2009

Figure 3-15. Example of Hollow Clay Tile Masonry and Brick Quoins in the Raw Materials Lab

Photograph taken by: Jon Riley, April 2009

Figure 3-16. Example of Precast Sills/Lintels in the Raw Materials Lab

Photograph taken by: Jon Riley, April 2009

Figure 3-17. Example of Monitor Roof With Clerestory in the Nitrate House No. 5

Table 3-6. Extant Buildings and Structures Representing the Industrial Army Vernacular Style

Building Name	Building Number	Approximate Area (square feet)
Old Filtration Building	1C	6,524
Reservoir Pumping Station	1D	5,342
Drum Storage Area Building	5	2,174
Raw Material Lab	6	3,711
Power Service Shop No. 2	16	59,878
Lime and Nitrogen Building	22	131,749
Project Operations Office	25	7,029
Chemical Plant Warehouse	33	37,849
Machine Shop	37	42,554
Engineering Lab	39	18,007
Sheet Metal Shop	41	6,622
Pipe Shop	42	10,933
Project Operations Bath House	44	12,370
Pilot Plant Building	47	14,895
Paint Storage Building	48	606
Autoclave Building	50	15,693
Tin Shop	53	4,718
Lime and Nitrogen Hydrating Building	54	1,228
Boiler House and Stack	56	4,305
Substation No. 2	57	996
Substation No. 4	68	1,352
Catalyzer Building No. 1	69	10,827
Catalyzer Building No. 2	70	11,546
Catalyzer Building No. 3	71	11,103
Catalyzer Building No. 4	72	11,099
Catalyzer Building No. 5	73	11,165
Catalyzer Building No. 6	74	10,999
Substation No. 5	72A	1,446
Substation No. 6	74A	1,446
Nitric Acid Tanks (2 tanks)	76	N/A
3A Nitrate House	79	9,397
5A Nitrate House	81	8,594
Cuba Yard Railroad Scales	93	N/A
Greenhouse Complex (eight individual buildings and structures)	118	7,917
Flume, Water Plant	N/A	N/A
Sidewalks	N/A	N/A
Narrow Gauge Rail System	N/A	N/A
Bus Bar Terminal	N/A	N/A

Source: Architectural and Historic Assessment, Lord, Aeck, and Sargent Architecture 2009

New Deal and TVA

The World War I armistice was signed shortly after partial testing of the USNP2 facility was begun, and the future of the plant was uncertain. It was not until 1933 at the signing of the TVA Act that the USNP2 began operating near its full capacity. During the massive mobilization and construction period that followed the creation of TVA, the TVA Board of Directors recruited Hungarian-born Roland Wank as chief architect. Wank had only been in the U.S. for around nine years when TVA was created, but during that time, he had enjoyed success at the architectural firm of Fellheimer and Wagner. Employing a design philosophy borrowing heavily from art deco and international styles, Wank immediately had an impact on design and construction at TVA. Although he left TVA to return to private practice in 1944, his influence remained through contract design work for TVA, specifically at the Reservation through conceptual designs for water plant facilities, medical facilities, and the ERC.

The eligible buildings associated with this architectural style exhibit strong design elements from the international style, which was popular during the early part of the 20th century, including:

- Linear, rectangular massing
- Flat roof (see Figure 3-18)
- Asymmetrical façade (see Figure 3-19)
- Windows set flush with outer walls (see Figure 3-18)
- Precast concrete window surrounds

These buildings are located immediately to the west of the USNP2 site. These buildings are eligible for listing in the NRHP under Criteria A and C as a building complex and as contributing elements to the MSHD (Table 3-7). The ERC Building is individually eligible for listing in the NRHP under Criterion B. An additional explanation of the ERC's historical significance is contained in Appendix L (Ezzell 2008).

Photograph taken by: Jon Riley, April 2009

Figure 3-18. Example of Flat Roof, Flush Windows of the Old Medical Building

Photograph taken by: Jon Riley, February 2009

Figure 3-19. Example of Asymmetrical Façade of the Environmental Research Center Building

Table 3-7. Extant Buildings and Structures Representing the New Deal and TVA Style

Building Name	Building Number	Approximate Area (square feet)
Chemical Feed House	1A	1,967
Filter Building	1B	3,721
Environmental Research Center Building	17A	69,137
Service Building	17B	21,269
Old Medical Building	21	7,561

Source: Architectural and Historic Assessment, Lord, Aeck, and Sargent Architecture 2009

3.5 Socioeconomic Resources

3.5.1 Regional Overview

The MSR study area is located in Colbert County, Alabama. The 2009 population of Colbert County is estimated to be 54,639 (see Table 3-8). Colbert and Lauderdale counties, adjacent and north of the Tennessee River, form the Florence-Muscle Shoals, Alabama Metropolitan Statistical Area (MSA). For purposes of this study, the MSA and other counties adjacent to Colbert County are considered a part of the potential impact area, along with Limestone County, Alabama, due to its proximity and relatively easy access to the MSR. So defined, the impact area consists of the following counties where the socioeconomic effects of the potential MSR redevelopment would likely be realized:

- Colbert, Alabama
- Lauderdale, Alabama
- Franklin, Alabama
- Lawrence, Alabama
- Limestone, Alabama
- Tishomingo, Mississippi

The estimated 2009 population of the impact area is 307,041 (Table 3-8). Population trends suggest that the population of Colbert County is likely to be about 57,000 and the impact area about 336,000 by the year 2020.

Table 3-8. Population and Economic Characteristics

	Colbert County	Impact Area	Alabama	United States
Population				
Estimate, 2009	54,639	307,041	4,708,708	307,006,550
Projection, 2020	57,010	335,768	5,115,863	341,509,922
Employment and Income, 2008				
Total Employment	30,511	151,858	2,640,717	181,755,100
Farm (%)	2.4	4.4	1.9	1.5
Manufacturing (%)	13.2	13.3	11.1	7.8
Per Capita Personal Income	$29,314	$29,544	$33,655	$40,166

Sources: U.S. Census Bureau (http://factfinder.census.gov/home/saff/main.html?_lang=en); U.S. Bureau of Economic Analysis (http://www.bea.gov/regional/reis/); population projections are linear trend, 1990-2009

Both farming and manufacturing account for a larger share of employment in the area than the Alabama and national averages (Table 3-8). Farming accounts for 2.4 percent of total employment in Colbert County and 4.4 percent in the impact area, compared to 1.9 percent statewide and 1.5 percent nationally. Manufacturing accounts for 13.2 percent of the total in Colbert County and 13.3 percent in the impact area, compared to 11.1 percent statewide and 7.8 percent nationally.

Average income levels in Colbert County and in the impact area are lower than the Alabama and national levels (Table 3-8). In 2008, per capita personal income in Colbert County was $29,314, which is slightly lower than the impact area average of $29,544 and noticeably lower than the Alabama average of $33,655 and the national average of $40,166.

3.5.2 Study Area Population

The MSR study area is generally bounded by Hatch Boulevard, Second Street, Wilson Dam Road (SR 133), and Reservation Road (see Figure 1-2). The entire site is included in Census Tract 207.01, Block Group 1. This block group had a total population of 681 (U.S. Census Bureau 2000). None of this population, however, is within the Reservation boundaries. The population in this block group is largely located in the area near the Tennessee River to the northeast of the MSR study area, east of Wilson Dam Road (SR 133). None of the blocks directly north of the site in Colbert County are populated.

The Reservation is bordered by other parts of Census Tract 207.01 to the north, east, and west, and by Census Tract 207.02 to the south. It is close to Census Tract 201 to the west and northwest. The areas adjacent to the site on the south and nearby to the west and northwest are densely populated enough to be considered part of the Florence Urban Area. Nearby areas to the west include parts of Census Tract 207.01, Block Group 1. Areas along and near the northern boundary are also in Census Tract 207.01, Block Group 1. Census Tract 207.01, Block Groups 1 and 2, adjoin the eastern boundary of the site. Along the southern boundary, the site adjoins Census Tract 207.02, Block Groups 2 and 3. Census Tract 207.02, Block 1000, lies immediately southwest of the site. Population, as of the 2000 Census of Population, is shown in Table 3-9 for populated blocks around the site.

Table 3-9. Population, Blocks Adjacent to Muscle Shoals Reservation Site, 2000*

Direction From Site	Census Tract	Block	Total Population
West	207.01	1000	4
East	207.01	2035	57
East	207.01	2053	5
East	207.01	2055	2
East	207.01	2057	30
East	207.01	2058	23
East	207.01	2059	17
East	207.01	2061	23
South	207.02	2018	9
South	207.02	3005	6
South	207.02	3006	24
South	207.02	3007	1
South	207.02	3009	152
South	207.02	3013	9
South	207.02	3024	11
South	207.02	3025	5
South	207.02	3027	69
South	207.02	3028	69
South	207.02	3029	39
South	207.02	3030	98
Southwest	207.02	1000	9

*Unpopulated blocks are not listed. Source: U.S. Census Bureau, Census of Population, 2000 (http://factfinder.census.gov/servlet/DatasetMainPageServlet?_program=DEC&_submenuId=datasets_1&_lang=en)

3.5.3 Potential Development Sites

Several sites in the Shoals area (Colbert and Lauderdale counties) are currently available for industrial development purposes, most of which include existing buildings with relatively small acreage (http://www.tvaed.com/solutions.htm). There are presently five known sites in these two counties with at least 200 acres each of land available. The partially developed Barton industrial site in western Colbert County (see Section 1.6) is among these sites. The largest of these, however, would provide only about 300 contiguous acres. To the east, Lawrence County has three relatively large sites available for industrial use. The largest available tract is Alabama Highway 20-Mallard-Fox Industrial Park West, which offers up to 1,251 acres. The Lawrence County Road 150-Courtland Hood Harris and the Alabama Highway 20-Lawrence Industrial Airpark sites offer about 1,000 acres and 500 acres, respectively. However, neither of the latter two sites has rail access. Somewhat farther away, roughly 40 miles from Colbert County, Limestone County has several large sites including Alabama's first certified automotive megasite (2,010 acres) near Interstate 65 just west of Huntsville.

The MSR study area includes approximately 1,400 acres, with the capability of providing much larger sites than are currently available elsewhere in Colbert County. Norfolk Southern Corporation provides rail access to Tuscumbia, Muscle Shoals, and Sheffield with yards and spur lines servicing local nearby businesses including the Occidental Chemical facilities just east of Wilson Dam Road. An additional short spur line could be constructed to enhance the MSR infrastructure. The MSR study area could be used for one or a few relatively large employers, or for a cluster of related facilities.

Based on TVA staff observations of the current land use, economic activity, and presence of vacant or undeveloped property in the Muscle Shoals community and Colbert County

area, there appears to be ample land and market incentives (Lord, Aeck, and Sargent Architecture 2009) to attract and accommodate new or expanded commercial, retail, and residential development. Such development, which typically can occur on less acreage than required for industrial sites, could increase urban sprawl and reduce opportunities for economic development if located on the MSR study area. Development on the MSR study area could be better planned and controlled through implementation of the anticipated Master Plan and, thus, potentially be more attractive to new tenants and customers. Given the amount of public land along the Tennessee River including parks and recreation lands, the amount of conservation land appears relatively stable and would likely remain available for such use in the foreseeable future. This includes such land on the MSR north of Reservation Road.

3.5.4 In-lieu-of-Tax Payments

TVA pays annual in-lieu-of-tax payments to the Tennessee Valley states, including Alabama, based, in part, on the value of its power properties in the state. The State of Alabama, under state law, then redistributes most of its receipts to the counties and municipalities served by TVA, including Colbert County and its municipalities, based on the value of all TVA power properties in Colbert County, including Colbert Fossil Plant and power properties on the MSR study area. The value of power assets associated with the MSR is small, less than one-half of 1 percent of the value of TVA power assets in the county. If the MSR study area is transferred from federal ownership, it would then be subject to annexation and taxation by local governments.

3.6 Environmental Justice

Executive Order (EO) 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations*, provides that certain federal agencies make the achievement of environmental justice a part of its mission “to the greatest extent practicable and permitted by law.” Pursuant to the EO, these agencies must determine whether their activities will have adverse human health or environmental effects on minority and low-income populations. As a matter of policy, TVA typically addresses environmental justice issues in its NEPA reviews. A part of this process includes involvement of a broad scope of people potentially affected by a federal action in the public involvement and agency decision-making process.

TVA conducted public scoping and informed people in the Shoals community of its land disposal and redevelopment proposal during summer 2009. Following notification in the area of the proposed action, a public meeting was held at Muscle Shoals High School on July 14, 2009. In addition, a 48-day comment period was made available from June 18, 2009, to August 5, 2009. Interested parties were encouraged to provide input via phone, letter, e-mail, or the Internet. Comments were considered and summarized in a final Scoping Report in December 2009, which was posted on the project Web site (see Section 1.5.2). See Section 1.4 for a description of the NEPA Process and Section 1.5.3 for a discussion of further public involvement in the draft EIS review process. TVA has considered all input from persons or groups regardless of race, income status, or other social and economic characteristics.

Minority and Low-Income Populations

Minority populations are a relatively low share of the total in Colbert County as well as in the impact area (e.g., Colbert, Lauderdale, Franklin, Lawrence, and Limestone counties, Alabama, and Tishomingo County, Mississippi). In Colbert County, the estimated minority population share in 2009 was 19.9 percent of the total, well below the 32.0 percent in Alabama and the 34.9 percent nationally. The impact area, considered to be the same as that defined for the socioeconomic analysis in Section 3.5.1, as a whole has a minority share of 17.8 percent, somewhat lower than Colbert County (Table 3-10).

The poverty level in Colbert County is lower than the state average and the impact area as a whole and just slightly lower than the national level. For 2008, the poverty level in Colbert County is estimated to be 12.7 percent of the population, compared to 15.2 percent in the impact area and 15.9 percent in Alabama. Those below the poverty level nationally made up 13.2 percent of the population in 2008 (see Table 3-10).

Table 3-10. Minority and Low-income Populations

	Colbert County	Impact Area	Alabama	United States
Minority Population (%), 2009	19.9	17.8	32.0	34.9
Below Poverty Level (%), 2008	12.7	15.2	15.9	13.2

Source: U.S. Census Bureau 2009a and 2009b

The MSR study area is in Census Tract 207.01, Block Group 1, parts of which also border it on the north and the west. It is bordered on the east by Tract 207.01, Block Group 2, and on the south by Tract 207.02. As of the 2000 Census of Population, Census Tract 207.01 had a minority population of 996, 16.8 percent of the total population of 5,918 (see Table 3-11). In Census Tract 207.02, minority population was 1,524, about 16.9 percent of the total population of 9,019. In blocks immediately around the site, minority populations were less than other populations (about 11.6 percent of total population), as was the total population of 662. Minority population shares in the local area in 2000 were well below the state and national levels of 29.7 and 30.9 percent, respectively, and slightly below the county level of 19.1 percent.

Table 3-11. Minority and Low-Income Populations in Areas Adjacent to the Muscle Shoals Reservation Site, 2000

Population Area	Total Population	Percent Below Poverty Level	Minority Population	Percent Minority
West of Site				
CT 207.01	5,918	11.7	996	16.8
BG 1	681	18.0	44	6.5
Block:				
1000	4	-	0	0.0
East of Site				
CT 207.01	5,918	11.7	996	16.8
BG 2	1,150	25.3	535	46.5
Blocks:				
2035	57	-	23	40.4

Population Area	Total Population	Percent Below Poverty Level	Minority Population	Percent Minority
2053	5	-	5	100.0
2055	2	-	0	0.0
2057	30	-	9	30.0
2058	23	-	0	0.0
2059	17	-	0	0.0
2061	23	-	0	0.0
South of Site				
CT 207.02	9,019	6.1	1,524	16.9
BG 2	1,436	3.7	314	21.9
Blocks:				
2018	9	-	0	0.0
BG 3	3,169	5.1	622	19.6
Blocks:				
3005	6	-	0	0.0
3006	24	-	0	0.0
3007	1	-	0	0.0
3009	152	-	9	5.9
3013	9	-	9	100.0
3024	11	-	6	54.5
3025	5	-	2	40.0
3027	69	-	2	2.9
3028	69	-	1	1.4
3029	39	-	0	0.0
3030	98	-	11	11.2
Southwest of Site				
CT 207.02	9,019	6.1	1,524	16.9
BG 1	1,021	10.6	118	11.6
Block:				
1000	9	-	0	0.0
Total, Adjacent Blocks	662	-	77	11.6

- = Not available
CT = Census tract
BG = Block group

Overall, the area around the site has relatively low poverty levels, as of the 2000 Census of Population. Census Tracts 207.01 and 207.02 had relatively low poverty levels of 11.7 percent and 6.1 percent, respectively. These were lower than the county level at that time of 14.0 percent, the state level of 16.1 percent, and the national level of 12.4 percent. Among the block groups around the site, Census Tract 207.01, Block Groups 1 and 2, had higher poverty rates of 18.0 and 25.3 percent, respectively. However, Census Tract 207.02, Block Groups 2 and 3, had much lower poverty levels of 3.7 and 5.1 percent, respectively (see Table 3-11). (Poverty data are not available for individual blocks.)

3.7 Land Use

Land use/land cover of the MSR study area was determined from aerial photography flown in March 2010 and geographic information system analyses (Figures 3-20 and 3-21). About 12 percent of the study area is developed, and over 60 percent is vegetated. Wetlands cover approximately 12 percent of the land area, including almost 3 acres of man-made wetlands constructed for experimental projects over the years. Pasture and hay land accounts for nearly 12 percent of the land use, with ponds or other open water covering close to 2 percent of the land. Most of the barren land is the phosphate slag storage area on the northern side of Reservation Road. Approximately 182 acres of land in the MSR study area, classified as grassland/herbaceous or pasture/hay, are included in TVA's agricultural land use licensing program. These tracts are licensed for local agribusiness production (see Section 3.9).

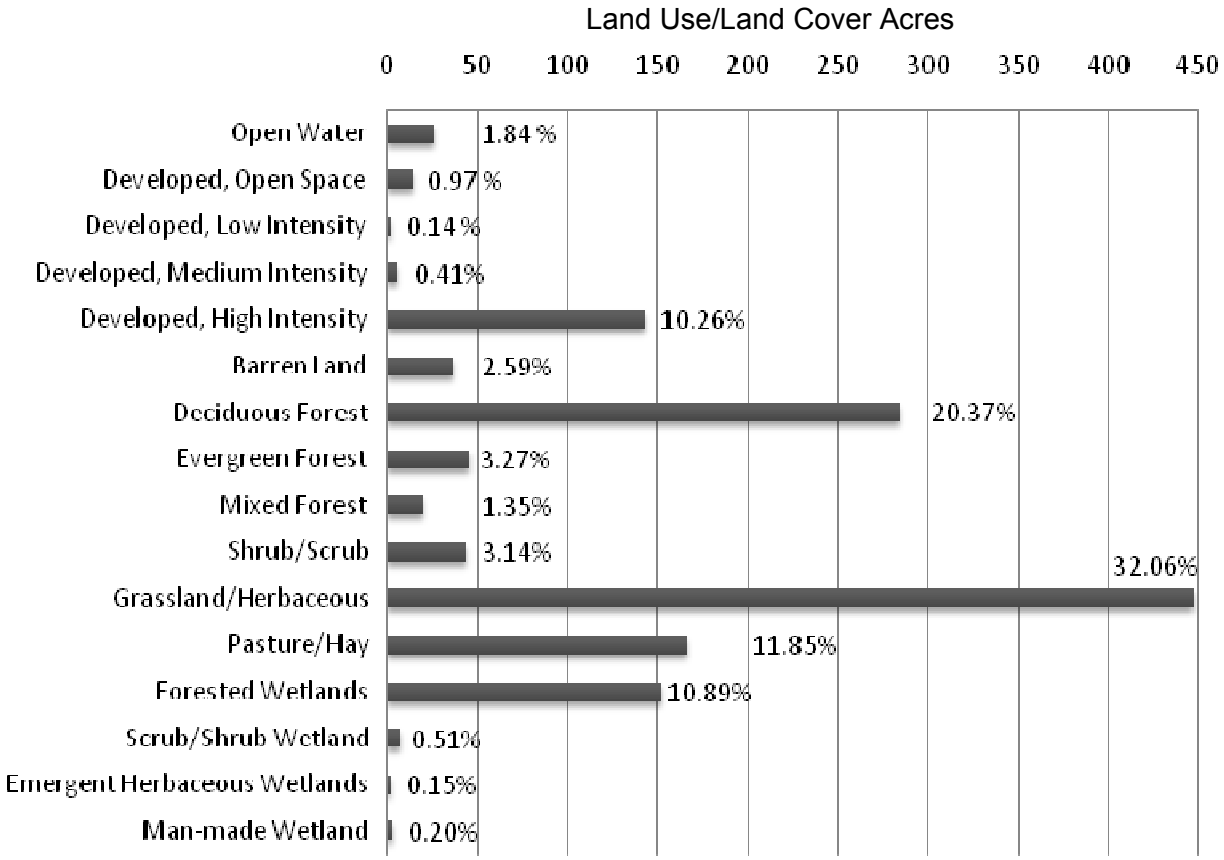


Figure 3-20. Land Use/Land Cover Acreage and Percent of the Muscle Shoals Reservation Study Area

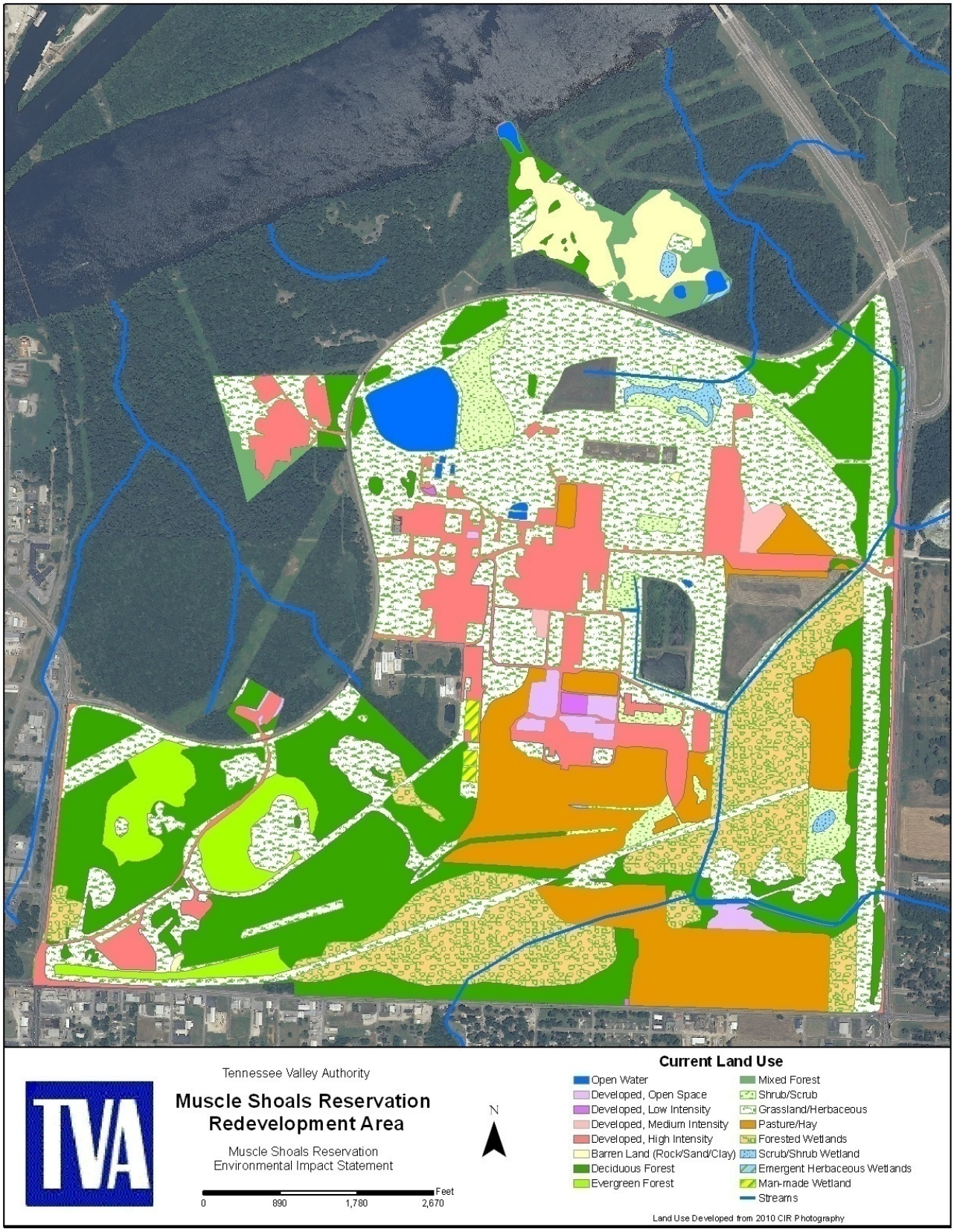


Figure 3-21. Land Use for the Muscle Shoals Reservation Study Area

An estimated 64 acres of four monitored SWMUs are present on the MSR study area, and these four areas would be retained by TVA. These areas were impacted by the disposal of waste material from past operations. These areas are classified as approximately 76 percent undeveloped, containing forest, scrub-shrub, and grassland, and 17 percent developed, including some maintained grassy open areas. The remaining 7 percent of this land is divided among pasture/hay, ponds, forested wetlands, and barren areas.

The City of Muscle Shoals' zoning of lands adjacent to the eastern boundary of the MSR study area is mostly heavy industrial, bounded by some residential parcels on the north and south. The primary occupant of the industrial area is Occidental Chemical Corporation, manufacturer of alkalis and chlorine (USEPA 2010). The Muscle Shoals Wastewater Plant is located across the street from the southern boundary of the study area. This narrow strip along Second Street is dominated by general business zoning, with about 16 parcels zoned for mobile homes. South of this business district is a large residential area that includes single-family homes and apartments.

The city of Sheffield is situated on the western side of the MSR study area, north of the city of Muscle Shoals. All the area adjacent to the MSR study area is zoned as general business.

The MSR study area is not currently within the corporate limits of any of the surrounding cities and not zoned by them. Development within the MSR study area would offer no known conflicts with any plans, programs, or activities of the Shoals Economic Development Authority, Northwest Alabama Council of Local Governments, Top of Alabama Regional Council of Governments, or any other similar county-level planning or economic development organizations. TVA is working with the newly formed NACD, comprised of representatives from the cities of Florence, Muscle Shoals, Sheffield, and Tuscumbia, and Colbert and Lauderdale counties, on this potential land disposal and redevelopment project.

3.8 Air Quality, Greenhouse Gas Emissions, and Global Climate Change

3.8.1 Air Quality

Through its passage of the Clean Air Act (CAA), Congress has mandated the protection and enhancement of our nation's air resources. National Ambient Air Quality Standards (NAAQS) establish concentration limits in the ambient air for the following criteria pollutants to protect the public health and welfare:

- Sulfur dioxide (SO_2)
- Ozone (O_3)
- Nitrogen dioxide (NO_2)
- Particulate matter whose particles are less than or equal to 10 micrometers (PM_{10})
- Particulate matter whose particles are less than or equal to 2.5 micrometers ($PM_{2.5}$)
- Carbon monoxide (CO)
- Lead (Pb)

The primary NAAQS were promulgated to protect public health, and the secondary NAAQS were established to protect the public welfare from any known or anticipated adverse effects associated with the presence of pollutants in the ambient air. A listing of the NAAQS is presented in Table 3-12. Areas in violation of the NAAQS are designated as nonattainment areas. Any new sources of air pollution to be located in or near these areas may be subject to more stringent air permitting requirements than are new sources in attainment areas. The USEPA promulgated new, more restrictive standards for particulate matter in 2006 and for 8-hour O_3 in 2008 (USEPA 2008a). In 2009, USEPA issued its "endangerment finding" that GHGs such as carbon dioxide (CO_2) contribute to air pollution that may endanger public health and welfare. This endangerment finding compelled USEPA to issue GHG emission standards for new motor vehicles, which in turn had the effect of making GHGs subject to air permitting requirements, effective January 2, 2011. USEPA will phase in the permitting requirements for emissions of GHGs from stationary sources in at least three phases.

The feasibility of new development at the MSR study area may be affected by several air quality considerations. One of the factors is regulatory status or attainment of air quality standards. Sources locating in clean air areas are subject to the Prevention of Significant Deterioration (PSD) New Source Review (NSR) rules, whereas those locating in or affecting areas failing to attain air quality standards must comply with nonattainment NSR rules. An overriding constraint in either NSR program is that no source of air pollution may cause or significantly contribute to a violation of an ambient air quality standard. The MSR study area is not presently subject to nonattainment NSR analysis because the site is not currently located in a nonattainment area for any of the criteria pollutants. The only nearby current nonattainment area is the Birmingham area, where Jefferson, Shelby, and Walker counties are in partial nonattainment for $PM_{2.5}$. However, USEPA's proposal to decrease the 8-hour "primary" O_3 standard to a level within the range of 0.060-0.070 ppm, or any future tightening of air quality standards, could impact the Shoals area.

PSD regulations restrict the increment by which ambient pollutant levels may increase due to emissions from major new sources, or the modification of existing sources, and require the use of best available control technology on such sources. PSD regulations include protection of national parks and wilderness areas that are designated as PSD Class I air quality areas. A new or expanding major air pollutant source (i.e., the generator of the pollutant) is required to estimate the potential impact of its emissions on the air quality of any nearby Class I area, as specified by the state or local air regulatory agency, with input from the federal land manager(s) having jurisdiction over the given Class I area(s). The closest PSD Class I areas are the Sipsey Wilderness Area in Alabama (about 50 miles away) and the Cohutta Wilderness Area in Georgia (about 230 miles away) (USEPA 2009a). Generally, dispersion modeling is required to demonstrate that pollution levels would not increase beyond the allowable increments. For the site considered in this EIS, ambient air quality data necessary for PSD analysis purposes are available.

The air quality in the vicinity of the MSR study area is generally good. Table 3-13 shows the results of ambient air quality monitoring of criteria pollutants that are considered representative of the site. Colbert County is currently in attainment for all criteria pollutants.

Table 3-12. National Ambient Air Quality Standards

Pollutant	Primary Standards[a]		Secondary Standards[b]	
	Level	Averaging Time	Level	Averaging Time
Carbon Monoxide (CO)	9 ppm (10 mg/m^3)	8-hour [1]	None	
	35 ppm (40 mg/m^3)	1-hour [1]		
Lead (Pb)	0.15 µg/m^3 [2]	Rolling 3-Month Average	Same as Primary	
	1.5 µg/m^3	Quarterly Average	Same as Primary	
Nitrogen Dioxide (NO_2)	53 ppb [3]	Annual (Arithmetic Average)	Same as Primary	
	100 ppb	1-hour [4]	None	
Particulate Matter (PM_{10})	150 µg/m^3	24-hour [5]	Same as Primary	
Particulate Matter ($PM_{2.5}$)	15.0 µg/m^3	Annual [6] (Arithmetic Average)	Same as Primary	
	35 µg/m^3	24-hour [7]	Same as Primary	
Ozone (O_3)	0.075 ppm (2008 standard)	8-hour [8]	Same as Primary	
	0.08 ppm (1997 standard)	8-hour [9]	Same as Primary	
	0.12 ppm	1-hour [10]	Same as Primary	
Sulfur Dioxide (SO_2)	0.03 ppm	Annual (Arithmetic Average)	0.5 ppm	3-hour [1]
	0.14 ppm	24-hour [1]		
	75 ppb [11]	1-hour	None	

Source: USEPA 2011
ppm = parts per million
ppb = parts per billion
mg/m^3 = milligrams per cubic meter
µg/m^3 = micrograms per cubic meter
[a] Standards set to protect public health
[b] Standards set to protect public welfare
[1] Not to be exceeded more than once per year
[2] Final rule signed October 15, 2008
[3] The official level of the annual NO_2 standard is 0.053 ppm, equal to 53 ppb, which is shown here for the purpose of clearer comparison to the 1-hour standard
[4] To attain this standard, the 3-year average of the 98th percentile of the daily maximum 1-hour average at each monitor within an area must not exceed 100 ppb (effective January 22, 2010).
[5] Not to be exceeded more than once per year on average over 3 years.
[6] To attain this standard, the 3-year average of the weighted annual mean $PM_{2.5}$ concentrations from single or multiple community-oriented monitors must not exceed 15.0 µg/m^3.
[7] To attain this standard, the 3-year average of the 98th percentile of 24-hour concentrations at each population-oriented monitor within an area must not exceed 35 µg/m^3 (effective December 17, 2006).
[8] To attain this standard, the 3-year average of the fourth-highest daily maximum 8-hour average ozone concentrations measured at each monitor within an area over each year must not exceed 0.075 ppm (effective May 27, 2008).
[9] (a) To attain this standard, the 3-year average of the fourth-highest daily maximum 8-hour average ozone concentrations measured at each monitor within an area over each year must not exceed 0.08 ppm.
(b) The 1997 standard—and the implementation rules for that standard—will remain in place for implementation purposes as USEPA undertakes rulemaking to address the transition from the 1997 ozone standard to the 2008 ozone standard.
(c) USEPA is in the process of reconsidering these standards (set in March 2008).
[10] (a) USEPA revoked the 1-hour ozone standard in all areas, although some areas have continuing obligations under that standard ("anti-backsliding").
(b) The standard is attained when the expected number of days per calendar year with maximum hourly average concentrations above 0.12 ppm is $\leq$1.
[11] Final rule signed June 2, 2010. To attain this standard, the 3-year average of the 99th percentile of the daily maximum 1-hour average at each monitor within an area must not exceed 75 ppb.

Table 3-13. Ambient Concentrations of Criteria Air Pollutants in the Vicinity of the MSR Study Area Compared With Air Quality Standards

Pollutant	Level of Standard (ppm)[a]	One-Year Maximum or Mean	
		Concentration (ppm)[a]	Percent of Standard
O_3 (New Standard)	4th Highest 8-hour average (0.075)	0.062[c]	83
SO_2	Maximum 3-hour average (0.5)	0.036[b]	7
	Maximum 24-hour average (0.14)	0.007[b]	5
	Annual mean (0.030)	0.002[b]	7
NO_2	Annual mean (0.053)	0.006[d]	11
CO	Maximum 1-hour average (35)	8.7[e]	25
	Maximum 8-hour average (9)	2.6[e]	29
PM_{10} (Old Standard)	Maximum 24-hour average (150 µg/m^3)	34(µg/m^3) [g]	23
$PM_{2.5}$ (New standard)	Annual average (15 µg/m^3)	9.14 (µg/m^3) [f]	61
	24-hour average (35 µg/m^3)	21.3 (µg/m^3) [f]	61
Pb	Quarterly mean (1.5 µg/m^3)	0.0193 (µg/m^3) [h]	1

[a] - ppm unless otherwise noted
[b] - SO_2 values for Colbert Fossil Plant, Colbert County, Alabama, 2007
[c] - O_3 values for Muscle Shoals, Colbert County, Alabama, 2009
[d] - NO_2 values for Muscle Shoals, Colbert County, Alabama, 2002
[e] - CO values for Birmingham, Jefferson County, Alabama, 2009
[f] - $PM_{2.5}$ values for Muscle Shoals, Colbert County, Alabama, 2009
[g] - PM_{10} values for Huntsville, Madison County, Alabama, 2009
[h] - Pb value for Birmingham, Jefferson County, Alabama, 2006

3.8.2 Greenhouse Gas Emissions and Global Climate Change

Relationship of Greenhouse Gases and Global Climate Change

GCC and its relationship to GHGs is an item of intense international study as well as of importance to TVA. In common usage, “global warming” often refers to the warming of the earth that can occur as a result of emissions of GHGs to the atmosphere. Global warming can occur from a variety of both natural and man-made causes. “Climate change” refers to any substantive change in measures of climate, such as temperature, precipitation, or wind. The two terms are often used interchangeably, but climate change is broader as it conveys that there are other changes in addition to rising temperatures.

Certain substances present in the atmosphere act like the glass in a greenhouse to retain a portion of the heat that is radiated from the surface of the earth. The common term for this phenomenon is the “greenhouse effect,” and it is essential for sustaining life on earth. Both man-made and natural processes produce GHGs. Water vapor and, to a lesser extent, water droplets in the atmosphere are responsible for 90 to 95 percent of the greenhouse effect. The most abundant long-lived GHGs are CO_2, methane (CH_4), and nitrous oxide (N_2O). Several classes of halogenated substances that contain fluorine, chlorine, or bromine are also GHGs. However, for the most part, they are solely a product of industrial activities. According to numerous sources, increases in the earth’s average surface temperatures are linked in part to increasing concentrations of GHGs, particularly CO_2, in the atmosphere. This has been a cause for concern among scientists and policymakers. This phenomenon has been studied internationally since 1992 by the United Nations Framework Convention on Climate Change, Intergovernmental Panel on Climate Change (IPCC).

The global carbon cycle is made up of large carbon sources and sinks. Billions of tons of carbon in the form of CO_2 are absorbed by oceans and living biomass (i.e., carbon sinks) and are emitted to the atmosphere annually through natural and man-made processes. According to the IPCC (2007), since the Industrial Revolution (i.e., about 1750), global atmospheric concentrations of CO_2 have risen about 36 percent, principally due to fossil fuel use.

Greenhouse Gas Emissions

The primary GHG emitted by human activity is CO_2 produced by the combustion of coal and other fossil fuels. Coal- and gas-fired electric power plants and automobiles are major sources of CO_2 emissions in the U.S. (U.S. Energy Information Administration 2009). Other important sources include gas combustion used for heating buildings. Indirectly, buildings that utilize large quantities of electric power contribute to CO_2 emissions because of the fuel combustion required for power generation. Forests and other vegetated landforms represent sinks of CO_2.

GHG emissions are also affected by development activities associated with land or forest clearing and land use changes; construction activities involving use of fossil-fuel-powered equipment (e.g., bulldozers, loaders, haulers, trucks, generators, etc.); increases in demand for electric power due to greater industrial, residential, or commercial activity; changes to amounts and patterns of traffic flow; or by the incorporation of parks or recreational areas that can serve as potential “sinks” for the storage of CO_2.

Worldwide man-made annual CO_2 emissions are estimated at 30 billion tons, with the U.S. responsible for about 20 percent. U.S. electric utilities, in turn, emit 2.2 billion tons, roughly 40 percent of the U.S. total. Figure 3-22 shows how TVA’s approximately 73 million tons of annual CO_2 emissions in 2009 from energy production ranks in terms of worldwide, national, and industry emissions. This amount is down from 104 million tons produced by TVA in 2008.

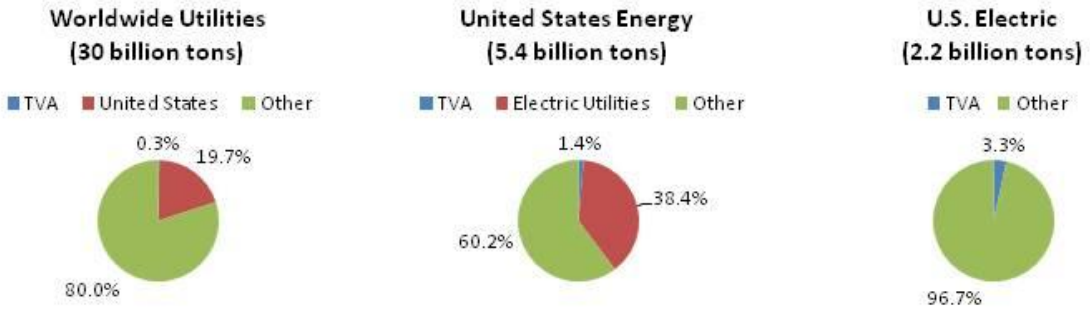


Figure 3-22. 2009 Man-Made Carbon Dioxide Emission Percentages

Regional Climate Change in the Southeast and the Tennessee River Valley

Compared to the rest of the U.S., the climate of the Southeast is warm and wet, with high humidity and mild winters. Average annual temperature across the southeastern U.S. did not change significantly over the last century; however, since 1970, annual average temperature has risen about 2 degrees Fahrenheit (°F). The greatest seasonal increase in temperature has been during the winter months. Since the 1970s, the number of freezing

days in the Southeast has declined by four to seven days per year for most of the region. Average autumn precipitation has increased by 30 percent for the region since 1901. There has been an increase in heavy downpours in many parts of the region, while at the same time, the percentage of the region experiencing moderate-to-severe drought increased over the past three decades.

In order to understand future climate scenarios in the TVA region better, TVA contracted with the Electric Power Research Institute (EPRI) to prepare a report on the impacts of GCC on various resources throughout the Tennessee Valley, including water and air that could be reasonably anticipated to occur over the 21st century (EPRI and TVA 2009). Emphasis was placed on the near future (through 2050), as higher uncertainty exists for longer-range predictions. The basis for this report is the United Nations IPCC's *Fourth Assessment Report*, published in 2007, that assumes a medium GHG emissions projection (the A1B scenario), which does not reflect additional efforts to reduce GHG emissions. The TVA region spans two large model regions, the Central and Eastern North America regions. Temperature forecasts for the Tennessee Valley are similar for the two model regions and predict an increase in annual mean temperatures in the Valley of about 0.8 degrees Celsius (°C) (1.4°F) from 1990 to 2020 and up to 4.0°C (7.2°F) by 2100. Precipitation forecasts for the two model regions are more variable. In the Central Region (the western portion of the Tennessee Valley), winter precipitation is forecast to increase by 2.6 percent from 1990 to 2020 and by 3.6 percent by 2100. Central region summer precipitation is forecast to decrease by 6.1 percent from 1990 to 2020 and by 3 percent by 2100. In the eastern region, winter precipitation is forecast to increase by 11.3 percent from 1990 to 2020 and by 13 percent by 2100. No change in Eastern Region summer precipitation is forecast from 1990 to 2020 or by 2100. It is important to note that these forecasts are based on coarse-scale model results, and localized downscaled analyses are needed for finer scale results.

To help improve its working knowledge and internal expertise, research underway includes the evaluation of carbon capture technologies. TVA is conducting a small-scale, terrestrial carbon sequestration pilot project in the Tennessee Valley. Environmental stewardship will be an integral part of this project. Mixed vegetation (trees, native warm season grasses, and legumes), as opposed to a monoculture, will be used to support biodiversity and provide habitat for wildlife (TVA 2011).

Other Regional Patterns and Influences on Local Climatology

The TVA MSR in northwest Alabama is located west of the southern Appalachian region, and its climate is not influenced by major topographical features. In fact, Muscle Shoals is fairly flat, and this characteristic is conducive to nocturnal fog formation and flooding problems during heavy rains. The relatively narrow width of the Tennessee River at Muscle Shoals does not result in a detectable lake breeze. However, warm river water temperatures in autumn and early winter also contribute to nighttime fog formation. Local weather is dominated much of the year by the Azores-Bermuda anticyclonic circulation shown in the annual normal sea level pressure distribution. This circulation over the southeastern U.S. is most pronounced in the fall and is accompanied by extended periods of fair weather and widespread atmospheric stagnation. In winter, the normal circulation pattern becomes more varied as the eastward-moving migratory high and low pressure systems, associated with the midlatitude westerly current, bring alternating cold and warm air masses into the area with resultant changes in wind direction, wind speed, atmospheric stability, precipitation, and other meteorological elements. In summer, the migratory systems are less frequent and less intense, and the area is under the dominance of the western edge of the Azores-Bermuda anticyclone with a warm moist air influx from the

Atlantic Ocean and the Gulf of Mexico. Generally, Muscle Shoals experiences a temperate climate with adequate rainfall throughout the year, hot and humid summers, and cool, damp winters.

3.9 Soils and Prime Farmland

The approximately 1,400 acres that comprise the MSR study area have several areas either not covered by soil or covered by soil that is unusable for various reasons. Approximately 64 acres are unusable for any purpose because these areas are managed as SWMUs under RCRA. These areas contain buried hazardous waste and are capped to prevent precipitation from percolating through the waste material (see Sections 3.1 and 4.1). Consequently, these areas are restricted and cannot be disturbed. About 165 acres are developed to some degree, and these areas are largely covered by pavement and buildings (see Section 3.7 and Figure 3-21).

According to the Natural Resources Conservation Service (NRCS) *Soil Survey of Colbert County, Alabama* (Bowen 1994), the urban area covers 289.5 acres of the MSR study area. Since the following description of soils is based on the NRCS soil survey, the 289.5 acres of urban area is excluded from the discussion of soils. The soil survey provides little information concerning the suitability of urban areas for various uses. Approximately 29 acres of the MSR study area are covered by water, which includes a water treatment plant reservoir and several small man-made ponds. Excluding these areas, approximately 1,080 acres from the total 1,400-acre MSR study area are considered soil that could be impacted by this proposed redevelopment.

Within the 1,080 acres of soils in the MSR study area that could be affected by development, 182 acres are included in TVA's agricultural land use licensing program. Vegetation in these areas, maintained by the licensees, is dominated by fescue fields included in 20 separate tracts that range in size from about 5 to 40 acres. The soils in nearly all of these licensed areas are considered prime farmland and are best suited for agricultural purposes (see Section 3.9.2). These licensed tracts occur in three areas: adjacent to the ERC, on the southern boundary along Second Street, and on the eastern boundary along Wilson Dam Road. These three areas contain much of the nonforested, easily accessible farmland.

3.9.1 Soils

The soils that make up the MSR study area are a mixture of upland and floodplain soils. They were formed from cherty limestone and limestone, and the lower floodplain soils have high amounts of alluvium, while the soil at higher elevations is primarily residuum. The well-drained areas, adjacent to the ERC complex and south of Reservation Road, are nearly level or gently sloping and are well suited for farming and only slightly limited for building and recreational purposes. The areas north of Reservation Road have moderate to severe limitations for farming due to their steep slope and the presence of many small stones in the surface layers. Along the western, southern, and eastern boundaries, i.e., along Hatch Boulevard, Second Street, and Wilson Dam Road, the soils have moderate to severe limitations for farming due to frequent flooding or excessive moisture. Some of the better-drained areas along these borders have been urbanized.

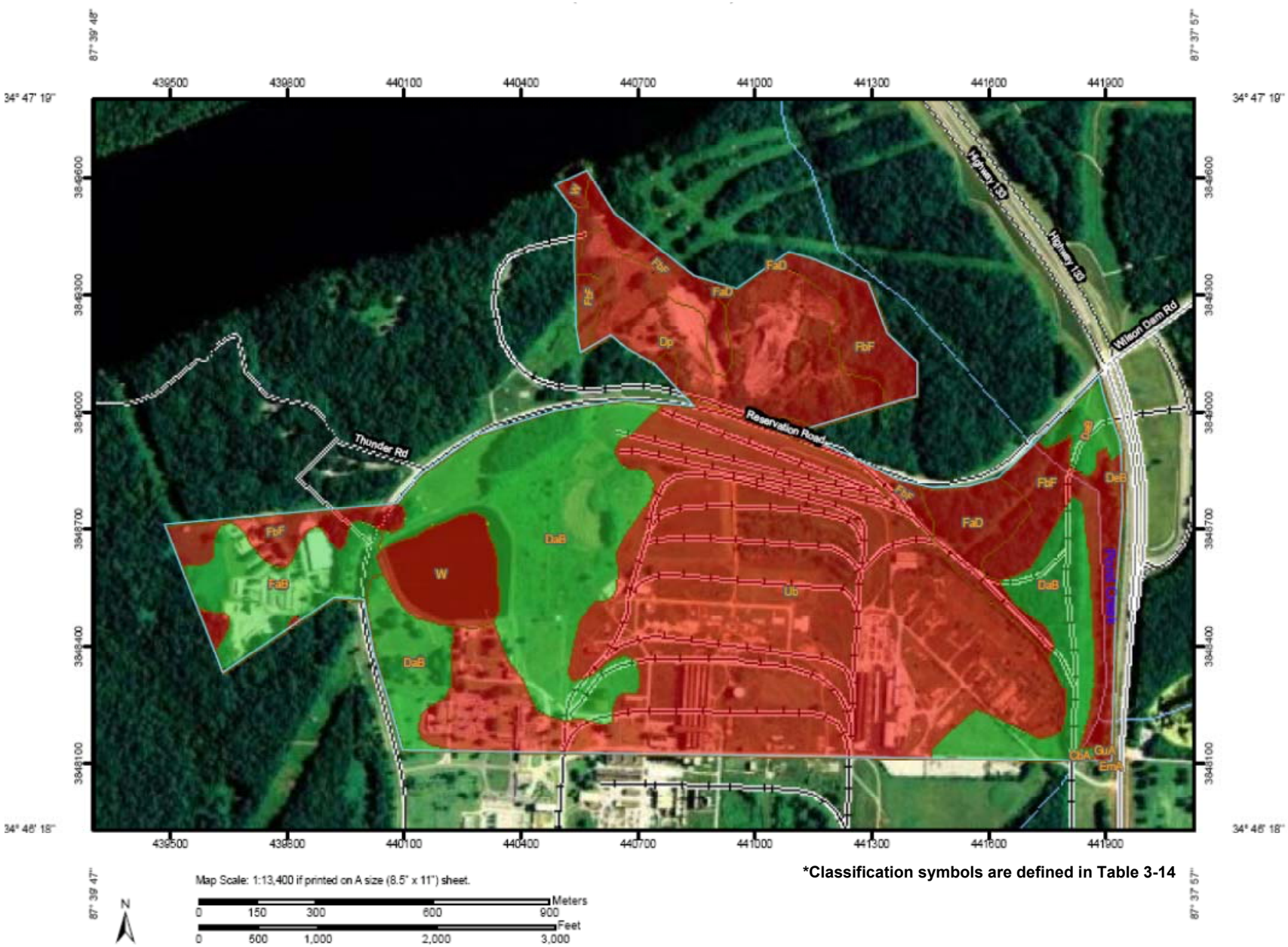
A list of soils described in the NRCS soil survey is provided as Table 3-14. The soil classification maps for the MSR study area are shown in Figures 3-23 and 3-24 for the northern and southern portions of the MSR study area. These maps were prepared using the U.S. Department of Agriculture (USDA) NRCS's Web Soil Survey.

Approximately 46 acres of the MSR study area is covered by a phosphate slag storage area, a legacy from phosphorus fertilizer production. This area lies north of Reservation Road (within a 90-acre area) and is designated as barren land (see Section 3.7). According to the NRCS land classifications, this barren land is considered a dump. It is not suitable for any type of farming.

Table 3-14. Soil Classification – Summary by Map Unit – Muscle Shoals Reservation Study Area

Soil Symbol	Soil Description	Acres	Percent	Rating
CbA	Chenneby silt loam, 0 to 2% slopes, occasionally flooded	132.7	9.5	All areas are prime farmland
DaB	Decatur silt loam, 2 to 6% slopes	478.4	34.2	All areas are prime farmland
DaC2	Decatur silty clay loam, 6 to 10% slopes, eroded	23.8	1.7	Not prime farmland
DeB	Decatur-Urban land complex, 2 to 8% slopes	51.9	3.7	Not prime farmland
DkA	Dickson silt loam, 0 to 3% slopes	11.1	0.8	All areas are prime farmland
Dp	Dumps	45.6	3.3	Not prime farmland
EmA	Emory silt loam, 0 to 2% slopes, ponded	13.1	0.9	Prime farmland if drained
EnA	Emory-Urban land complex 0 to 1% slopes	0.9	0.1	Not prime farmland
EtB	Etowah silt loam, 2 to 6% slopes	13.3	1.0	All areas are prime farmland
FaB	Fullerton cherty silt loam, 2 to 6% slopes	33.8	2.4	All areas are prime farmland
FaD	Fullerton cherty silt loam, 6 to 15% slopes	14.7	1.1	Not prime farmland
FbF	Fullerton-Bodine complex, 15 to 45% slopes	95.3	6.8	Not prime farmland
GuA	Guthrie silt loam, 0 to 2% slopes, frequently flooded	99.4	7.1	Not prime farmland
PUA	Pruitton and Sullivan silt loams, 0 to 2% slopes, occasionally flooded	65.0	4.7	Prime farmland if protected from flooding or not frequently flooded during the growing season
Ub	Urban land	289.5	20.7	Not prime farmland
W	Water	29.3	2.1	Not prime farmland
Totals for Muscle Shoals Reservation Study Area		**1,397.8**	**100.0**	

Source: Bowen (1994)



*Classification symbols are defined in Table 3-14

Figure 3-23. Soil Classifications for the Northern Section of the Muscle Shoals Reservation Study Area

Figure 3-24. Soil Classifications for the Southern Section of the Muscle Shoals Reservation Study Area

There are 14 soil types in the MSR study area. Detailed descriptions are provided in Appendix M. Although they appear to be scattered over the MSR study area, the soils are grouped in a concentric fashion in terms of their physical properties. Reservation Road, which generally forms the northern boundary of the MSR study area, follows the contour of a broad ridge. On this ridge lies the best soil from an agricultural standpoint due to its depth, silty texture, good drainage, and gentle slope. North of the ridge, the quality of the soil declines due the undulating terrain and the abrupt slope toward the Tennessee River (Pickwick Reservoir). Encircling the broad ridge to the west, south, and east are floodplain soils that are poorly drained and become increasingly moist (wet) from the ridge and approach the highways, which form the western, southern, and eastern boundaries. Much of the land along the highways that forms these borders is urban complex soils. These soils are located on the better-drained areas along the periphery of the MSR study area. A large part of the ridge, on which the best soil in the MSR study area lies, is considered urban due to the buildings, pavement, and roads associated with the ERC and research-related facilities.

3.9.2 Prime Farmland

Prime farmland is defined by the USDA as land that has the best combination of chemical and physical characteristics for producing food, feed, forage, fiber, and oilseed crops. To be considered prime farmland, it cannot be urban, built up, or covered by water. See list of soils on the MSR study area and prime farmland classification in Table 3-14 above.

Concern regarding the conversion of prime farmland to urban or industrial use prompted the passage of the 1981 Farmland Protection Policy Act (FPPA). This act requires that all federal agencies evaluate impacts to farmland prior to permanently converting the land to a nonagriculture land use. Form AD1006, “Farmland Conversion Impact Rating,” must be completed by federal agencies with assistance from the NRCS before action is taken.

Including the soils that are prime farmland if protected from flooding (Pruitton and Sullivan soils [PUA]) or drained (Emory silt loam [EmA], 0 to 2 percent slopes, ponded), about 53 percent (about 747.4 of the 1,400 acres) of the MSR study area is prime farmland. Another 21 percent of the MSR study area (289.5 acres) is classified as urban land. The ERC complex is classified as urban land because it is primarily buildings and pavement. Because this area is surrounded by prime farmland, primarily Decatur silt loam, 2 to 6 percent slopes, much of the soil beneath the ERC complex was likely prime farmland.

In other parts of Colbert County, these soils are primarily used for growing cultivated crops or pasture. Prime farmland soils around buildings and adjacent to Reservation Road are maintained as turf and are landscaped with trees and ornamentals. All of the prime farmland soils are level or gently sloping, well drained, and not prone to flooding. The two soils that are conditionally prime farmland (PUA and EmA) have the same capability as the prime farmland soils. The capability classes range from Class I (highest capability) to Class VIII (lowest capability). All of the prime farmland soils in the MSR study area are considered Class II. The two wet soils, PUA and EmA, are Class IIw. The suffix “w” denotes that water may interfere with plant growth. The suffix “s” denotes that the soil is shallow or stony. The other prime farmland soils have the capability class of IIe. The suffix “e” means that the soil may be susceptible to erosion.

The soils not considered prime farmland are those that occur on steep slopes, are too wet, or have been urbanized. In the capability rating system, wet soils have a capability class of V, and sloping or steep soils have capability classes of III, IV, VI, VII, or VIII. The Guthrie silt loam is Class Vw. All the other nonprime farmland soils are classified as Class IVe

except for the Fullerton-Bodine complex, 15 to 45 percent slope, which is classified as Class VII. Fullerton is Class VIIe, and Bodine is Class VIIs. The phosphate slag storage area is Class VIIIs. The urban complex soils are not assigned a capability class.

Colbert County NRCS Soils Specialist Milton Tuck was asked to provide input for a Farmland Conversion Impact Rating. His input is shown in Form AD-1006 (see Appendix N). On a scale of 0 to 100 points, the *Relative Value of Farmland to Be Converted* is 55 points. This score was added to the score from the site assessment completed by TVA for this evaluation. The *Total Site Assessment* score was 34 points. This score was relatively low due to the large percentage of urbanized land around the site and the large acreage that had already been converted to industrial use. In the past, the ERC, although called a research facility, contained several small-scale industrial processes. Because only small portions of the total area (13 percent) have been farmed in recent times, the relative farming value of the land also is reduced.

The total points for farmland conversion associated with the potential TVA land disposal and redevelopment is 89 points. A score of 160 or higher implies that the land's value for farming is high enough to recommend that it not be converted to nonfarm use.

3.10 Surface Water Quality

The MSR is located along the southern shore of the Tennessee River (Wilson Dam tailwater-upper Pickwick Reservoir). In addition to the Tennessee River, two streams are located on or adjacent to the MSR study area. Pond Creek flows north through the eastern section of the property and enters the Tennessee River approximately 1 mile downstream of Wilson Dam at TRM 258.06. An unnamed tributary to the Tennessee River drains the western portion of the Reservation. However, most of the watershed of this stream lies outside of the MSR study area. The Tennessee River and Pond Creek are the two surface water bodies that could be affected by changes in land use on the MSR study area. There is also a water supply reservoir and several small man-made ponds located on the MSR study area. None of these have outlets and do not discharge water to other surface water bodies.

3.10.1 Tennessee River

During 2003, tributary embayments located on Guntersville, Wheeler, Wilson, and Pickwick reservoirs of the Tennessee River basin were intensively monitored. Water quality monitoring of the main stem reservoirs of the Tennessee River system is conducted by TVA through its Reservoir Vital Signs Monitoring Program. Objectives of the program are to provide basic information on the "health" or integrity of the aquatic ecosystem in each TVA reservoir and to provide screening level information for describing how well each reservoir meets the "fishable" and "swimmable" goals of the CWA. Sampling activities involve examination of appropriate physical, chemical, and biological indicators in the forebay, midregion, and headwater areas of each reservoir. Initiated in 1990, the TVA program provides results of monitoring activities to ADEM on an annual basis through program reports (ADEM 2005).

TVA monitored Pickwick Reservoir annually from 1991 through 1994 to establish baseline data on the reservoir's ecological health under a range of weather and flow conditions. Pickwick is now evaluated every other year. The overall ecological condition in Pickwick Reservoir rated "fair" in 2010. Pickwick has scored about the same every year, either "high fair" or "good," depending primarily on chlorophyll concentrations, which are affected by reservoir flows, and conditions in the Bear Creek embayment, which generally rates lower

than at other monitoring locations on the reservoir. The inflow rating, which is based on fish and bottom life, was “good” in 2010 and contributed to the overall higher score for the reservoir that year.

The average annual flow estimates for the Tennessee River at Pond Creek is approximately 50,000 cubic feet per second (cfs). The estimated annual low flow for the Tennessee River at Pond Creek is 6,750 cfs. The proposed utility corridor across the phosphate slag storage area could provide access to the Tennessee River approximately 1.5 miles downstream of Wilson Dam.

3.10.2 Pond Creek

The State of Alabama’s antidegradation policy provides for protection of high-quality waters that constitute an outstanding national resource (Tier 3), waters whose quality exceeds the levels necessary to support propagation of fish, shellfish, and wildlife, and recreation in and on the water (Tier 2), and existing instream water uses and the level of water quality necessary to protect the existing uses (Tier 1) (ADEM 2010). Pond Creek is classified as Agricultural and Industrial Water Supply. Pond Creek is a Tier 1 stream, and there are no total maximum daily loads (TMDL) calculated for this stream at this time. A TMDL is a calculation of the maximum amount of a pollutant that a water body can receive and still safely meet water quality standards.

Sections 305(b) and 303(d) of the federal Clean Water Act direct states to monitor and report the condition of their water resources. Pond Creek is on the most recent 303(d) list for impairment due to organic enrichment and metals (arsenic, cyanide, and mercury) (ADEM 2008). The ADEM Water Quality Branch evaluated Pond Creek for the Muscle Shoals Wastewater Treatment Plant (NPDES Permit No. AL0024180). ADEM indicated that the organic enrichment and metals impairment do not appear to be related to nutrient loading. The ADEM Water Quality Branch believes that the low dissolved oxygen issues in Pond Creek are due to natural conditions of low flow, low slope, and slow stream velocities. The probable sources for both the organic enrichment and metals impairments are listed as nonirrigated crop production, urban runoff/storm sewers, and natural/wildlife.

The unnamed tributary that drains the western portion of the site has not been assessed because only small portions of the extreme headwaters of this stream lie within the MSR study area.

3.10.3 Current Muscle Shoals Reservation Water Withdrawals

TVA has owned and operated a 2.0 MGD potable water treatment plant on the MSR since the 1930s. The potable water treatment plant is situated near and draws water from the Tennessee River and distributes it throughout the MSR. The TVA facility also requires large volumes of nonpotable process water, which is supplied by two large water intake structures located on the Tennessee River. The intakes are known as the PDW intake pumping station and the Fleet Hollow intake pumping station. The PDW pumping station is located downstream of Wilson Dam, and the Fleet Hollow pumping station is situated upstream of the Wilson Dam. Both stations incorporate multiple pumps with screening capability. Each station is capable of pumping 29 MGD. TVA has all the required operating and environmental permits from the State of Alabama and USEPA to own and operate the two intakes, the potable water plant, and associated distribution piping system for both facilities. The permits are valid, active, and in good standing.

3.11 Wetlands

Wetlands, as defined in EO 11990, are those areas that are inundated by surface water or groundwater with a frequency sufficient to support and under normal circumstances does or would support a prevalence of vegetative or aquatic life that requires saturated or seasonally saturated soil conditions for growth and reproduction. Wetlands generally include swamps, marshes, bogs, and similar areas such as sloughs, potholes, wet meadows, mud flats, and natural ponds. EO 11990 directs federal agencies to minimize the destruction, loss, or degradation of wetlands and to preserve and enhance the natural and beneficial values of wetlands. In addition, activities in wetlands are regulated under the authority of the federal CWA and various state water quality protection regulations.

Wetlands are ecologically important because of their beneficial effect on water quality, their moderation of flow regimes by retaining and gradually releasing water, their value as wildlife habitat, and as areas of botanical diversity. Wetlands are typically transitional ecosystems between terrestrial and aquatic communities.

Nonjurisdictional wetlands are wetlands that lack one of the three criteria (prevalence of wetland vegetation, hydric soils, and wetland hydrology) used to identify wetlands that are regulated by state and federal regulations. In the project area, nonjurisdictional wetlands typically lack hydric soils but will have a prevalence of wetland vegetation and undergo saturation or inundation long enough to drive the composition of the plant community. Jurisdictional wetlands, as the name suggests, fall under the jurisdiction of state and federal wetland regulations as described in Section 4.11. Nonjurisdictional wetlands are not regulated by state or federal law but are afforded protection under EO 11990. The EO's definition of wetlands is based primarily on a prevalence of wetland vegetation.

Wetlands on the MSR were identified primarily via National Wetland Inventory maps, remote sensing and aerial photography interpretation, and limited ground surveys. No distinction was made between jurisdictional and nonjurisdictional wetlands.

In accordance with TVA procedures for implementing EO 11990 in *Instruction IX, Environmental Review* (TVA 1983), TVA must evaluate the effect of the proposed action on natural and beneficial wetland values and alternatives that would eliminate or minimize such effects. TVA must then determine whether there is a practicable alternative that will avoid affecting wetlands. If there is no practicable alternative to development in wetlands, then all practical measures to minimize impacts to wetlands must be incorporated into plans to develop these areas. TVA does not transfer federally owned wetlands to nonfederal ownership without assurances that future impacts from development would be avoided or minimized.

Estimates of wetland types and extent of occurrence (i.e., location and size) on the MSR study area were determined using aerial photography flown in March 2010 and resulting land use/land cover analysis and interpretation of this photography. Results of TVA's photointerpretation are shown in Table 3-15 and Figure 3-21. The 2.75 acres of constructed wetlands are the result of past research projects. Because of the timing of the photography and nature of this data collection, the size of area representing wetlands on the MSR study area could be liberal and overestimate the actual acreage of wetlands present on the ground. However, as mentioned below, some field verification was undertaken.

Table 3-15. Wetlands by Type, Size, and Percent on the Muscle Shoals Reservation Study Area

Wetland Type	Acreage	Percent of Area
Forested wetlands	152.07	10.89
Scrub-shrub wetlands	7.10	0.51
Emergent herbaceous wetlands	2.03	0.15
Man-made wetlands	2.75	0.20
TOTAL	**163.95**	**11.75**

During spring 2010, field surveys were completed to verify the aerial estimates and provide more details about the wetland habitats present on site. Common vegetation associated with wetlands on the MSR study area includes water oak (*Quercus phellos*), willow oak (*Quercus nigra*), sweet gum (*Liquidambar sytraciflua*), sycamore (*Platanus occidentalis*), black willow (*Salix nigra*), Chinese privet (*Ligustrum sinense*), red maple (*Acer rubrum*), green ash (*Fraxinus pennsylvanica*), alder (*Alnus serrulata*), sedges (*Carex* spp.*),* soft rush (*Juncus effusus)*, green dragon (*Arisaema dracontium)*, cattail (*Typha latifolia*), smartweed (*Polygonum* spp.), and jewelweed (*Impatiens capensis*).

Although they are heavily impacted by invasive species, primarily Chinese privet, the MSR study area wetlands provide valuable habitat for wildlife, including resident and migrant birds. This provides an especially important function within the context of what is primarily an urbanizing environment. These wetlands also provide important flood retention functions.

3.11.1 Regional Wetland Resources

The MSR study area is located within the Interior Plateau Level III ecoregion, as defined by Griffith et al. (2001). See more detailed description of this ecoregion in Section 3.14.1. Wetlands comprise approximately 0.70 percent of the total land cover in this ecoregion (Loveland and Acevedo 2006). In terms of wetland type, data prepared for the TVA *Reservoir Operations Study* (TVA 2004) provide general estimates of the type and extent of wetland acreage associated with specific TVA reservoirs. These data indicate the most common type of wetlands on and near the MSR study area is forested wetlands. Forested wetlands are generally associated with floodplains of rivers and streams. Emergent and scrub-shrub wetlands are relatively common and are typically found on reservoir shorelines and coves. Wetlands are more common in the western part of the Tennessee River system due to the flatter topography and broader floodplain areas.

3.11.2 Regional Trends

At present, there are approximately 3.6 million acres of wetlands in Alabama (USDA 2009). Most of these wetlands are associated with river systems. General trends in wetland loss in the Southeast and in Alabama indicate that forested, emergent, and scrub-shrub wetlands have suffered a net loss in acreage over the last 10 years. This is primarily due to transportation impacts, the continued growth of urban/suburban development associated with continued population growth, and to a lesser degree, agriculture and timber harvesting (Hefner et al. 1994; Dahl 2006; Keeland et al. 1995). Agricultural practices cause a continuing net loss of approximately 24,000 acres of wetlands per year (USDA 2009). However, recent research has indicated that there is an overall gain in wetland resources in Alabama and nationwide (Sifneos et al. 2009). This trend reflects an overall increase in ponds created as agricultural impoundments and shallow ponds associated with urban and suburban development. Additionally, compensatory mitigation for the loss of emergent

wetlands has contributed to the trend (Dahl 2006). However, regionally there is still an overall acreage loss in both forested and scrub-shrub wetland habitat types.

3.12 Floodplains

The approximately 1,400-acre MSR study area includes TVA's property identified as the phosphate slag storage area (potential utility corridor) at about TRM 257.7 and property along Pond Creek from the mouth at TRM 258.06 upstream to Wilson Dam Road at Mile 2.7. Areas lying within the limits of the 100-year floodplain can occur along Pond Creek (Figure 3-25) and along the Tennessee River. TVA's Section 26a jurisdiction applies to obstructions across, along, or in the Tennessee River or any of its tributaries.

Pond Creek begins east of Muscle Shoals and flows mainly through undeveloped, relatively flat land before passing through the industrial areas in the Listerhill community and Muscle Shoals. Pond Creek has an average fall of 2 feet per mile. The Pond Creek drainage area at its mouth is 22 square miles (Federal Emergency Management Agency 2010). As shown in Figure 3-25, on the MSR study area, there is an estimated 114 acres within the floodplain of Pond Creek below elevations identified below. This does not include a small area at the mouth of Pond Creek along the Tennessee River.

In accordance with TVA procedures for implementing EO 11988 (Floodplain Management) in *Instruction IX, Environmental Review* (TVA 1983), TVA must evaluate the effect of the proposed action on natural and beneficial floodplain values and alternatives that would eliminate or minimize such effects.

TVA must then determine whether there is a practicable alternative that would avoid affecting floodplains. If there is no practicable alternative to development in the floodplain, then all practical measures to minimize impacts to floodplains are incorporated into plans to develop these areas.

Figure 3-25. Estimated 114-Acre Pond Creek Floodplain Within the Muscle Shoals Reservation Study Area

At TRM 257.7, the 100-year flood elevation is 431.6 feet mean sea level (msl). The 100-year floodplain is the area that would be inundated by the 100-year flood. The Flood Risk Profile (FRP) elevation at TRM 257.7 is 433.7 feet msl. At this location, the FRP elevation is equal to the 500-year flood elevation and is used to control flood-damageable development for TVA projects and on TVA Lands. The Tennessee River 100-year flood elevation at the mouth of Pond Creek (TRM 258.06) is 432.6 feet msl, and the FRP elevation is 434.8 feet msl. On Pond Creek, computed flood elevations are available from Mile 1.42 to 2.70 (Wilson Dam Road). The 100-year flood elevations along Pond Creek vary from 511.3 feet msl at Mile 1.42 to 514.6 feet msl downstream of Wilson Dam Road at Mile 2.70. The 500-year flood elevations vary from 513.0 feet msl at Mile 1.42 to 515.9 feet msl at Mile 2.70. All elevations are NGVD (National Geodetic and Vertical Datum) 1929. Tabulations of the Pond Creek 100- and 500-year flood elevations are included in Table 3-16.

Table 3-16. Pond Creek Flood Profiles - Muscle Shoals Reservation Study Area

Pond Creek Mile	100-Year Flood Elevation (feet) [1]	500-Year Flood Elevation (feet) [1]
1.42	511.3	513.0
1.56	511.8	513.5
1.67	512.1	513.8
1.78	512.5	514.2
1.82	512.6	514.4
1.88	512.7	514.5
1.90	512.7	514.5
1.94	512.8	514.5
2.02	512.9	514.6
2.06	512.9	514.6
2.08	512.9	514.6
2.20[2,4]	513.0	514.7
2.20[3]	514.1	515.5
2.39	514.3	515.6
2.70[2,5]	514.6	515.9

[1]All Elevations are NGVD 1929
[2]Downstream of bridges
[3]Upstream of bridges
[4]Landmark is U.S. railway
[5]Landmark is Wilson Dam Road (SR 133)

In Muscle Shoals, Pond Creek and numerous sinkholes tend to overflow during rainstorms and cause serious flood damage to residences and businesses. In spring 1973, heavy flood damage occurred in Muscle Shoals, Alabama, as water rose in the “Old Gusmus Pond” sink area (TVA 1974). The combination of 8 inches of rain, runoff from the local area draining into the sink, and overflow from Pond Creek exceeded outflow capacity of the sink. Although the rainfall and the overflow from Pond Creek ended on March 17, 1973, the floodwaters rose in the sink until the morning of March 19, 1973, and did not drop below the floor of the lowest building until April 2, 1973. At the crest, floodwaters were up to 2.5 feet deep in 18 businesses and up to 2 feet deep in 15 homes and a housing project. Water surrounded many other businesses and homes and damaged several mobile homes. The

Southgate Mall Shopping Center was completely surrounded by water, 0.5 foot below the floor levels. The shopping center was closed for about a week (TVA 1974).

Muscle Shoals, Sheffield, Tuscumbia, Florence, Colbert County, and Lauderdale County participate in the National Flood Insurance Program. They have adopted the 100-year flood as the basis for their floodplain regulations, and all development would be consistent with these regulations. There is a published floodway beginning at Mile 2.57 on Pond Creek and continuing upstream of the land disposal and redevelopment area.

3.13 Aquatic Ecology

3.13.1 Fish and Aquatic Life

The MSR is located along the southern shore of the Tennessee River (Wilson Dam tailwater—Pickwick Reservoir). Two streams are located on or adjacent to the MSR study area. Pond Creek generally flows north through the eastern section of the property and enters the Tennessee River approximately a mile downstream of Wilson Dam (see Section 3.12). An unnamed tributary to the Tennessee River drains the western portion of the MSR study area. However, most of the watershed of this stream lies outside the Reservation. Several man-made ponds are located here, and generally, these ponds support relatively poor aquatic communities due to impacts from past industrial fertilizer operations on the MSR study area.

Pond Creek is listed on the Alabama 303(d) list as impaired (see Section 3.10). Impaired waters are those that do not presently fully support their designated uses. The most recent TVA aquatic life survey of Pond Creek (TVA unpublished data 2007) supports this listing. While Pond Creek has adequate physical habitat, both the fish and benthic macroinvertebrate community conditions indicated severe impairment of this stream. The unnamed tributary that drains the western portion of the site has not been assessed because only small portions of the extreme headwaters of this stream lie within the MSR study area (see Figure 3-25).

Both Pond Creek and the unnamed tributary stream flow into the Tennessee River (Wilson Dam tailwater—Pickwick Reservoir). This portion of the Tennessee River supports a very diverse aquatic community, including several mussel species listed as endangered or threatened. The Wilson Dam tailwater has been designated by the U.S. Fish and Wildlife Service (USFWS) as a Nonessential Experimental Population (NEP) area for 16 federally listed mussel species and one federally listed snail species (USFWS 2001). The harvest of freshwater mussels in this section of the river is restricted by the State of Alabama. The shoreline portion of the area considered for a utility corridor is located in this reach of the Tennessee River, approximately 1 mile downstream of Wilson Dam. A more detailed description of the reach of the river designated for the Tennessee River/Wilson Dam NEP is provided in Section 3.15.

No invasive fish or other aquatic life is known from or reported from Pond Creek, on-site ponds, or any other creek or river tributaries.

3.13.2 Aquatic Endangered and Threatened Species

Numerous species listed under the Endangered Species Act as endangered, threatened, or candidates for listing have been reported from or are known to occur in this reach of the Tennessee River (Wilson Dam tailwater—Pickwick Reservoir) in Colbert County, Alabama (see Table 3-17). No state or federally listed aquatic animal species are known or likely to occur in Pond Creek. Due to the level of impairment of Pond Creek, it is not expected to

support any state- or federally listed aquatic species (see Section 3.10). Pond Creek and the unnamed tributaries that drain other parts of the Reservation are too small to support any of the listed mussel species present in the main stem Tennessee River.

Table 3-17. State- and Federally Listed Species Known to Occur in Colbert County, Alabama

Common Name	Scientific Name	Alabama Status (Rank)	Federal Status
Crustaceans			
Alabama blind cave shrimp	*Palaemonias alabamae*	PROT (S1S2)	END
Troglobitic crayfish	*Procambarus pecki*	TRKD (S2)	-
Troglobitic crayfish	*Cambarus jonesi*	SPCO (S2)	-
Mussels			
Black sandshell	*Ligumia recta*	TRKD (S2)	-
Cumberland combshell	*Epioblasma brevidens*	PROT (S1)	END
Deertoe	*Truncilla truncata*	TRKD (S1)	-
Dromedary pearlymussel	*Dromus dromas*	PROT (S1)	END
Fanshell	*Cyprogenia stegaria*	PROT (S1)	END
Kidneyshell	*Ptychobranchus fasciolaris*	TRKD (S1)	-
Monkeyface	*Quadrula metanevra*	TRKD (S3)	-
Ohio pigtoe	*Pleurobema cordatum*	TRKD (S2)	-
Pink mucket	*Lampsilis abrupta*	PROT (S1)	END
Pink papershell	*Potamilus ohiensis*	TRKD (S3)	-
Purple lilliput	*Toxolasma lividus*	TRKD (S2)	-
Pyramid pigtoe	*Pleurobema rubrum*	PROT (S2)	-
Rabbitsfoot	*Quadrula cylindrica cylindrica*	PROT (S1)	CAND
Ring pink	*Obovaria retusa*	PROT (S1)	END
Rock pocketbook	*Arcidens confragosus*	TRKD (S3)	-
Rough pigtoe	*Pleurobema plenum*	PROT (S1)	END
Round pigtoe	*Pleurobema sintoxia*	TRKD (S1)	-
Sheepnose	*Plethobasus cyphyus*	PROT (S1)	-
Spectaclecase	*Cumberlandia monodonta*	PROT (S1)	CAND
Slabside pearlymussel	*Lexingtonia dolabelloides*	PROT (S1)	CAND
Spike	*Elliptio dilitata*	TRKD (S1)	-
Tennessee pigtoe	*Fusconaia barnesiana*	TRKD (S1)	-
Wavy-rayed lampmussel	*Lampsilis fasciola*	TRKD (S1S2)	-
White heelsplitter	*Lasmigona complanata*	TRKD (S2S3)	-
White wartyback	*Plethobasus cicatricosus*	PROT (S1)	END
Snails			
Anthony's river snail	*Athearnia anthonyi*	PROT (S1)	END
Round-rib elimia	*Elimia nassula*	TRKD (S1)	-
Slowwater elimia	*Elimia interveniens*	TRKD (S2)	-
Spiral hornsnail	*Pleurocera brumbyi*	TRKD (S2)	-

Common Name	Scientific Name	Alabama Status (Rank)	Federal Status
Varicose rocksnail	*Lithasia verrucosa*	TRKD (S3)	-

- = No Protection
Federal status abbreviations: CAND = Candidate for federal listing; END = Endangered
State status abbreviations: PROT = Protected; TRKD = Tracked by the state natural heritage program; SPCO = Special concern
State rank abbreviations: S1 = Critically imperiled, often with five or fewer occurrences; S2 = Imperiled, often with less than 20 occurrences; S3 = Rare or uncommon, often with less than 80 occurrences; S#S# = Occurrence numbers are uncertain

3.14 Terrestrial Ecology

3.14.1 Vegetation

The MSR study area occurs in the Eastern Highland Rim of the Interior Low Plateau ecoregion. Within the Eastern Highland Rim, Mississippian-aged limestone, chert, shale, and dolomite predominate, and springs, sinks, and caves have formed by solution of the limestone. Natural vegetation is transitional between the oak-hickory type to the west and the mixed mesophytic forests of the Appalachian ecoregions to the east. Much of the original bottomland hardwood forests have been inundated by impoundments. The flatter areas in the east and on both sides of the Tennessee River have very deep, well-drained, reddish soils that are intensively farmed (Griffith et al. 2001).

Approximately 1,206 acres (86 percent) of the 1,400-acre MSR study area has the following land cover: barren land, deciduous forest, evergreen forest, mixed forest, scrub-shrub forest, grassland/herbaceous, pasture/hay, forested wetland, scrub-shrub wetland, emergent herbaceous wetland, and man-made wetland (Figures 3-20, 3-21). The remaining 13.6 percent (190.3 acres) is occupied by varying intensities of developed areas or by open water.

Three Alabama Champion trees, the largest of their species in the state, also occur within 5 miles of the MSR study area. These three Champion trees include black walnut (*Juglans nigra*), paper mulberry (*Broussonetia papyrifera*), and tree-of-heaven (*Ailanthus altissima)*. The Champion paper mulberry tree is growing on TVA land but is outside the MSR study area. The former Alabama Champion American chestnut tree occurs within the MSR study area. As of April 2010, it has been heavily infested with the chestnut blight; however, live sprouts still persist. According to the Alabama Forestry Commission (2009), a larger American chestnut was found recently in Talladega County, making the MSR tree the second largest in the state.

Deciduous, evergreen, and mixed forests cover about 25 percent of the MSR study area and contain loblolly pine, American elm, hackberry, sweetgum, wild black cherry, and various oaks and hickories along with tree-of-heaven in the canopy. Common understory vegetation includes pokeweed, Japanese honeysuckle, Chinese privet, Virginia creeper, wild grape, greenbriers, and poison ivy. Scrub-shrub communities occur along fencerows, edges of small woodlots and larger woodlands, railroad rights-of-way, and roadsides. Commonly encountered species include callery pear, Chinese privet, persimmon, sumacs, multiflora rose, honey-locust, kudzu, red bud, tree-of-heaven, blackberry, Virginia creeper, Japanese honeysuckle, and poison ivy.

Grassland/herbaceous and pasture/hay cover over 43 percent of the MSR study area. Hay production, which occurs under agricultural license, contains fescue, clovers, orchard grass,

Johnson grass, Bermuda grass, and numerous broad-leaved weeds. Seventeen acres have been converted to areas of native warm season grasses with big blue stem, eastern gama grass, little blue stem, Indian grass, sideoats grama grass, and switch grass. Successional fields consist of broomsedge, callery pear, joe-pye-weed, iron weed, coreopsis, lespedeza, various asters, and several native grass species along with saplings of persimmon, sumacs, red bud, honey-locust, multiflora rose, and blackberries.

Forested wetlands are found as riparian woodlands in low-lying areas and along Pond Creek. These areas are dominated by water and willow oak and also contain American sycamore, river birch, hackberry, winged elm, sweetgum, and hop hornbeam.

Scrub-shrub, emergent herbaceous and man-made wetland communities are dominated by black willow, buttonbush, silky dogwood, and tag alder. Herbaceous species such as arrowhead, cardinal flower, cattails, jewelweed, poison hemlock, water plantain, water-willow and several species of grasses, rushes, and sedges are commonly found.

The American Chestnut Research Orchard

In 1994, TVA and the Alabama Chapter of TACF entered into an agreement to collaborate on research to assist in the development of blight-resistant American chestnut trees. An approximately 4-acre area of a larger managed field was dedicated to this project. When TVA federal appropriations ended in the late 1990s, TACF continued to conduct active research at this site (see Figure 3-26).

TACF Research Orchard has produced American/Chinese chestnut hybrids that are a critical component to the national effort to reintroduce this extirpated keystone species back into the forests of the Appalachians (U.S. Forest Service [USFS] 2009). According to Morris et al. (2006), the goal of the Alabama orchards is to produce trees whose genomes would be compatible with the regional environment. Seedlings obtained from these hybrids would likely have a better chance of survival when reintroduced into Alabama forests. Similar breeding and restoration programs are being conducted across the historical range of the American chestnut. In addition, preliminary research has shown that American chestnut was among the fastest-growing hardwoods of the eastern U.S. and would be of great use to help mitigate accelerated global warming through the uptake and storage of carbon (Diamant 2005). These results are of great interest to those who could benefit from planting American chestnut to help offset emissions, while providing excellent wildlife habitat and high value timber and contributing to the restoration of the species (Diamant 2005).

Figure 3-26. Location of The American Chestnut Foundation Research Orchard on the MSR Study Area

Invasive Plants

Most lands in and around the TVA power service area have been affected by the introduction of nonnative plants. Nonnative plants are known to occur across southern Appalachian forests, accounting for 15 to 20 percent of the documented flora (USFS 2008).

Not all nonnative species pose a threat to native ecosystems and the Tennessee Valley region. Many species introduced by European settlers are naturalized additions to our flora and are considered nonnative noninvasive species. These “weeds” have very little negative impacts to native vegetation. Examples of these are Queen Anne’s lace and dandelion. However, other nonnative species are considered invasive and do pose threats to the natural environment. EO 13112 defines an invasive species as any species, including its seeds, eggs, spores, or other biological material capable of propagating that species, that is not native to that ecosystem and whose introduction does or is likely to cause economic or environmental harm or harm to human health (USDA 2007). According to NatureServe (2009), invasive species are the second-leading threat to imperiled native species.

Much of the native vegetation within and surrounding the MSR study area has been altered by previous land use. A few of the more commonly encountered invasive plant species occurring within the project area include autumn olive, callery (Bradford) pear, Chinese privet, crown vetch, Japanese honeysuckle, Johnson grass, kudzu, mimosa, multiflora rose, sericea lespedeza, and tree-of-heaven. Most of the invasive species found on the MSR study area are considered a severe threat to the natural environment and are of high

priority to TVA for control or eradication. Many of these species are abundant throughout Colbert County.

3.14.2 Wildlife

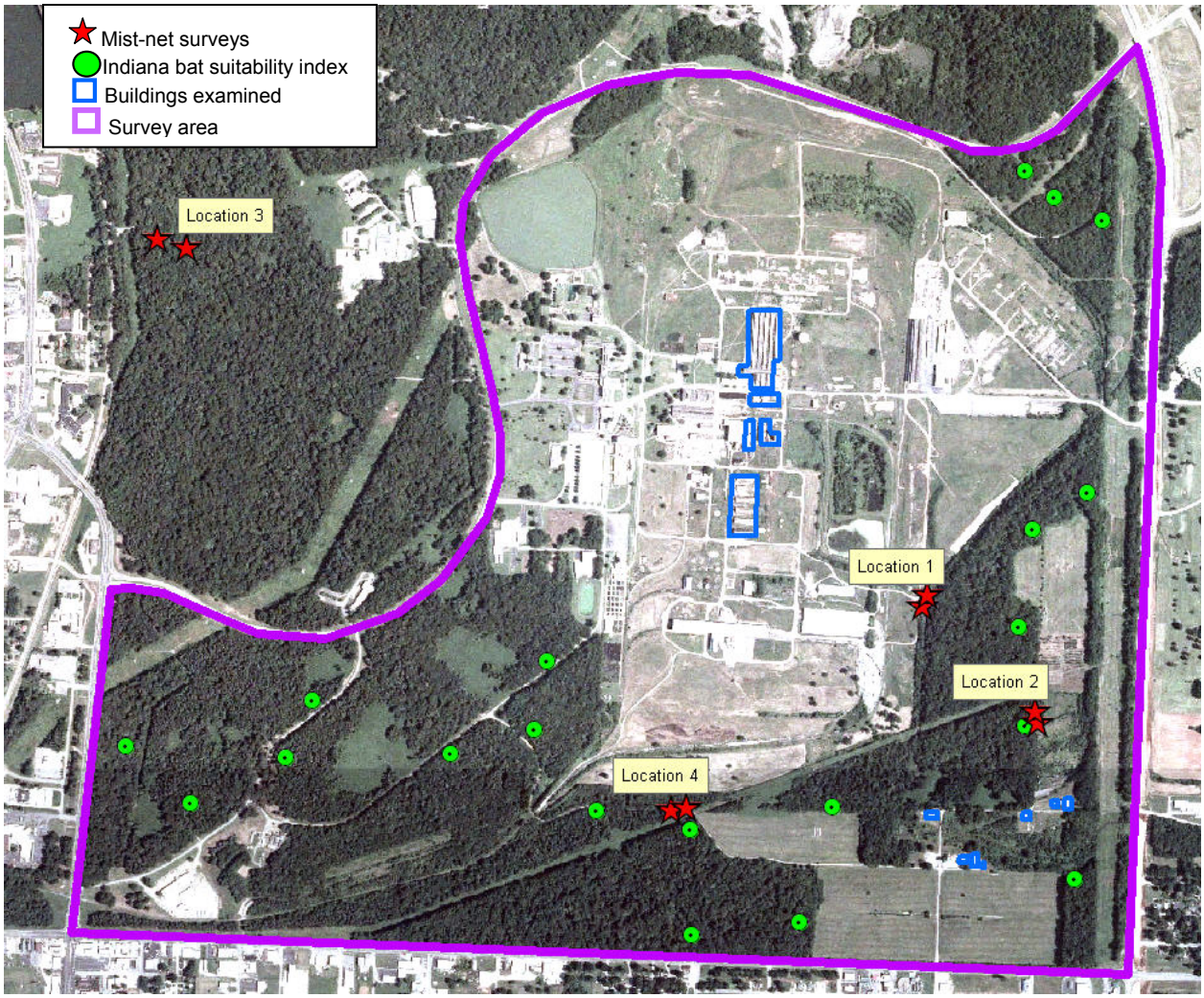
Habitats occurring in the MSR study area vary from areas of barren lands to forested tracts dominated by deciduous forests. Review of land use/land cover data reveals that approximately 36 percent of the MSR study area is comprised of forested habitats including forested wetlands. This habitat (501 acres) is largely characterized as upland deciduous and mixed forest and forested wetlands (see Figure 3-20). Approximately 47 percent of the MSR study area is comprised of early successional habitats (scrub-shrub, pasture/hay, and grasslands). Some narrow riparian zones, including Pond Creek, cross the property, and a few small ponds and a reservoir occur on the MSR study area. This diverse habitat provides for diverse animal communities. There have been few surveys for mammals (other than bats), reptiles, and amphibians. Those species with known distribution ranges within the MSR study area are listed in Appendix O.

Forested habitats on the Reservation are used by a variety of wildlife. Numerous species of migratory songbirds migrate through the area during spring and fall and reside in the MSR study area during summer months. Common species include northern cardinal, brown-headed cowbird, eastern towhee, blue jay, Carolina chickadee, tufted titmouse, American redstart, yellow-rumped warbler, and magnolia warbler. Mammals such as raccoon, opossum, nine-banded armadillo, white-tailed deer, eastern cottontail, eastern gray squirrel, and gray fox are common in these areas.

An approximately 4-acre forested wetland section in the southwestern corner of the MSR study area is mixed with several acres of forest edge, abandoned fields, and privet- and kudzu-infested areas. Smaller isolated areas of forested wetlands also occur in this area. The diversity of habitats attracts many bird species during fall migration. Surveys of the southwestern area conducted since 2002 have recorded a total of 132 bird species. Approximately 200 bird species have been recorded on the entire Reservation (Appendix O). Most numerous are gregarious species such as American robin and brown-headed cowbird. Of the migrant songbirds, magnolia warbler and American redstart are most abundant. Thirty-two species of warblers, seven species of vireos, five species of thrushes, and nine species of flycatchers have been recorded. Due to the large numbers and diversity of migrants in this location, active bird watching occurs here between late August and mid-October (also see Section 3.16). More than 250 species of resident and migratory birds have been recorded on the MSR and other TVA land from Wilson Dam to Hatch Boulevard, including Jackson and Patton Islands, and along the Tennessee River in the vicinity of Wilson Dam.

Forested tracts in the MSR study area have been surveyed for bats in recent years (Fiedler et al. 2007). Locations of these surveys are provided in Figure 3-27. Eastern pipistrelle bats, red bats, and big brown bats were captured during TVA surveys and are considered common on these properties. Twenty abandoned buildings were examined for colonies of bats; none were located.

Forested wetlands provide habitat for a mixture of amphibians and reptiles; however, these areas are somewhat degraded, especially on the western portion of the properties due to their proximity to the nearby highway and the prevalence of dense understory/midstory dominated by exotic species. Chinese privet is common on the MSR study area (Figure 3-28).



Source: Fiedler et al. 2007

Figure 3-27. 2007 Bat Survey Locations on the Muscle Shoals Reservation Study Area

Source: Fiedler et al. 2007

Figure 3-28. Typical Upland Forested Area With Thick Privet Understory on the Muscle Shoals Reservation Study Area

Early successional habitats on the MSR study area are partially comprised of areas maintained by agricultural licenses. These areas are dominated by fescue fields that offer lower-quality habitat for wildlife. In contrast, a small portion of the early successional habitats have been converted to warm season grasses, which provide excellent habitat for wildlife, especially birds and small mammals that occur in the MSR study area. Common birds found in early successional habitat and associated hedgerows include mourning dove, eastern kingbird, indigo bunting, prairie warbler, common yellowthroat, white-throated sparrow, red-winged blackbird, and American goldfinch. Grassland communities within the MSR study area are inhabited by birds such as northern bobwhite, American kestrel, eastern bluebird, common yellowthroat, savannah sparrow, vesper sparrow, dickcissel, and bobolink.

Fragmentation of habitat is currently present both within the proposed redevelopment area boundary and the area north of Reservation Road. Such fragmentation is in the form of existing rights-of-way, roads, agricultural use, industrial use, and other disturbances. These areas also are surrounded by land use practices (commercial, residential, etc.) outside the Reservation that have smaller tracts of forests and fragmented habitat also used by wildlife. Species of terrestrial animals that continue to use these habitats have either evolved or adapted to such conditions to fulfill all or a part of their life cycles.

Open water habitats on the property attract a variety of wading birds and some species of migrant, resident, and transitory gulls and other waterfowl. Common species that occupy or use the area include double-crested cormorant, great blue heron, ring-billed gull, wood ducks, bufflehead, ring-necked duck, and lesser scaup.

An April 2010 review of the TVA Natural Heritage database indicated that six caves are reported in the region. No caves occur on the MSR study area. No unique terrestrial habitats were observed on these tracts during field investigations associated with bat surveys (Fiedler et al. 2007).

3.14.3 Terrestrial Endangered and Threatened Species

3.14.3.1 Vegetation

An April 2010 review of the TVA Natural Heritage database indicated that there are no federally listed plants on the MSR study area; however, one federally listed as threatened plant, the lyrate bladderpod, is reported from Colbert County, Alabama. Habitat to support populations of this federally listed plant does not occur within or adjacent to the MSR study area. Six state-listed plants are known to occur within 5 miles of the MSR study area (see Table 3-18). Two of these, Dutchman's breeches and false rue-anemone, are known to occur on the Reservation but not within the MSR study area. Descriptions of these plant species and their habitats are provided below.

Table 3-18. Species of Conservation Concern Within 5 Miles of the Muscle Shoals Reservation and Federally Listed Species Known to Occur in Colbert County, Alabama

Common Name	Scientific Name	Alabama Status (Rank)	Federal Status
Alabama lipfern	*Cheilanthes alabamensis*	SLNS (S3)	-
Blue-eyed Mary	*Collinsia verna*	SLNS (S1)	-
Dutchman's breeches	*Dicentra cucullaria*	SLNS (S2)	-
False rue-anemone	*Enemion biternatum*	SLNS (S2)	-
Lyrate bladderpod	*Lesquerella lyrata*	SLNS (S1)	LT
White trout-lily	*Erythronium albidum*	SLNS (S1S2)	-
Yellowwood	*Cladrastis kentukea*	SLNS (S3)	-

- = No Protection
Federal status abbreviation: LT = Listed threatened
State status abbreviation: Alabama does not give status to state-listed species; SLNS = No state status
State rank abbreviations: S1 = Critically imperiled, often with five or fewer occurrences; S2 = Imperiled, often with less than 20 occurrences; S3 = Rare or uncommon, often with less than 80 occurrences; S4 = Apparently secure in the state with many occurrences; S#S# = Occurrence numbers are uncertain

Lyrate bladderpod is a member of the mustard family and federally listed as threatened. This species is endemic to two counties in northeast Alabama where it grows in gladelike habitat that exhibits various levels of disturbance, including unimproved pastures, fallow or cultivated fields, and roadside rights-of-way (USFWS 1990). Habitat capable of supporting this species does not occur within the MSR study area.

Dutchman's breeches occurs at the edge of its range in north Alabama. Populations in and around the MSR study area are frequently encountered. This species is a member of the poppy family. It is known to occur in the Old First Quarters SWA on the Reservation north of Reservation Road but outside the MSR study area.

False rue-anemone, a member of the buttercup family, is a northern species that reaches the limit of its range in north Alabama. It often is found growing with Dutchman's breeches in rich woods and coves. Habitat capable of supporting this species does occur within the Reservation proper but has not been reported within the MSR study area.

3.14.3.2 Wildlife

An April 2010 review of the TVA Natural Heritage database indicated that there are no records of federally or state-listed terrestrial animals within the MSR study area. However, TVA field surveys revealed that the federally listed Indiana and gray bats could occur in or near the proposed project area (see more information below). Two other federally listed species and one federally protected species are recorded from Colbert County, Alabama. These are the gray bat, red-cockaded woodpecker, and bald eagle (see Table 3-19). Within a 3-mile radius, there is a record of one Alabama state-listed species (Table 3-19). Some species identified as having conservation concern occur in the MSR study area (Mirarchi 2004). These animals of conservation concern, which include 2 federally endangered bats, are denoted in Tables O-1, O-2, and O-3 in Appendix O. Most of these species have no official status; however, two species, the gray and Indiana bats, are federally listed. No designated critical habitat for any federally listed species occurs within the study area.

Table 3-19. Protected Terrestrial Animals in the Vicinity of the Muscle Shoals Reservation Study Area

Common Name	Scientific Name	Alabama Status	Federal Status
Alligator snapping turtle*	*Macrochelys temminckii*	PROT	-
Red-cockaded woodpecker	*Picoides borealis*	PROT	END
Bald eagle	*Haliaeetus leucocephalus*	PROT	Federally Protected
Gray bat	*Myotis grisescens*	PROT	END
Indiana bat	*Myotis sodalis*	PROT	END

- = No Protection
Federal status abbreviation: END = Endangered
State status abbreviation: PROT = Protected
* Record is considered unreliable (Jim Godwin, aquatic biologist, Alabama Natural Heritage Program, personal communication, April 2009)

Alligator snapping turtles require large aquatic features such as rivers and reservoirs. Suitable habitat for this species does not occur within the MSR study area.

Red-cockaded woodpeckers form colonies in mature pine, or pine-oak savannahs, with an open understory. These areas are usually maintained by frequent landscape disturbance (i.e., fire). No such habitat was found within the project area. The species historically occurred in Colbert County in 1890. Red-cockaded woodpeckers are now considered extirpated from northern portions of Alabama.

Bald eagles roost and nest in forested habitat near large bodies of water such as rivers and reservoirs. This species nests along the Tennessee River on nearby Wheeler, Wilson, and Pickwick reservoirs. While numbers of breeding bald eagles continue to increase in the vicinity, densities of bald eagles are lower in the vicinity than in other portions of the Tennessee River Valley, especially on Guntersville and Kentucky reservoirs. Bald eagles are not known to nest within the MSR study area. A pair recently nested in the vicinity, below Wilson Dam. This species is observed regularly foraging in the tailwater of Wilson Dam during winter months.

Gray bats roost in caves year-round and migrate between summer and winter roosts during spring and fall. Five gray bat caves occur within 10 miles of the project area. These are Collier Cave (4.7 miles), Key Cave (6.5 miles), McKinney Cave (7.4 miles), Baker Cave (8.0 miles), and Bat Cave (8.6 miles). Gray bats are locally common in the area and forage regularly over nearby Wheeler, Wilson, and Pickwick reservoirs and associated tributaries. Results of mist-net surveys show that this species forages through stream and road corridors within the MSR study area. No caves were found in the project area during field investigations, and no evidence of roosting bats was found in abandoned buildings on site (Figure 3-27). Gray bats use the project area for foraging, and an abundance of foraging habitat occurs locally and in the surrounding landscape.

Indiana bats hibernate in caves and form roosts in mature forests with open understories, available roosts, and nearby water sources. Historical records were reported from Saltpeter Cave (20 miles away and now underwater) and an abandoned chalk mine (26 miles west of MSR). Recent investigations by researchers at Auburn University did not find Indiana bats in the chalk mine. Although no caves suitable for hibernating bats were found during field investigations, forested habitat in the MSR study area potentially provides suitable foraging and summer habitat for this species. Habitat suitability assessments and mist-net surveys were performed throughout the MSR study area. No Indiana bats were captured during mist-net surveys, and all forested habitat sample points ranked as low quality for Indiana bats (Figure 3-27). Therefore, this species is very unlikely to use habitat within the project area.

3.15 Natural Areas

Natural areas include TVA- and non-TVA-managed areas, ecologically significant sites, and Nationwide Rivers Inventory (NRI) streams. Managed areas include lands held in public ownership that are managed by an entity (e.g., TVA, USDA, USFS, State of Tennessee, Colbert County) to protect and maintain certain ecological and/or recreational features. Ecologically significant sites either are tracts of privately owned land that are recognized by resource biologists as having important environmental resources or are identified tracts on TVA lands that are ecologically distinct in attributes or character but are not specifically managed by TVA's Natural Areas Program. NRI streams are free-flowing segments of rivers recognized by the U.S. National Park Service (USNPS) as possessing outstandingly remarkable natural or cultural values. There are no NRI streams or Wild and Scenic Rivers within 3 miles of the MSR study area.

Fourteen formally designated natural areas occur within 3 miles of the MSR study area (Figure 3-29). Of the 14, six are located on or immediately adjacent to the MSR study area. The Muscle Shoals National Recreational Trail (also known as Reservation Road Trail) and an associated trail complex border Reservation Road and also occur partially within the MSR study area. The Tennessee River/Wilson Dam NEP, the Wilson Dam Tailwater Restricted Mussel Harvest Area, and the Trail of Tears National Historic Trail are located immediately adjacent to and north of the phosphate slag storage area, which is within the scope of the MSR study area. The Old First Quarters SWA and the Potential National Natural Landmark (PNNL) are located on the MSR immediately adjacent to and north of the Multipurpose Building Complex, but are outside the MSR study area. The objective of the USNPS National Natural Landmarks (NNL) Program is to identify and recognize nationally significant natural areas throughout the U.S. and to encourage their continued preservation. Additional information is available at http://www.nature.nps.gov/nnl/.

Muscle Shoals National Recreational Trail (Reservation Road Trail) Complex is a 15-mile loop greenway urban trail/bikeway for public use located on part of the MSR, largely north of Reservation Road, in Lauderdale and Colbert counties. It is a designated National Recreation Trail System Trail (Sabrina L. Melton, recreation specialist, TVA, personal communication, July 13, 2011; National Recreation Trails Program 2009) and connects numerous historical sites on the Reservation while not infringing upon them (see Section 3.16). Buildings and structures dating to the early 1900s, which were part of the war effort, are featured and accessible by the trail. The two trails built by the CCC in the 1930s, the Rockpile Hiking Trail and the Old First Quarters SWA Trail, contain a historic aspect of the Muscle Shoals National Recreation Trail Complex. These trails exhibit stone stairs, erosion-control check dams, small footbridges, and benches built by the CCC. An informal forest/wetland trail complex used for interpretational nature walks adjacent to and south of Reservation Road and east of Hatch Boulevard is located in the southwest quadrant of the MSR study area. The Rockpile and Reservation Road trails are designated as part of the northwest loop of the North Alabama Birding Trail.

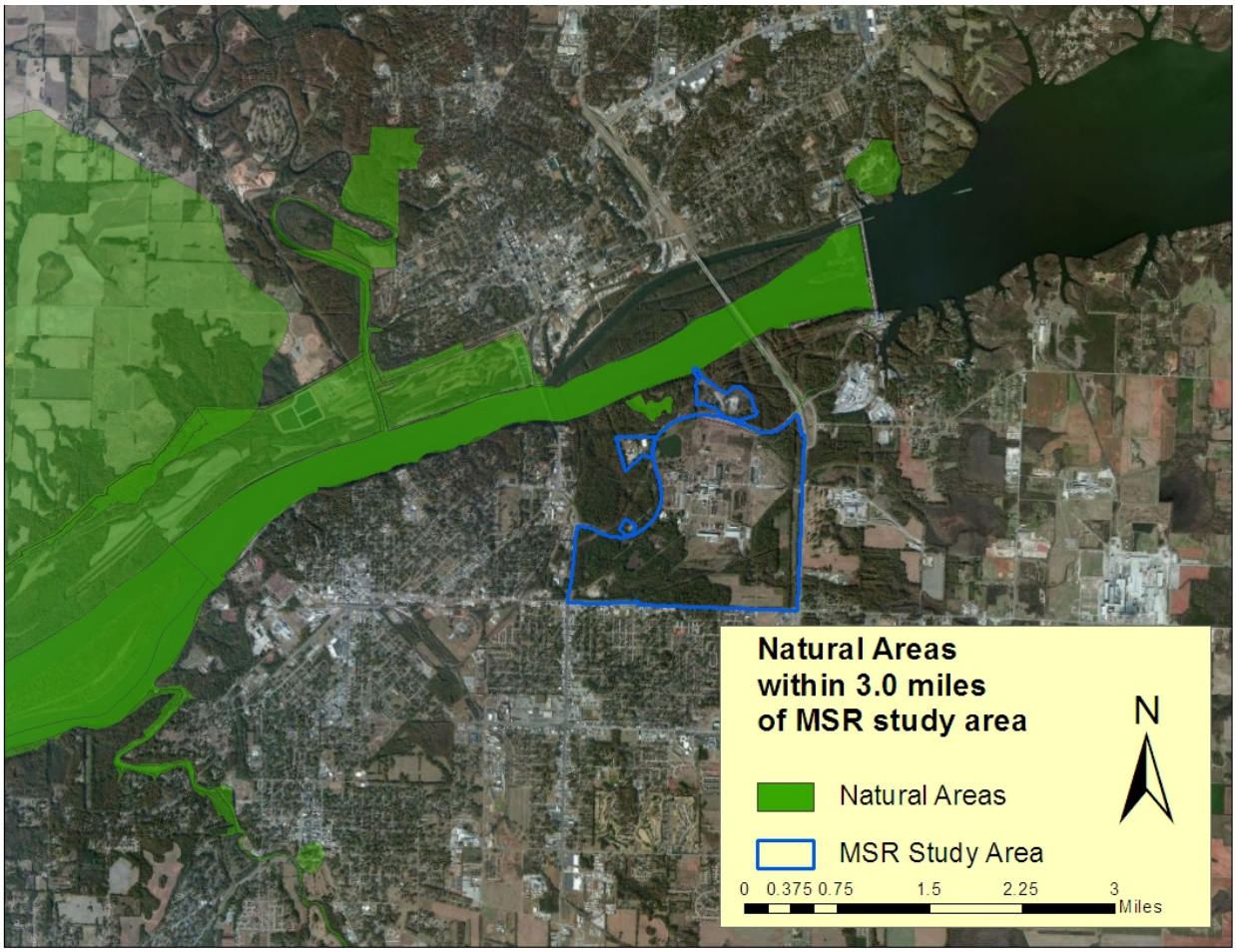


Figure 3-29. Natural Areas Occurring Within 3.0 Miles of the Muscle Shoals Reservation Study Area

The Tennessee River/Wilson Dam NEP is a specific reach (or stream segment) of the Tennessee River extending from the base of Wilson Dam at TRM 259.4 to the backwaters of Pickwick Reservoir at TRM 246. It includes the lower 5 river miles of all tributary streams

that enter the Wilson Dam tailwater. This segment of the river, located in both Lauderdale and Colbert counties, has been designated by the USFWS for reintroduction of 16 federally listed as endangered mussels and one federally listed as endangered aquatic snail into historical habitat in this and other such reaches of the river.

Wilson Dam Tailwater Restricted Mussel Harvest Area is a section of Pickwick Reservoir that is designated and managed by Alabama Department of Conservation and Natural Resources (ADCNR) Division of Game and Fish. The taking, catching, killing, or any attempt to take, catch, or kill freshwater mussels is prohibited in this area. This restricted area is located in Lauderdale and Colbert counties in Alabama and extends from Wilson Dam downstream to the upper end or head of Seven Mile Island.

Trail of Tears National Historic Trail was designated by the USNPS to commemorate the 1838 historic passage of thousands of Cherokee Indians from their homelands in the Southeast to Indian Territory in the West to what is now Oklahoma. Many Cherokee people perished during this journey. There are land and water components of the trail crossing through north Alabama in Colbert and Lauderdale counties. The water component used by the Cherokees to canoe is located on Pickwick Reservoir/Tennessee River immediately north of the phosphate slag storage area. The land component of the trail is located approximately a mile north of Muscle Shoals/Wilson Dam Reservation across Pickwick Reservoir (Tennessee River).

Old First Quarters SWA and PNNL is an area with exceptional natural, scenic, and aesthetic qualities featuring a trail for public use that is part of the trail complex located on Muscle Shoals/Wilson Dam Reservation north of Reservation Road. This 25-acre SWA and PNNL features spring wildflower displays, foot trails, an intermittent stream, wooden bridges, and scenic bluffs overlooking Pickwick Reservoir, and historic stone stairs and check dams built by the CCC in the 1930s. This area is under consideration by the USNPS for designation as an NNL to recognize the national importance of this natural area.

Muscle Shoals National Heritage Area (NHA) includes six counties in northwestern Alabama designated in 2009 as an NHA. This NHA includes Colbert and Lauderdale counties. NHAs are designated by Congress for natural, cultural, historic, and recreational resources and intended to encourage historic preservation and appreciation of the history and heritage of the area. The MSR study area is within the boundaries of the Muscle Shoals NHA. There are currently 49 NHAs throughout the U.S. The local coordinating entity for the NHA is the Muscle Shoals Regional Center, located at the University of North Alabama in Florence.

Eight additional formally designated natural areas occur within 3 miles of the Reservation. McFarland Park is located approximately 0.5 mile northwest of the Reservation across Pickwick Reservoir. Veterans Park is located approximately 1.3 miles northeast of the Reservation across Wilson Dam and Reservoir. The Seven Mile Island State Wildlife Management Area (WMA) is located approximately 1.5 miles west of the Reservation. Florence Municipal Park and Wildwood Park are located approximately 1.8 and 2.1 miles, respectively, northwest of the Reservation across Pickwick Reservoir. Key Cave Aquifer Hazard Area is located approximately 2.6 miles west, and Tuscumbia Spring PNNL is located approximately 2.8 miles southwest of the Reservation. Coffee Bluff TVA Habitat Protection Area (HPA) is located approximately 3.0 miles to the west of the Reservation.

McFarland Park is a 327-acre public park located along the north side of the Tennessee River in Lauderdale County and is host to numerous festivals and special events. This park

is managed by the City of Florence Parks and Recreation, and it features playgrounds, lighted walking trails, a floating restaurant, lighthouse, beach area, picnic tables, boat slips, boat ramp, and camping facilities.

Veterans Park is a 95-acre public park located across the Tennessee River on Wilson Dam Reservation lands in Lauderdale County adjacent to Wilson Dam. This park is owned by TVA and managed by the City of Florence Parks and Recreation under a permanent recreation easement. It features playgrounds, tennis courts, softball fields, picnic shelters, a disc golf course, and campsites.

Seven Mile Island State WMA is approximately 4,700 acres of public land in Lauderdale County that consists of a maze of islands, shallow water, sloughs, wetlands, swamps, riverine forests, cliffs, caves, agricultural lands, and reverting agricultural lands. This WMA is owned by TVA but is under easement to and managed by ADCNR Division of Game and Fish for waterfowl hunting and other recreational activities such as hiking and camping.

Florence Municipal Park is an approximate 72-acre public park located in Lauderdale County that features picnic facilities and a skate park. This park is managed by the City of Florence Parks and Recreation.

Wildwood Park is an approximate 286-acre park located in Lauderdale County that features picnic tables, nature trails, pavilions, mountain biking trails, and a canoe and kayak ramp. This park is managed by the City of Florence Parks and Recreation.

Key Cave Aquifer Hazard Area consists of approximately 2,300 acres of hardwood forests, croplands, and sinkholes surrounding Key Cave that acts as an aquifer recharge area. The area's sinkholes are an integral component of groundwater recharge to the caves. The area directly north of Key Cave was identified as a potential high hazard risk area for contaminants released to the groundwater. Within this large area is Key Cave National Wildlife Refuge (NWR) managed by USFWS in cooperation with TVA. This refuge consists of 1,047 acres of land and contains designated critical habitat for federally listed Alabama cavefish (*Speoplatyrhinus poulsoni)* and a priority-one maternity cave for the federally listed gray bat. Priority-one caves are considered major hibernacula, the most important maternity colonies for these bats. Another cave present in the vicinity, approximately 1.5 miles northeast of Key Cave, Collier Cave, provides habitat for these endangered species as well. This area also supports Neotropical migratory birds, raptors, white-tailed deer, wild turkey, and other wildlife. Both caves are on the northern shore of Pickwick Reservoir in a limestone karst area that contains several sinkholes and underground cave systems. Other activities on these areas include wildlife observation, hiking, photography, and hunting. Entry into the caves for research is by permit only.

Tuscumbia Spring PNNL is a geological feature consisting of a cave spring that provides habitat for the Tuscumbia darter (*Etheostoma tuscumbi*a). This spring-dwelling darter, endemic to the Tennessee River drainage, has become extinct in Tennessee. It remains in only three Alabama springs. The NNL Program was established in the 1970s by the USNPS to identify nationally significant examples of ecologically pristine or near pristine landscapes or other unique natural features. This feature, while meeting the criteria for listing, has not yet been registered as an NNL.

Coffee Bluff TVA HPA consists of approximately 250 acres of land along Pickwick Reservoir that features bluffs, waterfalls, caves, ravines, scenic views, and a variety of plant life and wildlife. Key Cave and Collier Cave are located within the HPA. This HPA, located

to the south of the Key Cave Aquifer Hazard Area, serves as a buffer for Key Cave and Collier Cave located there.

Other naturally appearing landscapes and research areas, which occur within portions of the MSR study area proposed for redevelopment, include the following: native grass plots south of Reservation Road and east of the water supply reservoir, forested and other types of wetland areas, an informal trail complex located in the southwestern corner of the redevelopment property, forested areas throughout the Reservation, and TACF Research Orchard (see Section 3.14.1) located on the eastern portion of the property parallel to Wilson Dam Road (SR 133). The native grass plots, forested areas containing informal trails, and TACF Research Orchard provide wildlife habitat as well as additional recreational and research opportunities for the public. These areas, within the MSR study area, were all substantially previously disturbed by land uses from the industrial and other supporting activities and programs of TVA and others. These lands, which have been managed by TVA over the years, provide a variety of services from aesthetically pleasing ornamental trees and forests to large areas of mowed and maintained grassland (see Sections 3.7 and 3.14).

3.16 Recreation

The Muscle Shoals/Wilson Dam Reservation and vicinity is a regionally significant recreation and open space resource that attracts users from within and outside of the Shoals communities and Colbert and Lauderdale counties area. Recreational use opportunities on the Reservation, largely outside the MSR study area and north of Reservation Road, include walking, jogging, bicycling, hiking, fishing, power and nonpower boating, wildlife and nature observation, and picnicking (see Sections 3.14.2 and 3.15). Recreational facilities and popular features available to the public on or in the vicinity of the larger 3,000-acre Muscle Shoals/Wilson Dam Reservation are described in Section 3.15.

The Muscle Shoals National Recreational Trail (Reservation Road Trail) Complex, designated as a National Recreation Trail by the Secretary of the Department of the Interior, includes a total of approximately 15 miles of trails (Sabrina L. Melton, recreation specialist, TVA, personal communication, July 13, 2011; National Recreation Trails Program 2009). Major elements of the complex include an 8-mile-long paved trail, designed to accommodate walking, jogging, and bicycling, that generally parallels Reservation Road and approximately 7 miles of unpaved foot trails. Unpaved foot trails include the Rockpile Hiking Trail that parallels the Tennessee River (Wilson Dam tailwater), the Southport Historical Trail, the Old First Quarters SWA Trail, and an exercise trail. Both the Rockpile and Old First Quarters SWA trails were originally built by the CCC in the 1930s. A central parking area and restrooms have been built at the trailhead by TVA to accommodate users of the trail complex. Although the trail complex on the Muscle Shoals/Wilson Dam Reservation carries the National Recreation Trail designation, its continuing management and maintenance are the responsibility of TVA. It is estimated that the trail complex receives 35,000 visits annually (National Recreation Trails Program 2009) (Figure 3-30).

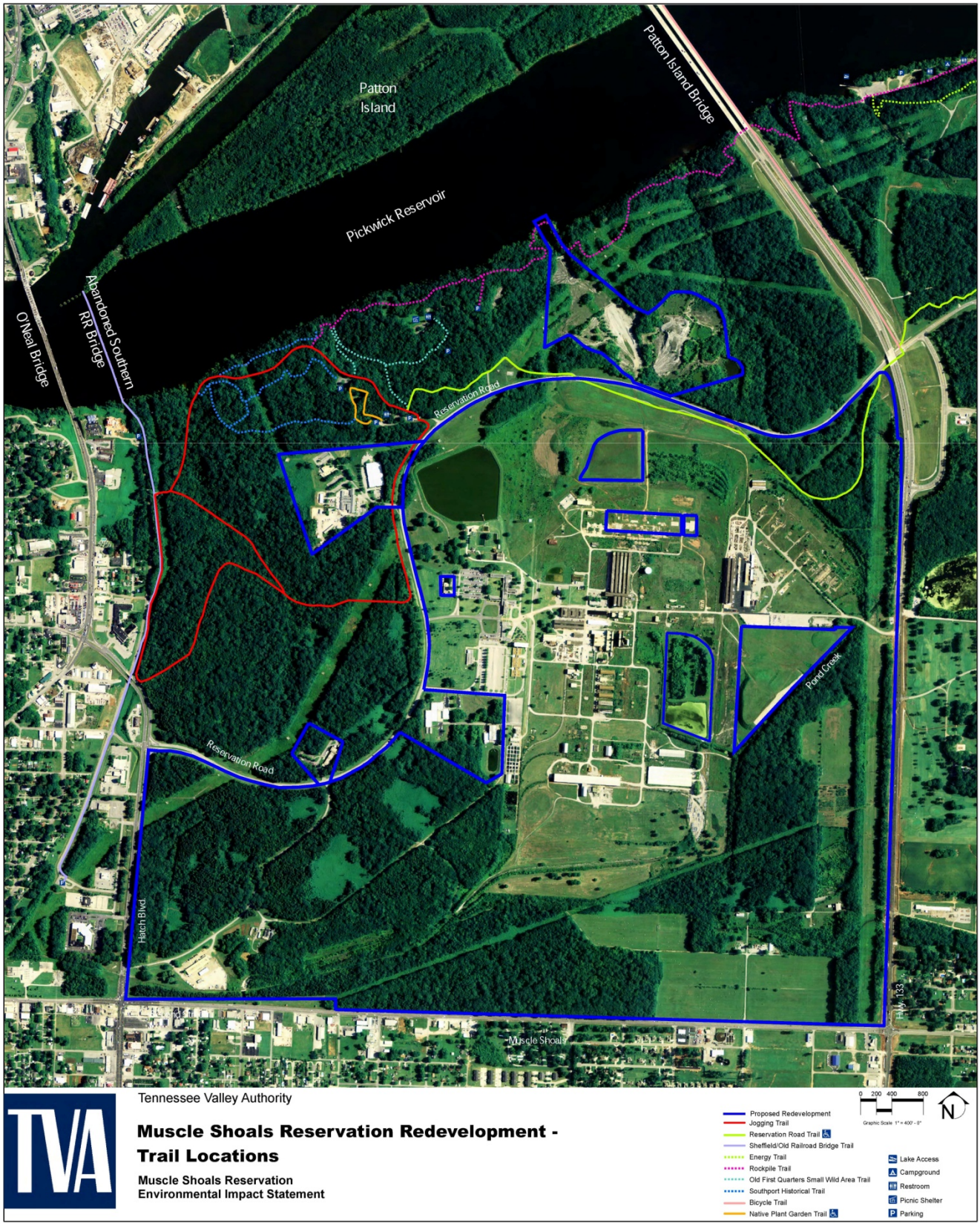


Figure 3-30. Trail Locations in the Vicinity of the Muscle Shoals Reservation Study Area

The Muscle Shoals Trail Complex also connects to a network of off-reservation trails. It connects and enhances the City of Sheffield's Rails to Trails project on the south side of the Tennessee River and the City of Florence's River Heritage Trails on the north side. These trails are linked by a pedestrian/bikeway crossing of the river via the Patton Island Bridge (also known as Singing River Bridge). Combined, these trails make it possible to travel by nonmotorized means to and from several locations in the Florence, Muscle Shoals, and Sheffield communities.

The importance of the trail system as a recreation resource is likely to increase in the future. Based on public surveys conducted as part of the 2008-2012 Alabama Statewide Comprehensive Outdoor Recreation Plan, walking for pleasure is the most popular outdoor recreation activity among Alabama residents. Survey results also indicate the demand and need for additional trails to accommodate walking, hiking, and bicycling are increasing statewide as well as within the state planning region that includes the MSR study area.

While the majority of MSR recreational use takes place north of Reservation Road and outside the boundaries of the proposed MSR study area, sections of two trails, which are part of the National Recreation Trails Complex, are located within this area. These include two segments of the paved walk/bike trail along Reservation Road and a section of the Rockpile Hiking Trail along the Tennessee River.

The 1-mile segment of the trail complex is part of a 2.2-mile trail extension completed at its present location just south of and along Reservation Road in 2003. The project was accomplished with monies contributed by an FHWA transportation project enhancement grant administered by ALDOT in 2001 (Agreement for a Transportation Enhancement Project between the State of Alabama and Tennessee Valley Authority, Colbert County, Reservation Road Bike/Pedestrian Trail Project No. STPTE-TE01[918], TVA Contract No. 00004014). Based on this agreement, no change in use or ownership of real property acquired or improved with funds provided under the terms of this agreement will be permitted without written approval from ALDOT and FHWA.

In addition, the portion of the proposed redevelopment area located north of Reservation Road and fronting the Multipurpose Building complex includes a 900-foot section of the original paved trail constructed by TVA in the 1970s. The trail is located between Reservation Road and the existing buildings within the complex.

As previously mentioned, the Rockpile Hiking Trail parallels the Tennessee River where a 300-foot section could be crossed by construction associated with the utility corridor (in the vicinity of the slag storage area) such as a water intake or gas pipeline. This section of the trail, which is used heavily for shoreline fishing and by hikers, crosses an inlet via a concrete skimmer wall constructed as part of the old Wilson power plant facility (see Figure 3-30).

Some informal recreation use also occurs on the MSR study area south of Reservation Road within the proposed redevelopment area (see description of naturally appearing landscapes in Section 3.15). In particular, some of the land and old abandoned road networks located on the southwestern part of the Reservation (roughly defined as the area bounded by Second Street on the south, the TVA Customer Service Center on the west, Reservation Road on the north, and the International Fertilizer Development Center on the east) are used for walking and jogging. In addition, nature observation is common in this area. During the fall months, the area attracts small groups of bird watchers from Alabama, Georgia, and Tennessee (see description of seasonal birdlife use of the southwest portion

of property in Section 3.14.2). The location of this informal recreational use area and the trail segments located within the MSR study area are shown in Figure 3-30.

Wilson Dam Reservation, approximately 400 acres of land, which adjoins the northeastern boundary of the MSR, lies on both sides of the Tennessee River at Wilson Dam. This area serves primarily to protect the integrity of the dam itself while also affording recreational use to the public. It also includes recreation facilities developed and maintained by TVA. Veterans Park, on the north side of the river and under a permanent recreation easement to the City of Florence, occupies a portion of this reservation.

In addition to portions of the paved trail and the eastern section of the Rockpile Hiking Trail, Wilson Dam Reservation south of the river includes the Rockpile Recreation Area that provides for overnight camping and day use activities, including bank fishing. A boat launching ramp provides access to the river (Wilson Dam tailwater). There is also a boat launching ramp in Fleet Hollow on the eastern edge of Wilson Dam Reservation that provides access to the waters above Wilson Dam. These facilities are located outside of the proposed MSR study area.

The Tennessee River (Wilson Dam tailwater) that defines the northern boundary of the MSR is also a highly valuable recreation resource. Its waters receive heavy boating and bank fishing use, and the area is a renowned recreational fishery. Based on recreation use data collected in 2002 as part of TVA's *Reservoir Operations Study*, the Wilson Dam tailwater receives an estimated 169,000 recreation visits annually (TVA 2004).

3.17 Transportation

This section describes the highway transportation network, traffic counts, and levels of service (LOS) in the vicinity of the MSR study area. As previously stated, the MSR study area is located in Colbert County, Alabama, near the cities of Muscle Shoals and Sheffield and is bounded generally by Wilson Dam Road to the east, Second Street to the south, Hatch Boulevard to the west, and Reservation Road to the north (see Section 1.5).

3.17.1 Data Collection

Data collection included an analysis of historical traffic counts conducted by ALDOT, counts of turning movements at nine intersections near the MSR study area, and reviews of the roadway characteristics. Planned transportation projects in the immediate vicinity were also considered. The analysis focused on two different types of traffic counts—annual average daily traffic (AADT) counts and peak period turning movement counts. AADT counts are reported annually by ALDOT. The transportation study area includes the MSR study area, and all traffic counts locations are indicated on Figure 3-31.

Roadway Inventory

An inventory was conducted to determine various existing roadway characteristics, including lane configurations at each intersection and the type of traffic control (i.e., traffic signal, stop sign, yield sign, free flow).

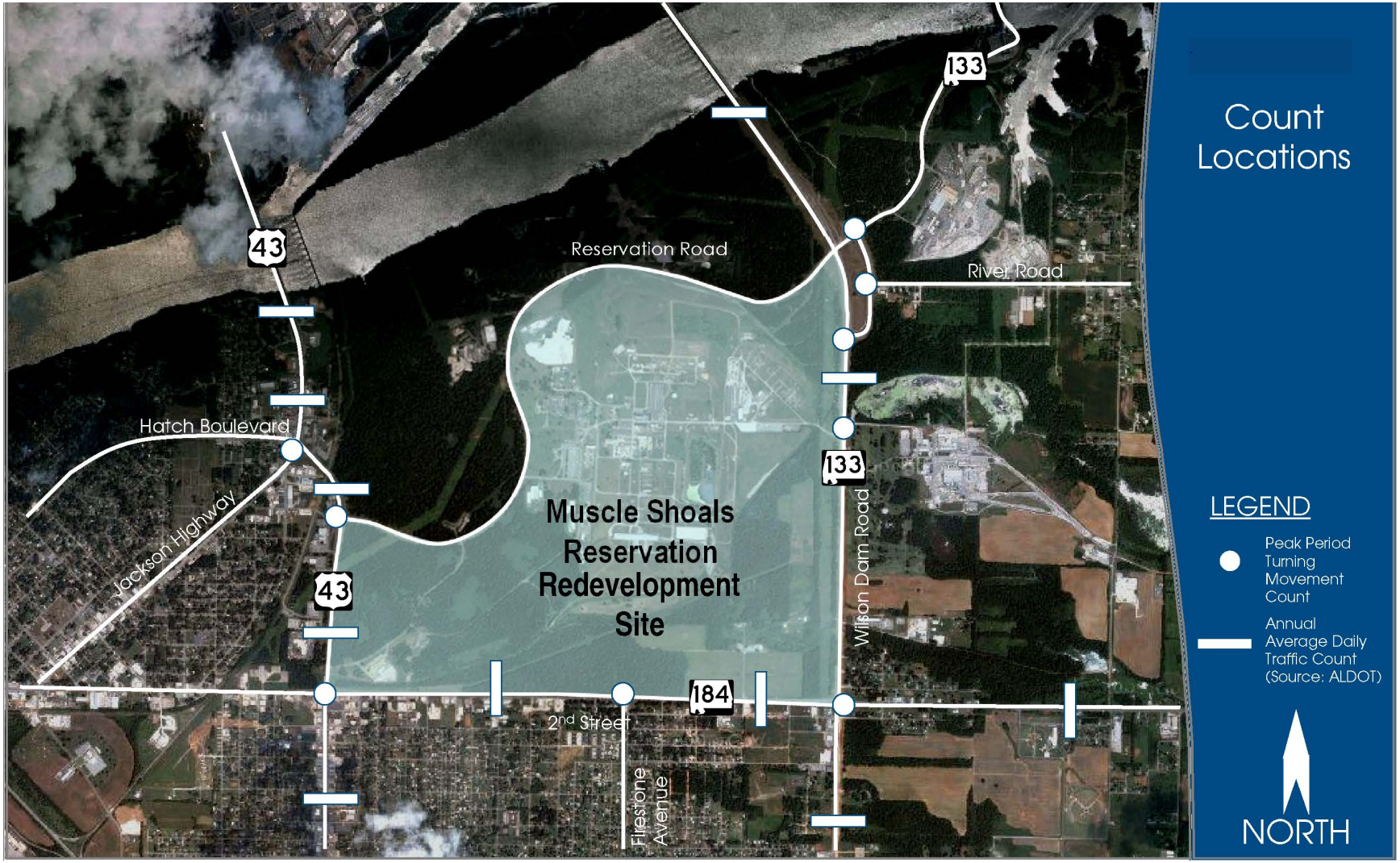


Figure 3-31. Transportation Study Area and Count Locations

Hatch Boulevard – This roadway consists of two major segments, one that travels north-south bordering the west side of the MSR study area and one that is primarily east-west beyond its intersection with Jackson Highway (see Figure 3-31). Through its north-south alignment, Hatch Boulevard is an urban principal arterial where a four-lane divided section is utilized with an AADT of 26,000 vehicles per day. The speed limit is posted at 45 miles per hour. This segment of Hatch Boulevard carries the US 43 and US 72 route designations. On the east-west segment, Hatch Boulevard is a two-lane urban minor arterial with a posted speed limit of 35 miles per hour. A challenge to motorists on Hatch Boulevard is associated with its alignment at the intersection with Jackson Highway, where the east-west segment transitions into the north-south segment. Traffic movement at this intersection is controlled by traffic signals and southbound through-vehicles following the US 43/72 route designation are forced to make a left turn. Likewise, northbound through-vehicles wishing to stay on the US 43/72 route designation must make a right turn. Forcing a large majority of vehicles into turning at this intersection causes congestion problems.

US 43/72 – While the US 43/72 route designation is placed on Hatch Boulevard through the majority of the transportation study area, there is another US 43/72 segment in the northwest corner. This segment, between the Hatch Boulevard-Jackson Highway intersection and the Tennessee River, is an urban principal arterial utilizing a seven-lane section (six through-lanes and one two-way, left-turn lane). The AADT is about 42,000 vehicles per day near the O'Neal Bridge over the Tennessee River.

Wilson Dam Road – This roadway is a north-south urban minor arterial that forms the east boundary of the MSR study area. Wilson Dam Road was recently widened to a six-lane section with a center turn lane, serving an AADT between 10,000 and 14,000 vehicles per day. The speed is posted at 55 miles per hour. For the majority of the MSR study area, Wilson Dam Road carries the SR 133 route designation.

Second Street – This four-lane urban principal arterial travels east and west and forms the southern border of the MSR study area. The roadway serves between 9,000 and 14,000 vehicles per day with a posted speed limit of 45 miles per hour. Throughout the transportation study area, Second Street carries the SR 184 route designation.

Reservation Road – This road is a two-lane rural minor arterial that travels east to west within the MSR. On the east end of the site, it carries the SR 133 route designation. The posted speed limit is 45 miles per hour.

River Road – This road is a two-lane rural minor arterial that travels east to west east of the MSR study area. The posted speed limit is 45 miles per hour.

Firestone Avenue – This two-lane collector travels south to north. It is located south of the MSR study area. The posted speed limit is 25 miles per hour.

Jackson Highway – This roadway is a four-lane undivided urban minor arterial that travels southwest to northeast west of the MSR site. The posted speed limit is 45 miles per hour.

Background Traffic

Background traffic is defined as the traffic that would exist in the future regardless of whether the MSR study area is redeveloped or not. This was determined by using historical AADT counts conducted annually by ALDOT since 2000. Historical AADT counts

conducted in the vicinity of the MSR study area were used to determine historical traffic growth trends in the region. These trends were then analyzed to determine a reasonable and sustainable growth rate of 1.90 percent to forecast future traffic conditions regardless of whether the MSR study area is redeveloped (URS Corporation 2010). The 1.90 percent growth rate was applied to the existing traffic counts to determine conditions in the year 2035.

Existing Conditions

In order to determine a baseline of existing conditions in the MSR study area, an analysis of typical weekday peak hour congestion was conducted at the MSR study area intersections. Site-specific peak period turning movement counts were conducted. A count program for nine locations was developed to focus on those intersections most likely to be impacted directly by redevelopment at the MSR study area. Counts were conducted during a typical week (April 5-9, 2010) when local schools were in session. Each location was counted for a total of eight hours during three peak periods, i.e., 6:00 to 9:00 a.m., 11:00 a.m. to 1:00 p.m., and 4:00 to 7:00 p.m. The count data were analyzed to determine a number of important factors for the analysis including a.m. and p.m. peak hour turning movement counts, peak hour factors, and traffic distribution patterns.

The a.m. and p.m. peak period turning movement counts were summarized at each intersection to determine the peak hour turning movement traffic volumes within each peak period. The peak hour factor and peak hour truck percentages were collected from the turning movement counts. The peak hour factor was determined for each intersection turning movement and represents a ratio of traffic volume in the peak hour to the traffic volume in the peak 15 minutes. The peak hour truck percentage representing the ratio of heavy vehicles such as 18-wheel trucks and school buses (i.e., not pickup trucks) to all vehicles in the peak hour was also determined for each intersection turning movement.

The turning movement counts were also used to estimate the distribution pattern of traffic entering and leaving the MSR study area. This was determined by analyzing all eight hours of turning movement counts and determining the amount of vehicles entering and exiting the MSR study area at each study area entry/exit point relative to other entry/exit points. The resulting traffic distribution percentages, indicated in Figure 3-32, were applied within the project analysis to estimate the number of new vehicles that would be generated by each Action Alternative at each of the MSR study area intersections.

3.17.2 Level of Service Determination

Highway Capacity Manual (HCM) methodology (Transportation Research Board 2000) was followed to identify potential traffic flow problem areas in the vicinity of the MSR study area using the data described above in Section 3.17.1. The HCM provides a qualitative method to measure traffic flow and motorists perceptions of traffic flow. Six LOS are defined and given letter designations from A to F, with LOS A representing the best conditions (free flow) and LOS F representing the poorest conditions (severe congestion) as shown in Figure 3-33. The HCM defines LOS by type of intersection being analyzed, i.e., signal controlled (traffic light) versus unsignalized (stop or yield sign). The average control delay includes initial deceleration delay, queue move-up time, stopped delay, and final acceleration delay. LOS thresholds for unsignalized and signalized intersections are shown in Figure 3-33. Typically, LOS E and LOS F are defined as undesirable and indicate the need for transportation improvements. Nine intersections in the immediate vicinity of MSR were analyzed for LOS during a.m. and p.m. peak hours (see Table 3-20).

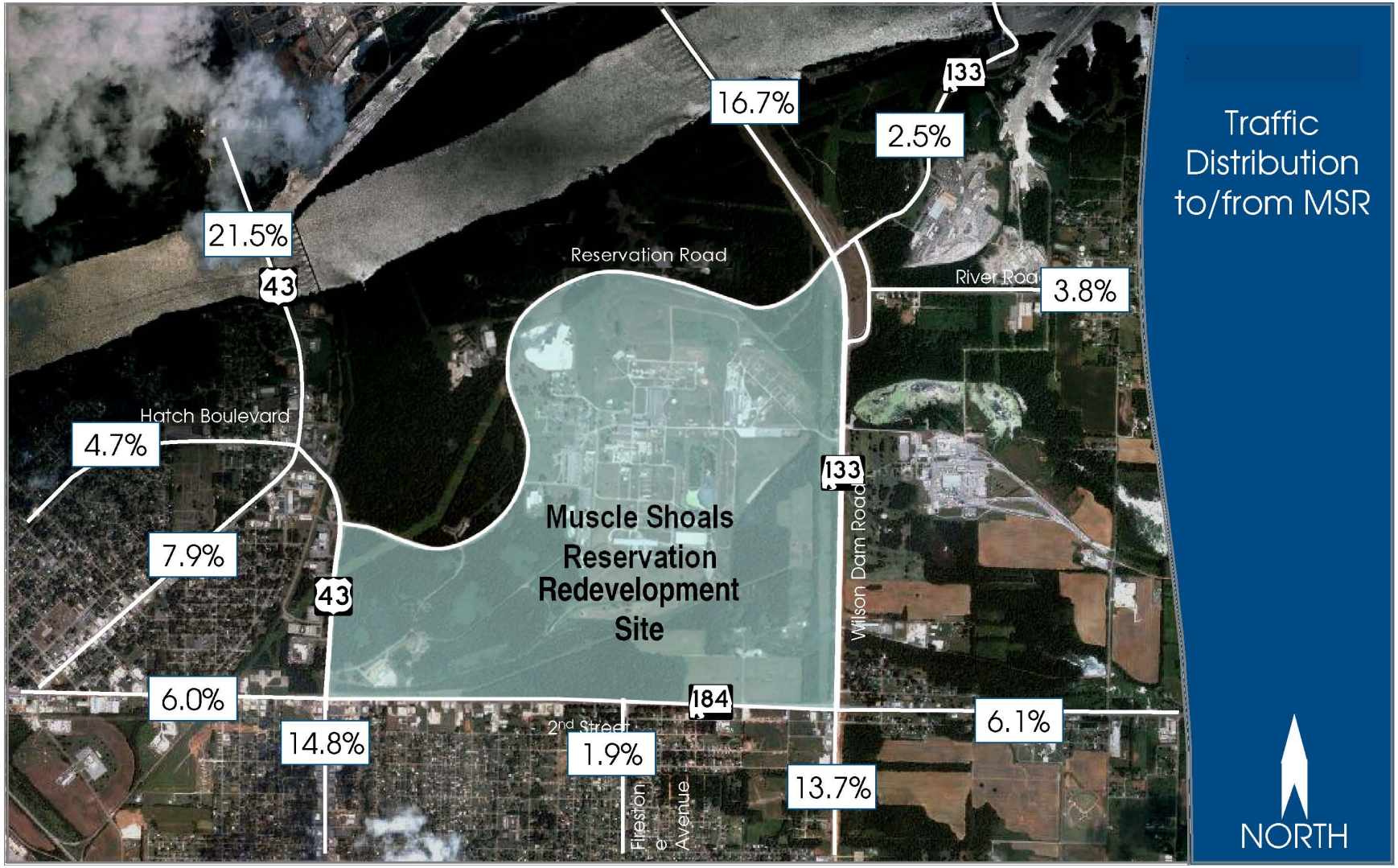
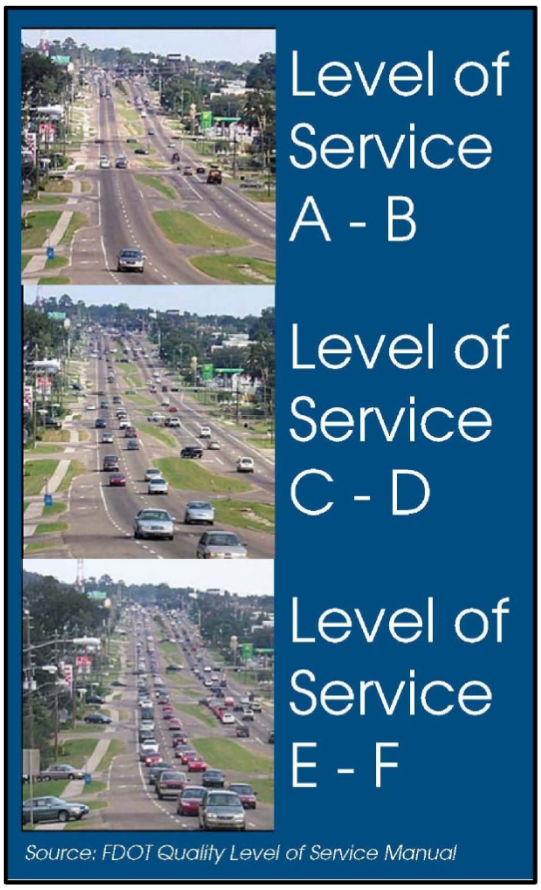


Figure 3-32. Traffic Distribution To and From the Muscle Shoals Reservation Transportation Study Area



LOS Thresholds for Unsignalized Intersections

Level of Service	Average Control Delay (sec/vehicle)
A	≤ 10.0
B	> 10.0 and ≤ 15.0
C	> 15.0 and ≤ 25.0
D	> 25.0 and ≤ 35.0
E	> 35.0 and ≤ 50.0
F	> 50.0

LOS Thresholds for Signalized Intersections

Level of Service	Average Control Delay (sec/vehicle)
A	≤ 10.0
B	> 10.0 and ≤ 20.0
C	> 20.0 and ≤ 35.0
D	> 35.0 and ≤ 55.0
E	> 55.0 and ≤ 80.0
F	> 80.0

Figure 3-33. Level of Service Designations

Table 3-20. Current Levels of Service for Intersections in the Vicinity of the Muscle Shoals Reservation

Location	A.M. LOS	P.M. LOS
Hatch Boulevard at Jackson Highway	C	**E**
Hatch Boulevard at Reservation Road	A	A
Hatch Boulevard at Second Street	C	B
Second Street at Firestone Avenue	B	B
Second Street at Wilson Dam Road	C	C
Wilson Dam Road at MSR Access	C	**E***
Wilson Dam Road at Access Road	A	A
Access Road at River Road	B	B
Access Road at Reservation Road	A	B

Bolded Letters representing LOS mean that improvements to the roadways are needed.
* No observations at this intersection indicate actual LOS E or F conditions; see text for explanation.

Overall, the results indicate minimal current congestion in the vicinity of the MSR study area. Two locations indicate LOS E conditions during the p.m. peak hour. The first location is at the intersection of Hatch Boulevard and Jackson Highway, where US 43/72 through-traffic is forced to turn right or left in order to stay on the US 43/72 route designation. The

congestion is caused primarily because these movements are the major movements at this intersection, and it is difficult for a traffic signal to provide enough green light time to process heavy turn volumes. The second intersection noted is the unsignalized access point to the MSR off Wilson Dam Road. As an unsignalized intersection, only the stop-controlled movement was analyzed (in this case, the eastbound movement). Despite relatively low volumes (10 vehicles turning left and 18 vehicles turning right), the analysis indicated LOS E conditions. This is due primarily to a limitation in the software analysis in which a constant flow of traffic is assumed on the major roadway, which results in few gaps for vehicles to turn. As a result, when unsignalized intersection results indicate LOS E or F conditions, field observations often indicate minimal, if any, congestion. No observations at this intersection indicate actual LOS E or F conditions.

3.18 Scenic Resources

Scenic resources are evaluated based on existing landscape character, positions and distances of available views, sensitivity of viewing positions (scenic visibility), human perceptions of landscape beauty/sense of place (scenic attractiveness), and the degree of visual unity and wholeness of the natural landscape in the course of human alteration (scenic integrity). A description of the “Scenic Value Criteria for Scenery Inventory and Management” is found in Appendix P.

Within the MSR study area, the landform slopes gently from the west, along Reservation Road, to the east at Pond Creek. There are varying types of vegetation, land uses, and aboveground construction within the MSR study area. All these elements may be considered both separately and as interrelated parts to characterize the landscape. These elements can affect how the landscape is perceived from specific viewing positions or as a whole. This perception can result in an association with the landscape, creating a sense of place.

In a broad context, the MSR study area may be classified into the following four landscape character types:

- Urban
- Rural
- Pastoral
- Naturally appearing

These landscape character types are expressed as a range from areas exhibiting dense human concentration or alteration (i.e., urban) to areas exhibiting predominantly natural qualities where human alteration may not be discernable (i.e., naturally appearing). The occurrence of these existing landscape character types across the site is shown in Figure 3-34.

Urban Landscape Character

The urban landscape character expressed within the MSR study area comprises about 605 acres (around 43 percent of the total acreage of the site). See Figure 3-35 for an example of this landscape character. These areas of urban landscape character include: (1) the USNP2 plant site, (2) the Western Area Radiological Laboratory building site, (3) the Multipurpose Building and Office Service Warehouse Annex Complex site, (4) the TVA Customer Service Center area, and (5) most of the phosphate slag storage area.

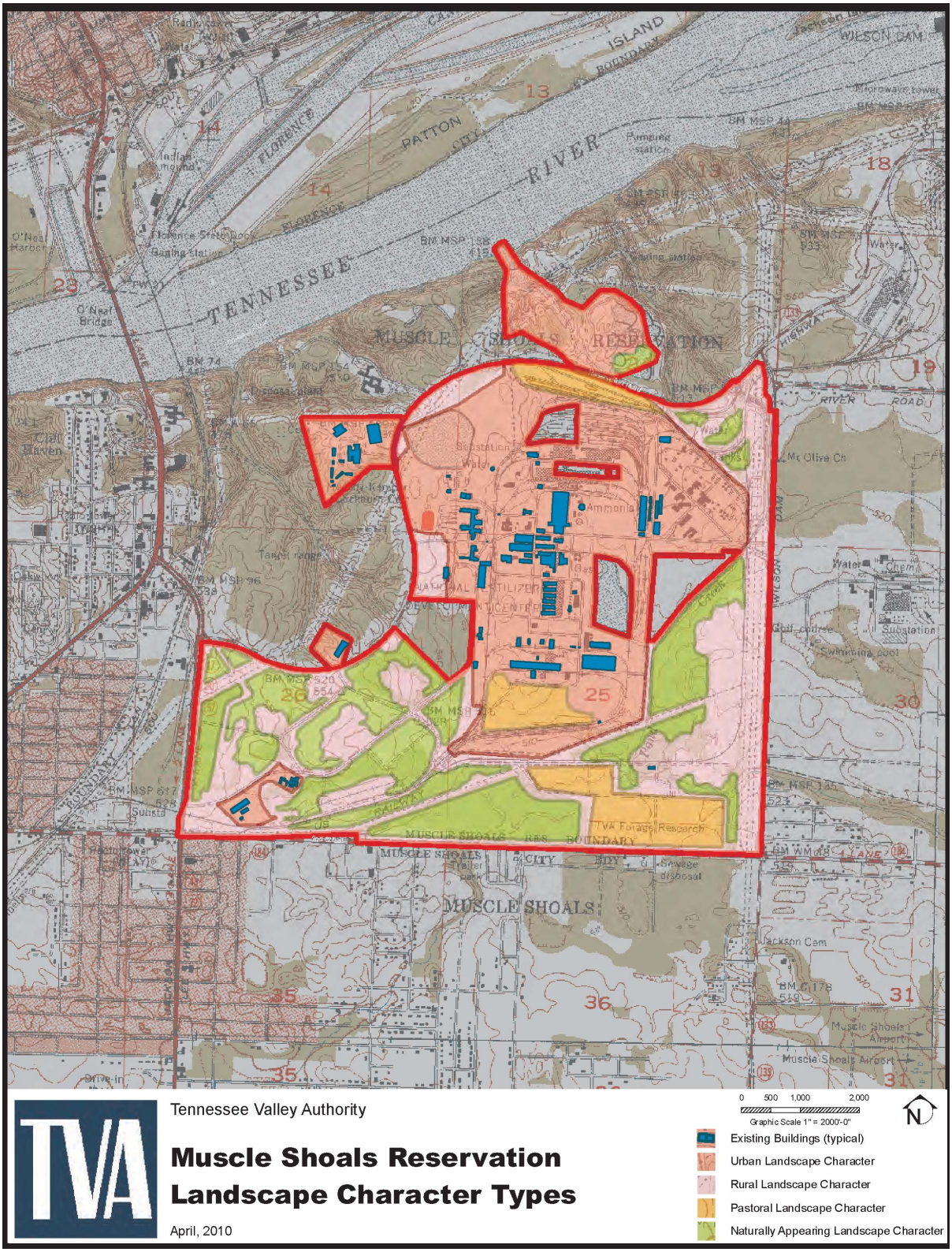


Figure 3-34. Landscape Character Types on the Muscle Shoals Reservation Study Area

Photograph taken by: Jon Riley, May 2009

Figure 3-35. Example of Urban Landscape Character on the Muscle Shoals Reservation Study Area

In these areas, scenic attractiveness is minimal. The landforms have been graded to relatively uniform slopes. Vegetation in these areas consists of maintained turf and landscape plantings or sparse groupings of emerging woody vegetation. The scenic integrity of these areas is generally very low. Landforms and vegetation patterns have been heavily altered, and the built environment dominates the landscape. The scenic visibility has a low sensitivity, due to restrictions on access for TVA project operations where the number of views are restricted to those who work at locations along Reservation Road and those who travel this two-lane road. Duration of view may vary between constituent groups and would be very low for passing motorists and much higher for employees. The viewing distance is restricted primarily to the foreground (up to 0.5 mile) viewing distance. These areas have a poor scenic value class.

Rural Landscape Character

Rural landscape character comprises approximately 415 acres of the MSR study area (approximately 30 percent of the total acreage). The rural landscape character of the study area is expressed as rights-of-way, thin bands of mature trees, lower areas near some portions of Pond Creek, and portions of the former construction village which have reverted to expanses of lower growing herbaceous vegetation (see Figure 3-36 for an example). Vegetation patterns are important features of this landscape character type. From positions outside the MSR study area, mature trees serve to screen views of the urban landscape character expressed to the interior of the site. The topography is gently sloping to flat, and vegetation patterns range from maintained turf and forest edges along some rights-of-way to moderately dense scrubby vegetation along portions of Pond Creek. The scenic attractiveness within these areas is common, and the scenic integrity is moderate.

Photograph taken by: Jon Riley, May 2009

Figure 3-36. Example of Rural Landscape Character on the Muscle Shoals Reservation Study Area

Generally, the scenic visibility is of moderate sensitivity. The number of viewers increases substantially to include motorists travelling Wilson Dam Road, Hatch Boulevard, and Second Street. Residents and employees of businesses located across these collector and arterial streets are also included in the expanded constituent viewer groups. Visitors to the Reservation for informal recreation add to the number of viewers in these areas (see Section 3.16). Frequency and duration of views within these constituent groups vary substantially. The viewing distance is varied, with some views restricted to the foreground viewing distance and some opening into the middleground (0.5 mile to 4 miles) viewing distance. The scenic value class for these areas is good.

Pastoral Landscape Character

The pastoral landscape character expressed within the boundary of the MSR study area comprises roughly 106 acres (approximately 7 percent of the total acreage). These areas are identifiable at the north of the MSR study area, along Reservation Road, at the south near the experimental farm area, and toward the southern portion of the USNP2 site. The topography of these areas has been uniformly graded, and the areas have been under cultivation for an indeterminate period of time. Vegetation consists of grasses and other lower-growing herbaceous material. Taller shrubs or trees may line the periphery of the pastoral fields near roadways, fences, streams, or where topography recedes to lower elevations and may be subject to inundation with water (see Figure 3-37 for an example). Scenic attractiveness is common, and scenic integrity is moderate to low. Due to the limited number of viewers and the frequency and duration of available views, scenic visibility for these areas has a moderate to low sensitivity. Viewing distance remains within the foreground viewing distance, as adjacent land uses and/or mature trees prevent views beyond 0.5 mile. The resulting scenic value class for these areas ranges from fair to good.

Photograph taken by: Jon Riley, May 2009

Figure 3-37. Example of Pastoral Landscape Character on the Muscle Shoals Reservation Study Area

Naturally Appearing Landscape Character

Areas expressing a naturally appearing landscape character show little evidence of human alteration (see Figure 3-38 for an example). These areas occur only where there are sufficient contiguous identical or similar landscape character types to firmly establish the naturally appearing context. Within the MSR study area, there are around 270 acres (20 percent of the total acreage) of areas exhibiting a naturally appearing landscape character. These naturally appearing landscapes occur primarily at the periphery of the property, away from the core of operations. Although crossed by rights-of-way and spotted with large areas of kudzu, the southwest corner of the Reservation contains much of the naturally appearing landscapes (also see Section 3.14). The composition of vegetation and the patterns of vegetation in the landscape are prominent features in the naturally appearing landscapes within the MSR study area. These areas separate and isolate views of other landscape character types expressed within the MSR study area. The topography in these areas is gently sloping, and the vegetation is dense, consisting of a variety of deciduous and evergreen trees, native and nonnative shrubs and small flowering trees, and a variety of herbaceous plants. Scenic attractiveness in these areas is common, and scenic integrity is generally high. Scenic visibility for the naturally appearing landscapes within the MSR study area is moderate to high. The number of available views within these segments of the MSR study area is low, although much of the area viewed from Hatch Boulevard and Second Avenue is of naturally appearing landscapes. The level of concern, i.e., how people feel about what they perceive is happening in their immediate environment, for these naturally appearing landscapes is moderate to high (see Scenic Visibility in Appendix P). Frequency and duration of views within these areas is generally low. The viewing distance is kept to the foreground viewing distance. The scenic value class for these areas is good.

Photograph taken by: Jon Riley, May 2009

Figure 3-38. Example of Naturally Appearing Landscape Character on the Muscle Shoals Reservation Study Area

Summary

The scenic value of the MSR study area, when considered as a whole, is defined by the existing landscape character and the context in which people view the landscape. Generally, the primary constituent viewer group consists of those who view the MSR study area in context with the adjacent urban and suburban development associated with the cities of Muscle Shoals, Sheffield, Tuscumbia, and Florence. This results in the perception of a rural to naturally appearing landscape character. Collectively, the scenic value class is good.

3.19 Navigation

Pickwick Reservoir was impounded by the construction of the Pickwick Landing Lock and Dam and was opened to commercial navigation in 1938. Additional improvements completed in 1948 provided a commercially navigable waterway upstream to Wilson Dam. Today, Pickwick Reservoir is an important link in the Tennessee River system, which provides 800 miles of slack-water navigation from Paducah, Kentucky, to Knoxville, Tennessee, and includes several navigable tributaries such as the lower Hiwassee and Clinch rivers. The Tennessee-Tombigbee Waterway enters Pickwick Reservoir at TRM 415.0. The Tennessee River Waterway is in turn linked to the 12,000-mile National Inland Waterway in several places and supports local, national, and international commerce. Approximately 54 million tons of commodities move on the Tennessee River system annually. On average, nearly 11.5 million tons of that traffic passes through Wilson Lock each year (USACE 2007). The Florence-Lauderdale County Port Authority, a major multimodal port, is located at TRM 256.5 on the right-descending riverbank. On average, over 270,000 tons per year of commodities are shipped into and out of the port, including goods such as corn, fertilizer, and aluminum (USACE 2007).

The MSR study area is located just downstream of Wilson Lock and Dam, on the south side of Patton Island and on the left-descending (south bank) bank of the Tennessee River. Wilson Main Lock is 110 feet by 600 feet. An Auxiliary Lock with two 60- by 360-foot chambers operates in tandem adjacent to the Main Lock. All commercial navigation traffic moving through this area uses the back channel of Patton Island, or “Florence Canal,” to access the lock. Florence Canal stretches from TRM 256.5 up to Wilson Lock at TRM 259.4 near the right-descending riverbank. The primary boat traffic on the south side of Patton Island, in the vicinity of the MSR study area, is recreational vessels (see Section

3.16). This portion of the river is immediately downstream of the spillways and hydroelectric generator discharge outlets of Wilson Dam.

3.20 Noise

Noise is normally described as continuous, intermittent, or impulsive. Continuous noise is produced by machinery that operates without interruption in the same mode (for example, blowers, pumps, and processing equipment). Intermittent noise occurs in cycles that increase or decrease rapidly with the duration of each cycle being measured. The noise from impacts or explosions (for example, pile drivers, punch presses, or gunshots) is called impulsive noise. Impulsive noise is brief and abrupt, and its startle effect causes greater annoyance than would be expected from a simple measurement of sound pressure level. Additionally, low-frequency noise has significant acoustic energy in the frequency range of 8 to 100 hertz (Hz). Noise in this range is typical for large diesel engines, trains, ships, and power plants. Because this noise range is hard to muffle, it spreads easily in all directions and can be heard for miles (Brüel and Kjær 2010).

Noise is usually measured in decibels (dB) on a logarithmic scale; therefore, increasing the noise level by 5 dB results in a noise level perceived by the human ear to be twice as loud as the original source. Noise frequencies below 500 Hz tend to be more disruptive with vibrations contributing to their effective range. Frequencies above 1,000 Hz tend to diminish more quickly with less disruptive effect (Cowan 1994).

Noise levels are also measured using an “A-weighted” version of the decibel scale. This scale closely follows the frequency response of sound detections by the human ear. The ear is most sensitive to frequencies below 1,000 Hz. Most people hear frequencies between 600-1,000 Hz. Very high and very low noise frequencies are not perceptible to the human ear. Thus, the A-weighted decibel (dBA), a measurement in which sound in frequencies above and below the range of human hearing are filtered out, is often more appropriately used for environmental noise assessments (Cowan 1994).

Noise levels exceeding 85 dBA are considered harmful to human hearing, while moderate noise levels can increase blood pressure, interfere with communication, disrupt sleep, and cause stress. Even low levels of noise can cause human annoyance and frustration (U.S. Department of Labor, Occupational Health and Safety Administration, 2008). Table 3-21 shows typical causes or sources of noise generation and levels or ranges of noise associated with them.

Table 3-21. Typical Sources and Associated and Characterized Noise Levels From Generally Recognized Activities

Source	Associated Noise Levels
Painful	
Rock music (peak)	150 dB
Firearms, air raid siren, jet engine	140 dB
Jackhammer	130 dB
Jet plane take-off, amplified rock music at 4-6 feet, car stereo, band practice	120 dB

Source	Associated Noise Levels
Extremely loud	
Rock music, model airplanes	110 dB
Timpani and bass drum rolls	106 dB
Snowmobile, chain saw, pneumatic drill	100 dB
Lawnmower, shop tools, truck traffic, subway	90 dB
Very loud	
Alarm clock, busy street	80 dB
Busy traffic, vacuum cleaner	70 dB
Conversation, dishwasher	60 dB
Moderate	
Moderate rainfall	50 dB
Quiet room	40 dB
Faint	
Whisper, quiet library	30 dB

Source: American Speech-Language-Hearing Association 2010

The outdoor acoustical environment varies dynamically in magnitude and character in most communities. The sound level variation can be temporal (dependent on time of day or seasonal), spectral (depending on the source), or spatial (depending on one's location). In urban areas, noise sources are innumerable, but studies illustrate that transportation systems and associated vehicle traffic are the worst offenders, with construction and industrial plant operations following closely behind (Bell and Bell 1994). The most important factors affecting environmental noise propagation are the type of source (point or line), distance from source, atmospheric absorption, wind, temperature and temperature gradient, obstacles such as barriers and buildings, ground absorption, reflections, humidity, and precipitation.

Noise sources are considered either point sources or line sources. If the dimensions of a noise source are small compared with the distance to the listener, it is called a point source. For example, fans and chimneystacks are point sources. The sound energy spreads out spherically, so that the sound pressure level is the same for all points at the same distance from the source, and decreases by 6 dB per doubling of distance. This holds true until ground and air attenuation noticeably affect the noise level. For example, an 89-dBA noise level measured at 1 foot from a point source would decrease to 55 dBA at a distance of 50 feet (The Engineering ToolBox 2005).

If a noise source is narrow in one direction and long in the other compared to the distance to the listener, it is called a line source. It can be a single source such as a long pipe carrying a turbulent fluid, or it can be composed of many point sources operating simultaneously, such as a stream of vehicles on a busy road. The sound level spreads out cylindrically, so the sound pressure level is the same at all points at the same distance from the line, and decreases by 3 dB per doubling of distance (Brüel & Kjær 2010).

Industrial construction, industrial plant operations, and commercial land development are processes that produce noise. Noise pollution (or environmental noise) is displeasing human-, animal- or machine-created sound that disrupts the activity or balance of human or

animal life. The source of most human-produced outdoor noise worldwide is transportation systems, stationary sources, and construction equipment and operations (Cowan 1994).

As mentioned in Section 3.7, current land use within the MSR study area represents a park-like setting with 60 percent of the area covered in landscaping or various stages of vegetation growth that is reverting to mature natural vegetation. Most vehicular traffic accessing TVA facilities uses Reservation Road to access the property from Wilson Dam Road (SR 133) or Hatch Boulevard (US 72/43). Reservation Road is generally a fairly tranquil low-traffic volume roadway carrying two lanes of traffic in a southwesterly to northeasterly orientation. Reservation Road has a speed limit of 45 miles per hour.

Second Street and Hatch Boulevard are four-lane highways, and traffic on these thoroughfares is generally heavier and more continuous than Reservation Road traffic, especially during the daylight hours. The speed limit for these highways is 45 miles per hour. Wilson Dam Road, along the eastern boundary of the MSR study area, has six lanes, and traffic is generally heaviest along this major Shoals area thoroughfare among those bordering the site. The speed limit is 55 miles per hour on the northern portion of this road but decreases to 45 miles per hour on the southern portion.

Since the early 1980s, virtually all industrial activities conducted by TVA on the MSR (and associated noise) have ceased. However, there are four active industrial shops along with semi-tractor trailer truck traffic associated with the delivery of goods and the transport of equipment and materials. Three of the shops are located behind the ERC in the center of the MSR study area, while the fourth (Power Shop #2) is located along SR 133 (northeast Wilson Dam Road), east of and outside the study area (see Figure 1-3).

USEPA has established noise assessment guidelines based on an equivalent sound level day/night (DNL). This represents a 24-hour average sound level with 10 dB added to hours between 10 p.m. and 7 a.m. to account for increased nighttime sensitivity to noise. USEPA recommends a guideline of DNL less than 55 dBA to protect the health and well-being of the public with an adequate margin of safety.

Muscle Shoals/Wilson Dam Reservation background noise level estimates have been previously developed by TVA. These estimates were made during the height of TVA work activity on the property when about 1,000 employees reported to work daily. The DNL was estimated to be approximately 54 dBA based on the population density of the area (Committee on Hearing, Bioacoustics and Biomechanics 1977). This would reflect a daytime average of 59 dBA and a nighttime average of 45 dBA in 1977.

From 1977 through 1980, approximately 950 TVA employees occupied the MSR study area. Currently, TVA's daily workforce on the MSR study area is 600 to 700 employees. The reduction in employees reporting to work on the MSR reduces the overall daytime environmental noise level. The current reduced use of the Reservation by TVA employees, combined with the increase in recreational uses, affirms that estimated noise measurements made in 1977 are applicable to this analysis.

Daytime point source noise level measurements made around the perimeter of the MSR study area are contained in Table 3-22. The monitoring times were selected to provide measurements when vehicular traffic around the MSR study area was relatively active.

Table 3-22. Muscle Shoals Reservation Point Source Noise Measurements Taken May 20, 25, and 28, 2010

Location	Time	Noise Level (dBA) With Traffic	Noise Level (dBA) Without Traffic
May 20, 2010			
RR-1	11:29 A.M.	69.2	43.7
RR-2	11:37 A.M.	77.0	46.2
RR-3	11:42 A.M.	76.9	50.4
RR-4	11:48 A.M.	73.4	50.2
RR-5	11:52 A.M.	76.2	50.3
RR-6	11:55 A.M.	77.2	54.3
H133-7	12:00 P.M.	79.1	57.2
Average background noise level measurements for this date		**75.57**	**55.33**
May 25, 2010			
RR-1	10:54 A.M.	74.7	44.1
RR-2	10:57 A.M.	77.1	46.0
RR-3	10:59 A.M.	86.2	45.4
RR-4	11:02 A.M.	75.2	44.7
RR-5	11:05 A.M.	79.2	52.1
RR-6	11:07 A.M.	68.8	53.7
H133-7	11:11 A.M.	90.6	No Reading
H133-8	11:14 A.M.	82.5	52.1
H133-9	11:17 A.M.	78.0	No Reading
SS-10	11:20 A.M.	71.6	54.0
SS-11	11:23 A.M.	79.3	No Reading
SS-12	11:25 A.M.	78.6	No Reading
SS-13	11:27 A.M.	79.3	No Reading
SS-14	11:30 A.M.	77.7	No Reading
Average background noise level measurements for this date		**78.48**	**49.01**
May 28, 2010			
HB-15	11:16 A.M.	79.0	52.7
RR-16	11:20 A.M.	77.3	47.1
RR-17	11:25 A.M.	71.3	44.2
Average background noise level measurements for this date		**75.87**	**48.00**
Average Background Noise Level Measurements for May 20, 25, and 28, 2010		**76.64**	**50.78**

Abbreviations: RR = Reservation Road; H133 = Highway (SR) 133; SS = Second Street; HB = Hatch Boulevard

Source: Noise levels measured using an EXTECH 407790 Sound Level Meter, Serial # 090510293, calibrated with an EXTECH 407744 Sound Level Calibrator, Serial # H.179025, on 5/20/2010 at 09:45 A.M. by D. Keith McPeters, Certified Safety Professional (CSP).

Note: Noise level measurements were made every 0.4 mile starting at the north side of the ERC entrance following the perimeter of the MSR study area site.

Figure 3-39 illustrates the approximate locations of the point source noise measurements made around the perimeter of the MSR study area. The population of Colbert County, the location of the proposed redevelopment property, slightly decreased from 2000 compared to the 2009 estimate (U.S. Census Bureau 2000). The two factors of decreased population of the surrounding area and the reduced TVA MSR workforce support a minimal external environmental noise impact (i.e., noise generated on the MSR site) and would support the 1977 DNL estimates. However, based on the point source sound level measurements made around the perimeter of the MSR study area, travel patterns and daytime traffic noise levels have increased at the property boundaries since prior estimates in the area were developed.

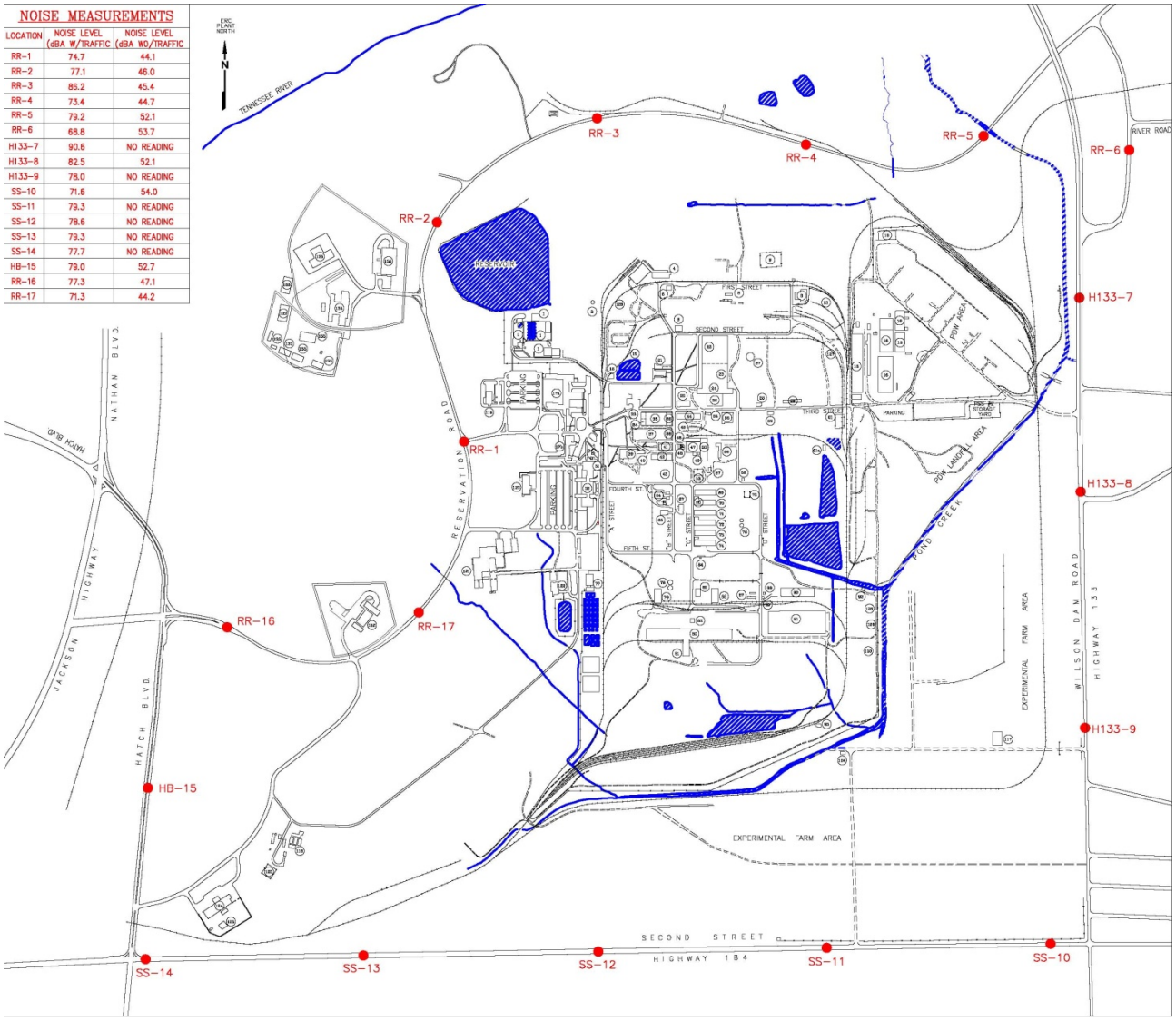


Figure 3-39. Approximate Locations of the Point Source Noise Measurements Taken Near the Muscle Shoals Reservation Study Area

Along with Reservation Road, three other roadways border the MSR study area. Hatch Boulevard, Second Street, and SR 133 (Wilson Dam Road) are the three major thoroughfares bordering the land under consideration along the west, south, and east sides, respectively. These roadways are populated with businesses and housing developments. Hatch Boulevard has a large hotel, two restaurants, a National Guard Armory, and other businesses. Second Street has a residential neighborhood, a car wash, a trailer park, commercial buildings, and other businesses adjacent to the south side of the MSR study area. SR 133 has an abandoned golf course, the Occidental Chemical plant, and a few businesses along its eastern right-of-way. These multiple-use businesses and dwellings represent the closest sensitive receptors bordering the MSR study area that would be exposed to noise generated from the site (i.e., external noise receptors).

The Northwest Alabama Regional Airport at Muscle Shoals is a little more than a mile from the southeast corner of the MSR study area. Because of its size, the airport can accommodate small to medium size airplanes. Approaching and departing planes regularly pass over the MSR area and would also be an external source of noise at MSR.

Internal noise receptors include on-site workers. People still work in the ERC as well as the office areas behind the ERC. Other internal receptors include recreational users and various species of wildlife found on and near the MSR study area. Recreational use of the Reservation land currently consists of walking/bicycling trails, bird watching wetland areas, wild animal habitats, and public fishing areas. Many of the recreational use areas (walking trails, fishing areas, picnic grounds) lie to the north of the proposed project area along Reservation Road.

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