



**TENNESSEE DEPARTMENT**

**OF**

**ENVIRONMENT AND CONSERVATION**

**DOE OVERSIGHT OFFICE**

**ENVIRONMENTAL MONITORING PLAN**

**JANUARY through DECEMBER 2013**

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## **TDEC DOE Oversight Office Environmental Monitoring Plan Changes for 2013**

### **1. AIR QUALITY MONITORING**

*The Perimeter Air (Low Volume) Monitoring Program* was discontinued.

*Monitoring Fugitive Radioactive Air Emissions on the Oak Ridge Reservation* added a high volume monitor at the Y-12 National Security Complex. Analysis has shifted from gross alpha, gross beta, and gamma spectrometry at Y-12 and K-25 to U-234, U-235, and U-238 at Y-12 and to the uranium isotopes and Tc-99 at K-25.

### **2. BIOLOGICAL MONITORING**

*Benthic Macroinvertebrate Monitoring*: Dropped 1 site

*Periphyton Monitoring*: Increased sampling sites from 4 to 6, dropped water sampling

*Deer Monitoring*: DOE-O can now sedate deer; road kill deer samples will be collected and stored.

*Bat Identification and Monitoring*: New project to identify species and map locations

### **3. GROUNDWATER MONITORING**

Emphasis on moved from ETTP to Bear Creek Valley, increased number of monitoring wells to co-sample

### **6. SURFACE WATER MONITORING**

*Ambient Sediment Monitoring*: Number of sites cut from 15 to 7 and analytes pared.

*Ambient Surface Water Monitoring*: Only change is alkalinity added

*Benthic Macroinvertebrate Surface Water Sampling*: Pared analytes, specifically metals

*Ambient Trapped Sediment Monitoring*: New trap design, dropped one site and pared analytes, specifically metals

## LIST OF COMMON ACRONYMS AND ABBREVIATIONS

ASER	Annual Site Environmental Report (written by DOE)
ASTM	American Society for Testing and Materials
BCK	Bear Creek Kilometer (station location)
BFK	Brushy Fork Creek Kilometer (station location)
BMAP	Biological Monitoring and Abatement Program
BNFL	British Nuclear Fuels Limited
BOD	Biological Oxygen Demand
BWXT	Y-12 Prime Contractor (current)
CAA	Clean Air Act
CAAA	Clean Air Act Amendments
CCR	Consumer Confidence Report
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFR	Code of Federal Regulations
COC	Contaminants of Concern
COD	Chemical Oxygen Demand
CPM (cpm)	counts per minute
CRM	Clinch River Mile
CROET	Community Reuse Organization of East Tennessee
CWA	Clean Water Act
CYRTF	Coal Yard Runoff Treatment Facility (at ORNL)
D&D	Decontamination and Decommissioning
DOE	Department of Energy
DOE-O	Department of Energy-Oversight Office (TDEC)
DWS	Division of Water Supply (TDEC)
<i>E. coli</i>	<i>Escherichia coli</i>
EAC	Environmental Assistance Center (TDEC)
ED1, ED2, ED3	Economic Development Parcel 1, Parcel 2, and Parcel 3
EFPC	East Fork Poplar Creek
EMC	Environmental Monitoring and Compliance (DOE-O Program)
EMWMF	Environmental Management Waste Management Facility
EPA	Environmental Protection Agency
EPT	<i>Ephemeroptera, Plecoptera, Trichoptera</i> (May flies, Stone flies, Caddis flies)
RadNet	EPA Ambient Monitoring Radiation Network (RadNet), Formally ERAMS
ET&I	Equipment Test and Inspection
ETTP	East Tennessee Technology Park
FDA	U.S. Food and Drug Administration
FRMAC	Federal Radiation Monitoring and Assessment Center
g	gram
GHK	Gum Hollow Branch Kilometer (station location)
GIS	Geographic Information Systems
GPS	Global Positioning System
GW	Ground Water
GWQC	Ground Water Quality Criteria

HAP	Hazardous Air Pollutant
HCK	Hinds Creek Kilometer (station location)
IBI	Index of Biotic Integrity
IC	In Compliance
“ISCO” Sampler	Automatic Water Sampler
IWQP	Integrated Water Quality Program
K-####	Facility at K-25 (ETTP)
K-25	Oak Ridge Gaseous Diffusion Plant (now called ETTP)
KBL	Knoxville Branch Laboratory
KFO	Knoxville Field Office
L	liter
LC <sub>50</sub>	Lethal Concentration at which 50 % of Test Organisms Die
LWBR	Lower Watts Bar Reservoir
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MBK	Mill Branch Kilometer (station location)
MCL	Maximum Contaminant Level (for drinking water)
MDC	Minimum Detectable Concentration
MEK	Melton Branch Kilometer (station location)
µg	microgram
mg	milligram
MIK	Mitchell Branch Kilometer (station location)
ml	milliliter
µmho	micro mho (mho=1/ohm)
MOU	Memorandum of Understanding
mR	microroentgen
mrem	1/1000 of a rem – millirem
N, S, E, W	North, South, East, West
NAAQS	National Ambient Air Quality Standards
NAREL	National Air and Radiation Environmental Laboratory
NAT	No Acute Toxicity
NEPA	National Environmental Policy Act
NIC	Not In Compliance
NOAEC	No Observable Adverse Effect Concentration (to Tested Organisms)
NOV	Notice of Violation
NPDES	National Pollution Discharge Elimination System
NRWTF	Non-Radiological Waste Treatment Facility (at ORNL)
NT	Northern Tributary of Bear Creek in Bear Creek Valley
OMI	Operations Management International (runs utilities at ETTP under CROET)
OREIS	Oak Ridge Environmental Information System <a href="http://www-oreis.bechteljacobs.org/oreis/help/oreishome.html">http://www-oreis.bechteljacobs.org/oreis/help/oreishome.html</a>
ORISE	Oak Ridge Institute for Science and Education
ORNL	Oak Ridge National Laboratory
ORR	Oak Ridge Reservation
OSHA	Occupational Safety and Health Association
OSL	Optically Stimulated Luminescent (Dosimeter)
OU	Operable Unit
PACE	Paper, Allied-Industrial, Chemical, and Energy Workers Union
PAM	Perimeter Air Monitor
PCB	Polychlorinated Biphenol
pCi	1x10 <sup>-12</sup> curie (picocurie)
PCM	Poplar Creek Mile (station location)

pH	Proportion of Hydrogen Ions (acid vs. base)
PWSID	Potable Water Supply Identification “number”
ppb	parts per billion
ppm	parts per million
ppt	parts per trillion
PRG	Preliminary Remediation Goals
QA	Quality Assurance
QC	Quality Control
R	Roentgen
RBP	Rapid Bioassessment Program
RCRA	Resource Conservation and Recovery Act
REM (rem)	Roentgen Equivalent Man (unit)
RER	Remediation Effectiveness Report
ROD	Record of Decision
RPM	Radiation Portal Monitor
RSE	Remedial Site Evaluation
RSP	Radiation Sensor Panel
SLF	Sanitary Landfill
SNS	Spallation Neutron Source
SOP	Standard Operating Procedure
SPOT	Sample Planning and Oversight Team (TDEC)
SS	Surface Spring
STP	Sewage Treatment Plant OR Site Treatment Plan
SW	Surface Water
TDEC	Tennessee Department of Environment and Conservation
TDS	Total Dissolved Solids
TIE	Toxicity Identification Evaluation
TLD	Thermoluminescent Dosimeter
TOA	Tennessee Oversight Agreement
TRE	Toxicity Reduction Evaluation
TRM	Tennessee River Mile
TRU	Transuranic
TSCA	Toxic Substance Control Act
TSCAI	Toxic Substance Control Act Incinerator
TSS	Total Suspended Solids
TTHM’s	Total Trihalomethanes
TVA	Tennessee Valley Authority
TWQC	Tennessee Water Quality Criteria
TWRA	Tennessee Wildlife Resources Agency
U.S.	United States
UT-Battelle	University of Tennessee-Battelle (ORNL Prime Contractor)
VOC	Volatile Organic Compound
WCK	White Oak Creek Kilometer (station location)
WM	Waste Management
WOL	White Oak Lake
X-####	Facility at X-10 (ORNL)
X-10	Oak Ridge National Laboratory
Y-####	Facility at Y-12
Y-12	Y-12 Plant (Area Office)

## INTRODUCTION

The Tennessee Department of Environment and Conservation (TDEC), Department of Energy (DOE) Oversight Office (the office), is providing an annual environmental monitoring plan for the calendar year 2013 under terms of the Tennessee Oversight Agreement (TOA) Section A.7.2.1. Individual work plans describing independent environmental monitoring and surveillance make up the 2013 Environmental Monitoring Plan. Monitoring of chemical and radiological emissions in the air, water, biota, and sediment on the Oak Ridge Reservation and its environs is emphasized. A description of TDEC's Oversight of DOE's environmental monitoring and surveillance programs is also included. The goal is to assure that DOE's Oak Ridge Operations have no adverse impact to public health, safety, or the environment. Results from monitoring and findings of the quality and effectiveness of the DOE's environmental programs are reported in the quarterly and annual status reports. Each spring an annual environmental monitoring report is provided that details the technical results of these studies.

This plan offers the Department of Energy the opportunity to review and consult on the office's monitoring activities and to take split-samples as needed. The office may perform short-notice or no-notice sampling for situations such as storm events, non-permitted discharges, emergencies or spills. DOE will be informed as soon as a decision is made to take short-notice or no-notice samples. Environmental monitoring is a dynamic process and will periodically change. Major changes to this plan will be made in writing to DOE.

Judicious use of cost cutting strategies will be used to complete our projects with the monies available. The strategies include the compositing of samples, use of only critical sampling stations, decreasing the frequency of sampling, and decreasing the number of analytes to only those critical for the projects. In some cases samples may be held as contingency, in case of accidental release. Project monies will be closely tracked for efficiencies.

This office or the Tennessee Department of Health's, Environmental Laboratory and Microbiological Laboratory Organization (Laboratory Services or the state lab) will process quantitative chemical samples. Laboratory Services has expertise in a broad scope of services and analyses. Certain analyses and quality assurance/quality control (QA/QC) samples are subcontracted out by the state lab to independent certified laboratories. Bench level QA/QC records and chain-of-custody records are maintained by the state for all samples collected by the office. The *Laboratory Services Standard Operating Procedures* are followed and also serve as a guide to the office's laboratory procedures. General sampling and analysis methods follow EPA guidelines.

Benthic macroinvertebrates and other biological samples are taxonomically identified at the state lab, in the office's laboratory, or by Laboratory Services subcontractors. Common water quality measurements and radiological readings are done in the field with calibrated instruments. Environmental dosimeters are analyzed by outside vendors. All work follows EPA, state, and instrument manufacturer's protocols as appropriate. Data loggers are used to reduce transcription errors.

### **Air Quality Monitoring**

The office's integrated air quality monitoring is designed to verify and enhance DOE monitoring of the air quality on the Oak Ridge Reservation and in surrounding areas which may be impacted from DOE Oak Ridge Operations. The office implements EPA's ambient monitoring system, RadNet. Radiological surveillance of ambient air quality in the vicinity of the ORR is provided and compared to the results of the national RadNet program. Three precipitation monitors are now included in the Oak Ridge Reservation RadNet system from which radiological contaminants in rain and snow will be assessed. TDEC performs oversight of the ORR perimeter program. This year we will not perform independent analysis of the perimeter program pre-filters. This is a change from previous years caused by budget needs and comparative value of this low volume air sampling compared with our other high volume air samplers. Portable samplers are also set up to measure hazardous and radioactive contaminants around selected DOE demolition and remediation projects. The EMWFM location was added in 2005 as an air-sampling site for fugitive emissions. Results are used to verify that DOE keeps contamination contained during cleanup and disposal activities. In the event of a large catastrophic release, any of these data could be used for consequence assessment and to guide recovery efforts, even in the community.

### **Biological Monitoring**

To determine the impact of DOE operations the office provides independent biological monitoring and oversight on and off the Oak Ridge Reservation. It also works in conjunction with the Tennessee Wildlife Resources Agency (TWRA), the Tennessee Valley Authority (TVA), and with other Tennessee Department of Environment and Conservation offices to coordinate valley-wide monitoring efforts related to fishing advisories. Specific contaminant pathways are investigated on the Oak Ridge Reservation as well. Results are used to formulate recommendations on clean up and to measure potential human and/or environmental risk. The office is currently measuring impacts to aquatic biota, contamination in geese, and effects on other indicator species such as lichens, watercress and diatoms. Invasive plants are also being mapped on a 3000-acre conservation easement. TWRA is assisting us in a deer telemetry project that will determine how far deer in Melton Valley range. This is important to assess the potential for contaminated deer to be harvested off the Oak Ridge Reservation, a pathway potentially as important as offsite groundwater pathways.

Bat communities will be inventoried this year using acoustical recording equipment whereby the ultrasonic bat calls are identified much like a bird can be identified by its singing. For bats, the recordings are analyzed by computer software that can identify bat species. Information will feed into general resource conservation efforts and into any regulatory decisions involving habitat management and/or resource injuries.

### **Drinking Water Monitoring**

Public water systems on the Clinch and Tennessee Rivers can be adversely impacted by DOE activities on the Oak Ridge Reservation. Independent drinking water monitoring supports the public water system's monitoring efforts related to releases from the Oak Ridge Reservation. The office implements EPA's RadNet Drinking Water Program. Results are compared to the national program. The office provides labor; EPA provides expendables and analysis. DOE plant water distribution systems operate at a fraction of historical capacity and can stagnate, causing a loss of chlorine. Therefore, chlorine residuals in DOE facilities are also monitored. Sampling and analysis for possible chemical and radiological constituents may be accomplished during oversight of water

main repairs and line-flushing activities. The comprehensive goal is to document trends and ensure that systems continue to be safe from radiological, chemical, and bacteriological contamination.

### **Groundwater Monitoring**

The office's groundwater monitoring program provides information about Oak Ridge Reservation releases and potential impacts on health and the environment. Given the implications of contaminant transport off the Oak Ridge Reservation via groundwater, the office will continue to emphasize the identification of groundwater pathways. This will be accomplished by monitoring water supplies, wells, and springs, both on and off the ORR and by conducting hydrogeological investigations such as aquifer evaluations and dye traces. Integration of groundwater and surface water sampling results allows concepts of groundwater behavior to be refined. Much groundwater tracing is opportunistic, as staff must take advantage of favorable weather, or discoveries made during construction or remediation, etc. Citizen reports of large springs in the ORR environs are useful and guide sample collection planning.

### **Radiological Monitoring**

The office's radiological monitoring is directed toward the development of a comprehensive radiological monitoring system as prescribed by the Tennessee Oversight Agreement, Attachment C.2 "Radiological Oversight." The primary focus of the program is the detection of radiological contamination with the potential to impact human health and the environment. Our radiological program contributes in all media areas and reviews CERCLA and NEPA documents, waste disposition, and other projects involving radionuclides. Autonomous monitoring includes facility surveys, gamma monitoring of the ORR, surplus sales surveys, and real-time gamma monitoring around active demolition and remediation sites. Automated gamma monitoring is being done at the Environmental Management Waste Management Facility (EMWMF) in Bear Creek Valley, for example. The DOE weigh scales database is compared to our gamma-monitoring data. Using time stamps to match data, the office monitors radiation readings on waste shipments delivered for disposal and assures that radioactive shipments are weighed and documented. The office has deployed its gamma radiation portal monitor at the EMWMF waste cell entrance. This instrument will measure gamma radiation levels of truckloads of waste entering the EMWMF on a real time basis. Previously used measurement instruments have only been able to display readings after manual downloads resulting in lengthy delays of relevant data. The portal monitor will allow the office to see gamma rates before waste is buried.

### **Surface Water Monitoring**

The office measures trends in the quality of water and sediments in the Clinch River and Oak Ridge Reservation tributaries. Surface water is one of Tennessee's most important economic and environmental resources, but local waterways rarely unconditionally meet all designated uses. For example, there are advisories on fish consumption from local reservoirs and streams. Legacy pollution from DOE, other industries, and non-point source origins are continuing problems. Long term monitoring can define success or failure of clean-up actions, source controls, and attenuation. Specifically, the office is analyzing water from Bear Creek to isolate legacy source inputs. It is hoped that the long-term monitoring strategy for the new Environmental Management Waste Management Facility can be positively affected and that existing sources/pathways can be found, analytically isolated, trended, and remedied.

From another perspective, the Clinch and Tennessee Rivers are drinking water sources for several municipalities. Knowing the pollutant concentration is vital to the monitoring of those drinking water sources. In 2013, monitoring and investigation will continue in closer proximities to remediation projects and new construction.

**Invitation for Public Comment**

This plan is published to inform the public about state sampling on the ORR and environs. Any comments from the public on where or how future sampling should be done are greatly appreciated. Comments can be sent to:

Sonya Isabell  
TDEC DOE-O  
761 Emory Valley Road  
Oak Ridge TN 37830

Comments can also be sent to [sonya.isabell@tn.gov](mailto:sonya.isabell@tn.gov) or faxed to (865) 482-1835.

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# AIR QUALITY MONITORING

## Monitoring of Hazardous Air Pollutants on the Oak Ridge Reservation

### Introduction

This independent monitoring project is conducted under authority of the Tennessee Oversight Agreement. The project was initiated in 1997 at the East Tennessee Technology Park (ETTP or K-25 site) in response to the heightened level of public concern regarding potential impacts to public health from the Toxic Substance Control Act Incinerator emissions. Monitoring of hazardous metals in air expanded to the National Security Complex (Y-12) and the Oak Ridge National Laboratory (ORNL or X-10) in the following year. Following the closure of the TSCA Incinerator at ETTP, the project continues to monitor hazardous metals in fugitive emissions associated with demolition activities or other non-point sources at the three Oak Ridge Reservation (ORR) sites. Levels of arsenic, beryllium, cadmium, chromium, lead, nickel and uranium (as a metal only) in the ambient air are monitored.

A high-volume total suspended particulate (TSP) ambient air sampler is deployed at each site at one of several potential sampling locations. These locations were selected based on wind rose data, availability of electrical power, and co-location with DOE and TDEC radiological air monitors. The proposed sampling sites for next year differ slightly from those used over the previous eight years. The sites are as follows:

- ORNL: X-10E, east of the main entrance to the site  
X-10C, at the corehole 8 remediation site  
X-10W, west of the site (See Figure 1)
- Y-12: Y-12E, east of the plant entrance  
Y-12W, west of the plant site (See Figure 2)
- ETTP: K-11, near the north end of the K-25 building  
42/TSCA-1, on Blair Road  
35/TSCA-2, on Gallaher Road (See Figure 3)

The current plan is to keep samplers located at the X-10C, Y-12E and K-11 sites throughout the coming year, and to split samples with the radiological monitoring group throughout the year at all three sites. Due to closure of the TSCA incinerator, the K-2 site was abandoned in favor of the K-11 site, which is closer to the ongoing demolition activities at the K-25 and K-27 gaseous diffusion buildings. As was the case with the K-2 site, DOE maintains an air monitor for metals and radiological emissions at the K-11 site, so monitoring results from this site may still be compared to data collected by DOE. The X-10C site is located adjacent to the Tank W1A (Corehole 8) soil removal project, which is nearing completion but is located near potential sources of fugitive emissions from ORNL demolition activities, and samples are to be split with the radiological monitoring program. This sampler is mounted on a trailer and may be moved to either the X-10E or X-10W site if conditions at ORNL warrant a change in sample location. Power

supply at the X-10E site is provided via a temperature sensitive source, making deployment at this site potentially problematic during the coldest months. The Y-12E air monitor was relocated a few hundred meters to the north of the old site to accommodate construction activities on the west end of the Y-12 plant.

### **Methods and Materials**

On a weekly basis, sample filters will be collected from samplers and sent for analysis to the state Department of Health Environmental Laboratory in Nashville. Composite samples will be analyzed quarterly by the laboratory using inductively-coupled plasma and atomic absorption techniques. Some samples may be split for analysis by a sub-contractor of the state laboratory according to EPA Method IO-3.5, determination of metals in ambient air particulate using inductively coupled plasma/mass spectrometry (ICP-MS). The composite sample will be made using one quarter of each filter. This effectively gives each filter equal weight in the composite, even though the volume of air sampled may vary somewhat from filter to filter. To prevent the average quarterly concentrations in air computed for the composite from differing significantly from a true volume weighted composite, filters collecting particulate from air volumes differing from the quarterly mean sample volume by more than 20 percent will be sent to the state lab for individual analysis. Results from these filters (if any) and those obtained for the composite may then be weighted by volume of air sampled to more accurately determine the actual mean quarterly concentrations.

Methods and protocols for sampler maintenance and calibration have been developed based on high volume total suspended particulate (TSP) system maintenance manuals supplied by the manufacturer and sampling criteria tailored specifically to this project and DOE-O's mission and staffing levels (Yard, 2011 and Standard Operating Procedures (SOPs) developed for maintenance and calibration of TSP systems by the TDEC-DOE radiological monitoring program, 2010). Routine maintenance is generally limited to brush and motor changes. At intervals less than two months since the last brush change, the sampler motor will be disassembled and the motor's brushes inspected for condition and evaluated for longevity. When it is anticipated that the brushes may not last until the next site visit, they will be replaced. Based on experience with the typical lifetime of the sampler motor, it will be changed about twice annually. The sampler will also be inspected to ensure that the sampling orifice remains level and parallel to the ground. At each site visit the sampling cartridge will be removed and replaced with one holding a new filter. The cartridge will be covered both top and bottom for transport to the DOE Oversight laboratory. The sample will be removed at the DOE-O laboratory and placed in a zip-lock bag until the composite sample is made and sent to the Department of Health Environmental Laboratory for analysis. The 24-hour chart recording pressure differential will be removed and replaced weekly and its pen trace will be evaluated for average readings for the weekly period. Relevant information will be recorded on the reverse side of the chart. Date and time of sampling and elapsed time will be recorded, and readings of atmospheric pressure and ambient temperature may also be recorded on the chart. Proper chain of custody for samples will be maintained. DOE-O staff will maintain a quarterly calibration check that will be carried out in accordance with the manufacturer's specifications.

Reporting on the status of analytical results from each sampling location will be done annually. Comparison of mean values with reference to air concentrations from 40 CFR 266 and with sampling results from DOE monitors at the ETTP site will be made. Annually, a report will be

prepared presenting conclusions regarding current levels of HAPs metals in ambient air and included in the DOE-O environmental monitoring report.

Materials required for this project include:

hi-volume sampler	filters
sampler replacement parts	calibration kit
level	flow charts
extension cords	waterproof marking pens
tool kit	project data/custody forms
motor brushes	plastic sample bags

### **References**

Boiler and Industrial Furnace Regulations, Title 40 CFR Part 266 Appendix V.

Guidelines for the Control of Toxic Ambient Air Contaminants, Draft New York State Air Guide-1, Appendix B of Air Guide-1, Ambient Air Quality Impact Screening Analyses, New York State Department of Environment Control, 1994 Edition.

Operations Manual for GMW Model 2000H Total Suspended Particulate Sampling System, Graseby GMW Variable Resistance Calibration Kit # G2835. 1998.

Tennessee Department of Environment and Conservation, TDEC DOE-O Procedure Number: SOP-ES&H-004 Air Monitoring/Air Sampling.

Tennessee Oversight Agreement, Agreement Between the U.S. Department of Energy and the State of Tennessee. Tennessee Department of Environment and Conservation, DOE Oversight Office. Oak Ridge, Tennessee. 2011.

Yard, C. R., Health, Safety and Security Plan, Tennessee Department of Environment and Conservation, DOE Oversight Office, Oak Ridge, Tennessee. 2011.

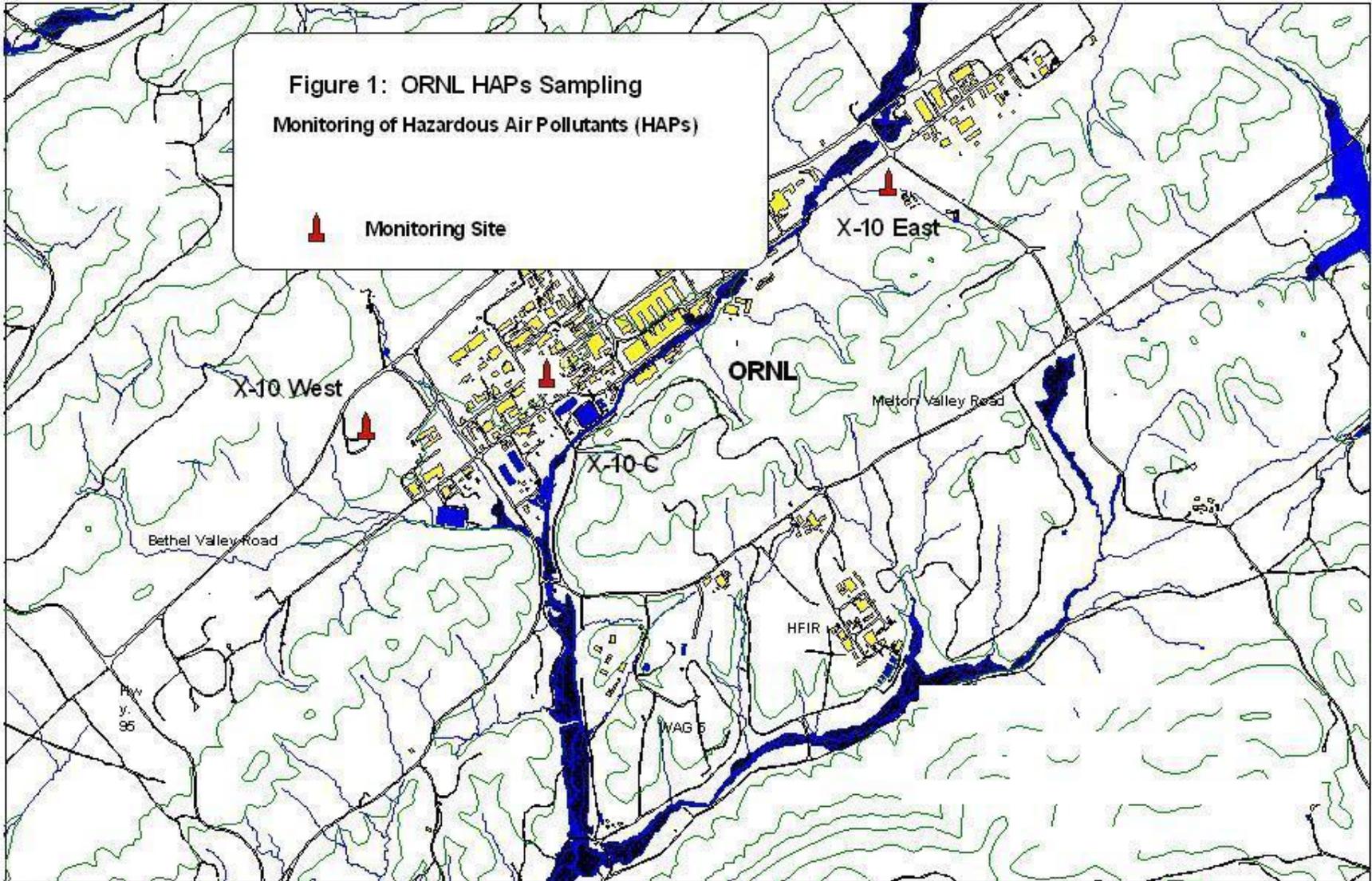


Figure 1: ORNL HAPs Sampling Locations

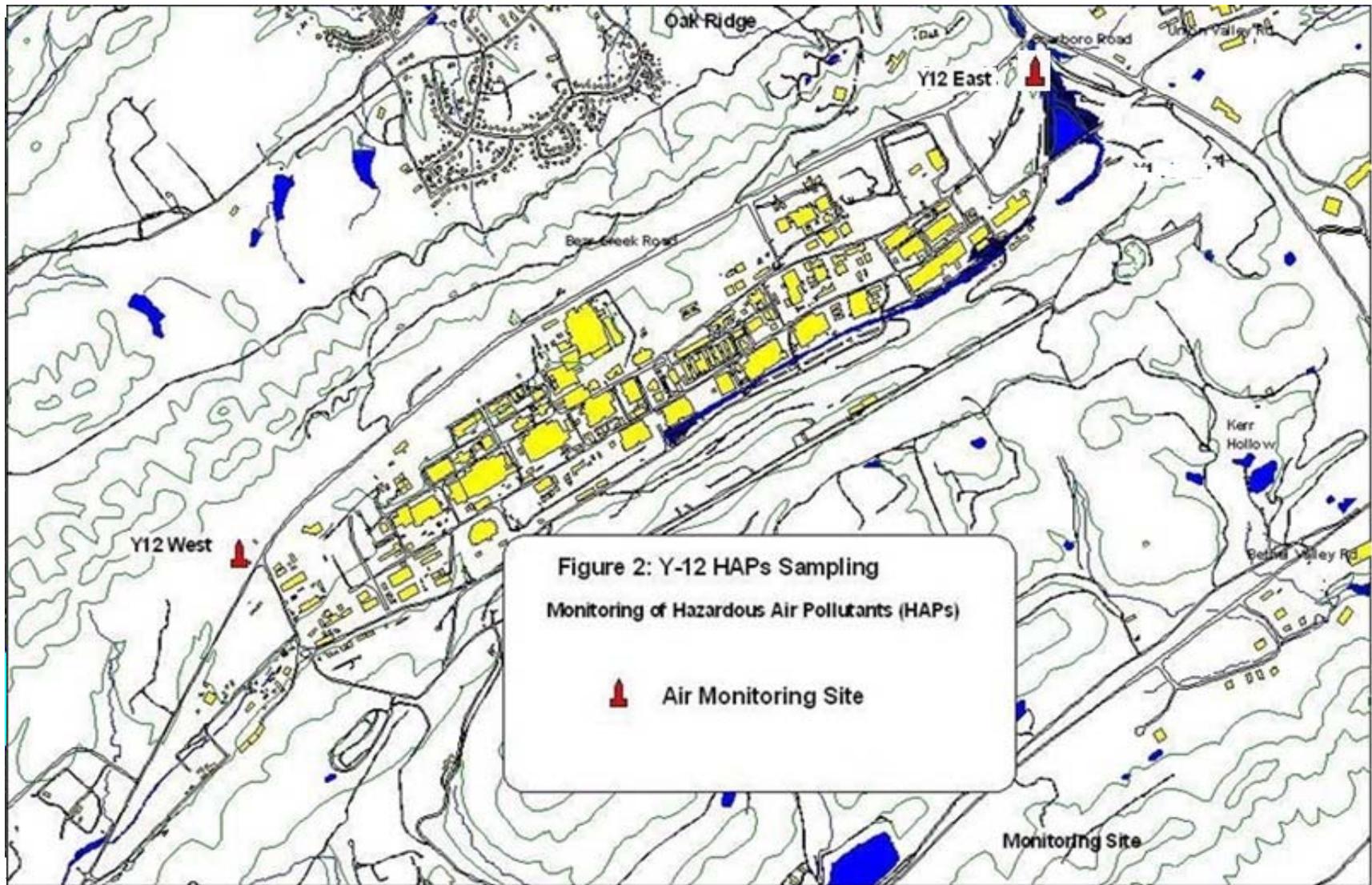
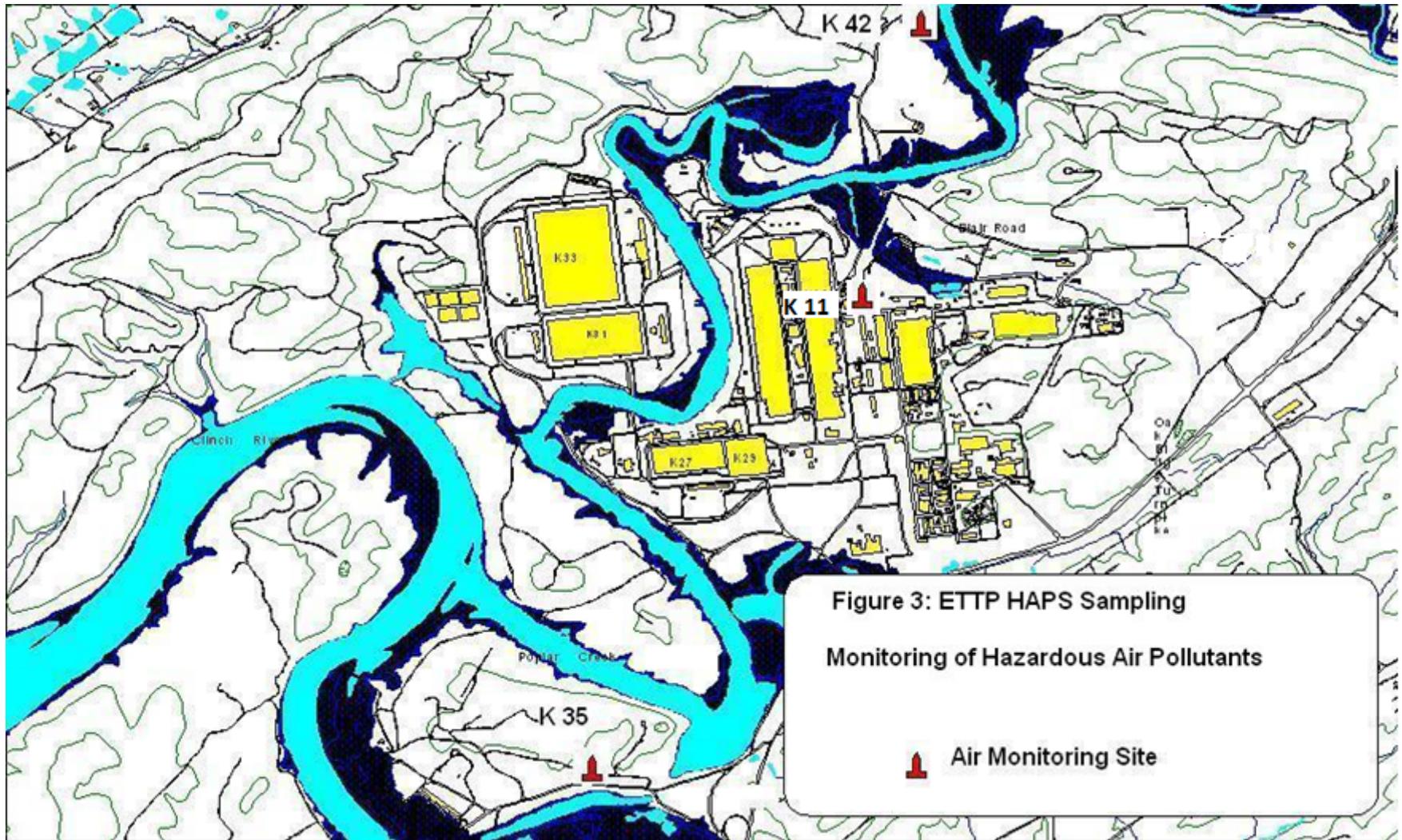


Figure 2: Y-12 HAPs Sampling Locations



**Figure 3: ETP HAPS Sampling Locations**

## RadNet Air Monitoring on the Oak Ridge Reservation

### Introduction

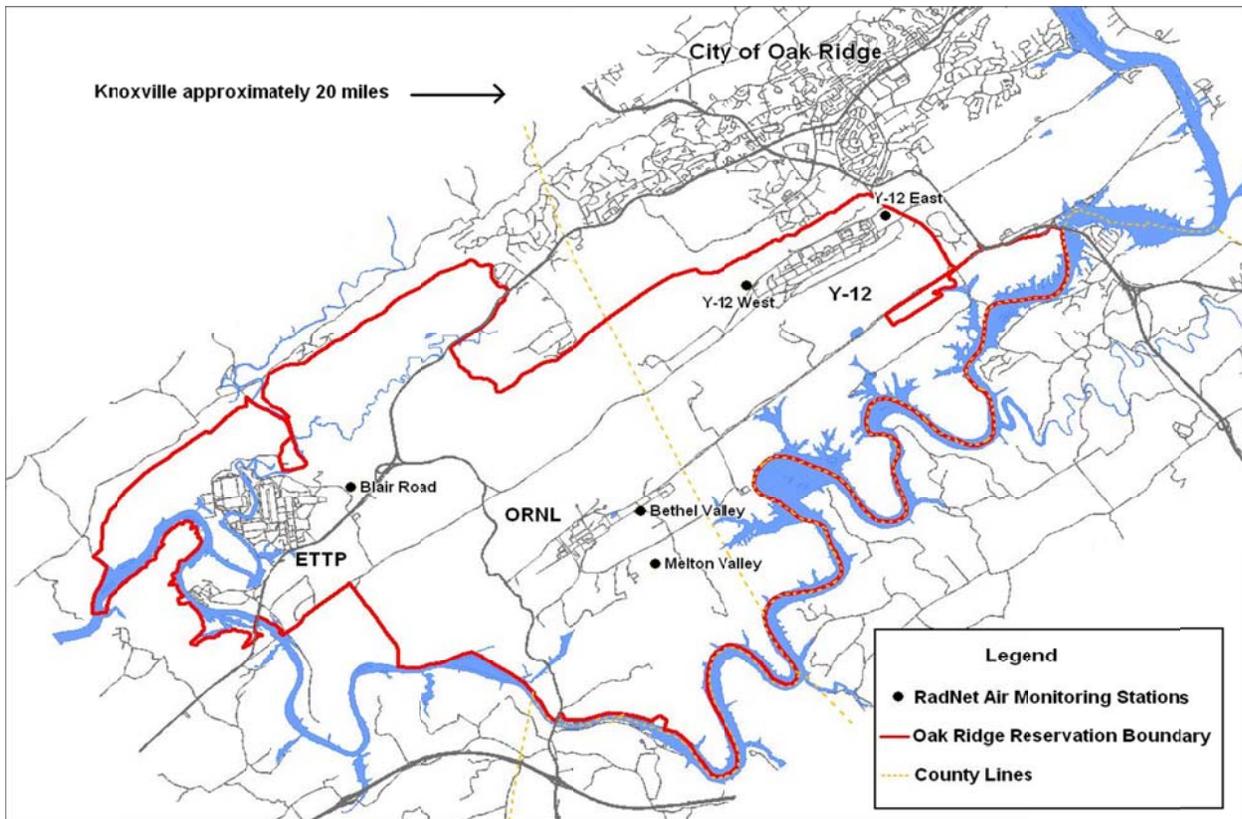
The Tennessee Department of Environment and Conservation DOE Oversight Office, a part of the Division of Remediation (the division), will continue to monitor the air at five locations on the Oak Ridge Reservation (ORR) in 2013 with EPA's RadNet Air Monitoring Program. This is one of three main air monitoring programs used by the office to assess the impact of ORR air emissions on the surrounding environment. The program also assesses the effectiveness of DOE controls and monitoring systems. The other two air-monitoring programs, Perimeter Air Monitoring and Fugitive Air Monitoring (described in associated plans) focus on monitoring at exit pathways, diffuse emissions, and sites of special interest (e.g., remedial sites). There is an additional air-monitoring program, which samples the air indirectly via precipitation (described in the RadNet Precipitation Monitoring plan). The office's participation in EPA's RadNet Air Program targets specific operations (e.g., the High Flux Isotope Reactor, and D&D at ETTP and Y-12) and provides verification of state and DOE monitoring, via independent third party analysis.

### Methods and Materials

The five RadNet air monitors use synthetic fiber filters (ten centimeters in diameter) to collect particulates as air is pulled through the units at approximately 60 cubic meters per hour (about 35 cubic feet per minute). The monitors are operated continuously and the filters will be changed twice weekly (Monday and Thursday) by office staff. The quantity of radioactivity on each filter will be estimated by staff, using a radiation detector, in accordance with the RadNet Standard Operating Procedure (US EPA, 2006). The filters will then be mailed to EPA's National Air and Radiation Environmental Laboratory (NAREL) in Montgomery, Alabama for analysis. Each RadNet air monitor will undergo calibration verification quarterly and undergo full calibration at least annually. The sampling results received from NAREL will be compared to data collected in the fugitive air monitoring program (to verify the quality of state analysis) and to the Clean Air Act (to assess compliance with applicable standards). Analytical parameters and frequencies for the RadNet Air Monitoring Program are provided in Table 1. Results from these analyses will be provided to the office and will be available on EPA's RadNet website via [http://iaspub.epa.gov/enviro/erams\\_query\\_v2.simple\\_query](http://iaspub.epa.gov/enviro/erams_query_v2.simple_query), the EPA searchable Envirofacts database. More information on the program can be found on the EPA RadNet webpage (<http://www.epa.gov/radnet>). The approximate locations of the five RadNet air monitoring stations are depicted in Figure 1.

**Table 1: EPA Analysis of RadNet Air Samples**

ANALYSIS	FREQUENCY
Gross Beta	Twice weekly on each sample
Gamma scan (conditional)	When samples are found to have $> 1 \text{ pCi/m}^3$ in the gross beta analysis
Plutonium-238, Plutonium-239, Plutonium-240 Uranium-234, Uranium-235, Uranium-238	Annually, on composites of the air particulate filters



**Figure 1: Approximate Locations of Air Stations Monitored in Association with EPA’s RadNet Air Program on the Oak Ridge Reservation**

**References**

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## **Monitoring Fugitive Radioactive Air Emissions on the Oak Ridge Reservation**

### **Introduction**

In 2013, the Tennessee Department of Environment and Conservation, Division of Remediation's DOE Oversight Office (the office), with the cooperation of DOE and its contractors, will continue monitoring fugitive radioactive air emissions on the Oak Ridge Reservation (ORR). This program uses mobile high volume air samplers to supplement air monitoring performed at fixed locations. The mobile high volume air monitors, along with more frequent sampling and analysis, provide greater measurement sensitivity and resolution than can be achieved with the low volume monitors used in the office's Perimeter Air Monitoring Program. Monitoring performed with the mobile units will focus on nonpoint sources of air emissions and sites of special interest (e.g., remedial activities). Currently, high-volume samplers are stationed at each of the three ORR sites in order to monitor the demolition of buildings that once housed operations to 1) enrich uranium (ETTP), 2) process irradiated uranium (ORNL), and 3) manufacture nuclear weapons (Y-12). Results from the program will be used to assess DOE monitoring and control measures to prevent airborne releases to the environment, as required by the Tennessee Oversight Agreement.

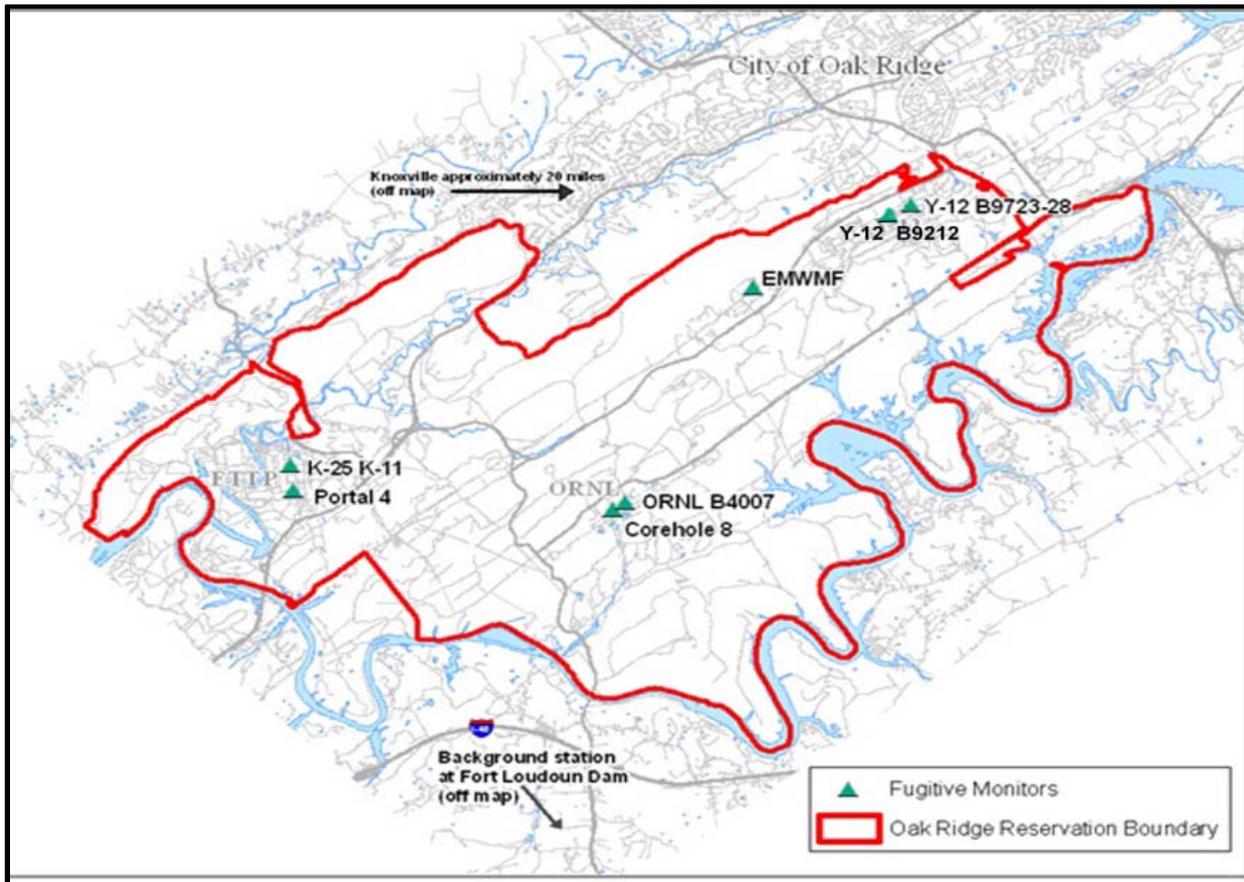
### **Methods and Materials**

In 2013, the office will deploy eight high volume air monitors in the program. One of the monitors will be stationed at Fort Loudoun Dam in Loudon County to collect background data. The other units will be placed at locations on the ORR where there appears to be a potential for the release of fugitive/diffuse emissions (e.g., demolition of contaminated facilities, excavation of contaminated soils, waste disposal operations, etc.). Current monitoring stations are provided in Table 1, along with the activities being monitored. The locations of the monitoring stations are depicted in Figure 1. Each of the samplers in the program uses an 8x10-inch glass fiber filters to collect particulates as air is pulled through the unit at a rate of approximately 35 cubic feet per minute. Instrument calibrations are performed on the samplers quarterly, in accordance with Standard Operating Procedure (SOP) 202, *Calibrating High Volume Total Suspended Particulate Samplers*, and instrument maintenance is performed as described in SOP 203, *High Volume Total Suspended Particulate System Maintenance*.

Samples from the low volume monitors are collected weekly and shipped to the State of Tennessee's Environmental Laboratory in Nashville, Tennessee, for analysis following procedures outlined in Standard Operating Procedure (SOP) 201, *Fugitive High Volume Sample Collection*. Analyses requested are based on the contaminants of concern for the location being monitored and previous findings: consequently, the analysis varies for different locations. Table 1 includes the analysis performed for the current sites being monitored. Where gross analyses are indicated, radionuclide specific analysis will be performed if the gross results exhibit significant spikes, upward trends, consistently elevated results, and/or exceed screening levels. The screening levels for gross alpha and gross beta measurements will be the Clean Air Act (CAA) limits for uranium-235 and strontium-90 respectively. To assess the concentrations of the contaminants measured for each location, results from the station will be compared with the background data and the standards provided in the CAA. Associated findings will be reported to DOE and its contractors as warranted and included in the office's annual Environmental Monitoring Report for submission to DOE and public review.

**Table 1: Current Fugitive Air Monitoring Stations and Associated Radiochemical Analysis**

Station	Activity Monitored	Frequency		Analysis			
		Sampling	Analysis	Gross Alpha & Beta	Uranium Isotopes	Gamma Spectrometry	Technitium-99
Y-12 : B9723-28	Y-12 facility reduction activities	weekly	biweekly (composite)		X		
Y-12 : B9212	Y-12 facility reduction activities	weekly	biweekly (composite)		X		
ETTP: K-25 K-11	K-25, K-33, and K-1073-B remedial activities	weekly	biweekly (composite)		X		X
ETTP: Portal 4	K-25, K-27, K-33 remedial activities	weekly	biweekly (composite)		X		X
ORNL: Corehole 8	ORNL Central campus remedial activities	weekly	weekly	X		X	
ORNL: B4007	ORNL Central campus remedial activities	weekly	weekly	X		X	
EMWMF	Disposal activities at EMWMF	weekly	weekly	X		X	
Fort Loudoun Dam (Loudon County)	Background	Weekly	biweekly (composite)		X		X
		weekly	weekly	X		X	



**Figure 1: Fugitive Air Monitoring Locations**

**References**

National Emissions Standards for Hazardous Air Pollutants (NESHAPS), Clean Air Act, Title 40 CFR Part 61, Subpart H., U.S. Environmental Protection Agency, 1994.

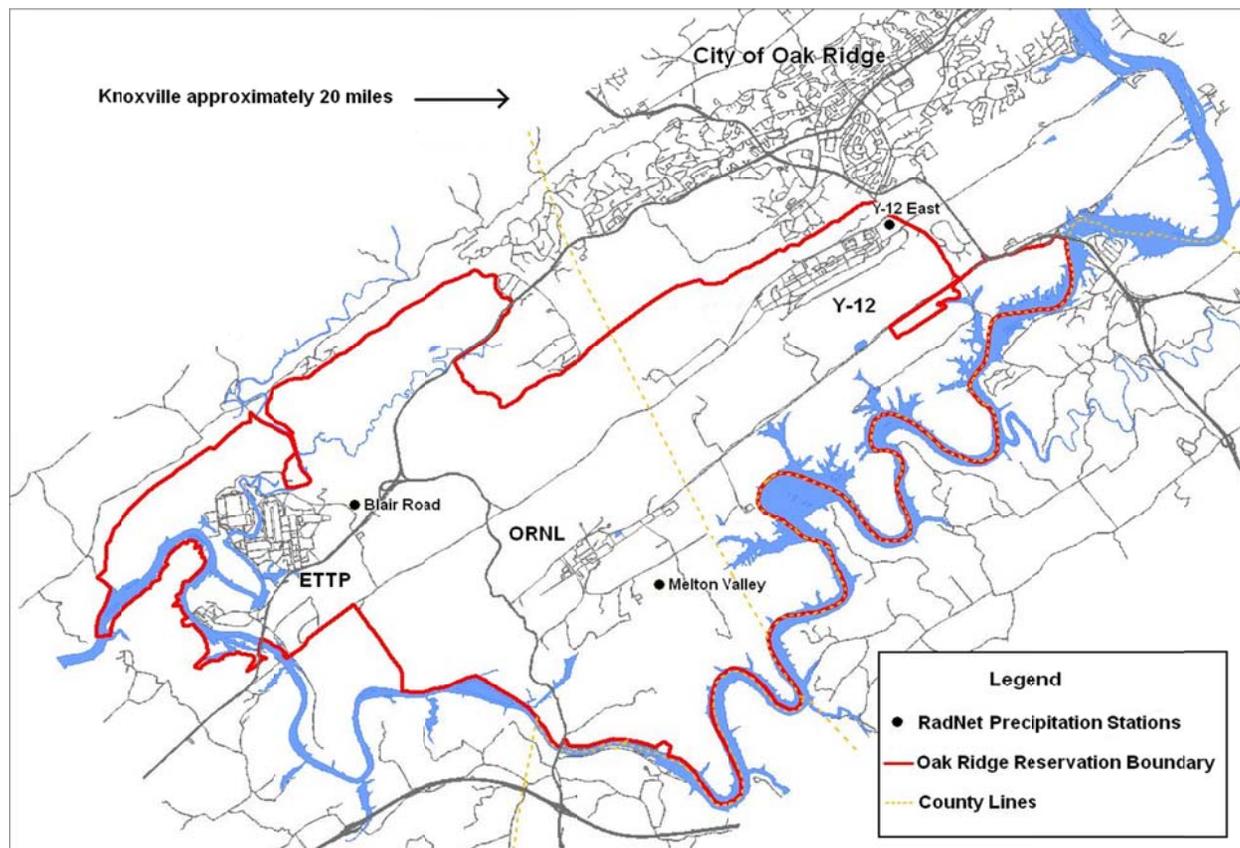
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Yard, C.R., Health, and Safety Plan, Tennessee Department of Environment and Conservation, DOE Oversight Office. Oak Ridge, Tennessee. 2011.

## RadNet Precipitation Monitoring on the Oak Ridge Reservation

### Introduction

The Tennessee Department of Environment and Conservation DOE Oversight Office, a part of the Division of Remediation (the division), will continue to monitor the air at three locations on the Oak Ridge Reservation in 2013 with EPA's RadNet Precipitation Monitoring Program. The project measures radioactive contaminants that are washed out of the atmosphere and carried to the earth's surface by precipitation. There are no standards that apply directly to contaminants in precipitation, but the data provide an indication of the presence of radioactive materials that may not be evident in the particulate samples collected by the office's air monitors. All precipitation samplers are co-located next to RadNet air monitoring locations (described in the RadNet Air Monitoring Plan) on the Oak Ridge Reservation (Figure 1).



**Figure 1: Approximate Locations of Precipitation Stations Monitored on the Oak Ridge Reservation**

One of the radioactive contaminants of concern in the atmosphere above the reservation is tritium. Small amounts of this radionuclide are produced naturally, but the isotope is also released as water vapor in reactor effluents and from evapotranspiration associated with buried wastes. In light of the above, the first precipitation monitor provided by EPA was placed co-located with the RadNet air station near ORNL's High Flux Isotope Reactor and the SWSA 5 (solid waste storage area) burial grounds, the major source area for tritium on the reservation in 2005. Another precipitation monitor was placed near the TSCA Incinerator in April 2007 and is co-located with the Blair Road RadNet air station, east of ETP. This sampler is now used to

monitor D&D at ETPP. The third and final precipitation station is co-located with the RadNet station east of Y-12 and was deployed in March 2008. This station is used to monitor Y-12 and to provide an indication of potential tritium transport toward the city of Oak Ridge from Melton Valley, where tritium levels are high. Tritium data received to date for the three Oak Ridge Reservation stations have been among the higher values reported for the RadNet monitoring stations across the nation. It should be noted, however, that the Oak Ridge stations are the only stations located near nuclear sources, hence the higher values.

### **Methods and Materials**

The precipitation monitors provided by EPA's RadNet Program will be used to collect samples for the program. Each monitor collects precipitation that falls on a 0.5 square meter fiberglass collector which drains into a five-gallon plastic collection bucket. Each station will be checked twice a week and a sample will be collected from the bucket (using a four-liter cubitainer) when a minimum of one liter of precipitation has accumulated. The sample will then be processed as specified in the *Environmental Radiation Ambient Monitoring System (ERAMS) Manual* (U.S. EPA, 1988) and shipped to EPA's National Air and Radiation Environmental Laboratory in Montgomery, Alabama, for analysis. Results from the gamma and tritium analysis will be provided to the office and will be available on EPA's RadNet website via the EPA searchable Envirofacts database ([http://iaspub.epa.gov/enviro/erams\\_query\\_v2.simple\\_query](http://iaspub.epa.gov/enviro/erams_query_v2.simple_query)). More information on the program can be found on the EPA RadNet webpage (<http://www.epa.gov/radnet>). The data will be used to identify anomalies in radiological contaminant levels to assess the significance of precipitation in contaminant pathways, to evaluate associated control measures, and to appraise conditions on the Oak Ridge Reservation compared to other locations in the RadNet program.

### **References**

- Tennessee Oversight Agreement, Agreement Between the U.S. Department of Energy and the State of Tennessee. Tennessee Department of Environment and Conservation, DOE Oversight Office. Oak Ridge, Tennessee. 2011.
- Environmental Radiation Ambient Monitoring System (ERAMS) Manual. Doc. EPA 520/5-84-007, 008, 009. United States Environmental Protection Agency. Washington: GPO. May, 1988.
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- National Air and Radiation Environmental Laboratory. United States Environmental Protection Agency. <http://www.epa.gov/radnet> (Last updated September 7, 2012).
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## BIOLOGICAL MONITORING

### Monitoring and Inventory of Bats (Chiroptera) on the Oak Ridge Reservation

#### Abstract

There is a paucity of available information regarding the distribution and occurrence of bats in the southeastern United States, including the occurrence of bat species on the Oak Ridge Reservation (ORR). Although the presence of the federally endangered gray bat has been documented on the ORR, the status of the federally endangered Indiana bat and knowledge of the overall bat community is not well known. Previous ORR bat investigations have been limited by short term 2-4 night surveys of mist-netting and acoustic surveys at project sites (i.e., to meet the requirements of section 7 of the Endangered Species Act of 1973 for threatened and endangered species). Because of this, no long term, intensive monitoring data is available. Accordingly, we intend to significantly expand the number of bat monitoring events and to increase the number of ORR monitoring stations in order to enhance data collection. Further, we will also conduct acoustic surveys (i.e., mobile transects) on ORR roads. As with any inventory, site selection is crucial in obtaining good data. Water sources (streams, ponds, riparian zones, rivers, wetlands) and travel corridors (e.g., linear landscape features, forested roads, trails, dry creek beds) are areas that are heavily used by bats. Wooded ravines, ridgetops, forested bottomlands also provide summer habitat for many bats. Ultimately, we will acoustically monitor most of these habitats.

Bats (order *Chiroptera*) are fundamental ecosystem components for insect suppression, pollination and seed dispersal. Bats in the eastern United States use ultrasonic echolocation to locate prey and navigate in their surroundings. Echolocation calls of most bats are species specific. Ultrasonic detectors are widely used to record and analyze bat echolocation calls and have improved conservation efforts by providing increased knowledge of bat ecology. They also help to efficiently characterize and inventory bat communities at study sites.

The TDEC (Tennessee Department of Environment and Conservation) Division of Remediation, DOE-Oversight Office, plans to conduct a pilot project to investigate and inventory the bat community present on the Oak Ridge Reservation in 2013. Following emergence from winter hibernation, the ORR bat community will be monitored using nonintrusive methods such as the Anabat™ system to record calls that enable acoustic identification of species. Recorded bat calls will be analyzed and species determined using specialized software. We will use a combination of active and passive ultrasonic field surveys beginning after April 15, 2013, and continuing through November 15, 2013. Due to concerns with the white nose syndrome disease, bats will not be trapped nor physically handled during the pilot project.

White-nose syndrome (WNS) is an emergent disease of hibernating bats that has spread from the northeastern to the central United States at an alarming rate. Since the winter of 2006-2007, millions of insect-eating bats in 19 states and four Canadian provinces have died from this devastating disease. Infected bats are principally cave-dwelling species and WNS is now known in several Tennessee caves. The disease is named for the white fungus, *Geomyces destructans*, which infects skin of the muzzle, ears, and wings of hibernating bats. A leading hypothesis

suggests that *G. destructans*-infected bats arouse prematurely from torpor, compelling them to use up their fat reserves prior to spring emergence, essentially starving the bats because there are no available insects for bats to eat during the colder months. Mortality at affected caves has been documented at >80-97%.

## **Introduction**

Bat fossils have been found that date back approximately 50 million years, but, surprisingly, ancient bats very closely resembled those we know today (Tuttle 1997). For example, Pleistocene fossils of *Myotis grisescens* are known from caves and quarries in Georgia, Maryland and West Virginia (Decher and Choate 1995). Bats are mammals, but such unique ones that scientists have placed them in a group of their own, the Chiroptera, meaning hand-wing (Tuttle 1997). Like dolphins, most bats communicate and navigate with high-frequency sounds (i.e., echolocation). Using sound alone, bats can *see* everything but color, and in total darkness they can detect obstacles as fine as a human hair. In addition, bats are not blind and many have excellent vision (Tuttle 1997). Although 70 percent of bats are insectivores, many tropical species feed exclusively on fruit or nectar. Tuttle (1979) estimated that a maternity colony of approximately 250,000 gray bats may consume as much as one ton of insects each night. A few are carnivorous, hunting small vertebrates, such as fish, frogs, mice, and birds (Tuttle 1997).

Bats in the eastern United States use echolocation to locate prey and navigate in their surroundings (Britzke 2003). During summer nights, bat roost-emergence and feeding activity commonly peaks immediately after sunset and can continue for several hours (Kunz, 1973; Barclay, 1982). Typically, a lesser activity peak occurs before sunrise as bats return to their diurnal roosts after foraging (Kunz 1973). They typically roost in tree cavities or under exfoliating bark of snags or live trees, where they form maternity colonies of more than 100 individuals during summer (May–July, Caceres and Barclay, 2000).

Echolocation calls of bats consist of three phases: search, approach, and terminal (Griffin et al. 1960). Search phase calls are produced to locate prey, approach phase calls are produced to identify exact locations of prey, and terminal phase calls are produced just prior to capture. Search phase calls are useful in the study of bat echolocation because they constitute a majority (ca. 90%) of calls produced by bats, exhibit consistency in structure throughout the call sequence, and may possess species-specific characteristics (Betts 1998, Fenton and Bell 1981, O'Farrell et al. 1999). A call is defined as a single sound emission, and a call sequence as a series of calls emitted by an individual bat (Fenton et al. 1999, O'Farrell et al. 1999). Bat echolocation call data begins with vibrations of the bat's larynx imparting pressure waves on the air (i.e., sound) that propagate through the air at high velocity (i.e., speed of sound, Figure 1). Echolocation call data recorded on detectors can then be downloaded into software such as Analook-W for analysis and determination of species (Figures 2 and 3). Also, for screening Anabat echolocation bat calls, we shall use automated acoustic bat identification software

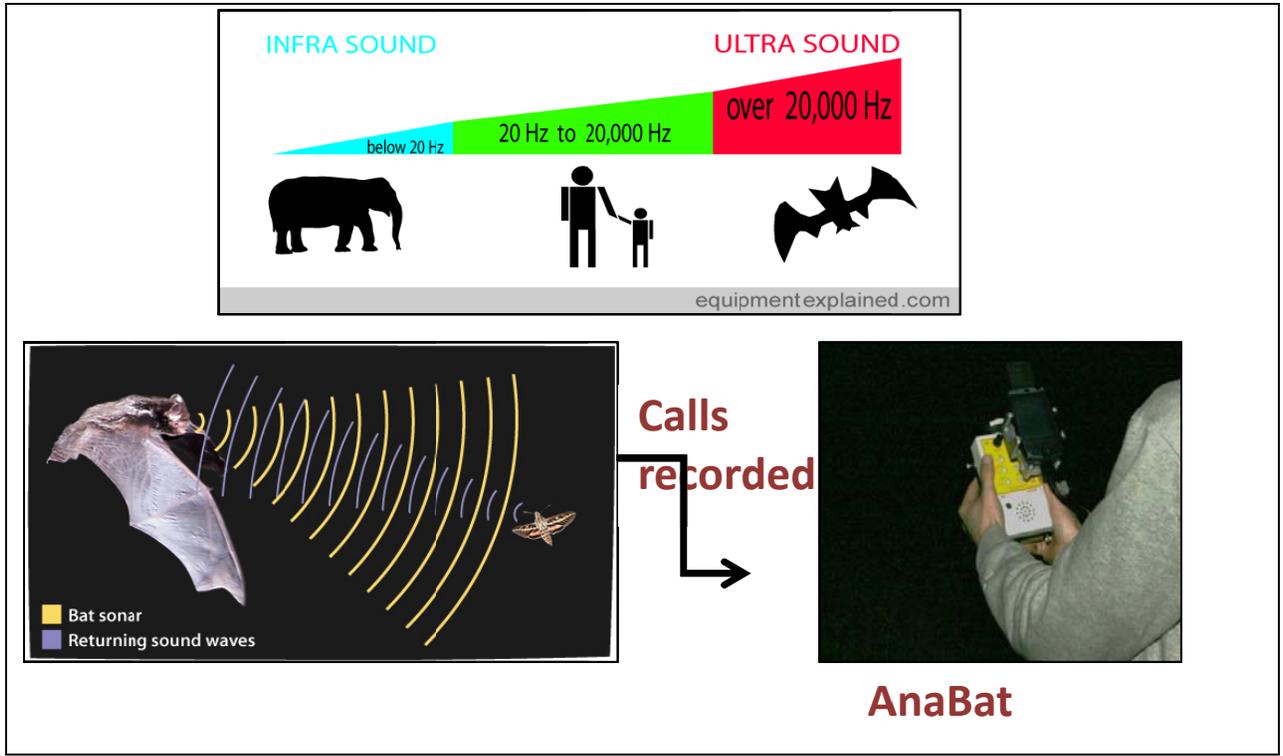


Figure 1: Schematic of bat frequencies and echolocation calls recorded with Anabat detector

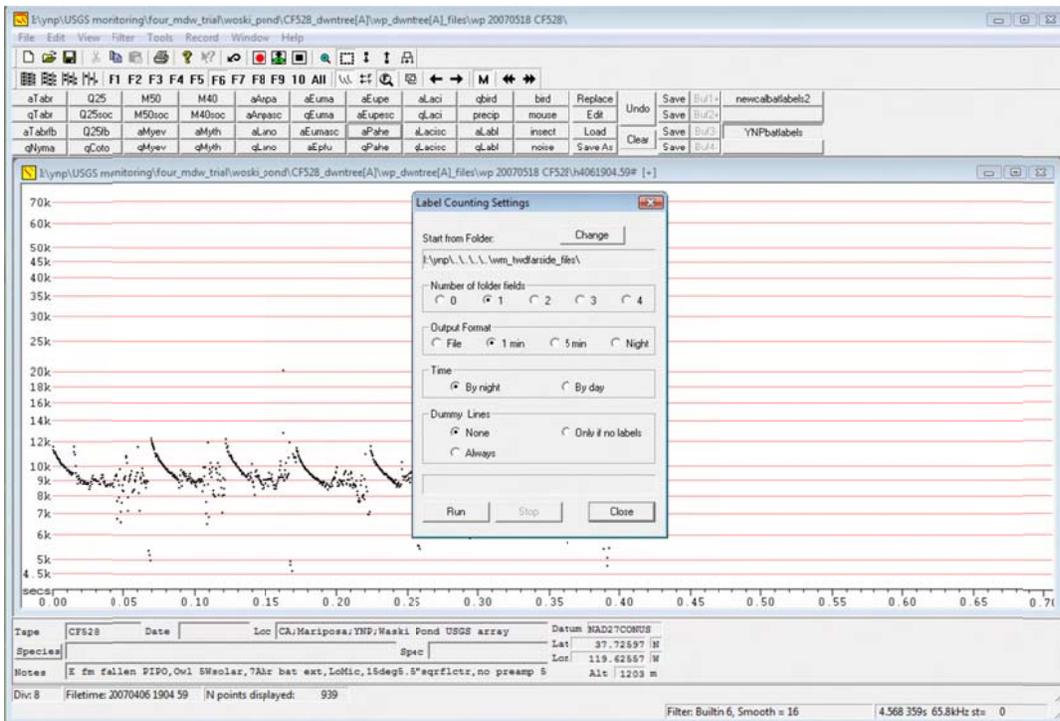


Figure 2: Example of Analook-W software time-frequency output

programs recommended by the US Fish and Wildlife Service (USFWS) including (1) EchoClass (Dr. Eric Britzke, US Army Engineer Research and Development Center, Vicksburg, MS) and (2) BCID East (Ryan Allen, Bat Call Identification, Inc.). Threatened and endangered bat species detected on the ORR will be independently confirmed by bat identification experts. Confirmed T&E species information will then be submitted to the USFWS, Tennessee Wildlife Resources Agency (TWRA), DOE and the TDEC Division of Natural Areas.

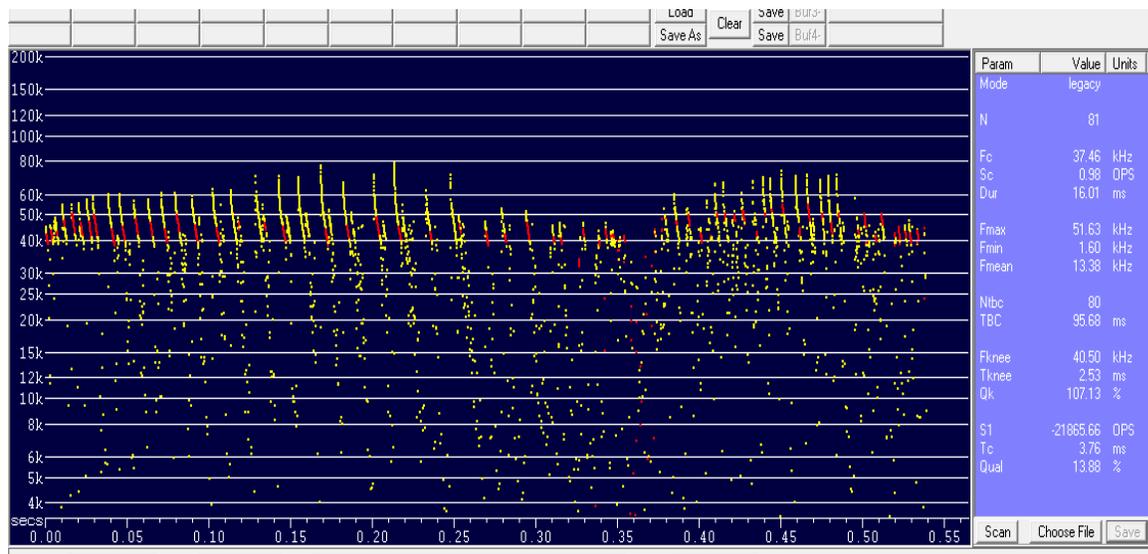


Figure 3: Example of Anabat data plotted with Analook-W software (i.e., Indiana Bat)

In addition to serving as numerous components for studying local biodiversity, their small size, mobility and longevity combine to make bats well suited for use as indicators of general environmental conditions. Although field evidence for the occurrence of the gray bat on the ORR has been documented (i.e., mist net captures, acoustical surveys), the status of the Indiana bat and other species on the ORR remains unclear. Further, little information has been published providing roost survey data or an inventory of bat species occurring on the reservation. One reason for this paucity of information is likely due to the fact that federal agencies such as TVA or DOE usually have to meet the conditions of section 7 of the Endangered Species Act of 1973 which only requires 2-4 survey nights of mist netting and acoustic surveys to determine presence (or absence) of federally endangered Indiana or gray bats on project sites.

The Tennessee Oversight Agreement mandates a comprehensive and integrated monitoring and surveillance program for all media (i.e., air, surface water, soil sediments, groundwater, drinking water, food crops, fish and wildlife, and biological systems) and the emissions of any materials (hazardous, toxic, chemical, radiological) on the ORR and environs. Accordingly, monitoring the ecological recovery progress of wildlife and environmental restoration of habitat are important aspects of remedial activities on the ORR. Additionally, the Environmental Monitoring section has lead responsibility for threatened and endangered species issues within the TDEC DOE-Oversight Office.

Parks and other protected lands (e.g., the National Environmental Research Park, or NERP) can provide important source habitat for bats and act as valuable dispersal corridors in urbanizing environments (Lookingbill et al. 2010). Of the 20+ bat species in the southeastern United States (Table 1), 16 are known to occur in Tennessee. Locally, two bats are listed as federally endangered, the gray bat (*Myotis grisescens*) and the Indiana bat (*Myotis sodalis*). Bats of the genus *Myotis* (i.e., mouse-eared bats) consume a variety of insects, including *Coleoptera*, *Diptera*, *Ephemeroptera*, *Lepidoptera*, *Neuroptera* and *Trichoptera* (Best et al. 1997).

**Table 1: Bats of the Eastern United States**  
(Source: Bat Conservation International 2011)

**FAMILY PHYLLOSTOMIDAE – NEW WORLD LEAF-NOSED BATS**

*Artibeus amaicensis* Jamaican fruit-eating bat (FL Keys only)

**FAMILY MOLOSSIDAE – FREE-TAILED BATS**

*Eumops floridanus* Florida bonneted bat (southern FL only)

*Molossus molossus* Pallas' mastiff bat (FL Keys only)

*Tadarida brasiliensis* Mexican free-tailed bat ‡◇

**FAMILY VESPERTILIONIDAE – PLAIN-NOSED (VESPER) BATS**

*Corynorhinus* (= *Plecotus*) *rafinesquii* Rafinesque's big-eared bat\*◇

*Corynorhinus townsendii ingens*◇

*C.t. virginianus* Ozark and Virginia big-eared bats\*†

*Eptesicus fuscus* big brown bat\*◇

*Lasionycteris noctivagans* silver-haired bat\*◇

*Lasiurus borealis* (eastern) red bat\*◇

*Lasiurus cinereus* hoary bat\*◇

*Lasiurus intermedius* northern yellow bat

*Lasiurus seminolus* Seminole bat ‡◇

*Myotis austroriparius* southeastern myotis\*◇

*Myotis grisescens* gray myotis\*†◇

*Myotis leibii* small-footed myotis\*◇

*Myotis lucifugus* little brown myotis\*◇

*Myotis septentrionalis* (formerly *M. keenii*) eastern long-eared myotis\*◇

*Myotis sodalis* Indiana myotis\*†◇

*Nycticeius humeralis* evening bat\*◇

*Perimyotis* (*Pipistrellus*) *subflavus tri-colored bat (eastern pipistrelle)\*◇*

\* range includes Kentucky

‡ vagrants can be found in Kentucky

† Federally Endangered Species and/or Sub-species

◇ species known to occur in Tennessee

The gray bat is highly migratory and establishes nursery colonies in warm caves during summer and hibernates in different cold caves during the winter (Gardner and Hofmann 1986, Gore 1992, Decher and Choate 1995). It typically forages almost exclusively over rivers, streams and lakes where insects are abundant usually within 2 km of their cave or abandoned mine (Tuttle 1976, LaVal et al. 1977, LaVal and LaVal 1980, Mitchell and Martin 2002). They migrate between summer and winter caves and will use transient or stopover caves along the way. One-way migrating distance between winter and summer caves may vary from as little as ten miles to well over 200 miles. An important hibernacula for gray bats is Hubbards Cave, Tennessee, which has been gated since the early 1970s to prevent human disturbances of the bat colony (Tuttle 1985, 1986). Gray bats may roost at man-made sites that simulate summer caves, such as abandoned barns (Gunier and Elder 1971) and storm drains (Hayes and Bingham 1964, Timmerman and McDaniel 1992).

In contrast, the Indiana bat is a highly migratory species and forms maternity roosts in snags and trees with exfoliating bark that are partially exposed to sunlight during summer. They are more concentrated in caves during winter hibernation (Gardner and Hofmann 1986). The sunlight is thought to speed the development of the young pups (French 2009). However, Salyers et al. (1996) discovered two male Indiana bats roosting in a bat box in Indiana, and elsewhere, immature males were captured beneath a concrete bridge (Mumford and Cope 1958). Indiana bats forage in and around the tree canopy of floodplains (i.e., forest edge of floodplains), as well as in riparian and upland forests (USDOE 2007). Factors contributing to the decline of bat species include stream channelization, cattle farming, deforestation, insecticide poisoning, urban expansion, and more recently, white nose syndrome disease (Gardner and Hofmann 1986).

Some species have adapted to roosting in structures such as bridges, abandoned houses, wells, cisterns and mines (Keeley and Tuttle 1999, Trousdale and Beckett 2004). Bat houses have proven very effective in providing roosting habitats for some species, and bat house surveys may be useful for providing data on bat communities (Martin and Britzke 2010).

Snags in mixed pine/hardwood forests are a crucial habitat element for numerous animals, including woodpeckers and bats (Shackelford and Conner 1997, Graves et al. 2000, Perry and Thill 2008, Johnson et al. 2009). Indiana bat maternity colonies have been found foraging along forested riparian zones, snag-rich bottomlands and hydric forests (LaVal and LaVal 1980, Menzel et al. 2005, Carter 2006).

Bat detectors enable bats to be studied in greater detail and are now employed by most researchers in censuses of bat faunas (Barataud 1998, Pauza and Pauziene 1998) and in the analysis of habitat use (Vaughan et al. 1997, Avila-Flores and Fenton 2005). Acoustic surveys of bat echolocation calls are often used to model a species' occurrence at a site (i.e., occupancy model, French 2009), and improve conservation efforts by increased knowledge of bat ecology (Britzke et al. 2011). The application of bat ultrasonic monitoring devices such as the Anabat SD-2 detector has allowed ecologists to quickly and efficiently characterize and inventory bat communities at multiple areas (O'Farrell and Gannon 1999, Owen et al. 2004), and to transform those calls into frequencies which are audible to humans (Parsons et al. 2000).

## Study Site

The study will be conducted on the Oak Ridge Reservation, Oak Ridge, Tennessee, which consists of approximately 34,500 acres (14,000 ha) within Anderson and Roane counties (Figure 4). The reservation is bound on the north and east by residential areas of the City of Oak Ridge and on the south and west by the Clinch River. The ORR lies in the Valley and Ridge Physiographic Province of East Tennessee. The underlying geology consists of complex geologic structures dominated by a series of thrust faults and is characterized by a succession of elongated southwest-northeast trending valleys and ridges. In general, sandstones, limestones, and/or dolomites underlie the ridges that are relatively resistant to erosion. Weaker shales and more soluble carbonate rock units underlie the valleys (TDEC 2011). The ORR, consisting of the Oak Ridge National Environmental Research Park and associated lands surrounding DOE facilities, is mostly contiguous native forest in the valley and ridge (Mann et al. 1996). Relatively protected from urbanization and intensive agriculture for more than 70 years, the ORR has become an important site for conservation of many plant and animal species, including birds and bats, especially those species that require large blocks of contiguous habitat (Mitchell et al. 1996). Thus, about 70% of the ORR is in forest cover and about 20% is transitional land use, consisting of old fields, agricultural areas, recently clear-cut forest lands, and road and utility corridors. The remainder consists of urbanized or DOE-regulated areas (Washington-Allen et al. 1995).

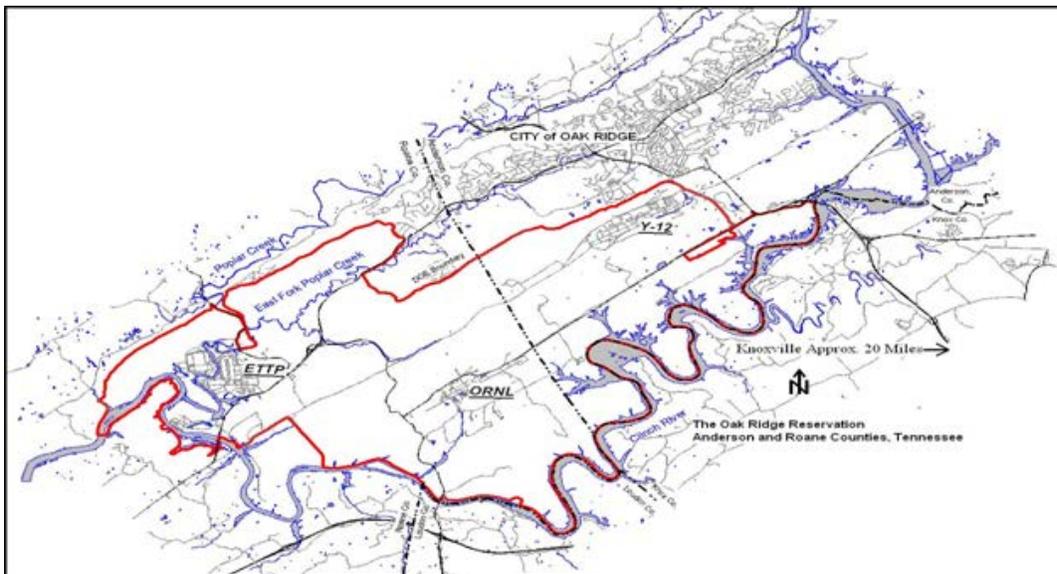


Figure 4: Map of the Oak Ridge Reservation

## Regulatory Justification

Monitoring and protection of threatened and endangered species (T&E species) on the ORR falls under the purview of the TDEC DOE-Oversight Environmental Monitoring section. Because the two federally endangered bat species likely present here are important regulatory drivers, as well as being significant indicators of ecological recovery, it is critical to carefully document their occurrence and status in ORR environmental habitats. We also support the Division of Natural Areas in TDEC's Bureau of Parks and Conservation which is dedicated to restoration and protection of plants, animals, and natural communities which represent the natural biological diversity not only on the ORR, but also the rest of Tennessee.

An example of a federal law that protects T&E species includes the Endangered Species Act of 1973 (ESA), as amended. This law provides for the inventory, listing, and protection of species in danger of becoming extinct and/or extirpated, and for the conservation of the habitats on which such species thrive. Another law, the National Environmental Policy Act (NEPA), requires that federally-funded projects avoid or mitigate impacts to listed species (Giffen et al. 2007).

The purpose of the Endangered Species Act (16 USC 1531–1544) of 1973 is to preserve plants and animals facing extinction. It mandates the conservation of proposed and listed threatened and endangered (T&E) species and the designated critical habitats supporting them. Section 7 of the ESA requires all federal agencies, including DOE, to ensure that any action they authorize, fund, or carry out does not jeopardize the continued existence of any T&E species or result in the destruction or adverse modification of designated critical habitats that are important in conserving those species (Giffen et al 2007).

NEPA requires all federal agencies to consider the effects of their actions on the environment. For example, when DOE proposes an action, it must develop a NEPA document (e.g., categorical exclusion, environmental assessment, environmental impact statement) to consider the potential impacts. If DOE proposes an action on the ORR and if no previous NEPA documentation exists for the area involved in any alternative under consideration, a biological survey and evaluation might be required to determine if any T&E species are or could be present. Section 7(a) of the act requires federal agencies to use their authorities to further the purposes of the act by carrying out programs to conserve listed T&E species (Giffen et al. 2007).

More specifically, and according to the Federal Facilities Agreement, Section III.A.2 (Purpose of Agreement) states:

*Establish a procedural framework and schedule for developing, implementing, and monitoring appropriate response actions at the Site in accordance with CERCLA, the NCP, RCRA, NEPA, appropriate guidance and policy, and in accordance with Tennessee State law. Hence, DOE is required to implement the substantive requirements of NEPA when conducting remedial actions.*

### **Nature of the Problem**

The southeastern United States is undergoing unprecedented landscape alterations caused by rapid human population and urban expansion (Wear and Greis 2002). Reindustrialization of former government properties is also creating habitat loss (i.e., hardwood forests with potential Indiana bat roosts in trees or snags with exfoliating bark) that may affect sensitive bat communities. Indeed, the roosting and foraging ecology of the federally endangered Indiana bat continues to be impacted throughout its range by habitat alteration, conversion of forest to agricultural land, surface-mining and wetland losses (Menzel et al. 2005).

On the Oak Ridge Reservation, former DOE acreages (i.e., land parcels such as ED-1) have been deeded over to local governments for economic development and reindustrialization as well. Although several bat surveys have been conducted by DOE contractors on these parcels, these efforts have been usually of short duration (2-4 survey nights per survey site) with a small

number of stations monitored. This is in part due to the U.S. Fish and Wildlife Service only requiring mist netting and acoustic surveys for 2-4 nights at a site to determine the presence (or absence) of Indiana bats per section 7 of the Endangered Species Act of 1973. Because of this, there is no available, long term ORR bat monitoring data. In contrast, more intensive bat studies have been completed at other DOE facilities such as the Savannah River Site (SRS), South Carolina. Among species common to the SRS are the southeastern myotis (*Myotis austroriparius*) and Rafinesque's big-eared bats (*Corynorhinus rafinesquii*) which are listed by South Carolina as threatened and endangered species, respectively. The presence of these two species, and a growing concern for the conservation of forest-dwelling bats, led to extensive and focused research on the SRS between 1996 and 2003 (Menzel et al. 2003). For example, in 2001, wildlife biologists conducted a sitewide bat survey at SRS, using the Anabat system. Areas representative of most site habitats (i.e., wetlands, floodplains, marshes, riverine, ponds, lakes, upland hardwoods, bottomland hardwoods, pine forests, mixed pine/hardwoods, etc., Menzel et al. 2003) were sampled at 449 stations. Accordingly, we shall use the SRS bat study as a model for our methods and sampling plan for the ORR bat investigation. The fact that two federally endangered bat species have been documented on the ORR should be adequate justification for the ORR bat project.

Although the federally endangered gray bat has been documented and confirmed to be present on the ORR (Harvey and Britzke 2003, 2004, USDOE 2007, 2009, 2011, Jackson 2011), the occurrence of the Indiana bat on the ORR is less certain. The only evidence for the Indiana bat on the ORR is one echolocation call recorded during a 2008 Anabat survey in the western portion of the East Tennessee Technology Park (ETTP, USDOE 2009). To address these problems, we intend to monitor multiple fixed-point sites by passively monitoring with the Anabat detector, either for 20 minutes per site, or overnight for sites that are determined to have high bat activity. We will also employ the mobile transect method where the detector is mounted on the car roof while the biologist drives roads at 15-20 mph recording opportunistic bat echolocation calls. All these surveys will start 30 minutes past dusk.

The ORR contains many acres of high quality Indiana bat habitat with upland forest and dead pine snags adjacent to large bodies of water. Summer colonies of Indiana bats are more dispersed in forests and more difficult to detect and monitor in annual surveys than gray bats. The nearest known hibernation cave to the ORR is in the Great Smoky Mountains National Park (Blount County). Maternity roosts were found for the first time in our region in the Nantahala National Forest in 1999 and in the GSMNP in 2001 (Britzke et al. 2003). Individuals of the species have been collected in the Cherokee National Forest near Tellico Lake in Monroe County (USFS 2007). No maternity roosting colonies of Indiana bats are known on the ORR. However, high quality Indiana bat roosting habitat on the ORR should be identified and monitored periodically (Mitchell and Martin 2002). Hence, one of the objectives of the project is to conduct daylight roost and tree habitat surveys on the ORR.

More than 20 caves have been identified on the ORR. Mitchell et al. (1996) surveyed seven of the caves (Copper Ridge, Flashlight Heaven, Walker Branch, Big Turtle, Little Turtle, Pinnacle, and Bull Bluff), but no gray bats were found. There is an unverified report of ten gray bats roosting in Little Turtle Cave in September 1996 (Webb 2000). Therefore, Anabat surveys (i.e., Titley **AnaBat™ Roost Logger**) of ORR cave entrances will also be conducted on multiple

nights to determine bat species that may be present. Due to concerns with white-nose syndrome, we should note that ORR caves will not be entered at any time.

## Objectives

- Conduct passive fixed-point Anabat surveys at multiple ORR sites
- Conduct Anabat mobile transect surveys on ORR access roads
- Record light and temperature data at overnight Anabat monitoring stations
- Identify roost trees and other roosting habitats (i.e., bridges, rock crevices, etc.)
- Compare bat communities in different forest stands (e.g., mixed hardwoods vs. pines)
- Develop occupancy models for endangered bat species (i.e., *Myotis sodalis*, *M. grisescens*)

## Methods

Acoustic surveys will be conducted at approximately 149 fixed-point locations, and in addition, mobile transect surveys will be driven on 30+ miles of gravel access roads on the ORR (Figures 5-9). The fixed-point survey stations were chosen at random near roads or selected from map points within forests, riparian zones, fields, trails, ponds, streams, known caves, river edges, or other areas we suspected would have concentrated bat activity. Stations are shown as red stars on the figures. The road transects were selected from bar-gated reservation access roads that pass through multiple environmental habitats and the routes are shown as red dashed lines on the figures.

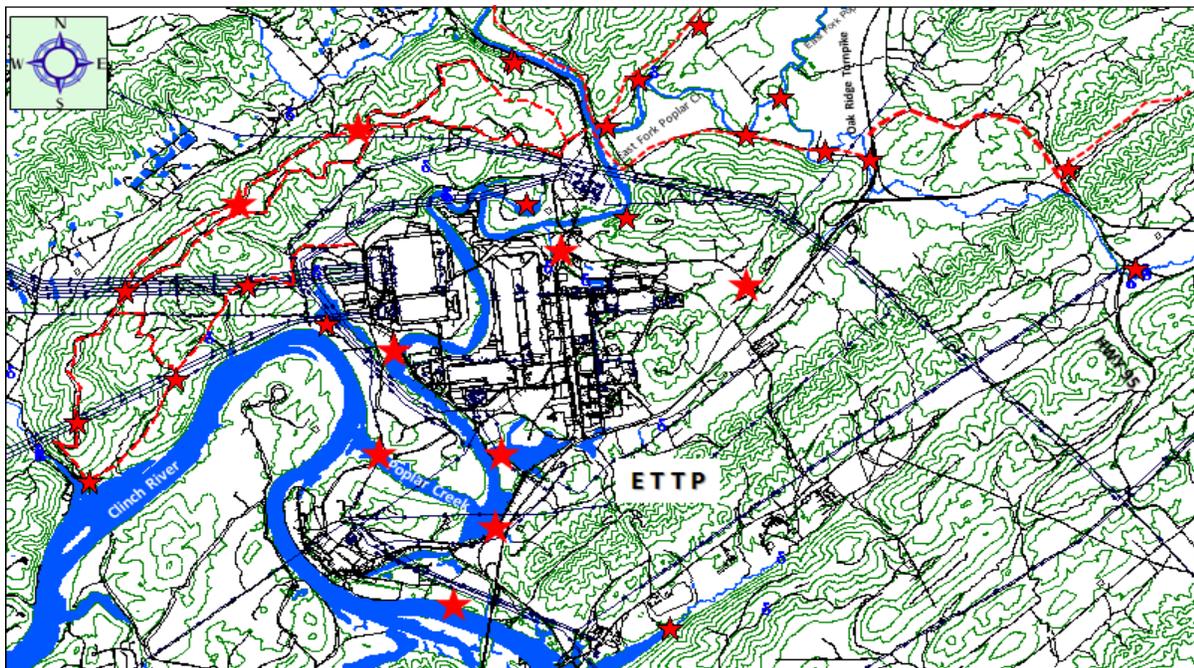


Figure 5: ETTP vicinity bat survey map (red stars = passive monitoring sites; red dashed line = mobile transect routes)

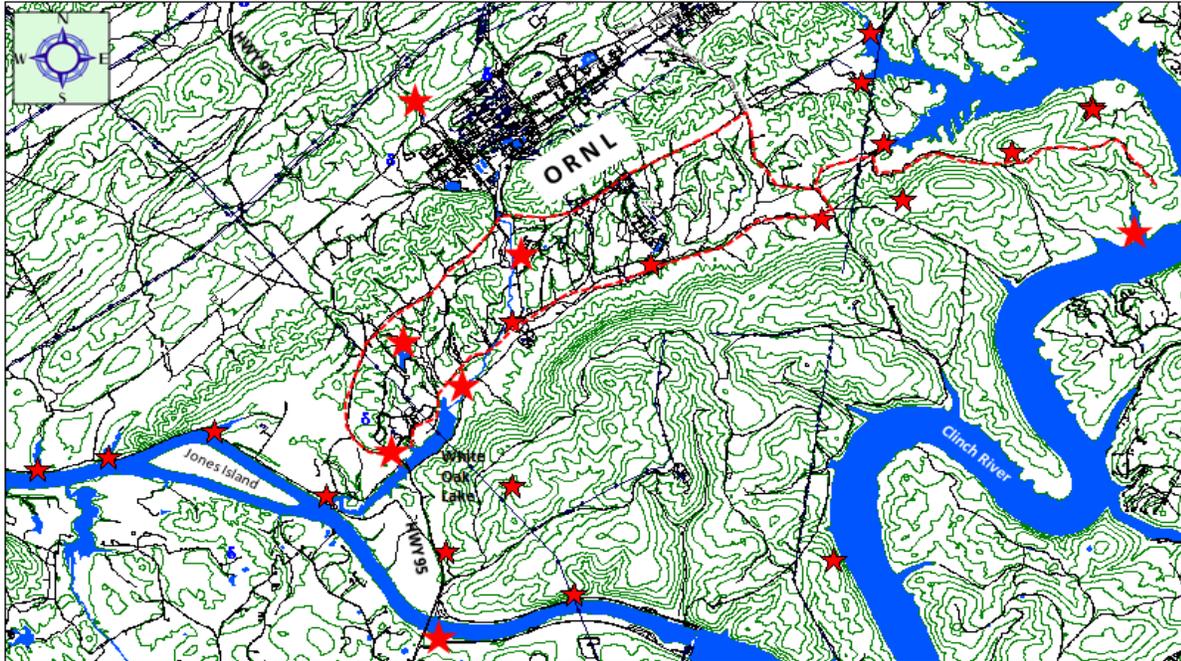


Figure 6: ORNL vicinity bat survey map (red stars = passive monitoring sites; red dashed line = mobile transect routes)

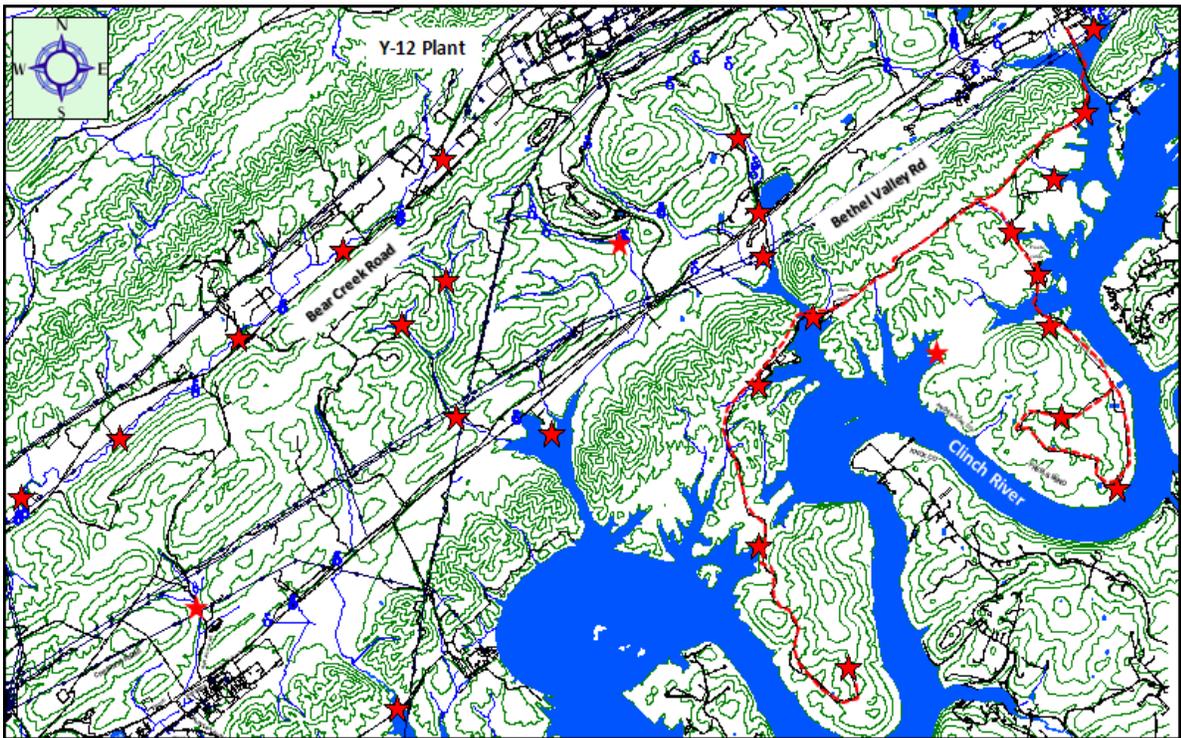


Figure 7: Y-12 and Three Bends vicinity bat survey map (red stars = passive monitoring sites; red dashed line = mobile transect routes)

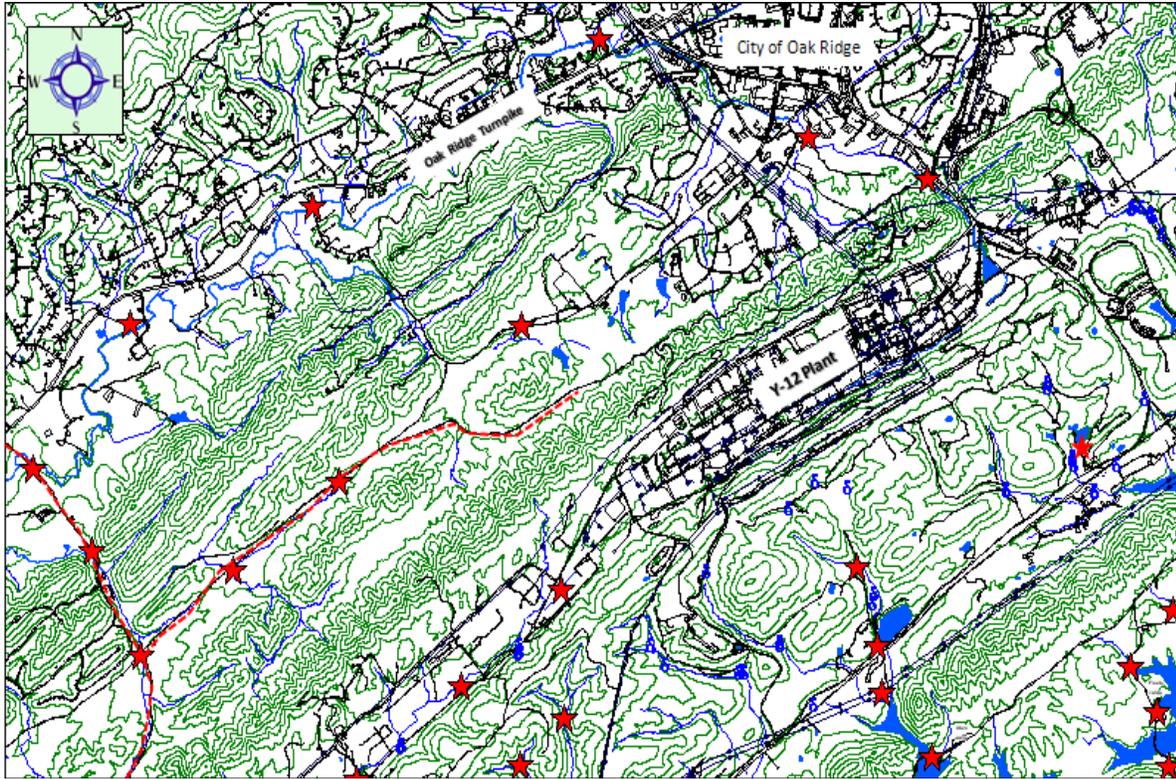


Figure 8: Y-12 and City of Oak Ridge vicinity bat survey map (red stars = passive monitoring sites; red dashed line = mobile transect routes)

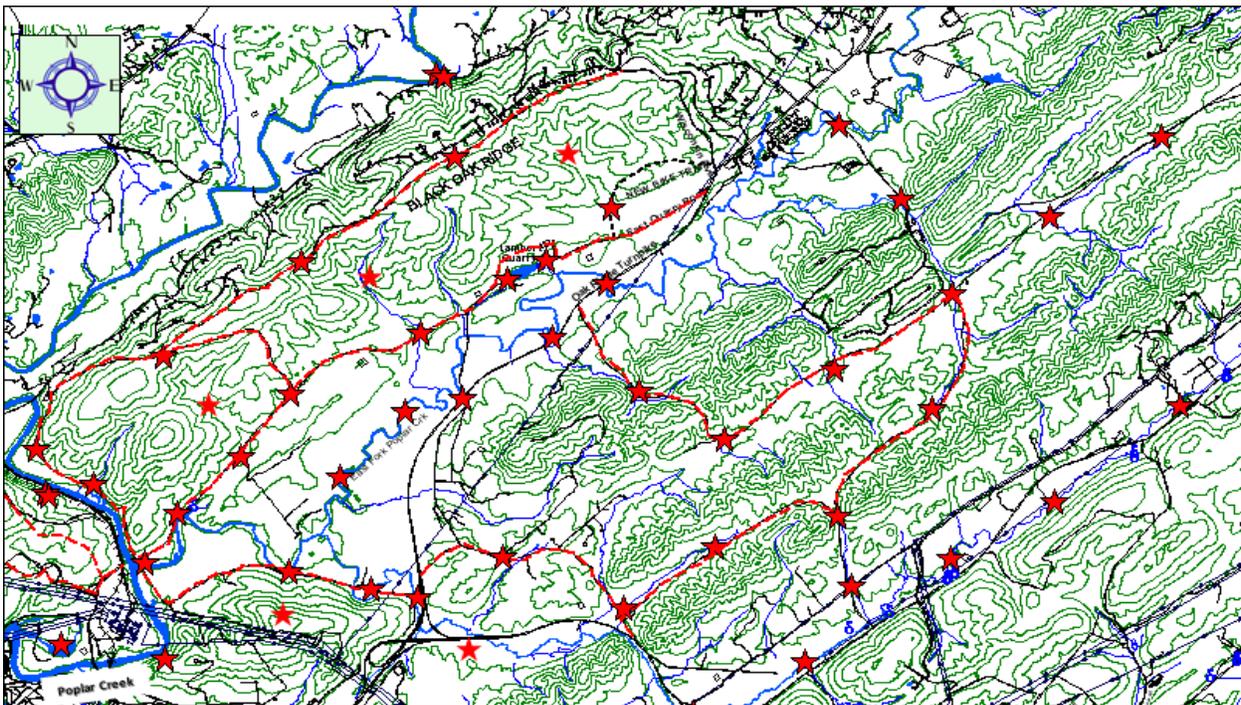


Figure 9: East Black Oak Ridge Conservation Easement and McKinney Ridge vicinity bat survey map (red stars = passive monitoring sites; red dashed line = mobile transect routes)

For this project, we will deploy two Anabat SD-2 detectors (Titley Electronics, Ballina, NSW, Australia, Figures 10-a,-b,-c) to record bat echolocation calls at each study site. It was recommended by the U.S. Fish and Wildlife Service (USFWS 2011) that a project area of suitable bat habitat would require the deployment of two detectors for two nights for a total of four detector readings. It is important to note that Anabat detectors are the currently accepted technology for most government bat surveys as recommended and approved by the U.S. Fish and Wildlife Service. However, for our 2013 bat surveys, we shall expand the number of survey nights significantly. Thus, in accordance and cooperation with the Division of Natural Area's (TDEC Bureau of Parks and Conservation) mission to restore and protect plants, animals, and natural communities that represent the natural biological diversity of Tennessee; and generally following the bat monitoring guidance and protocols of Kuenzi and Morrison (1998), Murray et al. (1999), Jones et al. (2004), Szewczak (2004), Manley et al. (2006), Britzke et al. (2011), and the U.S. Fish and Wildlife Service (USFWS 2011), we propose the following Anabat survey methods:



Figure 10-a: Anabat™ SD-2 Detector



Figures 10-b/c: Anabat with PDA attachment

- Fixed-point survey with Anabat on station for 20 minutes and surveying multiple sites per work session. Surveys will begin 30 minutes past sunset and continue for approximately 2-3 hours (Wear 2004, Ford et al. 2005, Schirmacher et al. 2007);
- Passive survey at fixed-point location recording bat echolocation calls overnight (program Anabat to begin recording 30 minutes past sunset and continue until dawn, Martin and Britzke 2010). Detector systems placed in the field for remote, passive sampling are often housed in waterproof containers with an aperture through which the microphone can be fitted (Figure 11, Britzke et al. 2010). Detectors will be placed a few feet off the ground on camera tripods to reduce recording ultrasonic insect clutter (Weller and Zabel 2002). Hobo Pendant® light/temperature meters will also be deployed with Anabats left in the field for overnight recording sessions (Figure 12);



Figure 11: Protective plastic housing for Anabat



Figure 12: Hobo Pendant® Data Logger

- Mobile Anabat transect monitoring will begin 30 minutes past sunset and the route will be driven at 20 mph along approximately 20-30 miles of gravel access roads. This activity will be conducted every two weeks from mid-April through mid-November 2013. The Anabat microphone will be mounted on the roof of the car during the survey (Figure 13);
- Cave surveys: Duchamp et al. (2006) determined that using a second detector at a site increased the probability of detecting different species of bats at a site (i.e., double observer method). We will likely deploy two Anabat detectors at some overnight sites, such as caves, with each detector oriented 5 m apart. The microphones will face opposite directions, yet will be pointed towards the most open area of the habitat. This will allow sampling of an area distinct from the other detector. We may also deploy the AnaBat™ Roost Logger (AnaBat™ RL1) which is a weatherproof and very low power bat detector. This device is optimized for monitoring bats at and around caves, mines and other roost areas (Figure 14). Ours will be optimized for 40 KHz colonial roosting bats with a peak frequency of 42KHz. Note that detectors will be deployed outside of the cave entrance and that the cave will not be entered.



Figure 13: Anabat roof mount microphone

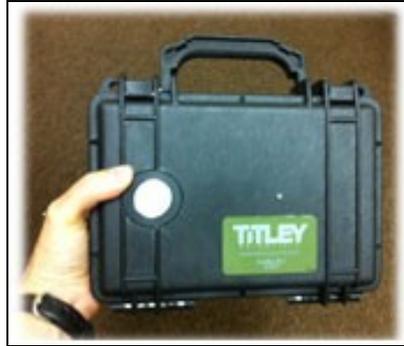


Figure 14: Anabat™ Roost Logger (Anabat™ RL1)

Anabat data files will be analyzed with Anabook-W software to determine species identifications. Additionally, freeware available from the USFWS will also be used (i.e., EchoClass) to analyze bat populations. For model development, Program MARK may be used to build the occupancy models (French 2009). Anabat data are easily utilized in occupancy models which require only presence or absence data (MacKenzie et al. 2006).

Because most bats in the east Tennessee area hibernate from about early-November until late March, acoustic field surveys will be conducted between April and October. Spot surveys will also be conducted during the winter months to monitor for species that may arouse on unseasonably warm days. It is anticipated that completion of surveys will likely take several years to adequately cover all these proposed monitoring stations and roads, thus the initial year (2013) is considered a pilot project (phase 1). In fact, a goal is to monitor the ORR bat community long term once significant field stations are determined based upon bat activity and occurrence. Due to the concerns with white nose syndrome, bats will not be trapped (i.e., mist nets) nor physically handled during phase 1.

Suspected bat habitats to be monitored include water resources (streams, ponds, riparian zones, springs, rivers, wetlands), travel corridors (linear landscape features, rocky outcrops, bluffs, forested roads, trails, dry creek beds) and karst features such as caves (LaVal et al. 1977, Racey 1998, Grindal and Brigham 1999, Menzel et al. 2005). For example, *Myotis sodalis* (Indiana bat) may forage in forests with intact canopies, near headwater streams (Menzel et al. 2005, Schirmacher et al. 2007), and within riparian zones (Webb 2000, Ford et al. 2005). The Indiana bat may form maternity roosts in shaggy-barked trees and snags with exfoliating bark during summer and then hibernate in caves during winter (Menzel et al. 2001, Timpone et al. 2010).

Habitat assessments will determine and measure habitat type, slope, temperature, % canopy cover, % shrub cover, tree species, number of snags, and the number of trees with exfoliating bark. Proximity to water (within 10 m of site), riparian zones, rock outcroppings with crevices and geologic/karst features will also be noted (Timpone et al. 2010).

## **Timetable**

Mid-April: Launch pilot project

Weekly: Anabat fixed-point survey\*\*

Weekly: Overnight Anabat survey

Every two weeks: Roost and habitat (tree) survey

Every two weeks: Mobile transect surveys\*\*

Mid-November: Suspend major operations until following April

November-April: Spot monitoring during unseasonably warm periods of winter

\*\*Conduct surveys the first 2-3 hours following sunset

## **Benefits of Research**

Acoustic surveys may be used to assess a species' occurrence at a site, which can then be applied as a variable in models of species-environment relationships (Ekman and de Jong 1996, Russ and Montgomery 2002). With the information gathered from our Anabat surveys, we may be able to provide occupancy models for *M. sodalis* and *M. grisescens* on the ORR. French (2009) developed occupancy models for *M. sodalis* on the Cumberland Plateau using Program MARK. He focused on detection probability, modeling detectability (as a function of survey night), survey time, survey temperature and survey group.

Despite previous ORR bat surveys, there has been limited research on many bat species in our area of east Tennessee. We have the potential to develop a comprehensive list of bat species present on the ORR which will be helpful to scientists and regulators making management decisions regarding environmental cleanup on the ORR. Lastly, if we were to identify a roosting maternity colony of federally endangered bats (e.g., *Myotis sodalis*) during our ORR roost surveys, this would generate considerable scientific interest and expand our knowledge of habitats where these bats may choose to colonize and rear their pups.

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## **Benthic Macroinvertebrate Biological Monitoring**

### **Project Description**

The objective of this monitoring program is to perform biological monitoring on streams affected by the U.S. Department of Energy (DOE) activities and practices on the Oak Ridge Reservation (ORR). Methods outlined in the *State of Tennessee Department of Environment and Conservation (TDEC), Division of Water Pollution Control (WPC) Quality System Standard Operating Procedure for Macroinvertebrate Stream Surveys* (TDEC 2011) will drive the project.

### **Introduction**

Because benthic macroinvertebrates are relatively sedentary and long-lived, they are excellent indicators of the “overall health” of an aquatic system. In systems where the source of the toxicant is non-point (e.g. runoff or seeps) or where the combined effects of pollutants in a complex effluent exceed individual toxicity, benthic macroinvertebrate communities may be one of the only means of evaluation. Hence, macroinvertebrates are used by biologists as indicator organisms (i.e., habitat assessments) to determine if a stream is supporting fish and aquatic life

Benthic macroinvertebrates are collected from various ORR streams and analyzed to measure the degree of impact from past and present DOE operations. The office conducts annual semi-quantitative biomonitoring on the following ORR watersheds: Bear Creek, Mitchell Branch, White Oak Creek, Melton Branch, and East Fork Poplar Creek. Benthic samples are also collected from Clear Creek near Norris Dam which serves as an ecoregion reference site for all ORR test sites.

### **Methods and Materials**

During 2013, benthic macroinvertebrate samples will be collected from 20 stream sites (Figures 1-5) and processed following TDEC Water Pollution Control (WPC) standard operating procedures (SOP, TDEC 2011). The semi-quantitative Riffle Kick (SQKICK) collection technique for single habitat analysis will be used. This test method involves standing in a body of water, kicking up sediment and catching the suspended organisms in a 1-m square kick net. Two SQKICK samples will be collected at each station and combined into one sample. A riffle kick is done in relatively fast-moving water and a run kick in slower-moving water. Care will be taken to avoid losing sample material from the sides or bottom of the net. Another method is the undercut bank jab, done by sampling the sediment below water level in a bank area that may be partially obscured by brush or partially submerged tree roots.

Samples will be collected from two riffles at each site. Both samples will be combined and transferred into one sample container. The container will be labeled internally and externally with site-specific information and stored in the office laboratory for future processing. Standard methods will be altered when sampling lower White Oak Creek due to the presence of radioactive contamination in the stream sediment. The two kick samples will be combined in a five-gallon bucket, creek water will be added and the sample swirled to suspend the lighter material (invertebrates), which will then be poured through a sieve. This process will be repeated five times, collecting the majority of organisms. Any material not used will be returned to the creek. For quality control purposes, duplicate samples will be collected at 10% of the stream sites.

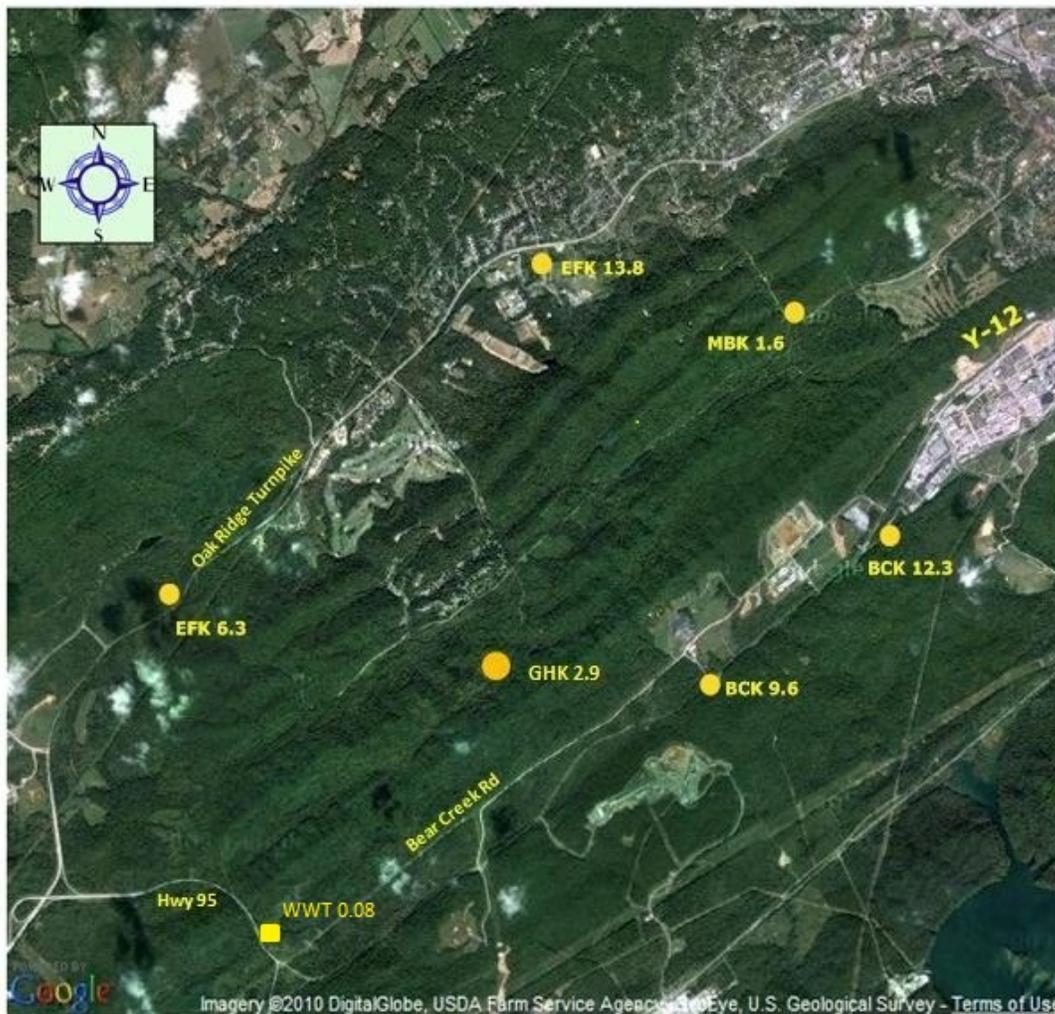


**Figure 1: Upper East Fork Poplar Creek / Y-12 Plant**

Water quality data, surface water samples and habitat assessment data will be collected at each sampling location. These activities are addressed in a separate report. All work associated with this program will be in compliance with the office's Health, Safety, and Security Plan (Yard 2010).

Once collections have been made at all 20 sites, the semi-quantitative samples will be processed in-house by office staff with expertise in macroinvertebrate taxonomy. Sample analyses will include the identification and enumeration of the benthic macroinvertebrates to genus. Using the raw benthic data from the semi-quantitative sub-samples, a numerical value will be generated for seven biometrics. These metrics include (1) EPT (Ephemeroptera, Plecoptera, and Trichoptera) richness, (2) taxa richness, (3) percent OC (oligochaetes and chironomids), (4) percent EPT (EPT abundance), (5) NCBI (North Carolina Biotic Index), (6) percent nutrient tolerant, and (7) percent clingers (contribution of organisms that build fixed retreats or that have adapted to attach to surfaces in flowing waters). After values have been calculated for the metrics, a score of 0, 2, 4, or 6 is assigned to each metric based on comparison to the ecoregion reference database. The seven scores are totaled and the site's biological condition is determined (i.e., fully supporting, etc). Metric equations and the biocriteria used to determine biological condition can be obtained

by referring to the SOP (TDEC 2011). Office data will be compared to TDEC Protocol benthic sampling data compiled by biologists with the Oak Ridge National Laboratory Biological Monitoring and



**Figure 2: East Fork Poplar Creek / Bear Creek Watersheds**

Abatement Program (ORNL BMAP). In order to validate species-level taxonomy, light trapping and other collection methods may be employed to trap adult insects in ORR streams and springs during 2013 (DeWalt and Webb 1998, Weinzierl et al. 2005, Nowinszky et al. 2010).

**Sampling Locations in Kilometers (mile equivalents) for RBP III Semi-Quantitative Sites (Figures 1-5):**

- East Fork Poplar Creek:* EFK 25.1 (15.6), EFK 24.4 (15.2), EFK 23.4 (14.5), EFK 13.8 (8.6), and EFK 6.3 (3.9). Reference site: Hinds Creek HCK 20.6 (12.8).
- Bear Creek:* BCK 12.3 (7.6) and BCK 9.6 (6.0). Reference sites: Gum Hollow Branch GHK 2.9 (1.7), Mill Branch MBK 1.6 (1.0), and White Wing Tributary ET-1 [WWT 0.08 (0.05)].
- Mitchell Branch Creek:* MIK 0.71 (0.44) and MIK 0.45 (0.28). Reference sites: MIK 1.43 (0.89).

White Oak Creek: WCK 2.3 (1.4), WCK 3.4 (2.1), and WCK 3.9 (2.4). Reference site: WCK 6.8 (4.2).

Melton Branch: MEK 0.3 (0.2)

Clear Creek: CCK 1.45 (ecoregion reference site).

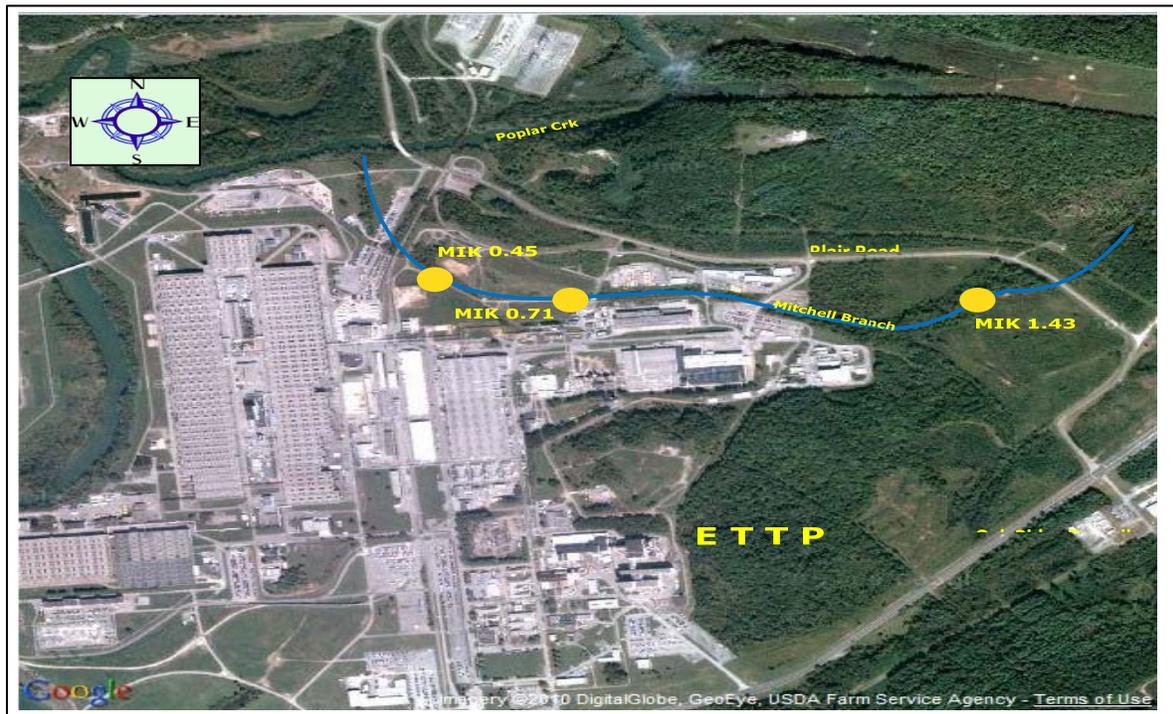


**Figure 3: Clear Creek and Hinds Creek Reference Sites**



**Figure 4: White Oak Creek / Melton Branch Watersheds (ORNL)**

Weather permitting, field sampling will be completed within a four-week time span in April and May 2013.



**Figure 5: Mitchell Branch Watershed (ETTP)**

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## **Benthic Macroinvertebrate Surface Water Monitoring**

### **Project Description**

The objective of this monitoring program is to conduct surface water sampling relative to streams which have been impacted by the Department of Energy (DOE) operations on the Oak Ridge Reservation (ORR). The surface water monitoring program will be conducted in conjunction with the Benthic Macroinvertebrate Biological Monitoring to ensure that the evaluation of each stream's biotic integrity will be further enhanced.

### **Introduction**

Because benthic macroinvertebrates are relatively sedentary and long-lived, they are excellent indicators of the biotic integrity, or the "overall health", of an aquatic system. In systems where the source of the toxicant is non-point (e.g. runoff or seeps) or where the combined effects of pollutants in a complex effluent exceed individual organism toxicity, the evaluation of benthic macroinvertebrate communities is used to determine if a stream is supportive of fish and aquatic life. An integral element of this evaluation is the physical and chemical analysis of the stream's surface water.

Surface water samples are collected from various ORR streams and analyzed to measure the degree of impact from past and present DOE operations. The office conducts surface water monitoring on the following ORR watersheds: Bear Creek, Mitchell Branch, White Oak Creek, and East Fork Poplar Creek. Surface water samples are also collected from Clear Creek near Norris Dam which serves as an ecoregion reference site for all ORR test sites.

### **Methods and Materials**

During 2013, surface water quality data will be collected at each sampling location to include pH, temperature, dissolved oxygen, and conductivity. YSI Professional Plus and YSI 556 MPS multi-parameter field instruments will be utilized. Each stream's flow will be measured with a Sontek Flowtracker. Habitat assessment forms will be recorded at each benthic sampling location.

Surface water samples will be collected annually at all sites and will complement the macroinvertebrate sampling. The surface water monitoring program will follow both the 2011 TDEC WPC Quality System Standard Operating Procedure for Chemical and Bacteriological Sampling of Surface Water and the 2011 TDEC WPC Quality System Standard Operating Procedure for Macroinvertebrate Stream Surveys. In addition, all work associated with this program will be conducted in compliance with the office's Health, Safety, and Security Plan. Weather permitting, field sampling will be completed within the Spring of 2013.

The surface water samples will be transported to Laboratory Services in Knoxville and analyzed for the following analytes:

*Inorganics:* alkalinity (as CaCO<sub>3</sub>), chloride, hardness (total as CaCO<sub>3</sub>), nitrogen (ammonia), nitrogen (NO<sub>3</sub> & NO<sub>2</sub>), nitrogen (total Kjeldahl), phosphorus (total), residue (dissolved), residue (suspended), and sulfate.

*Metals:* arsenic, cadmium, calcium, chromium, copper, hexavalent chromium (*Mitchell Branch only*), iron, lead, magnesium, manganese, mercury, potassium, sodium, and zinc.

*Radionuclides:* gamma radionuclides, gross alpha, and gross beta.

The Tennessee Department of Health's Laboratory Services has expertise in a broad scope of services and analyses. This expertise is available to the Tennessee Department of Environment and Conservation, Department of Energy Oversight Office and other TDEC divisions statewide. General sampling and analysis methods will follow Environmental Protection Agency (EPA) guidelines as listed in appropriate parts of Title 40 Code of Federal Regulations (CFR). Laboratory Services may also subcontract certain analyses and QC samples out to independent laboratories. Bench level quality assurance/quality control (QA/QC) records and chain-of-custody records are maintained at Laboratory Services, as are QA records on subcontracted samples.

The office will primarily use the Knoxville branch of Laboratory Services for our analyses. Wet chemistry and metals samples will be analyzed in Knoxville, while organics samples will be sent to Laboratory Services in Nashville. All Laboratory Services analyses will follow appropriate methods as documented in the Laboratory Services Inorganic Chemistry SOP and Organic Chemistry SOP. Specific analytical methods are covered in the Standard Operating Procedures (SOP) manuals for Laboratory Services. The SOPs direct analysts to the proper EPA or other methodology.

**Sampling Locations in Kilometers (mile equivalents), (see Figures 1-5 in the previous chapter)**

*East Fork Poplar Creek:* EFK 6.3 (3.9). Reference site: Hinds Creek HCK 20.6 (12.8).

*Bear Creek:* BCK 12.3 (7.6) and BCK 9.6 (6.0). Reference site: Mill Branch MBK 1.6 (1.0).

*Mitchell Branch Creek:* MIK 0.45 (0.28). Reference site: MIK 1.43 (0.89).

*White Oak Creek:* WCK 2.3 (1.4). Reference site: WCK 6.8 (4.2).

*Clear Creek:* CCK 1.45 (ecoregion reference site).

**References**

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## **Periphyton Monitoring**

### **Introduction**

During 2013, the office will continue efforts to characterize diatom assemblages for water quality assessment of impacted watershed streams on the Oak Ridge Reservation (ORR). The goal of this monitoring program is to monitor temporal changes in periphyton biomass and community composition in response to remedial actions affected by activities and practices on the ORR. Methodology for the project will follow periphyton survey as outlined in the Tennessee Department of Environment and Conservation (TDEC) Division of Water Pollution Control (WPC) Regional Characterization of Streams in Tennessee with Emphasis on Diurnal Dissolved Oxygen, Nutrients, Habitat, Geomorphology and Macroinvertebrates (Arnwine et al. 2005). Periphyton samples will be collected quarterly from natural substrates in the Bear Creek watershed and a reference site. The main objectives of the project include: (1) determine diatom composition and abundance of the periphyton community in the Bear Creek watershed, (2) investigate longitudinal variation in diatom populations downstream from DOE pollution sources, (3) complement the office's comprehensive and integrated monitoring and surveillance programs for all media (i.e., surface water, groundwater, sediments, biological communities) and emissions of hazardous substances on the ORR, and (4) determine water quality scores (calculated from metrics) for each monitoring station.

Because periphyton assemblages are attached to natural substrates, the benthic algae community responds to biological and physiochemical disturbances that occur longitudinally in a stream reach during algal colonization (Medley & Clements 1998). Benthic algae and diatoms are primary producers in the food web and the literature suggests they are excellent biological indicators for many types of pollution in aquatic systems (Dixit et al. 1992, Kelly et al. 1995, Stevenson & Pan 1999). Periphyton communities contain many diatom taxa with individual tolerances to anthropogenic stressors such as elevated concentrations of heavy metals and high nutrient loads (Deniseger et al. 1986, Takamura et al. 1989, Medley & Clements 1998). Thus, by examining diatom community assemblages, and determination of shifts in species composition and structure over time, impaired water quality trends can be detected (Patrick 1973).

### **Methods and Materials**

Periphyton will be sampled monthly at four stream riffle zone sites (Figure 1) in Bear Creek (BCK):

- Bear Creek: BCK km 12.3 (BCK mi 7.6), BCK km 9.6 (BCK mi 5.9), NT-3 (North Tributary 3) and NT-5 (North Tributary 5).

The significance of the bioassessment of Bear Creek in 2012 is that clear diatom responses to Bear Creek impacts were documented in the data during 2006-07 monitoring of BCK 12.3 and BCK 9.6 sites (see 2007 TDEC Environmental Monitoring Report). Further, the outfall from the EMWFM site (NT-3 & NT-5) into Bear Creek may generate additional variables impacting the periphyton community due to waste disposals since 2007.

Office staff will collect benthic algae samples from either natural substrates (i.e., stream cobbles and sediments, small rocks) or submerged artificial substrates (ceramic tiles glued to masonry

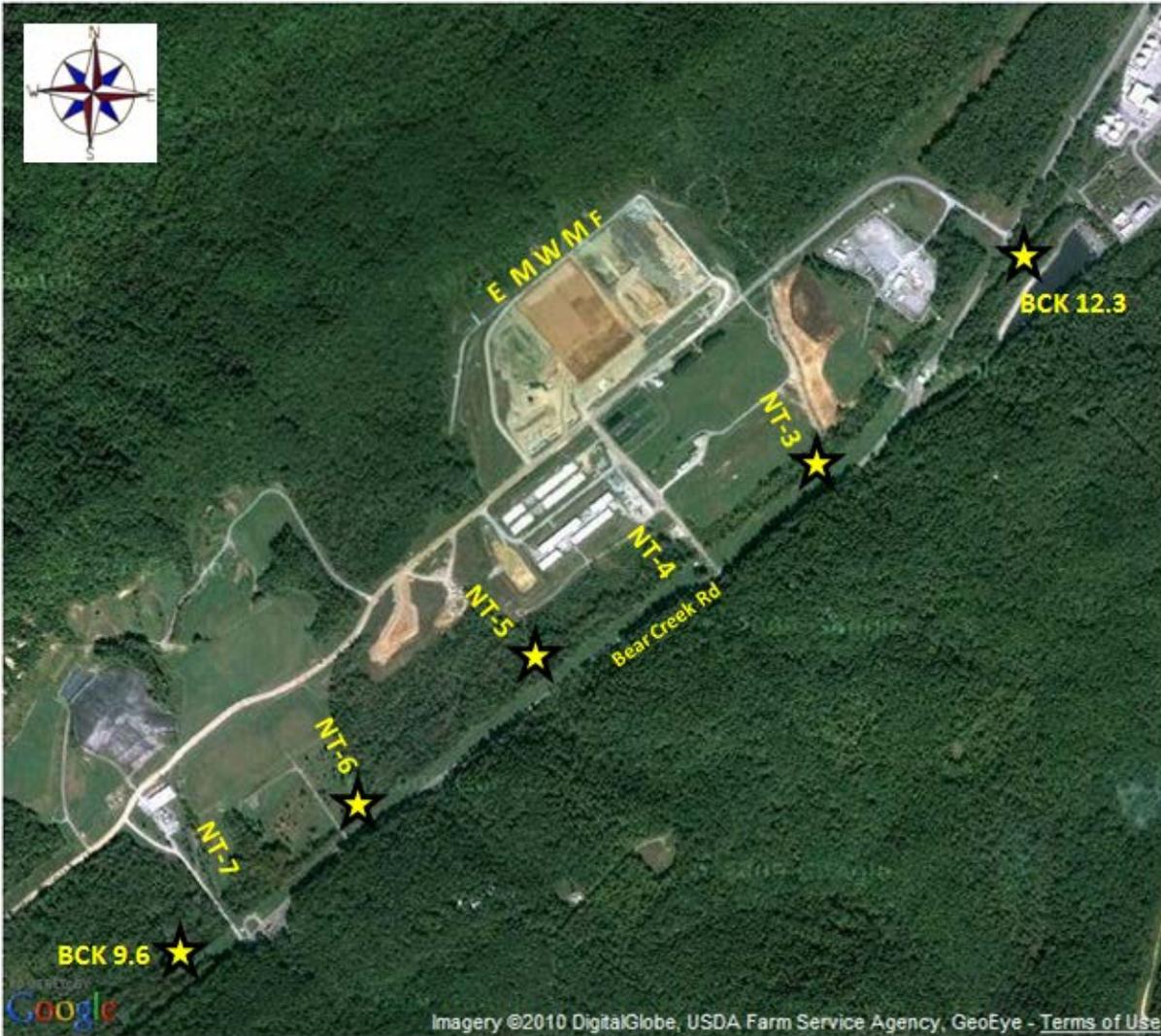


Figure 1: North Tributary and Bear Creek periphyton sampling locations.

bricks). Water temperature, conductivity, total dissolved oxygen and pH measurements will also be determined during each sampling event (Horiba U-10® Water Quality Checker) and recorded in the field logbook. Additional real-time field data may be collected including stream flow velocity, water depths and photosynthetic light data. Methods and materials for these procedures have been modified from the TDEC Water Pollution Control's Quality System Standard Operating Procedure for Periphyton Stream Surveys (TDEC WPC 2010) and EPA's Rapid Bioassessment Protocols for Use in Wadeable Streams and Rivers (1999).

In the field, three submerged rocks (sized ~10-15 cm<sup>2</sup> each) or one to two ceramic tiles (sized approx. 1 sq. in) with attached periphyton will be randomly selected at each stream site and later composited into one sample (W. R. Hill, in Adams et al. 1998, Barbour et al. 1999, Moulton II et al. 2002, Ponader & Charles 2005). Rocks will be placed in labeled, double-bagged one-gallon lockable baggies and placed in an ice chest for transport. Volumetric determinations of algal

biomass removed from the rocks will be determined by the aluminum foil gravimetric method (Carr et al. 2005, Ponader & Charles 2005).

Water quality samples will be collected twice-a-year at these sites (concurrent benthic monitoring project) and will complement the diatom sampling. Water samples will be transported to Laboratory Services in Knoxville and analyzed for nitrates, metals and radionuclide constituents. All work associated with this program will be in compliance with the office's Health, Safety, and Security Plan (Yard 2011). HOB0® light meters will be deployed six times a year to collect photosynthetic light data.

Samples will be examined in-house by office staff using the Olympus® BH-1stereo microscope, the TrueVision® XSP15B stereo microscope (w/ PupilCam® digital camera), and the Zeiss® inverted microscope (on loan to TDEC). Identifications will be determined on both fresh sample material and cleaned diatoms. To clean diatoms, they must be boiled in an acid bath to clear their frustules of organic and intercellular material (Hill and Boston 1991, KDOW 2008). The cell wall structure, ornamentation, size, and shape of siliceous frustules are the main diagnostic characters for taxonomic keying of diatom taxa (Stoermer and Smol 1999). Taxonomic identification sources will include: Smith (1950), Patrick & Reimer (1966, 1975), and Wehr & Sheath (2003).

Enumeration of diatom cells in each sample will involve examining 2.45 ml of sample slurry in a settling chamber using the Zeiss® inverted microscope. For consistency, at least ten microscope FOVs (fields-of-view) will be counted to obtain a cell count of +500, or continue counting FOV until 500 cells are determined per sample. During enumeration, diatom taxa counts will be recorded on laboratory bench sheets and organized by genus. Non-diatom taxa (e.g., filamentous green algae, desmids, dinoflagellates) will also be recorded and counted following the protocol of the KDOW (2008). Periphyton samples with very low biomass may require counting up to a maximum of 100 FOV. The laboratory method for counting diatoms in microscope slides will follow the protocols of Hill and Boston (1991) and KDOW (2008).

The identification and counting of algal taxa will be used in a set of six metrics to compute a score for individual Bear Creek monitoring stations. Water quality determinations can thus be assessed based upon scores derived from the metric calculations. The reader is referred to TDEC WPC Quality System Standard Operating Procedure for Periphyton Surveys for details of metric calculations (TDEC WPC 2010).

### **Quality Control**

Replicate samples will be collected and analyzed at 10% of the ORR monitoring sites to evaluate precision or repeatability of sampling technique and taxonomy. Quality assurance/quality control (QA/QC) samples should be counted by another taxonomist (or outside laboratory) to assess taxonomic precision and bias. These laboratory QA/QC procedures adhere to EPA methods for assessing periphyton communities in lotic systems as outlined in Barbour et al. (1999) and Moulton et al. (2002).

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# **Aquatic Vegetation Monitoring on the Oak Ridge Reservation**

## **Introduction**

The Tennessee Oversight Agreement (TOA) requires the state to perform monitoring to assess the effectiveness of DOE contaminant control systems on the Oak Ridge Reservation (ORR). If surface water bodies (e.g., springs and ponds) have been impacted by radiological contamination, certain aquatic organisms in the immediate vicinity may uptake radionuclides. This program will focus on the detection and characterization of radiological constituents that may be bioaccumulated by aquatic vegetation on and in the vicinity of the Oak Ridge Reservation.

Target vegetation for sampling includes, but will not be limited to: watercress (*Nasturtium officinale*), common cattail (*Typha latifolia*), and willow (*Salix* sp.).

Locations considered as potential monitoring sites include springs, seeps, streams, creeks, wetlands, and ponds. Watersheds such as Bear Creek and its tributaries, White Oak Creek/Lake and its tributaries, Mitchell Branch, and East Fork Poplar Creek are all probable target locations for sampling.

In 2013, the monitoring will focus on areas likely to have radiological contamination, either from past or current DOE activities. Current activities may include areas downstream of the demolition of buildings with radiological contamination from past activities to determine if radiological constituents are migrating into the environment. Previous sampling locations that exhibited elevated results in past years may be resampled.

## **Methods and Materials**

Aquatic vegetation samples will be collected at sites both on and off the ORR, the latter for background data. Each vegetation type sampled on the ORR will have a background sample of the same type collected and analyzed for reference.

At least one gallon of vegetation, including roots but minimal other debris, will be sent to the State of Tennessee Environmental Laboratory in Nashville, Tennessee, for analysis. Samples are analyzed for gross alpha, gross beta, and gamma radionuclides. Additional radiological analysis may be performed if merited. Metals analysis may also be conducted on the vegetation from the various sites if needed. Metals analysis could consist of any of the RCRA eight metals: Arsenic, Barium, Cadmium, Chromium, Lead, Mercury, Selenium, and Silver.

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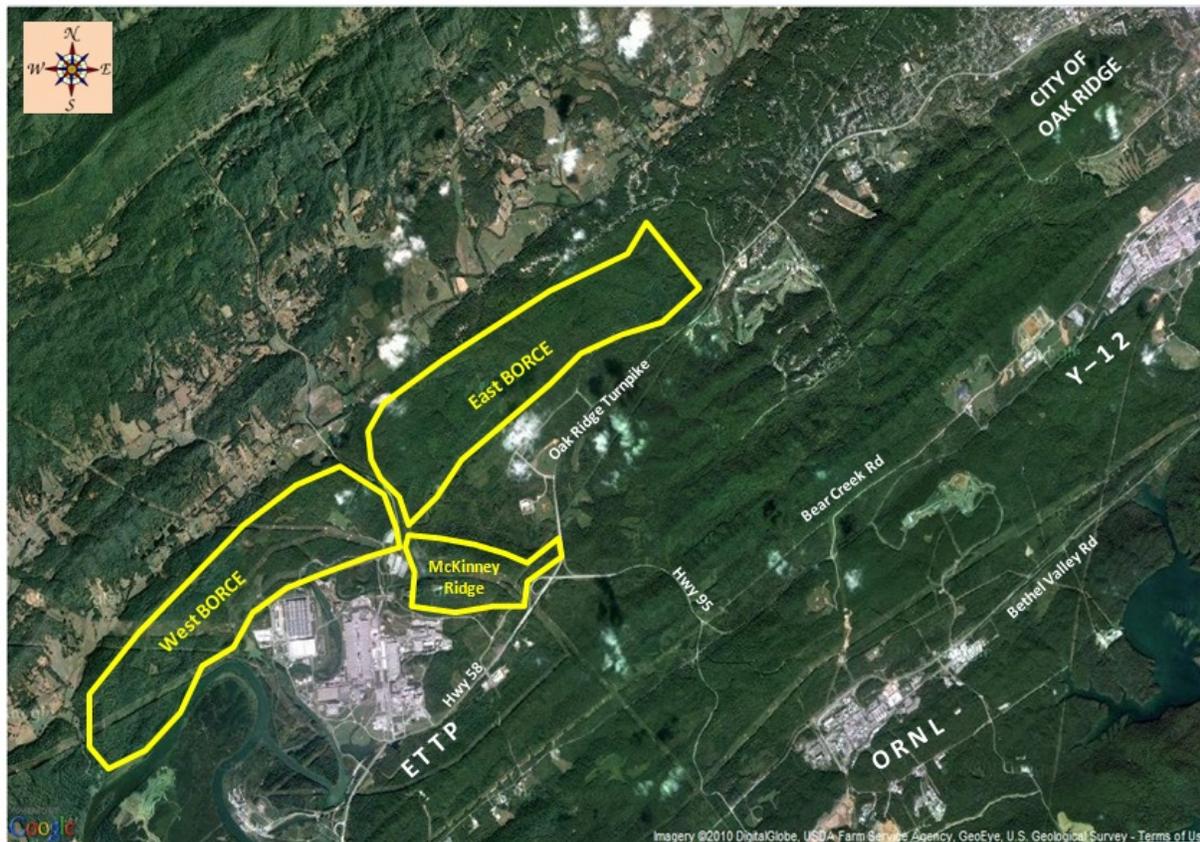
## Threatened & Endangered Species Monitoring

### Introduction

More than thirty rare animal species and twenty-one state-listed and federal-candidate plant species are known to be present on the Oak Ridge Reservation. More than 1000 different species of plants grow on the reservation, reflecting its diversity. The reservation supports a wide variety of wildlife species including 60 reptilian and amphibian species; 63 fish species; more than 120 species of terrestrial birds; 32 species of waterfowl, wading birds, and shorebirds; and about 40 mammal species (Salk 2004). Habitats supporting the greatest number of species are those dominated by hardwood forests and wetlands. The ORR's plant and animal life is situated in a relatively intact ecosystem that is highly diverse compared to surrounding areas in the same physiographic province (Mann et al. 1996). All areas of the ORR are relatively pristine compared to the surrounding region, especially in the Ridge and Valley province. The ORR, consisting of the Oak Ridge National Environmental Research Park and associated lands surrounding DOE facilities at Oak Ridge, Tennessee, is about 15,000 ha of mostly contiguous native forest in the valley and ridge province (Mann et al. 1996). Approximately 20 miles of greenway trails are available for hiking and bicycling on the Black Oak Ridge Conservation Easement (BORCE, Figure 1) which consists of about 3000 acres of mainly forested uplands including the Dyllis Orchard greenway trail (opened to the public in October 2007). About half of the BORCE has been surveyed for rare vascular plant species by TDEC personnel. Additional ORR geomorphic and topographic features supporting rare plant communities include wetlands, karst features (caves), rocky bluffs, limestone cedar barrens, and an area of old growth forest. About 70% of the ORR is in forest cover and less than 2% remains as open agricultural fields. The forests are mostly oak-hickory, pine-hardwood, or pine. Communities are generally characteristic of the intermountain regions of Appalachia (Mann et al. 1996). Oak-hickory forest, which is most widely distributed on ridges and dry slopes, is the dominant association. Minor areas of other hardwood forest cover types are found throughout the ORR. These include northern hardwoods, a few small natural stands of hemlock or white pine, and floodplain forests (Mann et al. 1996). Among these are numerous TDEC-designated natural areas on the ORR. Currently, most of the ORR is a wildlife management area (WMA), thus the BORCE site and the WMA is managed by the Tennessee Wildlife Resources Agency (TWRA).

This project will incorporate the office's oversight role of environmental surveillance and monitoring (TDEC 2011). Additionally, several federal and state laws support this effort. The Federal Endangered Species Act of 1973 (ESA), as amended, provides for the inventory, listing, and protection of species in danger of becoming extinct and/or extirpated, and for conservation of the habitats on which such species thrive. The National Environmental Policy Act (NEPA), requires that federally-funded projects avoid or mitigate impacts to listed species. The Tennessee Rare Plant Protection and Conservation Act of 1985 (Tennessee Code Annotated Title 11-26, Sects. 201-214), provides for a biodiversity inventory and establishes the State list of endangered, threatened, and special concern taxa. National Resource Damage Assessments (NRDA), as directed by the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980, as amended by SARA (Superfund Amendments and Reauthorization Act of 1986), relates to damaging natural resources on the ORR.

For 2013, major functions and focus of the threatened and endangered species (T&E species) project planned for the ORR include: (1) provide botanical oversight and field support to the



**Figure 1: Black Oak Ridge Conservation Easement (BORCE)**

TDEC Division of Natural Areas as needed relating to ORR T&E species, (2) inventory and mapping of the botanical diversity that exists on the ORR, (3) independently monitor and verify biological survey information provided by DOE, and compliance with T&E species requirements per CERCLA and NEPA regulations, (4) identify and protect T&E species and TDEC-designated natural areas that represent biological diversity on the ORR, (5) provide field oversight during DOE subcontractor vascular plant surveys on ORR projects (i.e., road construction projects, land transfers, etc.), and (6) identify areas of the ORR infested with exotic pest plants (Drake et al. 2002, TEPPC 2002).

### **Methods and Materials**

During 2013, monitoring of vascular plants on the ORR by office staff will follow a modified version of the methods and guidance outlined in Washington-Allen et al. (1995) and Awl et al. (1996). Additionally, field methods for documentation of pteridophytes (ferns and fern allies) will follow the field protocols of the All Taxa Biodiversity Inventory fern forays project in the Great Smoky Mountains National Park (ATBI 2007). Field mapping of native and invasive plant species will utilize field stations (50-foot diameter mini-plots) at pre-selected intervals (i.e., grid patterns, traverses, etc.) based on specific reconnaissance projects. Unusual or rare plants will be located and mapped, if found, between these intervals. Generally, field biodiversity inventories

will begin with existing roads and trails, then transects will be walked cross-country (similar to a “timber cruise”) in generally north-south, east-west traverses to complete a grid pattern of coverage over the parcel. Habitats such as small drainage ravines, floodplains, wetlands, watersheds, sub-watersheds, sinkholes, cedar barrens, rock outcroppings, cliffs, springs, caves, etc. will be field surveyed for plant taxa. Field surveys are designed to locate and identify T & E plant species, invasive plant species, aquatic and wetland taxa.

Each field station (mini-plot) will be mapped and located using a Global Positioning System (GPS) hand-held field unit (Garmin® Etrex). Each field station will be defined as a 50-foot circle from center point or circumference. Plant taxa will be organized and compartmentalized as canopy, sub-canopy, shrub, herbaceous, or groundcover layers. Digital camera images will be made at most field sites to record and document plant taxa. Additionally, the boundaries of the pine deadfall areas (pine-beetle devastated areas) will be mapped whenever possible in the field. These sites may become important ecological study areas to determine if native climax species or exotic pest species will re-establish here.

Terrestrial plant species may be collected for preservation as herbarium specimens (vouchers). Each sample will be collected as much as possible with either flower or fruit, then pressed and dried, and mounted on herbarium paper with appropriate identification labels. These are quite useful for training purposes but, more importantly, properly document and confirm plant species (especially rare species) encountered in the field. Care will be taken while collecting plant specimens so as not to destroy or damage a rare plant colony.

Vascular plant identifications will require the use of the following sources and taxonomic keys: Radford et al. (1968), Prescott (1980), Cobb (1984), Lellinger (1985), Wofford (1989), Gleason & Cronquist (1991), Chester et al. (1993), Chester et al. (1997), Carman (2001), Wofford & Chester (2002), University of Tennessee Herbarium (2007), and Weakley (2007).

Field data sheets (survey logs) will be completed for each survey station and later placed in a database for inclusion in the environmental monitoring report. Maps will be prepared with available GIS software to illustrate locations of all field stations with plant data, geologic features and other pertinent biological habitat and field data.

Field monitoring methods and health and safety procedures will follow the guidelines in the office’s Health, Safety, and Security Plan (Yard 2011).

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# **White-tailed Deer Monitoring Program on the Oak Ridge Reservation**

## **Introduction**

During 2013, the Tennessee Department of Environment and Conservation Department of Energy Oversight Office (DOE-O) will continue chemical immobilization and collaring of ORR white-tailed deer. The primary objectives of this monitoring program are to track the movements and determine the home range of deer both on and off the ORR. A secondary objective will be to collect additional deer tissue samples (i.e., road kill, hunter kill) for metals analysis.

## **Methods and Materials**

The ORR road- and hunter-killed carcasses will be sampled immediately upon notification. It is estimated that approximately 20 road-killed deer will be sampled and archived during 2013. Further, top predators such as coyote, grey fox and bobcat will be collected and sampled if found deceased on the ORR (estimate = 5 animals). Offsite reference carcasses will be sampled in such locations as Catoosa Wildlife Management Area (WMA), the City of Oak Ridge and adjacent communities (estimate = 5 deer). The archived samples will be analyzed in the future for: arsenic (As), beryllium (Be), cadmium (Cd), lead (Pb), mercury (Hg), selenium (Se), and methylmercury (MeHg).

Three additional Telonics store-on-board global positioning system (GPS) collars will be deployed on ORR deer during 2013. Field activities will commence following the final Oak Ridge Wildlife Management Area deer hunt (after December 15th). The focus will be to collar bucks as we currently have four does with collars. Four deer were collared during 2011-2012 (all does). Two collars will drop off in March 2013 and the other two collars will drop off on March 2014. Because two of the currently deployed collars are programmed to collect GPS coordinates for two years, we may opt to dart those deer early and redeploy the two-year collars on different deer for the final year of collar data collection capacity. Following that time, DOE-O staff will initiate efforts to locate and retrieve the collars with a VHF receiver. Three of the collared deer are located in the Melton Valley area of the Oak Ridge National Lab and the third is within the City of Oak Ridge boundary. Once collars have been recovered, GPS data can be downloaded for analysis. Recovered collars will be returned to Telonics, Inc. (Mesa, Arizona) to be reprogrammed. Refurbished collars will be deployed on deer during 2013 or 2014. Chemical immobilizing drugs will be delivered to the deer using the PneuDart Model 389 dart projector, and following successful anesthesia, collars and numbered ear tags will be applied to each animal.

## **Procedures**

### **Darting and Collar Attachment Protocol**

Deer will be caught using a variety of methods

- (a) Darting from vehicle
- (b) Clover traps

Deer require sedation/general anesthesia with drugs administered by dart gun so that collars and ear tags can be attached to the animal. Deer are at high risk of stress, shock and capture myopathy during capture and restraint, particularly if allowed to struggle and in hot weather. Accordingly, care will be taken to dart and capture deer between December and April while East Tennessee weather conditions are on average relatively cool (<65° F). Deer immobilization will

be done with the cooperation of a local veterinarian and the Tennessee Wildlife Resources Agency (TWRA). General guidance for handling a sedated deer:

- Always cover the eyes as soon as possible to help calm the animal, e.g. with a blanket or large towel thrown over before the deer is under control; this measure helps to reduce stress.
- Deer must be kept in sternal recumbency (on brisket) at all times during general anesthesia and recovery.
- Do not allow the animal to roll on its side or back at any time as this may lead to regurgitation and death through asphyxiation or inhalation.
- **Keep the head elevated during anesthesia to reduce the risk of regurgitation.**
- **Intubation may be required in some cases, together with passing a stomach tube to prevent bloat (gas accumulation).**
- **Constant monitoring for bloat is recommended.**
- Monitor body temperature (rectal thermometer), heart rate (stethoscope), respiration (observed through thoracic movements) and hemoglobin saturation (i.e., SpO<sub>2</sub> pulse oximeter) throughout any general anesthetic procedure.

#### *Darting from Vehicle*

The team typically consists of 3 staff members: one driver and two designated marksmen. Once the deer has been darted and is under anesthesia, one staff member fills out the capture record sheet while the other two handle the downed deer. Upon capture, the deer will be immediately blindfolded and the dart will be removed with a sterile scalpel. Antibiotic is to be administered on the wound (Walter et al., 2005). The deer is placed in sternal recumbency, and the mouth checked for obstructions. The tongue should not be rolled back. Staff has been trained to handle the drugs and dart projector and how to monitor the deer while under anesthesia and recovery (i.e., Safe-Capture International certified training). Deer will be darted primarily using a dose of 5 mg per kg of telazol and 2.5 mg per kg of xylazine. Xylazine is a CNS (central nervous system) depressant that sedates but does not cause loss of consciousness. Telazol (tiletamine + zolazepam) produces rapid immobilization with altered consciousness. Whenever secondary dosages are necessary, ketamine (cyclohexamine) will be administered to enhance anesthesia and to avoid a zolazepam accumulation and enable a quicker recovery (Fahlman, 2005). Cyclohexamines provide partial analgesia with minimal circulatory and respiratory depression.

Once under complete anesthesia, the deer collar (Telonics, Mesa, Arizona) will be fitted and trimmed if necessary to custom fit the neck, allowing enough slack such that three fingers can fit between the neck and collar. It may be necessary to allow additional slack in the collar to compensate for neck swelling in bucks (rut season). Once fitting is determined, the bolts holding the collar are tightened and the collar installation is complete. Next, numbered ear tags are affixed to each ear, and lastly a hair sample is collected using a curry comb (for laboratory analysis of contaminants).

Prior to field excursions, the telazol-xylazine drug mixture will be loaded into darts under a laboratory hood for safety. Care will be taken in the field handling the darts and dart projector to prevent accidental exposures to staff. Drugs will be kept under lock and key both in the laboratory and in the field. We will use Pneu-dart 1.5 cc, barbed and 1-inch long needled darts

(Pneu-dart®, Williamsport, Pennsylvania, USA). Darts will be delivered to the animal via the Pneu-dart model 389 projector at a distance ranging from 10 to 20m from the vehicle. The secondary ketamine dosage, if necessary, will be administered with syringe. While under anesthesia, deer vital signs will be monitored every ten minutes (heartbeat, respiration, rectal temperature) and the animal will be kept in sterna recumbency at all times. Additionally, hemoglobin saturation (SpO<sub>2</sub>) and heart rate will be monitored by a pulse oximeter with a transmission probe placed on the tongue (Morandi and Nicoloso 2009). The reversal drug tolazoline will be administered 90 minutes following initial immobilization. Tolazoline should antagonize the effects of xylazine in 3-5 minutes after intramuscular injection. At least one staff member will remain with the recovering animal until it is standing and walking away, observing from a distance so as not to excite the deer. This is a precaution to prevent predators from feeding on the immobilized deer.

### *Clover Trap and Collar Attachment Protocol*

#### Trap Set-up

Clover trap installation and set-up will be demonstrated in the field using hands-on techniques during the set-up process and before actual trapping. At a minimum, nitrile gloves should be worn to minimize human scent while handling the trap. Coordinates should be recorded at each site with a hand-held GPS unit.

#### Trap Placement

Clover traps will be strategically placed as to allow for “element of surprise” to the animal during the approach to trap by biologists and is accomplished using any available brush or woodland debris available. Trap site setups should be secluded to prevent human interference (i.e., “out-of-sight and out-of-mind”). The goal is to avoid as much stress to the animal as possible prior to and during handling.

#### Checking Traps

A clover trap team consists of at least two biologists plus a qualified wildlife biologist who is certified to handle tranquilizing drugs and a dart gun. One person is designated as the restrainer or handler (especially if tranquilizing drugs do not take effect on the deer). The second person is designated data collector and equipment manager. The restrainer is responsible for subduing and controlling the deer as needed. The equipment person is responsible for carrying the capture kit, blindfolding the deer, checking age and sex, administering ear tags, making photographs and recording the data.

Bait should be placed past the trip wire, but also within the bounds of the trap walls to prevent feeding from outside the trap (see Figure 1). “Chumming” the trap at the door with some corn is encouraged. After setting and before leaving the trap site, verify that no vegetation will interfere with the operation of the door closing or movement of the “trip” wire. It is also recommended to remove larger branches and rocks from within the trap to reduce injury to animals or team members. Otherwise the trap should be adjusted as to avoid having objects/debris on the trap floor.



**Figure 1: Baited clover trap (Photo credit: und.nodak.edu)**

Typically, biologists drive a trap line in the early morning. Each trap is checked for animals, then re-baited and repaired as necessary. If the trap is sprung but has nothing in it, inspect the trip wires and replace them if necessary, inspect netting for holes, check to make sure the trap is still properly staked, and reset the door making sure all the cable sleeves are aligned and pointing away from the trap door. Trained staff will dart the animal using the following procedure.

#### Capture Procedure<sup>a,b</sup>

1. During deployment, the clover trap must be checked at least once per day (ideally early AM) for presence of deer or other animals in the trap.
2. Check for presence of deer from a good distance with binoculars if necessary to avoid distressing the animal.
3. If deer is present in the clover trap, trained staff will sedate the animal with the dart gun.
4. After administration of tranquilizing drugs to the deer (i.e., xylazine-telazol mixture), allow time for the drug to take effect and for the deer to calm down. Everyone must remain at a good distance from the trap during this time to minimize stress to the deer.
5. Double glove with nitrile and heavy leather or cotton gloves to avoid cuts from deer hooves and self- and cross-contamination during animal handling.
6. One biologist with protective gear (gloves, helmet and shin protection) will enter the trap. The immediate goal is to quickly subdue the deer by restraining the body and legs (if necessary). If the drug has not brought the deer down, approach it from the side and wrap

<sup>a</sup>Handling of live animals will follow the recommendations and guidelines of the Animal Care and Use Committee of the American Society of Mammalogists (Gannon et al. 2007, Sikes et al. 2011).

<sup>b</sup>Methods modified from James and Stickles (2010).

your arms around the front of the body. Grip the front legs below the “elbow” and tuck them into the chest of the deer. Then straddle the animal and slowly put your weight on its back. In doing this, the restrainer can use his/her body weight to gain control of and safely but slowly allow the animal’s legs to fold as the biologist body weight is applied. However, if the tranquilizing drug has taken full effect on the deer, restraint may not be necessary. If the deer is down but still aroused, administer ketamine to enhance immobilization.

7. Once the animal is subdued by the restrainer, the assisting person can enter the trap, closing the door behind them to prevent escape. The assistant places the facemask (hood) over the animal’s head/eyes and processing can begin. The eyes of the animal must be covered to reduce stress. Also, make sure the animal’s breathing is not restricted in any way.
8. Fit the collar to the deer’s neck and trim excess collar material if necessary. Attach the holding plate and tighten the nuts with 11/32 nut driver thus securing the collar around the deer’s neck. The second biologist will then affix the numbered ear tags to each ear per prescribed method, record field notes and vital data about the animal (i.e., age, sex, weight estimate, etc.), and also photograph events (see Figure 2).



Figure 2: Collaring sedated deer (Photo credit: TDEC DOE-O)

9. While under anesthesia, the deer will be monitored every ten minutes for body temperature, heartbeat and respiration. Continue doing this until the animal recovers.
10. During processing of the animal, the capture data sheet must be filled out completely by the assistant or assigned data collector.
11. Using a curry comb, a 5-10g sample of deer hair (i.e., softball-size wad) will be collected from the mid-dorsal region of the deer’s back. Place the hair sample in a labeled [Ziploc®](#) baggie, and then store in an ice chest for transport.
12. The clover trap door will be left open while the deer recovers from the drug. At least one biologist must remain within sight of the deer while it recovers from the drug and leaves the trap on its own power. After 90 minutes, the reversal drug Tolazoline will be administered by syringe such that the animal should be on its feet within 5-10 minutes. These measures are designed to provide protection from predators while the deer is down.

Tissue Sampling of Deer Carcasses (modified from Mills et al. 1995, Wobeser 1996, Munson 2006)

1. Double glove with nitrile gloves to avoid self- and cross-contamination during sampling.
2. Before and after each dissection, stainless-steel cutting tools will be sanitized.
3. Using a bone-cutting tool, extract approximately a 3-4 inch section of shin bone from the lower front leg of the deer.
4. Using stainless-steel forceps place the bone sample into a labeled ZipLoc® baggie or Whirl-Pak® and seal. Store in ice chest for transport to lab at 4° C by using ice or freezer packs.
5. Using a stainless scalpel or knife, cut approximately 50-75g of muscle from the rump and place into a labeled plastic vial and close cap. Store in ice chest for transport to lab.
6. With one person holding the deer on its back, the second person makes a 6-8 inch incision near the sternum, finds the liver and extracts approximately 50-75g of liver tissue. Place the liver sample in a labeled ZipLoc® baggie or Whirl-Pak® and seal. Store in ice chest for transport.
7. Using a clean curry comb, brush approximately 5-10g of hair (wad of hair about the size of a softball) from the mid-dorsal area of the deer. Place hair sample into a labeled ZipLoc® baggie or Whirl-Pak® and seal. Pack in ice chest for transport to the lab.
8. Upon returning to the TDEC DOE-O lab, place all samples in the deep freezer until time to deliver samples to the Tennessee Department of Health Environmental Laboratory for analysis.
9. Record all pertinent information on lab sheets, sample labels, and make necessary entries into field notebook.
10. Deliver tissue samples to state lab within appropriate holding time frames, and sign chain of custody forms.

**Required Equipment (Deer Immobilization & Tissue Sampling)**

Clover trap	Aluminum foil
Heavy gloves	ZipLoc® bags / Whirl-Pak® (24-oz & 69-oz)
Hockey-type helmet & shin-guards	Sample labels
Telonics GPS collars	Cooler/ice packs
Field notebook	Stainless-steel scalpels (knives)
Latex gloves (purple nitrile)	Stainless-steel saw
Deionized water	Stainless-steel scissors
Rubber gloves	Hand sanitizer
VHF receiver	Curry comb
Magic Marker (Sharpie®)	Bone-cutting tool (stainless)
Hand-held GPS unit	Plastic vials (tissue samples)
Deer eye cover (mask/hood)	11/32 nut driver (to affix collar)
Antibiotic ointment	Ear tags (yellow numbered)
Flagging tape	Zip-ties
Extra nuts/plates for collars	Hole punch ear tagger
Wire cutters/nippers	Needle nose pliers
Pneu Dart 389 Projector	Super shears (leather cutter)

Stakes / small sledge hammer	Toolbox
Blankets (to cover deer)	Pneu Dart 1.5 cc Type C Darts
Immobilization Drugs (Xylazine/Telazol)	Reversal Drugs (Tolazoline)
Backpack with deer supplies & gear	Syringes
Bushnell Range Finder	Stethoscope/anal temperature probe
Telonics TR-4 VHF receiver	Pulse oximeter

### **Laboratory Procedures**

The Tennessee Department of Health, Environmental Laboratory and Microbiological Laboratory Organization (Laboratory Services) has expertise in a broad scope of services and analysis available to the Tennessee Department of Environment and Conservation (TDEC) Department of Energy Oversight (DOE-O) and other TDEC divisions statewide. General sampling and analysis methods are to follow Environmental Protection Agency (EPA) guidelines as listed in appropriate parts of 40 Code of Federal Regulations (CFR). Laboratory Services may subcontract certain analyses and QC samples out to independent laboratories. Bench level Quality Assurance/Quality Control (QA/QC) records and chain-of-custody records are maintained at the Tennessee Environmental Laboratory, as are QA records on subcontracted samples.

DOE-O will primarily use the Knoxville branch of Laboratory Services. Wet chemistry and metals samples will generally be analyzed in Knoxville while organics samples will be sent on to the Central Laboratory in Nashville. Methylmercury (MeHg) samples are analyzed at Brooks-Rand Laboratory in Seattle, Washington. All laboratory analysis will follow appropriate methods as documented in the Laboratory Services Inorganic Chemistry SOP and Organic Chemistry SOP. Specific analytical methods are covered in the Standard Operating Procedures (SOP) manuals for the Tennessee Laboratory Services Division. The SOPs direct analysts to the proper EPA or other methodology.

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# DRINKING WATER MONITORING

## Sampling of Oak Ridge Reservation Potable Water Distribution Systems

### Introduction

The water distribution systems at each of the DOE ORR sites are regulated by the Tennessee Safe Drinking Water Act, (T. C. A. 68-13-701), and by the Regulations for Public Water Systems and Drinking Water Quality (Chapter 1200-5-1). The Tennessee Department of Environment and Conservation, Division of Remediation, Office of Department of Energy Oversight (the office) may conduct oversight of sampling for total coliform bacteria and free chlorine residuals at various sites throughout the potable water distribution systems on the Oak Ridge Reservation (ORR). In addition, the office will oversee ORR line-flushing practices, water main repairs, cross-connection control programs, and water-loss/leak detection activities in order to identify potential threats to the potable water supply. If potential threats are identified or requests are made by ORR personnel, then additional chemical and radiological sampling may be conducted during 2013 to insure that the quality of the potable water is maintained.

The office, through a memorandum of understanding (MOU) with the TDEC Division of Water Supply (DWS), reviews chemical, radiological, and bacteriological sampling results from the drinking water distribution systems on the ORR, due to the potential for contamination from the site to backflow into the system during leaks. Each site has agreed to provide us the same monthly documentation that is sent to the DWS.

### Methods and Materials

The following sections provide information regarding the sample processing and analytical laboratory procedures.

#### *Free Chlorine Residual*

The sample will be collected in two small sample containers provided with the Hach® Pocket Colorimeter Kit. One of the sample containers will be designated as the blank and the other will be the actual sample to be analyzed. The blank is filled with 10 ml of water, placed into the pocket colorimeter and the “zero” button is depressed. The blank is then removed from the pocket colorimeter after the instrument has been zeroed. The actual sample is filled with 10 ml of water. A DPD powder pillow (test reagent) is added to the sample container and gently shaken, then placed in the pocket colorimeter. The “read” button is depressed and the free chlorine residual is analyzed (read directly from the pocket colorimeter display) within one minute.

Independent chlorine sampling will be conducted quarterly at either the Y-12 NNSA Complex facility or the Oak Ridge National Laboratory facility. Reasonable attempts will be made to rotate sampling between these two facilities each quarter. Specific sampling sites and number of samples to be taken will be determined based on water usage patterns, distribution system layouts, and other factors, such as construction activities and line breaks.

Independent chlorine sampling at the East Tennessee Technology Park facility will only be conducted upon request or in case of line breaks/repairs since the city of Oak Ridge accepted ownership of the system at ETTP.

As stated previously, if it is determined by evidence that shallow subsurface plume infiltration, cross connections, low chlorine residuals, line breaks/leaks, or other upset conditions have occurred which could cause a possible threat to the quality of the drinking water at Y-12, ORNL, and/or ETTP, then, as needed independent sampling of organic, inorganic, and radiological constituents will be conducted. The following methods will be used for sampling organic, inorganic, and radiological constituents.

#### *Bacteriological*

The U.S. Environmental Protection Agency (EPA)-approved method for coliforms (Colilert® in the pass/fail mode) will be the methodology utilized by Laboratory Services. The lab has expertise in a broad scope of services and analyses available to the office and other TDEC divisions statewide. For bacteriological testing on raw water sources, the counting application of the Colilert kits would be identified and utilized.

Sample collection will be completed by filling an appropriate sample container with 100 ml of water. All chain-of-custody procedures for conducting bacteriological sampling will be followed.

#### *Organic, Inorganic and Radiological*

Analytical methods are provided in the Standard Operating Procedures (SOP) manuals for Laboratory Services. The SOPs refer to proper EPA and/or other methods. In order to assess methods used, office staff should communicate with their sampling and analytical counterparts within the ORR on a basis that facilitates technical exchange and openness. General sampling and analysis methods will follow EPA guidelines as listed in the appropriate section of Title 40 of the Code of Federal Regulations (CFR).

#### *Quality Control/Quality Assurance*

If independent sampling activities are conducted, care will be taken to include quality control samples. The level of quality control methodology implemented will be commensurate with the level of independent sampling conducted. Forms of control sampling to be considered will be blanks, duplicate analysis, division-split samples, or even-split samples with site DOE contractor. Information pertaining to the quality control samples will be included in program files and spreadsheets.

Equipment that will be required to accomplish this oversight and sampling project include:

- latex or vinyl exam gloves
- Hach Pocket Colorimeter Kit,
- Hach free chlorine DPD powder pillows
- bound field book
- state vehicle
- Health, Safety, and Security Plan
- sample bottles
- sampling cooler
- disinfectant (full strength) spray bottle
- ice

- chain-of-custody forms
- sample labels

Table 1 displays sampling sites, constituents, and anticipated frequency.

**Table 1: Anticipated Sampling**

SITE	CONSTITUENTS	FREQUENCY	NUMBER OF SAMPLES
<b>Y-12</b>	Free Chlorine	Every other Quarter	1 per every other Quarter
	Bacteriological	As Needed	As Needed
	VOCs <sup>1</sup>	As Needed	As Needed
	Radiological <sup>2</sup>	As Needed	As Needed
	Mercury	As Needed	As Needed
<b>ORNL</b>	Free Chlorine	Every other Quarter	1 per every other Quarter
	Bacteriological	As Needed	As Needed
	VOCs <sup>1</sup>	As Needed	As Needed
	Radiological <sup>2</sup>	As Needed	As Needed
	Metals including Mercury	As Needed	As Needed
<b>ETTP</b>	Free Chlorine	As Needed	As Needed
	Bacteriological	As Needed	As Needed
	VOCs <sup>1</sup>	As Needed	As Needed
	Radiological <sup>2</sup>	As Needed	As Needed
	Metals including Mercury	As Needed	As Needed

<sup>1</sup> = volatile organic compounds

<sup>2</sup> = gross alpha/beta and gamma will be collected

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Tennessee Oversight Agreement, Agreement Between The U.S. Department of Energy and the State of Tennessee. Tennessee Department of Environment and Conservation, DOE Oversight Office, Oak Ridge, Tennessee. 2011.

Tennessee Safe Drinking Water Act, (T.C.A. 68-13-701), Tennessee Department of Environment and Conservation. Nashville, Tennessee.

Total Coliform Rule U.S. Environmental Protection Agency, Office of Drinking Water and Ground Water. <http://www.epa.gov/safewater/tcr/tcr.html#distribution>

Yard, C.R. Health, Safety, and Security Plan. Tennessee Department of Environment and Conservation, DOE Oversight Office, Oak Ridge, Tennessee, 2011.

## RadNet Drinking Water on the Oak Ridge Reservation

### Introduction

In 2013, the Tennessee Department of Environment and Conservation, DOE Oversight Office, a part of the Division of Remediation (the division), will continue to monitor drinking water quarterly at five area water treatment plants through EPA's RadNet Drinking Water Monitoring program. This program is important because it conducts radiological analysis of public drinking water processed from waters near the Oak Ridge Reservation (ORR). Since any radiological contaminants released on the ORR can enter local streams and be transported to the Clinch River, the possibility that ORR pollutants could impact area water supplies remains. To date, the monitoring of the river via local water treatment facilities has indicated that concentrations of radioactive contaminants are below regulatory criteria. The program provides a mechanism to evaluate the impact of DOE activities on water systems located in the vicinity of the Oak Ridge Reservation and to verify DOE monitoring in accordance with the *Tennessee Oversight Agreement* (TDEC, 2011).

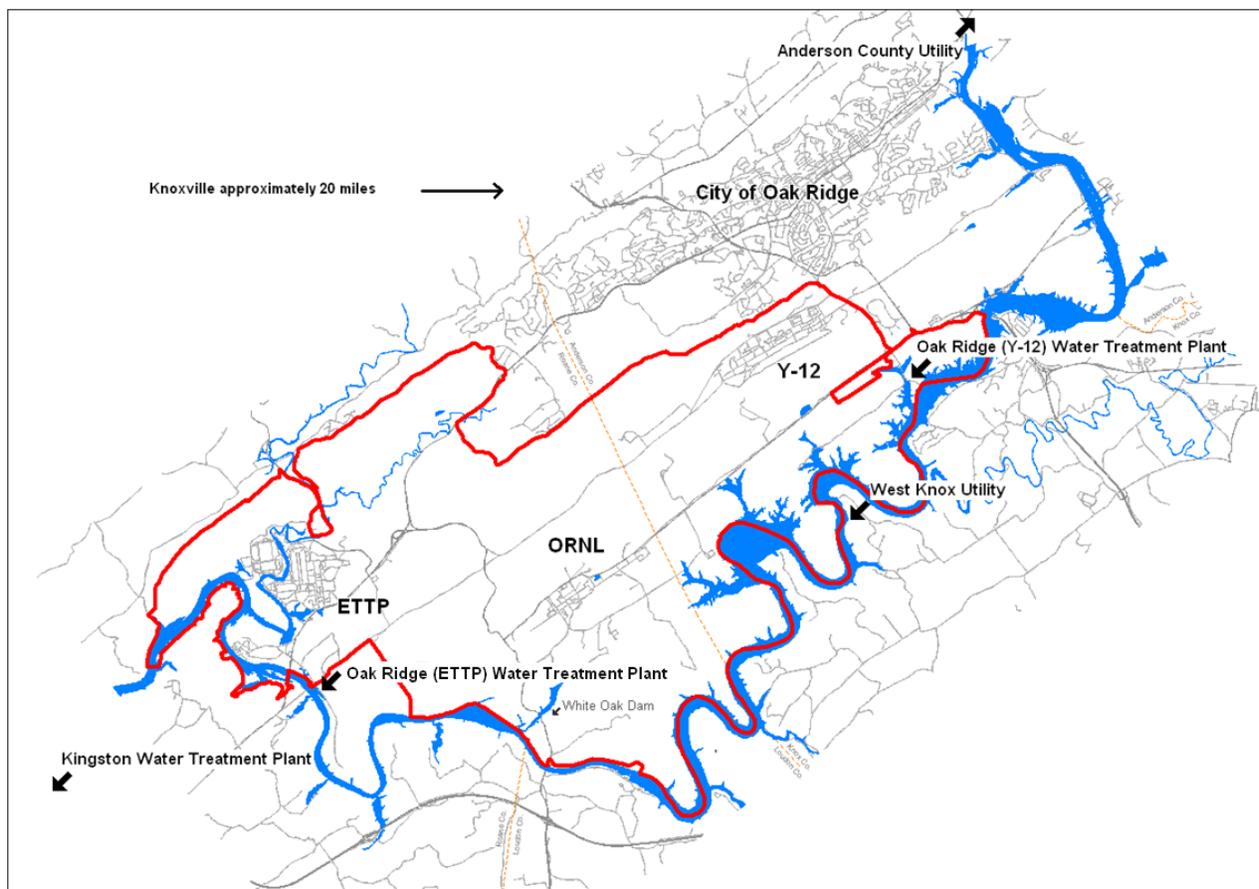
### Methods and Materials

As in the past, EPA will provide radiochemical analysis of finished drinking water samples collected quarterly by office staff at five public water supplies located on and in the vicinity of the ORR. This analysis will be performed at EPA's National Air and Radiation Environmental Laboratory in Montgomery, Alabama. When received, the results will be compared to each other (to identify anomalies) and to drinking water standards (to assess DOE compliance, adequacy of contaminant controls, and any associated hazards). Analytical parameters and the frequencies of RadNet analysis are provided in Table 1. Results from these analyses will be provided to the office and will be available on EPA's RadNet website via the EPA searchable Envirofacts database ([http://iaspub.epa.gov/enviro/erams\\_query\\_v2.simple\\_query](http://iaspub.epa.gov/enviro/erams_query_v2.simple_query)). More information on the program can be found on the EPA RadNet webpage (<http://www.epa.gov/radnet>).

**Table 1: EPA Analysis for RadNet Drinking Water Samples**

ANALYSIS	FREQUENCY
Tritium	Quarterly
Gross Alpha	Annually on composite samples
Gross Beta	Annually on composite samples
Gamma Scan	Annually on composite samples
Iodine-131	Annually on one individual sample/sampling site
Strontium-90	Annually on composite samples
Radium-226	Annually on samples with gross alpha >2 pCi/L
Radium-228	On samples with Radium-226 between 3-5 pCi/L
Plutonium-238, Plutonium-239, Plutonium-240	Annually on samples with gross alpha >2 pCi/L
Uranium-234, Uranium-235, Uranium-238	Annually on samples with gross alpha >2 pCi/L

The five Oak Ridge area monitoring locations in the program are the Kingston Water Treatment Plant, the City of Oak Ridge Water Treatment Facility at ETTP, West Knox Utility District, the City of Oak Ridge Water Treatment Facility at Y-12, and the Anderson County Utility Board Water Plant. Figure 1 depicts the approximate locations of raw water intakes associated with these facilities.



**Figure 1: Approximate locations of the intakes for public water systems monitored in association with EPA’s RadNet drinking water program**

**References**

Tennessee Oversight Agreement, Agreement Between the U.S. Department of Energy and the State of Tennessee. Tennessee Department of Environment and Conservation, DOE Oversight Office. Oak Ridge, Tennessee. 2011.

Environmental Radiation Ambient Monitoring System (ERAMS) Manual. Doc. EPA 520/5-84-007, 008, 009. United States Environmental Protection Agency. May 1988.

National Air and Radiation Environmental Laboratory. United States Environmental Protection Agency. [http://iaspub.epa.gov/enviro/erams\\_query\\_v2.simple\\_query](http://iaspub.epa.gov/enviro/erams_query_v2.simple_query) (Last updated September 17, 2012).

National Air and Radiation Environmental Laboratory. United States Environmental Protection Agency. <http://www.epa.gov/radnet> (Last updated September 7, 2012).

Yard, C.R., Health and Safety Plan, Tennessee Department of Environment and Conservation, DOE Oversight Office. Oak Ridge, Tennessee. 2011.

# GROUNDWATER MONITORING

## Groundwater Monitoring Plan for the Oak Ridge Reservation

### Introduction

The Division of Remediation's Department of Energy Oversight Office (referred to as DOR/DOE-O or the office), established under the Tennessee Oversight Agreement (TOA) and the Federal Facilities Agreement (FFA), will conduct monitoring of the groundwaters of the Oak Ridge Reservation (ORR).

The objective of the 2013 groundwater program is to develop an understanding of the fate and transport of Bear Creek Valley contaminants in groundwater within the Cambrian/Ordovician carbonates and fractured clastics where legacy waste was emplaced. In addition, the groundwater program will monitor several springs and a well on the periphery of the ETTP to determine trends in water quality from springs that discharge to surface water and a well that is currently being used by TVA just west of a contaminated spring. Program staff will also co-sample monitoring wells for oversight of DOE's sampling in Melton Valley, perform reconnaissance for springs in Bear Creek Valley and in Melton Valley. Tracing may be performed when and where feasible in support of the monitoring efforts. The sample locations are shown on Figure 1 and listed in Table 1. In the event that residential wells are to be sampled, our sampling plan will be modified to accommodate our laboratory budget.

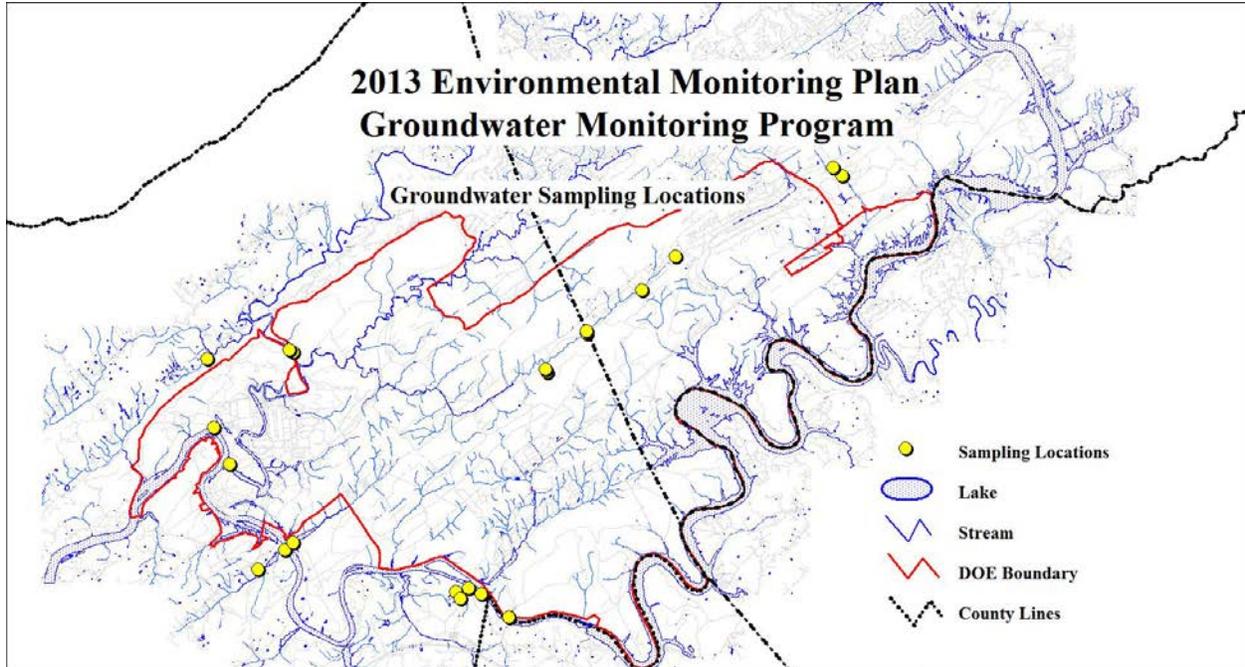


Figure 1: 2013 Groundwater Sampling Locations

## **Methods and Materials**

To meet all the objectives of the groundwater program, the investigative methods of tracing, spring reconnaissance, and sampling will be utilized.

### **Tracing**

In carbonate, karst and fractured rocks, assumptions about the functioning of wells and the implicit assumption of the existence of a porous medium are not valid (ASTM, 1995; USEPA, 1997). The only reliable way to base the design of a monitoring system in these settings is by the use of groundwater tracing. This should involve using contaminants as tracers, and/or natural isotopic and geochemical fingerprints.

However, these tracers do not yield all flow and transport data. For old facilities, it is often the case that contaminants have been in the ground for decades and even detection down gradient does not yield data revealing initial migration velocities. The only reliable way to obtain these data is by injected tracing.

Traced velocities in carbonates and other non-carbonate fractured rocks range from 0.001 m/s to 1 m/s with the highest velocities correlated to highest stage conditions (Worthington et al., 2000a, 2000b). The least expensive, most reliable and easily detectable injectable tracers are fluorescent dyes (ASTM 1995). (Injected fluorescent tracers can also serve as surrogates for contaminants. Studying this data is the only way to reliably determine where to sample for contaminants, to determine the appropriate sampling frequency and to determine the maximum contaminant load at a monitoring point.

When and where feasible, the office will conduct tracing in support of monitoring efforts.

### **Reconnaissance**

The groundwater program will conduct efforts to locate springs, seeps, and wells that are potential discharge locations and/or that may have been impacted by DOE activities. If feasible, detailed geologic maps and/or hydrogeological cross sections may be generated with the cooperation of the Division of Geology.

### **Sampling**

Residential or water supply wells will be sampled by collecting water as close to the wellhead as possible. The residential or supply wells will be sampled after being purged for at least 20 minutes or after field parameters stabilize. Monitored wells will be co-sampled by facility personnel using contractor sampling equipment or by office personnel using disposable bailers and/or passive diffusive samplers. Parameters, such as, pH, temperature, dissolved oxygen, oxidation reduction potential, and conductivity will be collected before sampling and recorded in the field notes.

Springs will be sampled based on field observation of flow and safety considerations. Where possible, sampling will be conducted at a variety of stages (dry season, wet season, normal precipitation) for all sampling locations. Water quality data logger (In-Situ Trolls and Hobo Temperature Conductivity meters) provide continuous monitoring of water quality parameters to

determine optimum frequency, timing of sampling events, and understanding of the hydrogeologic conditions.

Samples will be analyzed based on known or suspected DOE contamination, and for the acquisition and compilation of hydrogeological and hydrogeochemical data. The list of analyses provided in Table 1 is subject to change as understanding of the nature of groundwater and associated contaminants improve.

**Table 1: Proposed Sampling Locations and Rationale**

Area	Location	Number of Samples	List of Analyses	Rationale	
Y-12	Cattail Spring	1	VOCs, Rad, Metals, Inorganics	Located in Union Valley and monitoring east end plume.	
	Gallaher Spring	2			
	U-Spring	2		Develop an understanding of Groundwater in Bear Creek.	
	GW-123	2			
	GW-214	2			
	GW-601	2			
	GW-684	2			
	GW-685	2			
	GW-710	2			
GW-711	2				
	Bootlegger Spring	1	VOCs, Rad	Located in the UT Arboretum south of Cattail Spring and is tied to the eastern security pit plume.	
ETTP	Spring 10-895	2	VOCs, Rad	Source area presently unidentified. Discharges to Surface Water	
	PCO Seep	1		Source area presently unidentified. Discharges to Surface Water	
	Wanker's Bane	1		Near pond K-901-A, Discharges to Surface Water	
		Substation Well	2	VOCs, Rad, Metals, Inorganics	TVA well located just south of Spring 10-895.
		Regina Loves Bobby Spring	2		North side of Black Oak Ridge. Discharges to Surface Water
ORNL (Melton Valley)	OWM-1D	1	VOCs, Rad, Metals, Inorganics	Sampling for oversight in Melton Valley	
	OMW-2C	1			
	OWM-3D	1			
	OMW-4B	1			
		Eddies Spring	1	Copper Ridge, parameters suggest compounds similar to the Melton Valley Plumes, therefore the sampling location is used to determine potential extent of the Melton Valley Plumes.	
ORNL (Bethel Valley)	RWA-104	13	VOCs	Passive Diffusive Samplers spaced approximately every 50 feet in the water column to verify previous grab sample and determine proper depth of contamination.	

VOCs - Volatile Organic Compounds

Radionuclides - Includes gross alpha, gross beta, alpha/beta by liquid scintillation, gamma radionuclides, strontium 89/90, tritium, technetium 99, uranium (isotopic), and radium

Metals - Includes aluminum, antimony, arsenic, barium, beryllium, cadmium, calcium, chromium, copper, iron, lead, lithium, potassium, magnesium, manganese, nickel, selenium, silver, sodium, strontium, thallium, uranium, and occasional mercury and/or chromium hexavalent

Inorganics - Includes alkalinity as CaCO<sub>3</sub>, boron, chloride, conductivity, fluoride, hardness as total as CaCO<sub>3</sub>, nitrogen as nitrate, ammonia, pH, dissolved residue, silica, sulfate

GW - Groundwater Monitoring Well

OMW - Offsite Monitoring Well

PCO - Poplar Creek Orange

RWA - Residential Water Well

TVA - Tennessee Valley Authority

UT - University of Tennessee

Table 1 contains locations, analyses and sampling rationale. Specific radiochemical analyses will be determined prior to sampling. If domestic water supplies show a gross alpha activity greater than 5 picocuries/liter, then radionuclide isotope-specific analysis for alpha emitters will be performed on the laboratory-archived sample.

As contaminants may transport in turbulent groundwater on sediment, occasional sediment samples may be collected and analyzed for inorganic and radiologic parameters.

As new contaminants of concern are identified by the regulatory and monitoring community, new parameters may be added to the analysis of ground and surface waters sampled by the program.

Appropriate lab, field and trip blanks (QA/QC) will be utilized.

### **DOE Coordination/Communication**

DOE will be notified, by this document and revisions to this document, of office groundwater sampling plans. Should the DOE request the opportunity to observe and/or take split samples, every effort will be made to facilitate DOE participation in the office's groundwater program. Analytical results will be made available to any and all interested parties upon request.

All results and findings will be reported in the DOE-Oversight Office's Environmental Monitoring Report.

### **References**

A Study of Groundwater Flow from Chestnut Ridge Security Pits Using a Fluorescent Dye Tracer. Y/SUB/90-00206C/6. Prepared by Geraghty & Miller, Inc. for Martin Marietta Energy Systems. Oak Ridge, Tennessee. 1990.

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# RADIOLOGICAL MONITORING

## Facility Survey Program and Infrastructure Reduction Work Plan

### Introduction

The Tennessee Department of Environment and Conservation's Department of Energy Oversight office (DOE-O), in cooperation with the U.S. Department of Energy and its contractors, operates a facility survey program (FSP) on the Oak Ridge Reservation (ORR). The DOE-O survey program provides a comprehensive, independent characterization of facilities on the ORR based on their operational history, present mission and physical condition. Inventories of radiological and/or hazardous materials, the degree of contamination present, contaminant release history, and the potential for a release of contaminants to the environment are also provided.

The goal of the program is to fulfill part of the commitments agreed to by the State of Tennessee and the Department of Energy in Section 1.2.3 of the Tennessee Oversight Agreement, which states that "Tennessee will pursue the initiatives in attachments A, C, E, F, and G. The general intent of these action items is to continue Tennessee's: (1) environmental monitoring, oversight and environmental restoration programs; (2) emergency preparedness programs; and (3) delivery of a better understanding to the local governments and the public of past and present operations on the ORR and potential impacts on the human health and/or environment by the Oak Ridge Reservation." As part of this larger endeavor, *the facility survey program is designed to provide a detailed assessment of all potential hazards affecting, or in any way associated with, facilities on the Oak Ridge Reservation.* To meet this objective, survey team members walk through each facility and gather information that is recorded in a database that allows the team to characterize facilities and evaluate their potential for release of contaminants to the environment (PER). The conditions of facilities are considered within a variety of environmental conditions ranging from catastrophic (i.e. tornado, earthquake) to normal everyday working situations. From an emergency preparedness perspective such information is essential.

In 2002, the Department of Energy instituted a formal, accelerated decommissioning and decontamination (D&D) program aimed at facility reduction through demolition. Facility survey staff responded to this activity by making facility visits and conducting external inspections of each facility prior to and during demolition. This activity will continue in 2013.

### Methods and Materials

The criteria used in the selection of facilities to be surveyed include 1) position of facility in surveillance and maintenance (S&M)/D&D programs; 2) physical condition of facility; 3) perceived levels of contamination; 4) types or quantities of inventories (hazardous or radiological); and 5) special circumstances (incidents, public or other agency request, or other unforeseen situations).

Using standard radiation survey instruments, inventory data, and historical documentation, staff walk through each facility and record information in a questionnaire format. Based on these results and professional judgment, staff then rank the potential for release of contaminants to the environment (PER) for each facility by scoring 0 (least potential) to 5 (greatest potential) for

each of 10 “categories.” Tables 1 and 2 illustrate the scoring guidelines for potential environmental release, and the categories to be scored.

**Table 1: Potential for Environmental Release Scoring Guidelines**

<b>Score</b>	Score is based on observations in the field and the historic and present-day threat of contaminant release to the environment/building and/or ecological receptors.
<b>0</b>	No potential: no quantities of radiological or hazardous substances present.
<b>1</b>	Low potential: minimal quantities present, possibility of an insignificant release, very small probability of significant release, modern maintained containment.
<b>2</b>	Medium potential: radiological or hazardous substances present, structures stable in the near to long term, structures have integrity but are not state-of-the-art, adequate maintenance.
<b>3</b>	Medium potential: structures unstable, in disrepair, containment failure clearly dependent on time, integrity bad, maintenance lacking, containment exists for the short term only.
<b>4</b>	High potential: radiological or hazardous substances present. Containment for any period of time is questionable; migration to environment has not started.
<b>5</b>	Radiological or hazardous substance containment definitely breached, environmental/interior pollution from structures detected, radiological and/or hazardous substances in inappropriate places like sumps/drains/floors, release in progress, or radiological exposure rates above Nuclear Regulatory Commission (NRC) guidance.
Note: A score of 0 or 1 designates a low Potential Environmental Release rank; a score of 2 or 3 designates a moderate rank; a score of 4 or 5 designates a high rank.	

**Table 2: Ten Categories Scored**

<b>1.</b>	Sanitary lines, drains, septic systems
<b>2.</b>	Process tanks, lines, and pumps
<b>3.</b>	Liquid Low-level Waste tanks, lines, sumps, and pumps
<b>4.</b>	Floor drains and sumps
<b>5.</b>	Transferable radiological contamination
<b>6.</b>	Transferable hazardous materials contamination or waste
<b>7.</b>	Ventilation ducts and exit pathways to create outdoor air pollution
<b>8.</b>	Ventilation ducts and indoor air/building contamination threat
<b>9.</b>	Elevated radiation exposure rates inside the facility
<b>10.</b>	Elevated radiation exposure rates outside the facility

Individual facility survey reports are delivered to DOE where they can be used to help prioritize D&D activities and corrective actions.

As facilities are surveyed, scored, and compared with each other, a relative “potential for environmental release” will emerge. The facilities that show a high potential for release of contaminants will be noted in the program’s annual environmental monitoring report. Staff will revisit these facilities at their discretion to evaluate changing conditions. Table 3 provides a list of target facilities to be surveyed during 2013.

**Table 3: Target Schedule of Facilities to be Surveyed 2013**  
**ORNL** **Y-12**

Facility	Completion Date	Facility	Completion Date
X-3618	Feb. 15	Y-9720-32	Feb. 15
X-3034	April 30	Y-9720-32A	Mar. 15
X-3036	June 29	Y-9201-3	May 15
X-2525	Aug. 30	Y-9720-33	July 15

- X-3618** WC-10 Tank Farm Bldg. and Pump house
- X-3034** Radioisotope Circle Support Facility
- X-3036** Radioisotope Service and Storage Facility
- X-2525** Laboratory Fabrication Services
- Y-9720-32** Storage Facility
- Y-9720-32A** Document Storage and Destruction Facility
- Y-9201-3** Alpha 3
- Y-9720-33** Storage Facility

**References**

*Tennessee Oversight Agreement Between the Department of Energy and the State of Tennessee.*  
 Tennessee Department of Environment and Conservation, DOE Oversight Office. Oak Ridge,  
 Tennessee. 2011.

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 and Conservation, DOE Oversight Office. Oak Ridge, Tennessee. 2005.

Yard, C.R., Health and Safety Plan, Tennessee Department of Environment and Conservation,  
 DOE Oversight Office. Oak Ridge, Tennessee. 2011.

## **Haul Road Radiological Surveys**

### **Introduction**

The Tennessee Department of Environment and Conservation, with the cooperation of the U.S. Department of Energy and its contractors, will continue to perform weekly surveys of the Haul Road in 2013. The Haul Road was constructed for, and is dedicated to, trucks transporting CERCLA radioactive and hazardous waste from remedial activities on the ORR to the Environmental Management Waste Management Facility in Bear Creek Valley for disposal. To account for wastes that may fall or be blown from the trucks in transit, TDEC personnel perform walk over inspections of the road and associated access roads weekly. Items noted are surveyed for radiological contamination, logged, and their description and location submitted to DOE for disposition.

### **Methods and Materials**

For safety and by agreement with DOE and its contractors, staff members performing inspections will log onto the road at the ETTP check-in station, where they will advise site personnel they will be entering onto the road to perform the survey. The DOE contractor responsible for the road will brief staff members on any known conditions that could present a safety hazard. The contractor will also provide a two-way radio or another approved equivalent form of communication, to maintain communication should unforeseen conditions arise that could present a safety hazard while on the road. Where excessive traffic presents a safety concern, the survey will be postponed to a later date. Alternate entrances may be used to access the road with DOE approval, but the basic requirements remain in effect. In the event the contractor is not working, ETTP plant shift supervisor will be notified prior to entering and upon exiting the Haul Road.

When staff arrives at the location to be surveyed, they will park their vehicle completely off the road (as far away from vehicular traffic as possible). No less than two people will perform the surveys, each walking in a serpentine pattern along opposite sides of the road to be surveyed. Typically, a Ludlum Model 2221 Scaler Ratemeter with Model 44-10 2"X 2" NaI Gamma Scintillator probe held approximately six inches above the ground surface will be used to scan for radioactive contaminants as the walk over proceeds.

Items found during the survey will be marked with contractor's ribbon at the side of the road and a description of the item and its location logged and reported to DOE and its contractors for disposition. Each item will be surveyed for radiological contamination and the findings included in the above report, along with the instrumentation and procedures used in the radiological assessments. Table 1 provides the current inventory of equipment available to staff for such assessments.

When staff members return to the road for the next weekly inspection, they will perform a follow-up inspection of items found in previous weeks. If any items remain, they will be included in subsequent reports, until removed or staff is advised the item(s) have been determined to be free of radioactive and hazardous constituents.

**Table 1: Office of DOE Oversight Portable Radiation Detection Equipment**

<b>Radiological Detection Instruments</b>	<b>Radiological Detection Probes</b>	<b>Radioactivity Measured</b>
Ludlum Model 2221 Scaler Ratemeter	Ludlum Model 44-10 2x2 inch NaI Gamma Scintillator	Gamma (cpm)
Ludlum Model 3 Survey Meter	Ludlum Model 44-9 Pancake G-M Detector	Alpha, Beta, Gamma (cpm)
Ludlum Model 3 Survey Meter	Ludlum Model 43-65 50 cm <sup>2</sup> Alpha Scintillator	Alpha (cpm)
Bicron Micro-Rem	Internal 1x1 inch NaI Gamma Scintillator	Tissue Dose Equivalent, Gamma (µrem/hr)
Ludlum Model 2224 Scaler/Ratemeter	Ludlum Model 43-93 Alpha/Beta Scintillator	Alpha, Beta
Ludlum Model 48-2748	Gas proportional detector with 821 cm <sup>2</sup> active.	Alpha, Beta
Identifinder-NGH	Isotopic Identifier and Ratemeter	Gamma Spectroscopy and Dose Rate Meter

**References**

Environmental Restoration Footprint Reduction Process, Tennessee Department of Environment and Conservation, DOE Oversight Office. Oak Ridge, Tennessee.

Federal Facility Agreement, Tennessee Department of Environment and Conservation, DOE Oversight Office. January 1992 (with revisions).

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Yard, C.R., Health and Safety Plan. Tennessee Department of Environment and Conservation, DOE Oversight Office. Oak Ridge, Tennessee. 2011.

# **Ambient Gamma Radiation Monitoring of the Oak Ridge Reservation Using Environmental Dosimetry**

## **Introduction**

Gamma radiation is emitted by various radionuclides that have been produced, stored, and disposed of on the Oak Ridge Reservation (ORR). Associated radionuclides are evident in ORR facilities and the surrounding soils, sediments, and waters. In order to assess the risk posed by these contaminants, the Tennessee Department of Environment and Conservation began monitoring ambient gamma radiation levels on and in the vicinity the ORR in 1995. In this effort, environmental dosimetry is used to measure the radiation dose attributable to external radiation at selected monitoring locations on and in the vicinity of ORR. The program is intended to provide:

- conservative estimates of the potential dose/risk to members of the public from exposure to gamma radiation attributable to DOE activities/facilities on the ORR,
- baseline values used to assess the need/effectiveness of remedial actions,
- information necessary to establish trends in gamma radiation emissions, and
- information relative to the unplanned release of radioactive contaminants on the ORR.

## **Methods and Materials**

Dosimeters used in the program will be obtained from Landauer, Inc., Glenwood, Illinois. Each of these dosimeters will use aluminum oxide photon detectors to measure the dose from gamma radiation (minimum reporting value = 1 mrem). At locations where there is a potential for the release of neutron radiation, the dosimeters will also contain an allyl diglycol carbonate-based neutron detector (minimum reporting value = 10 mrem for thermal neutrons and 20 mrem for fast neutrons).

To account for exposures that may be received in transit or while in storage, control dosimeters will be included in each batch of dosimeters received from the Landauer Company. These dosimeters will be stored in a lead container during the monitoring period and returned to Landauer with the associated field-deployed dosimeters for processing. Any dose reported for the control dosimeters will then be subtracted from the dose reported for the field-deployed dosimeters by Landauer. At the end of the year, the results will be summed for each location and the resultant annual doses compared to background values and the state/DOE primary dose limits for members of the public (100 mrem/year).

Monitoring locations are chosen to identify sources of external radiation on the ORR, to develop conservative estimates of the dose to the public from DOE operations/facilities, and to collect information relative to the need and/or effectiveness of remediation. In 2013, the Environmental Dosimetry Program will monitor the following areas:

- |   |                                   |
|---|-----------------------------------|
| 1) Oak Ridge National Laboratory                      | 5) Off site areas of interest     |
| 2) Y-12 National Security Complex                     | 6) Tower Shielding Facility       |
| 3) Spallation Neutron Source Site                     | 7) East Tennessee Technology Park |
| 4) Environmental Management Waste Management Facility | 8) ORAU/ORISE Neutron Source      |

**References**

Federal Facility Agreement, Tennessee Department of Environment and Conservation, DOE Oversight Office. Oak Ridge, Tennessee. January 1992 (with revisions).

Tennessee Oversight Agreement, Agreement Between the U.S. Department of Energy and the State of Tennessee, Tennessee Department of Environment and Conservation, DOE Oversight Office, Oak Ridge, Tennessee. 2011.

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# Real Time Monitoring of Gamma Radiation on the Oak Ridge Reservation

## Introduction

The Tennessee Department of Environment and Conservation, DOE Oversight Office, has deployed continuously-recording exposure-rate monitors on the Oak Ridge Reservation since 1996 and will continue the project in 2013. The monitors record gamma radiation levels at predetermined intervals over extended periods of time. The instruments have primarily been used to monitor remedial activities and supplement the integrated dose rates provided by environmental dosimeters. In this regard, the dosimeters provide a cumulative dose over the monitoring interval, but the data do not indicate the specific time and magnitude of fluctuations in the dose rates. Consequently, a series of small releases cannot be distinguished from a single large release using the dosimeters alone. In contrast, the exposure rate monitors provide a profile of gamma emissions that can be correlated with changing environmental and/or anthropogenic conditions, allowing the cause of the release to be tracked and appropriate precautions taken.

## Methods and Materials

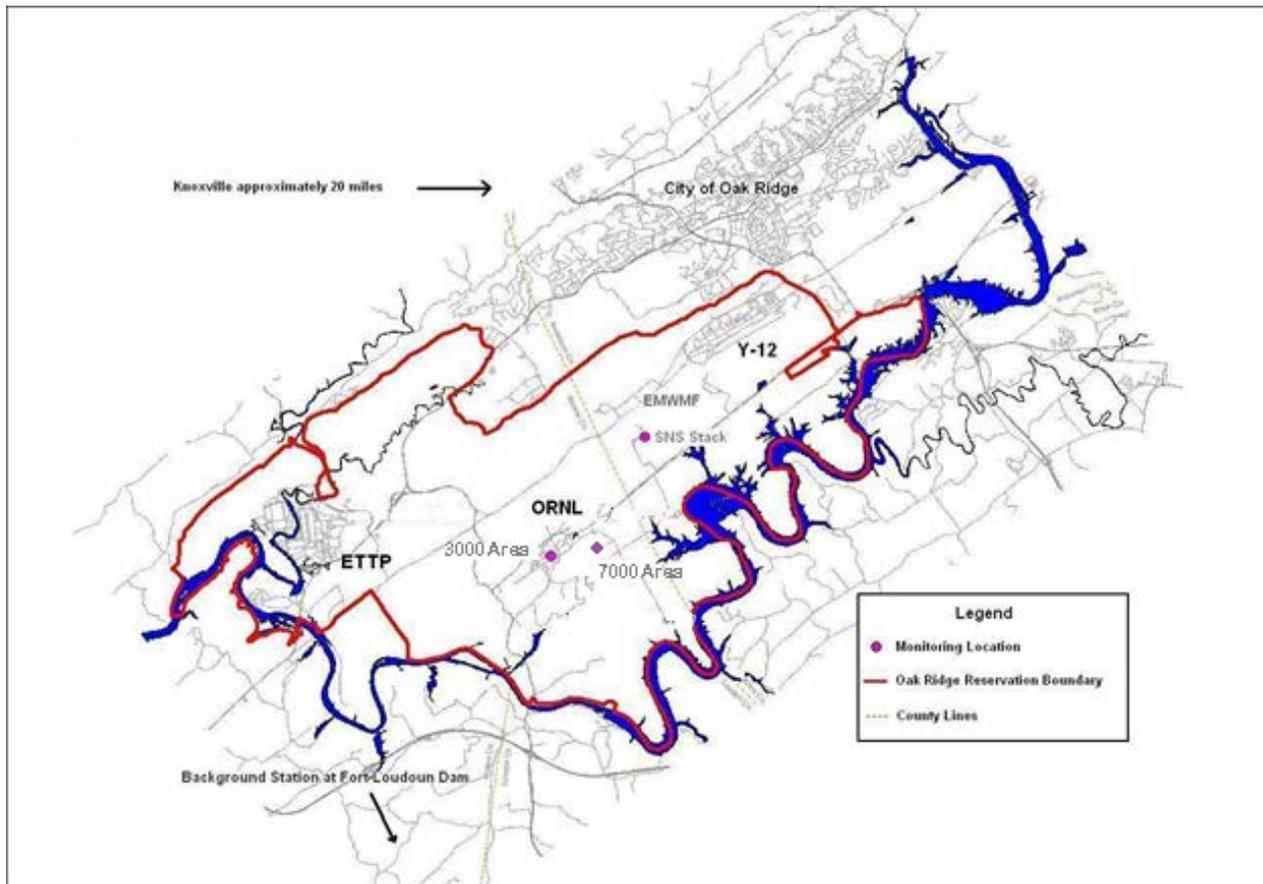
The continuous exposure rate monitors used in the program incorporate detection equipment, power supply, software, and associated instrumentation in a portable weather resistant case. The units are capable of measuring and recording gamma exposure rates from 1  $\mu\text{rem/hr}$  to 1  $\text{rem/hr}$  at preset intervals of one minute to two hours over extended time periods (e.g., a month). The data is downloaded in the field using an infrared transceiver, a lap top computer, and associated software.

Monitoring focuses on the measurement of exposure rates under conditions where gamma emissions are expected to fluctuate substantially over short time periods or where there is a potential for the unplanned release of gamma emitting radionuclides. The primary areas monitored in the program will be associated with remedial or waste management activities at sites where gamma radiation is known to be a concern. The locations of sites currently monitored in the program are depicted in Figure 1. These sites include:

- the 3000 Area remediation at Oak Ridge National Laboratory (ORNL),
- the Spallation Neutron Source stack,
- the 7000 Area Truck Monitor at ORNL, and
- the background station located at Fort Loudoun Dam in Loudon County.

Monitoring stations can be expected to vary as the sites subject to remediation change and findings warrant. Additional candidates for monitoring in 2013 include the demolition of buildings in the 2000 and 3026 complexes at ORNL. These facilities are considered to be some of the highest risk facilities at ORNL, due to the condition of the structures, the presence of loose radioactive contamination, and their proximity to active ORNL facilities.

To evaluate the exposure rates recorded, data collected from the monitoring locations will be compared to background concentrations, to the state limits for the maximum dose to an unrestricted area (2 mrem in any one hour period), and to the state/DOE dose limits for members of the public.



**Figure 1: Current Continuous Exposure Rate Monitoring Locations**

### References

Conley, T.B., Van Hoesen, S.D., Harper, M.A., Dillinger, D., Schneider .K.R., Walsh. T.M., Johnson, M.A., Billingsley K. M. D&D of the Radioisotope Development Laboratory (3026 Complex) and the Quonset Huts (2000 Complex) at Oak Ridge National Laboratory, Funded by the American Recovery and Reinvestment Act – 10255. WM2010 Conference. March 7-11, Phoenix AZ. 2010. (<http://www.wmsym.org/app/2010cd/wm2010/pdfs/10255.pdf>)

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Yard, C.R., Health Safety Plan. Tennessee Department of Environment and Conservation, DOE Oversight Office. Oak Ridge, Tennessee. 2011.

## **Surplus Material Verification**

### **Introduction**

Since 2002, the Tennessee Department of Environment and Conservation, Department of Energy Oversight Office (DOE-O), in cooperation with the U.S. Department of Energy and its contractors, has conducted random radiological surveys of surplus materials that are destined for sale to the public on the Oak Ridge Reservation (ORR). Standard radiological survey protocols and instrumentation are used for these surveys. In addition to performing the surveys, DOE-O reviews the procedures used for release of materials under DOE radiological regulations. The overall goal of the program is to ensure that DOE radiation controls are adequately preventing radiological contamination from reaching the public. Pre-auction surveys are performed for every auction where time and adequate staff are available for the survey.

Also reviewed are any occurrence reports that involve surplus materials. Some materials, such as scrap metal, may be sold to the public under annual sales contracts, whereas other materials are staged at various sites around the ORR awaiting public auction or sale. DOE-O, as part of its larger radiological monitoring role on the reservation, conducts these surveys to help ensure that no potentially contaminated materials reach the public.

In the event that radiological activity is detected, DOE-O will immediately report to the responsible supervisory personnel of the surplus sales program. DOE-O will follow their response to the notification, ensuring that appropriate steps (removal of items from sale, resurveys, etc.) are taken to protect the public. DOE-O reviews any occurrence reports, procedural changes and removal of items from sales inventories.

### **Methods and Materials**

Staff members make random surveys of items that are arranged in sales lots by using standard survey instruments and standard survey protocols. Instrumentation used is the Ludlum Model 2221 Scaler/Ratemeter with a Ludlum Model 44-10 NaI/Tl gamma radiation scintillation detector and the Ludlum Model 2224 Scaler/Ratemeter with a Ludlum Model 43-93 Alpha/Beta Scintillator. Potential items range from furniture and computer equipment to vehicles and construction materials. Particular survey attention is paid to smaller equipment and parts. Where radiological release information is attached, radiation clearance information is compared to procedural requirements. If any contamination that exceeds twice the background reading is detected during the on-site survey, the surplus materials manager for the facility will be notified immediately. In addition to radioactivity, any chemical concerns will be immediately brought to the attention of the manager.

### **References**

Tennessee Oversight Agreement, Agreement Between the U.S. Department of Energy and the State of Tennessee, Tennessee Department of Environment and Conservation, DOE Oversight Office. Oak Ridge, Tennessee. 2011.

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# **Monitoring of Waste at the Environmental Management Waste Management Facility Using a Radiation Portal Monitor**

## **Introduction**

In 2013, the Tennessee Department of Environment and Conservation Division of Remediation (DoR) will use a radiation portal monitor (RPM) to survey waste as it is transported into the disposal area at the Environmental Management Waste Management Facility (EMWMF). The EMWMF is used to dispose of CERCLA hazardous and radioactive waste generated by remedial activities on the Oak Ridge Reservation. Only low level radioactive wastes that do not contain concentrations of radionuclides in excess of limits specified in waste acceptance criteria (WAC), agreed to by FFA parties, are approved for disposal in the facility. To help ensure these provisions of the WAC are not violated, the state (with the assistance of DOE and its contractors), erected a radiation portal monitor at the check-in station for trucks delivering waste to the EMWMF disposal area.

The RPM uses two large area gamma-ray scintillators (placed on each side of the road at the check-in station) to measure gamma radiation emission as trucks transporting waste pass through the portal into the disposal area. The RPM stores the measurements and associated information (e.g., date, time). The data is viewable remotely in real time by the state, DOE, and DOE's authorized contractors by internet. If measurements exceed a predetermined level, the RPM software generates an alert notification that is sent by email to TDEC DOE-O staff members. When such a notification is received or anomalies are noted in daily reviews of the data, EMWMF staff will be notified and the source of the waste passing through the portal at the time of the measurements determined. If a review of available information indicates provisions of the WAC have been violated, FFA parties will be so notified.

## **Methods and Materials**

A Canberra RadSenrty POV-G portal monitor is used in the program. The system is comprised of two large area gamma-ray scintillators, an occupancy sensor, a control box, a computer, and associated software. The gamma-ray scintillators and instrumentation are contained in radiation sensor panels (RSPs) mounted on stands located on each side of the road leading to the check-in station (Figure 1). Measurements are initiated by the occupancy sensor when a truck enters the portal. Data from the RSPs is stored temporarily by the RPM control box. The data is routinely transferred to the computer, where it is stored, with associated information (date, time, background measurements, etc.).

RPM data will be reviewed daily by office staff and will be available for review by DOE personnel and its authorized contractors. The RPM is programmed to send an alert notification by email if measurements exceed a preset level. When an alert notification is received or anomalies are noted in the daily reviews of the data, EMWMF personnel will be contacted and the source of the waste lot passing through the portal monitor at the time of the measurements determined. If a subsequent investigation indicates that provisions of the WAC may have been violated, FFA parties will be so notified.



**Figure 1: TDEC Portal Monitor at the Environmental Management Waste Management Facility**

### **References**

Model S585 RadSentry Operations/Maintenance/Troubleshooting Manual9237096D V1.3, Canberra Industries, Inc., 800 Research Parkway, Meriden, CT 06450

Tennessee Oversight Agreement, Agreement between the U.S. Department of Energy and the State of Tennessee. Tennessee Department of Environment and Conservation, DOE Oversight Office. Oak Ridge, Tennessee. 2011.

Yard, C.R., Health and Safety Plan. Tennessee Department of Environment and Conservation, DOE Oversight Office. Oak Ridge, Tennessee. 2011.

# **SURFACE WATER MONITORING**

## **Surface Water Monitoring at the Environmental Management Waste Management Facility**

### **Introduction**

The Tennessee Oversight Agreement (TOA) requires the state to conduct radiological monitoring on the Oak Ridge Reservation (ORR), as necessary, to evaluate Department of Energy (DOE) monitoring programs and to assess the effectiveness of DOE contaminant control measures to prevent releases to the environment. During 2013, the Tennessee Department of Environment and Conservation's Division of Remediation will monitor surface waters, storm water, groundwater, effluents, and sediments at DOE's Environmental Management Waste Management Facility (EMWMF), located in eastern Bear Creek Valley. The EMWMF was constructed to dispose of low level radioactive waste and hazardous waste generated by remedial activities on the ORR and is operated under the authority of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA). While the facility holds no permit from any state agency, it is required to comply with substantive portions of relevant and appropriate legislation contained in the CERCLA Record of Decision (DOE, 1999) and DOE directives developed to address responsibilities delegated to the agency by the Atomic Energy Act of 1946.

While the availability of the EMWMF has presented the opportunity to expedite remedial activities on the ORR, the abundant rainfall of the region, complex hydrogeology of the location, and the proximity of the facility to local population centers present challenges to the landfill that would not be expected in more arid or remote locations. It is the intent of the project to assess the performance of the facility, evaluate EMWMF monitoring programs, and verify contaminant control measures at the facility are consistent with criteria agreed upon by the state, EPA, and DOE.

The ORR was established in 1942, as part of the federal government's World War II effort to develop and produce the first nuclear weapons. Four major installations were constructed at that time: the X-10 facility, now known as the Oak Ridge National Laboratory (ORNL); the Y-12 plant, now known as the Y-12 National Security Complex (Y-12); the K-25 plant, now known as the East Tennessee Technology Park (ETTP); and S-50, a liquid thermal diffusion uranium enrichment plant that was shut down after less than a year of operation. The initial objectives of ORR operations were the production of plutonium and enriched uranium for use in nuclear weapons. In the 70 years since, a variety of production and research activities have generated numerous radioactive and hazardous wastes, most of which are eligible for disposal at the EMWMF. Contaminants include a long list of radionuclides such as activation and fission products from isotope production facilities, reactor operations, and nuclear research at the ORNL facility, as well as uranium and related radionuclides associated with uranium enrichment operations and the manufacturing of nuclear weapons components at the K-25 and Y-12 plants.

The ORR encompasses approximately 35,000 acres located within the corporate boundaries of the City of Oak Ridge, Tennessee. It is bound on the north and east by the population center of

the City Oak Ridge and on the south and west by the Clinch River. The climate of the region can be broadly classified as humid subtropical, with rainfall averaging approximately 55 inches/year. The site is underlain by an assemblage of sedimentary rocks (carbonates, sandstone, shales) that have undergone intense deformation during the formation of the Appalachian Mountains. This resulted in a series of folded, tilted, and faulted strata containing highly developed fracture systems that extend both laterally and at depth (ORSSAB, 2012). As a result of the fracture systems, abundant rainfall, and solution development in the carbonates (karst), the hydrology of the ORR is extremely complex. Most groundwater flow is controlled by the fracture systems, making contaminant flow paths difficult to predict, using conventional modeling techniques. In addition, substantial groundwater flow can occur in preferential pathways in fractures and solution cavities, which evidence suggests can transport contaminants rapidly for relatively long distances. Typically, contaminants in groundwater on the ORR are discharged to local streams that drain to the Clinch River, which flows southwest into the Tennessee River.

The EMWWMF was constructed in eastern Bear Creek Valley, approximately one mile west of the Y-12 National Security Complex. The valley is formed by Pine Ridge on the north and Chestnut Ridge to the south with the major drainage, Bear Creek, flowing parallel to the ridges southwest down the axis of the valley. Flow in the stream is dominated by a mature karst network developed in the Maynardville Limestone formation underlying the channel, with gaining and losing reaches common. The stream is fed by the discharge from numerous springs located primarily on the south side of the channel and small tributaries on the north. The EMWWMF is located on the southern slope of Pine Ridge approximately 1,500 feet to the north of Bear Creek, between Northern Tributary (NT) 3 on the east and the NT 5 tributary on the west. To accommodate construction of the EMWWMF, flow from a third tributary, NT-4, was diverted upslope of the facility to the NT-5 tributary and the channel filled. Shortly after the facility became operational, groundwater levels above the filled channel were found to have risen to levels near the basal liner of the facility and the drainage provided by the NT-4 channel subsequently restored by the construction of a rock filled drain running north to south beneath the facility. The underdrain discharges to the old NT 4 channel south of the facility. Construction of the underdrain lowered the water table, but groundwater levels remain near a ten-foot geologic buffer required between the water table and the facility's liner.

Currently, the only authorized releases of contaminants from the EMWWMF are contaminated storm water (contact water) that tends to pond in the disposal cells above the leachate collection system. The contact water is routinely pumped from the disposal cells to holding ponds and tanks, sampled, and based on the results either sent off-site for treatment or released to a storm water sedimentation basin. The sedimentation basin discharges to the NT 5 tributary of Bear Creek. The EMWWMF was designed with a 5% slope along the centerline of each disposal cell to direct storm water and leachate to the southern (lower) end of the cells (Williams, 2004). This design feature, along with the abundant rainfall of the region and low porosity native soils used as a protective layer over the leachate collections system, have resulted in excessive pooling of the contact water at the lower end of the cells (Williams, 2004). Heavy rainfall the first year of operations resulted in the storm water and associated leachate overflowing the cell berms, releasing contaminants to adjacent land and into the NT 5 tributary. To avoid similar incidents, the allowable release limits at the contact water ponds were relaxed and the compliance point moved from the ponds to the discharge from the storm water sedimentation basin. The limit on releases from the holding ponds/tanks to the sedimentation basin is based on requirements

contained in DOE Order 5400.5 that restrict the release of liquid wastes containing radionuclides to an average concentration equivalent to 100 mrem/year. The limit for discharges from the sedimentation basin to NT-5 are based on state regulations (TDEC 1200-2-11-.16(2)) that restrict concentrations of radioactive material released to the general environment in groundwater, surface water, air, soil, plants or animals to an annual dose equivalent of 25 mrem. In addition, DOE Order 458.1 limits gross alpha and gross beta activity of settleable solids in liquid effluents to 5.0 pCi/g and 50 pCi/g respectively.

### **Methods and Materials**

As previously noted, the intent of the project is to assess the performance of the facility (does it leak?), evaluate EMWMF monitoring programs, and verify that contaminant control measures at the facility are consistent with criteria agreed upon by the state, EPA, and DOE. In that effort, samples will be collected of surface water, storm water, groundwater, and sediments, using standard EPA protocol. Analyses will vary based on the media being sampled, findings, and the particular wastes being disposed during the period. Since monitoring for all radionuclides disposed in the facility would be cost prohibitive, analysis will focus on the more mobile species (e.g. tritium and technetium-99), on contaminants that have contributed the most historically to the annual dose limits (uranium & strontium-90), and on radionuclides exhibiting anomalous results in EMWMF data. Gross analysis will be used to screen for alpha and beta emitting radionuclides, with more specific analyses performed in response to elevated results. Gamma spectrometry will be used to identify gamma emitters (e.g. cesium-137) in effluents and as otherwise merited. Analysis for selected metals will be performed semiannually at effluent-monitoring locations. Basic water quality parameters (pH, dissolved oxygen, turbidity, temperature, and flow rate of the discharge) will be monitored at the sedimentation basin outfall and at the discharge from the underdrain, using an In-Situ® Troll 9500 multi-parameter water quality probe. To assess EMWMF monitoring, office results will be compared with those generated by EMWMF monitoring at the same location and anomalies investigated.

Current monitoring stations at the EMWMF are depicted in Figure 1, followed by a description of each station, planned analysis, and rationale for sampling the location. Figure 2 provides the location of the monitoring wells at the site that will be used, along with eight piezometers (not pictured), to assess the height of the groundwater table. A portion of the wells will also be sampled in the program to assess the performance of the facility. Well GW-918/Cattywampus Spring in both figures is the background location. Cattywampus Spring was the headwaters of NT-4. The majority of the NT-4 channel was filled and associated waters diverted to NT-5 to accommodate construction of the EMWMF. Although up gradient of the diversion, Cattywampus Spring was subsequently covered by fill and well GW-918 placed at the location. The well/spring currently serves as the background location, for both surface water and groundwater monitoring. Samples are currently collected quarterly and analyzed for gross alpha, gross beta, uranium isotopes, strontium-90, technetium-99, tritium, and gamma spectrometry.

Contact water that collects in the cells is periodically pumped to holding ponds/tanks, sampled, and, based on the results and the judgment of EMWMF personnel, either sent for treatment or released to a drainage ditch that discharges into the storm water sedimentation basin. Retained in the sedimentation basin, the contact water mixes with uncontaminated storm water, and then discharges through a v-weir to NT-5, which flows into Bear Creek, approximately 1,500 feet to the south.



Google Maps (Google Maps (Digital Globe, et al., 2012))

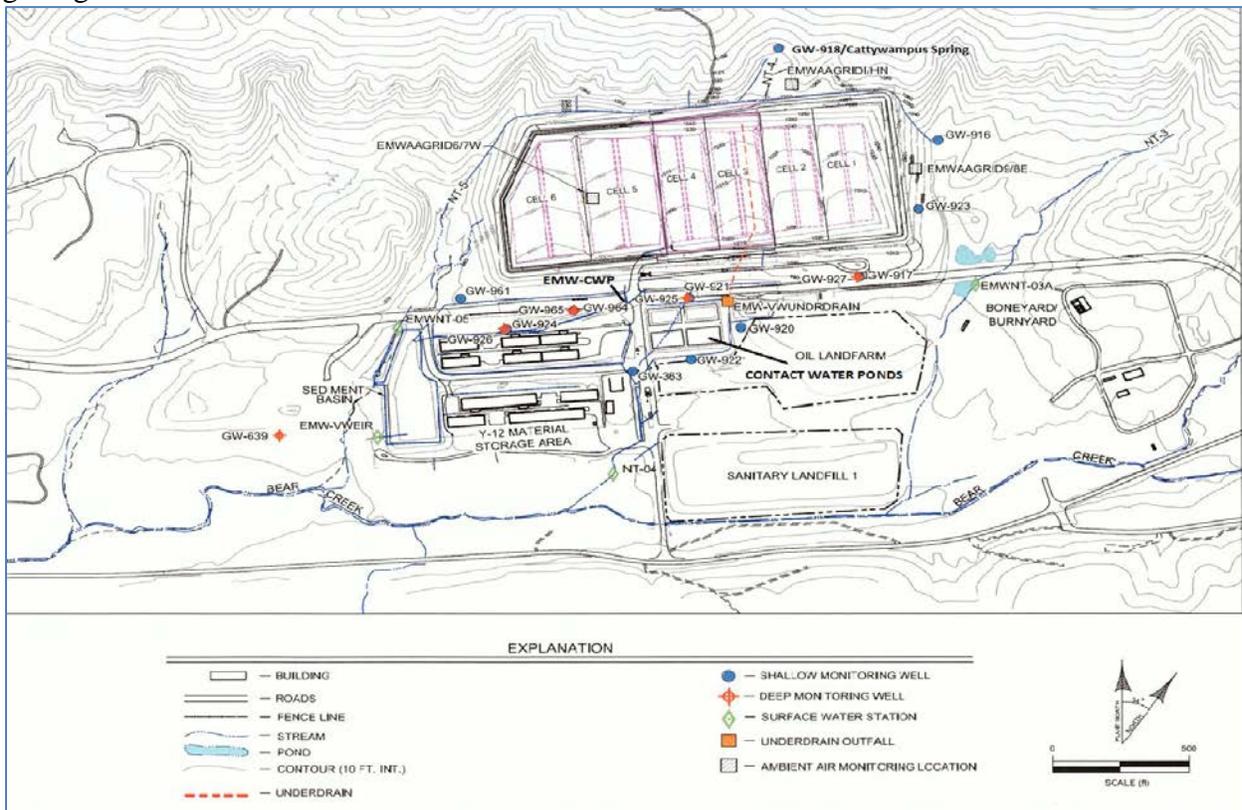
**Figure 1: Sampling locations at the Environmental Management Waste Management Facility**

To assess compliance with the DOE limit placed on radionuclides released from the contact water ponds and tanks (100 mrem/yr.), samples will be collected of the discharge of contact water as it is pumped to the drainage ditch at EMW-CWP (see Figure 1). To assess compliance with the TDEC limit placed out the outfall of the sedimentation basin, samples will be taken of the discharge from the v-weir at the basin (EMW-VWEIR) at the estimated time of the peak flow of the released contact water. Analysis will focus on those radionuclides that have historically contributed the most to the annual dose limits for each location (uranium isotopes and strontium-90) and the more mobile radionuclides (tritium and technetium-99). Gamma spectrometry will be used to identify gamma emitting radionuclides (e.g., cesium-137) and gross analysis to screen for other alpha and beta emitters, with more specific analysis performed as warranted. Gross alpha and gross beta analysis will be performed on suspended solids where merited to evaluate EMWMF compliance with DOE Order 458.1. Samples from both locations will be analyzed for selected metals semiannually. Basic water quality parameters (pH, dissolved oxygen, turbidity, temperature, and flow rate of the discharge) will be monitored at the sedimentation basin outfall, using an In-Situ® Troll 9500 multi-parameter water quality water quality probe. Gross analysis and gamma spectrometry will be performed on sediments collected from the sedimentation basin and the channel of NT-5 downstream of the basin annually. To assess EMWMF monitoring, the results will be compared with those taken at the same location and anomalies investigated.

To evaluate the performance of the liner and associated EMWMF monitoring, samples will be collected from the underdrain (EMW-VWUNDERDRAIN) bimonthly and selected wells co-sampled with EMWMF personnel quarterly, targeting those wells that have had anomalous results reported by the EMWMF historically. Figure 2 provides the location of EMWMF monitoring wells. To capture contaminants that could be migrating from the cells laterally in shallow groundwater, the NT-3 and NT-5 tributaries will be sampled down gradient of the waste

cells under base flow and high flow conditions, at the locations currently monitored under the EMWMF surface water program (EMWNT-03a & EMWNT-05 in Figure 2). Analysis will include the uranium isotopes, strontium-90, technetium-99, and tritium, all of which are mobile in groundwater and abundant in wastes disposed in the EMWMF. Gross analysis will be used to screen for other alpha and beta emitters, with more specific analysis performed as warranted. An In-Situ® Troll 9500 multi-parameter water quality probe will also be used at the underdrain, to monitor the specific conductivity, pH, dissolved oxygen (DO), turbidity, temperature, and the flow rate of the discharge.

Due to state and EPA concerns with shallow groundwater at the EMWMF, DOE agreed to maintain a 10-foot geologic buffer between the EMWMF liner and the groundwater table (based on TDEC Rule 1200-01-07(c)) and emplace a contingency plan to be implemented should groundwater intrude into the buffer. The contingency plan was implemented in 2003, resulting in the construction of the underdrain reestablishing the drainage previously provided by the filled NT 4 channel. Currently, the EMWMF takes quarterly water level measurements at thirty-two wells and piezometers at the site, to assess the height of the water table. To evaluate EMWMF monitoring, this data will be reviewed as it becomes available and used to model the potentiometric surface of the water table beneath the facility relative to the bottom of the geologic buffer.



Base map reproduced from *Annual Report for FY 2011 Detection Monitoring at the Environmental Management Waste Management Facility, Oak Ridge Tennessee* (DOE, 2012)

**Figure 2: Environmental Management Waste Management Facility Monitoring Well Locations**

## References

Annual Report for FY 2011 Detection Monitoring at the Environmental Management Waste Management Facility, Oak Ridge Tennessee. Elvado Environmental LLC. Knoxville Tennessee. March 2012.

Balancing Environmental Management Challenges with the Complexity of the Oak Ridge Reservation. Oak Ridge Site Specific Advisory Board. Oak Ridge, Tennessee. January 12, 2012.

DigitalGlobe, GeoEye, US Geological Survey, USDA Farm Service Agency (2010) Google Maps [online]. [Accessed 30 November 2012]. Available at <http://maps.google.com/>.

Record of Decision for the Disposal of Oak Ridge Reservation Comprehensive Environmental Response, Compensation, and Liability Act of 1980 Waste. DOE/OR/01-1791&D3. U. S. Department of Energy. Oak Ridge, Tennessee. November 1999.

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## Ambient Sediment Monitoring Program

### Introduction

The office is collecting sediment samples for chemical analysis to determine the degree of contamination at the benthic level of the Clinch River and Poplar Creek. Sediment samples are to be collected at six sites on the Clinch River and at one site on Poplar Creek. The sediment samples are analyzed for metals and radiological contamination in order to assess the sediment quality for public health and ecological considerations.

### Workplan Outline

Objective: To determine the degree of contamination at the river's benthic level. The sediment samples will be collected annually in late summer/early fall and analyzed for metals and radiological activity.

### Methods and Materials

Parameters to be analyzed:

*Inorganics:* aluminum, arsenic, barium, beryllium, boron, cadmium, chromium, copper, iron, lead, magnesium, manganese, mercury, nickel, selenium, uranium, and zinc.

*Radiological:* gross alpha (total), gross beta (total),  $^{89-90}\text{Sr}$ , isotopic uranium, gross gamma (total), *gamma radionuclides:*  $^{137}\text{Cs}$ ,  $^{40}\text{K}$ ,  $^{214}\text{Pb}$ ,  $^{214}\text{Bi}$ ,  $^{212}\text{Pb}$ ,  $^{228}\text{Ac}$ ,  $^{208}\text{Tl}$ ,  $^{212}\text{Bi}$  and others as detected.

### Schedule

The ambient sediment monitoring will be conducted in late summer/early fall of 2013. Sampling methods will follow the DOE-Oversight standard operating procedures for sediment sampling.

**Table 1: Sample Locations**

Embayment at Clinch River Mile ~19.3	CLINC019.3RO	CRM 19.3
Embayment at Clinch River Mile ~17.0	CLINC017.0RO	CRM 17.0
Embayment at Clinch River Mile ~16.1	CLINC016.1RO	CRM 16.1
Embayment at Clinch River Mile ~13.5	CLINC013.5RO	CRM 13.5
Embayment at Clinch River Mile ~11.2	CLINC011.2RO	CRM 11.2
Clinch River Mile ~9.3	CLINC009.3RO	CRM 9.3
Poplar Creek Mile ~1.2	POPLA001.2RO	PCM 1.2

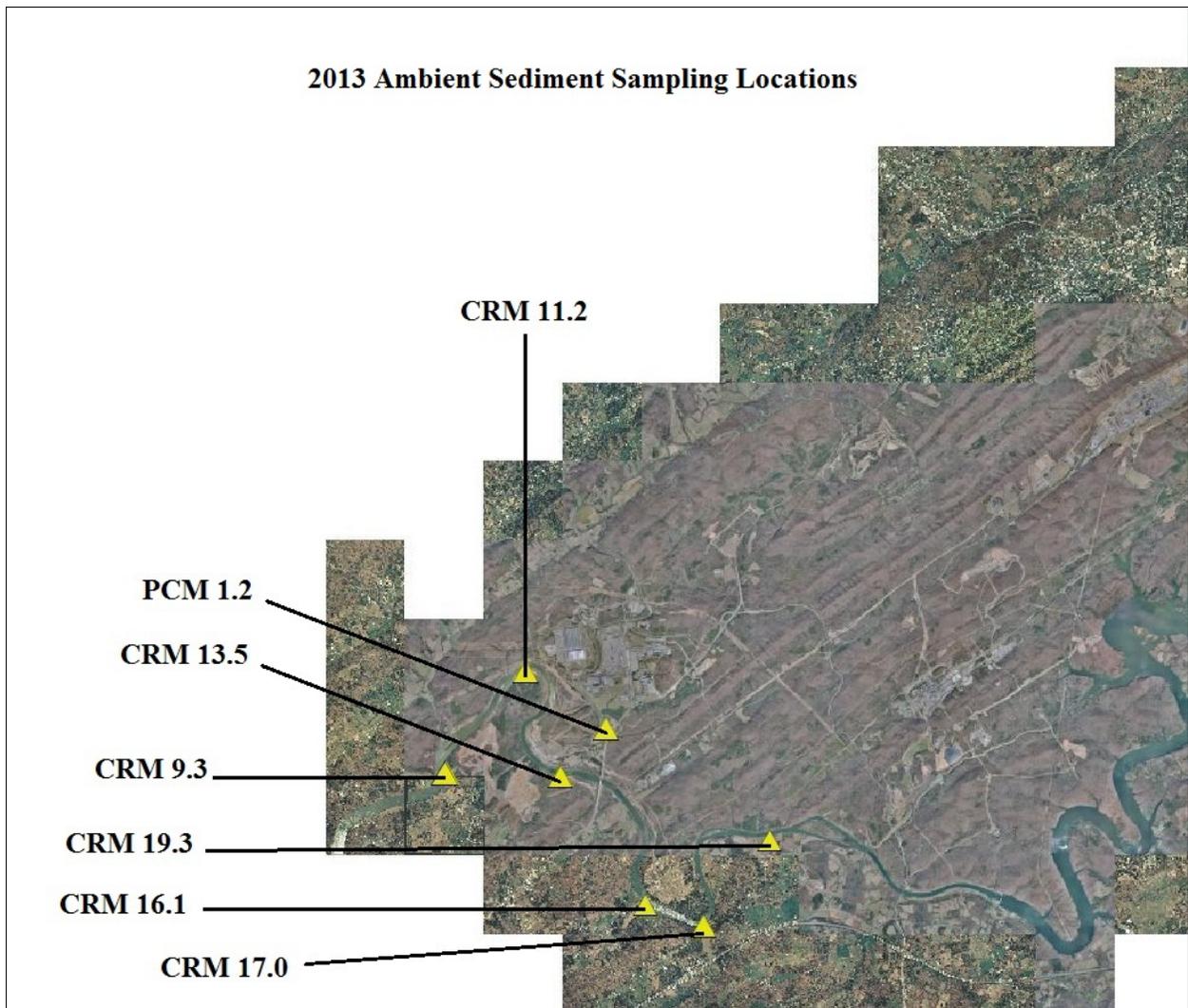


Figure 1: Ambient sediment sampling locations

***Laboratory Procedures***

The Tennessee Department of Health, Environmental Laboratory and Microbiological Laboratory Organization (the state lab) has expertise in a broad scope of services and analyses available to the Tennessee Department of Environment and Conservation (TDEC) Department of Energy Oversight (DOE-O) and to other TDEC divisions statewide. General sampling and analysis methods are to follow Environmental Protection Agency (EPA) guidelines as listed in appropriate parts of 40 Code of Federal Regulations (CFR). Laboratory Services may subcontract certain analyses and QC samples out to independent laboratories. Bench level Quality Assurance/Quality Control (QA/QC) records and chain-of-custody records are maintained at the Tennessee Environmental Laboratory, as are QA records on subcontracted samples.

DOE-O will primarily use the Knoxville branch of Laboratory Services. Wet chemistry and metals samples will generally be analyzed in Knoxville while organics samples will be sent on to the state lab in Nashville. Coastal Bioanalysts, Inc. will conduct the toxicity testing. All

laboratory analysis will follow appropriate methods as documented in the Laboratory Services Inorganic Chemistry Standard Operating Procedures and Organic Chemistry SOP. Specific analytical methods are covered in these manuals. They also direct analysts to the proper EPA or other methodology.

## **References**

Field Sampling Guidance Document #1215: Sediment Sampling. U.S. Environmental Protection Agency, Region 9 Laboratory. Richmond, California 1999.

Sediment Standard Operating Procedures. Tennessee Department of Environment and Conservation, Division of Remediation, DOE Oversight Office. Oak Ridge, Tennessee 2012.

Technical Standard Operating Procedure: Sediment Sampling SOP#EH-02. U.S. Environmental Protection Agency, Syracuse Research Organization, Region 8. East Helena Site, Montana. 2003.

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## Ambient Surface Water Monitoring

### Introduction

Surface water sampling is conducted twice yearly at sites located on the Clinch River and some of its tributaries. The surface water samples are analyzed for radiological activity, metals, nutrients and other parameters in order to assess the water quality for public health and ecological considerations. Clinch River Mile 78.7 and 52.6 are reference sites and are located upstream of the Oak Ridge Reservation (ORR). The other sites were chosen to detect contaminants being transported by surface water coming from the ORR or areas affected by Department of Energy (DOE) related activities.

**Table 1: Sample Locations**

Site	Location	Clinch River Mile*
CLINC078.7AN	Clinch River	78.7
CLINC052.6AN	Clinch River	52.6
CLINC041.2AN	Clinch River	41.2
CLINC035.5AN	Clinch River	35.5
CLINC017.9RO	Clinch River	17.9
CLINC010.0RO	Clinch River	10.0
MCCOY000.9AN	McCoy Branch (MCM 0.9)	37.5
RACCO000.4RO	Raccoon Creek (RCM 0.4)	19.5
GRASS000.7AN	Grassy Creek (GCM 0.7)	14.5
POPLA001.0RO	Poplar Creek (PCM 1.0)	12.0

\*For tributaries, the Clinch River Mile column refers to the mouth of the tributary.

### Methods and Materials

Parameters to be analyzed:

*Inorganics:* arsenic, cadmium, calcium, chloride, chromium, copper, iron, lead, magnesium, manganese, mercury, potassium, sodium, sulfate, zinc, nitrogen (NO<sub>2</sub> & NO<sub>3</sub>, ammonia, total Kjeldahl), selenium (McCoy Branch only), total phosphate, alkalinity as CaCO<sub>3</sub>.

*Other tests:* COD, dissolved residue, suspended residue, total hardness.

*Radiological:* Gross alpha and beta, gamma radionuclides, Sr-90 & Tc-99 (Raccoon Creek only).

### Schedule

The ambient water monitoring will be conducted in the second and fourth quarters of 2013.

### Standard Operating Procedures

The DOE-Oversight Office of TDEC uses the Division of Water Pollution Control's surface water sampling Standard Operating Procedure: Quality System Standard Operating Procedure for Chemical and Bacteriological Sampling of Surface Water (TDEC 2011).

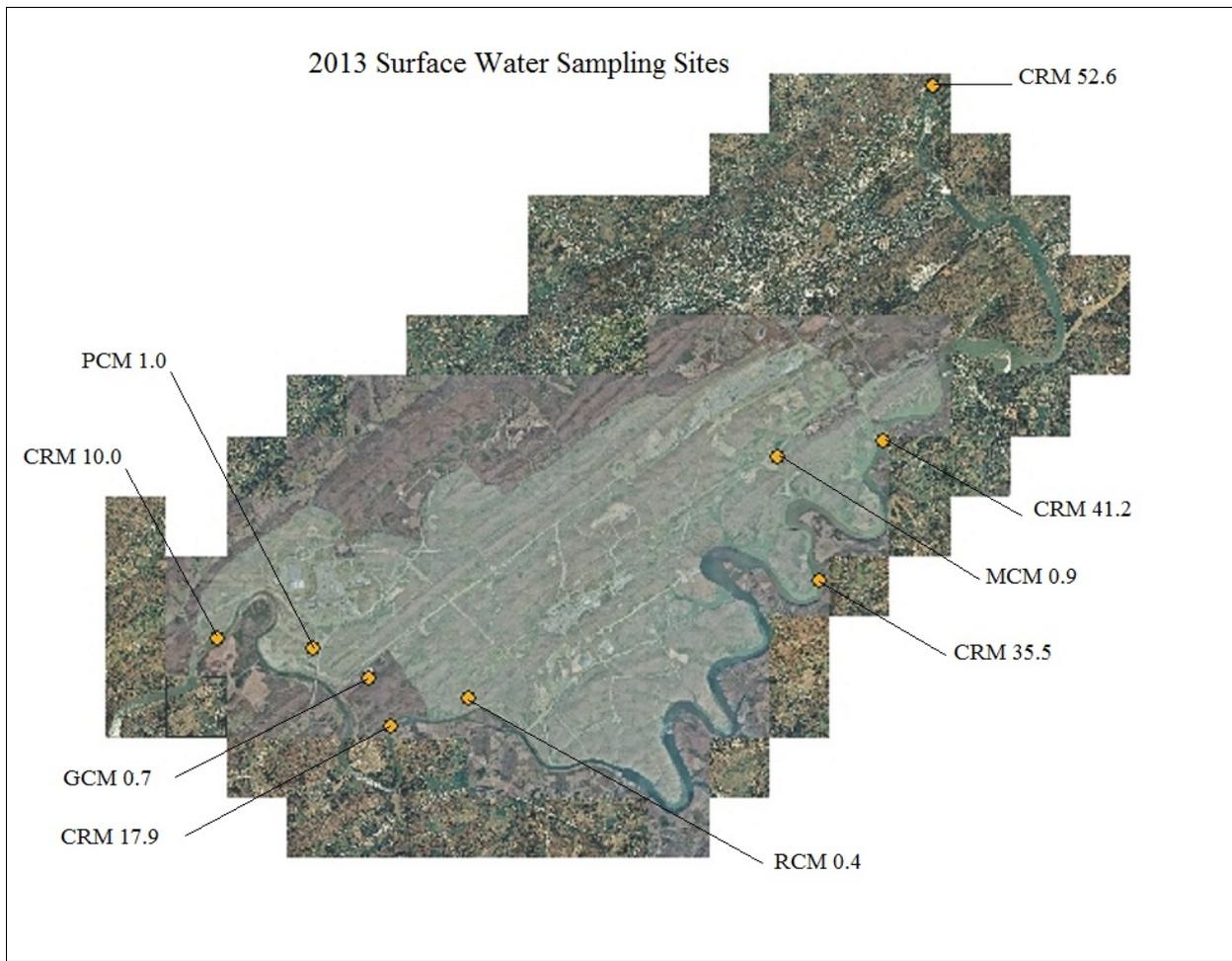


Figure 1: Ambient surface water sampling sites

***Laboratory Procedures***

The state lab has expertise in a broad scope of services and analyses available to the office and to other TDEC divisions statewide. General sampling and analysis methods are to follow Environmental Protection Agency (EPA) guidelines as listed in appropriate parts of 40 Code of Federal Regulations (CFR). Laboratory Services may subcontract certain analyses and QC samples out to independent laboratories. Bench level Quality Assurance/Quality Control (QA/QC) records and chain-of-custody records are maintained at the state lab, as are QA records on subcontracted samples.

DOE-O will primarily use the Knoxville branch of Laboratory Services. Wet chemistry and metals samples will generally be analyzed in Knoxville while organics samples will be sent on to the state lab in Nashville. All laboratory analysis will follow appropriate methods as documented in the Laboratory Services Inorganic Chemistry SOP and Organic Chemistry SOP. Specific analytical methods are covered in the state lab manuals and they direct analysts to the proper EPA or other methodology.

**References**

Quality System Standard Operating Procedure for Chemical and Bacteriological Sampling of Surface Water. Tennessee Department of Environment and Conservation, Division of Water Pollution Control. Nashville, Tennessee. 2011.

Tennessee Oversight Agreement, Agreement Between the U.S. Department of Energy and the State of Tennessee. Tennessee Department of Environment and Conservation, DOE Oversight Office. Oak Ridge, Tennessee. 2011.

Yard, C.R. Health, Safety, and Security Plan. Tennessee Department of Environment and Conservation, DOE Oversight Office. Oak Ridge, Tennessee. 2011.

# Surface Water Physical Parameters Monitoring Program

## Introduction

Due to the presence of areas of extensive point and non-point source contamination on the Oak Ridge Reservation (ORR), there exists the potential for contamination to impact surface waters on the ORR. During 2013, to assess the degree of surface water impact relative to this potential contamination displacement, stream monitoring data will be collected monthly to establish a database of physical stream parameters (conductivity, pH, temperature, and dissolved oxygen).

The primary objective of this monitoring project is to provide supplementary water quality data for office programs and organizations outside of TDEC. Furthermore, this monitoring task is directed toward determining long-term water quality trends, assessing attainment of water quality standards and providing additional baseline data for evaluating stream recovery. Table 1 lists the locations that have been selected for monitoring.

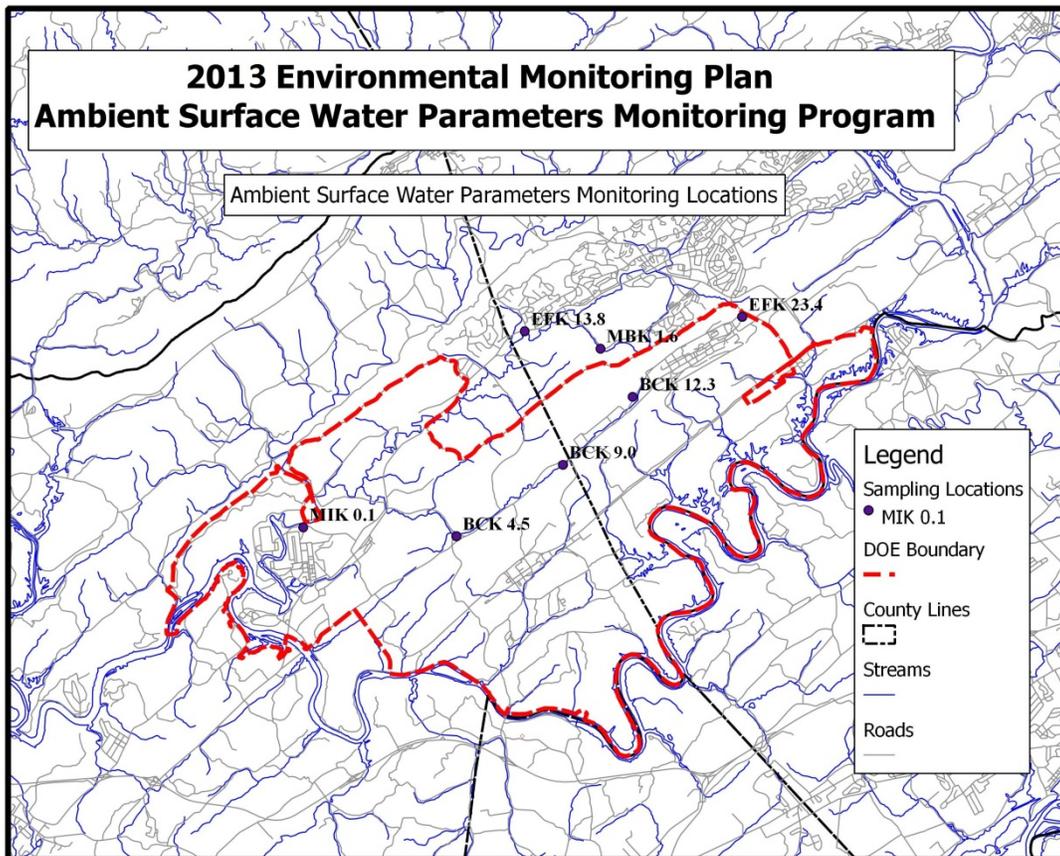


Figure 1: Sampling Locations

**Table 1: Sampling Locations in kilometers (mile equivalents)**

Site	Location
EFK 23.4 (14.5)	East Fork Poplar Creek (Station 17)
BCK 12.3 (7.6)	Bear Creek (near Y-12 west guard entrance)
BCK 9.0 (6.0)	Bear Creek (near Walk-in Pits)
BCK 4.5 (2.8)	Bear Creek (Weir at Hwy. 95)
MIK 0.1 (0.06)	Mitchell Branch (Weir at ETPP)
EFK 13.8 (8.6)	East Fork Poplar Creek (near Big Turtle Park)
MBK 1.6 (1.0)	Mill Branch (Reference)

### **Methods and Materials**

The surface water physical parameters of temperature, pH, conductivity, and dissolved oxygen will be measured. Field monitoring will follow the 2011 TDEC WPC Quality System Standard Operating Procedure for Chemical and Bacteriological Sampling of Surface Water.

### *Schedule*

Once per month, surface water monitoring will be conducted.

### **References**

The Status of Water Quality in Tennessee: Technical Report. Tennessee Department of Environment and Conservation, Division of Water Pollution Control. Nashville, Tennessee. 1998.

Quality System Standard Operating Procedure for Chemical and Bacteriological Sampling of Surface Water. Tennessee Department of Environment and Conservation, Division of Water Pollution Control. Nashville, Tennessee. 2011.

Yard, C. R., Health, Safety, and Security Plan. Tennessee Department of Environment and Conservation Department of Energy Oversight Office. Oak Ridge, Tennessee. 2011.

## Ambient Trapped Sediment Monitoring Program

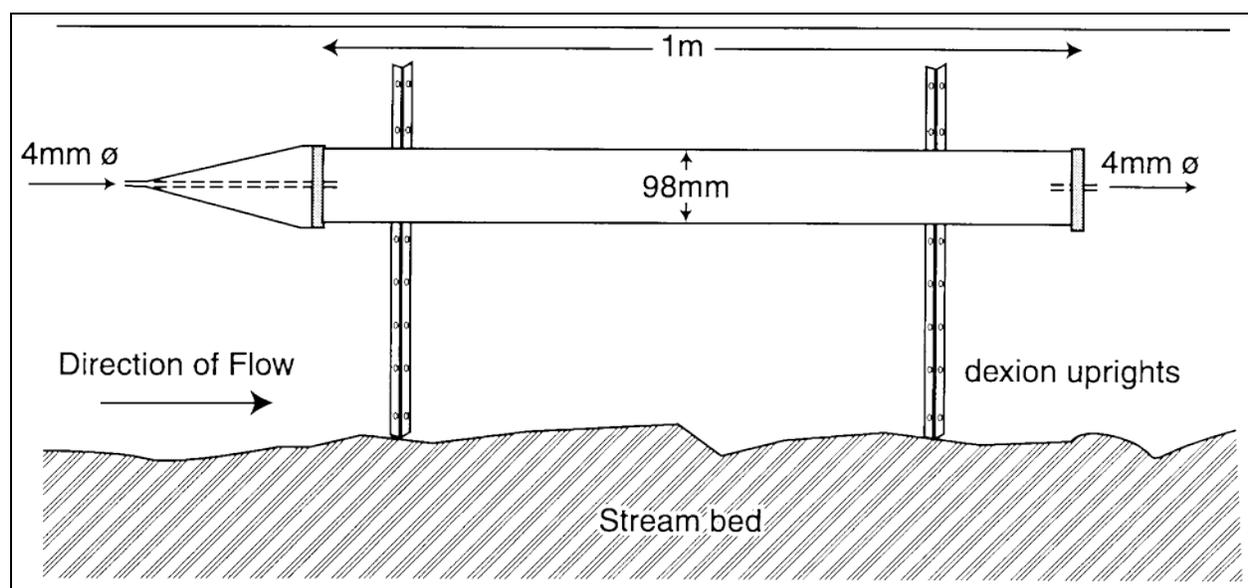
### Introduction

Sediment analysis is a key component of environmental quality and impact assessment for rivers, streams, lakes, and impoundments. Samples can be collected for a variety of chemical, physical, toxicological and biological investigations. The objective of this monitoring program is to assess the sediment that is being currently transported and deposited in Mitchell Branch, East Fork Poplar Creek, and Bear Creek. Sediment traps will be deployed at the following approximate stream locations: Mitchell Branch mile 0.1, East Fork Poplar Creek mile 4.0, Bear Creek 6.0. The exact location of deployment will depend on stream conditions at the time of deployment.

### Methods and Materials

#### *Sediment Sampler Design*

The passive sediment samplers will be modeled after a design described by Phillips *et al.* (2000).



Phillips *et al.* (2000)

Figure 1: Sediment Sampler Design

The following parameters will be analyzed utilizing TDH Laboratory services:

*Inorganics:* aluminum, arsenic, barium, beryllium, boron, cadmium, chromium, copper, iron, lead, magnesium, manganese, mercury, nickel, selenium, uranium, and zinc.

*Radiological:* gross alpha (total), gross beta (total),  $^{89-90}\text{Sr}$ , gross gamma (total), *gamma radionuclides:*  $^{137}\text{Cs}$ ,  $^{40}\text{K}$ ,  $^{214}\text{Pb}$ ,  $^{214}\text{Bi}$ ,  $^{212}\text{Pb}$ ,  $^{228}\text{Ac}$ ,  $^{208}\text{Tl}$ ,  $^{212}\text{Bi}$  and others as detected.

Selected sampling locations will also be analyzed for semi-volatile extractables, pesticides, and PCBs:

*Organics (extractables):* butylbenzylphthalate, bis(2-ethylhexyl)phthalate, di-n-butylphthalate, di-n-octylphthalate, diethylphthalate, dimethylphthalate, n-nitrosodimethylamine, n-nitrosodiphenylamine, n-nitroso-di-n-propylamine, isophorone, nitrobenzene, 2,4-dinitrotoluene, acenaphthene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, naphthalene, phenanthrene, pyrene, bis(2-chloroethyl) ether, bis(2-chloroethoxy)methane, bis(2-chloroisopropyl) ether, 4-bromophenylphenyl ether, 4-chlorophenylphenylether, hexachlorocyclopentadiene, hexachlorobutadiene, hexachlorobenzene, hexachloroethane, 1,2,4-trichlorobenzene, 2-chloronaphthalene, 4-chloro-3-methyl phenol, 2-chlorophenol, 2,4-dichlorophenol, 2,4-dimethylphenol, 4,6-dinitro-o-cresol, 2-nitrophenol, 4-nitrophenol, pentachlorophenol, phenol, 2,4,6-trichlorophenol

*Organics (pesticides/PCBs):* aldrin, alpha-BHC, beta-BHC, delta-BHC, gamma-BHC (lindane), technical chlordane, alpha-chlordane, gamma-chlordane, 4,4-DDD, 4,4-DDE, 4,4-DDT, dieldrin, endosulfan I, endosulfan II, endosulfan sulfate, endrin, endrin aldehyde, endrin ketone, heptachlor, heptachlor epoxide, toxaphene, methoxychlor, PCB 1016/1242, PCB 1221, PCB 1232, PCB 1248, PCB 1254, PCB 1260, PCB 1262

### ***Schedule***

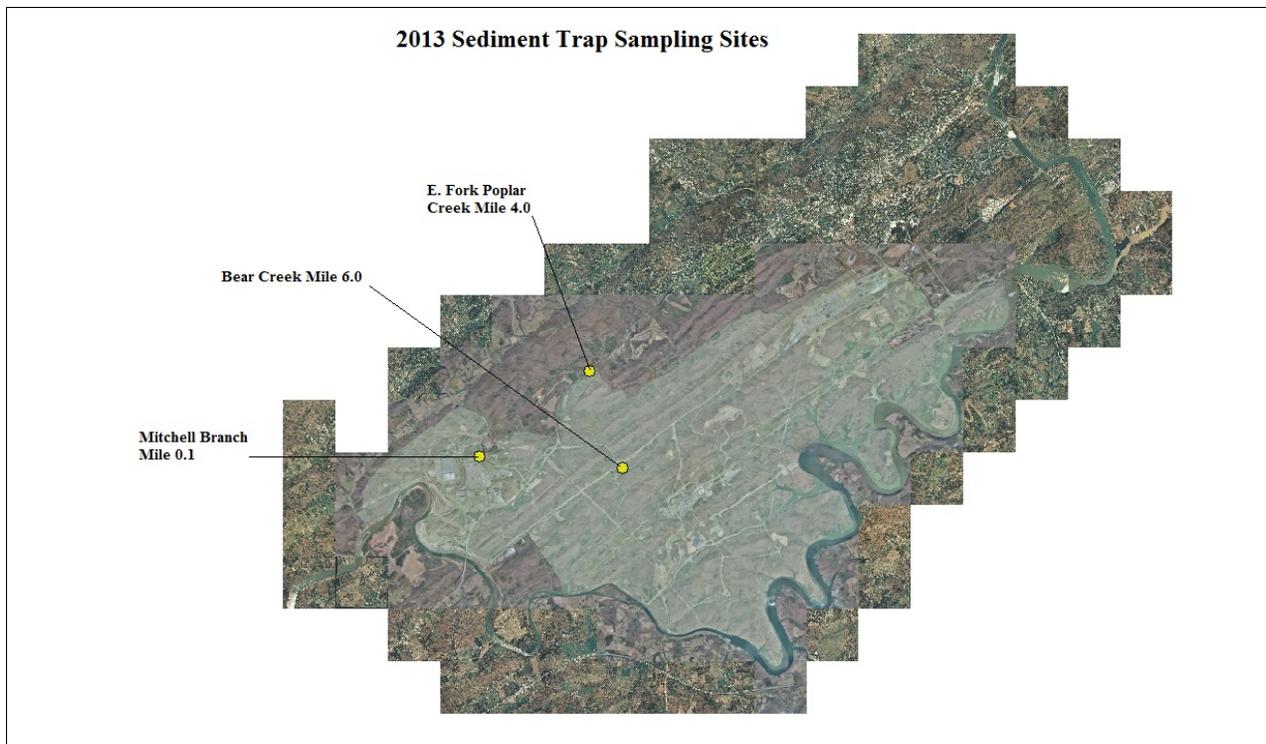
Passive sediment samplers will be deployed in the spring of 2013. They will be checked periodically; samples will be collected when the samplers are full.

### ***Sediment Standard Operating Procedures***

This procedure is to be used to obtain quality assured sediment sampling. The resulting data may be qualitative or quantitative in nature and is appropriate for use in preliminary surveys and in confirmatory sampling.

### ***Required Equipment***

aluminum foil	sample labels
sample jars	cooler with ice
sediment samplers	cable ties
stainless steel mixing bowls	stainless steel spoons
lab analysis request sheets	chain of custody forms
field book	GPS unit
nitrile gloves	electrical tape



**Figure 2: Trapped Sediment Site Locations**

***Procedure***

The passive sediment trap samplers will be installed in the stream horizontally with steel stakes driven into the stream bed. Step by step directions are as follows:

1. Locate a sampling site that is suitable for sediment collection (moderate current).
2. Don nitrile gloves to avoid self-contamination during sampling.
3. Drive two steel stakes into the stream bed in the location selected. Position the stakes with the proper distance to match the mounting rings on the passive sediment sampler.
4. Attach sampler to steel stakes with cable ties.
5. Check the trap approximately three months after deployment; collect the accumulated sediment when a sufficient quantity is obtained (>50 g). Carefully transfer sample into the appropriate containers using a stainless steel spoon. Seal sediment sample containers with electrical tape to prevent leakage.
6. Record all pertinent information on lab sheets, sample labels, and make necessary entries into field notebook.
7. Place all samples into cooler as soon as possible. Temperature within the cooler should be maintained at 4° C by using wet ice.
8. Deliver sediment samples to state lab within appropriate holding time frames, and sign chain-of-custody forms.

***Laboratory Procedures***

Laboratory Services has expertise in a broad scope of services and analyses available to DOE-O and to other TDEC divisions statewide. General sampling and analysis methods are to follow Environmental Protection Agency (EPA) guidelines as listed in appropriate parts of 40 Code of

Federal Regulations (CFR). Certain analyses and QC samples may be subcontracted out by Laboratory Services to independent laboratories. Bench level Quality Assurance/Quality Control (QA/QC) records and chain-of-custody records are maintained at the state lab as are QA records on subcontracted samples.

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### **References**

Phillips, J. M., Russell, M.A., and Walling, D.E. Time-integrated Sampling of Fluvial Suspended Sediment: A Simple Methodology for Small Catchments: Hydrological Processes, v. 14, no. 14, p. 2,589-2,602. 2000.

Tennessee Oversight Agreement, Agreement Between the U.S. Department of Energy and the State of Tennessee. Tennessee Department of Environment and Conservation, DOE Oversight Office. Oak Ridge, Tennessee. 2011.

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